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Strategies for Development of Medicinal Plants Sector in Maharashtra

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ABSTRACT

Maharastra State has varying soil types and agro-climatic conditions, which offers tremendous scope for cultivation of Medicinal and Aromatic plants. The regions like Melghat, Western Ghat Zone, Konkan, Satpuda Range, Sahyadri Hills ete, are the treasure house of Medicinal and Aromatic plants. There is an ever increasing demand of natural food, pharmaceutical, perfumery, flavours and cosmetic products based on medicinal and aromatic plants and the availability of medicinal plants is already under serious threat due to habitat degradation. It is estimated that around 500-600 species are being used for drug preparation by the pharmaceutical industries and around 70% of plant collection involve destructive harvesting from the forest areas. In view of the present status of medicinal plants used in various industries, there is a need to pay attention on the conservation and cultivation of medicinal plants which are extensively used by the industries and also which have become endangered/threaten.

During modern times there is a tremendous resurgence of interest into "Ayurveda" and as such medicinal plants have gained new ground. Considerable information about these Medicinal plants and their active principles has accumulated over the years. The international interest in '**Alternative Medicine'** has opened up new vistas in not only exploiting the already known medicinal plants but also in identifying newer active principles from plants and herbs for medicinal use.

In India, there are more than 10000 medium to large drug manufacturing units , which utilize several drug plants both from cultivation as well as wild sources as raw materials. Whereas, bulk of this raw material (95%) is obtained from forest and less than 40 medicinal plants species are under systematic cultivation. Due to extensive deforestation and over exploitation of our rich forestlands, the availability of valuable species has dwindled. Looking to the present deteriorating conditions of medicinal plants in natural forest, preservation/conservation and propagation of left out plants have become an important task.

Present Status of Medicinal and Aromatic Plants:

India with its varied soil and climatic conditions possesses rich flora that include about 2500 species accredited with virtues. Of these, about 500 to 600 plants find regular use in ayurvedic and unani system of medicine. India ranks good position in the supply of medicinal plants to the industrialized countries of the West, where demand for natural drugs/herbal products has been on the increase in recent years. According to one estimate, the world trade in plant based drug raw materials and phyto-chemical is around 62 billion US $ which is likely to raise to 5 trillion US $ in near future. The herbal wave all over the world is willing to welcome Ayurvedic treaties in growing proportion. At the same time, the 750 Ayurvedic manufacturing industries in Maharashtra are dependent on natural forests in Maharashtra and adjoining states like Madhya Pradesh for supply of plant parts for manufacturing their medicines. The trade of over 600 crores gives employment to over 1 lakh persons including forest and rural / tribal labourers for collection of medicinal plants from dense forests to village level traders. Industrial labourers are primarily engaged in processing and packing at district places. Transporters and marketing networks is spread all over the state. This trade also adds Rs. 100 crores every year to the revenue of the state by way of direct or indirect taxes. The purchase of raw materials like roots, barks and leaves like substances is expected to be over Rs.100 crores.

Demands of Medicinal Plants:

Medicinal Plants as a group comprises approximately 8000 species and account for around 50% of all the higher flowering plant species of India. CERPA (Center for Research, Planning and Action) report on demand study for selected medicinal plants stated that over 1200 medicinal plants are in use with the manufacturer / practitioners or are being traded or collected / cultivated. Out of these, 162 plants are very important, which accounts for 71% of the total medicinal plants material that becomes available through forest sector. The cultivation of Medicinal and Aromatic plants has now

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form an important area in the international agribusiness with an estimated growth rate of 10-15 per cent and thus the medicinal and aromatic plants being a natural source of raw material for industrial products offers great scope to achieve higher net returns with the up-liftment of rural economy. The annual growth rate of 32 medicinal plant species prioritized by National Medicinal Plants Board, New Delhi, demand analysis and species prioritized by Maharashtra state is given in Table-1,2 and 3 ,respectively.

Table 1 : Annual Growth Rate of 32 Prioritised Medicinal Plants

SN	Medicinal Plant Species	Habitat	Annual Growth Rate (%)
1*	Amla	Perennial Tree	22.5
2*	Ashok	Perennial Tree	15.0
3*	Ashwagandha	Annual herb	9.1
4	Atis	Biannual herb	18.4
5*	Bael	Perennial Tree	9.6
6	Bhumi amalaki	Annual herb	10.5
7	Brahmi	Annual herb	20.1
8*	Chandan	Perennial Tree	19.1
9	Chirata	Biannual herb	10.0
10	Daru haridra	Perennial shrub	15.5
11*	Giloe	Perennial climber	9.1
12*	Gudmar	Perennial climber	NA
13*	Guggal	Perennial shrub	19.2
14*	Isabgol	Annual herb	NA
15	Jatamansi	Perennial climber	8.7
16*	Kalihari	Annual climber	15.4
17*	Kalmegh	Annual herb	3.1
18	Kesar	Annual herb	NA
19	Kokum	Perennial Tree	NA
20	Kuth	Annual herb	8.9
21	Kutki	Annual herb	12.9
22	Makoy	Annual herb	1.8
23	Mulethi	Perennial herb	15.9
24	Patharchur	Annual herb	17.2
25*	**Pippali**	Perennial climber	**16.3**
26*	**Safed musli**	Annual herb	**NA**
27*	**Sarpgandha**	Perennial herb	**11.6**
28*	**Senna**	Perennial herb	**21.8**
29*	**Shatavari**	Perennial climber	**15.1**
30*	**Tulsi**	Annual herb	**17.9**
31	Vatsnabh	Perennial herb	30.0
32	Viavidang	Perennial Tree	NA

*** Species suitable for agroclimatic region of Maharashtra**

Table 2: -Demand analysis of Medicinal Plants

High	Very High	Very Very High
1 Talees	1 Siras	1 Apamarga/ Aghada
2 Ativish	2 Gheekwar	2 Bachnag
3 Vanshlochan	3 Agar	3 Afsanteen
4 Guggal	4 Brahmi	4 Neem
5 Kawach	5 Sonamukhi	5 Chitrak
6 Tulsi	6 Amaltas	6 Usir/Khas
7 Raktachandan	7 Dalchini	7 Shatawari
8 Arjun	8 Kali musli	8 Ashwagandha
9 Kalmegh	9 Kachor	9 Gulwel
	10 Wavading	10 Chirayata
	11 Aamla	11 Bhui-amla
	12 Kokkam	
	13 Gambhari	
	14 Kababchini	
	15 Chandan	
	16 Gajpippali	
	17 Petari/Kanghi	
	18 Ashoka	

(**Source** : Directory of Manufacturers of ISM& H Drugs-*IEMR* New Delhi, 2002.)

Table 3: Medicinal plant species prioritized for the State of Maharashtra according to their conservation and economic values.

S N	Botanical Name	Local name
A)TREE SPECIES		
1	*Aegle marmelos* (L.) Corr.	Bael
2	*Alstonia scholaris* (L.) R. Br.	Saptparna
3	*Callophyllum inophyllum* L.	Undi
4	*Cassia fistula L.*	Amaltash/ Bahava
5	*Emblica officinalis Gaertn.*	Amla
6	*Garcinia indica* (Du Petit. thou) Choisy	Kokam
7	*Gmelina arborea Roxb.*	Shivan/ Gambhari
8	*Mesua ferrea* L.	Nagkesar
9	*Nothapodytes nimmoniana* (Grah.)Mabb.	Narkya/ Amruta

10	*Oroxylum indicum* (L.) Vent.	Tetu
11	*Pongamia pinnata* (L.) Pierre.	Karanj/ Kadu badam
12	*Premna obtusifolia R.Br.*	Agnimanth/ Takala
13	*Pterocarpus marsupium* Roxb.	Bibla/Bija
14	*Santalum album* L.	Chandan
15	*Sapindus laurifolia* Vahl.	Ritha
16	*Saraca asoca* (Roxb.) de. Wilde.	Sita ashok
17	*Strychnos nux-vomica* L.	Kajra/Kutaj
18	*Symplocos aurina* (Retz) Wall.	Lodhrah, Mirioli
19	*Syzygium cumini* (L.) Skeel	Jambhul/Jamun
20	*Terminalia arjuna (Roth)*	Arjun
21	*Terminalia bellirica* (Gaertn.) Roxb.	Behada
22	*Terminalia chebula* Retz	Hirda
B)	**HERB SPECIES**	
1	*Acorus calamus L.*	Vekhand
2	*Aloe barbadensis*	Korphad
3	*Andrographis paniculata*	Kalmegh
4	*Baccopa monnieri*	Brahmi
5	*Boerhavia repens(L)*	Punarnava
6	*Cassia angustifolia*	Sonamukhi
7	*Chlorophytum borivilianum*	Safed musli
8	*Psoralia corylifolia*	Bawachi
9	*Glycyrrhiza glabra*	Jesthmadh
10	*Ocimum bassilicum*	Tulsi
11	*Plantago ovata Forsk*	Isabgoal
12	*Rauvolfia serpentina*	Sarpagandha
13	*Ruta graveolens*	Satap
14	*Spilanthus ealva DC*	Akkalkarra
15	*Uraria picta*	Pithavan
16	*Vetiver zizaniodes*	Khus/Wala
17	*Withania somnifera*	Ashwagandha
C)	**SHRUB SPECIES**	
1.	*Adhatoda vasaca L.*	Adulsa
2.	*Bixa orellana* L.	Shendri
3.	*Clerodendrum serratum* (L.) Moon.	Bharangi
4.	*Coleus barbatus Andr.*	Mine mula
5.	*Commiphora wightii (Am.) Bhandari*.	Guggul
6.	*Desmodium gangeticum* (L.) DC.	Salvan
7.	*Helicteres isora* L.	Murudsheng
8.	*Holarrhena antidysenterica (Heyne. ex Rotn.) Wall. ex DC.*	Pandhara Kuda
9.	*Plumbago zeylanica L.*	Pandhara Chitrak
10.	*Solanum indicum*	Chinchurdi, Dorli
11.	*Vitex negundo* L.	Nirgudi
D)	**CLIMBER SPECIES**	
1.	*Abrus precatorius* L.	Gunj
2.	*Acacia sinuata {Lour.} Merrill.*	Shikekai
3.	*Argyreia nervosa {BurmI} Bojer.*	Afurmari
4.	*Asparagus racemosus* Willd.	Shatavari
5.	*Celastrus paniculatus* Willd.	Malkangoni , Jyotishmati
6.	*Embelia ribes Burm.* f.	Wavding,/ Vidangah
7.	*Gloriosa superba* L.	Nagkaria,Kal-Iavi, Agnishikha
8.	*Gymnema sylvestre* (Retz.)R.Br.& S.	Gudmar
9.	*Hemidesmus indicus* (L.) R. Br.	Anantamul
10.	*Mucuna pruriens* fL.) DC.	Khaj Khujli/ Kawach beej
11.	*Piper longum* L.	Pimpli, Pipli
12.	*Rubia cordifolia* L.	Manjishtha
13.	*Tinospora cordifolia* (Willd.) Miers. ex Hk.f.& Th	Gulvel/Guduchi
14.	*Tylophora indica* (Burm. f.) Merrill.	Anantvel

Potential of Medicinal and Aromatic Crop Plants:

Medicinal and Aromatic Plants constitute the most viable alternative cash crops for growers and are virtually gold mines for pharmaceutical and essential oil industries. Medicinal and Aromatic plants have enormous potential for employment generation and thus can be an important factor in economic uplift of the rural masses. They are highly remunerative crops and have good profit margin, depending on the crop and area under cultivation. As such, they might form a viable enterprise under Agri-Business Consortium for small farmers. Indeed they open up possibilities of establishing cottage industry related Co-operative units for processing and marketing. The new interest among the drug companies in herbal preparation has precipitate greater attention and has resulted into commercial exploitation of important medicinal and aromatic plant. While it is imperative that such plants should be protected in their natural habitate, it is also necessary to cultivate the medicinal plants with such technical know how so as to maximize the

production with better elegance. The production technologies should emphasized on suitable cropping system, utilization of organic manures, bio fertilizers, efficient management of non monetary inputs, inter cropping, crop rotation and sequence so that these crops become an integral part of the cropping system. Technologies have therefore to be developed to overcome the problems of commercial cultivation. The research work to develop the agrotechnologies of commercial viable medicinal plant species is being carried out since long back under ICAR through various centres of All India Coordinated Research Projects on Medicinal and Aromatic Plants. Owing to the increasing importance of medicinal crops, the central government has also established a National Medicinal Plants Board (NMPB) under the department of AYUSH, Ministry of Health and Family Welfare, New Delhi which is the apex body for coordination and implementation of policies related to medicinal plants both at the Centre and State levels. Some of the agro technologies of medicinal and aromatic plants are given in Table 4 and 5.

Major Constraints:

i) Quality planting material:

The major constraints in the development of these plant species particularly of medicinal and aromatic plants experienced by our farmers are non-availability of quality planting material of improved varieties. Research so far conducted in the various medicinal plant research centers have developed / evolved good number of high yielding varieties with better quality attributes, however, no mass production programme is being implemented which resulted into non availability of good and genuine planting material.

ii) Lack of development and extension support:

Lack of development and extension support in the cultivation and processing of Medicinal and Aromatic plants, unorganized marketing with wide fluctuations in the market prices are the hurdles in the development of MAP sector. At present, there is no regulated, controlled market available in the State and development in this regard is very important. In view of above it is suggested to take-up cultivation on group basis/contract farming, which will facilitate for assured market.

iii) Quality Produce:

The pharmaceutical industries need regular supply and quantity and quality supply of the produce. Therefore one should cautious about the use of any insecticide/pesticide or chemical fertilizers for medicinal and aromatic crop plants. *We have to grow medicine (Alkaloids, Glycosides, Steroids, etc.) and not poison.* WHO as well as WTO also emphasized the need of medicinal and aromatic plants produce from organic cultivation.

It is true that the quality of the any agricultural produce, particularly horticultural/medicinal plants produce improves when the nutrients are supplied through organic manures than in the form of fertilizers. This is because of the supply of all the growth principles like enzymes, hormones, growth regulators etc. besides all the essential plant nutrients by the manure (Kumaraswamy, 2002). As a result, the metabolic functions get regulated more effectively resulting in better synthesis of proximate constituents and consequent improvement in the quality of the produce.

SWOT analysis for cultivation of medicinal plants in Maharashtra

STRENGTHS

- Variety of climate and soil conditions like Deccan plataue, Western ghats ,Satpuda hills and Coastal areas are suitable for growth of more than 100 perennial medicinal tree species and over 450 shrubs, herbs, climbers and seasonal/annuals.
- Availability of 2.9 million hectares cultivable waste land can be utilized for cultivation of medicinal and aromatic plants.
- The farmers in the state are innovative and willing to cultivate medicinal plants.
- Availability of skilled and unskilled manpower.
- Proximity to International Air Port and Harbour.
- Major Ayurvedic Companies trade from Mumbai or are based in Mumbai.

WEAKNESSES:

- Non availability of improved varieties of important medicinal plant species and their planting material.
- Non availability of agronomical practices for important medicinal plants.
- Non availability of statistical information about area, production, -productivity and consumption of these species.
- Non availability of buy back network for the medicinal crops.

Table 4: Cultivation practices of medicinal and aromatic plants in Vidarbha(Maharashtra).

S. N.	Name of Medicinal	Sowing period	Propagated by	Seed rate kg/ha	Spacing (cm)	Duration (months)	Yield (q/ha)
1	*Withania somnifera*	Aug/Sept.	Seeds	10.0	30 row	5-6 months	7-8 (roots)
2	*Cassia angustifolia*	September	Seed	15.0	30 x 30	4 - 5 yrs	2-3 (seed) 10-12 (dried leaves)
3	*Chlorophytum borivilianum*	June	Roots	3.33 lakh roots	30 x 10	6.0	3-4 (dried roots)
4	*Asparagus racemosus*	May/June	Seed	1.0	90 x 60	18 - 24	12-15 (dried roots)
5	*Andrographis paniculata*	June/July	Seed	2.0	30 x 30	4.5	25-30 (Foliage)
6	*Rauvolfolia serpentina*	June/July	Seed	5.5	45 x 30	18	10-12 (roots)
7	*Plantago ovata*	November	Seed	4.0	30	4.0	5-10 (seed)
8	*Ablemoschus moschatus*	June/July	Seed	12.0	45 x 30	6.0	5-8 (seed)
9	*Catharanthus roseus*	June/July	Seedling	2.5	45 x 30	8.0	10-15 (roots) 20-25 (foliage)
10	*Solanum virum*	June/July	Seed	1.0	60 x 45	8.0	15-20 (dried berries)
11	*Piper longum*	March	Cuttings	73000	40 x 30	12.0	2.5-4.5 (fruits)
12	*Cymbopogan martinii*	June/July	Seedling	2 - 3	45 x 30	4-5 Yrs.	75-85 kg oil
13	*Cymbopogan flexuosus*	June/July	RootedSlip	37000	60 x 45	4-5 Yrs	100-120 kg oil
14	*Cymbopogan winterianus*	June/July	RootedSlip	37000	60 x 45	4-5 Yrs	110-130 kg oil

Table 5: Plantation Practices of shrubs/trees having medicinal utility

S. N.	Name of Crop / Plant	Propogation	Spacing (mts)	Flowering period	Fruit maturity	Average yield per plant/year	Economic life (years)
1	*Emblica officinalis*	Seed/ grafting	7 x 7 to 10 x 10	June/ July	November / February	50-150 kg	15-20
2	*Aegle mormelos*	Seed	6 x 6	October/ December	March/ July	20-24 Kg	25-30
3	*Terminalia arjuna*	Seed	6 x 6	December	January / February	10-15 kg (bark)	30-35
4	*Terminalia belerica*	Seed	7 x 7	December	February / March	40-50 kg	30-40
5	*Terminalia chebula*	Seed	7 x 7	December	February / March	40-50 kg	25-30
6	*Semecarpus anacardium*	Seed	7 x 7	Sept/ Oct.	February / January	20-25 kg (fruits)	25-30
7	*Commiphora mukul (Guggal)*	Cutting	3 x 3	-	-	500-720 gm guggal	
8	*Mimusops hexandra*	Seed	7 x 7	February / March	April/ May	10-15 kg fruits	25-30
9	*Murraya koenigii*	Suckers	3 x 3	-	-	20-25 kg leaves	25-30
10	*Sapindus trifoliatus*	Seed	7 x 7	October	December/ January	20-25 kg (fruits)	25-30
11	*Acacia-concinna*	Seed	2 x 2	Dec/Jan	March/ May	2-4 kg	25-30
12	*Bixa orellana (Annatto)*	Seed	6 x 4.5	September / October	December/ January	2-4 kg seed	10-15

- Non willingness of major Ayurvedic manufacterers for guaranteed purchase of cultivated medicinal plant produce directly from farmers or their associations.
- Lack of organised marketing system in the state for medicinal plant produce.
- 'Poor packaging and post harvest handling system.
- Non availability of Quality parameters
- Lack of trained analytical hands to determine the quality
- Non willingness of paying extra cost for cultivated species as compared to wild harvested supply of herbal plant parts.

OPPORTUNITIES:

- Liberalization of economy and statutory control by signing WTO agreement.
- Ever increasing global acceptance especially to herbal products
- Current share in world herbal market is estimated 0.4%, which Dept. of Indian System of Medicine has decided to achieve target to 6% i.e. about $ 6.5 billion by year 2010 and $ 4.5 Trillion by year 2020. Thus estimated growth rate is 15 % in 8 years.
- A profit from export of cultivated agricultural produce is exempted from taxation.
- Enforcement of Bio-diversity Protection Act will forcibly initiate a systen1 of contract farming of medicinal plants.
- Enforcement of Good Manufacturing Practices in Ayurvedic Pharma Industry will automatically force the manufactures to purchase Organicallycultivated medicinal herbs for ease in analysis.
- Non availability of medicines for chronic diseases and physiologicaldisorders like obesity, diabetes, stress etc in modern medicinal system forces patients to adopt -alternative herbal drugs.

THREATS:

- China has emerged as the major producer and trader in the global herbal market.
- Highly perishable nature of fresh produce.
- Produce can not be sold directly to end users, hence this sector is a .monopoly buyers market not suitable to small farmers.
- Synthetic materials having identical therapeutic effect can be cheaper.

Strategy to promote the cultivation and trade of medicinal plants

Following strategies are suggested to promote the cultivation and trade of medicinal plants

- Buy back guarantee from industries and traders under contract farming system.
- Quality planting material of improved varieties .
- Good agricultural practices for production of raw drugs.
- Intercropping with traditional cropping pattern needs to be promoted.
- The selection of species for cultivation on farmers field

i) Should be based on high commercial demand of more than 100 ton annually at national level.

ii) Species not found wild or rare in the wild or their collection from wild is less or unviable.

iii) No botanical substitute in pharmacopoeia

iv) Preference to be given for herbs/shrubs, not for tree plantation

- R&D on all aspects of medicinal plants must be intensified.
- Crop-wise post harvest processing technology for obtaining high quality produce must be developed.
- Phyto-medicinal monographs for each of the medicinal plant, including information on physiological effects, efficacy, quality standard and references etc., are needed to be developed.

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Gene Effects of Seed Yield and Component Traits in Castor Crosses

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ABSTRACT

The P_1, P_2, F_1, F_2, BC_1 (F_1 x P_1), and BC_2 (F_1 x P_2) of three castor crosses *viz.*, JP 101 x SKI 291, JP 102 x JI 372 and JP 96 x JI 368 were studied for 12 metric traits. The scaling tests revealed the importance of additive-dominance model for days to maturity of main raceme, shelling out turn and oil content in JP 101 x SKI 291; and days to flowering of main raceme in JP 96 x JI 368. The result of rest of the cases depicted the epistatic digenic model including all types of interactions played a major role for the entire cross combinations. The study revealed the importance of additive and non-additive type of gene action for all the characters studied suggesting the use of reciprocal recurrent selection or biparental mating for improving the characters in castor. Duplicate type epistasis played a greater role than complementary epistasis in most of the cases.

Castor (*Ricinus communis* L.) is grown in tropical, sub-tropical and temperate regions of world. Castor is highly cross pollinated crop and being a sexually polymorphic species with different sex forms viz., monoecious, pistillate and pistillate with interspersed staminate flowers (ISF).The breeding method to be adopted depends mainly on the nature of gene action involved in the expression of the quantitative traits. Line x tester analysis is used to select the parents based on their combining ability but fails to detect the epistasis which remains the most complex problem and on which it is extremely difficult to obtain reliable results. The epistasis can be detected by the analysis of generation means using the scaling tests, whether it is additive x additive, additive x dominance and dominance x dominance type of gene interaction at the digenic level. After confirmation of epistasis, joint scaling test of six parameter model m, (d), (h), (i), (j) and (l) can be applied. Therefore, in this context, the objective of the present study was to obtain information on the gene effects to provide a basis of selection in a breeding programme for the improvement of castor.

MATERIAL AND METHODS

The experimental material was comprised of three castor crosses *viz.*, JP 101 x SKI 291, JP 102 x JI 372 and JP 96 x JI 368, each with six basic generations *viz.*, P_1, P_2, F_1, F_2, BC_1 and BC_2. The experiment was laid out in Compact Family Block Design with three replications at Oilseeds Research Station, Junagadh Agriculture University, Junagadh (Gujarat). The single row plot was sown for both parents and their F_1's, five rows for each F_2 generation and three rows for each backcross during *Kharif* 2010-11. The seed was dibbled with 90 cm and 60 cm as inter and intra row spacing, respectively and with 7.2 m of row length. All the recommended cultural and plant protection practices were followed to raise good crop. The data were recorded on individual plant basis in each replication on randomly selected five competitive plants in each of parents and F_1's, 20 plants in each of backcross and 40 plants in F_2 generations for 12 characters. The data were first subjected to estimates of individual scaling tests A, B and C of Mather (1949) and joint scaling test of Cavalli (1952) to detect the presence of epistasis. The gene effects were estimated using the models suggested by Jinks and Jones (1958) and Mather and Jinks (1980). The significance of the scales and gene effects were tested by using the t-test (Singh and Chaudhary, 2004).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among six basic generation means for all the characters studied in all the three crosses except number of effective branches per plant in JP 102 x JI 372 and number of nodes up to main raceme and number of effective branches per plant in JP 96 x JI 368 (Table 1). These characters which failed to show significant variation among the generations were not subjected to further statistical analysis. The estimates of genetic parameters for different characters recorded in three crosses are presented in Table 2. The estimates of

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individual scaling tests A, B and C were non-significant for days to maturity of main raceme, shelling out turn and oil content in JP 101 x SKI 291; and days to flowering of main raceme in JP 96 x JI 368 indicating the adequacy of simple additive-dominance model for these traits. When the simple additive-dominance model was found adequate to explain the variation among generation means, three parameters model proposed by Cavalli (1952) was employed for these four cases. Both additive (d) and dominance (h) gene effects in these non-interacting crosses were important in the inheritance of days to maturity of main raceme, shelling out turn and oil content in JP 101 x SKI 291; and days to flowering of main raceme in JP 96 x JI 368.

The significance of any one, two or all the three individual scaling tests A, B or C in all the crosses for all traits except for days to maturity of main raceme, shelling out turn and oil content in JP 101 x SKI 291; and days to flowering of main raceme in JP 96 x JI 368 indicated adequacy of epistasis model. This was also conformed by joint scaling test showing significant chi-square values for these cases, indicating involvement of digenic interaction parameters in the inheritance of these characters. The joint scaling test was found to be more efficient in detection of epistasis compared to individual scaling tests. Ketata *et al.,* (1976) in wheat also concluded superiority of joint scaling test over the simple scaling tests. As the simple additive-dominance model failed to explain the variation among generation means for these traits, six parameter perfect fit models proposed by Jinks and Jones (1958) was employed.

Among interacting crosses, both additive (d) and dominance (h) gene effects contributed significantly towards the inheritance of plant height up to main raceme, number of nodes up to main raceme and 100-seed weight in JP 101 x SKI 291; days to maturity of main raceme, plant height up to main raceme, number of nodes up to main raceme, length of main raceme, effective length of main raceme, shelling out turn, 100-seed weight and oil content in JP 102 x JI 372; and days to maturity of main raceme, plant height up to main raceme, length of main raceme, effective length of main raceme, shelling out turn and 100-seed weight in JP 96 x JI 368. Only additive (d) was significant for length of main raceme, effective length of main raceme and number of capsules on main raceme in JP 101 x SKI 291; seed yield in JP 102 x JI 372; and number of capsules on main raceme and oil content in JP 96 x JI 368. While only dominance (h) was significant for days to flowering of main raceme in JP 101 x SKI 291; and number of capsules on main raceme and seed yield per plant in JP 96 x JI 368. Neither additive (d) nor dominance (h) was significant for number of effective branches per plant and seed yield in JP 101 x SKI 291; and days to flowering of main raceme in JP 102 x JI 372. Several workers have earlier reported importance of additive and dominance gene effects in the inheritance of seed yield and its components i.e. by Thakkar (1987), Pathak *et al.* (1988) and Golakia *et al.*, (2004). Importance of only additive effects for seed yield was depicted by Giriraj *et al.*, (1973) and Kandaswamy (1977), while non-additive gene effects for seed yield was reported by Patel *et al.* (1986), Thakkar (1987) and Golakia *et al.*, (2004).

In the present study, main effects [m, (d), (h)] as well as all the three digenic interactions [(i), (j), (l)] were significant for number of nodes on main raceme and 100-seed weight in JP 101 x SKI 291; plant height up to main raceme, shelling out turn and oil content in JP 102 x JI 372; and length of main raceme and effective length of main raceme in JP 96 x JI 368 indicated the involvement of additive, dominance as well as epistasis gene interaction for controlling these traits. Solanki *et al*. (2003) observed additive, dominance and epistasis with high (dominance x dominance) for plant height up to main raceme, number of nodes up to main raceme, total length of main raceme, effective length of main raceme and number of capsules on main raceme, while Golakia *et al*. (2004) advocated presence of additive, dominance and epistasis gene effects for number of nodes up to main raceme, total length of main raceme, effective length of main raceme and seed yield per plant. Looking to the interaction components [(i), (j), (l)], the digenic additive x additive (i) interaction effect was significant for days to flowering of main raceme, length of main raceme, effective length of main raceme and seed yield in JP 101 x SKI 291; 100-seed weight in JP 102 x JI 372; and plant height up to main raceme, shelling out turn and 100-seed weight in JP 96 x JI 368. While additive x dominance (j) interaction effect was significant for number of effective branches per plant in JP 101 x SKI 291; seed yield in JP 102 x JI 372; and oil content in JP 96 x JI 368. Only dominance x dominance (l) gene effect was significant for days to flowering and days to maturity of main raceme in JP 102 x JI 372. The additive x additive (i) and additive x dominance (j) gene effects were involved in the inheritance of plant height up to main raceme and number of capsules on main raceme in JP 101 x SKI 291; and number of capsules on main raceme in JP 96 x JI 368.

Table 1: Analysis of variance (mean squares) among progenies within families of six generations for different characters in castor

Source of variation	d.f.	Days to flowering of main raceme	Days to maturity of main raceme	Plant height up to main raceme	Number of nodes up to main raceme	Length of main raceme	Effective length of main raceme	Number of effective branches plant^{-1}	Number of capsules on main raceme	Shellingout turn	100-seed weight	Oil content plant^{-1}	Seed yield
						JP 101 x SKI 291 (cross 1)							
Replications	2	0.083	2.73	55.00	0.51	27.10*	1.89	0.007	43.76*	8.34	0.12	0.64	11.46
Generations	5	32.88**	106.16**	2146.22**	12.00**	71.64**	216.22**	0.65**	193.10**	45.20*	16.60**	9.04**	1794.6**
Error	10	0.16	1.54	14.22	0.84	6.51	4.37	0.09	7.32	8.22	0.07	0.28	18.67
						JP 102 x JI 372 (cross 2)							
Replications	2	1.95	0.40	79.88	0.78	4.41	1.76	0.29	65.43**	0.005	0.24	0.40	131.74
Generations	5	24.05**	130.19**	1721.66**	25.81**	152.74**	341.93**	0.43	147.03**	22.56**	105.07**	16.41**	1178.2**
Error	10	3.36	0.57	46.60	1.31	5.18	6.03	0.14	7.92	0.09	0.45	0.67	122.71
						JP 96 x JI 368 (cross 3)							
Replications	2	9.62**	0.20	66.61	0.022	16.33	15.25*	5.34*	10.55	0.21	0.21	0.24	265.28
Generations	5	7.04*	144.58**	227.41**	0.50	82.55**	80.11**	1.52	129.89**	33.20**	40.12**	9.39**	6106.7**
Error	10	1.26	0.6	27.15	0.34	4.16	3.99	0.99	11.66	0.52	0.36	0.31	68.97

*** and ** Significant at 5 and 1 per cent levels, respectively**

Table 2: Estimates of individual scaling tests, joint scaling test and gene effects for various traits of three castor crosses

Cross	Individual scaling tests			Joint scaling test [$\div^2$]	M	[d]	[h]	[i]	[j]	[l]	Type of Epistasis
	A	B	C								
Days to flowering of main raceme											
C_1	**	**	**	**	47.43**±3.80	-0.30±0.17	9.06**±9.42	13.46**±3.79	0.88±1.25	2.30±5.76	C
C_2	**	**	**	**	59.16**±3.84	0.16±0.53	-12.53±9.47	2.40±3.80	-0.35±1.31	10.36*±5.20	D
C_3	-	-	-	-	56.62**±0.37	1.84**±0.36	-0.60**±0.85	-	-	-	-
Days to maturity of main raceme											
C_1	-	-	-	-	134.32**±1.33	3.67**±1.38	7.60**±1.54	-	-	-	-
C_2	**	**	**	**	156.53**±4.73	-2.16**±0.32	-65.30**±12.25	-7.90±4.72	1.13±1.76	57.16**±7.69	D
C_3	**	**	**	**	183.70**±4.43	1.83**±0.38	-120.06**±11.52	-31.93**±4.41	-1.15±1.66	86.03**±7.45	D
Plant height up to main raceme (cm)											
C_1	**	-	**	**	163.33**±18.81	-14.50**±2.68	-98.83*±46.13	-106.50**±18.62	46.50**6.39	-13.16±28.07	C
C_2	*	**	**	**	264.40**±15.39	-18.66**±1.90	-414.36**±38.19	-201.73**±15.27	23.55**±5.24	199.30**±24.41	D
C_3	**	*	**	**	117.33**±14.64	-2.83**±0.57	-69.50*±35.19	-51.83**±14.62	-0.83±4.38	20.16±21.14	D
Number of nodes up to main raceme											
C_1	**	**	**	**	26.86**±2.01	-1.53**±0.39	-22.80**±4.95	-12.60**±1.97	4.53**±0.72	10.00**±3.19	D
C_2	**	**	**	**	31.23**±1.58	-1.50**±0.49	-33.36**±4.27	-17.86**±1.50	0.60±0.76	10.66**±2.83	D
Length of main raceme (cm)											
C_1	**	-	**	**	61.50**±5.44	-5.33**±1.48	-26.33±14.04	-16.83**±5.23	3.00±2.33	3.16±9.24	D
C_2	-	-	**	**	101.50**±4.98	-5.00**±1.51	-125.00**±13.35	-58.16**±4.75	4.33±2.36	58.50**±8.83	D
C_3	**	-	**	**	18.33**±6.69	-4.50*±1.88	91.66**±17.02	37.83**±6.42	12.58**±2.84	-51.33**±0.79	D
Effective length of main raceme (cm)											
C_1	**	-	**	**	61.00**±5.37	-5.33**±1.48	-25.33±13.90	-16.33**±5.17	3.00±2.32	2.00±9.18	D
C_2	-	-	**	**	101.16**±4.97	-5.16**±1.47	-125.00**±13.34	-58.00**±4.75	4.41±2.34	58.83**±8.82	D
C_3	**	-	**	**	19.66**± 6.48	-4.50*±1.82	86.16**±16.33	36.50**±6.18	12.66**±2.71	-47.16**±10.37	D
Number of effective branches per plant											
C_1	*	-	-	*	2.90**± 0.78	-0.33±0.17	2.00±2.06	1.03±0.76	-0.76*±0.31	-0.36±1.55	D

Table 2: (Continue….)

Cross	Individual scaling tests A	B	C	Joint scaling test [÷2]	M	[d]	[h]	[i]	[j]	[l]	Type of Epistasis
Number of capsules on main raceme											
C_1	**	-	**	**	70.83**±9.80	-9.40**±1.68	-24.96±24.51	-25.16**±9.66	12.45**±3.53	-2.26±16.02	C
C_2	-	-	**	**	101.70**±8.65	1.40±2.83	-104.10**±23.22	-51.76**±8.17	-0.15±4.20	0.53**±15.53	D
C_3	-	**	**	**	36.36**±9.91	-5.66*±2.69	31.40±26.06	21.70*±9.54	9.13*±4.41	1.10±16.89	C
Shelling out turn (%)											
C_1	-	-	-	-	56.90**±0.09	-2.55**±0.09	8.70**±0.16	-	-	-	-
C_2	**	-	-	**	53.40**±1.90	-4.00**±0.09	15.00**±4.75	5.13**±1.90	2.10**±0.64	-8.06**±2.92	D
C_3	**	-	**	**	58.06**±2.49	3.33**±0.13	12.10*±6.15	4.86*±2.44	-0.28±0.81	-0.83±3.75	D
100-seed weight (g)											
C_1	**	-	**	**	17.64**±1.26	2.91**±0.06	12.93**±3.14	5.03**±1.26	-1.45**±0.42	-4.31*±1.92	D
C_2	-	-	**	**	14.61**±3.60	-5.32**±0.05	29.78**±9.21	8.87*±3.60	0.68±1.28	- 8.53±5.72	D
C_3	**	-	**	**	23.48**±2.17	4.42**±0.05	17.09**±5.25	6.79**±2.17	-0.54±0.65	-5.05±3.16	D
Oil content (%)											
C_1	-	-	-	-	49.74**±0.03	2.50**±0.03	0.57**±0.06	-	-	-	-
C_2	-	**	**	**	55.82**±1.45	-3.40**±0.04	-12.97**± 3.60	-5.00**±1.45	1.52**±0.47	6.56**±2.20	D
C_3	**	-	*	**	52.80**± 1.42	2.33**±0.20	-0.53±3.18	1.58± 1.41	-0.80*±0.36	0.28±1.79	D
Seed yield per plant (g)											
C_1	**	-	**	**	62.46±39.27	-45.23±33.64	-48.86± 114.11	67.03**±20.27	32.28±34.45	123.40±77.12	D
C_2	-	**	**	**	74.43**±18.17	-20.83**± 1.25	-29.63±47.25	5.66±18.13	19.70**± 6.24	70.26±37.52	D
C_3	**	**	**	**	164.50**±19.18	1.80±3.56	-375.66**±46.79	-29.36±18.85	-15.46*±6.62	383.56**±30.04	D

C_1= JP 101 x SKI 291; C_2= JP 102 x JI 372; C_3= JP 96 x JI 368; m=mid point; [d]=additive; [h]dominance; [i]=additive x additive; [j]=additive x dominance;

[i]=dominance x dominance. An asterisk (*, **) indicates that the value was significant by the t-test at the 5 & 1 %, respectively. D = Duplicate; C = Complementary.

Both (j) and (l) were significant for seed yield in cross JP 96 x JI 368. The additive x additive (i) and dominance x dominance (l) gene actions were expressed in the inheritance of number of nodes on main raceme, length of main raceme, effective length of main raceme and number of capsules on main raceme in JP 102 x JI 372; and days to maturity of main raceme in JP 96 x JI 368.

The present study revealed that additive and non-additive gene actions were important in the expression of the majority of traits studied. Further, duplicate type of epistasis was observed for all the cases except days to flowering of main raceme, plant height up to main raceme and number of capsules on main raceme in JP 101 x SKI 291; and number of capsules on main raceme in JP 96 x JI 368, where complementary type of epistasis was observed. The presence of duplicate epistasis for most of the cases would restrict rapid progress, making it difficult to fix genotypes with increased levels of character manifestation. Use of reciprocal recurrent selection or biparental mating was suggested for improving those characters, when both additive and non-additive gene effects are involved. The additive effects and gene interaction additive x additive (i) or other digenic complementary gene interaction can be exploited effectively by selection for the improvement of the characters *viz.*, days to maturity, plant height, length of main raceme and 100-seed weight. Presence of non-additive gene effects for number of nodes up to main raceme and seed yield indicating that conventional selection procedure may not be effective enough for improvement of yield. Therefore, postponement of selection in later generations or intermating among the selected segregants to break one or two undesirable linkages will allow the accumulation of favourable alleles for the improvement of these traits.

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Heterosis in Cytoplasmic Genetic Male Sterility Based Hybrid Pigeonpea

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ABSTRACT

Fourty eight pigeonpea hybrids derived from crosses between six cytoplasmic genetic male sterile lines based on *C. scarabaeoides* cytoplasm and eight diverse testers were evaluated in line x tester mating design.. An appreciable amount of heterosis was noticed for almost all the characters. Significant heterotic effects were recorded for seed yield per plant in the hybrids AKCMS-09A x AKPR-8, followed by AKCMS-10A x ICPR-2740, AKCMS-09A x AKPR-374, AKCMS-10A x AKPR-374, AKCMS-11A x AKPR-292, and AKCMS-09A x AKPR-292. They had significant heterosis for number of pods per plant, shelling per cent, 100 seed weight and days to maturity in addition to *per se* performance and expected to have contributed towards yield improvement in the hybrids.

Pigeonpea (*Cajanus cajan* (L.) Millsp.) is the second important pulse crop in India after chickpea. . It is grown in about 4.09 million hectares with a production of 3.27 million tonnes of grains(Anonymous 2010-11). The productivity of pigeonpea has been low and stagnant for last five decades and it is hovering only 600 to 700 kg ha^{-1}. On the other hand there is an ever growing demand of pigeonpea *dal*. Pure line breeding in pigeonpea had changed the scenario of unstable yields of the local varieties grown in early sixties. However, their productivity had been stagnant over past four decades. Non conventional breeding approaches especially the development of hybrid varieties offers good scope. Exploitation of heterosis has emerged as one of the potential option for breaking yield plateau in pigeonpea after the identification of genetic male sterility (Reddy *et al.*1978) . Six GMS based pigeonpea hybrids were released for commercial cultivation by ICRISAT and various SAU's including Dr. PDKV, Akola (M.S.). However, they suffered from a major technical bottleneck in large scale seed production. The need of rouging out 50 per cent of the fertile plants from the female parent was costly and skill oriented operation which could not be effectively handled by seed growers.

To overcome the inherent problems associated with GMS system, Cytoplasmic Genetic Male Sterility (CGMS) system was developed using various wild relatives of pigeonpea. These include A1 derived from *C. sericus* (Ariyanayagam *et. al.*, 1995), A2 from *C. scarabaeoides* (Tikka *et al*., 1997 and Saxena and Kumar, 2003), A3 from *C. volubilis* (Wanjari *et al.*, 2001) and A4 from *C. cajanifolius* (Saxena *et al.*, 2005). Tikka *et al*.,(1997) developed a first CGMS based line GT 288A having A2 cytoplasm which could be useful in hybrid breeding..

In the present investigation, an attempt has been made to study the extent of heterosis for yield and yield attributes in 48 experimental hybrids of pigeonpea developed on CGMS system based on *C. scarabaeoides* cytoplasm.

MATERIAL AND METHODS

The present investigation comprising six medium duration cytoplasmic genetic male sterile lines based on A2 cytoplasm viz., AKCMS-06 A, AKCMS-07A, AKCMS-09A, , AKCMS-10A, AKCMS-11A, AKCMS-13A and eight genetically diverse restorers viz., AKPR-8, AKPR-210, AKPR-292, AKPR-319, AKPR-359, AKPR-372, AKPR-374 and ICPR-2740 were crossed in Line x Tester fashion during *Kharif* 2010 at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.). The resultant 48 hybrids along with their 14 parents and one standard check PKV TARA were sown in a completely randomized block design in two replications during *Kharif* 2011. Each plot consisted of single row of 4 m.length spaced at 60 x 30 cm. Recommended package of practices were adopted for optimum crop growth and full phenotypic expression. The extent of heterosis for yield and yield contributing characters in hybrids over mid parent, better parent and standard check .

RESULTS AND DISCUSSION

The analysis of variance for different characters (Table 1) revealed that the female lines under study

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showed significant variation for all the characters except days to 50 per cent flowering, number of branches plant^{-1} and length of pod, while male lines also exhibited significant variation for all the characters except number of branches plant^{-1} and length of pod. It reflected in overall heterosis as tested by using parents verses hybrids contrast which was significant for all the characters except these three traits. The results are in agreement with earlier reports of Patel and Patel (1992), Narladkar and Khapre (1994), Hazarika *et al* (1998) Khorgade *et al* (2000), Jahagirdar (2003) and Kumar *et. al.*, (2009) in pigeonpea.

The estimates of top 15 hybrids showing high *per se* performance for seed yield along with their heterosis over mid parent, better parents and standard check PKV Tara (Table 2) revealed that the high performing crosses also indicated significant heterosis over mid parent, heterobeltiosis and standard heterosis. The overall results of heterosis, heterobeltiosis and standard heterosis indicated that the parents involved in the crosses possessed high *per se* yield, however, the magnitude varied with the characters.

Early flowering is desirable feature for a genotype. Therefore, negative heterosis for days to 50 per cent flowering was considered desirable. Among the top 15 hybrids for *per se* performance this trait ranged from -7.92 to 7.73 per cent over mid parent, -11.25 to 5.17 per cent over better parent and -7.39 to 6.09 per cent over standard check. In this study three hybrids viz., AKCMS-13A X ICPR-2740, AKCMS-10A x AKPR-8 and AKCMS-10A x AKPR-372 registered significant and negative heterosis on all the three bases of estimation. Similar findings were also reported by Khorgade *et. al*., (2000), Patel and Tikka (2008) and Chandirakala *et. al*., (2010) for this trait in pigeonpea. However these hybrids did not register significant and negative heterosis on all three bases for days to maturity instead of that only two hybrids viz., AKCMS-11A X AKPR-319 and AKCMS-11A X AKPR-8 exhibited significant and negative heterosis for days to maturity.

None of the top 15 hybrids exhibited significant heterosis, heterobeltiosis and standard heterosis for number of branches per plant. Khorgade *et. al*., (2000), Chandirakala *et. al*., (2010) and Shobha and Balan (2010) reported significant heterosis for this trait. Heterosis for plant height ranged from 2.53 to 37.73 per cent, -1.3 to 30.34 per cent and -6.89 to 17.70 per cent over mid, better and standard parent, respectively. However, negative heterosis in the context of breeding dwarf genotype will be desirable but none of the top ranking hybrids exhibited significant heterosis in negative direction. Patel *et. al.*, (1991) and Khorgade *et. al*., (2000) reported similar results for plant height in pigeonpea.

In pigeonpea number of pods plant^{-1} is a most important yield component which is positively associated with seed yield. In the present study heterosis for this trait ranged from 17.98 to 104.04 per cent over mid parent, -3.43 to 90.00 per cent over better parent and -13.78 to 35.34 per cent over standard check. Among the 15 top ranking hybrids 14 hybrids, exhibited significant and positive heterosis over mid parent except one *viz.*, AKCMS-10A x AKPR-372. Similarly 11 hybrids exerted significant and positive heterobeltiosis for this trait and three hybrids *viz.*, AKCMS-9A x AKPR 292, AKCMS-9 A x AKPR 372 and AKCMS-10A x AKPR-374 exhibited significant heterosis over check. High degree of heterosis in pigeonpea for these traits was also reported by Patel and Patel (1992), Tuteja *et al*. (1992), Valarmathi and Govil (1996) and Khorgade *et al*. (2000).

Shelling percentage is also one of the important trait in pigeonpea In the present investigation 5 and 3 hybrids had positive heterosis over mid and better parent, respectively, Ten hybrids exhibited significant heterosis over standard check.

Heterosis for 100 seed weight ranged from -20.97 to 60.26 per cent, -36.64 to 45.39 per cent and -27.84 to 31.96 per cent over mid, better and standard check, respectively. Among the 15 top ranking hybrids 9, 7 and 4 hybrids exhibited significant and positive heterosis over mid parent, better parent and standard check, respectively. Three hybrids *viz.*, AKCMS-10A x ICPR 2740, AKCMS-10A x AKPR 374 and AKCMS-11A x AKPR-292 exhibited significant and positive heterosis on all the three bases of estimation viz., mid parent, better parent and standard parent, respectively. The Khorgade *et al*. (2000) reported maximum heterosis 15.16 per cent over mid and 28.44 per cent over check for this trait.

Fertility restoration is a crucial requirement for successful hybrid synthesis using CGMS system in pigeonpea. Among the 15 high performing hybrids almost all the hybrids restored more than 83 per cent plant fertility. The plant fertility per cent ranged from 83 to 100 per cent. About 12 out of 15 hybrids exhibited more than

Table 1. Analysis of variances for parents and hybrids

Source of Variations	d. f.	Days to 50% Flowering	Days to Maturity	100 seed weight (g)	Number of pods plant^{-1}	Shelling (%)	Plant Height (cm)	Branches plant^{-1}	Length of Pod (cm)	Seed plant^{-1}
Genotypes	61	47.899**	33.535 **	5.096 **	1088.630 **	207.029 **	585.510 **	2.377	0.016	125.183 **
Parents	13	32.912*	23.989 **	4.070 **	753.838 **	197.562 **	650.728 **	3.266	0.025	53.604 **
Lines	5	26.150	9.883 **	8.022 **	1111.736 **	305.781 **	817.75 **	1.083	0.039	66.116 **
Testers	7	42.348**	36.205 **	0.477 **	561.339 **	131.301 **	583 **	4.143	0.011	52.134 **
Parents vs Hybrids	1	5.680	262.172 **	12.044 **	7364.413 **	370.320 **	15349.74 **	7.796	0.000	700.003 **
Error	61	13.572	1.485	0.118	141.963	14.119	100.323	2.340	0.020	5.529

**, * Significant at 5% and 1% level, respectively.

Table 2 : Heterosis (H1), Heterobeltiosis over better parent (H2) and standard heterosis over check (H3) exhibited for different characters for best fifteen hybrids based on *per se* performance for seed yield (g palnt^{-1})

S.N.	F_1 Hybrid	*Per se* performance for seed yield (g plant^{-1})	Seed Yield (g plant^{-1})			Days to 50%			FloweringDays to Maturity		
			H1	H2	H3	H1	H2	H3	H1	H2	H3
1	AKCMS-9A x AKPR-8	41.5	290.59 **	245.83 **	74.37 **	1.52	-2.5	1.74	-4.32 **	-6.63 **	-1.27
2	AKCMS-10A x ICPR-2740	38.75	125.62 **	93.75 **	62.82 **	-5.86 *	-9.96 **	-5.65	-5.17 **	-7.42 **	-0.64
3	AKCMS-9A x AKPR-374	37.6	179.55 **	113.03 **	57.98 **	3.77	1.74	1.74	-0.6	-0.9	4.78 **
4	AKCMS-10A x AKPR-374	37.3	98.14 **	86.50 **	56.72 **	-4.89	-6.96 *	-6.96 *	-3.84 **	-5.15 **	-0.32
5	AKCMS-11A x AKPR-292	37.25	80.61 **	73.66 **	56.51 **	-0.21	-0.85	1.3	0.92	0	4.46 **
6	AKCMS-9A x AKPR-292	34.95	127.69 **	62.94 **	46.85 **	7.73 **	5.17	6.09 *	2.14 **	0.6	6.37 **
7	AKCMS-9A x AKPR-372	34.3	94.61 **	31.92 **	44.12 **	5.08 *	2.59	3.48	0.76	-0.6	5.10 **
8	AKCMS-11A X AKPR-319	30.7	82.74 **	55.05 **	28.99 *	-2.63	-5.53	-3.48	-7.37 **	-8.61 **	-1.91 *
9	AKCMS-10A x AKPR-359	30.6	76.88 **	53.00 **	28.57 *	-3.62	-4.05	-7.39 *	-4.40 **	-6.80 **	0.32
10	AKCMS-13A X ICPR-2740	30.2	53.89 **	21.29 *	26.89 *	-7.92 **	-10.79 **	-6.52 *	-4.20 **	-5.34 **	1.59 *
11	AKCMS-11A X AKPR-8	27.35	72.01 **	38.13 **	14.92	-6.11 *	-7.08 *	-3.04	-4.04 **	-5.79 **	-1.59 *
12	AKCMS-11A X AKPR-359	27.05	57.27 **	36.62 **	13.66	-0.22	-2.98	-0.87	-6.61 **	-7.99 **	-0.96
13	AKCMS-10A x AKPR-8	26.75	67.19 **	33.75 *	12.39	-7.39 **	-11.25 **	-7.39 *	-1.41 *	-2.18 **	0
14	AKCMS-10A x AKPR-372	26.4	14.78	1.54	10.92	-5.31 *	-7.76 **	-6.96 *	-2.48 **	-2.79 **	0
15	AKCMS-10A x AKPR-319	25.8	52.66 **	29.00 *	8.4	-2.95	-3.17	-6.96 *	-4.86 **	-7.12 **	-0.32
	S.E. d		2.2265	2.5709	2.5709	2.8302	3.2680	3.2680	0.9999	1.1546	1.1546
	CD (p=0.05)		4.4791	5.1720	5.1720	5.6936	6.5744	6.5744	2.0116	2.3228	2.3228

Table 2 continued…..

S.N.	F1Hybrid	Number of branches plant^{-1}			Plant Height (cm)			Number of pods plant^{-1}		
		H1	H2	H3	H1	H2	H3	H1	H2	H3
1	AKCMS-9A x AKPR-8	-1.14	-2.25	0	20.68 **	19.17 *	-6.23	72.58 **	71.43 **	-13.78
2	AKCMS-10A x ICPR-2740	2.25	0	4.6	16.78 **	16.38 *	9.51	75.77 **	73.54 **	14.54
3	AKCMS-9A x AKPR-374	-0.56	-1.12	1.15	35.25 **	30.34 **	0	87.45 **	70.28 **	4.85
4	AKCMS-10A x AKPR-374	-2.79	-4.4	0	27.38 **	11.85	5.25	94.16 **	90.00 **	22.22 *
5	AKCMS-11A x AKPR-292	-3.83	-6.38 *	1.15	20.67 **	16.94 *	17.70 *	34.75 **	34.21 **	11.45
6	AKCMS-9A x AKPR-292	1.12	1.12	3.45	8.81	-1.39	-6.89	104.03 **	64.30 **	35.34 **
7	AKCMS-9A x AKPR-372	-0.56	-1.11	2.3	24.32 **	21.05 *	-1.97	81.66 **	41.08 **	28.24 **
8	AKCMS-11A X AKPR-319	1.11	-3.19	4.6	28.52 **	15.96 *	16.72 *	28.66 **	21.03 *	0.5
9	AKCMS-10A x AKPR-359	-2.76	-3.3	1.15	37.73 **	16.38 *	9.51	51.73 **	49.22 **	-4.01
10	AKCMS-13A X ICPR-2740	2.25	0	4.6	2.53	-1.3	-0.33	18.49 *	-3.43	1.17
11	AKCMS-11A X AKPR-8	0.55	-3.19	4.6	19.20 **	6.19	6.89	29.97 **	3.82	-13.78
12	AKCMS-11A X AKPR-359	-1.09	-3.19	4.6	36.63 **	12.38	13.11	24.48 *	8.85	-9.61
13	AKCMS-10A x AKPR-8	2.25	0	4.6	24.10 **	13.94	7.21	65.40 **	46.49 **	-5.76
14	AKCMS-10A x AKPR-372	-2.76	-3.3	1.15	23.60 **	14.98 *	8.2	17.98	0.74	-8.44
15	AKCMS-10A x AKPR-319	-0.56	-3.3	1.15	17.98 **	9.76	3.28	39.98 **	31.51 **	-3.76
	S.E.d	1.2274	1.4173	1.4173	8.8140	10.1775	10.1775	8.7250	10.0748	10.0748
	CD (p=0.05)	2.4692	2.8512	2.8512	17.7314	20.4744	20.4744	17.5524	20.2678	20.2678

Table 2 continued…..

S.N.	F1Hybrid	Pod length (cm)			Shelling (%)			100 Seed Weight (g)			Plant (%)
		H1	H2	H3	H1	H2	H3	H1	H2	H3	Fertility Mean
1	AKCMS-9A x AKPR-8	-1.14	-2.25	1.16	42.61 **	34.09 **	65.89 **	45.91 **	45.39 **	5.67	100
2	AKCMS-10A x ICPR-2740	2.25	0	5.81 *	-1.86	-19.96 **	25.46 **	56.57 **	44.63 **	31.96 **	98
3	AKCMS-9A x AKPR-374	-0.56	-1.12	2.33	21.34 **	8.77	49.47 **	36.84 **	29.08 **	-6.19	98
4	AKCMS-10A x AKPR-374	-2.79	-4.4	1.16	-24.41 **	-29.08 **	11.18	60.26 **	36.72 **	24.74 **	97
5	AKCMS-11A x AKPR-292	-3.83	-6.38 *	2.33	10.86 *	7.12	35.96 **	34.97 **	6.47 *	27.32 **	100
6	AKCMS-9A x AKPR-292	1.12	1.12	4.65	-16.97 **	-20.28 **	-5.64	5.45	2.84	-25.26 **	97
7	AKCMS-9A x AKPR-372	-0.56	-1.11	3.49	4.44	-4.71	25.85 **	12.80 **	10.14 *	-15.98 **	84
8	AKCMS-11A X AKPR-319	1.11	-3.19	5.81 *	17.80 **	13.25 *	43.73 **	-19.45 **	-36.64 **	-24.23 **	100
9	AKCMS-10A x AKPR-359	-2.76	-3.3	2.33	-10.48 *	-19.78 **	25.75 **	19.22 **	3.39	-5.67	99
10	AKCMS-13A X ICPR-2740	2.25	0	5.81 *	-0.35	-10.17	10.69	23.47 **	14.00 **	-11.86 **	98
11	AKCMS-11A X AKPR-8	0.55	-3.19	5.81 *	18.73 **	17.23 **	48.79 **	-20.97 **	-36.64 **	-24.23 **	100
12	AKCMS-11A X AKPR-359	-1.09	-3.19	5.81 *	-10.29 *	-11.26 *	12.63	24.86 **	-2.59	16.49 **	99
13	AKCMS-10A x AKPR-8	2.25	0	5.81 *	-39.02 **	-45.44 **	-14.48 *	-11.67 **	-20.90 **	-27.84 **	93
14	AKCMS-10A x AKPR-372	-2.76	-3.3	2.33	-19.65 **	-25.98 **	16.03 *	-0.31	-8.47 *	-16.49 **	83
15	AKCMS-10A x AKPR-319	-0.56	-3.3	2.33	-3.48	-15.69 **	32.17 **	-7.74	-19.21 **	-26.29 **	100
	S.E.d	0.1074	0.1240	0.1240	2.0902	3.5074	3.5074	0.3023	0.3491	0.3491	
	CD (p=0.05)	0.2160	0.2494	0.2494	6.1106	7.0559	7.0559	0.6082	0.7023	0.7023	

** Significant at 1 per cent level, * Significant at 5% level

H1: Heterosis over mid parent, H2: Heteroblтiosis and H3: Standard Heterosis over check variety PKV Tara

95 per cent fertility restoration which can be useful in their performance on commercial scale.

Yielding ability which is a complex character. In present study, 10 hybrids exhibited significant heterosis over standard check PKV Tara. Heterosis over standard check ranged from 8.4 per cent (AKCMS-10A x AKPR 319) to 74.37 per cent (AKCMS-9A x AKPR 8). The top 10 hybrids on the basis of *per se* performance among 15 exhibited significant and positive heterosis, heterobltiosis and standard heterosis seed yield. Pandey (2004), Patel and Tikka (2008) and Chandirakala *et. al*., (2010) reported high amount of heterosis for grain yield in pigeonpea.

The top performing hybrid combinations AKCMS-9A x AKPR 8 showed highest *per se* performance for yield showed highest significant heterosis, heterobeltiosis and standard heterosis for seed yield. This hybrid also showed significant heterosis in desirable direction for the characters studied except days to 50% flowering, number of branches and pod length. This hybrid has 100 per cent fertility. The hybrids *viz*., AKCMS-10A x ICPR-2740, AKCMS-9A x AKPR-374, AKCMS-10A x AKPR-374, AKCMS-11A x AKPR-292, AKCMS-9A x AKPR-292 and AKCMS-9A x AKPR-372 also appeared to be promising. These crosses could be considered for commercial exploitation after large scale testing.

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Genetic Divergence for Yield and its Components in Castor

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ABSTRACT

Genetic divergence was assessed among 37 genotypes of castor using Mahal-naobis D^2 statistics. It indicated considerable diversity in the material studied. Canonical analysis indicated that days to maturity, days to 50 per cent flowering, number of nodes up to primary spike, number of capsules on secondary spikes, effective length of secondary spike, number of capsules on tertiary spikes and seed yield plant^{-1} were important sources of variation. The importance of these characters was also confirmed on the basis of variance of cluster mean. By using Tocher's method, all 37 genotypes were grouped into 14 clusters. The maximum average inter cluster distance was observed between cluster V and XIV (D = 30.42). On the basis of mean and standard deviation of parental divergence, 64 divergent parental combinations have been finally suggested for their utilization in hybridization programme.

Castor (*Ricinus communis Linn.*) is an important oilseed crop and is widely grown in tropical, sub-tropical and temperate parts of the world. India is the world leader in castor seed and oil production and dominates the international castor oil trade. Castor seed contains 42 to 58 per cent oil. Castor oil and its derivatives have wide range of uses in the manufacture of lubricants, plastics, adhesives, waxes, polishes, coating applications, inks, paints, varnishes, cosmetics, perfumes, flavours, fragrances, textile dyes and medicinal uses.

Genetic diversity plays a huge role in survival and adaptability of a species. The genetic diversity which is the basis of plant breeding is produced due to inherent genetic difference in plant species and is the major interest of plant breeder. The more diverse the parents within overall limits of fitness, the greater are the chances of heterotic F_1's and broad spectrum of variability in segregating generation (Arunachalum,1981).

The choice of parents based on *per se* performance and eco-geographic diversity had a limited success in the past. However, several methods of multivariate analysis have been found to be useful in selecting parents for hybridization. Among these methods, Mahalanobis D^2 statistics has been one of reasonable tests in estimation of genetic diversity.

Therefore, the present investigation was undertaken to estimate genetic diversity to determine the relative contribution of each component character towards total divergence and to identify genetically divergent parents for their exploitation in hybridization programme.

MATERIAL AND METHODS

The experimental material consisted of 37 castor genotypes obtained from Directorate of Oilseeds Research, Hyderabad and AICRP for Dryland Agriculture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The field experiment was conducted in randomised completely block design with three replications at the farm of AICRP for Dryland Agriculture, Dr. PDKV, Akola during *Kharif* 2009. The data were recorded on 17 characters viz., days to 50 per cent flowering, days to maturity, number of nodes up to primary spike, plant height, effective length of primary spike, effective length of secondary spike, effective length of tertiary spike, number of secondary spikes, number of tertiary spikes, total number of spikes, number of capsules on primary spike, number of capsules on secondary spikes, number of capsules on tertiary spikes, total number of capsules, 100 seed weight, seed yield per plant and oil content.

The analysis of variance was performed to test the significance among the genotypes for all the character studied. The analysis of dispersion was used to test the significance of differences in the mean values between the genotype for the aggregate of 14 characters (X_1 – X_{14}) based on Wilk's criterion as described by Rao (1952). The inverse matrix of original genotype variance and covariance matrix were computed to derive the relationship by which the original character mean (X_1 – X_{14}) were transformed to an uncorrelated set of variables Y_1 – Y_{14}. In term of variance and covariance, the D^2 Values were obtained as per methodology of Mahalanobis (1936). The grouping of genotypes was done by Tocher's

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Table1: Canonical vectors and roots

S.N.	Characters	Vector			
		I	II	III	IV
1	Days to 50 per cent flowering	0.15	0.34	0.15	0.13
2	Days to maturity	0.26	0.61	0.37	0.28
3	Number of nodes up to primary spike	-0.08	0.48	-0.2	-0.62
4	Plant height (cm)	-0.27	-0.16	0.73	0.05
5	Effective length of primary spike(cm)	-0.28	-0.23	-0.08	0.14
6	Effective length of secondary spike(cm)	-0.27	0.24	-0.18	0.23
7	Effective length of tertiary spike(cm)	-0.19	0.06	-0.14	0.42
8	Number of capsules on primary spike	-0.32	-0.13	0.01	-0.03
9	Number of capsules on secondary spikes	-0.47	0.25	-0.08	-0.03
10	Number of capsules on tertiary spikes	-0.30	0.20	-0.30	-0.35
11	Total number of capsules per plant	0	0	0	0
12	100 seed weight (g)	-0.21	0.03	0.23	-0.12
13	Seed yield per plant (g)	-0.44	0.15	0.25	-0.27
14	Oil content (%)	-0.01	0.03	0.08	-0.29

Values of canonical roots

$\lambda 1 = 1341.38$

$\lambda 2 = 724.11$

$\lambda 3 = 355.97$

$\lambda 4 = 201.75$

Contribution of each canonical root

$\lambda 1\% = 42.49\ \%$

$\lambda 2\% = 22.94\ \%$ 83.09 %

$\lambda 3\% = 11.28\ \%$

$\lambda 4\% = 6.39\ \%$

Table 2 : Distribution of genotypes into different clusters by Tocher's method

Cluster	Total No. of genotypes	Genotype
I	2	TRC 315, Jorhat Local
II	1	SKY 38
III	2	48-1, JBT 13/KA-51(13513)
IV	3	EC 158185, RC 1231, EC 168490
V	3	AQATION NO. 315-3, EC 168554, TRC 333
VI	18	DCS 9, RC 1284, 14, SKI-1, TRC 115, OTC -30-11, 7301, NO.35, EC 26486, SKY 116, SKP 23, SKY 31, SKY 70, SKP 9, EC 284470,EC 168483, 5954, EC 97706
VII	1	SKP-67(R2,SP,D)
VIII	1	1093-1
IX	1	JBT 13/KA-2(13464)
X	1	NC 62705
XI	1	SALEM 91
XII	1	JBT 13/KA-50(13512)
XIII	1	SH 10
XIV	1	AKC 1

method as described by Rao (1952). Canonical root method suggested by Rao (1952) was followed. Average intra and inter-cluster distance and cluster means were calculated using all possible D^2 values. Selection of parents for hybridization from different clusters was made firstly on the basis of mean statistical distance as suggested by Bhatt (1970) and finally it was made on the basis of mean and standard deviation of parental

Table 3 : Cluster means for various quantitative characters

Cluster	Days to 50% flowering	Days to maturity	No of nodes up to primary spike	Plant height (cm)	Effective length of primary spike(cm)	Effective length of secondary spike (cm)	Effective length of tertiary spike(cm)	Number of capsules on primary spike	Number of capsules on secondary spikes	No. of capsules on tertiary spikes	Total number of capsules	100 seed weight (g)	Seed yield plant(g)$^{-1}$	Oil content (%)
I	56.17	125.00	15.67	93.89	18.61	10.13	6.78	29.50	11.81	7.41	48.72	29.31	36.00	47.79
II	57.00	125.33	13.89	83.78	17.39	11.73	5.00	30.72	13.16	4.97	48.86	23.37	19.50	44.02
III	66.50	141.83	22.39	140.78	28.33	13.18	5.55	45.08	17.37	8.24	70.68	31.38	47.19	48.32
IV	55.33	126.11	14.38	92.13	21.22	16.04	8.22	36.89	19.61	10.72	67.22	29.25	42.37	45.55
V	59.89	131.44	12.00	90.20	14.52	8.87	4.94	22.85	9.20	4.53	36.59	27.09	19.85	46.15
VI	57.80	129.44	19.98	109.50	24.49	15.10	8.61	42.05	20.86	10.71	73.62	28.02	46.80	46.62
VII	68.67	143.00	17.89	111.78	18.00	20.58	7.79	25.67	15.18	8.37	49.22	23.33	22.34	44.20
VIII	51.00	121.33	14.67	103.44	27.39	17.11	12.14	46.91	25.80	19.35	92.07	31.82	51.35	49.02
IX	68.00	136.67	22.22	72.33	14.72	20.98	15.02	40.24	24.07	14.11	78.43	26.17	43.43	46.97
X	68.00	141.00	13.33	170.27	31.56	13.76	6.79	46.11	16.42	9.70	72.23	27.89	43.24	47.78
XI	57.33	129.33	16.33	110.78	26.11	16.40	8.03	52.9	29.00	13.23	95.12	37.53	81.13	45.66
XII	55.33	128.67	10.22	175.85	33.22	9.18	5.42	55.52	17.71	11.80	85.04	25.53	42.27	44.75
XIII	49.67	119.00	17.44	140.22	31.11	16.04	8.06	69.52	35.73	12.53	117.78	25.85	86.13	45.68
XIV	48.33	118.00	17.78	155.44	46.56	31.16	14.08	63.64	39.20	15.49	118.32	29.70	90.75	45.35
Variance	47.47	67.70	12.96	1896.53	45.66	33.83	10.49	192.03	77.73	16.49	624.39	13.84	531.35	2.36

Table 4 : Average intra(bold) and inter cluster distance D (D= " D^2)

Cluster	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	XIII	XIV
I	4.05	5.67	12.18	7.57	6.99	10.99	12.89	14.45	15.70	13.52	15.85	14.39	20.07	26.18
II		0.00	14.17	8.81	5.82	12.60	12.17	15.76	16.51	15.02	18.20	15.60	21.98	27.84
III			4.61	11.98	13.89	10.94	10.00	16.80	12.69	9.23	13.21	15.52	18.99	24.75
IV				5.49	11.21	9.33	12.71	9.91	13.02	12.27	11.23	12.72	15.97	21.14
V					5.32	14.34	11.85	19.09	17.83	14.30	19.63	16.39	24.44	30.42
VI						10.55	13.34	11.94	12.72	13.32	12.46	15.23	16.53	22.31
VII							0.00	19.52	11.70	12.40	18.31	18.83	24.31	28.24
VIII								0.00	15.44	16.04	10.00	14.13	12.39	16.16
IX									0.00	17.05	15.08	21.64	21.03	25.30
X										0.00	13.30	9.38	17.88	22.85
XI											0.00	13.81	9.63	15.79
XII												0.00	14.52	20.77
XIII													0.00	12.04
XIV														0.00

Table 5: Genetically diverse parental combinations based on mean and standard deviation of parental divergence

S.N.	Cluster combinations	Average inter cluster distance	Mean parental divergence (m)	Standard deviation of parental divergence (s)	m+s	m-s	Parental combinations
1	V X XIV*	30.42	925.61	90.09	1015.70	835.52	(8x1)(26x1)
2	VII* X XIV*	28.24	797.25	-	-	-	(23x1)
3	II* X XIV*	27.84	775.19	-	-	-	(28x1)
4	I X XIV*	26.18	685.22	39.27	724.48	645.95	(25x1) (33x1)
5	IX* X XIV*	25.30	640.24	-	-	-	(19x1)
6	III X XIV*	24.75	612.53	4.88	617.41	607.65	(3x1) (20x1)
7	V X XIII*	24.44	597.17	59.79	656.96	537.38	(8x32)
8	VII* X XIII*	24.31	591.05	-	-	-	(23x32)
9	X* X XIV*	22.85	522.14	-	-	-	(16x1)
10	VI X XIV*	21.55	497.74	120.98	599.81	359.66	(2x1) (4x1) (21x1) (9x1) (22x1) (30x1) (37x1) (27x1)(29x1) (36x1) (11x1) (12x1) (17x1)
11	II* X XIII*	21.98	482.97	-	-	-	(28x32)
12	IX* X XII*	21.64	468.35	-	-	-	(19x35)
13	IV X XIV*	21.14	447.06	24.20	471.26	422.86	(15x1) (31x1)
14	IX* X XIII*	12.56	157.78	-	-	-	(19x31)
15	XII* X XIV*	20.77	431.52	-	-	-	(35x1)
16	I X XIII*	20.07	402.88	24.64	427.51	378.24	(25x32) (33x32)
17	V X XI*	19.63	385.22	51.80	437.02	333.41	(8x6) (26x6)
18	VII* X VIII*	19.52	380.96	-	-	-	(23x14)
19	V X VIII*	19.09	364.46	46.94	411.40	317.53	(8x14) (26x14)
20	III X XIII*	18.99	360.81	17.34	378.14	343.47	(3x32) (20x32)
21	VII* X XII*	18.83	354.48	-	-	-	(23x35)
22	VII* X XI*	18.31	335.42	-	-	-	(23x6)
23	II* X XI*	18.20	331.40	-	-	-	(28x6)
24	X* X XIII*	17.88	319.79	-	-	-	(16x32)
25	V X IX*	16.87	318.01	28.25	346.85	289.14	(8x19)
26	IX* X X*	17.05	290.65	-	-	-	(19x16)
27	III X VIII*	16.80	282.22	12.23	294.45	269.98	(3x14) (20x14)
28	VI X XIII*	16.53	273.40	94.89	368.29	178.50	(2x32) (4x32) (21x32) (9x32) (18x32) (22x32) (34x32) (30x32) (37x32) (29x32) (36x32) (11x32) (12x32) (17x32)
29	II* X IX*	16.51	272.66	-	-	-	(28x19)
30	V X XII*	16.39	268.48	41.30	309.78	227.17	(8x35)

* Consist of single genotype in cluster.

Figures in parenthesis indicate the serial number of genotype.as 1)AKC 1 2)DCS 9 3)48-1 4)RC 1284 5)AQATION NO. 315-3 6)SALEM 91 7)EC 97706 8)EC 168554 9)OTC -30-11 10)SKI-1 11)EC 284470 12)EC 168483 13)EC 168490 14)1093-1 15)EC 158185 16)NC 62705 17)5954 18)7301 19)JBT 13/KA-2(13464) 20)JBT 13/KA-51(13513) 21)14 22)NO.35 23)SKP-67(R2,SP,D) 24)TRC 115 25)TRC 315 26)TRC 333 27)SKY 31 28)SKY 38 29)SKY 70 30)SKY 116 31)RC 1231 32)SH 10 33)Jorhat Local 34)EC 26486 35)JBT 13/KA-50(13512) 36)SKP 9 37)SKP 2

divergence as suggested by Arunachalum and Bandopadhyay (1984).

RESULTS AND DISCUSSION

The analysis of variance revealed significant differences among 37 genotypes for all the characters under study except number of secondary spikes, number of tertiary spikes and total number of spikes. The aggregate effect of all the 14 characters for 37 genotypes was tested by Wilk's criterion. This test also confirmed highly significant differences among the genotypes.

Canonical analysis indicated that about 83.09 per cent of total variation was accounted by four canonical roots indicating that the differentiation for 14 traits among 37 genotypes have been completed in four phases. In vector I, days to maturity and days to 50 per cent flowering were important sources of variation, while days to maturity, number of nodes up to primary spike, days to 50 per cent flowering, number of capsules on secondary spikes, effective length of secondary spike, number of capsules on tertiary spikes and seed yield per plant were important sources of variation in vector II. In vector III, plant height, days to maturity, seed yield per plant, 100 seed weight and days to 50 per cent flowering played important part in variation. In vector IV, effective length of tertiary spike, days to maturity, effective length of secondary spike, effective length of primary spike, and days to 50 per cent flowering were important sources of variation(Table 1). Importance of these characters was also confirmed on the basis of variance of cluster mean.

All 37 genotypes were grouped into 14 clusters. Cluster VI was the largest one having 18 genotypes, followed by cluster IV and V (3 genotypes each), cluster I and III (2 genotypes each), whereas cluster II, VII, VIII, IX, X, XI, XII XIII and XIV contained only one genotype each. In the present investigation, the clustering pattern showed that the genotypes coming from different geographic area were included in the same cluster, while genotypes having common source placed into different clusters indicating no relationship between genetic diversity and geographic diversity(Table 2).

Cluster XIV showed lowest cluster mean values for days to 50 per cent flowering and days to maturity and highest cluster mean values for effective length of primary spike, effective length of secondary spike, number of capsules on secondary spikes, total number of capsules and seed yield plant^{-1}, while the cluster VIII showed the maximum mean values for two characters viz., number of capsules on tertiary spikes and oil content. Cluster IX showed lowest mean value for plant height, whereas highest mean value for number of capsules on tertiary spikes. Cluster XII possessed lowest cluster mean value for number of nodes up to primary spike. Cluster XI and XIII possessed highest cluster mean value for 100 seed weight and number of capsules on primary spike, respectively (Table 3). The maximum average inter cluster distance was observed between cluster V and XIV (D = 30.42), whereas the minimum average inter cluster distance was found between cluster I and II (D=5.67) (Table 4).

Considering mean statistical distance as a guideline to select the parents, 30 cluster combinations above mean statistical distance (D=16.20) have been identified. The parents selected from these cluster combinations may yield desirable segregants in hybridization programme; however, when divergent parents are crossed, heterosis is not bound to occur always. Therefore, while selecting the genotypes from a particular cluster, the information on mean and standard deviation of the genetic divergence among the parents should be taken into consideration as practically suggested by Arunachalum and Bandyopadhyay (1984).

Hence taking into consideration the limit of parental divergence for getting good amount of heterosis in F_1, mean and standard deviation of parental divergence were worked out and 64 genetically diverse parental combinations have been finally suggested for hybridization programme which are expected to produce maximum heterotic effect in F_1 generation and yield desirable segregants in subsequent generations (Table 5).

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Organic Manure Based Potting Mixtures for Quality Seedling Production in *Oroxylum indicum* (L.) Vent.

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ABSTRACT

Oroxylum indicum (L.) Vent. is one of the medicinal tree species of the Western Ghats. Bark, root and leaves are used in traditional medicine. Plant contains falvonoids like chrysine, baicalein and oroxylin-A. Many pharmaceutical industries are using this plant resource as raw material in various medicinal preparations. Production of quality seedlings for commercial plantation is one of the main objectives. In the present study, several organic manures based potting mixtures such as soil alone, soil and sand in 1:1 ratio, soil and sand with farm yard manure (2:1:1), vermicompost (2:1:½), poultry manure (2:1:½), neem cake (2:1:½) and forest/ habitat soil (2:1:½) were evaluated for better growth and vigour in seedlings of *Oroxylum indicum*. The maximum seedling growth and biomass was recorded in potting mixture containing soil, sand and vermicompost in the ratio of 2:1:½, followed by standard potting mixture containing soil, sand and farm yard manure in the ratio of 2:1:1. Therefore, it is suggested to use any one of these two potting mixtures for raising quality seedlings of *O. indicum* in large quantity for commercial plantation.

Oroxylum indicum (L.) Vent. (Family-Bignoniaceae) is one of the commercial important medicinal tree species of Western Ghats and is commonly known as Tetu, Shonyak or Midnight horror. This species is scatterly distributed throughout the greater part of India. Root, leaves and stem bark of this species have been used as a single drug or as a component of certain compound drug preparations in the Indian Ayurvedic system of medicine for treating various disorders and also used as a tonic, Rasayana drug, *Dashmoolarishta*. This species is used as an astringent, carminative, diuretic, stomachic and for respiratory disorders (Kausik and Dhaman, 2000). Traditionally, the powder prepared from stem bark is used to treat dysentery, diarrhea, sore throat, cough, and bone fractures. It contains falvonoids like chrysine, baicalein and oroxylin-A (Lawania *et al.* 2010). The raw materials required for the preparation of medicine are mainly procured from the natural source. Over exploitation could be one the causes for rarity of species from the natural habitat (Gokhale and Bansal, 2005 and Maiti, 2006). Therefore, conservation is very essential for this species. Interestingly, domestication and commercialization of species may also help in conservation of species both in natural forest as well as on farm-field. Production of quality seedlings is one of the approaches of commercial forestry where successful plantations can be established. Hence, the present study was undertaken to improve the seedling quality through organic manure based potting mixtures.

MATERIAL AND METHODS

The present study was undertaken to evaluate different organic based potting mixture on seedling growth and vigour in *Oroxylum indicum*. The experiment was conducted at the Forest Nursery, College of Forestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Ratnagiri district of Maharashtra. For the study, seven different organic manure based potting mixtures *viz.*, FYM, forest soil, vermicompost, poultry manure, neem cake were used along with mixture of soil and sand in 1:1 proportion and details are mentioned in table 1. In the experiment, poly bag of size 10 × 15 cm was used. The experiment was laid out in Randomized Block Design (RBD) with four replications having 25 seedlings each. General nursery operations like weeding and irrigation were carried out as and when required.

Table 1. Treatment details for potting mixture

S. N.	Treatments	Ratio
1	Soil alone	1
2	Soil + Sand	1:1
3	Soil +Sand+ FYM (Standard potting mixture)	2:1:1
4	Soil+ Sand+ Forest Soil	2:1:½
5	Soil+ Sand+ Vermicompost	2:1:½
6	Soil Sand+ Poultry manure	2:1:½
7	Soil+ Sand+ Neem cake	2:1:½

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Seedlings were raised using local seed source. Preliminary observation on seed lot such as seed weight, seed length and width were recorded. These seeds were sown on nursery bed and germinated seeds having two leaves were transplanted to polybags containing various potting mixture treatments. Further, seedling growth observations such as seedling height, collar diameter, number of leaves and leaf area were recorded at monthly interval from August to January. For biomass observation, eight seedlings from each treatment were uprooted and root was washed in running water. Care has been taken to avoid loss of root during washing. The entire plant is cut into three parts as shoot, leaves and root. Later, fresh weight of shoot, leaves and root was recorded using sensitive weighing balance. Then, these samples were dried using hot-air oven at 40 ^{0}C for 48 h. and observation on dry weight of shoot, leaves and root was recorded. By using growth and biomass data, few quality indices *viz.,* relative growth rate, sturdiness quotient and quality index were calculated by using appropriate formulae following Williams (1946), Thompson (1985) and Dickson *et al.* (1960), respectively.

All the data collected during experimentation were processed and further subjected to statistical analysis using statistical package, AGRESS. Analysis of Variance (ANOVA) was constructed for all the parameters studied using appropriate statistical design following Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Seedlot collected for the present study was examined for various seed traits. The overall mean of 100 seed weight, seed length and seed width of seed lot was 11.2g, 6.97 mm and 4.10 mm, respectively.

There was a significant variation among different organic based potting mixtures on seedling growth and biomass (Table 2 and 3). The maximum seedling height, basal diameter, number of leaves and leaf area were recorded in potting mixture containing soil, sand and vermicompost @ 2:1:½ ratio (T5), followed by standard potting mixture containing soil, sand and farm yard manure @ 2:1:1 ratio (T3; Table 2). However, other treatments were on par with control treatment containing soil alone. The similar trend of growth was recorded among different treatments at periodic intervals from third months up to six months after transplanting.

Similarly, maximum fresh and dry biomass of plant was recorded in treatments *viz.,* T5 and T3 containing vermicomost and farmyard manure, respectively (Table 4). The overall results showed that on an average 3.57 g dry biomass plant^{-1} could be obtained in six months period using poly bag of size 10 × 15 cm. Root biomass is one of the economical parts of this plant, where dry root biomass of 1.2 g was obtained in soil alone. However, different organic manures like farmyard manure (T3), vermicompost (T5) and poultry manure (T6) doubled the root biomass (>2.0 g) as compared to soil alone (Table 3). Among treatments, Sturdiness quotient ranged between 2.86 (T2) to 4.04 (T5), where sturdy seedlings may be obtained by using treatments like T2 containing soil and sand, and T7 containing soil, sand and neem cake in the ratio of 2:1:½. Further, quality index, a measure of quality obtained using growth and biomass data, varied from 0.56 (T1) to 1.30 (T5). This also showed that potting mixture containing vermicompost and farm yard manure resulted in better quality seedlings as compared to soil alone (Table 4). However, RGR (relative growth rate) did not vary among different treatments imposed to seedlings of *O. indicum.*

There are several approaches to improve the seedling growth and vigour at nursery stage. However, standardization of potting mixture is one of the components that help to improve the seedling vigour at the early stage. Features such as nature of species as fast or slow growing, requirement of light like light demander/ shade bearer nature, planting materials such as seeds or vegetative propagative materials used while raising plants needs are to be considered while evaluating proper potting mixture for a particular species. In case of black soil region, potting mixture constituting black soil, vermicompost and black sand in 2:1:1 proportion is best for growing *Gliricidia sepium* (Devaranavadgi *et al.*, 2010). It is also reported that potting mixture consisting of FYM and Vermicompost resulted in better seedling growth in *Acacia nilotica* (Bahuguna and Pyarelal, 1990). The positive influence of potting mixture on seedling growth and biomass was also reported in other species such as *Terminalia crenulata, T. chebula, Pongamia pinnata* (Devar, 2002, Lokesh *et.al.*, 2009 and Ramesh, 2007). Similarly, all the organic manures used in the present study resulted in positive response on seedling growth and vigour. Further, Ginwal *et al.* (2001) quantified the best treatment of potting mixture using Dickson quality index. However, in the present study, treatments such as potting mixture containing vermicompost and farm yard manure resulted in higher quality index as proposed by Dickson *et al.* (1960).

It is concluded that different organic manures used in potting mixture influenced the seedling growth and vigour in *O. indicum*. However, treatments such as potting mixture containing soil, sand and vermicompost at 2:1:½ ratio (T5) as well as potting mixture having soil, sand and farm yard manure at 2:1:1 (T3) ratio resulted in better seedling growth and vigour than other organic manures and soil alone. Therefore, it is suggested to use any one of these two treatments for raising quality seedlings as well as to increase the root biomass at nursery stage.

Table 2. Influence of organic based potting mixtures on seedling growth in *Oroxylum indicum*

Treatments	Seedling height (cm)	Basal diameter (mm)	Number of leaves plant^{-1}	Leaf area (cm^2)
T_1-Control (Soil alone)	8.78	2.72	2.85	9.24
T_2-Soil: Sand (2:1)	6.94	2.44	3.09	9.73
T_3-Soil: Sand: FYM (2:1:1)	10.92	2.94	3.99	10.86
T_4-Soil: Sand: Forest Soil (2:1:½)	8.81	2.42	3.29	8.65
T_5-Soil: Sand: Vermicompost (2:1:½)	13.59	3.42	4.59	11.24
T_6-Soil: Sand: Poultry manure (2:1:½)	9.84	2.80	3.39	8.58
T_7-Soil: Sand: Neem cake (2:1:½)	7.39	2.55	2.54	6.99
Mean	9.48	2.75	3.39	9.33
SEm (±)	0.47	0.15	0.23	1.16
CD at 5%	1.40	0.44	0.67	3.04

Table 3. Influence of potting mixture on seedling biomass in *Oroxylum indicum*

Treatments	Fresh weight (g)				Dry weight (g)			
	Shoot	leaves	Root	Entire plant	Shoot	leaves	Root	Entire plant
T1-Soil alone (1:0:0)	0.78	1.27	2.13	4.18	0.35	0.37	1.20	1.92
T2-Soil + Sand (2:1)	1.07	1.09	4.12	6.28	0.31	0.34	1.33	1.98
T3-Soil +Sand+ FYM (2:1:1)	2.29	5.99	7.15	15.42	1.02	2.21	2.06	5.29
T4-Soil+ Sand+ Forest Soil (2:1:1/2)	1.20	2.12	4.11	7.44	0.68	0.86	1.81	3.34
T5-Soil+ Sand+ Vermicompost (2:1:1/2)	2.60	4.63	11.87	19.10	0.95	2.13	2.89	5.98
T6-Soil Sand+ Poultry manure (2:1:1/2)	2.17	3.18	6.88	12.24	0.82	1.18	2.29	4.29
T7-Soil+ Sand+ Neem cake (2:1:1/2)	0.78	1.09	3.02	4.88	0.36	0.55	1.27	2.17
Mean	1.55	2.77	5.61	9.93	0.64	1.09	1.83	3.57
SEm (±)	0.33	0.59	1.16	1.71	0.15	0.29	0.37	0.64
CD at 5%	0.97	1.74	3.44	5.09	0.46	0.86	1.09	1.90

Table 4. Seedling quality indices calculated for different organic based potting mixtures in *Oroxylum indicum*

Treatments	Sturdiness Quotient	Quality Index	Relative Growth Rate
T_1-Soil alone (1:0:0)	3.24	0.56	2.16
T_2-Soil + Sand (1:1)	2.86	0.63	4.08
T_3-Soil +Sand+ FYM (2:1:1)	3.73	1.00	5.85
T_4-Soil+ Sand+ Forest Soil (2:1:1/2)	3.65	0.86	3.61
T_5-Soil+ Sand+ Vermicompost (2:1:1/2)	4.04	1.30	2.87
T_6-Soil Sand+ Poultry manure (2:1:1/2)	3.51	0.95	4.16
T_7-Soil+ Sand+ Neem cake (2:1:1/2)	2.93	0.75	4.07
Mean	3.42	0.86	3.83
SEm (±)	0.16	0.08	1.03
CD at 5%	0.49	0.25	NS

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Evaluation of Biparental Progenies Developed Through Bud and Mixed Pollination for Horticultural and Quality Trainsin Late Cauliflowr

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ABSTRACT

The five plants from each progeny of biparental (BIP) of a cross PSB-1 x KT-9 were selected for bud and mix pollination (BP & MP) to produce bud and mix pollinated seeds of BIP's. The materials thus, developed were evaluated in compact family block design with three replications for horticultural and quality traits. PCV and GCV were low for all the traits except gross curd weight and net curd weight. These characters also exhibited high heritability and genetic advance as percentage of mean indicating the additive gene effects for these traits. The high heritability with low genetic advance was found for stalk length and days to harvesting whereas, rest of the traits had low to moderate heritability with low genetic gain indicating the influence of environment.

Cauliflower was introduced in India from England by Britishers in 1822 (Chatterjee, 1986) and in a short period of its introduction, it has gained a lot of importance among the breeders, farmers and consumers. Consequently, a large number of cultivars are available for cultivation in early and mid season group. This probably is due to the presence of greater variability in both the groups. However, there are limited cultivars in Snowball/ late group as much variability is not available in this type.

Though snowball group provides ideal genotypes both to the farmers and consumers, yet these cultivars are very sensitive to fluctuating environmental conditions resulting sometimes in the development of undesirable traits which make the curds unfit for marketing. Thus an attempt was made to study the progenies (bud and mixed pollinated) developed by biparental mating between late group genotypes for the performance of different horticultural and quality traits in cauliflower.

MATERIAL AND METHODS

The present studies were carried out at experimental farm of Department of Vegetable Crops, Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, H.P. (India). The experimental materials comprised different biparental progenies selected from heterotic cross (PSB-1 x KT-9) of cauliflower. These biparental progenies were identified on the basis of their performance and five plants from each progeny of biparental (BIP) were selected. These plants were bud and mix pollinated (BP & MP) to produce bud and mix pollinated seeds of BIP's. The materials thus, developed were evaluated in compact family block design, whereby whole populations generated in BIP under bud pollination and mix pollination were treated as main plot or family and randomized. The progenies developed from the selected plants were also randomly planted along with the checks in each family / main plot and considered as sub plots. These entries were replicated thrice and spaced at 60 x 45 cm. The plot size per entry comprised three rows per replication and each row had four plants. The observations were recorded on various characters viz., plant frame (cm), No. of leaves per plant, No. of leaves per whorl, stalk length (cm), days to harvesting, gross curd weight (g), net curd weight (g) and harvest index (%) and quality traits viz., color, compactness and riceyness. Coefficients of variability (phenotypic and genotypic) were calculated as per the method suggested by Burton and DeVane (1953). Heritability and Genetic advance was estimated as per Allard (1960) and Genetic gain was calculated as per Johnson et al. (1955b).

RESULTS AND DISCUSSION

Mean performance of BIP's (BP) with respect to different traits has been given in Table 1. It is evident from the table that 10 progenies showed less plant frame than the mean value of which BIP 2-1-BP, BIP 2-3-BP, BIP 3-11-BP, BIP 2-5-BP and BIP 3-17-BP were highest. Seventeen BIP's (BP) had less number of leaves plant^{-1} as well as number of leaves whorl^{-1} of which BIP 14-41-BP, BIP 2-3-BP, BIP 7-31-BP, BIP 14-43-BP and BIP 3-11-

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Table 3. Coefficients of variability (phenotypic and genotypic), heritability and genetic gain for different characters in different progenies of cauliflower

Characters		PCV (%)	GCV (%)	H (%)	Genetic advance	Genetic gain
Plant frame (cm)	1	6.11	5.91	93.50	6.15	11.76
	2	5.33	5.21	95.50	5.66	10.48
Number of leaves per whorl	1	6.68	5.29	62.70	0.42	8.59
	2	5.75	5.15	80.10	0.49	9.42
Stalk length (cm)	1	9.49	6.17	42.30	0.27	8.33
	2	12.48	5.14	16.90	0.13	4.36
Days to harvesting	1	1.85	1.39	56.60	2.81	2.15
	2	3.64	3.62	98.90	9.60	7.42
Gross curd weight (g)	1	10.97	10.70	95.00	399.36	21.48
	2	14.90	14.76	98.20	573.97	30.13
Net curd weight (g)	1	10.60	10.58	99.70	195.80	21.76
	2	13.84	13.48	94.90	235.96	27.05
Harvest index (%)	1	8.07	7.58	88.20	7.20	14.68
	2	7.69	7.38	92.10	6.74	14.58

1 = BIP's (BP), 2 = BIP's (MP)

BP were promising. Minimum stalk length was found in BIP 3-11-BP and 18 BIP's (BP) gave the stalk shorter than the mean. Minimum and maximum days to harvesting were exhibited by BIP 14-43-BP and BIP 7-33-BP, respectively. BIP 14-43-BP, BIP 14-47-BP, BIP 14-41-BP, BIP 14-45-BP and BIP 14-49-BP were early while BIP 7-33-BP, BIP 7-35-BP, BIP 15-53-BP. BIP 15-51-BP and BIP 15-57-BP were significantly late in maturity. BIP 7-35-BP recorded highest gross curd weight, followed by BIP 2-9-BP, BIP 14-45-BP, BIP 7-33-BP and BIP 4-23-BP. BIP 2-9-BP recorded highest net curd weight, followed by BIP 14-45-BP, BIP 3-11-BP, BIP 7-35-BP and BIP 3-13-BP. Harvest index was maximum in BIP 3-11-BP and BIP 7-39-BP, BIP 14-41-BP, BIP 3-13-BP and BIP 2-9-BP were also promising. White colour of the curd was exhibited by majority of the lines except BIP3-15-BP, BIP3-17-BP, BIP3-19-BP, BIP4-23-BP, BIP4-27-BP, BIP 7-31-BP and BIP 7-39-BP which gave white to creamish yellow colour. Compact curds were found in BIP 7-31-BP, BIP 7-37-BP, BIP7-35-BP, BIP7-39-BP and BIP 15-55-BP. Majority of the BIP's showed non ricey curds, however BIP4-23-BP, BIP4-21-BP, BIP4-29-BP and BIP 3-15-BPgave considerable percentage of ricey curds. From the above results, it may be concluded that BIP 2-9-BP, BIP 7-35-BP, BIP 14-45-BP, BIP 3-11-BP and BIP 7-33-BP which possessed good yield and quality traits were found best.

Mean performance of BIP's (MP) with respect to different traits has been given in Table 2. It is evident from the table that eight progenies showed less plant frame than the mean value of which BIP 3-12-MP, BIP 3-20-MP, BIP 3-18-MP, BIP 4-22-MP and BIP 2-6-MP were promising. Sixteen BIP's (MP) had less number of leaves per plant as well as number of leaves per whorl of which BIP 3-12-MP , BIP 7-32-MP, BIP 3-20-MP, BIP 7-40-MP and BIP 4-30-MP were promising. Minimum stalk length was found in BIP 2-2-MP and 16 BIP's (MP) gave the stalk shorter than the mean. Minimum and maximum days to harvesting were exhibited by BIP 14-46-MP and BIP 4-28-BP, respectively. BIP 14-46-MP, BIP 3-12-MP, BIP 14-44-MP, BIP 15-54-MP and BIP 15-60-MP were early while BIP 4-28-MP, BIP 4-30-MP, BIP 7-34-MP, BIP 7-32-MP and BIP 4-24-MP were significantly late in maturity. BIP 2-2-MP recorded highest gross curd weight, followed by BIP 2-8-MP, BIP 15-56-MP, BIP 3-14-MP and BIP 2-4-MP. BIP 2-2-MP recorded highest net curd weight, followed by BIP 2-4-MP, BIP 15-56-MP, BIP 2-6-MP and BIP 2-10-MP. Harvest index was maximum in BIP 2-6-MP followed by BIP 2-4-MPand BIP 3-12-MP were also promising. White colour of the curd was exhibited by all the progenies where BIP2-2-MP, BIP3-14-MP, BIP7-38-MP, BIP14-42-MP, BIP15-58-MP and BIP 15-60-MP which gave 100 per cent white curds. Compact curds were found

Table 1. Mean performance of Biparental (BP) Progenies with respect to different traits in PSB-1 x KT-9.

BIP (BP)	Plant frame (cm)	No. of leaves plant^{-1}	No. of leaves whorl	Stalk length (cm)	Days to harvesting (days)	Gross curd weight (g)	Net curd weight (g)	Harvest index (%)	Curd colour			Compactness, %			Riceyness	
									Snow White	White	Creamish Yellow	Compact	Semi compact	Loose	Ricey	Non-Ricey
BIP 2-1-BP	46.80	19.20	4.80	3.53	129.80	1370.00	710.00	51.43	6.67	93.33	-	26.67	53.33	20.00	100.00	-
BIP2-3-BP	45.28	17.60	4.40	3.15	131.20	1660.00	750.02	45.67	13.33	86.67	-	20.00	66.67	13.33	93.33	6.67
BIP2-5-BP	47.16	18.60	4.65	3.41	129.80	1930.00	980.00	51.66	-	100.00	-	13.33	46.67	40.00	86.67	13.33
BIP2-7-BP	52.46	18.40	4.60	3.55	131.20	1690.00	900.00	53.25	6.67	86.67	6.66	20.00	60.00	20.00	93.33	6.67
BIP2-9-BP	52.78	19.80	4.95	3.53	128.80	2230.00	1130.00	51.83	6.67	86.67	6.66	26.67	60.00	13.33	100.00	-
BIP3-11-BP	45.98	18.40	4.60	2.88	129.00	1700.00	1040.00	61.14	-	80.00	20.00	-	20.00	80.00	80.00	20.00
BIP3-13-BP	51.48	19.20	4.80	3.16	128.80	1900.00	1020.00	53.73	-	86.67	13.33	13.33	33.33	53.34	100.00	-
BIP3-15-BP	51.42	19.80	4.95	3.14	128.80	1870.00	910.00	48.24	6.67	60.00	33.33	6.67	13.33	80.00	66.67	33.33
BIP3-17-BP	48.62	19.40	4.85	3.20	132.40	1940.00	975.00	50.77	6.67	66.66	26.67	20.00	20.00	60.00	73.33	26.67
BIP3-19-BP	49.65	18.67	4.67	3.38	131.50	1986.33	906.44	48.43	-	73.33	26.67	20.00	53.33	26.67	73.33	26.67
BIP4-21-BP	55.08	20.75	5.19	3.09	133.00	1845.78	875.00	47.69	13.33	66.67	20.00	40.00	53.33	6.67	60.00	40.00
BIP4-23-BP	53.94	21.42	5.35	3.13	131.67	2091.89	993.67	48.34	6.67	53.33	40.00	53.33	40.00	6.67	53.33	46.67
BIP4-25-BP	52.57	18.75	4.69	3.12	132.65	1668.18	788.71	47.57	6.67	80.00	13.33	33.33	46.67	20.00	73.33	26.67
BIP4-27-BP	52.35	20.75	5.19	3.12	132.17	1835.33	869.33	48.12	-	73.33	26.67	60.00	26.67	13.33	80.00	20.00
BIP4-29-BP	54.27	19.31	4.83	3.57	131.36	1947.35	833.33	43.09	-	86.67	13.33	26.67	53.33	20.00	60.00	40.00
BIP7-31-BP	52.30	17.83	4.46	3.02	129.50	1783.00	854.33	46.36	6.67	66.66	26.67	100.00	-	-	100.00	-
BIP7-33-BP	55.02	20.33	5.08	3.53	133.42	2112.83	945.33	45.24	-	100.00	-	66.67	26.66	6.67	100.00	-
BIP7-35-BP	58.26	21.33	5.33	3.27	133.33	2266.89	1024.72	45.15	-	93.33	6.67	80.00	13.33	6.67	100.00	-
BIP7-37-BP	55.25	20.17	5.04	3.66	132.17	1775.00	843.67	47.90	6.67	73.33	20.00	86.67	13.33	-	100.00	-
BIP7-39-BP	52.67	18.92	4.73	3.20	130.92	1693.33	900.00	54.85	-	66.67	33.33	80.00	13.33	6.67	100.00	-
BIP14-41-BP	49.74	17.42	4.35	3.65	128.42	1776.67	961.67	54.74	-	100.00	-	46.67	33.33	20.00	93.33	6.67
BIP14-43-BP	49.77	18.25	4.56	3.03	125.75	1515.18	775.00	51.92	20.00	66.67	13.33	40.00	46.67	13.33	86.67	13.33
BIP14-45-BP	52.72	19.33	4.83	3.57	128.50	2221.00	1043.67	47.97	6.67	73.33	20.00	66.67	26.66	6.67	100.00	-
BIP14-47-BP	52.22	18.67	4.68	3.10	128.36	1652.67	813.34	49.45	-	93.33	6.67	33.33	46.67	20.00	100.00	-
BIP14-49-BP	54.67	19.08	4.77	3.05	128.50	2083.00	940.98	44.16	6.67	80.00	13.33	53.33	40.00	6.67	100.00	-
BIP15-51-BP	54.17	21.67	5.42	3.02	132.67	1938.00	925.33	50.45	-	93.33	6.67	66.67	20.00	13.33	100.00	-
BIP15-53-BP	55.47	20.42	5.10	2.93	132.75	1881.08	843.65	45.24	-	100.00	-	66.67	33.33	-	100.00	-
BIP15-55-BP	56.17	20.33	5.08	3.07	131.83	1800.00	826.33	45.80	6.367	86.66	6.67	80.00	20.00	-	100.00	-
BIP15-57-BP	54.00	20.50	5.13	2.94	132.50	1845.80	897.57	49.74	-	100.00	-	60.00	20.00	20.00	100.00	-
BIP15-59-BP	56.32	20.58	5.15	3.06	130.50	1884.00	884.01	47.12	20.00	73.33	6.67	73.34	13.33	13.33	93.33	6.67
Mean	52.28	19.55	4.89	3.24	130.63	1859.41	899.98	49.04								
CD P = 0.05	1.81	NS	0.18	0.12	1.07	145.93	79.29	2.70								

Table 2. Mean performance of Biparental (MP) Progenies with respect to different traits in PSB-1 x KT-9.

BIP (BP)	Plant frame (cm)	No. of leaves plant^{-1}	No. of leaves whord	Stalk length (cm)	Days to harvesting	Gross curd weight (g)	Net curd weight (g)	Harvest index (%)	Curd colour			Compactness, %			Riceyness	
									Snow White	White	Creamish Yellow	Compact	Semi compact	Loose	Ricey	Non-Ricey
BIP 2-2-MP	53.86	21.00	5.25	2.46	127.60	2560.00	1175.00	45.63	-	100.00	-	33.33	66.67	-	100.00	-
BIP2-4-MP	60.78	22.60	5.65	2.58	129.80	2150.00	1100.00	50.73	6.67	93.33	-	33.33	53.34	13.33	100.00	-
BIP2-6-MP	51.14	19.80	4.95	2.68	128.20	1810.00	1000.00	56.97	6.67	93.33	-	33.33	60.00	6.67	100.00	-
BIP2-8-MP	52.06	20.80	5.20	3.10	129.60	2488.33	913.33	36.90	6.67	86.67	6.67	40.00	53.34	6.67	100.00	-
BIP2-10-MP	53.50	20.09	5.00	3.00	125.60	2100.00	970.00	45.42	13.33	86.67	6.67	26.67	73.33	-	100.00	-
BIP3-12-MP	48.15	18.20	4.55	3.70	121.40	1720.00	860.00	49.03	-	93.33	6.67	46.67	40.00	13.33	100.00	-
BIP3-14-MP	58.43	22.40	5.60	3.12	129.60	2450.00	950.00	39.22	-	100.00	-	46.67	46.66	6.67	86.67	13.33
BIP3-16-MP	53.80	20.60	5.15	2.82	130.81	1750.00	785.00	44.65	13.33	73.34	13.33	13.33	66.67	20.00	100.00	-
BIP3-18-MP	50.35	20.00	5.00	2.74	125.40	1580.00	690.00	44.49	-	80.00	20.00	66.67	33.33	-	100.00	-
BIP3-20-MP	49.70	19.60	4.90	2.81	132.60	1606.67	700.00	43.98	-	93.33	6.67	60.00	26.67	13.33	100.00	-
BIP4-22-MP	50.84	19.92	4.98	2.73	129.50	1679.06	750.0	45.01	20.00	80.00	-	66.67	33.33	-	86.67	13.33
BIP4-24-MP	55.36	20.67	5.17	2.97	132.43	1833.11	820.33	44.69	13.33	80.00	6.67	80.00	20.00	-	80.00	20.00
BIP4-26-MP	57.85	22.17	5.54	3.14	129.66	1903.33	909.44	48.14	6.67	80.00	13.33	53.33	46.67	-	93.00	6.67
BIP4-28-MP	56.05	21.00	5.25	2.86	138.50	1708.11	837.33	49.18	20.00	80.00	-	40.00	60.00	-	100.00	-
BIP4-30-MP	52.53	19.71	5.17	3.07	137.50	1833.11	871.63	48.05	13.33	66.67	20.00	40.00	40.00	20.00	86.67	13.33
BIP7-32-MP	54.29	18.36	4.60	3.03	136.50	1341.44	656.32	47.78	6.67	86.66	6.67	86.67	13.33	-	100.00	-
BIP7-34-MP	54.93	20.08	5.02	3.06	137.50	1908.06	925.00	48.98	6.67	93.33	-	80.00	20.00	-	100.00	-
BIP7-36-MP	53.03	20.92	5.23	2.95	136.50	2120.67	925.00	45.04	13.33	80.00	6.67	93.33	6.67	-	100.00	-
BIP7-38-MP	54.67	20.67	5.14	2.83	131.67	2008.11	967.06	48.42	-	100.00	-	86.67	13.33	-	100.00	-
BIP7-40-MP	51.19	19.67	4.92	2.87	131.67	2016.89	873.00	43.51	6.67	93.33	-	93.33	6.67	-	100.00	-
BIP14-42-MP	54.33	21.58	5.40	3.13	128.75	1816.33	784.33	43.65	-	100.00	-	66.67	26.66	6.67	100.00	-
BIP14-44-MP	53.40	20.73	5.23	3.11	121.40	1850.00	800.00	43.46	13.33	73.34	13.33	66.67	20.00	13.33	100.00	-
BIP14-46-MP	55.74	21.53	5.40	3.15	121.17	1802.78	851.30	48.50	-	93.33	6.67	53.33	40.00	6.67	100.00	-
BIP14-48-MP	56.95	21.83	5.46	3.24	124.67	1850.00	812.67	44.44	13.33	86.67	-	80.00	13.33	6.67	100.00	-
BIP14-50-MP	55.12	21.17	5.29	2.93	124.67	1733.11	843.33	47.25	26.67	66.66	6.67	80.00	20.00	-	100.00	-
BIP15-52-MP	56.07	20.50	5.13	3.25	130.50	1915.67	916.56	48.62	6.67	93.33	-	100.00	-	-	100.00	-
BIP15-54-MP	51.94	20.17	5.04	2.76	129.67	1570.33	730.77	46.93	13.33	86.67	-	66.67	33.33	-	100.00	-
BIP15-56-MP	58.99	23.00	5.75	3.03	125.75	2475.00	1094.59	44.71	6.67	93.33	-	93.33	6.67	-	100.00	-
BIP15-58-MP	55.84	22.17	5.54	2.50	131.67	2002.03	920.03	47.83	-	100.00	-	80.00	20.00	-	100.00	-
BIP15-60-MP	52.21	22.17	5.54	2.90	124.67	1792.00	807.33	44.99	-	100.00	-	93.33	6.67	-	100.00	-
Mean	53.98	20.75	5.20	2.98	129.44	1905.08	872.17	46.21								
CD P = 0.05	1.88	NS	0.20	0.12	1.82	181.87	96.57	2.75								

in BIP 15-52-MP, BIP 7-36-MP, BIP15-56-MP, BIP15-60-MP, BIP 7-32-MP and BIP 7-38-MP. All of the BIP's showed non ricey curds. From the above results it may be concluded that BIP 2-2-MP, BIP 2-6-MP, BIP2-4-MP, BIP 15-56-MP and BIP 2-10-MP which possessed good yield were found best.

Estimates of the phenotypic and genotypic coefficients of variability (Table 3) were comparatively low for all the traits in BIP (BP) progenies. These were comparatively more i.e., 14.90 and 14.76 per cent for gross curd weight and 13.84 and 13.48 per cent for net curd weight in BIP (MP) progenies and were low for the remaining characters. The differences between phenotypic and genotypic coefficients of variability were negligible. The phenotypic coefficients of variability were larger in magnitude than genotypic coefficients of variability for all the traits in different families. The difference in the values of these estimates were also less in most of the characters indicating that genetic factors had played major role in the expression of these characters. The Characters like stalk length, days to harvesting, gross curd weight and net curd weight gave higher values of coefficient of variation under mixed pollination while plant frame, number of leaves per whorl and harvest index showed more values under bud pollination in BIP's. Overall net curd weight, followed by gross curd weight and harvest index had high coefficients of genotypic and phenotypic variability. Earlier workers like Jamwal *et al.* (1992) and Khar *et al.* (1997) had also reported high values for these characters.

Heritability and genetic advance are two complimentary parameters, the former may be used to estimate expected genetic advance through selection. The success of any selection programme depends upon the extent of heritability as well as genetic advance which usually changes for population to population and environment to environment. Burton (1952) was of the opinion that the genetic coefficient of variation along with heritability give the best picture of the genetic advance to be expected from selection whereas, Johnson *et al.* (1955b) advocated that heritability together with genetic advance is more useful than the heritability alone in predicting the resultant effects in selecting best individuals in soyabean.

Heritability in broad sense (Table 3) was found to be high for net curd weight (99.70, 94.90%), gross curd weight (95.00, 98.20%), plant frame (93.50, 95.50%), harvest index (88.20, 92.10%) and number of leaves whorl^{-1} (62.70, 80.10%) in both the progenies i.e. BIP's (BP & MP), respectively. These were low to moderate for other characters indicating that these characters were largely controlled by genetic factors. Genetic advance was found maximum in gross curd weight (399.36, 573.97), net curd weight (195.80, 235.96) and low for other characters. Genetic gain was found maximum in net curd weight (21.76, 27.05%) and gross curd weight (21.48, 30.13%). It was found to be moderate for harvest index (14.68, 14.58%) and plant frame (11.76, 10.48%) and low for remaining characters viz., number of leaves per whorl (8.59, 9.42%), stalk length (8.33, 4.36%) and days to harvesting (2.15, 7.42%). Similar results were also reported by Lal *et al.*, (1990), Jamwal *et al.*, (1992), Radhakrishna and Korla, 1994 and Sanjeev, (1998). In the present studies the characters like gross curd weight and net curd weight exhibited high genotypic coefficients of variability, heritability and genetic advance as percentage of mean indicating thereby that selection would be effective for the improvement of these characters as these are controlled by additive gene action (Panse, 1957, Lal *et al.*, 1990, and Radhakrishna and Korla, 1994). Whereas, high heritability with low to moderate genetic advance was found for stalk length and days to harvesting (Kanwar and Korla, 2002a & 2002b). The other characters exhibited low values of either of these estimates indicating that these were controlled by non-additive gene and selection would not be effective for bringing the improvement.

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Early Growth Performance of Tree Species from *Dashmool* Group

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ABSTRACT

The growth performance of tree species from *Dashmool* group viz. Beal (*Aegle marmelos)*, Tetu (*Oroxylum indicum*), Padal (*Streospermum chelenoides)*, Shivan (*Gmelina arborea*), and Agnimanth (*Premna obtusifolia*), were planted in June 2008 in Randomized Block Design having five replications at spacing of 3 x 3 meter with 9 plants per replication. Study was conducted at College of Forestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth., Dapoli. Observations on growth parameter, like survival percent, height, collar diameter and canopy volume were recorded every year upto the age of three years. Tree growth parameters measured during the study period differed significantly between differented species except for survival percent. Above-ground biomass estimates showed that stem biomass and dry biomass varied significantly between the species.

The importance of the Dashmool plants has mentioned in the renowned ancient literature such as *Charak-sahita, Susuruta, Dhanvantari, Bhavprakash Nigantu,* etc. In *Ayurveda*, roots of 10 perennial medicinal plants are used together (5 herbs and 5 tree species) as *Dashmool*, considered highly efficacious in management of several common ailments (Sharma, 2004 & Pathak *et al.*, 2005). Amongst, the classical formulations the "*Dashmoolarishta*" is most popular and is used as basic ingredient in manufacture of over 109 drug formulations having more than 240 uses. The roots of Dashmool plants i. e. Bilva (*Aegel marmelos*), Agnimantha (*Premna obtusifolia*), Shivan or Gambhari (*Gmelina arborea*), Patala (*Stereospermum suaveolens*), Shalaparani(*Desmodim Gangeticum*), Bruhati (*Solanum indicum*), Kantakari (*Solanum xanthocarpum*), Gokshura (*Tribulus terrestris*), Bala (*Sida cordifolia*) and Tetu (*Oroxylum indicum*) have huge demand in national and international market for preparation of drugs *viz. 'Dashmularishta', 'Dashmuladiquath' etc.* Presently the pharmaceutical industries are getting the raw material from forest areas and from waste lands. But, due to its continuous exploitation from wild habitat, populations of the plants are on the line of rarity. Also, the demand has increased in several folds in the recent days for these root drugs. Therefore, there is urgent need for commercial plantation on large scale. It is also used as basic ingredient in many other preparations. It is a good recuperative tonic for women after delivery and to strengthen the nerves and corrects anaemia, etc. It is also known to prevent excessive postnatal hemorrhage (Pathak, *et al.*, 2005, Mehta and Mehta, 1953, Sharma, *et al*, 2011 and Dasgupta, *et al.*, 1984).

Dashmool plants are becoming rare due to its continuous harvesting especially for roots portion. Through scientific cultivation, pressure can be reduced and it will help for conservation of these species. The study was conducted to know the growth performance of tree components of *dashmool* group under field condition and to evaluate the biomass productivity

MATERIAL AND METHODS

The study was conducted at the Forest Nursery of College of Forestry, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth., Dapoli, Ratnagiri district of Maharashtra. The study site, Dapoli is situated on the West Coast of Maharashtra at an attitude of 280 m above mean sea level (MSL). It is located in the subtropical region at 17°45' North latitude and 13°12' East longitude. The study area is characterised by lateratic soils, which are shallow having rough texture and the soils are low in organic carbon and available nitrogen , pH ranged from 6.0 to 6.5.

The *Bruhatpanchmulas* plant species viz Bilva (*Aegel marmelos*), Agnimantha (*Premna obtusifolia*), Shivan or Gambhari (*Gmelina arborea*), Patala (*Stereospermum suaveolens*) and Tetu (*Oroxylum indicum*) were planted in June 2008 in Randomized Block Design at spacing of 3 x 3 meter. Five replications were used with 9 plants replication^{-1}. The pits were dug of size 2x2x2 meter in summer season and filled with 2 kg of well decomposed Farm Yard Manure (FYM) and glyricidia leaves as a green manure before planting. The earthing up operation and stacking were carried out one month after planting to get proper support to plants.

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Amrut sanjiwani (mixture of jaggary and cow urine) concentration of 10 per cent was applied @ 500 ml per plant, 3 month after planting. Sugercane pressmud was applied 250 gram per plant, 6 month after planting. The mulching of dried waste material, such as, weed, small branches and leaves, and other waste material were used to reduce transpiration and it was curried out in the month of December every year. The weeding operation also conducted every year to make plot weed free during rainy season. Water was provided from December to June every year with the help of drip irrigation. The plot was grown organically, without any chemical fertilizer and pesticide. Observations on growth parameter, like survival percent, height, collar diameter and canopy spread were recorded in the month of January every year upto the age of three years. Data collected on growth parameters were analysed using the SPSS statistical package (SPSS 1997) and the significance of treatments was tested with F test (Panse and Sukhatme, 1967).

RESULTS AND DISCUSSION

The average survival per cent recorded was 92.06 having maximum survival in *Aegle marmelos* (97.78 %). The height growth of the trees in all stands ranged from 35.02 to 151.80 cm and collar diameter ranged from 0.64 to 2.82 cm. The maximum height of 151.8 cm was attained by Agnimantha (*Premna obtusifolia*), whereas the maximum collar diameter of 2.82 was recorded in *Gmelina arborea* over the period of three years. In all the tree species the height growth differed significantly with each other. The collar diameter for *Gmelina arborea* was statistically significant as compared to other species while the observations recorded for Agnimantha (*Premna obtusifolia*) and *Stereospermum suaveolens* were statistically at per. The crown volume was maximum in Agnimantha (*Premna obtusifolia*) (171.9 cm^2), followed by *Gmelina arborea* (97.61 cm^2). The crown volume exhibited statistically significant differences with each other. The minimum crown area was recorded in *Oroxylum indicum* (20.39 cm^2). Tree growth parameters measured during the study period differed significantly between different species except for survival percent (Table 1).

Above-ground biomass estimates showed that stem biomass and dry biomass varied significantly, whereas moisture content differences were not significant (Table 2). The maximum fresh weight was recorded in *Premna obtusifolia* (769.60 g) , which was observed to

Table 1. Growth performance of *Dashmool* tree species at the age of three years.

Species	Survival (%)	Height (cm)	Collar Dia (cm)	Crown volume (cm^2)
Shivan or Gambhari (*Gmelina arborea*)	93.33	129.3	2.82	97.61
Agnimantha (*Premna obtusifolia*)	95.55	151.8	2.44	171.9
Bilva (*Aegel marmelos*)	97.78	62.28	0.64	39.47
Patala (*Stereospermum suaveolens*)	95.55	88.45	2.13	70.83
Tetu (*Oroxylum indicum*)	78.09	35.02	0.68	20.39
Mean	92.06	93.38	1.74	80.05
SE (m) $\pm$	2.48	6.56	0.128	5.86
CD at 5%	NS	18.66	0.365	16.611

Table 2. Above ground biomass yield of *Dashmool* tree species at the age of three years

Species	Fresh Weight	Dry weight	Moisture percent
Shivan or Gambhari (*Gmelina arborea*)	688.40	278.70	41.09
Agnimantha (*Premna obtusifolia*)	769.60	368.50	49.19
Bilva (*Aegel marmelos*)	375.60	190.9	51.11
Patala (*Stereospermum suaveolens*)	349.40	128.60	37.10
Tetu (*Oroxylum indicum*)	61.06	21.83	40.67
Mean	370.20	159.40	43.83
SE (m) $\pm$	753.9	338.6	4.89
CD at 5%	2458.8	1104.3	NS

Gmelina arborea

Premna obtusifolia

Aegel marmelos

Stereospermum suaveolens

Oroxylum indicum

Dashmool Block Plantation

Figure 1. Tree species of Dashmoola group at the age of two years.

be statistically at per with *Gmelina arborea* (688.40 gm). The minimum fresh weight was recorded in *Oroxylum indicum* (61.06 g). Similarly dry biomass varied significantly, the maximum dry weight was recorded in *Premna obtusifolia* (368.50 g) , which was observed to be statistically at per with *Gmelina arborea* (278.70 g). The minimum fresh weight was recorded in *Oroxylum indicum* (21.83 g). The moisture content in tall the species ranged from 37.10 in *Streospermum chelenoides* to 51.11 percent in *Aegle marmelos*.

The growth performance of *Gmelina arborea* from different locations in the country were evaluated by, many workers and it was observed that the growth rate changed in accordance with the site type, soil and climatic factors (Tiwari, 1995). Fonweban, *et al.* (1997) evaluated the growth performance of *Gmelina arborea* in a 12 year provenance trial, variation in growth parameters due to differences in provences was reported, which may be attributed to genetic variability amongst the genotypes. The effect of nutrient growth of nine indigenous tree including *Gmelina arborea* planted on coal mine spoil was studied. The response to nutrient application varied among species and was greater in non-leguminous than in leguminous species (Saini *et al*., 1997). The log-transformed height-diameter relationships were significant for all tree species and treatments, with respect to growth parameters. (Singh and Singh, 2001). The causes of variation in tree growth and biomass may include genetic variation and differences in climate, site and management practices (Swami et al, 2003). A similar trend was observed by Nambiar (1990), Swamy (1998) in young tree plantations. No such studies on growth performance of *Dashmool* species except *Gmelina arborea* are available, hampered the comparative evaluation. The experiment is being monitored for further evaluation of root biomass yield.

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Haematological Alteration in Gastrointestinal Helminth Infected Horses

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ABSTRACT

In the present investigation haematological parameters were studied in 18 GIT helminth infected horses. The study revealed significant decrease in Hb, PCV and TEC, whereas, increase in TLC, neutrophil (%), monocyte (%), and eosinophil (%) in helminth infected group as compared to normal healthy control group. These findings indicated normochromic, normocytic anaemia in helminth infected horses.

Gastrointestinal helminths cause damage to the animals both during the infection phase, when the invading larvae are undergoing early developmental stages of their life cycle in various tissues of the body and then developed fully to adult parasites. It is clinically manifested by unthriftness, weight loss, weakness, tissue destruction, hemorrhages, anemia, mechanical obstruction, intoxication, reduced absorption of nutrient, wasting and finally death of animal (Varshney, 1999).

In the present investigation, haematological parameters were evaluated to assess the alteration in these evaluates due to gastrointestinal helminth infection in horses.

MATERIAL AND METHODS

Total 18 horses positive for helminth infection (Group II) were considered for the study. One group of 9 healthy horses free from helminthosis was kept as a normal control (Group I) for comparison. Blood samples were collected from all the horses under study for haematological evaluations. The haematological parameters viz**.** Haemoglobin (Hb), Packed Cell Volume (PCV), Total Erythrocyte Count (TEC), Total Leucocyte Count (TLC) and Differentional Leucoyte Count (DLC) were determined by method suggested by Benjamin (2007). The data were statistically analyzed as per the method described by Snedecor and Cochran (1998).

RESULTS AND DISCUSSION

Total 18 horses were found positive for mixed and single infection of *Strongyles* sp., *Parascaris equorum*, *Strongyloides* sp. and *Oxyuris equi*. The haematological values in helminth infected and healthy horses are presented in table 1.

Table 1: Average values of haematological parameters in normal healthy and helhinth infected horses

S.N.	Parameters	Group I	Group II
1	Hb (g/dl)	11.9 ± 0.12*	8.41 ± 0.37
2	PCV (%)	36.55 ± 0.60*	32.71 ± 0.92
3	TEC (X 10^6 /cumm)	8.08 ± 0.33*	5.40 ± 0.41
4	TLC (X 10^3 /cumm)	11.24 ± 0.22	12.23 ± 0.30
5	Neutrophil (%)	39.11 ± 1.96*	48.82 ± 1.90
6	Lymphocyte (%)	59.77 ± 2.19*	44.66 ± 1.81
7	Monocyte (%)	0.77 ± 0.75*	4.71 ± 4.50
8	Eosinophil (%)	0.44 ± 0.17*	2.77 ± 3.00

* Significant difference between group I and Group II within respective parameters.

In normal uninfected group (I), Hb concentration was 11.90 gm/dl ± 0.12. In helminth infected group, the Hb concentration was 8.41 gm/dl ± 0.37. The analysis of variance revealed remarkable variation in Hb concentration ($P<0.01$), with significant decline in Hb level in helminth infected group as compared uninfected group (I). In normal uninfected group (I), PCV was 36.55 % ± 0.60, whereas, in helminth infected group it was decreased significantly to 32.71 % ± 0.92. In helminth infected group (II), the TEC was found significantly low (5.40 millions/cu mm ± 0.41) as compared to uninfected group (I). In helminth infected group (II), TLC was 12.23 Th/cu mm ± 0.30, which revealed non significant variations in TLC between both the groups. The DLC revealed significant ($P<0.01$) increase in neutrophil, monocyte and eosinophil per cent and decrease in lymphocyte per cent in helminth infected group (II) as compared to normal healthy control group(I).

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These findings are in accordance with that of Jeremy *et al*. (2004), Mahboob *et al*. (2008) and Sonone (2010), who also recorded decrease in Hb concentration, PCV, TEC, lymphocyte per cent and increase in TLC with neutrophil, monocyte and eosinophil per cent in gastrointestinal parasitism in horses. The decrease in Hb % and TEC count might be due to the blood sucking nature of the *Strongyles* sp. and by continuous haemorrhage from feeding points even after the worm detachment causing severe anaemia (Alam Sher Sipra *et al*., 1999). This haematological picture is suggestive of normocytic, normochromic anemia in horses infected with GIT parasites (Lewa *et al*., 2000; Mahboob *et al*., 2008 and Sonone, 2010).

The increase in TLC in helminthiasis might be due to defensive response of the body to the invaders. It is stated that the worms causes inflammation in the intestine which further contribute to leucocytosis in helminth infected animal (Sastry, 1983 and Winterzer, 1986).

The alteration in differential leucocyte count (DLC) could be due to defensive and immune response of the body to the action of nematodes infection. The increased eosinophil count can be attributed to the extremely elevated level of IgE in parasitized animals which mediate mast cell degranulation, thereby, stimulate release of eosinophils, chemotactic factor of anaphylaxis and resulting in the release of large number of eosinophils into the circulation (Tizzard, 1982). The worms themselves excrete toxic, inflammatory and allergic substances that further contribute to neutrophilia, eosinophilia and leucocytosis in helminthosis (Wintzer, 1986). The reduction in lymphocyte per cent might be due to relative rise in neutrophils in response to inflammation caused by the helminths in intestine (Sastry, 1983 and Thakare, 1999).

The present study concluded that GIT helminths causes severe anaemia hence incorporation of haematinic therapy along with effective anthelmintics is suggested to bring about quick clinical recovery in horses with helminthiasis.

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Path Analysis Studies on Feeding of Urea Ammoniated Soybean Straw to Lactating Cows

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ABSTRACT

Feeding of untreated Soybean straw (T_2) and 2 per cent urea treated Soybean straw (T_3) was evaluated on the performance of lactating cows in reference to Jowar straw diet (T_1) to utilize urea treated non conventional SBS as protein source roughage in the ration of lactating cows and association between nutrients nutritive values and milk production. The values for DCP and TDN content were found as 4.72 and 64.91, 5.86 and 53.05 and 6.28 and 57.11 per cent in the ration of Jowar straw diet (T_1), untreated Soybean straw (T_2) and 2 per cent urea treated Soybean straw (T_3) treatments, respectively. The path analysis clearly demonstrated that daily milk yield in cows was not influenced substantially by a single factor. However, DCP and TDN intakes, MAT and RH-I levels effects could be the significant contributors for their direct and indirect impact on milk yield. In other words, increase intake of DCP and TDN in cows under hot dry climate would favour the milk production in all the feeding treatments. Therefore hot dry climate was found favourable to DCP, TDN intake and milk production under Akola agro climatic conditions.

Livestock plays a vital role in Indian economy especially in rural economy as it is a source of subsidiary income, employment generation to family labour as well as nutritional security to the millions of farmer of the country. The lower productivity in milking animals may occur as a result of complex climate, economic problem and under nutrition. In which nutrition status and feeding management had significant impact on milk production (Garg *et. al.*, 2007). During couple of years, a significant change in cropping pattern has been noticed where the farmers have concentrated on the cultivation of cash crops like soybean instead of conventional feed source crops like Jowar, Maize and Bajra due to low cost of production and remunerative selling price in the market. During 2012-13, 30.69 lakh ha of land was put under soybean crop against an average of 12.70 lakh ha under sorghum in Maharashtra, indicating the popularity to these non-conventional crops among farmers (Anonymous, 2012), which results in deficit of feed and fodder to the livestock. Therefore, one has to search alternative feed resources and development of technology for increasing the nutrients from non conventional feeds in order to harvest optimum milk production from animals. On this background soybean straw offers one of the most important roughages due to its high CP content and availability on large scale at farmer's level.

Therefore, present investigation entitled "Path Analysis Studies on Feeding of Urea Ammoniated Soybean Straw to Lactating Cows" was conducted at Livestock Instructional Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, for a period of 120 days (starting from 05th February 2012 to 03rd June, 2012).

MATERIAL AND METHODS

Fifteen mid lactation stage cows were selected from the herd. These cows were randomly divided into three groups, each of five animals on the basis of nearness in their average milk production and body weight. The differences between BW and milk production of the groups were non significant, indicating formation of homogenous groups. Further, each group was allocated randomly to treatments, namely, Untreated Jowar straw ad lib. + Concentrate mixture 1kg for maintenance and 40% for milk production (T_1), Untreated Soybean straw ad lib. + Concentrate mixture 1kg for maintenance and 20% for milk production (T_2) and 2% Urea ammoniated Soybean straw ad lib. + 1kg Concentrate mixture for maintenance (T_3). Beside this, 5 kg green fodder (Hybrid Napier- Yashwant) fed to all cows and Concentrate Sugras a product of MAIDC, Maharashtra was fed as per treatment.

Record of observations

Meteorological observations

The meteorological observations for the experimental period *viz.*, maximum temperature (^{0}C) and relative humidity (%)were obtained from the Meteorological Observatory, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola .

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Daily milk yield

Milk yield was recorded both in the morning and evening for whole experimental period.

Feed intake

The cows were given computed quantity of feed and fodder. The feed intake was quantitatively monitored once in a week to assess the feed consumption by individual animal on the different treatments. Feed samples were collected once in a week for estimating its proximate principles. Dried samples were pooled, ground and stored in covered polythene bags for laboratory analysis.

Analysis of feed stuff and faeces

The feed stuffs i.e. Jowar straw, untreated/ treated soybean straw, Hybrid Napier and concentrate (Sugras) were analyzed for proximate analysis as per the standard procedures recommended by the Indian Standard Institute (BIS- 7874, Part –I, 1975) and DCP and TDN were calculated by standard formulas referred by Jagdish Prasad and Neeraj (2008).

Statistical analysis

Correlation and Path analysis studies were taken as suggested by Singh and Choudhary (1977).

RESULTS AND DISCUSSION

Meteorological observations:

Mean values of maximum temperature and morning relative humidity (RH-I) over the experimental period were recorded from Meteorological observatory and presented in Table 1. During this trial period the monthly mean values of maximum ambient temperature and RH-I were recorded as 33.5^{0}C and 45.5, 37.8^{0}C and 53.1, 41.1^{0}C and 33.4, 42.3^{0}C and 41.7% in Feb., March, April and May, respectively.

Nutritional Values and milk production:

The availability of nutrient in terms of DCP, TDN and milk production of cows were worked out and the data in this regard are tabulated in Table 1.

A perusal of Table 1 indicates that, the DCP content of 2% urea treated SBS ration was significantly higher (6.28%) than the ration containing T_1 control Jowar straw (4.72%) and T_2 untreated SBS (5.68%). On the other hand, TDN content of rations exhibited a different trend where T_2 untreated SBS diet had significantly lowest TDN content (53.05%) over T_1 and T_3 rations. However, the TDN content of T_1 (54.88%) and T_3 (55.12%) rations did not differ significantly. This means T_3 diet had the TDN content as that of T_1 control diet and urea treatment was advantageous to increase the TDN levels in the diets, thereby energy value. Otherwise, Pachauri and Negi (1976) opined that SBS was deficient in energy value. These observations are supportive to present trend. In general, it appears from the nutritive value of different rations that the rations were containing the DCP nearer to the recommended level (5.02%, ICAR, 1985) for the ration of lactating cows (maintenance + production)), While, the TDN values were found higher than the recommended levels (52.67% ICAR, 1985).

It is evident from Table 1 that the cows maintained on T_3 urea treated SBS ration produced significantly more milk than the cows fed with T_1 Jowar straw control and T_2 untreated SBS rations. Moreover, the milk production noticed under T_2-untreated SBS group was also significantly more than that of T_1 Jowar straw group. The overall milk production was 4.15, 4.18 and 5.25 kg day^{-1}cow^{-1} under T_1, T_2 and T_3 groups, respectively.

Correlation and Path analysis studies:

Correlation and its classification in direct and

Table 1: Effect of different feeding treatments on nutrient intake and milk production over experimental period.

S.N.	Parameters	Treatments			F Test	SE(m) ±	C.D.	CV(%)
		T_1	T_2	T_3				
1	DCP (kg.day/cow)	0.419(4.72%)	0.425(5.86%)	0.540(6.28%)	Sig.	0.0034	0.0095	6.815
2	TDN(kg.day/cow)	4.87(64.91%)	3.97(53.05%)	4.74(57.11%)	Sig.	0.0236	0.0655	5.181
3	Milk Production (Kg/day/cow)	4.15	4.18	5.25	Sig.	0.1654	0.4586	5.181
Meteorological observations (Mean values of experimental period)								
1	Temp.Max. **(^{0}c)**	38.89						
2	**RH I(%)**	40.72						

-Values shown in table were pooled weekly mean values of 17th week period.

- Sig.- Significant, NS- Non significant., CD at P<0.05.

indirect effects through DCP and TDN intake, Maximum Ambient Temperature (MAT) and Morning Relative Humidity (RH-I) on average daily milk yield of the cows under different feeding treatments are presented in Table 2.

The DCP and TDN intakes, MAT and RH-I levels established significant association with daily milk yield in all feeding groups.DCP intakes had greater influence on milk yield in all groups as the correlation values were positive significant of high magnitude being r= 0.835, 0.705 and 0.814 in T_1 Jowar straw group, T_2 untreated SBS and T_3 Urea ammoniated SBS groups, respectively. On the other hand TDN intakes exhibited a positive significant medium degree association with milk yield in T_1 (r= 0.546) and T_2 (r= 0.680) group, while it was also positive significant but of high order (r=0.814) in T_3 group. This trend did indicate that there was increase in milk yield with the increase of DCP and TDN intakes in cows.

In respect of impact of MAT on milk yield, it was observed that MAT had positive significant influence in T_1, T_2 and T_3 groups, the r values being 0.407, 0.631 and 0.907, respectively. In contrast RH-I levels affected milk yield significantly in negative direction. The correlation values were -0.477 and -0.415 in T_2 and T_3 groups, respectively. This means milk yield was more when more MAT with lower morning humidity levels were prevailing over the feeding trial and vice-versa. Thus the trend on association of different attributes with milk yield appeared supportive to earlier results where it was emphasized that higher intake of DCP and TDN in T_3 group was the cause to raise milk production in cows as compared to T_1 group cows.

The observed correlation co-efficients were classified in to direct and indirect effects. The direct effects were due to the variables, directly affecting the dependable variables i.e. Milk yield, while the indirect effects were through the in dependable variables on milk yield. On going through the direct and indirect effects of DCP on milk yield in T_1 group, it is evident from Table 2, that the degree of direct effects contribution was of moderate order while indirect effect, on milk yield through TDN, MAT and RH-I was positive but was of low magnitude, indicating that 79.28% of the total effect was through DCP intake and 20.72% effect was due to TDN, MAT and RH-I on milk yield.

On the other hand in T_2 untreated SBS group the direct contribution of DCP intake on influencing milk yield was to the tune of 54.04%, whereas its indirect effects through TDN intake, MAT and RH-I accounted to the level of 45.96%. In contrast surprisingly DCP intake exhibited highly negative direct effect (-1.060) on milk yield in T_3 group. Its indirect effects via TDN intakes, MAT and RH-I were positive (1.874). The higher order positive indirect contribution was the reason to result in to positive significant correlation of DCP with milk yield on feeding 2% urea treated SBS ration to cows. This trend might have arose on account of, I) The higher protein value of T_3 diet was mainly due to enrichment of SBS with 2% urea. II) It was suggested by past workers that urea diets needed provision of easily digestible energy source like molasses or jagarry or grains. III) In the absence of these sources and despite of higher DCP intake in T_3 group, the cows might not have been utilized full efficiency of protein intake for milk production,

Table 2. Correlation co-efficient and Path analysis of selected variables and mode of effect on daily milk yield in cows.

Treatments	Factors	Correlation with milk production	Direct effect	Indirect effect
T_1	DCP	0.835**	0.662(79.28)	0.173(20.72)
	TDN	0.546*	0.302(55.31)	0.244(44.69)
	Temp. Max.	0.407*	-0.342(-84.03)	0.749(184.03)
	RH-I	-0.506*	-0.225(44.46)	-0.281(55.54)
T_2	DCP	0.705**	0.381(54.04)	0.324(45.96)
	TDN	0.680**	-0.065(9.56)	0.745(90.44)
	Temp. Max.	0.631**	0.415(65.76)	0.216(34.44)
	RH-I	-0.477*	-0.206(43.18)	-0.271(56.82)
T_3	DCP	0.814**	-1.060(-130.22)	1.874(230.22)
	TDN	0.814**	1.465(179.97)	-0.651(-79.97)
	Temp. Max.	0.907**	0.673(74.20)	0.234(25.80)
	RH-I	-0.415*	-0.006(1.45)	-0.409(98.55)

(a) * Significant at 5% level, and **1% level. (b)Figures in brackets () indicate percentage contribution in total association.

resulting a negative direct contribution in milk production of cows.

With regards to TDN intakes, it had positive direct effect on milk yield of cows in T_1 Jowar straw group to the extent of 55.31%, while its indirect effect through other variables were also positive to the level of 44.69%, indicating near about equal impact of direct and indirect effects on milk yield of cows. In contrast in T_2 untreated SBS fed group, TDN intake exhibited low order negative direct effect (9.56%) on milk yield of cows. But its indirect effect via DCP intake, MAT and RH-I accounted to high degree of 90.49 per cent in positive direction on milk production. It is already pointed out earlier that T_2 cows just fulfilled TDN requirements on untreated SBS diet. As a result cows might have experienced short of energy, reflecting TDN direct contribution in milk production. The lower DMI in T_2 group was the reason to affect TDN intakes in cows. In support of this, Pachauri and Negi (1976) and Kumar and Garg (1995) reported that SBS possessed lower energy value in comparison to cereal straws. On the other hand, the cows consumed more DM on T_3 urea treated died resulting more TDN intakes in cows. Therefore, its direct contribution in milk yield was positive and of higher order (1.465 i.e. 179.97%), while DCP, MAT and RH-I influenced indirectly in negative directions (-0.651 i.e. -79.97%). This trend appears to be in support of DCP intake impact on milk yield of T_3 cows.

The MAT could establish positive significant association with daily milk yield in T_1 group. But the direct effect of MAT on milk yield could be considered as contributor in negative directions to the tune of 84.03%. However, DCP and TDN intakes along with RH-I had sizable contribution in positive direction (184.03%) on milk yield as indirect effects. The higher degree of positive indirect effects, the correlation value resulted in to positive, whereas temperature had shown moderately order positive direct effects on milk yield of cows under T_2 and T_3 groups on feeding SBS rations. Temperature accounted directly to the extent of 65.76 and 74.20% in T_2 and T_3 groups, respectively. While its indirect contribution through DCP and TDN intake and RH-I were to the tune of 34.24 and 25.80 in T_2 and T_3 groups, respectively. This trend did indicate that fluctuations in maximum ambient temperature along with morning humidity levels were responsible for change in daily milk yield of cows. With regards to impact of morning humidity levels, it was observed that RH-I levels had contributed directly in negative direction to the level of 44.46, 43.18 and 1.45% under T_1 Jowar straw conventional, T_2 untreated SBS and T_3 2% urea treated SBS diet, respectively. This means changes in morning humidity levels had negligible direct influence on milk yield of cows. On the contrary the indirect negative effects via DCP and TDN intakes and MAT were more pronounced in T_3 group as appeared from contribution level of 98.55% as compared to 55.54 and 56.82% in T_1 and T_2 groups, respectively.

CONCLUSION

Thus, the path analysis clearly demonstrated that daily milk yield in cows was not influenced substantially by a single factor. However, DCP and TDN intakes, MAT and RH-I levels effects could be the significant contributors for their direct and indirect impact on milk yield. In other words, increase intake of DCP and TDN in cows under hot dry climate would favour the milk production in all the feeding treatments. Therefore, the results do suggest that 2% urea treated SBS can find a place in the ration of lactating cows without any adverse effect on performance of cows.

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Comparative Efficacy of Anthelmintics Against Gastrointestinal Helminth Infection in Horses

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ABSTRACT

The present study was undertaken to evaluate the efficacy of ivermectin and pyrantel pamoate against gastrointestinal helminth infected horses of Akola district of Maharashtra state. Out of total 97 positive horses for gastrointestinal helminths infection, 18 were selected and randomly divided into two equal groups. One group (T1) was treated with single dose of ivermectin @ 0.2 mg kg^{-1} body weight orally. Another group (T2) was treated with single dose of pyrantel pamoate @ 6.6 mg kg^{-1} body weight orally. The treatment with single dose of ivermectin recorded 100 per cent reduction in fecal egg count (FEC) on 10^{th} day post treatment. However, pyrantel pamoate showed 99 per cent reduction as FEC on 10^{th} day and eliminated 100 per cent FEC on 13^{th} day post treatment. From the above study, it is concluded that both the drugs were highly effective against gastrointestinal helminth parasites of horses; however, ivermectin brought early reduction in FEC than parantel pamoate. The reappearance of eggs in faeces was recorded from 67^{th} day onward after treatment, indicated that both the drugs demonstrated the protection up to 9 weeks.

The gastrointestinal parasites commonly endanger the health and performance of horses as they colonize within the host and derive their nutrition from the host. Sometimes gastrointestinal parasitic infestations threaten the survival of the animals which resulted into economic losses to the horse owners. Traditionally, the control of equine parasites was relied almost entirely on routine administration of anthelmintics. However, repeated use of same anthelmintic throughout the year resulted into resistance to an anthelmintic and eventual failure of the parasite control program. Very little insight has been given to study the effect of these treatment programs on the emergence of anthelmintic drugs resistance. Also, it is essential to monitor the efficacy of the anthelmintic drugs by faecal eggs counts and determining the duration of protection of anthelmintic. Therefore, the present study was undertaken to evaluate the efficacy of anthelmintic drugs against gastrointestinal parasites in horses of Akola district.

MATERIAL AND METHODS

The present study was carried out to assess the comparative efficacy of anthelmintics against gastrointestinal helminth infection in horses in and around Akola district. Out of 97 horses found positive for gastrointestinal helminth infection, 18 were selected and randomly divided into two equal groups. One group (T1) of nine helminth infected horses was treated with single dose of ivermectin @ 0.2 mg kg^{-1} body weight orally. Another group (T2) was treated with single dose of pyrantel pamoate @ 6.6 mg kg^{-1} body weight orally. Both the anthelmintic drugs (Ivermectin and Pyrantel Pamoate) were given in the form of paste and administered orally.

Egg per gram of faeces (EPG) was determined as per Stoll's dilution technique described by Soulsby (2005). All the horses were subjected for EPG on '0' day (before treatment) and on 3^{rd}, 5^{th} day and then at every two days interval till the FEC revealed nil, their after faecal samples were examined at every 15 days interval till the recurrence of infection occurs to determined the protection period of anthelmintic drugs.

Anthelmintic efficacy was calculated by the faecal egg count reduction (FECR) test according to the formula described by Coles *et al.* (1992). The data was analyzed statistically by application of completely randomized design (Snedecor and Cochran, 1998).

RESULTS AND DISCUSSION

The comparative efficacy of ivermectin and pyrantel pamoate was evaluated on the basis of EPG count before and after treatment. The EPG of faeces was recorded in both the groups at different intervals with its per cent efficacy presented in Table 1.

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In group (T1), the overall mean EPG of faeces at pre treatment was 1377.78 ± 75.97, which was significantly reduced from third day post treatment (477.78 ± 46.48) till the 7thday (44.44 ± 17.56) post treatment as compared to the faecal egg count at pretreatment (1377.78 ± 75.97). On day 3rd, 5th and 7th post treatment, ivermectin showed 65 per cent, 87per cent and 97per cent FECR, demonstrated progressive reduction in FECR during the post administration of drug. All the horses become completely free from parasitic eggs on 10th day, as FEC were zero on 10th day post treatment (Table 1). Thus, the single dose of ivermectin eliminated worm burden and demonstrated 100 per cent FECR on 10th day post treatment. Many studied carried out by other workers also reported 100 per cent efficacy of single dose of ivermectin against nematodes of equines (Bacher *et al.*, 2002 and Godra *et al.*, 2010). The ivermectin binding of GABA to special receptor at nerve junctions in parasite, thus interrupting nerve impulses, thereby, paralyzing and killing the parasites.

It is observed that, the mean EPG count began to rise from day 67 to day 70. Thus, the present study shown that ivermectin consistently suppressed faecal egg count (FEC) upto 9 weeks following drug administration and thus gave the protection upto 9 weeks. Devender Pal (2002) recorded protection period of ivermectin as 6 weeks in organized farm.

In group T2, the overall mean EPG of faeces on '0' day was 1233.33 ± 28.86 which was significantly lowered from 3rd day post treatment (600 ± 62.36) till 10th day post treatment (11.11 ± 11.11) (Table 1). There was 94 per cent and 99 per cent reduction in EPG on 7th and 10th day post treatment, respectively. Average EPG of faeces was zero on 13th day post treatment, indicated single dose of pyrantel pamoate eliminated worm burden completely and showed 100 per cent reduction in FEC on 13th day post treatment. Thus, pyrentral pamote was highly effective and extremely consistent in suppressing faecal egg output of horses. Many workers reported 83 per cent to 100 per cent efficacy of pyrentral pamote in horses (Dorny *et al.*, 2000; Devender Pal, 2002; Davies and Schwalbach, 2002). The mechanism of action of pyrantel pamoate is attributed to depolarizing nematodal parasites causing persistent contracture of the musculature leading to spastic paralysis.

It is observed that the reappearance of GIT helminth eggs was recorded from 67th day onwards after treatment; indicates that pyrantel pamoate gave protection against helminths infection upto 9 weeks. Devender Pal (2002) recorded highest protection period of pyrantel pamoate ranging from 8-14 weeks against *Strongyles* infection in equines of Terai, plains and hills of Uttaranchal and U.P. In the present study protection period was comparatively less, which could be attributed to different geo-climatic zones and pasture larval burden.

Table 1. Comparative efficacy of ivermectin and pyrantel pamoate with its per cent efficacy

Days of observation	Mean EPG	
	Ivermectin (T1)	**Pyrantel pamoate (T2)**
	Pre treatment	
0th	$1377.78^{A} \pm 75.97$	$1233.33^{a} \pm 28.86$
	Post treatment	
3rd	$477.78^{B} \pm 46.48$ (65.00)	$600^{b} \pm 62.36$ (51.00)
5th	$177.78^{C} \pm 27.77$ (87.00)	$277.78^{c} \pm 22.22$ (77.00)
7th	$44.44^{C} \pm 17.56$ (97.00)	$77.78^{d} \pm 32.39$ (94.00)
10th	00 (100.00)	$11.11^{d} \pm 11.11$ (99.00)
13th	-	00 (100.00)
	Recurrence of infection	
67th day	66.67	10.0
70th day	188.89	200.0
73rd day	-	266.67

Figures in parenthesis refer to per cent reduction in EPG ($P<0.01$)

Similar superscript indicates non-significant differences.

From the above observation, it is evident that both the drugs were highly effective against gastrointestinal helminths parasites of horses, however, 100% reduction in faecal egg count brought by single dose of ivermectin showed faster effect than treatment with pyrantel pamoate. Thus, ivermectin found to be better choice than pyrantel pamoate.

The present study concludes that the single dose of ivermectin @ 200 µg kg^{-1} body weight and pyrantel pamoate @ 6.6 mg kg^{-1} body weight eliminated 100 per cent faecal eggs count of wide range of GIT nematode with protection period upto 9 weeks. Therefore, repeat treatments with these anthelmintics after every 8-9 weeks intervals in horses of Akola district is suggested.

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Bio-efficiency of Mushroom on Different Agro-waste

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ABSTRACT

The experiment was undertaken in Amravati district, Maharashtra state of India, to determine duration of spawn run, pin head and fruiting bodies formation and yield during three harvests of *Pleurotus djamor*. Chemical sterilization and poly bag technique were used for cultivation. The yields and biological efficiency of *P. djamor* on different agro-wastes were compared. The results revealed that the average period for three harvests required for different substrates ranged between 41 and 44 days. On an average, the yield of *P. djamor* declined from first to third flush with all selected substrates. The variation in the yield under the influence of various substrates was highest in the third flush (CV = 44.72). The significant higher yields were recorded in soybean (BE 109.0 %) over the chickpea (BE 81.21 %), pigeonpea (BE 74.9 %) mung bean (BE 68.6 %) and wheat (BE 51.9 %). The lowest yield was recorded (BE 31.0 %) in sorghum.

The bioconversion of agriculture and industrial wastes into food has attracted worldwide attention in recent years. Mushroom cultivation is highly efficient method of disposing agriculture wastes and simultaneously producing nutritious food. Mushrooms can be cultivated on variety of ligno-cellulolatic substrates considering its role in degrading agriculture residues and converting them into a good source of protein. This takes place by degrading lignin, cellulose, hemicelluloses, tannin and crude fibre in the straw and making it as an ideal animal feed.

In this region, *Pleurotus sajor-caju* and *P. florida* are commonly cultivated on wheat and paddy straw in Amravati district. The main objective of present investigation was to work-out the suitable alternative *Pleurotus* species and agro-waste potential for cultivation of oyster mushroom. Attempts were thus made to find out the time interval in between the formation of spawn run, pin head and fruiting body, yield potential and biological efficiency.

MATERIAL AND METHODS

The pure cultures of *P. djamor* were obtained from the Department of Plant Pathology, Tamilnadu Agriculture University, Coimbtore. Spawns were prepared by standard method using wheat grains and the experimental trial of cultivation was carried out in the laboratory of Krishi Vighyan Kendra, Durgapur.

Fresh and dry agro-wastes from various crops viz., soybean (*Glycin max*), chick-pea (*Cicer arientinum*), pigeon-pea (*Cajanus cajan*), mung-bean (*Vigna mungo*), wheat (*Triticum aestivum*) and sorghum (*Sorghum vulgare*) were collected from farmer's fields. The experiment was conducted in winter 2010. The straws were chopped into 2 -5 cm pieces and soaked in water containing 75 ppm bavistin and 500 ppm formaldehyde for 18 hours (Vijay and Sohi, 1987). The excess water was drained out and the straw was dried in shade to retain 60–70 per cent moisture. A poly-bag technique (Baskaran *et al.*, 1978) was employed for cultivation of mushroom. The polybags (30 x 45 cm) were filled with three kg wet substrate equivalent to one kg dry straw of agro-wastes. There were four replications of each type of straw. The multilayer technique (Bano, 1971) was adopted for spawning by using 60 g spawn for each bag.

The inoculated bags were kept in incubation room at maintained humidity, temperature, sunlight and ventilation. After spawn run and pinhead formation, the polybags were torn-off. Formation of fruiting bodies was evident within 3-4 days. The beds were maintained up to three flushes. Time interval, yield at each harvest and the total yield of *Pleurotus djamor* on six agro-wastes were recorded separately. The biological efficiency (BE) was calculated following (Chang et al., 1981). The data were statistically analysed and discussed.

RESULTS AND DISCUSSION

Table 1 depicts time duration for spawn run, formation of pin head, fruit body and duration between three harvests. It was observed, when *Pleurotus djamor* was cultivated on six different substrates, spawn run period ranged from 12-15 days. Minimum spawn run period of 12 days was observed in wheat. Soybean and chick pea required 13 days, followed by 14 for sorghum

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Table 1: Time duration for Spawn run, Pin head and Three Harvests (Days)

S.N.	Substrate	Spawn run	Pin head	First harvest	Second harvest	Third harvest
1	Soybean	13	16	19	29	44
2	Chick pea	13	16	19	30	41
3	Pigeon pea	15	17	20	31	42
4	Mungbean	15	18	21	32	42
5	Wheat	12	15	18	27	42
6	Sorghum	14	18	22	28	43
	Mean	13.6	16.6	19.8	29.5	42.3

while, a longer spawn run of 15 days observed in pigeonpea and mung bean. Pin head formation appeared after 15-18, that is, 3-4 days of spawn run and the fruiting bodies developed after 3-4 days (18-22 days) on most of the substrates. The first harvest was taken on same day of the fruiting body formation.

On an average, three weeks were required for the formation of fruiting bodies on various agro-wastes. These findings are in conformity with Quimio, (1978). It is evident that total cropping days for the three harvests differed on different substrates. The cropping days ranged from 41 to 44 days. Chickpea required minimum period of 41 days, while pigeonpea, mung bean and wheat required 42 days. Soybean took maximum period of 44 days for third harvest. Similarly, the period between second and third harvest ranged between 10-15 days. It was minimum in mung bean (10 days) and maximum in soybean (15 days).

The data depicted in Table 2 shows total yield of *P.djamor* obtained after three harvests on the six agro-wastes. The maximum yield (1090 g) was obtained on soybean straw, followed by on chickpea (812 g), pigeonpea (749 g), mung bean (686 g), wheat (519 g), and the lowest yield was obtained on sorghum (310 g).

When the data were analysed for analysis of variance (ANOVA), it was found out that the yield of *Pleurotus djamor* in first harvest was higher and statistically significant at (p = 0.05) on soybean straw while, in the second and third harvests, the yield was statistically insignificant on sorghum straw over all other substrates. The variation in the yield under the influence of various substrates was highest in the first flush (CV = 44.72). Anjuly Chaubey *et al.*, (2010) reported seasonal variation in the yield of mushroom. The total yield and biological efficiency of the three harvests were significantly higher on the soybean, chickpea and pigeonpea straw over the sorghum straw. Similar results regarding yield of *P. sajor-caju* on different substrates were reported by other workers namely, Deshmukh and

Table 2: Yield Performance of *Pleurotus djamor* on different Agro-wastes (g)

S.N.	Substrate	First harvest	Second harvest	Third harvest	Total yield (g)	Biological efficiency (%)
1	Soybean	736	226	128	1090	109
2	Chickpea	385	301	126	812	81.2
3	Pigeonpea	413	220	116	749	74.9
4	Mungbean	361	215	110	686	68.6
5	Wheat	311	140	68	519	51.9
6	Sorghum	165	95	50	310	31.0
Mean		395	199	99	694.33	
S. D.		188.6	72.3	32.7	265.2	
C. V.		44.72	36.2	32.7		
S.E. (m) $\pm$		76.9	29.51	13.3		
C. D. at 5%		197.9	75.84	34.3		

Mane (2001), who reported 105 per cent biological efficiency for *P. sajor-caju* on soybean straw and Ingle and Ramteke, (2010) who also reported 87.56 per cent biological efficiency of *P. florida* on soybean and wheat straw, respectively. Bhawna and Thomas, (2003) reported biological efficiency of *P. platypus* as 50.9 per cent, *P. djamor* as 36.7 per cent, *P. florida* as 62.7 per cent and *P. eous* as 50.0 per cent on leaf stalks biomass of coconut palm. Nallathami and Marimuthu, (1993) reported yield of *P. platypus* on sorghum stem with the biological efficiency of 85.5 per cent and yield of *P. eous* on Sorghum with biological efficiency of 73 per cent.

CONCLUSION

The present study explored the possibilities of cultivating *Pleurotus djamor* on different agro-wastes as Soybean, Wheat, Sorghum, Pegionpea and Chickpea. The highest yield of *P. djamor* on soybean straw indicated wide scope for cultivation of mushroom, followed by chickpea and Pegionpea except sorghum. Pleurotus dijamor is the alternative to P sajor caju and P florida which are commonly cultivated in the region. The spawn run period was least in wheat straw whereas the time duration was least in chickpea straw. Cultivation of *pleurotus dijamor* can also be considered as an agri-business for the people of this region to improve their financial status and health conditions. The increased proportion of nitrogen and decreased proportion of carbon in the spent straw can facilitate the use of spent straw as good manure, better animal feed, and efficient fuel.

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Development of Protocol for Liquid *Azotobacter*

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ABSTRACT

The biofertilizers play an important role in the nitrogen economy. They are inexpensive and ecofreindly. The carrier based biofertilizers have short shelf life (six months), sensitive to temperature, difficulty in storage and transport, and labour intensive as compared to liquid biofertilizers. Cyst formation in *Azotobacter* attributes for its long survivability in liquid medium. *Azotobacter* strain -3 survived in liquid broth up to twelve months of storage. At twelve months of storage, the *Azotobacter cfu* was 1.33 x 10^8 in MPKV liquid *Azotobacter*, whereas it was 1 x 10^8 in liquid *Azotobacter* of a commercial firm. But after twelve months of storage there was drastic reduction in the *cfu* count. MPKV liquid *Azotobacter* recorded highest germination percentage, number of leaves, plant height and dry matter/green fodder weight in sorghum and maize, respectively. The per cent increase in dry matter weight in sorghum was 64.08 per cent whereas it was 87.44 per cent, in respect of green fodder weight in maize.

Liquid bioinoculant for *Azotobacter* has been developed and patented in India vide No. 178503 in 1993, but the scientific cause for long survival was not investigated. However, recently, Inamdar *et a1,* (2000) have studied the details of *Azotobacter* and its long survivability attributed to its cyst formation characteristic. The study has claimed shelf-life of cyst bioinoculant for over two years besides high nitrogen fixing ability of *Azotobacter* strains. The cyst based *Azotobacter* in the liquid bioinoculants has been claimed to be a superior biofertilizer production technology for increasing shelf life instead of laborious large-scale carrier based production (Inamdar *et al*, 2000). The liquid biofertilizers also improve the soil quality and, therefore the farmers can cut down the cost of soil maintenance tremendously (Chin,2010). Unlike the lignite based biofertilizers these liquid biofertilizers have a longer shelf life(Rao, 2004).*Azotobacter* has an ability to produce antifungal antibiotics and fungistatic compounds against pathogens *viz. Fusarium*, *Alternaria* and *Candida* (Mishustin and Shilnikova, 1972). Seed germination and vigour of the young plants were also observed to be improved due to *Azotobacter* inoculation (Shende *et al.*, 1986), particularly in nitrogen fixing liquid biofertilizers, liquid *Azotobacter* can save 10-15 kg of nitrogen ha^{-1}.

In organic farming biofertilizers are one of the most important components. They are inexpensive and ecofreindly. However, it is necessary to use good quality biofertilizers. The carrier based biofertilizers have some limitations. They have short shelf life (six months), sensitive to temperature, difficulty in storage and transport, and labour intensive. In order to overcome the limitations of carrier based biofertilizers, the studies were undertaken at BNF Scheme, College of Agriculture Pune to develop the protocol for preparation of liquid biofertilizer.

MATERIAL AND METHODS

The pure culture of *Azotobacter chroococcum* strain-3 available with BNF Scheme was used for inoculation. The Jensen's broth was used for *Azotobacter* mass multiplication. Cell protectant viz., trehalose, PVP, arabinose and glycerol were used to maintain the cell count in liquid medium. The seeds of sorghum (var. Maldandi-35) and maize (var. African tall) were obtained from Agronomy Section, College of Agriculture, Pune.

Pure culture of *Azotobacter* strain -3 was grown on Jensen's agar medium. A loopful of inoculum from the slants was transferred in 300 ml of broth. The flasks were kept on shaker (260 rpm) for 72 to 96 hours. Jensen's broth was prepared using cell protectant viz. trehalose, PVP @ 2.0 mM/lit and 1per cent, respectively, dissolved separately and added into the broth before sterilization (Rao *et al*, 2009). The sterilization of the broth was carried out at 15 lb sq^{-1} inch for 15 min. Saturated stock solution of glucose and 1per cent stock solution arabinose were prepared and sterilized separately and added in to the sterilized broth prepared earlier. This broth was inoculated with pure starter culture @ 10 ml l^{-1} under aseptic conditions. The flasks were incubated at 28^0C for 5 days.

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The count per ml reached to 10^9 cells confirmed by dilution and pour plate technique. Sterilized glycerol was added to the inoculated broth and the broth was dispensed in to the previously sterilized polypropylene bottles and made it airtight by screw cap. Twelve polypropylene plastic bottles were filled in order to check the *cfu* count at monthly interval. Twelve bottles of inoculated Jensen's broth without addition of cell protectant were served as control. The liquid *Azotobacter* of commercial firms was kept as a check. All the bottles were kept at room temperature. The observations for *cfu* count were recorded at monthly interval. The N_2 fixing efficiency of *Azotobacter* strain was estimated after twelve months storage (Jackson 1973).

Pot culture experiments were conducted at BNF Scheme, College of Agriculture, Pune during 2010-11 to study the effect of liquid formulation of *Azotobacter* on plant growth of sorghum and maize. The experiments were laid out in Randomized Block Design with four replications and five treatment *viz.*, T1 (Liquid *Azotobacter* MPKV + 75% RDN),T2 (Liquid *Azotobacter* commercial firm + 75% RDN), T3 (*Azotobacter* Carrier based + 75% RD), T4 (100% RDF) and T5 (Un-inoculate control). The liquid formulation of MPKV *Azotobacter chroococcum* and commercial firm having *cfu* ml^{-1} 1.33×10^8 and 1×10^8 were used for seed treatments. Seeds were inoculated with liquid formulation of *Azotobacter* @ 1 ml kg^{-1} seeds for five min. Seed treatment with *Azotobacter* (carrier based) @ 25 g kg^{-1} of seeds were carried out just before sowing of seeds. The well decomposed farm yard manure @ 100g Kg^{-1} of soil was applied. On the basis of recommended dose of fertilizers to sorghum and maize, chemical fertilizers were applied as per the treatments. Treatment without seed inoculation served as a control.

Observations on germination percentage, number of leaves $plant^{-1}$, plant height (cm) and dry matter wt.$plant^{-1}$ (g) of sorghum at harvest and green fodder weight $plant^{-1}$ (g) of maize were recorded at 60 DAS..

RESULTS AND DISCUSSION

The data presented in Table 1 reveled that at one month of incubation the *Azotobcater cfu* count was 14.33×10^9 in MPKV liquid *Azotobacter*, whereas it was 13.33×10^9 in liquid *Azotobacter* of commercial firm, whereas in absolute control the *cfu* count was 3.66×10^9. But after one month interval the *cfu* count gradually decreased upto eight months of storage. However, in absolute control the *Azotobcater* did not survive for more than one month. After eight months of inoculation, the *Azotobcater cfu* count was 4.33×10^9 and 3.66×10^9 in MPKV liquid *Azotobacter* and liquid *Azotobacter* of commercial firm, respectively. This was quite higher than limit prescribed by BIS (1×10^8 at six months of storage). However, after nine months of inoculatuion the *cfu* count significantly decreased and recorded 2.66×10^8 in MPKV liquid *Azotobacter* as well as in liquid *Azotobacter* of commercial firm. At twelve months of storage the *Azotobacter* counts were 1.33×10^8 and 1×10^8 in MPKV liquid *Azotobacter* and liquid *Azotobacter* of commercial firm, respectively. But after twelve months of storage there was drastic reduction in the *cfu* count. These results are in conformity with that of Chandra (2009) who reported that the liquid *Azotobacter* ensures the shelf life upto 12 months and retained the maximum bacteria 1×10^8 future, he also reported that the *Azospirillum* retained maximum count of 1×10^8 upto 12 months but thereafter it was reduced drastically.

The N-fixing efficiency of MPKV and commercial liquid *Azotobacter* at the end of 12 months expiry was established to be 16 mg and 14 mg g^{-1} of sucrose consumed, respectively. These results are in agreement with the results of Murkute *et al*. (1990) who reported that the *Azotobacter chroococcum* fixed 6.44 to 20.38 mg of nitrogen per gram of sucrose.

From Table 2, it was observed that MPKV liquid *Azotobacter* recorded highest germination percentage of sorghum (80 %) over control (73.33%), followed by treatment of 100 RDF (80 %) and liquid *Azotobacter* of commercial Firm (80 %).

Number of leaves (7.66) of sorghum significantly increased by seed inoculation of MPKV liquid *Azotobacter* over control (5.00) and at par with Liquid *Azotobacter* commercial Firm (7.00), 100 RDF treatment (7.00) and *Azotobacter* carrier based (6.66). Similar results were reported by Sharma and Thakur (2001) who noted that among individual treatment of biofertilizers, the application of *Azotobacter* resulted in significant improvement in number of branches, number of leaves etc. in tomato.

The increase in plant height was significant due to MPKV liquid *Azotobacter* (105.33 cm) than control (84.33 cm) and 100 RDF treatment (95.66 cm) but found at par with Liquid *Azotobacter* commercial Firm (100.66 cm).

Table 1. *Azotobacter* count at monthly interval.

Month	MPKV liquid *Azotobacter*	Commercialliquid *Azotobacter*	Control
1	14.33×10^9	13.33×10^9	3.66×10^9
2	11.66×10^9	10.66×10^9	-
3	10.33×10^9	10.33×10^9	-
4	8.66×10^9	8.33×10^9	-
5	7.66×10^9	7.33×10^9	-
6	5.33×10^9	6.66×10^9	-
7	4.66×10^9	5.33×10^9	-
8	4.33×10^9	3.66×10^9	-
9	2.66×10^8	2.66×10^8	-
10	2.33×10^8	2.66×10^8	-
11	2.0×10^8	1.33×10^8	-
12	1.33×10^8	1.0×10^8	-

Table 2. Effect of liquid *Azotobacter* on growth parameter of Sorghum.

Tr. No.	Treatment Details	Germination %	No. of leaves	Plant height (cm)	Dry matter wt./plant (g)	% increase dry at harvest matter over control
T_1	Liquid *Azotobacter* MPKV+ 75% RDN	80	7.66	105.33	35.00	64.08
T_2	Liquid *Azotobacter* VSI+ 75% RDN	80	7.00	100.66	32.66	53.11
T_3	*Azotobacter* (carrier based) + 75% RDN	78.33	6.66	91.66	32.66	53.11
T_4	100% RDF	80	7.00	95.66	30.33	42.19
T_5	Un-inoculated control	73.33	5.00	84.33	21.33	0.00
	SE (m) ±	**2.26**	**0.66**	**2.34**	**1.57**	-
	CD at 5%	**6.78**	**1.99**	**7.03**	**4.72**	-

Table 3. Effect of liquid *Azotobacter* on growth parameter of Maize.

Tr. No.	Treatment Details	Germination %	No. of leaves	Plantheight (cm)	Green fodder wt/plant (g)	% increase dry matter over control
T_1	Liquid *Azotobacter* MPKV+ 75% RDN	80.00	11.00	119.66	149.33	87.44
T_2	Liquid *Azotobacter* commercial Firm+ 75% RDN	79.00	10.00	118.00	139.50	73.22
T_3	*Azotobacter* (carrier based) + 75% RDN	75.33	8.66	117.33	120.66	51.46
T_4	100% RDF	79.66	9.66	118.00	107.83	35.35
T_5	Un-inoculate control	72.00	6.00	101.66	79.66	0.00
	SE (m) ±	**2.09**	**1.13**	**1.59**	**1.71**	-
	CD at 5%	**6.27**	**3.39**	**4.77**	**5.15**	-

The results are also in agreement with reports by Reddy and Lakhdive (1982) in hybrid sorghum (CSH-5).

Seed inoculation with MPKV liquid *Azotobacter* was found effective to increase the dry matter weight of sorghum at harvest and recorded significantly highest dry matter weight (35.00 g) over control (21.33 g) and found at par with other treatments. The per cent increase in dry matter weight in sorghum due to MPKV liquid *Azotobacter* was 64.08 per cent, whereas it was 53.11 per cent in liquid *Azotobacter* of commercial Firm. Deokar and Sawant (2002) reported that hybrid Sorghum had response to the liquid bioinoculant. The foliar application with vitormone (MCLF) was more beneficial to hybrid sorghum var. CSH-9 at 30,60 and 90 days of crop growth for getting increased crop growth rate, stem diameter, plant height, dry matter weight and better grain yield. Gaikwad *et al.* (2008) also reported that the foliar sprays of bioinoculant vitromone and azomeal were at par with commercial *A. chroococcum* strains for kernel weight, grain and dry matter yield of groundnut.

The data presented in Table 3 reveled that the growth of maize plant was vigorous due to application of nitrogenous liquid biofertilizers (*Azotobacter*). Germination percentage of maize significantly increased by seed treatment of MPKV liquid *Azotobacter* (80.00 %), followed by treatment of 100 RDF (79.66 %) and liquid *Azotobacter* of commercial Firm (79.00 %), whereas control treatment recorded minium germination percentage (72..00 %). The results are in conformity with Shende *et al.* (1986) who reported that seed germination and vigour of the young plants were also observed to be improved due to liquid *Azotobacter* inoculation MPKV liquid *Azotobacter* recorded highest number of leaves per plant (11.00) than control treatment (6.00) but at par with liquid *Azotobacter* of commercial Firm (10.00). Sharma and Thakur (2001) investigated that among individual treatments of biofertilizers, the application of *Azotobacter* resulted in significant improvement in number of branches, number of leaves etc. in tomato. It was observed that plant height was significantly increased by treatment of MPKV liquid *Azotobacter* (119.66 cm) over control (101.66 cm) and found at par with liquid *Azotobacter* of commercial Firm, 100 RDF and *Azotobacter* carreer based which were 118.00 cm, 118.00 cm and 117.33 cm, respectively. Similar results were reported by Dibut, *et al.* (1993) that the inoculation of dilute preparation of *Azotobacter chroococcum* immediately after sowing increased the plant height in onion.

All above growth promoting parameters helped in increasing the green fodder of maize plant. The significantly highest green fodder weight was recorded with MPKV liquid *Azotobacter* (149.33g plant^{-1}) over all other treatments at 60 DAS. The liquid *Azotobacter* of commercial firm, *Azotobacter* carreir based, 100 per cent RDF and control treatments reocrded 139.50g, 120.66g, 107.33g and 79.66 g green fodder weight per plant, respectively. The per cent increase in dry matter weight in maize was 87.44 per cent thereof seed inoculation of MPKV liquid *Azotobacter,* whereas it was 73.22 per cent in liquid *Azotobacter* of commercial Firm. The reults are in conformity with Chaudhari *et al.* (2008) who noticed that treatment with liquid *Azotobacter* along with 60 kg N/ha remarkably improved the stem thickness, length of main inflorescence, number of spikelets and seed weight which resulted in increased grain and dry matter yield of grain amarantha.

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Response of Soybean to Combined Inoculation of Biofertilizers and Bioagents

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ABSTRACT

The present investigation was undertaken to ascertain the compatibility of *Bradyrhizobium japonicum*, *Bacillus megaterium* var. *phosphaticum* and *Trichoderma* spp. in soybean.. Combined inoculation of *Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. enhanced test weight (13.0 g), protein content in grain(42.10%), N and P content (1.72% and 0.178% respectively)and its uptake (37.97 kg ha^{-1} and 3.95 kg ha^{-1}, respectively) by plant compared to 10.66 g test weight in control, 38.68 per cent protein content, 1.47 per cent and 0.136 per cent N and P content, 19.10 kg ha^{-1} and 1.76 kg ha^{-1} N and P uptake by plant as recorded in uninoculated control. The yield recorded due to combined inoculation of *Bradyrhizobium japonicum*, *Bacillus megaterium* var. *phosphaticum* and *Trichoderma* spp was significantly higher (1887 kg ha^{-1}) than control (1342 kg ha^{-1}).

Soybean (*Glycine max* (L.) Merill), Family leguminoceae is a unique crop of versatile nutritional attribute yielding both oil and protein grown in various countries. It is considered as "Golden Bean" of 21st century and also known as "Gold of Soil" It has less requirement of nitrogenous fertilizers, pesticides and easy for cultivation. Soybean rank 1st among oil seed crops in world.

Soybean has its manifold importance in agriculture, medicinal and industrial sector. It is having high nutritive value. It contains 40 - 44 per cent protein, 18 - 20 per cent oil, 30 per cent carbohydrates, 5 per cent fibre, 4 per cent saponins, and 0.5 per cent lecithins. It also contains vitamin A, B, C, D, E, K and all other essential amino acids. It is an excellent health food in the form of soy paneer, soy flour, soy grits, Feed like soy meal and industrial crop as used in beverages, nuggets and milk. Soybean due to its various uses is called Wonder crop and "Golden gift" of nature to mankind.

In Maharashtra, Vidarbha region has attained the highest production of the crop as the average rainfall of 800 to 1000 mm and pH of soil around 7.7 to 8.5 is well suited for soybean. Black cotton soils are more suitable for the production.

Being leguminous crop soybean helps in soil conservation and enriching soil by fixing atmospheric nitrogen through *Rhizobium* root nodules thereby increasing the grain yield and partly diffused through roots into surrounding soil.

Bacterization of soybean seed with *Rhizobium* and PSB before sowing has been reported to increase profitable crop yield. With the increasing cost of chemical fertilizers there is need to integrate them with organic matter and biofertilizers which are good for soil health besides supplying nutrients for longer periods of time.

It is very important to study the interactions between microbes pelletizing / inoculating with seed to check the compatibility of *Rhizobium*, PSB and *Trichoderma* in soybean (*in vivo*) in field conditions. Some times the use of two or more cultures at a time results to create synergistic /antagonistic effects which may leads to increase /decrease in crop yield.

MATERIAL AND METHODS

A field trial on Soybean variety TAMS-38 was laid out in Randomized Block Design (RBD) with 12 treatments at experimental farm of Department of Plant Pathology, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.Seeds were treated with the carrier based inoculants as per treatments.

Treatment Details

T_1 = *Bradyrhizobium japonicum* (seed treatment) @ 25 g kg^{-1} seed

T_2 = *Bacillus megaterium* var. *phosphaticum* (ST) @ 25 g kg^{-1} seed

T_3 = *Trichoderma* spp. (ST) @ 4 g kg^{-1} seed

T_4 = *Trichoderma* spp. (soil application) @ 2.5 kg ha^{-1}

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T_5 = *Bradyrhizobium japonicum* (ST) @ 25 g kg^{-1} seed + *Trichoderma* spp. (ST) @ 4 g kg^{-1} seed

T_6 = *Bradyrhizobium japonicum* (ST) @ 25 g kg^{-1} seed + *Trichoderma* spp. (SA) @ 2.5 kg ha^{-1}

T_7 = *Bacillus megaterium* var. *phosphaticum* (ST) @ 25 g kg^{-1} seed + *Trichoderma* spp. (ST) @ 4 g kg^{-1} seed

T_8 = *Bacillus megaterium* var. *phosphaticum* (ST) @ 25 g kg^{-1} seed + *Trichoderma* spp. (SA) @ 2.5 kg ha^{-1}

T_9 = *Bradyrhizobium japonicum* (ST) @ 25 g kg^{-1} seed + *Bacillus megaterium* var. *phosphaticum* (ST) @ 25 g kg^{-1} seed + *Trichoderma* spp. (ST) @ 4 g kg^{-1} seed

T_{10} = *Bradyrhizobium japonicum* (ST) @ 25 g kg^{-1} seed + *Bacillus megaterium* var. *hosphaticum* (ST) @ 25 g kg^{-1} seed + *Trichoderma* spp. (SA) @ 2.5 kg ha^{-1}

T_{11} = 100 per cet Recommended dose of chemical fertilizers 30: 75 NP kg ha^{-1}

T_{12} = Uninoculated control

Estimation of N content and uptake in plant

Nitrogen content in plant and grain was determined by Micro-Kjeldhal's method given by Somichi *et. al.* (1972). and the same value was converted to crude protein by multiplying N percentage with the factor 6.25.

The phosphorus content was determined by Vando Molydate Phosphoric Yellow Colour Method (Jackson, 1967).

The initial and residual N and P content in soil was estimated by Micro-kjeldhal's method and Olsen method, respectively (Jackson, 1967).

RESULTS AND DISCUSSION

Test weight

Data in Table 1 on test weight (100 seed weight) indicated differences due to various treatments. Pelleting of *Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. (T_9) recorded highest test weight (13.00 g). The treatments T_{10} [*Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* (ST) + *Trichoderma* spp. (SA)] with 12.33 g and T_{11} (100% RDF) with 12.00 g were at par with T_9 The synergistic effect of combined inoculation of biofertilizers and *Trichoderma* seems to be responsible for increasing boldness of seed and ultimately test weight in these treatments. The test weight recorded in individual application of biofertilizers and *Trichoderma* was at par with control. Present finding conforms the results of Anjum *et al.* (2006), Khutate *et al.* (2005) and Kanase *et al.* (2006)

Grain yield

The data pertaining to grain yield presented in Table 1 indicated significant differences in various treatments over uninoculated control. Seed treatment with *Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. (T_9) showed highest grain yield 1888 Kg/ha, which was significantly superior overall other treatments. Combined application of biofertilizers and biocontrol agent in the form of seed treatment might have provided available nutrients and disease free atmosphere to the crop which resulted in obtaining maximum grain yield.Increase in grain yield due to fixation of N by *Rhizobium* and solubilization of P by PSM have also been reported by Anjum *et al.* (2006), Kanase *et al.* (2006) and Tyagi *et al.* (2004) in soybean crop.

Protein content

The data presented in Table 1 indicated significant differences in protein content of grain due to different treatments. Higher protein content over uninoculated control have been recorded in many treatments. Combined application of *Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. (T_9) showed highest protein percent *i.e.* 42.10 per cent which was found significantly superior over *Bradyrhizobium japonicum* (T_1) i.e. 41.10 per cent, *Bacillus megaterium* var. *phosphaticum* (T_2) i.e. 39.78 per cent, *Trichoderma* spp. (T_3) i.e. 38.93 per cent and 100 per cent RDF (T_{11}) i.e. 39.47 per cent. Lanje *et al.* (2005), Tyagi *et al.* (2004), Jain and Trivedi (2005), Mohankumar *et al.* (2005) also observed more protein content in soybean seed due to application of biofertilizers.

N content in plant and uptake

The data in Table 1 showed that there were significant differences in N content by the plant over uninoculated control. The seed treatment with

Table 1 : Effect of inoculation of *Bradyrhizobium japonicum, Bacillus megaterium* var. *phosphaticum* and *Trichoderma* spp.

	Test weight	Protein content in grain (%)	N content in plant (%)	N uptake by plant (Kg ha^{-1})	P content in plant (%)	P uptake by plant (Kg ha^{-1})	Grain yield (Kg ha^{-1})
T1	11.66	41.10	1.60	29.37	0.147	2.696	1755
T2	11.66	39.78	1.51	25.20	0.177	2.287	1443
T3	10.66	38.93	1.46	21.08	0.141	2.022	1369
T4	11.33	40.18	1.51	18.36	0.143	1.73	1354
T5	11.00	39.45	1.61	29.22	0.140	2.538	1654
T6	11.66	41.22	1.54	24.98	0.144	2.341	1632
T7	11.00	41.55	1.49	19.17	0.155	2.605	1582
T8	11.00	40.22	1.50	21.19	0.153	2.160	1560
T9	13.00	42.10	1.72	37.97	0.178	3.953	1888
T10	12.33	40.62	1.55	31.49	0.152	3.092	1805
T11	12.00	39.47	1.53	25.89	0.146	2.482	1728
T12	10.66	38.68	1.47	19.10	0.136	1.760	1342
SE(m)±	0.45	0.33	0.028	2.58	0.0024	0.25	27.38
CD (P= 0.05)	1.32	0.99	0.082	7.58	0.0069	0.75	80.31

Bradyrhizobium japonicum + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. (T_9) recorded highest N content *i.e.* 1.72 per cent, followed by the seed treatment with *Bradyrhizobium japonicum* + *Trichoderma* spp. (T_5) *i.e.* 1.61 per cent, *Bradyrhizobium japonicum* (T_1) *i.e.* 1.60 per cent.

Similarly there was significant variation in respect to nitrogen uptake by the plants due to different treatments over uninoculated control. The treatment T_9 [*Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. (ST)] showed maximum nitrogen uptake by plant *i.e.* 37.97 kg/ha and was at par with T_{10} [*Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. (SA)] *i.e.* 31.49 kg ha^{-1}.The results obtained by Balyan *et al.* (2002) and Paratey and Wani (2005) also lend support to the findings of present investigation.

P content and uptake

P content and P uptake presented in Table 1 showed significant differences. Treatment T_9 [*Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp.] recorded highest percentage of P content *i.e.* 0.178 per cent, which was at par with P content in seed treatment of *Bacillus megaterium* var. *phosphaticum* (T_2) i.e. 0.177 %. The other treatments of biofertilizers and *Trichoderma* showed P content at par with the treatment of 100 % RDF but significantly superior over uninoculated control.

Phosphorus uptake by the plants due to different treatments also differed significantly as recorded in Table. The treatment T_9 [*Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp. (ST)] showed maximum phosphorus uptake by plant *i.e.* 3.953 kg/ha. The same combination of treatment but in different form of application *i.e.* soil application of *Trichoderma* recorded lesser P uptake (3.092 kg/ha) compared to T_9. Although individual application of biofertilizers and *Trichoderma* significantly increased the P uptake, all the 3 tested bioinoculants combinely exhibited enhancement in P uptake compared to individually, may be due to synergistic effect on each other. Paratey and Wani (2005) and Solankey and Patel (1998) also recorded more P uptake due to treatments of biofertilizers.

Residual N and P status in soil

Meagre differences in residual N and P status in soil after harvesting of crop was noticed (Table 1). Although treatments T_1 (*Bradyrhizobium japonicum*), T_9 [*Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp.] and T_{11} (100% RDF) showed same residual 'N' content in soil after

harvesting *i.e*. 0.078 per cent. However almost all treatments recorded more residual N compared to control. In respect of residual phosphorus content in soil, treatment T_9 [*Bradyrhizobium japonicum* + *Bacillus megaterium* var. *phosphaticum* + *Trichoderma* spp.] and T_2 (*Bacillus megaterium* var. *phosphaticum*) recorded at par residual P *i.e*. 0.025 per cent and 0.024 per cent, respectively followed by T_1 (*Bradyrhizobium japonicum*) and T_{11} (100 % RDF) Although Paratey and Wani (2005) noticed differences in residual N and P content due to various treatments of biofertilizers, as stated earlier the conclusion can't be drawn from such studies for want of repeated analysis.

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Fungicide Tolerance and Enhancement of Bioefficacy of *Trichoderma* Mutants with Chemical Amendments Against *Macrophomina phaseolina*

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ABSTRACT

The tolerance of *Trichoderma* mutants M10 and M15 to different fungicides revealed high tolerance to metalaxyl + mancozeb and cymoxil + mancozeb as there was little restriction of colony growth in all concentrations (0.2,0.1, 0.05, 0.02 and 0.01%). Maximum inhibition was recorded by carbendazim + mancozeb as compared to other fungicides. The chemicals viz. salicylic acid, zink sulphate, benzoic acid, sodium nitrate and mannitol at different concentrations (100 ppm and 200 ppm) not only inhibit the growth of *Macrophomina phaseolina* but also enhance the mycoparasitic ability of biocontrol agent. There was drastic improvement in arresting the growth of pathogen with these chemicals.

Trichoderma viride and *Trichoderma virens*, the most common species that are being used in biological control of seed borne as well as soil borne pathogens (Mukhopadhyay, 1994). Strain improvement by mutation is an age-old as a successful method. Therefore, several approaches including chemical mutation, UV irradiation and their combinations were applied to obtain enhanced cellulose producing strains of *Trichoderma* (Kotchoni and Shonukan, 2002) and known to be unsurpassed chemical agent, it has a strong mutagenic property. Colchicine is also known as a polyploidy inducer in microbes (Oenfelt and Klasterska, 1983). The differential response of antagonistic flora to various fungicides might be due to their resistance to most fungicides and their ability to degrade chemicals (Papavizas, 1985). *In vitro* and *in vivo* study for compatibility of *Trichoderma harzianum* with three commonly used fungicides, six insecticides and NPK at recommended doses, Carbofuran**,** Copper oxychloride and Phorate were found highly compatible to *T. harzianum* and also found supportive to increase the population of *T. harzianum*. **(**Suseela and Thomas, 2010)**.** Arunasri *et al*.(2011) found that *Trichoderma* spp. highly compatible with thiram and captan and uncompatible with thiophanate methyl and propiconazole.

The objective of the present studies was to ascertain the tolerance of *Trichoderma* mutants, M10 and M15 to different concentration of fungicide (companion, curzet M-8, ridomil MZ and thiram) as well as to evaluate certain chemicals (salicylic acid, zink sulphate, benzoic acid, sodium nitrate and mannitol) for systemic resistance to the *Macrophomina phaseolina* and its synergistic effect on biocontrol agent.

MATERIAL AND METHODS

Conidiospores of selected T1 and T7 *Trichoderma* isolates were treated with ethymethane sulfonate at five concentrations, 50, 75, 100, 125 and 150 µl/ml for 30 and 60 minutes. Selected single cell colonies were again treated with 0.1 and 0.2% colchicine. On the basis of highest antagonism against *M. phaseolina*, mutants were selected for further study. Assaying the tolerance to fungicides, poisoned food method consisting fungitoxicant i.e. carbendazim + mancozeb (Companion), cymoxanil + mancozeb (Curzet M-8), metalaxyl + mancozeb (Ridomil MZ-72) and thiram with concentrtions of 0.2, 0.1, 0.05, 0.02, and 0.01 % were incorporated in the media (PDA). The plates were inoculated with seven days old culture disc (6 mm) of *Trichoderma* mutants M10 and M15 separately. Plate without fungicide served as control. Dual culture technique was followed to evaluate the systemic resistance of salicylic acid, zink sulphate, benzoic acid, sodium nitrate and mannitol (100 and 200ppm) incorporated in the media against *Macrophomina phaseolina* and its synergistic effect on *Trichoderma* mutants M10 and M15.. These plates were inoculated with seven days old culture of *Trichoderma* mutants and *Macrophomina phaseolina*, plate without chemicals were kept as control.

RESULTS AND DISCUSSION

The tolerance level of *Trichoderma* mutants M10 and M15 was tested against different fungicides. There was high tolerance in *Trichoderma* mutants both M10 and M15 with the combine product of fungicides, metalaxyl + mancozeb and cymoxanil + mancozeb where

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Table 1. Effect of fungicides on mycelial growth and percent inhibition of *Trichoderma* mutants

Fungicide	Concent-ration %	Radial mycelial growth (mm)		% inhibition	
		M_{10}	M_{15}	M_{10}	M_{15}
Thiram	0.2	10.77	16.11	88.03	82.10
	0.1	20.22	16.11	77.53	82.10
	0.05	35.55	40.55	60.50	54.94
	0.02	89.33	90.00	0.74	0.00
	0.01	89.89	90.00	0.12	0.00
Carbendazim + mancozeb	0.2	8.00	8.00	91.11	91.11
	0.1	8.00	9.90	91.11	89.01
	0.05	8.00	13.90	91.11	84.57
	0.02	8.00	8.00	91.11	91.11
	0.01	8.00	9.30	91.11	87.67
Metalaxyl + mancozeb	0.2	90.00	90.00	0.00	0.00
	0.1	90.00	90.00	0.00	0.00
	0.05	90.00	90.00	0.00	0.00
	0.02	90.00	90.00	0.00	0.00
	0.01	90.00	90.00	0.00	0.00
Cymoxanil + mancozeb	0.2	90.00	90.00	0.00	0.00
	0.1	90.00	90.00	0.00	0.00
	0.05	90.00	90.00	0.00	0.00
	0.02	90.00	90.00	0.00	0.00
	0.01	90.00	90.00	0.00	0.00
Control		90.00	90.00		

Table 2. Effect of *Trichoderma* mutants against *M. phaseolina* on chemicals amended medium

Chemical	Concentration (ppm)	Growth (mm)		% reduction in growth		Mycelial dry wt. (mg)		% reduction in wt.	
		M_{10}	M_{15}	M_{10}	M_{15}	M_{10}	M_{15}	M_{10}	M_{15}
Salicylic acid	100	50.11	59.44	31.66	18.94	150	190	31.81	36.36
	200	73.33	67.55	0.0	7.88	160	160	27.27	27.27
Zinc sulphate	100	57.22	73.33	21.96	0.0	180	150	18.18	31.81
	200	62.44	56.77	14.85	22.58	160	120	27.27	45.45
Benzoic acid	100	36.00	73.11	50.90	0.30	170	150	22.72	31.81
	200	51.89	63.00	29.23	14.08	190	160	13.63	27.27
Sodium nitrate	100	55.33	68.00	24.54	7.26	180	160	18.18	27.27
	200	55.66	60.00	24.09	18.17	210	190	0.45	13.63
Mannitol	100	60.00	51.66	18.17	29.55	160	150	27.27	31.81
	200	52.66	56.66	28.18	22.73	160	150	27.27	31.81
Control		73.33	73.33			220	220		

maximum mycelial growth (90.00mm) was recorded in all concentrations. Minimum mycelia growth (8.00mm) with 91.11per cent inhibition was recorded by M15 at 0.2 and 0.02 per cent concentration of carbendazim + mancozeb. Thiram recorded maximum radial mycelia growth (90.00mm) in M15 at 0.01 and 0.02 per cent concentration, followed by 0.12 per cent growth inhibition in M10 (89.89mm) at 0.01per cent concentration. Maximum inhibition (88.03%) and minimum mycelia growth (10.77mm) was recorded in M10 at 0.2 per cent concentration of thiram, followed by M15 (82.10%) having 16.11mm mycelial growth (Table 1). These results are in agreement with Charls (2008) who recorded that carbendazim and benomyl at low concentrations were effective in reducing the growth of *Trichoderma* while captan, copper oxychloride and carboxin were entirely compatible at all the tested concentrations. Pandey *et al.* (2006) tested eight fungicides against *Trichoderma* spp. at different concentrations and observed that tebuconazole and hexaconazole were extremely toxic while captan was fungistatic to *T. harzianum* and can be combined together. Khattabi *et al*. (2001) monitored the mycelial growth of *T. harzianum* and *Sclerotium rolfsii* on fungicide amended medium and observed that hymexozol improved antagonism of *T. harzianum*

The medium amended with salicylic acid (100 ppm) recorded maximum reduction in mycelia growth and mycelia dry weight of *Macrophomina phaseolina* in M10 (31.66%) and in M15 (36.36%), respectively (Table 2). Medium amended with zinc sulphate (100 ppm) exhibited 22.58 per cent and 21.96 per cent reduction in mycelia growth of *Macrophomina phaseolina* dual cultured with *Trichoderma* mutants M15 and M10. Reduction in mycelial growth of *Macrophomina phaseolina* (50.90%) was recorded in benzoic acid and sodium nitrate 24.54 per cent at 100 ppm dual cultured with M10, followed by 200 ppm (24.09%). Similarly, mannitol amended media gave 29.55 per cent reduction in mycelia growth of test pathogen with M15, followed by M10 at 200 ppm (28.18%) and maximum reduction in mycelia dry weight in M15 at 100 and 200 ppm (31.81%). Thus it is concluded that the test chemicals not only inhibit the *Macrophomina phaseolina* but also enhance the mycoparasitic ability of biocontrol agent. Present findings are similar to those of Sundarvadan and Alice (2006) working with *Trichoderma viride* against *M. phaseolina* where medium was amended with zinc sulphate. Jayraj and Ramabadran (1998) observed that ammonium nitrate, ammonium sulphate and sodium nitrate recorded maximum growth, sporulation, production of cellulose and antifungal substances by *T. harzianum* out of seven nitrogenous salts tested *in vitro*.

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Longevity of *Trichoderma harzianum* Grown on Various Substrates and Stored at Different Temperatures

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ABSTRACT

The viable propagules of *Trichoderma i.e.* cfu differed due to different substrates used for multiplication of *Trichoderma*. Sorghum grains were found supporting the maximum propagules in more or less period of storage. *Trichoderma* formulated in sterilized water showed the viability up to 180 days with gradual decrease in count at different period of storage. The suitable temperature for shelf life of *Trichoderma* was found 30^0C as it yielded maximum propagules during various storage period followed by 20^0C and 40^0C.*Trichoderma* multiplied on sorghum grains and formulated on talc showed better results, followed by soybean oil.

Among many fungi as a biocontrol agent, *Trichoderma* is widely used, as it posses antagonistic mechanisms, *i.e.* competition, antibiosis and mycoparasitism. *Trichoderma* is an ubiquitos, easy to isolate and culture, grow rapidally on many substrates and affect wide range of pathogens.

Biological and physical properties of formulation must remain stable for at least one year, preferable for greater than 18 months for commercialization (Couch and Ignoffo, 1981). Formulation helps in delivery systems of a bioagent. The formulation is mandatory in order to enhance the spore stability and increase in efficiency. The type of formulation ultimately depends upon the biology and physical properties of the antagonists, location and habitats of target pathogens. The solid carrier based formulations are mostly used for application because it is known to retain viability and virulence for larger time (Shamrao *et al.*,1998).However, increase in effectiveness of the bioagents, with addition of oil is also documented (Prior *et al*., 1988). It appears feasible for industry to produce various beneficial microbes including *Trichoderma* against plant pathogens through liquid fermentation using inexpensive media such as molasses and brewer's yeast (Papavizas *et al.*, 1984).*Trichoderma* is available in various formulations with known shelf life. During recent days it is mass multiplied by solid and liquid fermentation on various easily available substrates. However, it would be better if we could increase the shelf life of *Trichoderma,* not only by fomulating it differently but by multiplying it on various substrates.

Trichoderma have some limitations in the form of their longevity (shelf life) and virulence. Its longevity and virulence against pathogens detoriates with increased storage period. The composition and concentration of substrates are important in improving the efficiency of antagonists (Singh *et al.,* 2007). Keeping this in view the present study was conducted.

MATERIAL AND METHODS

The experiment was conducted in laboratory, in which *Trichoderma* was multiplied on different solid and liquid substrates and formulated differently *i.e.* talc and oil based formulations were stored at 3 different temperatures. Survival of propagule in the form of cfu was taken from each treatment at 60,120 and 180 days.

Treatment details:

Main factor:

1. The talc based *Trichoderma* grown on grain mould infected grains of sorghum.
2. Talc based *Trichoderma* on wheat straw.
3. Talc based *Trichoderma* on maize grains.
4. Talc based *Trichoderma* on PDB.
5. Talc based *Trichoderma* on sugarcane baggage.
6. Talc based *Trichoderma* on yeast molasses extract.
7. DCTRON oil Liquid based *Trichoderma* grown on PDB.
8. Sterilized water Liquid based *Trichoderma* grown on PDB.

Sub factor :

1. Storage at 20ºC. 2. Storage at 30ºC.
3. Storage at 40ºC.

The *Trichodema* multiplied and formulated differently which were stored at 3 different temperatures

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were tested for shelf life. One g ml^{-1} *Trichodema* from individual treatment stored at each temperature condition was taken and the propagule of *Trichoderma* was estimated by following serial dilution technique.

RESULTS AND DISCUSSION

All the treatments *i.e. Trichoderma* grown on different substrates showed the non-significant differences (Table 1) at 60 days of the storage. While *Trichoderma* grown on different substrates stored at three different storage temperatures showed the significant differences in respect to suevival. On an average *Trichoderma* stored at 30^0C temperature showed the maximum number of propagules *i.e.* 79.5 x 10^8 g^{-1}, whereas number of propagules recorded at temperature 20 and 40^0C were same *i.e.*71.45x10^8 g^{-1}. Present studies supported the findings of Sarode *et al.* (1998) who recorded room temperature was safe for storage of *Trichoderma* up to period of 8 months with the perceptible loss in cfu count compared to refrigerated conditions. The interaction of both factors *i.e.* A and B showed the non-significant differences among them.

The percent reduction at 20^0C was maximum in *Trichoderma* grown on potato dextrose broth *i.e.* 28.57 per cent followed by *Trichoderma* multiplied on yeast molasses extract *i.e.* 22.86 per cent and wheat straw 22.6 per cent. The lowest reduction in population of *Trichoderma* was recorded in *Trichoderma* grown on maize grain *i.e.* 9.32 per cent followed by sugarcane baggage (12.4%). The count of *Trichoderma* was reduced to maximum level when it was multiplied on wheat straw *i.e.* 20.38 per cent at 30^0C followed by sterilized water formulated *Trichoderma* (15.59%). The minimum reduction was recorded in *Trichoderma* grown on sugarcane baggage (4.41%) followed by sorghum grain (4.71%). At 40^0C, reduction was maximum when *Trichoderma* was grown on yeast molasses extract (29.21%) followed by sterilized water (23.91%), whereas sorghum grain grown *Trichoderma* exhibited minimum level of reduction *i.e.* 9.42 per cent.

Treatments consisting factor A were non significant at 120 DAS (Table 2). The average number of propagules of *Trichoderma* recorded at 120 DAS was maximum at 30^0C (39.5 x10^8), followed by temperature 20^0C (27.75 x10^8) and 40^0C (29.83 x10^8)

Interaction of factor A and factor B showed the non-significant differences among them. The decline in population of *Trichoderma* after 120 days of storage was maximum in sterilized water based formulation (77.17%) at 20^0C followed by *Trichoderma* multiplied on wheat straw (77.07%), while it was minimum in *Trichoderma* grown on maize grain (61.54%). At 30^0C, sterilized water based *Trichoderma* showed maximum reduction (65.58%), followed by wheat straw (55.93%). The lowest reduction was recorded in sorghum grain (50.2%). Sterilized water based *Trichoderma* exhibited maximum reduction (75.36%) at 40^0C followed by DC-Tron oil based (SOF) (73.38%) and on wheat straw (71.85%). Mako and Alimova (2006) also noticed viability of *Trichoderma harzianum* spores in water up to 120 days with fluctuation in count at different interval.

Significant differences were noticed among the treatments of factor A *i.e. Trichoderma* grown on various substrates at 180 DAS (Table 3). At 20^0C the maximum and same number of propagules were observed in *Trichoderma* multiplied on sorghum grains and in DC-Tron oil (40.00x$10^8$$g^{-1}$), whereas it was minimum in sterilized water based *i.e.* 18.00 x10^8. At 30^0C temperature potato dextrose broth multiplied *Trichoderma* showed the maximum cfu *i.e.* 28.33 x10^8, followed by maize grains *i.e.* 24.00 x$10^8$$g^{-1}$. Minimum cfu was observed in yeast molasses extract, followed by sterilized water formulated *i.e.* 13.00x10^8 g^{-1} and 15.00x10^8 ml^{-1}, respectively.

At 40^0C *Trichoderma* multiplied on potato dextrose broth and formulated in talc showed maximum population *i.e.* 25.33x10^8 g^{-1} and it was minimum in wheat straw (1.33x$10^8$$g^{-1}$), followed by sterilized water (4.66 x $10^8$$ml^{-1}$). In the present studies *Trichoderma* showed viability even up to 180 DAS in all the substrates and formulations, exhibiting maximum in PDB and talc formulation which is in agreement with the findings of Bhat *et al.* (2009) who stated that *Trichoderma* propagules could retained viability for more than 150 days of storage.

Maximum percent reduction was observed in sterilized water based *Trichoderma i.e.* 80.43 per cent at 20^0C and lowest reduction was recorded in sorghum grain *i.e.*52.94 per cent. The percent reduction at 30^0 C was maximum in *Trichoderma* grown on yeast molasses extract (85.39 %) followed by sterilized water formulated *Trichoderma* (83.9 %). Reduction at 40^0C was also maximum in sterilized water (94.93%) whereas lowest reduction was observed on potato dextrose broth (73.52%).

In the present study, *Trichoderma* formulated

Table 1. Colony forming units of *Trichoderma harzianum* grown on various substrates and stored at different temperature at 60 DAS

Treatments	Initial (cfux10^8 g^{-1})	Colony forming unit of *Trichoderma* (X 10^8 g^{-1}) (^{0}C)			Mean (A)	Per cent reduction of *Trichoderma* propagules (^{0}C)		
		20	30	40		20	30	40
T_1	85.00 *	69.66	81.00	77.00	75.88	18.05	4.71	9.42
T_2	90.00	69.66	71.66	71.00	70.77	22.60	20.38	21.12
T_3	82.33	74.66	78.00	72.66	75.11	9.32	5.26	11.75
T_4	95.66	68.33	84.33	75.66	75.44	28.57	11.85	20.91
T_5	83.33	73.00	79.66	73.00	75.22	12.40	4.41	12.40
T_6	89.00	68.66	80.66	63.00	70.77	22.86	9.38	29.21
T_7	87.66	72.33	83.00	71.33	75.55	17.49	5.32	18.62
T_8	92.00	75.33	77.66	70.00	74.33	18.12	15.59	23.91
Mean (B)		71.45	79.5	71.45	-	-	-	-
		A	B	A x B	-	-	-	-
SE (m) ±	0.45	2.31	1.41	4.01	-	-	-	-
CD at 5%	1.90	-	10.16	-	-	-	-	-

Table 2. Colony forming units of *Trichoderma harzianum* grown on various substrates and stored at different temperature at 120 DAS.

Treatments	Initial (cfux10^8 g^{-1})	Colony forming unit of *Trichoderma* (X 10^8 g^{-1}) (^{0}C)			Mean (A)	Per cent reduction of *Trichoderma* propagules (^{0}C)		
		20	30	40		20	30	40
T_1	30.66	42.33	33.33	35.44	63.92	50.2	60.78	
T_2	23.33	39.66	25.33	29.44	77.07	55.93	71.85	
T_3	31.66	36.66	30.00	32.77	61.54	55.47	63.56	
T_4	31.33	45.66	30.33	35.77	67.24	52.26	68.29	
T_5	29.66	38.66	29.00	32.44	64.40	53.60	65.19	
T_6	29.66	39.33	34.66	34.55	66.67	55.80	61.05	
T_7	24.66	42.00	23.33	30.00	71.86	52.08	73.38	
T_8	21.00	31.66	22.66	28.44	77.17	65.58	75.36	
Mean (B)	27.75	39.5	29.83	-	-	-	-	
	A	B	A x B	-	-	-	-	
SE(m)±	1.85	1.13	3.20	-	-	-	-	
CD at 5%	-	8.12	-	-	-	-	-	

(* Initial count in Table 1)

Table 3 : Colony forming units of *Trichoderma harzianum* grown on various substrates and stored at different temperature at 180 DAS

Treatments	Initial (cfux10^8 g^{-1})	Colony forming unit of *Trichoderma* (X 10^8 g^{-1}) (^{0}C)			Mean (A)	Per cent reduction of *Trichoderma* propagules (^{0}C)		
		20	30	40		20	30	40
T_1	40.00	23.66	15.33	26.33	52.94	72.16	81.96	
T_2	32.00	22.66	1.33	24.00	64.44	74.82	80.74	
T_3	36.00	24.00	13.33	24.44	56.27	70.84	83.80	
T_4	38.00	28.33	25.33	30.55	60.27	70.38	73.52	
T_5	24.00	20.33	18.33	20.88	71.19	75.60	78.00	
T_6	28.00	13.00	14.66	18.55	68.53	85.39	83.52	
T_7	40.00	22.00	10.66	24.22	54.36	74.90	87.83	
T_8	18.00	15.00	4.66	12.55	80.43	83.9	94.93	
Mean (B)	32.00	21.12	14.95	-	-	-	-	
	A	B	A x B					
SE (m) $\pm$	1.11	0.68	1.93	-	-	-	-	
CD at 5%	4.77	4.87	6.67	-	-	-	-	

(* Initial count in Table 1)

in sterilized water showed viability up to 180 days.Ingle (2005) also recorded viability of *Nomurea rileyi* in sterilized water up to six month with drastic decline in population gradually. Mako and Alimova (2006) stated that the viable propagules of *Trichoderma harzianum* could retained upto 120 days when the conidia were suspended in water. These results are quite encouraging. If the viability of *Trichoderma* at desired level could be retained in sterilized water it will be much more beneficial either for formulating or applying the *Trichoderma*. However such aspects need more confirmation for practical utility.

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Potential of Different Azadirachtin Based Products in Reducing Infestation of Chickpea by Pulse Beetle

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ABSTRACT

The present experiment was conducted at Seed Technology Research Unit, Mahatma Phule Krishi Vidyapeeth , Rahuri, Maharashtra during 2009-2010, 2010-11 and 2011-12 on chickpea seed, with an objective to avoid environmental hazards of chemical insecticides and to find out efficacy of different azadirachtin (neem) based products against major stored grain pest of chickpea seed. The treatments had significant difference regarding insect infestation and seed germination, and non significant difference in case of moisture content. Amongst, deltamethrin 2.8 E.C @ 0.04 ml kg^{-1} seed and Neem Azal T.S. 10000 ppm @ 1.5 ml kg^{-1} seed were found equally effective in maintaining insect infestation below ETL and had higher seed germination than MSCS up to 9 months of storage.

Chickpea (*Cicer arietinum* L.) is an important pulse crop in India and is the main source of protein for vegetarian population. India is the largest producer of this pulse contributing to around 63 per cent of the world's total production (Anonymous,2007). However, nearly 8.5 per cent of total annual production is lost during postharvest handling and storage (Agrawal *et al*., 1988). The pulse seed suffer a great damage during storage due to infestation of insects (Sharma, 1989). Among the insect pests attacking stored product the pulse beetle, *Callosobruchus chinensis* L (Coleoptera : bruchidae) is serious one causing weight loss, lower seed germination and deterioration in quality (Mukherjee *et al*., 1970; Singal and Singh,1985). Both qualitative as well as quantitative losses occur due to *C. chinensis* infestation. Singh and Sharma (1982) estimated 47.53-79.60 per cent loss of germination due to damage to grains by the beetle. This insect has been reported from the Philippines, Japan, Indonesia, Sri Lanka, Burma and India. It is a notorious pest of chickpea, mung, cowpea, lentil and pigeon pea (Aslam *et al*., 2002).

Control of stored grain insect pests attacking food grains is a difficult job particularly in bag storage where still jute bags are important receptacles for the storage of grains. To combat the problem heavy dose of chemical insecticides are used to control pulse beetle. But now it has developed resistance to a number of these chemical insecticides (Srivastava *et al*.,2000) Certain fumigants are being used against the stored grain pests which are costly and involve the risk of residual toxicity and environmental hazards. Under such circumstances the plant materials are inevitable favourites by virtue of lesser impact on the environment. The use of plant products is considered to be the novel approach, though it is good ageold method. The study on the efficacy of various plant products and vegetable oils against pulse beetle has been carried out by various workers. The sesamum oil 0.05 per cent (Doharey *et al*., 1983), cinnamon oil (Oliveira and Vendramin, 1999), soybean oil (Singh *et al*., 1998) and *Neem* and *Karanj* oil (Kadlag *et al*., 2011) were tried at different concentrations and found effective against pulse beetle on various pulses. The plant products may prove superior to synthetic chemicals as they are ecologically safe, easily degradable and besides easy availability at low cost. But a very little work on the storage of chickpea seed using neem based products has been carried out.

Keeping the above facts in view, investigations were carried out on efficacy of different neem based products for management of chickpea pulse beetle.

MATERIAL AND METHODS

A laboratory experiment was conducted at Seed Technology Research Unit. MPKV, Rahuri for three consecutive years from 2009-2010, 2010-2011 and 2011-2012 in completely randomized block design (CRD) using nine treatments in three replications. The treatments were as given in table 1. Freshly harvested 1 kg certified chickpea seed (Digvijay) with good germination percentage (>85 %) and low moisture content (<10 %) was taken for each treatment. Required quantity of insecticide was diluted in 5 ml of water to treat 1 Kg of

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seed for proper coating. After drying in shade, seeds were packed in 2 kg capacity gunny bag and kept in room temperature under ambient conditions.

Germination was determined as per ISTA rules (Anonymous, 1985). Insect infestation was determined by counting damaged seeds. The data were analysed using CRD design. Samples of treated seed were drawn and observations on per cent germination, per cent infestation and moisture content were recorded at three months interval i.e. 0, 3, 6 and 9 months of storage period.

RESULTS AND DISCUSSION

The germination test of chickpea seed treated with different neem based products and deltamethrin were carried out at 0, 3, 6 and 9 month after storage during 2009-10, 2010-11 and 2011-12 and pooled data on germination percentage are presented in Table 1. At initial month germination ranged between 94.89 to 96.00 per cent, whereas at 3 month after storage it ranged between 89.00 to 93.30 per cent indicating higher germination than the MSCS (85 %). However at 6 month after storage germination per cent in untreated control (83.00%) was below MSCS (85%). The significantly higher seed germination was found in deltamethrin 2.8 EC @ 0.04 ml/kg seed (90.11 %) and was at par with rest of treatments except neem oil (85.67%), Neem India 3000ppm @2.5 ml/kg seed (85.00%) and untreated control (83.00%). At 9 month after storage highest germination than MSCS (85 %) was found in deltamethrin 2.8 E.C @ 0.04 ml/kg seed (87.67%), Neem Azal T.S. 10000 ppm @ 1.5 ml/kg seed (86.67%) and Econim Plus 3000ppm @5.00 m/kg seed (85.67%) and they were also statistically at par with each other.

Thus the results revealed that neem based products viz, Neem Azal T.S. 10000 ppm @ 1.5 ml kg^{-1} seed and Econim Plus 3000 ppm @ 5.00 m kg^{-1} seed did

Table 1: Effect of different azadirachtin based products on germination of chickpea seed (3 years Pooled data)

S. N	Treatments (dose kg^{-1} seed)	Period after treatment (Month)			
		0	3	6	9
1	Neem oil @ 5.0 ml kg^{-1} seed	94.89	90.67	85.67	80.33
		(77.18)*	(72.45)	(67.80)	(63.69)
2	Neem India 3000 ppm @ 2.5 ml kg^{-1} seed	95.67	89.67	85.00	81.33
		(78.00)	(71.37)	(67.25)	(64.43)
3	Neem India 3000ppm @ 5.0ml kg^{-1} seed	96.00	91.33	86.33	82.33
		(78.69)	(72.99)	(68.40)	(65.18)
4	Econeem Plus 3000ppm @ 2.5ml/kg seed	95.67	90.67	86.67	82.33
		(78.08)	(72.32)	(68.66)	(65.17)
5	Econeem Plus 3000ppm @ 5.0ml/kg seed	95.78	91.33	88.67	85.67
		(78.59)	(73.00)	(70.38)	(67.80)
6	Neem Azal T.S. 10000 ppm @0.75ml/kg seed	95.67	90.00	86.33	83.33
		(78.60)	(71.68)	(68.36)	(65.93)
7	Neem Azal TS 10000ppm@ 1.5ml/kg seed	95.67	92.00	89.00	86.67
		(77.96)	(73.64)	(70.78)	(68.63)
8	Deltamethrin 2.8 EC (1 ppm) @ 0.04 ml/kg seed	95.33	93.3	90.11	87.67
		(77.69)	(75.34)	(71.79)	(69.49)
9	Untreated control	96.00	89.00	83.00	78.67
		(78.69)	(70.79)	(65.69)	(62.52)
	S.E. (m) ±	1.16	1.36	1.26	0.96
	C.D. at 5 %	3.38	-	3.58	2.72

Figures in parentheses are arcsine transformed values * Wt. mean

not affect the seed germination. A similar finding in relation to germination was also reported by Gupta *et al* (1989).

The data pertaining to seed infestation are presented in Table 2. The initiation of seed infestation was noticed from 3 month onward. At three month storage the treatment of neem oil @ 5 per cent, Neem India 3000 ppm @ 5ml kg^{-1}, Neem Azal T.S. 10000 ppm @ 0.75 ml and 1.5 ml kg^{-1} and deltamethrin 2.8 EC @ 0.04 ml kg^{-1} seed were found free from seed damage. The maximum seed damage was found in untreated control (7.78 %). At 6 month of storage treatment, deltamethrin 2.8 EC @ 0.04 ml kg^{-1} and Neem Azal T.S. 10000 ppm @1.5 ml kg^{-1} seed kept seed were free from damage and was at par with Econim Plus 3000 ppm @ 5ml kg^{-1} seed (0.33%). At 9 month after storage deltamethrin 2.8 EC @ 0.04 ml kg^{-1} recorded significantly least insect damage (0.11 %) and was at par with Neem Azal T.S. 10000 ppm @1.5 ml kg^{-1} seed (0.44 %), which was below ETL as per MSCS. The maximum (20.00%) seed damage was recorded in untreated control. Similar efficacy of neem products was reported by Jotwani and Sircar (1965 and 1967) and Jotwani and Srivastava (1981). The effectiveness of neem based products observed during present study corroborate with the results reported by Jane *et al*. (2009) who obtained protection of pigeonpea seed treated with neem based product such as Nimbicidine 300 ppm @ 5ml/kg seed up to twelve month of storage. Similarly, Neem Azal TS 1000 ppm @ 1.5 ml/kg seed was found effective against chickpea pulse beetle (Anonymous, 2010). Thus the present findings are more or less in conformity with earlier reports.

The least infestation in treated seed might be due to feeding inhibition, growth disruption and repellant property of azadirachtin (Schmutterer, 1990).

The moisture content in the seed for all the three years was found non significant and remained within the safe limit throughout the storage period. The moisture

Table 2: Effect of different azadirachtin based products on infestation of chickpea pulse beetle (3 years Pooled data)

S.N	Treatments (dose kg^{-1} seed)	Period after treatment (Month)			
		0	3	6	9
1	Neem oil @ 5.0 ml kg^{-1} seed	0	0.00 (0.54)*	2.11 (8.21)	4.22 (11.66)
2	Neem India 3000 ppm @ 2.5 ml kg^{-1} seed	0	1.67 (7.24)	4.78 (12.47)	6.89 (15.12)
3	Neem India 3000 ppm @ 5.0 ml kg^{-1} seed	0	0.00 (0.54)	1.67 (7.27)	5.44 (13.37)
4	Econeem Plus3000ppm @ 2.5 ml kg^{-1} seed	0	1.00 (5.45)	2.33 (8.19)	4.00 (11.35)
5	Econeem Plus3000ppm @ 5.0 ml kg^{-1} seed	0	0.00 (0.54)	0.33 (2.28)	1.45 (6.37)
6	Neem Azal TS 10000ppm@0.75 ml kg^{-1} seed	0	0.00 (0.54)	1.22 (5.27)	2.67 (9.33)
7	Neem Azal TS10000ppm@ 1.5 ml kg^{-1} seed	0	0.00 (0 .54)	0.00 (0.54)	0.44 (2.85)
8	Deltamethrin 2.8 EC (1 ppm) @ 0.04 ml kg^{-1} seed	0	0.00 (0.54)	0.00 (0.54)	0.11 (1.12)
9	Untreated control	0	7.78 (16.29)	13.11 (21.15)	20.00 (26.55)
	S.E. (m) ±	-	0.46	1.37	1.09
	C.D. at 5 %	-	1.35	3.89	3.09

Figures in parentheses are arcsine transformed values * Wt. mean

Table 3: Effect of different azadirachtin based products on moisture content of chickpea seed (Pooled data)

SN.	Treatments (dose kg^{-1} seed)	Period after treatment (Month)			
		0	3	6	9
1	Neem oil @ 5.0 ml kg^{-1} seed	9.41	11.35	9.94	8.53
		(17.85)	(19.68)	(18.37)	(16.98)
2	Neem India 3000 ppm @ 2.5 ml kg^{-1} seed	9.16	11.25	10.12	8.66
		(17.61)	(19.59)	(18.55)	(17.11)
3	Neem India 3000ppm @ 5.0ml kg^{-1} seed	9.11	11.10	10.02	8.51
		(17.56)	(19.46)	(18.45)	(16.95)
4	Econeem Plus3000ppm @ 2.5ml kg^{-1} seed	9.10	11.10	10.05	8.51
		(17.54)	(19.46)	(18.47)	(16.95)
5	Econeem Plus3000ppm @ 5.0ml kg^{-1} seed	9.25	11.16	10.23	8.46
		(17.69)	(19.52)	(18.65)	(16.90)
6	Neem Azal TS 10000ppm@0.75ml kg^{-1} seed	9.43	10.98	10.19	8.61
		(17.87)	(19.35)	(18.61)	(17.05)
7	Neem Azal TS10000ppm@ 1.5ml kg^{-1} seed	9.19	11.12	10.20	8.42
		(17.63)	(19.47)	(18.62)	(16.86)
8	Deltamethrin 2.8 EC (1 ppm) @ 0.04 ml/kg seed	9.33	11.15	9.71	8.34
		(17.77)	(19.51)	(18.15)	(16.79)
9	Untreated control	9.25	11.19	10.12	8.43
		(17.69)	(19.54)	(18.54)	(16.87)
	CD at 5%	-	-	-	-
	S.E. (m) ±	0.17	0.09	0.16	0.11
	C.V. (%)	1.63	0.80	1.48	1.13

Figures in parentheses are arcsine transformed values

content ranged from 8.34 to 8.66 per cent after 9 month of storage (Table 3).

Thus, the present investigation revealed that seed treatment of deltamethrin 2.8 E.C @ 0.04 ml/kg and Neem Azal T.S. 10000 ppm @ 1.5 ml/kg seed were found equally effective for maintaining insect infestation below ETL as per MSCS and maintaining higher seed germination than MSCS up to 9 months of storage.

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Evaluation of Some Plant Products and Oils As Surface Protectants Against Pulse Beetle

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ABSTRACT

The three plant products i.e Neem seed kernel powder,Vekhand powder, Econeem plus and four oils i.e Neem oil,Karanj oil, Castor oil,Ground nut oil @ 2.5 and 5.0 ml kg^{-1} seedsand one chemical treatment, Deltamethrin @ 0.04 ml kg^{-1} seeds tested each up to 180 days of storage against pulse beetle (*Callosobruches chinensis*) infesting stored pigeon pea seeds. The Deltamethrin @ o.o4 ml kg^{-1} seeds recorded excellent surface protectants for pigeon pea seeds in view of relatively,least number of eggs and exit holes and highest germination, vigour index, hundred seed weight. Among the plant products and oils treatments i.e Karanj oil, Neem oil and Econeem plus@ 2.5 and 5.0 ml kg^{-1} seeds are followed by Deltamethrin @ o.o4 ml kg^{-1} seeds .The germination percentage of pigeon pea was not adversely affected due to any of the oils and plant products and also low cost was incurred for 100 kg seeds by the treatments with Deltamethrin @ 0.04 ml kg^{-1}, Karanj oil, Neem oil and Econeem plus@ 5.0 ml kg^{-1} seeds.

Pigeon pea [*Cajanus cajan* (L)] is an important pulse crop in India. In central and north India pigeon pea locally known as "Arher" whereas, in Maharashtra it is commonly knows as *Tur* or *Tur* dal. Pigeon pea is the perennial member of family *fabicaceae,* In India, area under pigeon pea was 3.40 million hectares with production is 2.31 million tonnes (Anonymous, 2009). In Maharashtra, area under Pigeon pea was 1.18 million hectares with production 1.08 million tonnes. In Vidarbha, production was 0.54 million tonnes.

Several insect pests recorded on pigeon pea including stored pests. Among stored grain pests bruchids i.e *Callosobruchus* cause considerable damage in storage. The bruchids grubs attack the leguminous pods in the field from where they carried to stored godowan also. Among the several insect pests of stored grains, bruchids i.e *Callosobruchus* cause considerable damage to the stored pulses and *Callosobruchus chinensis* and *Callosobruchus maculates* (Fab) are most serious one in India. Raina (1970)The pulse beetles not only cause quantitative losses but also cause qualitative losses in nutrition and germination that make most pulses unfit for marketing as well as human consumption. Nearly about 8.5 per cent total production of pulses in India is lost during post harvest and storage. The pulse beetle caused 30.20 to 55.70 per cent loss in seed weight and 17.00 to 53.50 per cent loss of protein content (Gujar and Yadav, 1978). Present investigation on evaluation of plant products and oils as surface protectants against pulse beetle (*Callosobruchus chinensis*) will helps in identifying most economical and feasible plant products and oils. It will also provide information about other plant products and oils for control of stored grain pests. Findings of study will helpful to farmer for effective use of plant products and oils, and on the other hand, it will helpful for researchers for further study.

MATERIAL AND METHODS

The studies on "Evaluation of some plant products and oils as surface protectants against pulse beetles" (*Callosobruchus chinensis*) infesting stored pigeon pea (*Cajanus cajan*) were carried out at Seed Technology Research Unit, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Maharashtra, during June to Nov, 2010 under the laboratory conditions. .

The seeds of pigeon pea variety C-11 were obtained from Central Store, Central Research Station, Dr. PDKV, Akola. The seed was dried in bright sunlight for three days to bring down moisture content to <10 per cent for conducting this study. were procured from the Head, Dept. of Entomology. Dr. PDKV, Akola.

The experiment on use of different seed protectants for control of *C. chinensis* in pigeon pea was conducted under laboratory conditions for a period of 180 days.Seven seed protectants *viz.* Neem seed kernel powder 2.5 and 5 g kg^{-1} seeds, Vekhand powder 2.5 and 5

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g kg^{-1} seeds, Econeemplus, neem oil and karanj oil 2.5 and 5 ml kg^{-1} seeds, groundnut oil and castor oil 2.5 ml kg^{-1} seed and deltamethrin 0.04 ml along with untreated control were evaluated by using Complete Randomized Design with three replicationand forteen treatments.

Seed treatment with seed protectants

Required quantities of pesticide (Deltamethrin) were dissolved in distilled water to prepare stock solutions of 1000 ppm (1mg a.i per ml) of insecticide from these stock solutions, further dilution was made as per the requirement and measured quantities were taken on basis of grain weight to be treated. Application of insecticide was made to individual replicate in plastic vial (10.0x7.0 cm).Computed quantities of insecticides were applied to pigeon pea seeds kept in the vial by delivering insecticidal solution with pipette. The vial was tumbled mechanically for two minutes to insure uniform distributions, followed by drying for 15 minutes under ceiling fan.

The control without treatment with seed protectants was kept. Similarly the Neem oil, Groundnut oil, Karanj oil, Econeem plus, Vekhand powder, Neem seed kernel powder were be applied to 1kg seed sample Observations recorded on oviposition and adult emergence, germination percentage vigour index, hundred seed weight and moisture content and analysed by using Completely Randomized Designed method as per the statistical guidelines given by Gomez and Gomez (1984)

RESULTS AND DISCUSSION

Effect of seed protectants on oviposition of pulse beetles.

The treatment with deltamethrin @ 0.04 ml kg^{-1} seed recorded no oviposition at 180 days after treatment and it was found to be significantly superior to the rest of other treatments (Table 1).The next promising treatments were *Karanj* oil @ 5ml kg^{-1} seeds which recorded least number of eggs on per 100 seeds .It was followed by neem oil and Econeemplus @ 5 ml kg^{-1} seed and it was at par with each other. Different seed protectants recorded lowest number of eggs per 100 seeds than the untreated control. The results obtained by Rehaman and Yadav (1987) and Babu (1991). The plant products and oils i.e. karanj oil, neem oil and Econeem plus were relatively more effective than powders of various plant like, Neem seed kernel powder and vekhand powder. It was also observed that egg laying was decreased with corresponding increase in the dose of plant products used. The results are in conformity with Ali *et. al.,* (1983) who reported the adverse effect of *Neem* oil, *Karanj* oil and Econeem plus on deposition of eggs.

Effect of seed protectants and bruchid infestation on exit holes

Overall results of the experiment revealed that there was no exit hole at 30 days after treatments with deltamethrin, karanj oil, neem oil and Econeem plus but increase of storage period increased number of exit holes (Table 2). This indicated that the effect of surface protectants minimize as storage period longer. It might be due to no longer residual effect. The highest number holes occurred in untreated control. The treatment with seed protectants was occurred lowest number holes than the untreated control. The effectiveness of deltamethrin against pulse beetle was agreement with result obtained by Yadav (1985) and Jain and Yadav (1989). Similar results about the effectiveness of neem oil against the beetles were observed by Sangappa (1977). Results pertaining to pigeon pea crop were accordance with result obtained by Tripathi and Avasthi (2009).

Effect of seed protectants and bruchid infestation on test weight

The data presented in Table. 3 indicated that, the grains treated with deltamethrin recorded higher test weight and they were significantly superior over the remaining treatments. Karanj oil, neem oil and Econeem plus were the next in the order of excellence, which recorded higher hundred seed weight during the storage period. All the seed protectants tested recorded significantly higher test weight than the untreated controls.

The reduction in test weight during storage was mainly due to infestation of bruchid borer and similar observation was also reported by Charanjan and Tarar (1994). It was observed that, the loss of test weight was gradually increased due to the advancement in storage periods and infestation of the pest. Singh *et al.* (2001) observed that pea seed treated with neem oil @ 2 ml / kg seed reduced percent weight loss due to *C. chinensis*.

Effect of seed protectants and bruchid infestation on seed germination

Highest seed germination was recorded in treatment with deltamethrin @ 0.04 ml kg^{-1} seeds and it was at par with karanj oil, neem oil and Econeem plus @ 5 ml kg^{-1} seed (Table 4). The next promising treatment is

Table 1: Oviposition of pulse beetle in different treatments and storage periods

	Treatments	No. of Eggs laid per100 seeds						
			Storage Period (days)					
		Dose	30	60	90	120	150	180
T_1	Neem Seed Kernel Powder	2.5g kg^{-1} seed	12.33	28.67	52.33	83.00	95.67	104.00
	(NSKP)		(3.51)	(5.35)	(7.23)	(9.11)	(9.78)	(10.19)
T_2	Neem Seed Kernel Powder	5 g kg^{-1} seed	11.00	25.33	43.33	65.33	77.67	84.00
	(NSKP)		(3.31)	(5.03)	(6.58)	(8.08)	(8.81)	(9.16)
T_3	Vekhand Powder	2.5g kg^{-1} seed	10.00	23.67	42.00	50.00	86.33	96.67
			(3.16)	(4.86)	(6.48)	(7.07)	(9.29)	(9.83)
T_4	Vekhand Powder	5 g kg^{-1} seed	6.33	16.00	29.67	44.67	69.33	80.00
			(2.51)	(4.00)	(5.44)	(6.68)	(8.32)	(8.94)
T_5	Econeemplus 3000 ppm	2.5ml kg^{-1} seed	6.33	15.33	21.33	29.33	40.67	49.33
			(2.51)	(3.91)	(4.61)	(5.41)	(6.37)	(7.02)
T_6	Econeemplus 3000 ppm	5ml kg^{-1} seed	4.00	13.00	14.67	19.33	30.33	41.00
			(2.00)	(3.60)	(3.83)	(4.39)	(5.50)	(6.40)
T_7	Neem oil	2.5ml kg^{-1} seed	4.67	9.33	17.00	23.33	33.00	46.33
			(2.16)	(3.05)	(4.12)	(4.83)	(5.74)	(6.80)
T_8	Neem oil	5ml kg^{-1} seed	2.67	6.33	11.33	17.33	29.33	41.00
			(1.63)	(2.51)	(3.36)	(4.16)	(5.41)	(6.40)
T_9	Karanj oil	2.5 ml kg^{-1} seed	2.45	7.67	15.33	20.33	30.33	43.33
			(1.56)	(2.76)	(3.91)	(4.50)	(5.50)	(6.58)
T_{10}	Karanj oil	5 ml kg^{-1} seed	1.67	2.67	11.00	15.33	26.00	36.33
			(1.29)	(1.63)	(3.31)	(3.91)	(5.09)	(6.02)
T_{11}	Groundnut oil	2.5 ml kg^{-1} seed	13.00	33.33	48.33	81.00	97.00	106.00
			(3.60)	(5.77)	(6.95)	(8.99)	(9.84)	(10.29)
T_{12}	Castor oil	2.5 ml kg^{-1} seed	9.33	26.33	43.67	66.00	72.00	98.00
			(3.05)	(5.13)	(6.60)	(8.12)	(8.48)	(9.89)
T_{13}	Deltamethrin 2.8 EC	0.04 ml kg^{-1} seed	1.33	2.67	2.33	1.33	1.00	0.00
			(1.15)	(1.63)	(1.52)	(1.15)	(1.00)	(0.70)
T_{14}	Untreated control	—	26.00	65.00	94.33	155.67	195.33	214.67
			(5.09)	(8.06)	(9.71)	(12.47)	(13.97)	(14.65)
	SE (m) ±		0.08	0.06	0.05	0.06	0.09	0.04
	C.D. at 1 %		0.37	0.24	0.30	0.25	0.33	0.19

(Figures in parentheses indicate square root transformation values.)

Table 2: Exit holes (Adult emergence) of pulse beetle in different treatments and storage periods

	Treatments		No. of Exit Holes per100 seeds					
			Storage Period (days)					
		Dose	30	60	90	120	150	180
T_1	Neem Seed Kernel Powder	2.5 g kg^{-1} seed	4.00	10.33	23.00	31.00	36.67	40.00
	(NSKP)		(2.00)	(3.21)	(4.79)	(5.56)	(6.05)	(6.32)
T_2	Neem Seed Kernel Powder	5 g kg^{-1} seed	3.00	8.67	19.00	29.00	34.00	38.33
	(NSKP)		(1.73)	(2.94)	(4.35)	(5.38)	(5.83)	(6.19)
T_3	Vekhand Powder	2.5 g kg^{-1} seed	4.00	7.67	18.33	27.33	33.00	35.00
			(2.00)	(2.76)	(4.28)	(5.22)	(5.74)	(5.91)
T_4	Vekhand Powder	5 g kg^{-1} seed	2.67	6.00	17.00	25.00	30.00	33.00
			(1.63)	(2.44)	(4.12)	(5.00)	(5.47)	(5.74)
T_5	Econeemplus 3000 ppm	2.5 ml kg^{-1} seed	3.00	5.33	9.33	12.67	17.33	20.33
			(1.73)	(2.30)	(3.05)	(3.55)	(4.16)	(4.50)
T_6	Econeemplus 3000 ppm	5ml kg^{-1} seed	0.00	4.33	6.67	9.33	12.67	18.00
			(0.70)	(2.08)	(2.58)	(3.05)	(3.55)	(4.24)
T_7	Neem oil	2.5 ml kg^{-1} seed	2.00	3.00	8.33	12.33	16.33	22.00
			(1.41)	(1.73)	(2.88)	(3.51)	(4.04)	(4.69)
T_8	Neem oil	5 ml kg^{-1} seed	0.00	2.33	6.33	9.00	12.33	17.67
			(0.70)	(1.52)	(2.51)	(3.00)	(3.51)	(4.20)
T_9	Karanj oil	2.5 ml kg^{-1} seed	0.67	2.67	7.33	11.67	15.67	20.00
			(0.81)	(1.63)	(2.70)	(3.41)	(3.95)	(4.47)
T_{10}	Karanj oil	5 ml kg^{-1} seed	0.00	1.00	6.00	8.67	12.00	17.33
			(0.70)	(1.00)	(2.44)	(2.94)	(3.46)	(4.16)
T_{11}	Groundnut oil	2.5 ml kg^{-1} seed	4.33	12.33	19.33	27.33	32.00	34.33
			(2.08)	(3.51)	(4.39)	(5.22)	(5.65)	(5.85)
T_{12}	Castor oil	2.5 ml kg^{-1} seed	4.00	10.00	18.33	24.67	30.33	32.67
			(2.00)	(3.16)	(4.28)	(4.96)	(5.50)	(5.71)
T_{13}	Deltamethrin 2.8 EC	0.04 ml seed	0.00	0.67	1.00	1.33	1.67	2.00
			(0.70)	(0.81)	(1.00)	(1.15)	(1.29)	(1.41)
T_{14}	Untreated control	—	12.33	27.33	43.67	52.33	59.67	64.67
			(3.51)	(5.22)	(6.60)	(7.23)	(7.72)	(8.04)
	SE(m) ±		0.11	0.10	0.09	0.05	0.07	0.06
	C.D.at 1%		0.39	0.39	0.33	0.31	0.27	0.26

(Figures in parentheses indicate square root transformations values)

Table 3: Test seed weight (g) as influenced by seed protectants and bruchid infestation

Treatments	Test Weight (g)						
		Storage Period (days)					
	Dose	30	60	90	120	150	180
T_1Neem Seed Kernel Powder (NSKP)	2.5g kg^{-1} seed	11.26	11.06	10.73	9.83	9.23	8.88
T_2Neem Seed Kernel Powder (NSKP)	5 g kg^{-1} seed	11.30	11.06	10.76	9.86	9.26	8.91
T_3Vekhand Powder	2.5 g kg^{-1} seed	11.23	11.03	10.76	9.86	9.26	8.91
T_4Vekhand Powder	5 g kg^{-1} seed	11.26	11.10	10.76	9.90	9.30	8.95
T_5Econeemplus 3000 ppm	2.5 ml kg^{-1} seed	11.20	11.06	10.80	9.96	9.50	9.41
T_6Econeemplus 3000 ppm	5ml kg^{-1} seed	11.20	11.13	10.86	10.10	9.96	9.73
T_7Neem oil	2.5 ml kg^{-1} seed	11.20	11.13	10.83	9.93	9.60	9.41
T_8Neem oil	5 ml kg^{-1} seed	11.20	11.16	10.90	10.43	10.06	9.76
T_9Karanj oil	2.5 ml kg^{-1} seed	11.30	11.10	10.86	10.03	9.66	9.53
T_{10}Karanj oil	5 ml kg^{-1} seed	11.20	11.16	10.96	10.46	10.10	9.88
T_{11}Groundnut oil	2.5 ml kg^{-1} seed	11.23	11.06	10.86	9.86	9.13	8.60
T_{12}Castor oil	2.5 ml kg^{-1} seed	11.23	11.06	10.83	9.93	9.33	8.98
T_{13}Deltamethrin 2.8 EC	0.04 ml kg^{-1} seed	11.23	11.20	11.06	10.73	10.40	10.26
T_{14}Untreated control	—	11.26	10.86	10.26	9.36	8.76	8.41
SE (m) ±		0.05	0.07	0.03	0.08	0.04	0.09
C.D at 1%		-	-	0.18	0.33	0.38	0.38

karanj oil @ 2.5 ml kg^{-1} seeds and it was at par with neem oil and Econeem plus @ 2.5 ml kg^{-1} seed.

When overall result of seed germination was studied, deltamethrin recorded highest seed germination and it was at par with karanj oil, neem oil and Econeem plus 5ml/kg seed while, untreated control recorded lowest seed germination. All the seed protectants tested recorded significantly higher percentage of seed germination in considerate manner than this untreated control. The germination was adversely affected by infestation of C. *chinensis* and gradually decreased with advancement in storage period and infestation of pest. These results are in accordance with those of El. Hassan and Mudhithir (1982) and Patro *et al*. (2001). In the present study, different seed treatments had not affected the germination of seed up to 180 days of storage period and these result agreement with those of Singh *et al*. (1978), Jain and Yadav (1989) and Lolage and Patil (1991), Jane, *et.al.,* (2009).

Effect of seed protectants and bruchid infestation on Vigour index

Seed treatment with deltamethrin @ 0.04 ml/kg seeds recorded maximum vigour index at 180 days after treatment and it was at par with *Karanj* oil, neem oil and Econeem plus @ 5ml kg^{-1} but its vigour index was lower than deltamethrin.The next promising highest vigour index recorded in karanj oil, neem oil and Econeem plus @ 2.5 ml kg^{-1} seed. Untreated control recorded lowest vigour index than that of all seed protectants (Table 5).

The vigour index decreased with gradual increase in infestation and storage period which resulted into decreased germination percentage. However seed protectants did not show any adverse effect on seed vigour and viability. Similar results were also reported by Das (1987) and Charanjan and Tarar (1994).

Effect of seed Protectants and bruchid infestation on

Table 4: Seed germination as influenced by seed protectants and bruchid infestation

	Treatments		Germination (%)					
			Storage Period (days)					
		Dose	30	60	90	120	150	180
T_1	Neem Seed Kernel Powder	2.5 g kg^{-1} seed	92.67	88.33	85.00	83.33	76.67	73.00
	(NSKP)		(74.29)	(70.03)	(67.21)	(65.91)	(61.12)	(58.69)
T_2	Neem Seed Kernel Powder	5 g kg^{-1} seed	92.33	89.33	86.33	84.00	78.00	74.00
	(NSKP)		(73.93)	(70.94)	(68.31)	(66.42)	(62.02)	(59.34)
T_3	Vekhand Powder	2.5 g kg^{-1} seed	92.67	88.67	86.33	84.67	78.33	74.33
			(74.29)	(70.33)	(68.32)	(66.95)	(62.26)	(59.56)
T_4	Vekhand Powder	5 g kg^{-1} seed	92.00	89.33	87.67	85.33	79.00	74.67
			(73.59)	(70.96)	(69.44)	(67.50)	(62.72)	(59.78)
T_5	Econeemplus3000 ppm	2.5 ml kg^{-1} seed	93.00	89.00	87.00	86.00	80.00	76.67
			(75.68)	(70.66)	(68.89)	(68.03)	(63.45)	(61.12)
T_6	Econeemplus3000 ppm	5ml kg^{-1} seed	93.33	91.00	90.00	88.33	84.67	81.33
			(75.04)	(72.54)	(71.51)	(70.03)	(66.95)	(64.40)
T_7	Neem oil	2.5 ml kg^{-1} seed	93.67	90.00	88.33	87.67	81.00	77.67
			(75.46)	(71.56)	(70.03)	(69.44)	(64.17)	(61.79)
T_8	Neem oil	5 ml kg^{-1} seed	92.33	91.33	90.33	89.00	85.00	81.67
			(73.93)	(72.88)	(72.21)	(70.64)	(67.22)	(64.65)
T_9	Karanj oil	2.5 ml kg^{-1} seed	93.67	90.33	89.67	88.00	82.67	78.67
			(75.46)	(72.21)	(71.29)	(69.74)	(65.40)	(62.50)
T_{10}	Karanj oil	5 ml kg^{-1} seed	92.60	92.00	91.00	89.67	86.00	82.33
			(74.29)	(73.57)	(72.54)	(71.25)	(68.03)	(65.14)
T_{11}	Groundnut oil	2.5 ml kg^{-1} seed	92.67	85.33	82.67	81.00	75.00	72.00
			(74.29)	(67.48)	(65.39)	(64.16)	(60.00)	(58.05)
T_{12}	Castor oil	2.5 ml kg^{-1} seed	93.00	86.00	84.33	82.00	76.00	73.33
			(74.68)	(68.03)	(66.68)	(64.89)	(60.67)	(58.91)
T_{13}	Deltamethrin 2.8 EC	0.04 ml kg^{-1} seed	93.67	92.66	91.67	90.00	87.00	82.67
			(75.49)	(74.32)	(73.22)	(71.57)	(68.90)	(65.39)
T_{14}	Untreated control	—	92.33	75.67	61.67	53.00	45.33	41.00
			(73.93)	(60.45)	(51.74)	(46.72)	(42.32)	(39.81)
	SE(m) ±		0.57	0.49	0.41	0.49	0.55	0.36
	C.D. at 1 %		-	1.97	1.63	1.93	2.17	1.43

(Figure in parentheses is arcsine value)

Table 5: Vigour index as influenced by seed protectants and bruchid infestation

S. N.	Treatments		Mean vigour index at days of storage					
		Dose	30	60	90	120	150	180
T_1	Neem Seed Kernel Powder (NSKP)	2.5 gm/kg seed	2903.66	2561.66	2465.00	2389.33	2171.66	2068.33
T_2	Neem Seed Kernel Powder (NSKP)	5 gm/kg seed	2893.00	2650.00	2561.00	2463.66	2262.00	2171.00
T_3	Vekhand Powder	2.5 gm/kg seed	2873.00	2630.66	2561.66	2482.66	2271.33	2180.00
T_4	Vekhand Powder	5 gm/kg seed	2852.00	2650.66	2571.33	2502.66	2291.00	2190.00
T_5	Econeemplus3000 ppm	2.5 ml/kg seed	2913.33	2640.66	2581.66	2523.33	2319.33	2222.66
T_6	Econeemplus3000 ppm	5ml/kg seed	2924.33	2680.00	2639.33	2561.66	2455.66	2385.66
T_7	Neem oil	2.5 ml/kg seed	2934.00	2640.00	2591.00	2542.33	2321.66	2278.00
T_8	Neem oil	5 ml/kg seed	2893.33	2679.00	2650.00	2580.66	2464.66	2412.33
T_9	Karanj oil	2.5 ml/kg seed	2965.66	2669.33	2630.33	2522.66	2342.00	2281.66
T_{10}	Karanj oil	5 ml/kg seed	2903.33	2729.33	2699.66	2630.33	2494.00	2443.00
T_{11}	Groundnut oil	2.5 ml/kg seed	2903.66	2531.66	2452.66	2375.66	2174.66	2088.00
T_{12}	Castor oil	2.5 ml/kg seed	2913.66	2551.66	2501.66	2405.33	2204.00	2151.00
T_{13}	Deltamethrin 2.8 EC	0.04 ml/kg seed	2904.33	2780.00	2750.00	2699.66	2580.33	2480.00
T_{14}	Untreated control	—	2924.00	2244.00	1829.33	1554.00	1360.00	1244.00
	SE(m) ±		53.88	30.60	29.41	39.22	31.89	46.79
	C.D. at 1 %		-	117.47	114.92	153.27	124.62	182.84
	F test		N.S	Sig	Sig	Sig	Sig	Sig

moisture content of seeds

At initial stage, 0 days after seed treatment there was no significant difference in moisture content in seeds, and at 180 days after treatments, the treatment with deltamethrin @ 0.04 ml /kg seeds recorded lowest moisture content .The next promising treatments were treatment with karanj oil, neem oil and Econeemplus @ 5 ml kg^{-1} seed recorded lowest moisture content. The untreated control recorded highest seed moisture content. The relative humidity and temperature of the environment are the key factor that affect which absorb the moisture in the seed is protein. The treated seed has less moisture content than untreated seed at 180 days of storage period. Similar results were reported by Lolage and Patil (1991).

CONCLUSION

Taking in to consideration all the parameters of these studies, karanj oil, neem oil, Econeem plus @ 5 ml kg^{-1} seed and deltamethrin @ 0.04 ml kg^{-1} seeds were effective treatments against bruchid, *Callosobruchus chinensis* infesting pigeon pea in storage. Deltamethrin (0.04 ml kg^{-1} seeds) found most effective.The treatment with karanj oil, neem oil and Econeem plus registered minimum oviposition, exit holes, and average less loss in test weight but deltamethrin registered no oviposition, least number of exit holes and lowest average loss in test weight at 180 days after storage period.Besides, investigations are required to be conducted to decide whether the seed treatment with deltamethrin@ 0.04 ml/ kg seeds, karanj oil, neem oil and Econeem plus @ 5ml/ kg seeds will be effective to protect the seeds after harvest till the next sowing season.

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Information Technology Based Mapping of Macro and Micro-nutrients in Soils

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ABSTRACT

Mapping of macro and DTPA-extractable micronutrients were carried out by randomly collected georeferenced surface soil samples representing different soils types in Washim district using global positioning system (GPS). The soil pH ranged from 7.05 to 8.90. The electrical conductivity of soil varied from 0.10 to 0.37 dS m^{-1}. The free $CaCO_3$ content found to vary from 2.50 to 11.25 per cent. It was found higher in Malegaon and Risod tehsil. Organic carbon content in the soil ranged from 2.00 to 9.80 g kg^{-1} which was higher in Malegaon tehsil (3.60 - 9.80 g kg^{-1}). The available N was almost deficient in all the tehsils, whereas 38.2 per cent samples were deficient in available P. Available K was found more than sufficient in all the tehsil. The available zinc ranged from 0.11 - 4.63 mg kg^{-1} wherein 43.5 per cent samples were deficient .The available iron ranged from 3.57 to 20.82 mg kg^{-1}, out of which 31.6 per cent samples were deficient. The available Mn and Cu were found sufficient in most of the soils. The nutrient indices were found low in available N (1.03) and Zn (1.66), whereas medium in available P (1.71) and Fe (1.70), which indicates these sites may become deficient in near future and high in K (2.81), Cu (2.99) and Mn (2.56). It could be inferred that, fertility of soils in Washim district of Maharashtra was low in zinc, medium in iron while high in copper and manganese.

The soil micronutrient constraints to productivity and other related aspects are being studied since the post green revolution era. The wide spread deficiencies of micronutrients in soils of agriculturally progressive states are being observed. In the present era of precision farming, the inputs such as fertilizer, crop varieties and management practices are matched precisely with the variability of soil and climatic conditions so that inputs are applied as per the location specific requirements of the crop. The advances in information technology have provided tools like Global Positioning System (GPS) and Geographical Information system (GIS) which help in collecting a systematic set of georeferenced samples and generating the spatial data about the distribution of nutrients. Soil fertility is one of the important factors controlling yield of the crops. Soil characterization in relation to fertility status of the soils of an area or region is an important aspect in context of sustainable agricultural production. The soil factors viz. texture, pH, organic matter content, $CaCO_3$ type of clay minerals and interactions among the nutrients markedly regulate the availability of nutrients in soils (Malewar, 2005).Because of imbalanced and inadequate fertilizer use coupled with low efficiency of other inputs, the response (production) efficiency of chemical fertilizer nutrients has declined tremendously under intensive agriculture in recent years.

Micronutrients are important for maintaining soil health and increasing use efficiency of major nutrients and ultimately the productivity of crops. These are required in very small quantity. The soil must supply micronutrients for desired growth of plants and synthesis of human food. The deficiencies of micronutrients have become major constraints in productivity, stability and sustainability of soils. Most of the micronutrients are associated with the enzymatic system of plants. Whenever a micronutrient is deficient the abnormal growth of plant results which sometime cause complete failure of crop plants. Grains and flower formation do not take place in severe deficiency. The main sources of these micronutrients are parent material, organic and inorganic material. The availability of micronutrients is particularly sensitive to changes in soil environment. The factors that affect the contents and availability of micronutrients are organic matter, soil pH, lime content and texture.

The intensive cultivation of soils and use of improved crop varieties which take up nutrients from the soil are major causes of deficiency of these micronutrients; continuous application of one or two macronutrients may in due course deplete the soil reserve of other nutrients and limit the crop performance. For sustainability purpose there is need to know the micronutrients status of the soil. Keeping this in view, the present study was taken up with the objectives to assess the status of micronutrients in soils and to identify and delineate areas of micronutrient deficiencies in Washim district.

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MATERIAL AND METHODS

Washim district lies between 19°61' N and 21°16' N latitude and 76°7' E and 77°4' E longitudes. The total area covered by the district is 5150 km^2 (5,15,000 ha). The geology of Washim district mainly consists of deccan trap from lava floor and the alluvium along the major river course. River is the main river of the Washim district which flows through the Tehsil Risod and later through Washim and Hingoli districts. The rivers like Kas, Arunavati, Katepurna flows through Washim district. There are hilly ranges extending through the tehsils of Malegaon, Washim, Mangrulpir and Manora. There is plain region in the basin of river in the Risod tehsil.

The average annual rainfall of Washim district is 919 mm. In general the rainfall increases from Western to Eastern part of district.

Most of the soils in Washim district are Vertisols with clay texture formed from basalt rock. The northern half of the district, the central part of Washim tehsil and north-western part of Mangrulpir tehsil have good black soils. Area distribution of different soils in Washim district are deep black cotton soil (46.54%), medium deep black cotton soil (9.91%) and shallow black cotton soil (48.55%) of the total area of Washim district .

The 414 geo-referenced soil samples (0-20 cm) in 69 villages from six tehsils of Washim district were collected using Geographical Position System (GPS). Soil pH and EC were determined in soil: water suspensions (1:2.5 w/v) as described by Jackson (1973). Organic carbon was determined by the dichromate wet oxidation method of Walkley and Black (Nelson and Sommers, 1982). Free $CaCO_3$ was determined by rapid titration method (Piper, 1966).

The available N was estimated by alkaline permanganate method (Subbiah and Asija, 1956) and available P by Olsen's method (Olsen *et al.* 1954) and available K by ammonium acetate extraction method (Jackson, 1967). The available S was estimated by turbidimetric method (Chesnin and Yien, 1950).

The available zinc, iron, copper and manganese were extracted with 0.005M diethylene triamine penta acetic acid (DTPA) and the concentrations of nutrients were determined on Atomic Absorption Spectrophotometer (Lindsay and Norvell, 1978).

The nutrient indices were calculated by using the formula given by Parker *et al.* (1951). Simple linear correlation analysis was carried out to determine the relationship between micronutrients and other soil properties.

RESULTS AND DISCUSSION

Soil properties

The pH of soils in Washim district ranged from 7.05 – 8.90, indicating the neutral to alkaline nature of soil. The alkaline reaction of soil probably due to presence of sufficient free lime content in soil (Kaushal *et al* 1980). The EC varied from 0.101 - 0.390 dS m^{-1} that all the soils are non-saline in nature and suitable for healthy plant growth. The EC more than 1.0 dS m^{-1} indicated the hazard of soluble salts prescribed by Jackson (1967). The $CaCO_3$ content in soils of district varied from 2.50 – 11.25 per cent, which indicates that soils are calcareous in nature. High calcium carbonate is harmful, it reduces the concentration of micronutrient cations in soils to such a level that a sensitive plant suffer form deficiency of micronutrients (Deb *et al* 2009). The soils were medium to high in calcium carbonate content which may influence the micronutrient availability. The highest calcium carbonate content was noticed in Malegaon, Mangrulpir and Washim tehsil. The organic carbon content in soils ranged from 2.00 – 9.80 g kg^{-1} (Table 1). The reduced application of organic manure in the farmers' field, coupled with intensive cultivation of high yielding varieties of various crops could be among the main reason for decreasing organic carbon content in soils.

Major nutrients status

The available nitrogen ranged from 115.9 to 315.5 kg ha^{-1} and 96.6 per cent samples were found deficient. The soils were low in available N content in soils could be attributed to the differences in their physiographic as well as the differential cultivation and management of these soils. The deficiency of available nitrogen might be due to very less addition of organic manures and heavy uptake under intensive cultivation of improved high yielding varieties of different crops. The available P varied from 1.10 to 65.88 kg ha^{-1} and 38.2 per cent samples were found deficient. The deficiency of available P might be because of its fixation in the form of calcium phosphate due to alkaline nature of soil. The available K ranged from 134.4 to 952 kg ha^{-1} and 0.5 per cent samples were found deficient while 17.4 per cent samples were found medium (Table 2).

Table 1. Chemical properties of soil in Washim district

S.N.	Nameof tehsil	pH (1:2.5)		EC (dS m^{-1})		$CaCO_3$ (%)q		Organic carbon (g kg^{-1})	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean
1.	Malegaon	7.05-7.80	7.45	0.102-0.210	0.16	2.62-11.25	8.69	3.60-9.80	7.45
2.	Mangrulpir	7.69-8.61	8.26	0.101-0.340	0.18	3.12-11.25	7.59	3.30-9.70	7.39
3.	Karanja	7.10-8.75	7.71	0.104-0.341	0.21	2.75-10.62	6.76	3.07-9.73	7.2
4.	Manora	7.50-8.90	8.39	0.102-0.302	0.15	3.12-10.87	6.94	3.10-9.61	7.22
5.	Washim	7.38-8.50	8.06	0.113-0.372	0.24	2.50-11.25	7.71	2.00-9.73	6.42
6.	Risod	7.25-8.58	8.18	0.104-0.362	0.17	1.62-10.87	7.37	2.80-9.80	6.59
	Washim district	**7.05-8.90**	**8.01**	**0.101-0.372**	**0.185**	**2.50-11.25**	**7.51**	**2.00-9.80**	**7.05**

Table 2. Major nutrients status of Washim district

S. N.	Name of tehsil	N		P		K	
		Range	PSD	Range	PSD	Range	PSD
1.	Malegaon	120.4 – 305.5	95.8	2.47 – 45.34	26.4	168.0 – 922.0	00
2.	Mangrulpir	115.4 – 252.9	100.0	1.10 – 61.18	27.3	168.0 – 952.0	00
3.	Karanja	131.4 – 242.3	100.0	1.20 – 65.88	48.8	134.4 – 907.2	1.3
4.	Manora	115.9 – 231.8	100.0	2.13 – 41.21	48.9	134.4 – 929.6	1.5
5.	Washim	131.4 – 305.5	88.9	2.45 – 39.24	44.4	156.8 – 873.6	00
6.	Risod	126.4 – 315.5	95.0	3.75 – 56.79	35.0	156.8 -750.4	00
	Washim district	**115.9 – 315.5**	**96.6**	**1.10 – 65.88**	**38.2**	**134.4 – 952.0**	**0.5**

PSD – Percent sample deficient

Table 3. DTPA- extractable available micronutrients status (mg kg^{-1}) in soil

S. N.	Name oftehsil	Zn		Fe		Cu		Mn	
		Range	PSD	Range	PSD	Range	PSD	Range	PSD
1.	Malegaon	0.11 - 1.59	48.60	4.26 - 20.42	18.05	1.15 - 6.98	0.00	4.08 - 22.50	0.00
2.	Mangrulpir	0.24 - 1.91	48.50	3.57 - 17.86	33.30	1.09 - 5.41	0.00	4.38 - 21.58	0.00
3.	Karanja	0.38 - 3.89	42.30	3.97 - 13.89	51.30	1.30 - 5.44	0.00	4.35 - 19.65	0.00
4.	Manora	0.30 - 3.39	45.50	3.98 - 20.02	27.30	0.85 - 4.98	0.00	3.97 - 19.93	0.00
5.	Washim	0.30 - 3.80	41.70	4.11 - 20.82	18.00	0.94 - 6.76	0.00	3.78 - 23.15	0.00
6.	Risod	0.12 - 4.63	33.30	3.98 - 16.59	41.70	0.62 - 6.22	0.00	3.78 - 19.28	0.00
	Washim district	**0.11 - 4.63**	**43.48**	**3.57 - 20.82**	**31.64**	**0.62 - 6.98**	0.00	**3.78 - 23.15**	0.00

PSD – Percent sample deficient

Micronutrients status

The DTPA Zn in soils of Washim district ranged from 0.11 to 4.63 mg kg^{-1} (Table 2). Out of 414 samples, 43.5 per cent soil samples were found deficient in available Zn, whereas 46.6 per cent samples of available Zn were in medium (Table 3). The highest deficiency of zinc was observed in Malegaon tehsil followed by Mangrulpir and Manora tehsils. The availability of micronutrients cations (Zn, Fe, Cu and Mn) is generally low in alkaline soils and crops grown on these soils suffer from their hunger (Malewar, 2005). In these tehsils the major crops grown

are cotton, soybean, pigeonpea, green gram, wheat etc. These crops might have mined the zinc alongwith N, P and K. This indicates the widespread deficiency of zinc in Washim district. This may be due to high nutrient requirement of recently introduced high yielding varieties. Imbalanced use of N, P and K fertilizers , reduction in organic carbon contents of soil and decline in the level of micronutrient in soil to below normal level. The less availability of organic manures leading to non-application of manures to soil poses the problems of micronutrient deficiency. Moreover, the farmers are not testing the soils for micronutrients which are not being added along with macronutrients by them; hence this might be coming deficiency of micronutrients in the soils of Washim district. Patil and Kharche (2006) reported widespread deficiency of zinc in intensively cultivated districts of Western Maharashtra having predominant alkaline, calcareous, black clayey soils. It has also been reported that the soils of Maharashtra did not show response to application of zinc during seventies (Kharche *et al.*, 2003). However, afterwards due to intensification of agriculture the soils became deficient in zinc. The deficiency of nutrients creates imbalance in soils which results into nutritional stress in plants (Malewar, 2005). Sakal (2001) added that zinc deficiency was a most serious constraint to sustainable productivity in several states.

Table 4. Status of micronutrients and nutrient indices in Washim district.

Nutrients	Percent samples			Nutrient
	Low	Medium	High	index
N	96.6	3.4	0	1.03
P	38.2	52.4	9.4	1.71
K	0.5	17.4	82.1	2.81
Zn	43.5	46.6	9.9	1.66
Fe	31.6	66.7	1.7	1.70
Cu	00	0.5	99.5	2.99
Mn	00	36.0	64.0	2.64

Table 5. Relationship of available micronutrients with soil properties

S. N.	Parameter	Zn	Fe	Mn	Cu
1	pH	-0.15**	-0.16**	-0.11*	-0.11*
2	$CaCO_3$	-0.14**	-0.25**	0.02	-0.02
3	Org. Carbon	0.18**	0.04	0.21**	0.21**

* Significant at 1% level, ** Significant at 5% level

There was a great variation in the iron content (3.57 – 20.82 mg kg^{-1}) in Washim district. The per cent deficiency of iron was 31.6 per cent, while 66.67 per cent samples in medium category (Table 3). Increased removal of micronutrients as a consequence of adoption of high yielding varieties and intensive cropping together with a shift towards high analysis of NPK fertilizers have caused decline in the level of micronutrients in the soil below the critical level which are required for normal productivity of crops (Zende, 1987). Singh (2003) also enclosed the heavy depletion of micronutrients with time, particularly under intensive cropping of rice-wheat, maize-wheat and rice-rice. Patil *et al.*, (2004) reported 40 and 34.7 per cent soils deficient in zinc and iron in Vidarbha.

The DTPA extractable Cu in the soils of Washim district ranged from 0.62 – 6.98 mg kg^{-1} (Table 2). Patil and Sonar (1994) reported that in swell-shrink soils of Maharashtra, available Cu was in range of 0.58 to 1.7 ppm.

The DTPA-Mn status of soils ranged from 3.78 – 23.15 mg kg^{-1} (Table 3). Gajbhe *et. al*. (1976) reported that available Mn content in surface soils of Marathwada ranged from 13.3 to 65.20 ppm. The deficiencies of Mn and Cu in the soils of Washim district were not observed.

Nutrient Indices

In Washim district, the nutrient indices were found low in available N (1.03) and Zn (1.66), whereas medium in available P (1.71) and Fe (1.70) and high in K (2.81), Mn (2.56) and Cu (2.99), which indicates these sites may become deficient in near future.

Relationship of micronutrients with soil properties

The DTPA extractable zinc showed negative and significant correlation with soil pH (r = -0.15**) and calcium carbonate (r =0.14**). Sarkar *et al.* (2000) reported that low content of zinc might be due to high soil pH in Madhubani district showing negative relationship. Whereas, positive and significant correlation with organic carbon (r = 0.18**) was observed. Available zinc was positively and significantly correlated with organic carbon in some soil series of Punjab, (Chakraborty *et. al.*,1981). The results are in conformity with the findings reported by Mathur *et al.* (2006).

The positive and significant correlation of iron with organic carbon (r = 0.04) were noticed, indicating availability of iron increased with an increase of organic

carbon in soil and negatively and significantly correlated with pH (r = - 0.16**) and $CaCO_3$ (r = - 0. 25**). Significant negative relationship of available iron with pH and $CaCO_3$ content of soil were also reported by Maji *et al.* (1993). This indicates that higher the calcium carbonate in soil, lower the availability of iron and zinc in the soil. The findings are in line with the results reported by Shinde *et al.* (1980).

Available copper and manganese having negative and non- significant relation with pH of the soil. Patiram *et. al.*, (2000) reported negative relation of pH with available Mn.

Micronutrients are gradually becoming deficient in these soils and their shortage may be detrimental in sustaining crop productivity and maintenance of quality of agriculture produce which warrants their inclusion in fertilizer schedule based on site specific conditions and adoption of good management practices, like green manuring, addition of compost, FYM, Vermicompost and use of crop residues.

The study in Washim district reveals that 96.6 per cent samples were found deficient in available N, while 38.2 per cent in available P, whereas available K was found adequate. The content of available zinc, iron, copper and manganese ranged from 0.11 to 4.63, 3.57 to 20.82, 0.62 to 6.96 and 3.78 to 23.15 mg kg^{-1}, respectively. The soils were found wide spread deficient in zinc (43.48 %) and iron (31.64 %). Area growing under crops like soybean, wheat, cotton shows deficiency of zinc and iron.

The GIS based maps generated under the study will be helpful for guiding the amount and kind of nutrients to be applied to different crops for soil health management. The results of present study on micronutrient status of Washim district may be helpful to planners, extension workers, farmers, researchers for appropriate crop planning, their management and sustainable crop production by using organic manures and inorganic fertilizers in the area of deficiency of micronutrients.

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Response of *Bt* Cotton to Spacing and Nutrient Management Under Protective Irrigation on Entisols of Central Vidarbha

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ABSTRACT

A field experiment entitled "Response of *Bt* cotton to spacing and nutrient management under protective irrigation on entisols of central Vidarbha" was conducted on experimental farm of Zonal Agricultural Research Station, Central Vidarbha Zone (Dr. PDKV), Yavatmal for successive four years (2009-10 to 2012-13). The experiment was laid out in split plot design with three replications. The treatments comprised of five plant densities *viz.*, 120 cm x 90 cm (9259 plants ha^{-1}), 90 cm x 60 cm (18518 plants ha^{-1}), 150 cm x 30 cm (22222 plants ha^{-1}), 90 cm x 45 cm (24691 plants ha^{-1}) and 120 cm x 30 cm (27778 plants ha^{-1}) in main plot and three fertilizer doses *viz.*, 100:50:50 N:P:K kg ha^{-1}, 150:75:75 N:P:K kg ha^{-1} and 200:100:100 N:P:K kg ha^{-1} in sub plot. Results revealed that spacing of 120 cm X 30cm recorded significantly highest seed cotton yield, gross monetary, net monetary returns and B:C ratio over rest of the spacing. Similarly, application of 150:75:75 NPK Kg ha^{-1} recorded highest seed cotton yield, gross monetary, net monetary returns and B:C ratio.

The primary reason for the low productivity of cotton in India is mainly because of 70 per cent of cotton cultivation is under rainfed condition and inadequate supply of nutrients and their poor efficiency. Nutrients are most important limiting factor of crop production after water. Most often soils in the rainfed regions are not only thirsty but also hungry. It is now well established that for achieving high yields, the nutrient demand of crop should be timely met.

Sharma and Tomar (1994) observed that boll weight was increased significantly with increasing level of N up to 120 kg ha^{-1}. Rao and Setty (2008) reported that fertilizer dose of 150:75:100 kg NPK ha^{-1} was found to be better for obtaining higher seed cotton yield under black soils of Karnataka.

The information regarding plant population and nutritional requirement of *Bt* cotton on Entisols of Central Vidarbha Zone (CVZ) of Maharashtra is yet not available. Considering this a field experiment entitled "Response of *Bt* cotton to spacing and nutrient management under protective irrigation on entisols of central Vidarbha" was conducted on experimental farm of Zonal Agricultural Research Station, Central Vidarbha Zone (Dr. PDKV), Yavatmal during *Kharif* season of 2009 to 2012.

MATERIAL AND METHODS

A field experiment entitled "Response of *Bt* cotton to spacing and nutrient management under protective irrigation on entisols of central Vidarbha" was conducted on experimental farm of Zonal Agricultural Research Station, Central Vidarbha Zone (Dr. PDKV), Yavatmal ($20^0$23' N, $78^0$8' E and 1496 m MSL) for successive four years (2009-10 to 2012-13). The experiment was laid out in split plot design with three replications. The plot size was 9.0m x 4.5m. The soil of experimental plot was entisol and alkaline in reaction (pH 8.20) low in available nitrogen, medium in available phosphorus and high in potassium content. The treatments comprised of five plant densities *viz.*, 120 cm x 90 cm (9259 plants ha^{-1}), 90 cm x 60 cm (18518 plants ha^{-1}), 150 cm x 30 cm (22222 plants ha^{-1}), 90 cm x 45 cm (24691 plants ha^{-1}) and 120 cm x 30 cm (27778 plants ha^{-1}) in main plot and three fertilizer doses *viz.*, 100:50:50 N:P:K kg ha^{-1}, 150:75:75 N:P:K kg ha^{-1} and 200:100:100 N:P:K kg ha^{-1} in sub plot. *Bt* cotton hybrid NCS- 207 was sown in the first week of July during all the years of experimentation. Timely plant protection measures were followed to save the crop from pests and diseases. Two protective irrigations as and when required were allotted to the cotton crop during 2009, 2011 and 2012, however, one protective irrigation was allotted during 2010. The cotton crop was harvested in four pickings during all the years of experimentation.

RESULTS AND DISCUSSION

Effect of plant densities

From the four years pooled analysis it is revealed

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(Table 1 & 2) that the significantly highest plant height was recorded with the sowing of cotton at a spacing of 150 cm x 30 cm (22222 plants ha^{-1}). The number of sympodial branches were recorded significantly higher with the sowing of cotton at a spacing of 90 cm x 45 cm (24691 plants ha^{-1}) and it was at par at a spacing of 150 cm x 30 cm (22222 plants ha^{-1}) and 120 cm x 30 cm (27778 plants ha^{-1}). The bolls $plant^{-1}$, seed index, seed cotton yield (kg ha^{-1}) were significantly higher with the sowing of cotton at 120 cm x 30 cm (27778 plant ha^{-1}). It is evident from the results that narrow spacing increased significantly the sympodial branches $plant^{-1}$, bolls $plant^{-1}$, which ultimately added to the seed cotton yield. The number of plants was more in narrow row spacing producing more number of fruits $unit^{-1}$ area which contributed in the form of increased seed cotton yield. The gross and net monetary returns (Rs. ha^{-1}) were higher with the sowing of cotton at 120 cm x 30 cm (27778 plant ha^{-1}). The B: C was also recorded higher with the sowing of cotton at 120 cm x 30 cm (27778 plant ha^{-1}). Similarly the sustainable yield index (SYI) was greater with the sowing of cotton at a spacing of 120 cm x 30 cm (27778 plants ha^{-1}). The above results are in agreement with the findings of Sankaranarayanan *et al*., (2004), Buttar and Singh (2006) and Singh *et al*. (2007).

Effect of fertilizer doses

Fertilizer dose of 150:75:75 kg N:P:K ha^{-1} recorded significantly higher plant height, number of sympodial branches $plant^{-1}$, bolls $plant^{-1}$, and seed cotton yield (kg ha^{-1}). Optimum supply of nutrients under 150:75:75 kg N:P:K ha^{-1} treatment might have resulted into taller plants with more sympodial branches, bolls $plant^{-1}$, which reflected in higher seed cotton yield ha^{-1}, gross and net monetary returns (Rs. ha^{-1}) and B:C. Seed index was higher with the fertilizer dose of 200:100:100 kg N:P:K ha^{-1}, whereas sustainable yield index (SYI) was recorded higher with 150:75:75 and 200:100:100 kg N:P:K ha^{-1}. Similar findings were also reported by Mane *et al*. (1999), Tomar, *et al*. (2000) and Raza *et al*. (2004).

Table 1: Effect of different treatments on plant height, sympodial branches, bolls $plant^{-1}$ and seed index of *Bt* cotton grown on entisol.

Treatments	Plant height (cm)	Number of sympodial branches $plant^{-1}$	Number of Bolls $plant^{-1}$	Seed index
Main treatment (plant densities)				
120 cm x 90 cm (9,259 plant ha^{-1})	102.41	15.20	26.72	9.41
90 cm x 60 cm (18,518 plant ha^{-1})	103.72	13.95	28.25	9.47
150 cm x 30 cm (22,222 plant ha^{-1})	109.38	16.67	29.52	9.67
90 cm x 45 cm (24,691 plant ha^{-1})	98.33	16.87	29.36	9.81
120 cm x 30 cm (27,778 plant ha^{-1})	96.58	16.00	31.44	9.82
SE (m) ±	0.83	0.29	0.75	0.03
CD at 5%	2.69	0.95	2.44	0.09
Sub treatment (Fertilizer doses)				
100:50:50 NPK Kg ha^{-1}	101.03	15.44	28.31	9.58
150:75:75 NPK Kg ha^{-1}	103.68	16.09	30.11	9.62
200:100:100 NPK Kg ha^{-1}	101.55	15.69	28.75	9.72
SE (m) ±	0.49	0.13	0.35	0.03
CD at 5%	1.46	0.37	1.04	0.10
Interaction (Plant densities x Fertilizer doses)				
SE (m) ±	1.10	0.29	0.79	0.07
CD at 5%	NS	NS	NS	NS

Market rates of seed cotton: Rs. 4175 q^{-1}

Table 2: Effect of different treatments on seed cotton yield (kg ha^{-1}), sustainability yield index (SYI) and economics of *Bt* cotton grown on entisol.

Treatments	Seed cotton yield (kg ha^{-1})	Sustainability yield index (SYI)	Gross monetary returns (Rs. ha^{-1})	Net monetary returns (Rs. ha^{-1})	B:C
Main treatment (plant densities)					
120 cm x 90 cm (9,259 plant ha^{-1})	1132	0.40	47245	15953	1.50
90 cm x 60 cm (18,518 plant ha^{-1})	1277	0.44	53331	21535	1.67
150 cm x 30 cm (22,222 plant ha^{-1})	1372	0.50	57278	24918	1.77
90 cm x 45 cm (24,691 plant ha^{-1})	1655	0.55	69097	35653	2.06
120 cm x 30 cm (27,778 plant ha^{-1})	1769	0.61	73869	39832	2.17
SE (m) ±	32.64	-	1363	1328	—
CD at 5%	106.46	-	4446	4332	—
Sub treatment (Fertilizer doses)					
100:50:50 NPK kg ha^{-1}	1364	0.52	56940	26433	1.57
150:75:75 NPK kg ha^{-1}	1544	0.58	64469	31468	1.66
200:100:100 NPK kg ha^{-1}	1415	0.58	59083	24834	1.56
SE (m) ±	20.58	-	859	776	—
CD at 5%	60.72	-	2535	2291	—
Interaction (Plant densities x Fertilizer doses)			-		
SE (m) ±	46.03	-	1921	1736	—
CD at 5%	-	-	-	-	—

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Effect of Integrated Nutrient Management on Productivity and Soil Fertility in Sorghum-Wheat Crop Sequence

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ABSTRACT

A field experiment was conducted during 2007-08 to 2011-12 at All India Coordinated Research Project on Integrated Farming Systems Research Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India to study the "Effect of Integrated Nutrient Management on Productivity and Soil Fertility in Sorghum-Wheat crop sequence". Significantly highest grain yield of sorghum (37.15 q ha^{-1}) was noticed with the application of RDF whereas maximum grain yield of wheat (22.75 q ha^{-1}) was harvested with the application of 50 per cent RDF+50 per cent N through FYM. The five years pooled data indicated that the highest sorghum grain equivalent yield (70.48 q ha^{-1}) was recorded with 100 per cent RDF and also the maximum gross monetary return of Rs. 79146 ha^{-1} net monetary return of Rs. 53348 ha^{-1} and B:C ratio of 3.06 were obtained with the same treatment. Application of 100 per cent recommended dose of fertilizer and substitution of 50 per cent N through FYM and 50 per cent RDF to *Kharif* sorghum and 100 per cent RDF to *Rabi* recorded similar and higher sustainable yield index of 0.58. After harvest of the crop highest NPK and organic carbon content in soil was recorded with the application of 50 per cent RDF and 50 per cent N through FYM. The soil microbial biomass carbon was significantly increased under the integrated use of organic with chemical fertilizers.

Sorghum-wheat sequence cropping system is a popular double cropping under irrigated condition in semi arid tract of Vidarbha in Maharashtra. This system is fairly exhaustive but gives 3.1 to 3.7 tones/ha grain yield of sorghum and 2.0 to 2.3 tones ha^{-1} of wheat. Long term studies are carried out at several locations in various cropping systems throughout the country which indicate that the application of all essential nutrients through chemical fertilizers alone has adverse effect on soil fertility leading to unsustainable yields (Hegde, 1992). Limited information is available on integrated nutrient management in cereal-cereal sorghum-wheat crop sequence. It is realized that the system based on optimum use of different plant nutrient sources of organic, inorganic and in combination will be more remunerative for getting higher monetary returns with fertilizer economy and better soil health. With this aim an investigation was carried out to study the effect of chemical fertilizers alone and in combination with organics on yields, sustainable yield index, agronomic efficiency, nutrient status and biological properties of soil in sorghum-wheat crop sequence.

MATERIAL AND METHODS

Field trial was conducted during *Kharif* and *Rabi* seasons of 2007-08 to 2011-12 for five consecutive years at All India Coordinated Research Project on Integrated Farming Systems Research Farm of Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra.) The soil of the fixed experimental site was medium black *Inceptisol* containing organic carbon of 0.40 per cent, available NPK of 209, 11 and 350 kg ha^{-1}, respectively with pH 7.4 and EC 0.20 dSm^{-1}. The experiment was laid out in a randomized block design and replicated four times with 12 treatment combinations. The N content in different organic manures was determined each year and 25 per cent, 50 per cent nitrogen was applied either through organic farm yard manure, wheat straw and *leucaena loppings* along with 50 per cent to 75 per cent nitrogen, phosphorus and potassium through chemical fertilizers. The sorghum hybrid CSH-14 and wheat variety AKW-3722 were sown under recommended package of practices. Soil samples were collected before sowing and after harvest of *Kharif* and *Rabi* crops every year from each plot at 0-20 cm soil depth and analysed for organic carbon, available N, $P_2 0_5$ and K_2O. Observations on yields were recorded for each plot and economics were worked out on the basis of every year market prices of produce and inputs used. The formulae used for sustainable yield index, agronomic efficiency and other parameters are as suggested by Devasenapathy *et. al., (*2008).

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$$\text{Sustainable yield index} = \frac{Y - Sd}{Y_{max}}$$

Where,

Y = is estimated average yield of a practice over year

Sd = Estimated standard deviation

Y_{max} = Desired maximum yield in experiment

$$\text{Agronomic efficiency} = \frac{\text{Grain yield in fertilized plot (kg ha}^{-1}\text{)} - \text{Grain yield in unfertilized plot (kg ha}^{-1}\text{)}}{\text{Quantity of nutrient applied (kgha}^{-1}\text{)}}$$

(kg grain kg^{-1} nutrient)

$$\text{Crop equivalent yield} = \sum_{i=1}^{n} (Y_j ei)$$

Where,

Y_j = Yield of i^{th} component

ei = price of i^{th} crop

RESULTS AND DISCUSSION

Grain yield of sorghum and wheat

The data presented (Table 2) revealed that significantly maximum grain yield of sorghum (37.15 q ha^{-1}) was harvested in the treatment where 100% NPK was applied through inorganic fertilizer (T_5) and found at par with 50% RDF+50% N through FYM (T_6). However, treatment T_4, T_7, T_8, T_9, T_{10} and T_{11} were at par with each other. Similar trend was also observed in respect of fodder yield. The significantly lowest sorghum yield was recorded in control.

The highest grain yield of Wheat (22.75 q ha^{-1}) was obtained with the application of 50% nitrogen, phosphorus and potassium through chemical fertilizer + 50% N through farm yard manure to sorghum and 100% recommended nitrogen, phosphorus and potassium dose through fertilizer to wheat (T_6). It was at par with T_5, T_7 and T_{10} and found significantly superior to rest of the treatments. Wheat yield was drastically low in control (3.92 q ha^{-1}). The yield obtained in control treatment (T_1) and farmers practice (T_{12}) differed significantly. Similar trend was also observed in wheat straw yield. Treatment

Table 1 : Details of treatments used in the experiment.

Treatment	*Kharif* (Sorghum)	*Rabi* (Wheat)
T_1	No fertilizers, no organic matter (Control)	No fertilizers, no organic matter (Control)
T_2	50% recommended NPK dose through fertilizers	50% recommended NPK dose through fertilizers
T_3	50% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers
T_4	75% recommended NPK dose through fertilizers	75% recommended NPK dose through fertilizers
T_5	100% recommended NPK dose through fertilizers	100% recommended NPK dose through fertilizers
T_6	50% recommended NPK dose through fertilizers + 50% N through FYM	100% recommended NPK dose through fertilizers
T_7	75% recommended NPK dose through fertilizers + 25% N through FYM	75% recommended NPK dose through fertilizers
T_8	50% recommended NPK dose through fertilizers + 50% N through crop residue (wheat straw)	100% recommended NPK dose through fertilizers
T_9	75% recommended NPK dose through fertilizers + 25% N through crop residue (wheat straw)	75% recommended NPK dose through fertilizers
T_{10}	50% recommended NPK dose through fertilizers + 50% N through green organic matter (*Leucaena loppings*)	100% recommended NPK dose through fertilizers
T_{11}	75% recommended NPK dose through fertilizers + 25% N through green organic matter (*Leucaena loppings*)	75% recommended NPK dose through fertilizers
T_{12}	Farmer's practice (50:25:00 NPK)	Farmer's practice (40:25:12.5 NPK)

(RDF = Recommended dose of fertilizer 120:60:60 kg N P K ha^{-1} to both the crops.)

Table 2: Sorghum and wheat grain and fodder yields and sorghum grain equivalent yield (q/ha) as influenced by different treatments in sorghum-wheat crop sequence (Pooled over 5 years)

Treatment	Yield of Sorghum (q ha^{-1})		Yield of Wheat (q ha^{-1})		Sorghumgrain equivalent yield (q ha^{-1})
	Grain	Fodder	Grain	Straw	
T_1	5.19	28.01	3.92	9.71	11.07
T_2	27.11	73.90	13.21	30.50	46.53
T_3	28.69	80.24	18.58	39.05	55.55
T_4	31.61	85.89	16.55	35.62	56.12
T_5	**37.15**	**110.80**	22.46	40.22	**70.48**
T_6	34.37	102.13	**22.75**	**42.37**	68.58
T_7	34.86	104.92	21.15	40.21	65.83
T_8	31.41	85.41	18.58	38.18	59.74
T_9	33.45	93.32	17.95	34.80	60.28
T_{10}	32.85	94.56	21.25	41.56	64.28
T_{11}	34.57	100.19	18.93	39.01	62.94
T_{12}	24.63	72.50	11.48	21.22	41.41
SE (m) ±	1.16	4.15	1.06	2.05	1.84
CD 5%	3.26	11.66	2.99	5.76	5.18

T_2 and T_4 were at par with each other, whereas T_5 was significantly superior over T_1, T_2 and T_3 and T_4 and T_6, T_7, T_9, T_{10} and T_{11} are at par.

Sorghum grain equivalent yield

Pooled results showed the highest sorghum grain equivalent yield (Table 2) recorded in treatment where 100% nitrogen, phosphorus and potassium was applied through inorganic fertilizer (T_5) followed by integrated nutrient management treatment (T_6 and T_7). These treatments were at par with each other but significantly superior over rest of the treatments. Sorghum grain equivalent yield was found lowest in control, followed by the farmers' practice.

Monetary returns

In sorghum-wheat crop sequence the maximum gross monetary return of Rs.79146 ha^{-1}, net monetary return of Rs.53348 ha^{-1} and benefit to cost ratio of 3.06 (Table 3) were obtained with treatment T_5 which was closely followed by treatment T_6 and T_7. Similar result was reported by Jamwal (2005). The value of gross monetary return, net monetary return and benefit to cost ratio were lowest in control followed by the farmers practice.

Sustainable yield index and agronomic efficiency

Application of 100 per cent recommended dose of fertilizer (T5) and substitution of 50 per cent N through farm yard manure and 50 per cent recommended dose of fertilizer (T6) to *Kharif* sorghum and 100 per cent recommended dose of fertilizer to *Rabi* wheat produced equal and higher sustainable yield index of 0.58 (Table 2). The treatment of integrated nutrient management gave sustainable yield index in the range of 0.50 to 0.58. However, lower range of sustainable yield index (0.36 to 0.46) was observed in treatments of inorganic fertilizers alone. Lowest sustainable yield index was recorded in control, followed by farmers' practice.

Highest agronomic efficiency (28.88 kg grain kg^{-1} N) was recorded under farmers practice (T_{12}) followed by the treatment (T_2) where 50 per cent recommended dose of fertilizer was applied to both the crops (26.01 kg grain kg^{-1} N). Treatments consisting of 50 per cent recommended dose of fertilizer + 50 per cent nitrogen through wheat straw to sorghum and 100 per cent recommended dose of fertilizer to wheat (T_8) gave the lowest agronomic efficiency (17.03 kg grain kg^{-1} N) of the system.

Fertility status of Soil

Based on five years pooled data (Table 4), it was observed that the treatment T_6 recorded significantly highest 318.75, 33.99, 445.35, 0.66 and 325, 32.9, 313, 0.67 nitrogen, phosphorus, potassium (kg ha^{-1}) and organic carbon content (%), respectively in soil after harvest of

Table 3: Economics, sustainable yield index and agronomic efficiency as influenced by different treatments in sorghum-wheat crop sequence (Pooled mean)

Treatment	Gross monetary return(Rs ha^{-1})	Net monetary return (Rs ha^{-1})	Benefit to cost ratio	Sustainable yield index(SYI)	System agronomic efficiency (kg grain kg^{-1} N)
T_1	14390	-6169	0.70	0.09	0.00
T_2	52739	29560	2.27	0.36	26.01
T_3	62818	38197	2.54	0.41	25.69
T_4	62986	38422	2.56	0.46	21.69
T_5	79146	53348	3.06	0.58	21.04
T_6	76098	50477	2.97	0.58	20.00
T_7	74958	49894	2.98	0.52	21.93
T_8	65312	39991	2.58	0.50	17.03
T_9	67222	42308	2.69	0.50	19.57
T_{10}	72055	46934	2.86	0.52	18.75
T_{11}	71150	46325	2.86	0.53	20.58
T_{12}	47765	25199	2.11	0.32	28.88
SE (m) ±	2118	2118	—	—	—
CD 5%	5948	5948	—	—	—

Table 4: Fertility status of soil after harvest of *Kharif* and *Rabi* crops as influenced by different treatments (2011-12)

Treatment	Fertility status after harvest of *kharif* crop (kg ha^{-1})			Organic carbon	Fertility status after harvest of *rabi* crop (kg ha^{-1})			Organic carbon
	N	P	K	(%)	N	P	K	(%)
T_1	95	7.61	173.12	0.36	113	9.17	253	0.31
T_2	184.5	14.72	234.87	0.50	215	19.13	199	0.48
T_3	211.25	15.09	273.62	0.51	224	22.36	190	0.50
T_4	228.75	17.07	322.82	0.54	236	22.59	211	0.52
T_5	248.75	21.42	360.30	0.63	309	30.02	282	0.61
T_6	318.75	33.99	445.35	**0.66**	**325**	**32.9**	**313**	**0.67**
T_7	252.50	24.75	361.32	0.60	305	27.25	202	0.62
T_8	252.75	27.65	340.27	0.62	310	29.16	279	0.63
T_9	227.50	17.80	242.52	0.59	293	25.37	266	0.61
T_{10}	233.75	18.62	300.22	0.65	312	27.23	192	0.65
T_{11}	230.0	18.27	292.27	0.60	306	26.78	158	0.61
T_{12}	161.25	13.40	211.57	0.47	205	15.52	205	0.45
SE (m) ±	8.57	1.26	14.97	0.01	1.76	0.32	1.64	0.01
CD @ 5%	24.08	3.54	42.07	0.03	4.94	0.91	4.62	0.04
Initial status	**209**	**11**	**350**	**0.40**	—	—	—	—

Table 5: Balance sheet (net gain / loss) of nitrogen, phosphorus, potassium (kg ha^{-1}) and organic carbon (%) in soil (2011-12)

Treatment	*Kharif* sorghum				*Rabi* wheat			
	N	P	K	OC	N	P	K	OC
T_1	-114	-3.39	-176.88	-0.04	-96	-1.83	-97	-0.09
T_2	-24.5	3.72	-115.13	0.10	6	8.13	-151	0.08
T_3	2.25	4.09	-76.38	0.11	15	11.36	-160	0.1
T_4	19.75	6.07	-27.18	0.14	27	11.59	-139	0.12
T_5	39.75	10.42	10.3	0.23	100	19.02	-68	0.21
T_6	**109.75**	**22.99**	**95.35**	**0.26**	**116**	**21.9**	-37	**0.27**
T_7	43.5	13.75	11.32	0.20	96	16.25	-148	0.22
T_8	43.75	16.65	-9.73	0.22	101	18.16	-71	0.23
T_9	18.5	6.8	-107.48	0.19	84	14.37	-84	0.21
T_{10}	24.75	7.62	-49.78	0.25	103	16.23	-158	0.25
T_{11}	21	7.27	-57.73	0.20	97	15.78	-192	0.21
T_{12}	-47.75	2.4	-138.43	0.07	-4	4.52	-145	0.05

Kharif sorghum and *Rabi* wheat. It was found significantly superior over the rest of treatments. The lowest nitrogen, phosphorus, potassium and organic carbon content in soil was recorded in control (T_1) followed by farmers practice (T_{12}).

Net gain / loss of nutrients

The data (Table 5) indicated that the treatment of 50% recommended dose of fertilizer + 50% nitrogen through farmyard manure to *kharif* sorghum and 100% recommended dose of fertilizer to *rabi* wheat (T_6) showed the net gain of (105.25, 22.99, 95.35 NPK kg ha^{-1}) and 0.27% organic carbon content in soil after harvest of kharif sorghum which was closely followed by T_7 and T_5. The increased availability of the nutrients in the soil might be due to their subsequent release from organic manures.

Table 6: Soil microbial biomass carbon in soil as influenced by various treatments in sorghum-wheat crop sequence (*Kharif and Rabi)*

Treatment	SMBC (*Kharif*) (µg g^{-1} soil)			SMBC (*Rabi*)(µg g^{-1} soil)		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean
T1	150.00	144	147.00	129.75	142	135.88
T2	200.75	194	197.38	202.00	199	200.50
T3	197.25	209	203.13	175.25	213	194.13
T4	197.50	213	205.25	197.00	208	202.50
T5	190.50	220	205.25	213.75	223	218.38
T6	**232.25**	**256**	**244.13**	**242.00**	**267**	**254.50**
T7	201.00	233	217.00	212.50	231	221.75
T8	198.00	245	221.50	205.75	236	220.88
T9	214.50	234	224.25	171.50	231	201.25
T10	195.25	240	217.63	200.75	238	219.38
T11	196.50	226	211.25	158.25	228	193.13
T12	187.75	208	197.88	155.00	201	178.00
SE (m) ±	10.77	6.65	—	15.74	7.26	—
CD 5%	31.01	19.13	—	45.28	20.89	—

These results confirm the findings of Yadav *et al.* (2005) and Yadav *et al* (2008). Whereas, control recorded negative gain of all nutrients after harvest of *kharif* and *rabi* crops. However, after harvest of *rabi* wheat, treatment of 50% recommended dose of fertilizer + 50% nitrogen through farm yard manure (T_6) recorded higher values (116, 21.9 kg ha^{-1} and 0.26%) of nitrogen, phosphorus and organic carbon content which was nearly followed by treatment T_5, T_8 and T_{10}. Negative values were observed for potassium in all the treatments tried. It might be due to low availability and fixation of potassium in soil.

Soil biological properties

The soil microbial biomass carbon, was significantly increased under the integrated use of organics with chemical fertilizers over the use of only chemical fertilizers. The variability in the values of various treatments indicate their sensitivity to management practices which can be regarded as soil quality indicators.

Based on five years pooled data it can be concluded that, the recommended dose of fertilizers could be reduced by 50% to kharif sorghum (60:30:30 kg NPK ha^{-1}) and substituting 50% nitrogen through farmyard manure or *leucaena loppings* and in *rabi* 100% recommended dose (120:60:60 NPK ha^{-1}) to wheat for sustainable and high yield of both the crops with maximum improvement in soil fertility status through positive gain of nutrients and soil biological properties.

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Performance of Pulses in Akola District

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ABSTRACT

The present study has been undertaken with the objectives to study the market arrivals of selected pulses and to study the seasonal variation, cyclic variation and trends in arrivals and prices of selected pulses in all APMC'S of Akola district i.e., Akola, Akot, Balapur and Telhara for the period of 20 years i.e. 1987 to 2006. The main reason behind selecting all APMC's is that these are not only major collection centers but also important distribution centers. The study on arrival and price behavior of selected pulses. Viz., *Tur* and *Mung in* Akola district, has been made in detail to study the various aspects such as growth rates of production and arrival, seasonal variation and cyclic variation, trend in arrival and prices and coefficient of variation in real prices. The conclusions were drawn from the study are the monthly seasonal indices for selected pulses arrivals were higher immediately after harvest in all the study markets, the price indices of selected crops were lower during peak arrival months and vice versa. Cyclic fluctuations were found to be more pronounced than seasonal fluctuation in prices. This showed that when maximum production is there, prices decreased and increased during the pre harvest month. Coefficient of variation of real prices was found to be highest.

Marketing of food grains are generally marketed in regulated markets. These regulated markets are called as Agriculture Produce Marketing Committee. To help the farmer in disposing of their produce in the market smoothly by reducing the exploitation level and to promote fair trade by providing various infrastructure facilities the market regulation act came in to existence. The present study has been undertaken with the objective to study the trends in market arrivals of selected pluses, and to study the seasonal, cyclic variation, trends in arrivals and prices of selected pulses.

MATERIAL AND METHODS

The study is based on secondary data of arrivals and prices of pulses which included *Tur* and *Mung* at all APMC'S of Akola district i.e. Akola, Akot, Balapur and Telhara for the period from 1987 to 2006.

Analytical Tools

In present study, the seasonal indices and cyclical indices were estimated from the following formula

$$\text{Seasonal index} = \frac{\text{Actual data for the given month}}{\text{Moving average for that month}} \times 100$$

$$\text{Cyclical index} = \frac{Pt}{\hat{Pt}} \times 100$$

Where,

Pt = Original price (yearly)

Pt = Estimated trend value

RESULTS AND DISCUSSION

Seasonal indices of arrivals and prices of *Tur* selected markets

Tur being a long duration crop, its harvesting commences in December. The arrivals in APMC market starts rising from December with arrivals of new crop and continues up to March (232.70) where it is at its peak in Akola market, in Akot market peak arrival was observed in the month of February (209.16), in Telhara again in February (273.85) and in Balapur highest arrival were observed in the month of March (292.37), and lowest arrivals were observed in the pre harvest month in all markets. The seasonal variations in arrivals and prices of *Tur* in selected markets are shown in Table 1.

As regards price indices of *Tur* it was highest in the month of July in all markets except in Telhara, where it was in the month of August and lowest price indices in the month of August and lowest price indices were observed in the post harvest months. Prices of *Tur* crop were slightly fluctuating between seasons over a period of time.(Asmatoddin,2009)

The Seasonal Indices of monthly arrivals and prices of *Mung* in selected markets are shown in table 2.

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Table 1. Seasonal indices of monthly arrivals and prices of *Tur* in selected markets

MONTH	AKOLA		AKOT		TELHARA		BALAPUR	
	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price
July	49.80	104.43	89.47	107.06	23.81	104.58	23.03	105.60
Aug	46.69	103.10	89.28	100.78	20.84	105.99	22.65	103.13
Sept	37.20	102.31	54.94	102.22	20.92	105.02	45.23	102.22
Oct	26.03	99.94	33.83	104.89	12.74	100.15	10.71	100.94
Nov	16.08	98.04	28.23	99.60	13.41	93.09	5.80	94.60
Dec	34.47	100.84	25.26	99.66	29.00	95.38	18.09	97.32
Jan	138.57	95.81	125.48	96.60	85.96	98.74	113.31	99.31
Feb	203.85	96.13	209.16	96.24	273.85	98.73	279.65	96.84
March	232.70	96.64	176.32	96.13	256.09	97.28	292.37	97.34
April	1178.93	97.91	129.56	98.39	221.98	99.18	191.96	100.25
May	136.29	101.75	121.43	96.56	145.76	99.19	99.59	100.44
June	97.39	103.11	116.95	102.9	95.65	102.68	97.60	102.00

Table 2. Seasonal indices of monthly arrivals and prices of *Mung* in selected

MONTH	AKOLA		AKOT		TELHARA		BALAPUR	
	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price
July	15.39	100.24	19.54	101.00	4.14	97.92	12.42	95.06
Aug	97.90	93.91	107.16	92.73	70.43	88.67	135.47	91.62
Sept	502.64	86.89	503.44	89.47	616.98	90.90	577.03	93.88
Oct	252.97	94.58	255.55	97.35	281.02	96.69	264.04	99.25
Nov	124.09	97.28	96.07	95.79	108.58	98.00	63.57	99.42
Dec	68.41	100.02	48.12	96.67	46.85	98.10	50.11	97.55
Jan	47.87	100.26	45.50	99.55	21.87	100.27	21.84	99.88
Feb	23.74	100.01	41.61	97.88	12.78	106.00	12.23	101.26
March	16.64	104.80	23.62	104.62	7.24	105.17	11.89	106.42
April	14.39	108.56	15.59	106.52	7.19	105.96	10.02	105.92
May	11.32	106.90	21.80	109.97	7.40	104.18	12.31	104.74
June	24.64	106.55	23.00	108.43	15.53	108.15	29.07	105.00

The seasonal indices showed that maximum arrivals seen in a period of August to January when *Mung* was harvested with a maximum arrivals were observed in the month of September in all the market i.e. in Akola (502.64), Akot (503.04),Telhara(616.98) and Balapur (577.03).The arrivals observed steady dropped in the month of October till April, thereafter it rose again. The period between March and July the arrivals of mung was the minimum in the markets.

The maximum prices were obtained in the month of pre harvest period i.e., April, May and June and minimum prices were obtained in the month of post harvest period i.e. lowest in the month of September 86.89 and 89.47 in Akola and Akot markets and in the month of August 88.67 and 91.62 in Telhara and Balapur markets in the month of March (95.03).

Cyclical indices of arrivals and prices of *Tur* in selected markets

Cyclical indices of arrivals and prices of *Tur* in selected markets were presented in Table 3.

Table 3. Cyclical indices of arrivals and prices of *Tur* in selected markets

MONTH	AKOLA		AKOT		TELHARA		BALAPUR	
	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price
1987	98.71	87.21	110.24	82.67	84.92	88.03	137.04	87.64
1988	127.16	81.62	101.36	80.45	136.89	83.25	132.86	83.24
1989	111.09	89.17	80.21	90.31	128.89	91.18	109.80	90.40
1990	86.56	98.29	73.92	98.25	95.15	101.58	138.51	100.28
1991	67.98	94.99	78.92	95.76	82.11	99.39	32.35	97.05
1992	70.15	87.81	101.74	90.70	86.94	91.16	27.22	87.18
1993	96.11	97.83	121.80	99.58	92.26	94.49	41.64	92.12
1994	105.19	120.41	130.17	120.63	75.09	111.39	53.55	113.25
1995	100.78	120.61	126.58	122.38	63.64	115.70	40.60	119.58
1996	119.54	108.77	102.81	112.53	66.90	107.65	28.03	111.59
1997	141.41	116.31	102.74	117.83	95.19	115.03	31.86	117.11
1998	141.66	117.72	115.15	114.85	156.27	117.67	73.39	115.26
1999	121.28	102.37	95.16	100.24	169.31	104.30	130.54	100.62
2000	95.92	93.06	74.67	93.25	129.59	95,98	152.69	94.73
2001	95.45	92.89	83.39	94.02	115.41	95.61	150.28	95.93
2002	102.95	96.46	94.40	96.59	109.95	97.40	127.34	99.10
2003	93.45	97.97	86.27	97.49	82.87	97.06	102.83	99.88
2004	79.87	94.70	92.68	94.10	67.00	94.28	93.16	94.91
2005	74.36	92.65	89.26	94.08	87.92	93.65	91.45	94.27
2006	72.69	93.57	90.47	95.63	86.32	92.78	89.78	93.56

Table 4.Cyclical indices of arrivals and prices of *Mung* in selected markets

MONTH	AKOLA		AKOT		TELHARA		BALAPUR	
	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price
1987	114.02	98.09	118.57	107.80	144.82	108.42	151.86	95.09
1988	90.57	92.44	100.20	99.85	102.19	97.18	121.51	93.86
1989	83.72	83.97	79.64	87.99	70.73	84.69	84.57	95.81
1990	80.44	86.59	68.93	91.54	50.93	86.76	76.12	94.06
1991	83.27	93.56	83.31	99.37	55.29	97.75	103.26	95.47
1992	97.85	94.80	110.91	101.06	82.77	99.72	111.78	97.27
1993	96.45	97.07	113.16	99.08	88.62	96.26	97.29	97.06
1994	79.40	107.11	106.55	104.06	75.92	101.24	100.99	102.73
1995	75.67	115.22	93.37	113.19	67.94	110.53	81.87	109.04
1996	94.89	114.61	101.66	113.31	84.08	113.09	39.11	109.26
1997	110.60	112.73	143.92	106.86	124.76	111.56	44.11	110.24
1998	103.77	110.30	128.47	100.89	136.21	109.25	76.85	109.77
1999	111.85	109.26	77.36	99.52	134.88	108.60	86.74	107.28
2000	128.75	108.65	81.22	98.91	147.06	104.63	119.50	101.93
2001	138.88	98.00	105.33	89.75	138.39	86.07	153.01	89.56
2002	140.56	84.15	93.64	78.68	103.54	69.72	143.35	80.83
2003	103.06	86.04	67.97	79.80	71.16	76.83	122.94	85.31
2004	64.67	98.00	86.76	100.74	73.09	103.42	86.92	100.77
2005	64.65	89.65	86.94	98.27	75.29	104.52	84.69	97.36
2006	65.08	86.23	88.98	101.01	74.52	101.25	83.25	98.25

The cyclical movement of arrivals of Tur in selected market shows that arrival cycle in Akola market shows peak period from 1989 to 1990 and 1997 to 2000.In Akot market peaked from 1994 to 1999 and then it is below normal. In case of Telhara market peak period from 1989 to 1990. And 1999 to 2003. In Balapur market peaked from1990 to1991 and 2000 to 2003.While the price, it was seen that in selected four market no cyclical behaviour was observed. In selected four markets i.e. Akola, Akot, Telhara and Balapur it is below normal from1988 to 1994 and then above normal upto 2002 and then again below normal

The cyclical movement of arrivals of Mung in selected market showed that arrival cycle in Akola, peaked from 1999 to 2004,in Akot market peaked from 1993 to 1995 and 1998 to 1999,in Telhara market from 1998 to 2003 and in Balapur market from 2001 to 2004.While in price cycle it is seen that in Akola market it peaked from 1995 to 2001,in Akot market peaked from 1995 to 1998,in Telhara market peaked from 1996 to 2001 and in Balapur market peaked from 1995 to 2001(Rathore, 1995).

Trends in arrivals and prices of pulses crops in selected markets

The study of trend in arrivals and prices of Tur and Mung crop is important as food grains are important items of an economy. Any distortion in agricultural prices leads to disturbing of the whole price structure. Prices may rise faster at times or may fall rapidly due to a temporary imbalance of supply and demand. Both sharp rise and precious fall in agricultural prices have dangerous potentialities. One of the major factors responsible for temporal rise in prices is inflation. However the increase in price was seen in pulses.

Percentage change in the ratio of difference between averages of last 3 years i.e.2004 to 2006 over initial 3 years i.e.1987 to 1989 have been worked out.

The analysis of trend showed in Table 5 that the highest increase in arrival in Balapur market was (9370.62 %), followed by Telhara (279.03%), Akola(69.84%) and (Akot 66.71%).In case of price trend it was highest in Balapur market (194.11%). In Balapur

Table 5. Trends in arrivals and prices of *Tur* in selected markets

MONTH	AKOLA		AKOT		TELHARA		BALAPUR	
	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price
1987	6488.61	632.57	2656.71	651.61	266.26	611.04	0.0857	549.86
1988	6766.62	701.39	2765.23	714.83	318.54	674.38	10.35	620.74
1989	7044.62	770.21	2873.74	778.05	370.82	737.71	27.14	691.61
1990	7322.62	839.03	2982.26	841.27	423.11	801.04	50.46	762.49
1991	7600.63	907.85	3090.77	904.49	475.39	864.37	80.30	833.37
1992	7878.63	976.67	3199.29	967.71	527.67	927.70	116.67	904.25
1993	8156.64	1045.48	3307.8	1030.9	579.96	991.04	159.57	975.13
1994	8434.64	1114.30	3416.31	1094.15	632.24	1054.37	208.99	1046.01
1995	8712.64	1183.12	3524.83	1157.37	684.52	1117.71	264.64	1116.86
1996	8990.65	1251.94	3633.34	1222.59	736.81	1181.03	327.42	1187.76
1997	9268.65	1320.76	3741.86	1283.81	789.09	1244.37	396.22	1258.64
1998	9546.66	1389.58	3850.37	1347.03	841.38	1307.70	471.94	1329.52
1999	9824.66	1457.40	3958.89	1410.25	893.66	1371.03	554.00	1400.40
2000	10102.66	1527.22	4067.4	1473.47	945.94	1434.36	642.58	1471.27
2001	10380.67	1596.04	4175.92	1536.69	998.23	1497.70	737.69	1542.15
2002	10658.67	1664.85	4284.43	1599.91	1050.51	1561.03	839.32	1613.03
2003	10936.67	1733.67	4392.94	1663.13	1102.79	1624.36	947.48	1683.91
2004	11214.68	1802.49	4505.46	1726.35	1155.08	1687.69	1062.16	1754.79
2005	11492.68	1871.31	4609.97	1789.57	1207.36	1751.03	1185.38	1825.67
2006	11770.69	1940.13	4718.49	1852.79	1259.64	1814.36	1311.11	1896.54
%change	69.84	166.81	66.71	150.35	279.03	159.65	9370.62	194.11

Table 6. Trends in arrivals and prices of *Mung* in selected markets

MONTH	AKOLA		AKOT		TELHARA		BALAPUR	
	Arrival	Price	Arrival	Price	Arrival	Price	Arrival	Price
1987	11076.15	516.57	2777.50	475.43	304.53	400.91	23.50	382.19
1988	10866.63	603.48	2797.60	564.23	328.70	489.14	21.39	473.49
1989	10657.12	690.39	2817.70	653.02	352.01	577.36	21.24	564.79
1990	10447.60	777.30	2837.80	741.82	375.75	665.59	23.07	656.09
1991	10238.09	864.21	2857.90	830.62	399.99	753.81	26.85	747.39
1992	10028.57	941.11	2878.00	919.41	423.22	842.04	32.61	833.69
1993	9819.05	1038.02	2898.10	1008.21	446.96	930.26	40.33	929.99
1994	9609.54	1124.93	2918.20	1097.01	470.70	1018.49	50.20	1021.30
1995	9400.63	1211.84	2938.20	1185.81	494.44	1106.71	61.67	1112.60
1996	9190.51	1298.75	2958.10	1274.60	518.18	1194.94	75.30	1203.90
1997	8980.99	1385.65	2978.50	1363.40	541.92	1283.16	91.89	1295.20
1998	8771.48	1472.56	2998.60	1451.20	565.66	1371.39	108.45	1386.50
1999	8561.97	1559.47	3018.70	1540.99	589.40	1459.61	127.97	1477.80
2000	8352.45	1646.38	3038.80	1629.79	613.14	1547.84	149.46	1569.11
2001	8142.94	1733.29	3058.90	1718.59	636.88	1636.06	172.92	1660.41
2002	9733.42	1820.20	3079.00	1807.38	660.62	1727.29	198.35	1751.71
2003	7723.91	1907.10	3099.10	1896.18	684.35	1812.51	225.74	1843.01
2004	7514.39	1994.01	3119.20	1984.98	708.09	1900.74	255.10	1934.31
2005	7304.88	2080.92	3139.30	2073.77	731.83	1988.96	286.42	2025.61
2006	7095.36	2167.83	3159.40	2162.57	755.57	2077.19	319.72	2116.91
%change	-32.78	244.82	12.21	267.54	122.94	306.62	1205.54	327.80

market highest increase was in both arrival and price as compared to other market. Lowest price was in Akot market (150.35%), in Akola (166.81%) and in Telhara (159.65%) .

Percentage change in the ratio of difference between average of last three years i.e.1987 to 1989 have been worked out.

The analysis in mung showed that the highest increase in arrival in Balapur market was (1205.54%), followed by Telhara (122.94%), (Akot 12.21%) and Akola (-32.78), Akola market showed decreasing trend in arrival of mung .In case of price trend it was highest in Balapur market (327.80%), followed by Telhara (306.62%),Akot (267.54%) and Akola (244.82%) . The increase in price was more of pulses and less as compared to cereals.

CONCLUSIONS

1. The monthly seasonal indices for selected pulses arrivals were higher immediately after the harvest in all the study markets.The price indices of the selected crops were lower during peak arrival months and vice versa.
2. Cyclical fluctuations were found to be more pronounced than seasonal fluctuations in prices. This showed that when maximum production is there, prices decreased and increased during the pre harvest month.

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Correlates of Income and Employment Generation Behaviour of Women Members of Self Help Group

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ABSTRACT

The present study was undertaken in Akola district in Vidarbha region of Maharashtra state. The paper analyses the correlates of income and employment generation behaviour of self help groups (SHGs) based on the information collected through a personal interview with the women group members. The data used in the analysis were obtained through 150 women members of SHG scattered over 15 tahsils in Akola district by using Ex- post facto research design. Findings of the study revealed that, risk orientation, time lag, social participation and training received by the members showed positive and significant correlation with income and employment generation behaviour at 0.01 level of probability likewise education indicated positive and significant correlation with income and employment generation behaviour at 0.05 level of probability. The findings of the study have important policy implication for taking candid decisions to improve upon these aspects so as to raise the income and employment generation behaviour of self help group members.

Self Help Group is a small group of people who are living in the same area in similar or varied activities, maintaining an almost equal standard, a political and secular to achieve a common goal that is prosperity through thrift and credit and also facing similar problems, help each other to solve their problems (Raheem and Sultana, 2007). Self Help Group provides the women as base for self employment and empowerment through dynamics. Government of Maharashtra declared Mahila Arthik Vikas Mahamandal (better known as "MAVIM ") as a Nodal Agency to implement various women empowerment programmes through SHGs. The mission is **"**To bring about gender justice and equality for women, investing in human capital and the capacity building of women, thus making them economically and socially empowered and enabling them to access sustainable livelihood. The MAVIM is providing 2 to 10 days training on entrepreneurship development for the SHGs women and encouraging them to take up the enterprise. Even then they suffer from being economically and socially invisible. Hence, it was imperative to uncover the factors affecting the income and employment generation behaviour of women group members of SHG so that the policy could be framed to improve upon these aspects.

MATERIAL AND METHODS

The present study was conducted in Patur, Akola and Murtizapur tahsils of Akola district in Vidarbha region of Maharashtra State. The MAVIM institute is providing 2 to 10 days duration entrepreneurship development training for the SHGs women to take up the enterprises. The above three tahsils were selected purposively on the basis of supplementary entrepreneurship trainings provided by the MAVIM in these tahsil. From each selected tahsils list of women SHGs villages that were undergone trainings, and established relatively more enterprises than other SHGs were obtained from MAVIM office and accordingly seven villages from Patur, five from Akola and three villages from Murtizapur tahsil .Thus, total 15 villages were selected for data collection. From each selected village, the SHGs Women who had taken entrepreneurship training from MAVIM, Akola during the period 2007-2010 was listed out. In these three years, the total number of trained SHGs women in selected villages was 1008. Later, list of SHGs trainees who had established an enterprise were enumerated with the help of MAVIM personnel. The respondents were selected purposively from the list to constitute sample size of 150 respondents. The selected respondents were then interviewed personally and the information was collected in pretested schedule. Ex- post-facto type research design was used for the further investigations.

RESULTS AND DISCUSSION

Correlates of income generation behaviour

The correlation analysis helps the researcher in determining the relationship of selected personal, socio-economic, psychological and communicational characteristics of SHGs women and their income and employment generation behaviour.

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Table 1. Relationship between selected characteristics and income generation behaviour

S.N.	Variables	Coefficient of correlation (r) value
1	Age	0.0980
2	Education	0.1996*
3	Caste	0.0710
4	Marital status	0.0636
5	Family type	0.0324
6	Family size	0.0332
7	Annual income	-0.0443
8	Occupation of family	-0.0213
9	Loan matrix	0.1483
10	Information seeking behavior	-0.0010
11	Skill orientation	0.1405
12	Achievement motivation	-0.0478
13	Risk orientation	0.7979**
14	Time lag	0.9196**
15	Social participation	0.9547**
16	Training received	0.4925**

** Significant at 0.01 level of probability

* Significant at 0.05 level of probability

The results obtained in Table 1 indicated that out of 16 variables, risk orientation, time lag, social participation and training received showed positive and significant correlation with income generation at 0.01 level of probability, whereas variable education showed positive and significant correlation with income generation at 0.05 level of probability. It is highlighted that, education showed significant association with income generation, this meant that women with higher education had high income generating capacity led to improve awareness, decision making power, understanding skill and knowledge as well as self-confidence. Bharathamma *et al.*, (2006) and Vidya Tayde (2006) indicated that education showed highly significant relationship with women empowerment.Risk bearing ability also had positive and significant correlation with income generation. It may be due to the capacity to take decision under uncertainty and can also withstand the uncertainties in their activity. Time lag also had positive and significant correlation with income generation. It may be due to less time required to establish enterprise after attending training which is essential for setting up on enterprise. Social participation also had positive and significant correlation with income generation. The logical reasoning behind that might be due to increase in exposure through their social participation and awareness of women rights. When social urge of women has been satisfied, their self-confidence has naturally improved. Training received also had positive and significant correlation with income generation. It might be due to the interest of women to attend training for development of enterprise. All these variables found to be significant in correlation analysis. However, the variables namely age, caste, marital status, family type, family size, annual income, occupation of the family, loan matrix, information seeking behaviour, skill orientation and achievement motivation had not shown any noteworthy link.

Correlates of employment generation behaviour

The data presented in Table 2, indicates that, out of 16 variables, risk orientation, time lag, social participation and training received showed positive and significant correlation with employment generation behaviour at 0.01 level of probability, whereas variable education showed positive and significant correlation with employment generation behaviour at 0.05 level of probability.

Table 2. Relationship between selected characteristics with employment generation

S.N.	Variables	Coefficient of correlation (r) value
1	Age	0.1057
2	Education	0.1996*
3	Caste	0.0173
4	Marital status	0.0205
5	Family type	0.1410
6	Family size	0.1496
7	Annual income	0.1204
8	Occupation of family	-0.0156
9	Loan matrix	0.0345
10	Information seeking behavior	-0.0018
11	Skill orientation	0.1285
12	Achievement motivation	-0.0156
13	Risk orientation	0.9007**
14	Time lag	0.8355**
15	Social participation	0.8074**
16	Training received	0.6805**

** Significant at 0.01% level of probability

* Significant at 0.05% level of probability

It is evident from the Table 2 that, education, risk orientation, time lag, social participation and training received showed positive and significant correlation with employment generation. It is highlighted that, education showed significant association with employment generation behaviour meaning that women with higher education had high employment generating capacity. It is because; education improves awareness, decision making power, understanding skill and knowledge as well as self-confidence. Risk bearing ability also had positive and significant correlation with employment generation. It might be due to the capacity to take decision under uncertainty and also withstand the uncertainties in their activity. Time lag also had positive and significant correlation with employment generation. It might be due to less time required to establish enterprise after attending training which is essential for setting up an enterprise. Social participation also had positive and significant correlation with employment generation. The logical reasoning behind that, it might be due to increase in exposure through their social participation and awareness of women rights. When social urge of women has been satisfied, their self-confidence has naturally improved.

Training received also had positive and significant correlation with employment generation. It might be due to the interest of women to attend training for development of enterprise. All these variables are found to be significant in correlation analysis except age, caste, marital status, family type, family size, annual income, occupation of the family, loan matrix, information seeking behaviour, skill orientation and achievement motivation.

Factors facilitating the establishment and development of enterprise

It can be observed from Table 3 that in case of individual factor cooperation from husband/family at the time of start out of enterprise and self-confidence were the major factor as expressed by cent per cent (100%) women respondents which contributed mainly for establishment and development of enterprise, followed by cooperation from family members during operation stage as expressed by 94.66 per cent. Whereas, encouragement by the society and liberty to women as viewed by 46.66 per cent, followed by recognition and appreciation in the family (36.66%). Nandagopal and Chinnaiyan (2004) also observed similar findings who reported that hard work was reflected as the key factor for the success with mean score of 4.76, followed by support of family members (4.58) and self confidence (4.54).

In case of physical factors, availability of raw material (92.66%), accessibility of place of work (80.00%), availability of modern technologies (73.33%), availability of specified skill to work on specific project (76.00%), availability of modern technologies (73.33%), availability of labour, particularly skilled labour (46.66%) and adequate technical support for machinery utilization (40.00%) were the factors expressed by trained women entrepreneurs. In case of financial factors as viewed by the women entrepreneurs were financial assistance from the family (63.33%), in time availability of loan from the bank (56.66%), assistance from government initiatives by funding of loans and granting subsidies and availability of working capital (26.66%). Sushma (2007) observed that availability of loan from the bank, favourable attitude of customers and adequate training were the favourable factors for 60.76 per cent, 46.15 per cent and 46.15 per cent of the trained women entrepreneurs, respectively. In case of market factors, the trained women respondents of SHG expressed following factors were good market facility and good demand for the product/service in that area (96.66%), good transportation facility (96.00%), adequate publicity (80.00%), favourable attitude of customers and adequate information on changing markets (53.00%). In case of technical factors, women entrepreneurs expressed the following factors were adequate training (89.33%), good experience (84.00%), adequate guidance (60.00%), adequate skill (56.66%) and adequate knowledge (50.00%).

Overall levels of factors facilitating the establishment and development of enterprise

The data presented in Table 4 access that, maximum number of women respondents (63.33%) viewed medium level of factors facilitating the establishment and development of enterprise, followed by 23.34 per cent and 13.33 in high and low levels of factors facilitating the establishment and development of enterprise, respectively.

Table 3.Distribution of respondents according to the factors facilitating the establishment and development of enterprise

S. N.	Factors	Frequency	Percentage
A.	**A. Individual factors**		
a	Cooperation from husband/family at the time of start of enterprise	150	100.00%
b	Cooperation by family members during operation stage	142	94.66%
c	Encouragement by the society	70	46.66%
d	Liberty to women	70	46.66%
e	Recognition and appreciation in the family	55	36.66
f	Self confidence	150	100.00%
B	**Physical factors**		
a	Availability of raw material	139	92.66%
b	Accessibility of place of work	120	80.00%
c	Availability of modern technologies	110	73.33%
d	Availability of specified skill to work on specific project	114	76.00%
e	Adequate technical support for machinery utilization	60	40.00%
f	Availability of labour, particularly skilled labour	70	46.66%
C	**Financial factors**		
a	Financial assistance from the family	95	63.33%
b	In time availability of loan from the bank	85	56.66%
c	Assistance from government initiatives by funding of loans and granting of subsidies	40	26.66%
d	Availability of working capital	40	26.66%
D	**Market factors**		
a	Good market facility	145	96.66%
b	Good transportation facility	145	96.00%
c	Good demand for the product/service in that area	145	96.66%
d	Adequate publicity	120	80.00%
e	Favourable attitude of customers	80	53.33%
f	Adequate information on changing markets	80	53.33%
E	**Technical factors**		
a	Adequate knowledge	75	50.00%
b	Adequate skill	85	56.66%
c	Good experience	126	84.00%
d	Adequate training	134	89.33%
e	Adequate guidance	90	60.00%

(Note: The sum of total is more than 100 due to multiple responses.)

Table 4. Distribution of respondents according to the levels of factors facilitating the establishment and development of enterprise

S.N.	Category	Frequency	Percentage
1	Low (Up to 83)	20	13.33
2	Medium (84-89)	95	63.33
3	High (Above 89)	35	23.34
	Total	**150**	**100**

CONCLUSION

The characteristic namely risk orientation, time lag, social participation and training received by the SHG women members showed positive and significant correlation with income and employment generation behaviour at 0.01 level of probability. Likewise education indicated positive and significant correlation with income and employment generation behaviour at 0.05 level of probability. The findings of this study have important policy implications for taking candid decisions to improve upon these aspects, so as to raise the income and employment generation behaviour of self help group women members.

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Correlates of Socio-economic Attributes and Farmers Adaptations Towards Climate Change in Vidarbha

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ABSTRACT

The study of socio-economic attributes of farmers are extremely essential in any study related to climate change to develop effective adaptation strategies and to mitigate the impact of climate change. This paper analyzed the relationship between these attributes of farmers and their adaptation to climate change based on the information collected through personal interview with the farmers. The data used in the analysis were obtained through 300 farmers scattered over 10 villages across 5 tahsil of 2 highly suicide prone districts of Vidarbha in 2012. Findings revealed that farmers socio-economic attributes, namely education, landholding, farming experience, annual income, indebtedness, access to credit, agriculture infrastructure facilities, social participation and off farm employment were highly significant at 0.01 level of probability.

The adaptation concept is rather new for the research community and has origin in natural sciences (Smit & Wandel, 2006). "Adapt" means to make something or system more suitable by altering it (Smit *et al.*, 1999). Adaptation refers to the process of adapting and the condition of being adapted. According to Burton (1992), adaptation in social sciences was concerned with "the process through which people reduce the adverse effects of climate on their health and well-being, and take advantage of the opportunities that their climatic environment provides. Understanding the socio-economic attributes of farmers and adaptation concept are important to make the foundation for evaluating and identifying socio economic factors that lessen the impact of climate change for increasing adaptation measures by the farmers in order to decrease negative climate changes' impact, reduce significantly vulnerability and risk for human, environment and nature in climate change context.

MATERIAL AND METHODS

The study was conducted in two distress districts of two different agro-climatic zones based on rainfall, soil types, and vegetation namely, Akola from Western Vidarbha zone (rainfall 700 to 950 mm) and Yavatmal from Central Vidarbha Zone (rainfall 950 to 1250mm). The data were collected from 300 farmers spread over 10 villages across the 5 tahsil of highly suicide concentrated two districts by conducting field survey and applied diagnostic design of social research with exploratory approach. Apart from in-depth interviews with the randomly sampled 300 farmers, two FGDs and 10 group discussions were also carried out in the study area. The data regarding farmers' adaptation to climate change was obtained on parameter/indicators identified from relevancy ratings from experts, finalized during the construction and standardization of scale to measure farmers' adaptation to climate change. The standardized scale was administered to the respondents to measure the adoption of adaptation measures during the course of data collection. The scale consisted of 40 adaptation measures. Each given adaptation measure on the scale has to be rated on five point response continuum viz., adapted before the impact of climate change, adapted after the impact of climate change, under current consideration, no adaptation and no plans to adapt in future with score of 5,4,3, 2, and 1, respectively. The farmers were asked to respond to each statement in terms of adoption of given adaptation measure and the responses were recorded by a tick mark by the researcher in the appropriate column representing the five categories. The total score for each farmer was calculated by adding up the scores on all statements in the scale. The obtained score of an individual farmer on the scale indicated his adoption of adaptation measures in response to climate change. The adaptation score on the scale ranged from a minimum of 120.1 to maximum of 600.50.The coefficients of correlation (r) were worked out to find out the relationship of socio-economic attributes of farmers with their adaptations to climate change. The

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significance of calculated coefficient of correlation (r) was tested against the table value of 'r' at n-2 degrees of freedom. The relationship was considered to be significant if the calculated value of 'r' was greater than the Table value either at 0.01 or 0.05 level of probability.

RESULTS AND DISCUSSION

A closer look at the values of correlation coefficient in Table 1 brings into light that out of 15 attributes, four attributes namely, the gender, age, family size, and health of the farmers did not show any significant relationship with their adaptations towards climate change and its variability, whereas, all the other remaining 11 attributes established significant relationship with their adaptations about climate change and its variability. These findings go in line with the results of Enujeke and Ofuoku (2012) who found that the age of household heads which can also be used to capture farming experience did not have a significant relationship with adaptation to climate change. Some studies found that household gender was not a significant factor influencing farmers' decision to adopt conservation measures (Burton *et al.*, 2001). Deressa *et al.* (2008) revealed that for most of the adaptation methods, increasing household size did not significantly increase the probability of adaptation. Perversely Croppenstedt *et. al.*, (2003) argue that households with a larger pool of labour are more likely to adopt agricultural technology and use it more intensively because they have fewer labour shortages at peak times. The non-significant relationship of the attributes with adaptation indicates that these variables have no significant influence over the farmers' adaptation to climate change and variability. The reason might be that the adaptation might be governed by other socio-economic attributes, which were found significant in the present study.

Table 1. Correlational analysis of socio-economic attributes and adaptation

S .N.	Socio-economic attribute	**Adaptation** 'r' value
1	Gender	-0.006 NS
2	Age	0.091 NS
3	Education	0.283**
4	Family size	-0.006 NS
5	Land holding	0.781**
6	Farming experience	0.209**
7	Annual income	0.648**
8	Indebtedness	0.573**
9	Access to credit	0.481**
10	Agriculture infrastructure facilities	0.456**
11	Health	0.076 NS
12	Social participation	0.418**
13	Off farm employment	-0.422**
14	Vulnerability	-0.777**
15	Adaptive capacity	0.712**

*Significant at 0.01 level of probability
NS - non-significant

Education had established significant relationship with adaptation. The higher the farmers' level of education, higher the likelihood to perceive the changes in climate and their adaptation to climate change. The implication is that with higher levels of education, household heads and informed families are more likely to adapt better to climate change. Present findings affirmed with the findings of Enujeke and Ofuoku, (2012) that educational level of the farmers' significantly and positively related with adaptation to climate change. Maddison (2006) also reported the same. Deressa et al (2008) opined that a unit increase in number of years of schooling would result in a 1per cent increase in the probability of soil conservation and a 0.6 per cent increase in change in planting dates to adapt to climate change. Land holdings pointed out positive relationship with adaptation. Farmers' with large farms would adopt measures that require a large area of land such as farm ponds, livestock systems, while farmers' with small holdings are expected to diversify their options. Present findings go in consonance with Gbetibouo (2009) analysis, who concluded that coefficient on farm size is significant and positively correlated with the probability of choosing irrigation as an adaptation measure. Farming experience developed positive significant relationship. Farme'r experience increases the probability of uptake of all adaptation options. Gbetibouo (2009) also reported that experienced farmers' have an increased likelihood of using portfolio diversification, changing planting dates, and changing the amount of land under production. Dhaka *et al.* (2010) also revealed that making use of local successful lead farmers' as entry points in promoting adaptation among smallholder farmers' can have significant positive impact in increasing use of various adaptation options. Farming experience improves

awareness of change in climate, the potential benefits and willingness to participate in local natural resource management of conservation activities. However, Maddison (2006) stated that educated and experienced farmers' have more knowledge and information about climate change and agronomic practices that they can adopt in response. Annual income showed significant relationship with adaptation. Low income group were considered the most vulnerable group to climate change. Higher the annual income more likely to adapt better to climate change. Gbetibouo (2009) also observed that the farm income of the households surveyed has a positive and significant impact on conserving soil, using different crop varieties, and changing planting dates. Indebtedness revealed significant positive association. Increasing uncertainties of weather as well as a dependence on borrowed credit at a higher rate of interest from informal lenders were the reasons responsible for increasing indebtedness among the farmers'. Deshpande and Prabhu (2005) indicated that the Situation Assessment Survey of the National Sample Survey Organization has reconfirmed the gravity of the distress by revealing that 48 per cent of the farmers' were indebted. Access to credit established significant relationship. Access to credit increases the likelihood that farmers' will take up portfolio diversification. Benedicta et al. (2010) also observed positive correlation between adaptation to climate change and the availability of credit. Agricultural infrastructure showed significant positive association. The development of rural infrastructure is a necessary condition of agricultural development and alleviation of poverty. Kurukulasuriya (2006) also found that ownership of heavy machinery significantly and positively increased net farm revenue on African crop land and adaptation to climate change. Social participation had significant positive impact on the likelihood of adopting various climate change adaptation measures in the present study. Moreover, Dhuware and Pande (2002) also noted social participation had significant association with adoption of watershed management practices. Off farm employment had established negative but significant relationship with adaptation to climate change. It inferred that with increase in the off farm employment of farmer, indicated the impact of climate change on his farm and therefore he will pay less attention to take up adaptation measures and hence there will be less adaptation of farmers' towards climate change and vice-versa. Vulnerability in the present investigation consisted of 13 indicators under broad head of exposure, sensitivity and adaptive capacity. Vulnerability established negative but significant relationship. It inferred that with increase in vulnerability of farmers', there will be less adaptation of farmers' towards climate change and vice-versa. The IPCC (2001) work has highlighted the fact that certain regions, and certain populations within each region, are more vulnerable to climate change than others. In particular, developing countries are thought to possess limited adaptive capacity due to their limited endowments of technology, education, wealth and access to resources. This implies that the poor are expected to disproportionately suffer the impact of climate change. Adaptive capacity is a set of 11 indicators developed highly significant relationship. Jones, *et al.,* (2010) described five characteristics of the local adaptive capacity that were considered important for climate change adaptation are the Asset base ,Institutions and entitlements ,Knowledge and information ,Innovation and Flexible forward-looking decision-making and governance.Nhemachena and Hassan (2007) suggested that capital, land and labour served as an important factors for coping with and adapting to climate change. Farmers' who are aware of changes in climatic conditions have higher chances of taking adaptive measures in response to observed changes.

CONCLUSION

The relational analyses of socio-economic attributes of farmers have explored the attributes relating significantly with the adaptation of farmers to climate change and variability. There is need for effective capacity building of these attributes to strengthen the most vulnerable group in agricultural production with requisite knowledge and information necessary towards their adaptation to climate change and variability in Vidarbha region.

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Time Series Modeling of Reference Evapotranspiration

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ABSTRACT

The time variant characteristics of reference crop evapotranspiration (ET_o) necessitate the need for forecasting, which particularly in water resource projects planning, design and operation is of paramount importance. The potentially useful method to generate synthetic reference evapotranspiration series that relies on the past history of reference evapotranspiration in the area is a time series approach. Weekly reference evapotranspiration series of 28 years (1978-2005) from Akola, having semi-arid climate, were analysed using time series analysis techniques and a stochastic reference evapotranspiration generator was developed and evaluated for next two years (2006-2007). Weekly ET_o series were decomposed into trend, periodic and stochastic components. Analysis indicated that ET_o series at Akola were trend free. Periodic components were modelled by Fourier series analysis. Four harmonics were found to be significant. For stochastic component, autoregressive, AR(2) model was selected, due to minimum residual variance and Akaike Information Criteria. The estimated parameters of selected autoregressive model complied with the stationarity conditions. The formulated model superposes a periodic-deterministic process and a stochastic component. The basic statistical characteristics of historical and generated series were well within limits indicated that the formulated model preserve the historical statistics of respective station and suitable for long term generation of weekly ET_o series. One step ahead forecasting was also made for the period of two years. Performance indices and error statistics showed that the formulated model can be used for prediction of weekly ET_o with 0.5133 mm day^{-1} RMSE and 0.9214 model efficiency at Akola.

Evapotranspiration is an important component of the hydrologic cycle, which continues to be of foremost importance in water resources planning and management. Usually, estimates of evapotranspiration are needed in a wide array of problems in hydrology, agronomy, forestry and land resources planning, such as water balance computation, irrigation management, crop yield forecasting model, ecosystem modelling. A common practice for estimating evapotranspiration from a well watered agricultural crop is to first estimate reference crop evapotranspiration i.e. grass reference evapotranspiration (ET_o), from a standard surface and to then apply an appropriate empirical crop coefficient which accounts for the difference between the standard surface and crop evapotranspiration (ET_c).

Most reference evapotranspiration estimation methods that are currently in use are either purely deterministic or probabilistic and thus, do not represent the time-dependent characteristics of reference evapotranspiration. The time variant characteristics of evapotranspiration necessitate the need for forecasting, which particularly in water resource projects planning, design and operation is of paramount importance.

The potentially useful method to generate reference evapotranspiration series that relies on the past history of reference evapotranspiration in the area is a time series approach. Time series analysis has been used extensively in the modelling of many hydrological processes (Salas *et al.*, 1980). Time series techniques can be used to analyze the statistical behaviour of a series of data over time, where these data have significant correlations introduced by the sampling of adjacent time points.

Employing a mathematical model that represents the stochastic process of ET_o, the likely synthetic sequences of evapotranspiration values can be obtained. A mathematical model representing a stochastic process is called "stochastic model". A time series is often composed of trend, periodic and stochastic component. ET_o series is periodic-stochastic in nature. ET_o data available over time usually tend to be autocorrelated. Such a sequence of data, if modelled by ordinary regression, can produce misleading results, whereas time series techniques can produce consistent results. In stochastic modelling, data available at a constant interval of time are considered random variables. Any particular time series is supposed to be the only realization of all possible series that could be generated under the same set of conditions. Many investigators have developed stochastic models for the hydrological quantities such as precipitation, runoff discharge and irrigation requirement (Gupta and Chauhan, 1986; Sharma *et al.*,

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2002; JunWu *et al.*, 2005; Rai and Sherring, 2007). Hence, the study has been conducted to develop the stochastic model using historical series of ET_o.

MATERIAL AND METHODS

Mean weekly meteorological data were obtained from Agricultural Meteorological Observatory, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for a period of 30 years (1978-2007). Akola comes under semi arid eco region. The combination equation of Penman-Monteith (FAO-56) has been adopted as a reference equation for ET_o estimation and calibration of other equations. Therefore, mean weekly ET_o was estimated using Penman-Monteith (FAO-56) method, as measured data on ET_o was not available at the station. The methodology suggested in FAO-56 was used for estimation of each parameter of equation (Allen *et al.*, 1998).

Statistical characteristic of ET_o series

Estimated weekly ET_o time series were first analyzed for determining different statistical parameters like; Mean, Variance of the series, Standard deviation, Coefficient of variation, Skewness, etc. to study the time variability of ET_o

Modelling using Time Series Approach

In this study a time series analysis by an autoregressive modelling approach has been used to provide stochastic reference evapotranspiration generator. Weekly ET_o rates were used for this study. From the available data of 30 years, the first 28 years data were used for model development and the remaining two years data were used in evaluating the performance of the model. Details of the procedure followed are explained below.

Time series model development

The time series of ET_o was decomposed into a deterministic component in the form of periodic parameter and a stochastic (random) component. Mathematically, a discrete time series is denoted by X_t, t = 1, 2, 3, etc., where X_t are at equidistant time interval and decomposed by an additive type. The additive form provides a reasonable model in most cases and is expressed as:

$$X_t = T_t + P_t + S_t \qquad \ldots (1)$$

in which T_t is the trend component; P_t is the periodic component; and S_t is stochastic component having dependent and independent parts, at time t. The first two components in the model that described the time series are deterministic in nature. The presence of such deterministic components in the structure of the time series renders the series to be non-stationary. Since the model is applied to stochastic component, which is treated as random variable, the trend and periodic components were first removed from the time series. Each of the model components have been analyzed and determined by adopting stepwise procedure.

Trend component T_t

For detecting the trend in the time series turning point test was performed. In sequence X_i, i = 1, 2, . . . , N, where N represents years, a turning point p occurs at time t = i if is either greater than and or less than the two adjacent values. The expected number of turning points in a random series is E (p) = 2 (N-2)/3 and the variance is given by var (p) = (16 N-29)/90. Consequently, p can be expressed as a standard normal deviate, Z= (p-E(p))/ $(Var(p)^{1/2}$. The calculated value of Z was compared with its table value at P = 0.01 level of significance, viz, ± 2.58.

Periodic component Pt

The periodic component in a time series is deterministic in nature having the property to repeat itself at regular intervals. In a time series periodicity can be represented as a function of sine and cosine terms, if it exists, has been removed. The procedure used is termed as harmonic analysis. The existence of P_t was first identified by the serial correlogram, i.e., a graph of autocorrelation coefficients, r_k against lag k. The serial correlation coefficient, SCC (r_k) for ET_o series was computed using the expression:

$$r_k = \frac{\sum_{i=1}^{N-k} X_i X_{i+k} - \frac{1}{N-k}\left(\sum_{i=1}^{N-k} X_i\right)\left(\sum_{i=1}^{N-k} X_{i+k}\right)}{\left[\sum_{i=1}^{N-k} X^2_i - \frac{1}{N-k}\left(\sum_{i=1}^{N-k} X_i\right)^2\right]^{1/2}\left[\sum_{i=1}^{N-k} X^2_{i+k} - \frac{1}{N-k}\left(\sum_{i=1}^{N-k} X_{i+k}\right)^2\right]^{1/2}} \qquad \ldots (2)$$

Since a periodic time series $P_{(t)}$, usually not stationary, it was then expanded into a Fourier series representation expressed as:

$$P_{(t)} = \overline{X} + \sum_{k=1}^{h}\left[A_k Cos\left(\frac{2\pi kt}{p}\right) + B_k Sin\left(\frac{2\pi kt}{p}\right)\right] \qquad \ldots (3)$$

Where,

$$\overline{X} = \frac{1}{p}\sum_{t=1}^{p}\overline{X_t} \qquad \ldots (4)$$

$$A_k = \frac{2}{p}\sum_{t=1}^{p}\overline{X_t} Cos\left(\frac{2\pi tk}{p}\right) \qquad \ldots (5)$$

$$B_k = \frac{2}{p}\sum_{t=1}^{p}\overline{X}_t Sin\left(\frac{2\pi tk}{p}\right) \quad \ldots(6)$$

k = Harmonic
h = Total number of significant harmonics
P = Base period
A_k and B_k = Fourier series coefficients

Analysis of variance, Fourier decomposition of mean square and Cumulative periodogram were then carried out for determination and selection of the significant harmonic coefficients, A_k and B_k. The periodic component was then removed from the time series using the harmonic constants. The remainder being random was applied to the stochastic component.

Stochastic component (S_t)

The stochastic component, S_t was obtained by subtracting periodic component from time series and the serial correlation coefficients (r_k) for remainder S_t series were computed. Nevertheless, an autoregressive model of order p, AR(p) can mathematically be expressed as:

$$S(t) = \phi_{p,1}S_{(t-1)} + \phi_{p,2}S_{(t-2)} + \ldots + \phi_{p,p}S_{(t-p)} + a(t)$$

$$= \sum_{k=1}^{p}\phi_{p,k}S_{(t-k)} + a(t) \quad \ldots(7)$$

Where,

Autoregressive model parameters, k = 1, 2, . . . , p

a(t) = Independent random number

The fitting procedure of the AR(p) model involved three steps, viz. model identification, parameter estimation and model diagnostic checking. For selecting the best model and thereby to estimate the parameters of the model structure residual variance criteria method was used. The residual variance values were computed for all estimated lag p. The rule for this criterion is to select the model order with minimum value of residual variance, (Kottegoda, 1980). Based on this criterion, order of the AR model was identified. Akaike Information Criterion (AIC) was also used to select the proper order. The autoregression parameters of different orders were estimated before the proper order for AR terms has been identified. These parameters were estimated by the procedure described by Yule-Walker equations. The Yule-Walker estimates of the autoregressive parameters were obtained using the serial correlation coefficients, r_k. In general, the estimates of p^{th} order model has been obtained computing following equations recursively.

$$\phi_{p,p} = \left[\frac{r_p - \sum_{k=1}^{p-1}(\phi_{p-1,k})(r_{p-k})}{1 - \sum_{k=1}^{p-1}(\phi_{p-1,k})(r_k)}\right] \quad \ldots(8)$$

and for k = $\phi_{p,k} = \phi_{p-1,k} - \phi_{p,p}.\phi_{p-1,p-k}$ 1, 2, …, p-1 … (9)

In the estimated parameters, suffix p and k indicate the order and the number of parameters of AR (p) model. The estimated parameters of selected model order were tested for the stationarity conditions. The sum of the periodic and stochastic component forms the generated value of the ET_o. The difference between this generated and original value was termed as residual, which was tested to check the adequacy of the formulated model. The residuals of the AR(p) model may be computed from:

$$a_{(t)} = S_{(t)} - \sum_{k=1}^{p}\phi_{p,k}S_{(t-k)} \quad \ldots(10)$$

Once the proper order for AR terms has been identified, the selected model was validated for its suitability through the diagnostic checking. Serial correlation and sum of squares analysis of residuals series were used as a tool for diagnostic checking.

Performance evaluation of stochastic model

Generating the ET_o time series was first checked using the developed weekly ET_o model. In this five synthetic series of ET_o each of 28 years period were generated using developed model. For this independent random numbers were generated using the residual variance and mean zero. Random number generation tool available in MATLAB software was used for this purpose. The statistical characteristics of the historical series and their mean value for generated series were compared with 95 per cent confidence limits. One step ahead forecasting was also made for the period of two years (2006 to 2007) using formulated model. The variation of the predicted and original series was presented graphically with respect to time. The predicted series from the model were compared to the historical original series in respect of their basic statistical characteristics. Other statistical parameters like mean absolute error (MAE), mean absolute relative error (MARE), root mean square error (RMSE), correlatin coefficient (r), coefficient of determination (R^2), index of agreement (D) and model efficiency (E) were also computed for evaluation of performance of the developed model.

RESULTS AND DISCUSSION

Some of the statistical characteristics of mean weekly ET_o series for the period of 30 years (1978-2007) were computed week wise and are presented in Table 1.

The coefficients of variation were found greater than zero, which shows the importance of time variability of weekly ET_o. The ET_o series was found slightly positively skewed. Mostly the series was platykurtic in regards Kurtosis.

Trend component

For identification of trend component as suggested by Kottegoda (1980), only annual data of reference evapotranspiration series was used so as to suppress the effect of periodic component. The estimated values of the test statistic (-0.15) were within the acceptable range ($Z_{0.01} = \pm 2.58$). Hence, the hypothesis of no trend was not rejected, indicating that the reference evapotranspiration series is trend free.

Periodic component

The presence of periodic component in series is detected through the construction of autocorrelogram or correlogram. Autocorrelogram for the weekly series along with the tolerance limit estimated for an independent series is shown in Fig.1. It is seen that the autocorrelogram of the time series fall out of the confidence limits for all stations, indicating the presence of time dependant series.

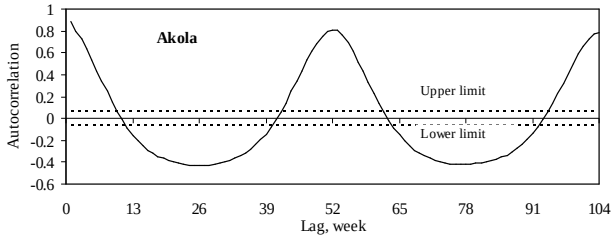

Fig. 1: Correlogram of weekly reference evapotranspiration series

Table 1: Statistical characteristics of weekly reference evapotranspiration

Week	Mean mm day^{-1}	S.D. mm day^{-1}	Cv, %	Cs	Ck	Week	Mean mm day^{-1}	S.D. mm day^{-1}	Cv, %	Cs	Ck
1	3.2	0.48	14.96	-0.20	1.66	**27**	5.4	1.69	31.02	0.57	-0.34
2	3.3	0.50	15.14	-0.56	0.46	**28**	4.8	1.29	26.95	0.61	-0.24
3	3.6	0.39	10.94	-0.73	0.62	**29**	4.4	1.04	23.71	0.12	-0.82
4	3.7	0.43	11.39	-0.51	0.55	**30**	4.2	0.87	20.71	0.50	0.10
5	3.9	0.59	14.99	-0.22	-0.01	**31**	4.0	1.10	27.33	1.15	1.53
6	4.2	0.51	12.06	-0.14	0.02	**32**	3.8	0.79	20.86	0.78	1.00
7	4.7	0.46	9.81	-0.42	0.93	**33**	4.1	0.80	19.65	0.61	0.16
8	5.0	0.57	11.43	0.11	1.94	**34**	4.0	0.87	21.66	0.88	0.13
9	5.5	0.60	10.89	-0.37	1.99	**35**	4.1	0.99	23.93	0.47	-0.81
10	5.7	0.66	11.65	0.05	0.01	**36**	4.4	1.02	22.99	0.22	-0.85
11	6.0	0.73	12.23	-0.87	1.45	**37**	4.7	0.85	18.05	-0.20	-0.02
12	6.6	0.83	12.56	-0.76	0.75	**38**	4.5	0.94	20.80	-0.24	-0.73
13	6.9	1.07	15.46	-0.43	0.07	**39**	4.4	0.73	16.49	0.15	-0.86
14	7.2	0.90	12.40	0.22	-0.04	**40**	4.4	0.67	15.12	-0.28	0.62
15	7.9	1.13	14.34	0.29	-0.37	**41**	4.2	0.56	13.31	0.48	0.50
16	8.3	1.52	18.33	0.41	1.93	**42**	4.1	0.59	14.31	-0.12	0.04
17	8.7	1.18	13.62	-0.42	0.88	**43**	4.0	0.67	16.92	1.04	2.91
18	9.0	1.46	16.16	-0.30	-0.91	**44**	3.9	0.62	15.66	0.62	0.53
19	9.7	1.52	15.71	0.18	-0.01	**45**	3.7	0.46	12.51	-0.40	0.01
20	10.3	1.53	14.85	0.44	-0.90	**46**	3.5	0.48	13.54	-0.25	0.38
21	10.4	1.55	14.84	-0.22	-0.97	**47**	3.3	0.52	15.65	-0.01	-0.45
22	10.0	1.71	17.02	-0.67	0.23	**48**	3.2	0.43	13.37	-0.22	0.12
23	9.2	1.97	21.45	-0.12	-0.66	**49**	3.2	0.47	14.85	-0.29	-0.35
24	7.4	1.83	24.73	0.26	0.18	**50**	3.1	0.50	15.89	0.29	0.11
25	6.3	1.60	25.23	0.08	-0.95	**51**	3.1	0.52	17.09	-0.58	0.50
26	5.7	1.51	26.62	0.97	0.42	**52**	3.1	0.49	15.84	-0.25	0.35

To estimate the coefficients of harmonics to be fitted in the periodic component, the numbers of harmonics that significantly contribute to periodicities were identified. The numbers of significant harmonics have been then detected from the analysis of variance. The analysis of variance is given in Tables 2. In this analysis, the parameters á and â were evaluated for all harmonics considered in weekly series to obtain the F-values. The harmonics, for which F-ratios were greater than the table value of F at 0.01 level of significance, have been considered as significant harmonics. The analysis of variance revealed that four harmonics were found to be significant.

The Fourier series coefficients A_k and B_k along with amplitude and phase angle (q) for the corresponding harmonic were computed and shown in Table 3. The contribution of the individual harmonics towards the mean square has been shown under the explained variance and those harmonics, which dominantly contribute to mean square, are selected as the significant harmonics. The results indicated that first four harmonics have contributed more than 82 of the total variation caused by the periodic component, while only about 1.3 has been contributed by the rest of the harmonics respectively.

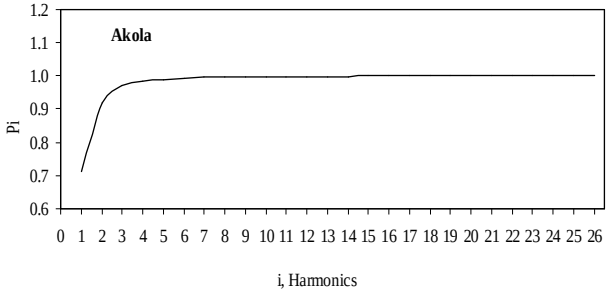

Fig. 2 Cumulative periodogram of weekly reference evapotranspiration series

A graph constructed by plotting Pi against i called the cumulative periodogram and is shown in Fig. 2. From the cumulative periodogram, it can be observed that the first four harmonics appeared to be the periodic part of the fast increase and after that the periodogram remains almost constant, which may be treated as non

Table 2: Analysis of variance of weekly reference evapotranspiration series

S.N.	Harmonic	Degree of freedom	Sum of squares	Mean squares	Fcal	Ftab 0.01	Ftab 0.05
1	6,7–,26	41	75.82	1.85	0.33	1.59	1.40
2	Residual	1414	7984.91	5.65			
3	5	4	26.57	6.64	1.20	3.32	2.37
4	Residual	1451	8034.17	5.54			
1	5,6,–,26	43	102.39	2.38	0.42	1.57	1.38
2	Residual	1412	7958.35	5.64			
3	4	3	85.58	28.53	5.19	3.78	2.60
4	Residual	1452	7975.15	5.49			
1	4,5, --,26	45	187.97	4.18	0.75	1.56	1.37
2	Residual	1410	7872.76	5.58			
3	3	2	351.30	175.65	33.11	4.61	3.00
4	Residual	1453	7709.4	5.31			
1	3,4, --,26	47	539.28	11.47	2.15	1.55	1.37
2	Residual	1408	7521.46	5.34			
3	2	2	1392.92	696.46	151.77	4.61	3.00
4	Residual	1453	6667.82	4.59			
1	2,3, --,26	49	1932.19	39.43	9.05	1.54	1.36
2	Residual	1406	6128.5	4.36			
3	1	2	4799.77	2399.89	1069.33	4.61	3.00
4	Residual	1453	3261.0	2.24			
	Total	**1455**	**8060.73**	**5.54**			

Table 3: Fourier decomposition of periodic components in weekly ET_o

Order	A_k	B_k	Amplitude	Theta	Explained variance	Cumulative explained variance
1	-1.792	1.839	2.568	-0.772	59.504	59.504
2	-0.521	-1.281	1.383	0.386	17.268	76.773
3	0.213	0.661	0.695	0.312	4.355	81.128
4	-0.221	-0.262	0.343	0.702	1.061	82.189
5	0.190	0.022	0.191	1.454	0.329	82.518
6	-0.166	0.088	0.187	-1.084	0.317	82.835
7	0.136	-0.091	0.164	-0.979	0.243	83.078
8	-0.057	0.091	0.108	-0.562	0.105	83.182
9	-0.029	-0.095	0.100	0.297	0.090	83.272
10	0.020	0.071	0.073	0.275	0.049	83.321
11	-0.047	-0.049	0.068	0.760	0.041	83.362
12	0.017	0.012	0.021	0.967	0.004	83.366
13	0.004	-0.001	0.004	-1.313	0.000	83.366
14	0.027	0.033	0.043	0.685	0.016	83.382
15	-0.042	-0.036	0.056	0.866	0.028	83.410
16	0.013	0.014	0.019	0.731	0.003	83.414
17	0.020	0.003	0.020	1.440	0.004	83.418
18	-0.006	0.009	0.010	-0.563	0.001	83.419
19	-0.008	0.025	0.026	-0.301	0.006	83.425
20	-0.011	-0.023	0.026	0.451	0.006	83.431
21	0.011	0.015	0.019	0.628	0.003	83.434
22	-0.007	-0.019	0.020	0.339	0.004	83.437
23	0.008	-0.001	0.008	-1.429	0.001	83.438
24	-0.019	0.027	0.033	-0.626	0.010	83.448
25	0.023	0.004	0.023	1.401	0.005	83.453
26	-0.012	0.000	0.012	1.571	0.001	83.454

Table 4: Residual variance [$S_{z\,(P)}^{\wedge 2}$] for different orders of model

Lag	Autocovariance at lag zero, (Co) = 0.9836	Auto-correlation	Residual variance $S_{z\,(P)}^{\wedge 2}$	Lag	Auto-correlation	Auto-covariance	Residual variance $S_{z\,(P)}^{\wedge 2}$
1	0.419	0.4121	0.8120	**14**	0.039	0.0384	0.8421
2	0.137	0.1348	0.7982	**15**	0.030	0.0295	0.8428
3	0.103	0.1013	0.8005	**16**	0.046	0.0452	0.8436
4	0.083	0.0816	0.8027	**17**	0.062	0.0610	0.8446
5	0.015	0.0148	0.8036	**18**	0.063	0.0620	0.8454
6	0.042	0.0413	0.8051	**19**	0.093	0.0915	0.8485
7	0.119	0.1171	0.8172	**20**	0.077	0.0757	0.8491
8	0.153	0.1505	0.8289	**21**	0.074	0.0728	0.8505
9	0.133	0.1308	0.8337	**22**	0.079	0.0777	0.8524
10	0.111	0.1092	0.8361	**23**	0.056	0.0551	0.8531
11	0.124	0.1220	0.8411	**24**	0.059	0.0580	0.8537
12	0.065	0.0639	0.8409	**25**	0.063	0.0620	0.8543
13	0.054	0.0531	0.8417	**26**	0.061	0.0600	0.8549

significant.

Above three criteria were used to identify the number of significant harmonics and used in modelling periodic component. Accordingly, the first four harmonics were considered in modelling the periodic component and the deterministic periodic component, $P_{(t)}$, has been computed for all values of t, where t is the total period. After determining the periodic component, the same was then removed by deducting it from the ET_o series. The remaining series is a stochastic component part, which is required to be fitted by an autoregressive model of suitable order.

Stochastic component (S_t)

For modelling the stochastic component, autocorrelation function is required. Selection and estimation of autoregressive parameters is based upon the determined values of autocorrelation function of different lags. To obtain the estimates of the parameters for different model order, Equation (8) and (9) were solved recursively.

Residual variance method has been used as a criterion to determine the order of autoregressive model. The estimated values for 26 lags are presented in Tables 4. Similarly Akaike Information Criterion (AIC) for first, second and third order model were estimated and compared for confirmation.

It is observed from Table 4 that residual variance was found to be minimum for the second order of autoregressive model. Similarly AIC for first, second and third order of model were obtained to be -301.13, -324.18 and -317.99 respectively. According to the comparison made, second order of autoregressive model has been selected because of minimum residual variance and AIC (Subbaiah, 2004). The selected model order and parameters are given in Table 5.

Table 5: Selected model order and autoregressive parameters

Station	Model order	$\Phi_{(p,k)}$	Value
Akola	AR(2)	$\Phi_{(2,1)}$	0.439
		$\Phi_{(2,2)}$	-0.047

The estimated parameters of selected model order were tested for the stationarity conditions. The stationarity conditions of second order model were used. The stationarity conditions to be met and their value are presented in Table 6.

Table 6: Compliance of stationarity conditions by model parameters

S. N.	Condition	Value
1	$\Phi_{(2,1)} + \Phi_{(2,2)} < 1$	0.392
2	$\Phi_{(2,2)} - \Phi_{(2,1)} < 1$	-0.485
3	$-1 < \Phi_{(2,2)} < 1$	-0.047

It is seen from Table 6 that the estimated parameters of selected autoregressive model complied with the stationarity conditions applied. Therefore it can be concluded that selected AR(2) model is stationary and can be used to represent the stochastic component of ET_o series. The residual series, a_t, is obtained using Equation (10) i.e. by deducting the generated series, which is the sum of periodic and stochastic component, from the historical time series. The analysis of obtained residual series showed that the residual series had zero mean.

Since the ET_o series were trend free, the sub-models of periodic and stochastic component were added together to form the newly developed model structure of the reference evapotranspiration series. The mathematical structure of the additive model can now be presented for weekly ET_o series as given below.

$$ET_o = 5.39 - 1.792\ Cos(2\delta t/p) + 1.839\ Sin(2\delta t/p) - 0.521\ Cos(4\delta t/p) - 1.281\ Sin(4\delta t/p) + 0.213\ Cos(6\delta t/p) + 0.661\ Sin(6\delta t/p) - 0.221\ Cos(8\delta t/p) - 0.262\ Sin(8\delta t/p) + 0.439\ S_{t-1} - 0.047\ S_{t-2} + a_t$$

The formulated model superposes a periodic-deterministic process and a stochastic component and it has been used to generate similar sequenced series of weekly reference evapotranspiration.

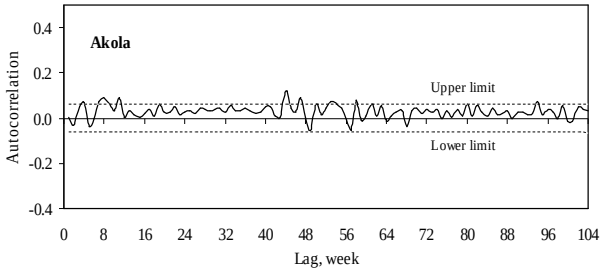

Fig. 3 Correlogram of the residual series

The formulated models were subjected to diagnostic checking for either rejection or acceptance. The resulting correlograms of residual series of ET_o are shown in Fig.3 along with the confidence limit at 0.05 level of significance. It shows that the autocorrelation

functions fall fairly within the confidence limits and almost all the coefficients are very small and hence can be treated as non-significant. It also indicates the suitability of the model for the ET_o series and the residuals were assumed to be white noise (random). So we can use this model and generate values of weekly reference evapotranspiration. The sum of squares of residuals and deviation of historical ET_o series from their mean value were estimated. The value of measure, R^2 was obtained and found to be 0.8539, indicates that the developed model has a best goodness of fit to generate weekly reference evapotranspiration series.

Performance evaluation of stochastic model

Generating the ET_o time series was first checked using the developed weekly ET_o model. The statistical characteristics of the historical series and their mean value for generated series were compared and presented in Table 7.

Table 7: Statistical characteristics of historical and generated series of weekly reference evapotranspiration

Statistical property	Historical value	Generated mean value	95% confidence limits	
Mean	5.388	5.387	5.4647	5.3090
Standard deviation	2.354	2.350	2.4131	2.2869
Variance	5.540	5.523	5.8205	5.2259
Skewness	1.165	0.704	0.8292	0.5782

The results show that for historical and generated series, basic statistical characteristics are not significantly different. It is also observed that statistical characteristics of historical and generated series were well within limits; only skewness of historical series was slightly higher. Other characteristics like mean, standard deviation and variance fall within interval at each station. Therefore it can be concluded that the formulated models preserve the historical statistics. Hence the model structure formulated may be employed for the long term generation of weekly ET_o series, which can be used in planning and operation of irrigation projects.

One step ahead forecasting was also made for the period of two years (2006 to 2007) using formulated models. The variation between original and predicted reference evapotranspiration series are presented in Fig.4. The basic statistical characteristics of the original and predicted series were also estimated for comparison as shown in Tables 8. Different performance indices were also worked out to evaluate the adequacy of formulated models in prediction of ET_o and presented in Table 9.

Table 8: Statistical characteristics of original and predicted weekly reference evapotranspiration series (2006 – 2007)

Series	Mean mm day^{-1}	S.D. mm day^{-1}	Skewness	Variance
Original	4.21	1.84	1.30	3.39
Predicted	4.10	1.95	0.99	3.78

Table 9: Performance indices of models developed

MAE, mm day^{-1}	MARE	RMSE, mm day^{-1}	Correlation coefficient	Coefficient of determination	Index of agreement	Model efficiency
0.43520.1218	0.5133	0.9661	0.9333	0.9811	0.9214	

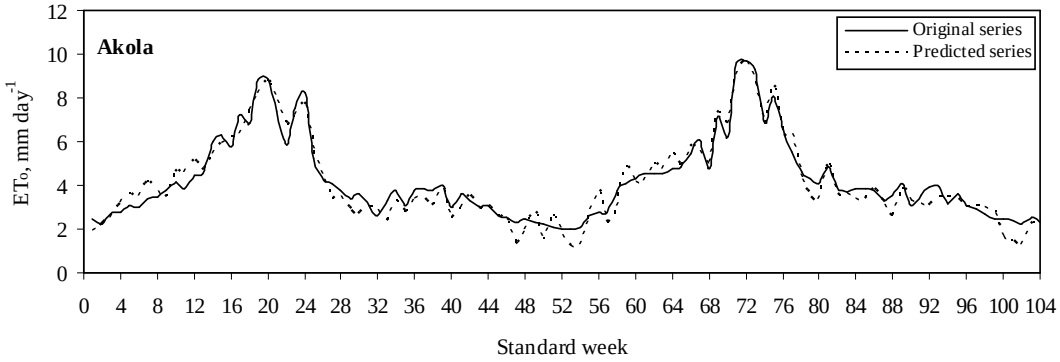

Fig. 4: Variation between original and predicted reference evapotranspiration for 2006-2007

There is a close agreement between original and predicted reference evapotranspiration throughout both the years (Fig. 4). It is seen from Table 8 that the statistical characteristics like mean, standard deviation, coefficient of skewness and variance for original and predicted series, are not significantly different. The data (Table 9) for original and predicted series of two years (2006 and 2007) indicate adequacy of formulated model for predicting reference evapotranspiration series. MAE, MARE and RMSE were found to be low enough at all stations. Higher values of correlation coefficient, determination coefficient, index of agreement and model efficiency confirm the reliability of the model.

CONCLUSION

It can be concluded that the formulated periodic-deterministic - stochastic model can be used for the generation or prediction of weekly reference evapotranspiration series.

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Testing of Modified Green Chickpea Pod Stripping Cum Shelling Machine

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ABSTRACT

A study was conducted in the year 2008 with an objective of preparing test procedure and testing of machine. Development of green chickpea pod stripping cum shelling machine is important because green chickpea is widely appreciated as health food. It is a protein rich supplement to cereal-based diets, especially to the poor in developing countries, where people are vegetarians or cannot afford animal protein. It can be marketed after shelling at higher profit to urban areas. Export of this produce may fetch foreign exchange. Thus the profit of farmers and rural entrepreneurs will increase. Also it will develop suitable agrobased industries in rural areas besides generating employment. The machine was developed at AICRP on Post Harvest Technology, College of Agricultural Engineering, Jabalpur. This machine mainly consists of three units viz. stripping, shelling, and cleaning unit. The capacity, stripping and shelling efficiency was observed to be 24 kg/h, 93.66 % and 89.44 per cent, respectively.

Chickpea is called Bengal gram or Gram *(Cicer aritinum* L.) in South Asia and it is a major pulse crop in India, widely grown for centuries and accounts for nearly 40 percent of the total pulse production. India is a major chickpea growing country of the world, accounting for 61.65 percent of the total world area and 68.13 percent of the total world production. Chickpea is widely appreciated as health food. It is a protein rich supplement to cereal-based diets, especially to the poor in developing countries, where people are vegetarians or can not afford animal protein. Chickpea has a very important role in human diet in our country. Green chickpea (*Cicer aritinum* L.) can be marketed after shelling, at higher profit to urban areas. Thus the profit of farmers and rural entrepreneurs will increase manifold. Export of this produce may fetch foreign exchange as its export potential exists in countries like USA, U.K., Canada, Saudi Arab, UAE, Srilanka, Malaysia, etc. (Anonymous, 2002).

Sustainable agricultural development needs designing and development of on farm processing machines for value addition. This will necessary for employment of agricultural labour and creation of agrobased industries in rural areas. Keeping in view the facts placed above, a machine has been developed at AICRP on Post Harvest Technology, College of Agricultural Engineering, Jabalpur which have functions like detaching the green chickpea pods from the plants, shelling the pods and separating the green seeds from the green husk of pods. However, there is no standard procedure of Bureau of Indian Standards for testing of this machine; hence a project was under taken to prepare a test procedure and testing the performance of the machine.

MATERIAL AND METHODS

Theoretical Consideration

The green chickpea stripping cum shelling machine mainly consists of three units which are stripping, shelling and cleaning units. The performance of these three units is affected by a number of crop and machine parameters.

Theoretical Capacity of Stripper

The theoretical capacity of stripper was calculated on the following observations while testing the machine.

1. One fourth circumference of stripper comes in contact with plant at the time of stripping
2. Three fourth length of plant is in contact with stripper

Calculations:

Diameter of the stripper = 260 mm

Therefore, circumference = $p \times 260 = 817$ mm

Considering time for which the plant is held before stripping unit is 15 seconds

The part of plant which can be stripped off in one second

$$= \frac{(1/4 \times 817)}{15} = 0.0136 \text{ m}$$

Considering, the rpm of the stripper to be 110.

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The length of the plant that would be stripped of in one hour

= 0.0136 × 1.83 ×3600 = 89.597 m (110/60 = 1.83 rps)

It was observed that, average length of the plant of variety JG315 = 0.478m

Therefore, part of the plant in contact with stripper = 3 / 4 × 0.478 = 0.359 m

Average weight of one plant = 0.125 kg

Thus, weight of plant that would be stripped off in one hour

$$= \frac{89.597 \times 0.125}{0.359} = 31.20 \text{ kg/ h}$$

Hence, theoretical capacity = 31.20 kg/h

Details and Operations of Machine

The green chickpea stripping cum shelling machine consists of stripping unit, shelling unit and cleaning unit. The machine occupies a floor area of 0.645 m × 1.455 m and its height is 1.765 m. Preliminary trials were conducted on a sample size of 500 g green chickpea plants for various speeds of shelling rollers (& obviously stripping roller)

A bunch of green chickpea plants is held in front of the stripping unit in such a way that leaves and pods are projected into the stripping loops and on rotation of the stripping cylinder, the pods are detached from the plants. The detached pods along with shreddings fall in the shelling unit, which consists of three rollers of 12 gauge m.s. sheet, upper two enclosed with rubber with corrugated metal sheet and third (lower) with only corrugated rubber sheet.

The upper two rollers operate at different speeds. One is fast (190 to 585 rpm) and other is slow (53 to 185 rpm) in reverse direction. The third roller operates at medium speed (81 to 265 rpm) having direction same as the fast roller (Table 1). As the pod falls on the rollers the slow roller offers compression and consequently holds the pod. Fast roller develops shearing force on pod. The third roller operates at medium speed and is used to improve the shelling. Because of this third roller, the double shelling action is given for getting better shelling efficiency. After shelling the husk and the green seeds drop in the cleaning unit in front of the blower, where the husk is blown off and the green seeds drop as the final product.

Fig. 1: Modified green chickpea pod stripping cum shelling machine

Procurement of Chickpea for testing

Freshly harvested Chickpea (JG315) plants were procured from the local market. The moisture content of green seed was observed to be 72.66 percent (wb).

Testing of stripping unit

In BIS No.: 3327-1965 the procedure for testing a foot operated paddy thresher is mentioned. This procedure was modified and adopted for testing the stripping unit of the machine. The details are given as follows.

Stripping efficiency was calculated by using the following expression.

Stripping efficiency (in percent)

$$= \frac{\text{(1-Weight of pods left on plants after stripping)}}{\text{Weight of plant fed}} \times \frac{\text{(1-Weight of shreddings)}}{\text{Weight of plant fed}} \times 100$$

(Mandhyan *et al.*, 2001)

Shelling unit

The shelling unit was tested as per the Indian standard specification for paddy dehusker no. IS: 8824 – 1977. This procedure was modified and adopted for testing the stripping unit of the machine. The details are given as follows.

Length of travel

The knowledge of length of travel is required to decide the clearance between the rollers. On the basis of dimensions of the pod, the length of travel of pod is calculated. Length of travel is an important factor affecting the breakage. It gives the idea about relation between clearance and breakage.

The complete path of travel of pod is calculated by the expression.

$$L = [0.5D (d-b) + 0.25(d^2-b^2)]^{0.5} \quad \text{(Phirke, 2004)}$$

Where, D = roller diameter

b = clearance between the rollers

d = initial size of the pod

L = length of section of path

Length of travel or path for 8 mm, 9 mm and 10 mm clearance is 35.50 mm, 26.88 mm and 13.54 mm, respectively. From these calculated results it is observed that as the clearance increased the length of travel decreased.

Calculation of shelling efficiency

Shelling efficiency was calculated by following expression

$$hc\ hulling = E\ hulling \times E\ wk$$

$$E\ hulling = \frac{(n_1 - n_2)}{n_1}$$

Where n_1 = amount of pods before hulling, kg

n_2 = amount of unshelled pod after hulling, kg

The coefficient of wholeness (E wk)

$$E\ wk = \frac{k_2 - k_1}{(k_2 - k_1) + (d_2 - d_1) + (m_2 - m_1)}$$ (Chakraverty, 1995)

Where,

$(k_2 - k_1)$ = yield of whole green seeds

$(d_2 - d_1)$ = yield of broken green seeds

$(m_2 - m_1)$ = yield of mealy waste in the product

RESULTS AND DISCUSSION

Preliminary trials were conducted to fix the range of annular gap between the top two rollers for shelling JG315 variety of green chickpea and three gaps identified were 8 mm, 9 mm and 10 mm. In second stage shelling the gap between top and bottom roller was kept 7 mm, 8 mm and 9 mm against the gap between top two rollers.

The results are presented with the help of graphs and tables. Their interpretation is also discussed in the following paragraphs.

Effect of speed of stripper on stripping efficiency and capacity of machine

The effect of speed on capacity is as shown in Fig. 2. It was observed that as the peripheral speed increased in the experiment zone, capacity increased from 18.46 kg/h at 1.306 m/s to 24 kg/h at 2.246 m/s. The actual capacity is somewhat low as compared to the theoretical capacity of 31.20 kg/h. This may be due to the reason that theoretical capacity was calculated on single plant basis and at no load condition offering zero resistance to the movement of plant inside the stripping unit.

It can be observed from the Fig. 2 that as the peripheral speed increased, there is increase in stripping efficiency but after some time it decreased. This is because with the pods the shreddings are increased and that results in reduction of stripping efficiency.

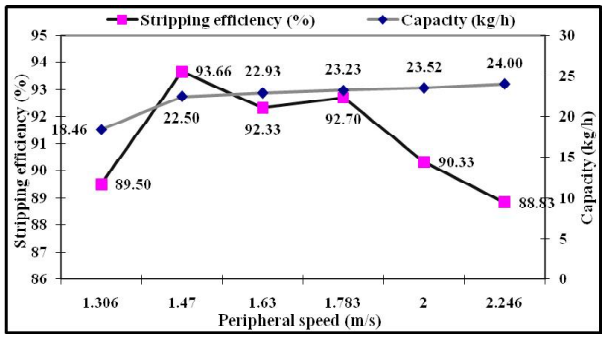

Fig. 2. Effect of speed of stripper on stripping efficiency and capacity

Effect of gap between the rollers, speed of rollers and speed ratio on shelling efficiency

The tests results of the green chickpea pod stripping cum shelling machine are shown in Table 1. A close look reveals that best operating parameters for shelling are top gap – 10 mm gap between rollers, bottom gap – 9 mm, 415 rpm of fast roller, 190 rpm of medium roller and 108 rpm of slow roller with the speed ratio 4: 1.5: 1 (Fast : Medium : Slow) where the shelling efficiency of 89.44 percent was obtained (Fig. 3).

Table 1 revealed that the best result of (3: 1.5: 1 speed ratio for) shelling efficiency 81.88 percent was

Table 1: The test results of the modified green chickpea pod stripping cum shelling machine

S.N.	Results										
	TopGap (mm)	Bottom Gap (mm)	Feed Rate (kg.)	RPM Stripper	Stripping efficiency (%)	RPM slow Shelling Roller	RPM Fast Shelling Roller	RPM Medium Shelling Roller	Coefficient of Hulling	Coefficient of Wholeness	Shelling Efficiency (%)
1	9	8	1	93	87.30	105 (1)	345 (3)	123 (1.5)	0.89	0.72	64.08
2	9	8	1	105	89.88	117 (1)	380 (3)	170(1.5)	0.93	0.74	68.82
3	9	8	1	126	89.63	140 (1)	460 (3)	210(1.5)	0.93	0.62	57.66
4	9	8	1	147	90.33	170 (1)	540 (3)	255(1.5)	0.94	0.61	57.34
5	10	9	1	105	85.97	126 (1)	395 (3)	170(1.5)	0.89	0.92	81.88
6	10	9	1	126	85.19	138 (1)	475 (3)	220(1.5)	0.89	0.86	76.54
7	10	9	1	147	89.55	160 (1)	525 (3)	235(1.5)	0.90	0.80	72.00
8	10	9	1	165	88.83	185 (1)	585 (3)	265(1.5)	0.90	0.74	66.60
9	8	7	0.5	48	83.32	53 (1)	190 (3)	81(1.5)	0.84	0.77	64.68
10	8	7	0.5	66	84.45	77 (1)	252 (3)	123(1.5)	0.97	0.67	64.99
11	8	7	0.5	93	83.61	96 (1)	310 (3)	129(1.5)	0.95	0.61	57.95
12	8	7	0.5	108	84.56	114 (1)	350 (3)	170(1.5)	0.95	0.68	64.60
13	10	9	1	117	88.65	108 (1)	415 (4)	190(1.5)	0.86	1.04	89.44
14	9	8	1	108	89.71	102 (1)	395 (4)	180(1.5)	0.87	0.99	86.13
15	8	7	1	108	93.66	99 (1)	370 (4)	170(1.5)	0.93	0.56	52.08
16	10	9	1	92	90.79	69 (1)	270 (4)	126(1.5)	0.80	0.74	59.20
17	10	9	1	96	89.50	78 (1)	320 (4)	150(1.5)	0.91	0.94	85.54
18	10	9	1	120	92.33	105 (1)	405 (4)	190(1.5)	0.90	0.89	80.10
19	10	9	1	131	92.70	125 (1)	425 (4)	210(1.5)	0.87	0.92	80.04

Note – Figures in parentheses shows speed ratio of the rollers

obtained for the operating parameters top gap - 10 mm clearance, bottom gap – 9 mm, 395 rpm of fast roller, 170 rpm of medium roller and 126 rpm for slow roller. It was the second best shelling recovery in all the tests which have been taken during testing.

Shelling is a function of compression, shear and abrasion. Here, the compressive forces are controlled by the gap and shear forces by varying speed ratios. In this machine the trend revealed that shelling efficiency is lower when gap is more also when the gap is less. The reason is that when gap is less, crushed green seeds are obtained in larger quantity because of higher compression and in case of more gap unshelled pods are obtained in large quantity because of less shearing action.

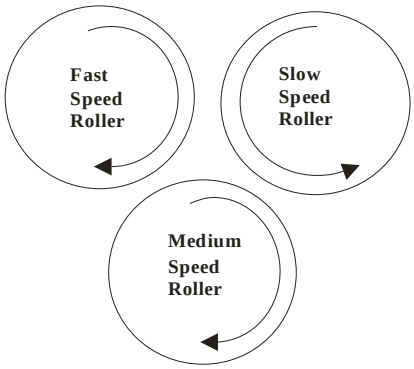

Fig.3 Principle of shelling unit

CONCLUSIONS

1. The capacity of the machine was 24 kg h^{-1}
2. The stripping and shelling efficiency were 93.66 and 89.44 per cent, respectively.

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RESEARCH NOTES

Phenology and Floral Morphology of Large Cardamom

Large cardamom (*Amomum subulatum* Roxb.) is an endemic cash crop of the Eastern Himalaya with its origin in Sikkim and mostly cultivated in Sikkim, Darjeeling, Nagaland, Uttarakhand, Manipur, Arunachal Pradesh and some parts of the North Eastern India. The plant is a perennial herb having subterranean rhizomes which give rise to leafy shoots and inflorescences. Leafy shoots are also called pseudostem and ranges from 1.5 to 3.0 m in height. Inflorescence is a condensed spike on a short peduncle bearing 40 to 50 flower buds in acropetal succession. This is essentially a cross pollinated crop due to its heterostylic (pin type) nature of flowers, though they are self fertile. It grows wild in ecosystem and also domesticated in the sub-Himalayan region, at altitudes ranging from 1000 to 2200 m above mean sea level. In the recent past there is considerable decline in the productivity of large cardamom contributing to seasonal and climatic changes (Saju *et al.* 2011). Phenology refers to periodic plant life cycle events influenced by seasonal and inter annual variation in climate and important for better understanding of ecological adaptations, interaction of individual cultivars and for germplasm conservation (Kasarkar and Kalkarni, 2011). The present paper deals with the phonological and floral morphological observations of four cultivars of large cardamom viz., Ramsey, Ramla, Sawney and Varlangey grown in Pangthang, East Sikkim with meteorological interactions.

The experiment was conducted in the years 2010-2011 with Randomized Block Design (RBD) with six replications at Indian Cardamom Research Institute, Regional Station, Spices Board, Research Farm at Pangthang, East Sikkim. The Pangthang farm is situated between $27^0$22'28''N latitudes and $88^0$37'20''E longitudes. The farm is situated at an altitude of 2160 M amsl. The climate and rainfall pattern of Pangthang farm was recorded during the period 2010-2011. The age of the plantation was 5-7 years with the spacing of 1.5 x 1.5 m plant to plant and row to row distance.

The phonological observations like tiller initiation time, tiller maturation period, flowering period, anthesis and specific period for fruit formation and floral morphological observations like flower length (cm), calyx and corolla length (cm), labellum length (cm) and shape, filament and style length (cm), stamen and ovary size(cm) were studied from different cultivars of large cardamom.

Ramsey is well-suited to high altitudes (1,500 m above mean sea level) and can be cultivated in steep slopes. This cultivar is identified by the maroonish colour of the tillers and narrow leaves. Its plants are 1.5-2.0 m tall, robust with a large number of tillers. Ramla is restricted to a few high altitude areas in North Sikkim. Colour of tillers resembles to that of Ramsey and leaves are broad and long. Its plant is 1.5-2.0 m tall and vigorous like Ramsey. Sawney is a widely adapted cultivar, which is most suited to medium and high altitude areas. Its plant is 1.5-2.0 m tall, robust in nature, leaves are ovate and broad. Varlangey grows in mid and high altitude areas. Its yield performance is exceptionally high at high altitudes. Its plant is 1.5-2.5 m tall, robust type and resembles to Ramsey with narrow leaves having wavy margins. Phenology and floral morphology of different cultivars are recorded in Table 1 and 2. The graphical representation of monthly average temperature maximum and minimum in degree Celsius of Pangthang farm during the period 2010- 2011 are given in Fig. 1 and Fig. 2. The graphical representation of monthly average rainfall in mm. of Pangthang farm during the period 2010- 2011 is given in Fig 3.

Tiller initiation tooke place in the month of November. The average maximum and minimum temperature in November 2010-11 were 11.15^0C and 6.73^0C, respectively. Monthly average rainfall in November 2010-11 was 2.6 mm. Tiller initiation to maturation period was found to be 11 months in all the four cultivars at Pangthang condition. The flowering period was March to August. The average maximum and minimum temperature during flowering period were

Table 1: Phenology of different cultivars of large cardamom

S.N.	PARAMETER	RAMSEY	RAMLA	SAWNEY	VARLANGEY
1.	Tiller initiation	November	November	November	November
2.	Tiller maturity period after initiation	24 months	24 months	24 months	24 months
3.	Flowering period	May-August	May-July	March-May	May-July
4.	Flower opening time				
	On sunny days	8.00-8.30 am	8.30-9.00 am	4.00-4.30 pm	8.00-8.30 am
	On rainy & cloudy days	8.30-9.00 am4	.00-4.30 pm	8.00-8.30 am	8.30-9.00 am
5.	Flower closing time	4.00-4.30 pm	8.00-8.30 am	8.30-9.00 am	4.00-4.30 pm
6.	Longevity of flower	14 hours	14 hours	14 hours	14 hours
7.	Dehiscence of anther				
	On sunny day	9.15-9.30 am	9.15-9.30 am	9.15-9.30 am	9.15-9.30 am
	On rainy & cloudy days	9.45-10.00 am	9.45-10.00 am	9.45-10.00 am	9.45-10.00 am
8.	Receptivity of stigma	12.00-2.00 pm	12.00-2.00 pm	12.00-2.00 pm	12.00-2.00 pm
9.	Flower bud initiation.	6.30-7.00 am	6.30-7.00 am	6.30-7.00 am	6.30-7.00 am
10.	Time period for fruit maturity after pollination	3-4 months	3-4 months	3-4 months	3-4 months

Table 2: Floral morphology of different cultivars of large cardamom

S.N.	CHARACTERS	RAMSEY	RAMLA	SAWNEY	VARLANGEY
1.	Flower length(cm)	5-6	5-5.5	6-6.7	5.5-6.5
2.	Calyx length (cm)	4.5-4.8	3.5-4	4-4.5	3.8-4.5
3.	Corolla tube length (cm)	2.1-2.5	2-2.5	2.5-2.7	2.2-2.8
4.	Labellum length (cm)	2.8-3.4	2.8-3	2.8-3	2.3-3.4
5.	Labellum shape (apex)	Round	Round	Round	Round
6.	Stamen size (cm)	1.9-2	2.3-2.6	2.2-2.5	1.8-2.3
7.	Filament length (cm)	0.6-1	0.6-1.1	0.8-1	0.5-0.8
8.	Style length (cm)	4-4.8	3.9-4.5	4.7-4.9	3.4-3.8
9.	Ovary size (cm)	0.4-0.5	0.4-0.6	0.4-0.6	0.4-0.6

19.22^{0}C and 13.28^{0}C, respectively in 2010 and 17.65^{0}C and 12.02^{0}C, respectively in 2011. A monthly average rainfall during flowering period in 2010-11 was 20.14 mm. The longevity of the flower was 14 hours (Gupta and John, 1987). Bud initiation period was from 6.30 to 7.00 am, flower opening period was 8.00 to 8.30 am on sunny days and 9.45 to 10.00 am on rainy and cloudy days. Opening of flower is early in the morning might be due to humidity in the nature. The flower closing period was 4.00 to 4.30 pm., 3 to 4 months were required for fruit formation and seed development. Some minute variations in floral morphology were observed among the cultivars (Thomas *et. al.*, 2009).

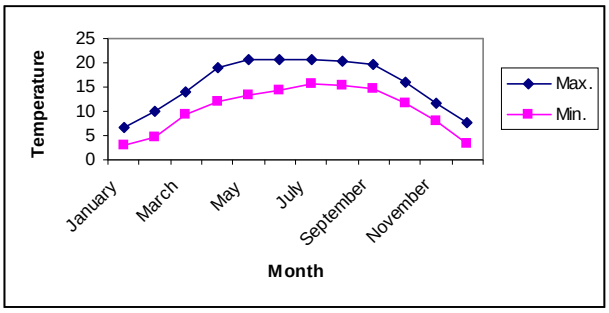

Fig. 1 : Graphical representation of monthly average temperature maximum and minimum in ^{0}C of year 2010

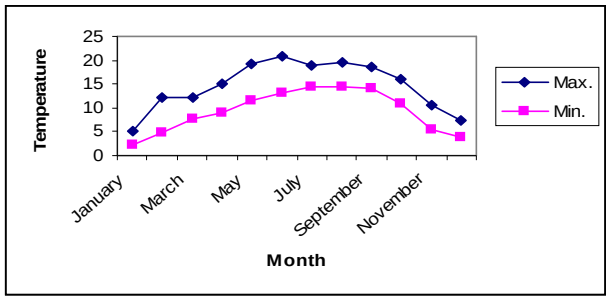

Fig 2: Graphical representation of monthly average temperature maximum and minimum in ^{0}C of year 2011

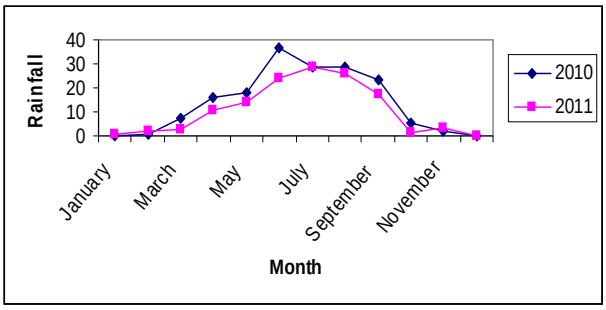

Fig 3 : Graphical representation of monthly average rainfall in mm of 2010 and 2011

Source: Indian Cardamom Research Institute, Regional Station, Spices Board, Pangthang research farm, East Sikkim

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Evaluation of the First Cycle Half-Sib Recurrent Selection Using Genetic Male Sterility in Safflower

Safflower (*Carthamus tinctorius* L.) is an important multipurpose *Rabi* oilseed crop of India and other countries of recent introduction. It is usually considered to be a self pollinated crop but the extent of cross pollination varies from 8 to 20 per cent depending mainly on insect activity and wind. There are twenty five species in the genus, out of which only *Carthamus tinctorius* L. 2n=24 is cultivated and used for oil production. The oil consists of 76 per cent linoleic acid (PUFA) which helps in reducing cholesterol level in human blood. In India, Maharashtra and Karnataka are the major safflower growing states accounting for 73 and 22 per cent area under safflower, respectively (Goyal, 2006). Breeders are paying more attention to population improvement programs and interested in applying more efficient breeding methods in self pollinated species to improve productivity potentials of these crops. One such method utilized to accumulate the desirable genes and to facilitate breaking of linkages is recurrent Selection. However, due to necessity for recombination in each cycle, this system has been principally used in out crossing species. Similarly, recurrent selection scheme designed for self pollinated crops, utilizing the mechanism like male sterility.

New random mating population which is being developed in collaboration with two safflower, AICRP centers viz. Akola and Solapur using new GMS line viz HUS-MS-305, which was supplied by Nagpur center. The material utilized for present study consisted of 135 families of safflower segregating for genetic male sterility and three checks viz., AKS-207, Bhima and PKV Pink were grown for evaluation in augmented block design in three blocks during 2011-12. Each block consisted 45 families and three checks which were randomized in each block. The spacing between plant to plant was 20 cm and row to row was 45 cm adopted to grow the crop. The experiment was conducted at the field of Oilseeds Research Unit, Dr. P.D.K.V. Akola. The data were recorded on three randomly selected fertile plants for days to 50 per cent flowering, days to maturity, plant height (cm), number of primary branches per plant, number of capitula per plant, number of seed per capitulum, 100 seed weight (g), oil content (%) and seed yield per plant (g.). The analysis of variance for augmented block design was worked out as per the standard method. (Hallauer, 1981).

Success in crop improvement programme depends on the amount of existing genetic variability and its utilization. The mean sum of square due to families were found significant for all the traits indicating that there was substantial variability existed among the half-sib families after first cycle of recurrent selection. Mean performance of yield and yield contributing character showed that seed yield plant^{-1} from 46.4 g (HS-30) to 75.4 g (HS-83), whereas check AKS-207 and Bhima plant^{-1} yielded 52.9 g, 53.0 g, respectively and PKV Pink 56.9 g . The estimation of genetic variance and additive variance was high and significant for plant height (67.33 and 269.32) followed by seed yield per plant (40.17 and 160.68), number of seeds capitulum^{-1} (29.52 and 118.08) number of capitula plantwere (20.78 and 83.12), days to 50 per cent flowering (7.97 and 31.88), days to maturity (4.41 and 17.64), oil content (2.52 and 10.08), number of primary branches per plant (0.77 and 3.08) and 100 seed weight (g) (0.11 and 0.45), repectively. The significant and high genetic variance among half-sib families was also reported Goyal (2006), Gawande (2010), Awchar (2011).

Estimates of heritability in narrow sense were ranged from 53.71 per cent for days to maturity to 70.20 per cent for seed yield plant^{-1}. (Table 1). High heritability was found for number of capitulas plant^{-1} (69.89 %) followed by plant height (69.73 %), number of seed capitulum^{-1} (68.61%), oil content (67.56%), day to 50 per cent flowering (65.92%), 100 seed weight (59.21%) while moderate heritability for number of primary branches plant^{-1} (56.20 %) and days to maturity (53.71%). Heritability is in determining the best method of selection to improve population for specific traits. High heritability has been reported in random mating populations of safflower for several agronomic traits by Goyal (2006), Reddii *et.al* (2010), Nagmote (2011) and Lande and Deshmukh (2012).

Expected genetic advance is a measure of expected progress under selection. In present study, the expected genetic advance at 5 and 10 per cent selection intensity expressed as per cent of population mean and

Table 1: Estimation of family component of variance and heritability in narrow sense

Half-sib family Component	Day to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches /pt	Number of capitula / plant	Number of seeds/ capitulum	100 seed weight	Oil content (%)	Seed yield / plant
σ^2 (H.S.) = M_F - M_E	7.97	4.41	67.33	0.77	20.78	29.52	0.11	2.52	40.17
σ^2 A = 4 x σ^2 (H.S.)	31.88	17.64	269.32	3.08	83.12	118.08	0.45	10.08	160.68 ^
σ^2 P (H.S.) = ¼ σ^2_A + σ^2_e	12.09	8.21	96.55	1.37	29.73	43.02	0.19	3.73	57.22
h^2 (n.s.) = $\frac{¼\ \sigma^2_A}{¼\ \sigma^2_A + \sigma^2_e}$	0.65	0.53	0.69	0.56	0.69	0.68	0.58	0.67	0.70

Table 2: Expected genetic advance per cycle using recurrent selection system

Unit evaluation yield selection	Cycle	Selection intensity	Days to 50% flowering	Days to maturity	Plant height (cm)	Number of primary branches/pt	Number of capitula/ plant	Number of seeds /capitulum	100 seed weight	Oil content (%)	and Seed
Expected genetic advance over population mean											
Half-sib	1	5%	5.49	1.89	18.97	17.95	42.96	33.15	9.60	8.26	19.09
		10%	4.68	1.62	16.20	15.29	36.72	28.32	4.52	7.08	16.31
Expected genetic advance over AKS- 207											
Half-sib	1	5%	5.60	1.91	21.94	21.25	51.40	35.39	9.48	8.58	20.66
		10%	4.85	1.32	20.06	17.24	35.72	29.95	4.61	7.59	17.61
Expected genetic advance over Bhima											
Half-sib	1	5%	5.69	1.93	23.49	20.23	41.79	35.06	9.77	8.84	20.66
		10%	4.85	1.32	20.06	17.24	37.72	29.95	4.61	7.59	17.61
Expected genetic advance over PKV Pink											
Half-sib	1	5%	5.69	1.88	20.20	15.78	44.40	32.46	8.34	8.30	19.22
		10%	4.85	1.61	17.25	13.45	37.95	27.74	3.93	7.12	16.43

per cent over check varieties have been presented in Table 2. As regards the expected genetic advance expressed as percent of population mean at 5 and 10 per cent selection intensity was high for number of capitulas plant^{-1} (42.96 and 36.72) and number of seeds capitulum^{-1} (33.15 and 28.32) while moderate estimates for seed yield plant^{-1} (19.09 and 16.31), plant height (18.97 and 16.20) and number of primary branches plant^{-1} (17.95 and 15.29) and low estimate for oil content (8.26 and 7.08), days to 50 per cent flowering (5.49 and 4.68) and days to maturity (1.89 and 1.62). The expected genetic advance percent over the three checks AKS-207, Bhima and PKV Pink at 5 and 10 per cent selection intensity was highest for number of capitulas plant^{-1} 51.40 , 35.72; 41.79, 37.72 ; 44.40, 37.95, respectively, followed by number of seeds capitulum^{-1} (35.39 and 29.95), (35.06 and 29.95) and (32.46 and 27.74).

Considerable genetic variability was observed for the characters under study and thereby indicated the scope for further improvement of yield and its contributing characters in safflower. In safflower, Goyal (2006) reported 42.29 and 35.98 per cent increase in yield over population mean and Bhima respectively in random mating population similarly high estimates of expected genetic advance are also reported in random mating populations of safflower for several traits by Reddii *et al.* (2010), Nagmote (2011) and Lande *et al.* (2012),

In present study, 20 half-sib families significantly superior over checks AKS-207, Bhima and PKV Pink were selected on the basis of high seed yield per plant and other yield contributing characters. Goyal (2006) reported 41 lines significantly superior over Bhima and A1 from first, second and third cycle of recurrent selection, respectively. Nagmote (2011) reported that the top 21 progenies were selected on the basis of high seed yield per plant and other yield contributing characters over the check Bhima.

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Genetic Diversity in Durum Wheat

Wheat is the world's most important crop that excels all other cereal crops both in area and production, thereby providing about 20.0 per cent of total food calories for the peoples of the world. The extent of genetic variability has been considered as an important factor which is an essential pre-requisite for a successful hybridization program aimed at producing high yielding progenies. The selection of parents becomes more difficult if the improvement is made for a polygenetically controlled complex character like grain yield. Precise information on the nature and degree of genetic divergence would help the plant breeder in selecting potential accessions for utilization in breeding program. Quantification of genetic diversity existing within and between groups of germplasm is important and particularly useful in proper choice of parents for realizing higher heterosis and obtaining useful recombinants.
Mahalanobis generalized distance estimated by D^2 statistic (Rao, 1952) is a unique tool for discriminating populations considering a set of parameters together rather than inferring from indices based upon morphological similarities, eco-geographical diversity and phylogenetic relationships.

Thirty six genotypes of durum wheat were evaluated in '6x6' Lattice design replicated twice during *Rabi* season of 2011-12 at Wheat Research Unit, Dr. P.D.K.V., Akola (M.S.). Each plot consisted six rows spaced at 23 cm. Recommended agronomic practices and prophylactic measures were adopted for raising a good crop. Data were recorded for 12 morphological and yield characters on 10 competitive plants over two replications and mean values were used for analysis. Analysis for genetic divergence using Mahalanobis D^2 statistic was carried out as described by Rao (1952). On the basis of magnitude of the D^2 values, the investigated genotypes were grouped in to different clusters by employing Tocher's method as outlined by Rao (1952).

Based on D^2 values 36 accessions were grouped into four clusters (Table 1), cluster I and II were the largest consisting of 19 and 15 accessions respectively, while cluster III and IV were the smallest with one accession each. As reported by researchers on wheat (Peshettiwar *et al.*, 2009; Maniee *et al*., 2009; Kahrizi *et al*., 2010 a and b) diversity was not associated with geographical origin.

In the present evaluation, the pattern of distribution of genotypes from various geographical regions into different clusters was at random. This tendency of genotypes to occur in clusters irrespective of geographical boundaries demonstrated that geographical isolation alone was not responsible for genetic diversity. Murthy and Arunachalam (1988) have suggested that genetic drift and forces of natural selection over diverse environmental conditions within a country could cause considerable diversity compared to geographical isolation.

Maximum inter cluster distance was observed between cluster III and cluster IV (D^2 13.65), while the closest proximity was noticed between cluster I and cluster II (D^2 8.78) (Table 2). The maximum intra cluster distance was observed in cluster II (7.03) revealing the presence of divergent genotypes within cluster and this might have been due to gene exchange or selection practiced among the genotypes for diverse characters. Cluster I displayed the least intra cluster distance (6.41) revealing the similarity of 19 genotypes within the cluster. The average inter-cluster distances were higher than the average intra-cluster distances, which showed the presence of wide genetic diversity among the genotypes of different clusters than those of the same cluster. The presence of variability in 36 accessions was also reflected in the cluster means for 12 different traits evaluated (Table 3). The maximum cluster means were revealed by cluster I for straw yield. Cluster II showed highest cluster mean value for days to maturity and 1000 grain wt. Cluster III and cluster IV showed highest cluster mean value for tillers m^{-1} at 45 days and the genotypes within this cluster can be utilized for durum wheat improvement through further selection for desirable traits.

Analysis for estimating the contribution of various characters towards the expression of genetic divergence (Table 4) indicated that straw yield (28.73), followed by effective tillers m^{-1} at harvest (25.71%), grain yield (15.24%), days to heading (5.71%), plant height (5.40%), ear weight (5.24%), ear density (3.97%) and spike length (3.65%) contributed towards genetic divergence in this collection. Since they accounted for more than 70 per cent of total divergence in the material, these attributes of the plant architecture need greater attention.

Table 1: Distribution of genotypes in different clusters by Tocher's method

Clusters	No. of genotypes	Genotypes
I	19	MPO-1275, UPD-94, GW-1286, MACS-3892, PBND-6054, PDW-333, PDW-332, HI-8739, MPO-1276, PDW-331, RKD-248, PDW-291, WHD-952, GW-1288, GW-1289, MACS-3929, HI-8738, GW-1287, PDW-334.
II	15	NIDW-706, MACS-3895, HI-8735, UAS-443, UAS-444, HI-8736, HI- 8737, DDW-23, HD-4727, DBW-17, RKD-247, WHD-951, HI-8498, AKDW-4750, HI-8740
III	1	NIDW-295
IV	1	DDW-24

Table 2: Average intra (Bold) and inter cluster (Without bold) distance (D="D^2)

Clusters	I	II	III	IV
I	**6.41**	8.78	12.35	9.15
II		**7.03**	9.19	11.21
III			**0.00**	13.65
IV				**0.00**

Table 3: Cluster means for 36 genotypes of Wheat

Cluster	Days to heading	Tiller sm^{-1} at 45 days	Spike sm^{-1}	Days to maturity	Plant height (cm)	Spike length (cm)	Ear density	Ear weight (g)	1000 grain wt (g)	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Effective tiller sm^{-1} at harvest
I	66.00	126.21	59.03	117.26	94.82	6.15	2.82	3.44	45.78	33.55	128.54	56.29
II	67.57	117.27	62.67	117.43	94.71	6.32	2.78	3.60	46.25	40.68	105.90	61.60
III	67.00	152.50	70.00	113.50	94.79	6.27	2.93	4.11	34.00	46.01	101.23	72.00
IV	72.50	136.50	63.00	116.00	84.48	8.31	2.06	2.55	37.18	30.02	118.96	55.00
Variance	8.38	228.65	21.01	3.29	26.49	1.01	0.15	0.42	37.95	51.35	154.74	59.78

Table 4: Contribution of various characters towards genetic divergence

S. N.	Characters	Times ranked first	Contribution (%)
1	Days to heading	36	5.71
2	Tillers m^{-1} at 45 days	18	2.86
3	Spikes m^{-1}	3	0.48
4	Days to maturity	7	1.11
5	Plant height (cm)	34	5.40
6	Spike length (cm)	23	3.65
7	Ear density	25	3.97
8	Ear weight (g)	33	5.24
9	1000 grain wt (g)	12	1.90
10	Grain yield (q/ha)	96	15.24
11	Straw yield(q/ha)	181	28.73
12	Effective tillers m^{-1} at harvest	162	25.71

Relatively less contribution was made by tillers m^{-1}at 45 days (2.86%), 1000 grain wt (1.90%), days to maturity (1.11%) and spikes m^{-1} (0.48%). These observations are in accordance with Reddy (2001) for plant height and spikes/0.5 m^2, Singh and Dwivedi (2002) for days to heading, plant height, spikelet's ear^{-1}, Singh and Garg (2003) for plant height, number of tillers per unit area, spikelet's ear^{-1}, biological yield, Dobariya *et al*. (2006) for number of spikes/meter in wheat genotypes evaluated by them.

The results of the present study indicate the presence of genetic diversity among the tested durum wheat genotypes. Parents from divergent clusters can be used for hybridization in order to isolate useful recombinants in the segregating generations. Accessions from the two most divergent clusters NIDW-295 from cluster III and the one accession DDW-24 from cluster IV were identified as potential parents in feature endeavors for improvement of durum wheat. Emphasis needs to be given to straw yield, effective tillers m^{-1} at harvest, grain yield, days to heading, plant height, ear weight, ear density and spike length during selection to improve grain yield in durum wheat. This information might be used in the genetics and breeding programs for improvement of durum wheat.

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Effect of Phosphorus, PSB and Sulphur on Yield, Quality and Nutrient Uptake in Soybean

An agronomic investigation entitled "Effect of Phosphorus, PSB and Sulphur on Quality and Nutrient Uptake in Soybean" was carried out during *Kharif* 2008-2009 at the farm of Agronomy Department, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The soil of experimental plot was Vertisol with uniform and leveled topography. Soil was slightly alkaline in reaction, medium in available nitrogen, low in available phosphorus and available sulphur and moderate in organic carbon.

The experiment was laid out in a split plot design with eight treatment combinations of four phosphorus levels viz. 0, 25, 50 and 75 kg P_2O_5 ha^{-1}, with and without PSB inoculation as main plot treatments and two levels of sulphur *viz.*, 20 and 40 kg S ha^{-1} as sub plot treatments with three replications.

Increasing level of phosphate application increased seed and straw yield of soybean significantly. Similarly, oil content in seed as well as oil yield were also increased. Goswami *et al*., (1991) reported similar findings. Protein content in seed was not affected but protein yield was increased due to phosphate application.

Result reported by Prasad *et al*., (1991) are in conformity with the findings of the present study.

PSB inoculation increased soybean yield by 1.87 q ha^{-1} but straw yield was not affected significantly. Oil content and oil yield were also increased by PSB inoculation. However, protein content in seed was unaffected.

As regards sulphur levels application of 40 kg S ha^{-1} recorded increase in seed and straw yield of soybean over 20 kg S ha^{-1}. Similarly, higher level of sulphur improved oil content as well as oil yield over lower sulphur level. Protein content in seed was not affected due to increase in sulphur level.

Table 1. Seed and straw yield , oil content, oil yield, protein content and protein yield (q ha^{-1}) as influenced by various treatments

Treatments	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})	Oil content (%)	Oil yield (q ha^{-1})	Protein content (%)	Protein yield (q ha^{-1})
A. Main plot treatments						
a. Phosphorus levels						
P_0 – 0 kg P_2O_5 ha^{-1}	18.64	29.50	17.27	3.23	36.94	6.88
P_1 – 25 kg P_2O_5 ha^{-1}	20.36	31.20	18.58	3.79	37.10	7.55
P_2 – 50 kg P_2O_5 ha^{-1}	21.50	32.84	18.88	4.07	37.16	7.99
P_3 – 75 kg P_2O_5 ha^{-1}	23.08	34.95	19.79	4.57	37.48	8.66
SE(m)±	0.46	0.51	0.28	0.12	0.28	0.17
CD at 5%	1.41	1.53	0.84	0.37	NS	0.52
b. PSB inoculation						
B_0 – Without PSB	19.96	31.79	18.38	3.68	36.99	7.38
B_1 – With PSB	21.83	32.45	18.88	4.14	37.35	8.16
SE(m)±	0.33	0.36	0.20	0.09	0.20	0.12
CD at 5%	0.99	NS	NS	0.26	NS	0.37
B. Sub plot treatments						
b. Sulphur levels						
S_1 – 20 kg S ha^{-1}	19.95	31.32	18.18	3.64	37.00	7.38
S_2 – 40 kg S ha^{-1}	21.84	32.92	19.08	4.18	37.34	8.16
SE(m)±	0.31	0.38	0.20	0.07	0.363	0.13
CD at 5%	0.93	1.15	0.59	0.22	NS	0.40

Interactions among different treatments except P x S were found not significant.

Table 2. Uptake of nitrogen, phosphorous and sulphur as influenced by various treatments

Treatment	Uptake of nitrogen (kg ha^{1})			Uptake of phosphorus (kg ha^{1})			Uptake of sulphur (kg ha^{1})		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
A. Main plot treatments									
a. Phosphorus levels									
P_0 – 0 kg P_2O_5 ha^{-1}	110.06	16.58	126.64	16.55	1.78	18.33	6.43	4.99	11.42
P_1 – 25 kg P_2O_5 ha^{-1}	120.81	19.09	139.90	18.18	2.35	20.53	7.17	5.40	12.57
P_2 – 50 kg P_2O_5 ha^{-1}	127.83	21.47	149.30	19.85	2.64	22.49	7.68	6.00	13.67
P_3 – 75 kg P_2O_5 ha^{-1}	138.62	24.76	163.38	20.69	3.38	24.07	8.69	6.89	15.58
SE(m)±	2.72	0.65	3.28	0.67	0.11	0.73	0.18	0.18	0.35
CD at 5%	8.26	1.98	9.96	2.03	0.34	2.21	0.53	0.54	1.05
b. PSB inoculation									
B_0 – Without PSB	118.16	19.12	137.28	17.78	2.23	20.01	7.37	5.71	13.09
B_1 – With PSB	130.50	21.83	152.33	19.86	2.84	22.70	7.61	5.93	13.54
SE(m)±	1.93	0.46	2.32	0.47	0.08	0.52	0.12	0.13	0.25
CD at 5%	5.84	1.40	7.04	1.44	0.24	1.56	NS	NS	NS
B. Sub plot treatments									
b. Sulphur levels									
S_1 – 20 kg S ha^{-1}	118.13	19.04	137.17	18.23	2.27	20.50	7.19	5.61	12.79
S_2 – 40 kg S ha^{-1}	130.53	21.91	152.44	19.40	2.80	22.20	7.80	6.03	13.83
SE(m)±	2.11	0.57	2.53	0.35	0.06	0.39	0.14	0.11	0.24
CD at 5%	6.34	1.70	7.59	1.04	0.17	1.17	0.42	0.32	0.72

Uptake of nitrogen, phosphorus and sulphur by grain and straw was studied at harvest. Increasing levels of phosphorus and sulphur increased the nitrogen, phosphorus and sulphur uptake by soybean significantly. Paratey and Wani (2005) also noted increased in phosphate uptake due to PSB inoculation.

PSB inoculation increased nitrogen and phosphorus uptake but sulphur uptake was increased significant.

The findings obtained indicate that application of 75 kg P_2O_5 and 40 kg S ha^{-1} was found beneficial in combination with PSB inoculation.

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Relative Incidence of Pink Stem Borer on different Late Sown Wheat Lines in Vidarbha Region

Pink borer, *Sesamia inferens* Walker, a polyphagous insect pest, originally a pest of rice (Pathak and Khan, 1994) became an important pest of wheat. Nagrajan (1989) and Singh (1986) described it as a well-established pest of wheat, occasionally causes heavy losses in restricted areas. In Rajastan (India), 5.7 to 11.1 % infestation of pink stem borer has been recorded in wheat varietal trials (Singh, 1986). Signs of its damage in wheat are similar to those recorded in rice and damage caused by larvae of this insect is expressed as "dead hearts' at seedling stage and 'white ears' at ear-head stage and causes 11 per cent reduction in yield in India (Deol, 2002, Saxena *et. al*., 1972 and Ahad *et.al*., 1994 and 1995).

Chemical control may cause several problems in agroecosystem. To overcome adverse effects of chemical management, it is a need to draw an attention of Researchers to develop resistant varieties against insect pests. A number of resistant varieties of different crops against different insect pests have already been developed. But very few sources of resistant (BAW 743 and BAW 769) are available in literature against this pest (Ahad *et al*., 2002). The present study was also undertaken to find any tolerant or resistant wheat lines suitable for breeding programme against this pest on the basis of borer infestation.

The field experiment was conducted at the Zonal Agricultural Research Station, Yavatmal, Maharashtra, India during Rabi season of 2009-2010 under irrigated conditions with 24 late sown wheat lines viz: AKAW-3722, AKAW-4127, AKAW-4210-6, AKAW-4510, AKAW-4627, AKAW-4649, AKAW-4694, AKAW-4697, AKAW-4705, AKAW-4706, AKAW-4710, AKAW-4719, AKAW-4722, AKAW-4723, AKAW-4728, AKAW-4734, AKAW-4735, AKDW-4021, AKW-381, NIAW-34, HD-2501, HI-977, AKAW-3997 and MACS-2826. The cultivated line AKW-381 was used as a check. The experiment was laid out in the Randomized Block Design with three replication having net plot size of 5m x 2m and plot to plot distance was 60cm. Wheat seeds were sown @ 10 lines $plot^{-1}$, the distance between rows were 20 cm and that plant to plant was 5 cm. The necessary agronomical practices were executed during the experimental period with no pesticidal application.

Pink borer infestation rates were assessed by weekly counting of dead hearts and/or white heads in each plot. Observations were recorded from 15 days to

three months after sowing of seed. The incidence was noticed from 10th February, 2010. The data on infestation and yield of tested wheat lines were analyzed statistically. The corresponding data on percent infestation transferred before statistical analysis into arc-sine values.

Infestation of Sesamia inferens Walker in form of deadheart were not observed in the fields so the infestation in the form of white head were counted which were varied significantly among the 24 tested wheat lines as shown in Table 1. The lowest incidence (2.42 %) of pink borer was observed in the line AKAW-4627 with 77.02 per cent decrease in wheat line AKDW-4021 with 23.46 percent increase in damage over the check.

Among the 24 tested wheat lines, three lines such as AKAW-4627, AKAW-4649 and NIAW-34 were statistically identical least infestation group and the percent infestation was in the tune of 2.42 to 5.63 percent white head infestation, with 77.02 to 46.53 per cent decrease in white head over check. Wheat lines such as AKAW-3997, AKAW-4649, AKAW-4127, HI-977, AKAW-4735, AKAW-4510 and AKAW-4210-6 were of moderate infestation in the tune of 7.22 to 10.83 per cent with 31.43 to 4.18 per cent decrease in white head over check. The control line AKW-381 was recorded 10.53 percent dead heart. Beant Singh (2012) also in the conformity of this study that comparatively higher incidence of pink stem borer in the month of March late sown crop may also be attributed to the second generation larvae of pink stem borer. Singh (1986) also noticed higher incidence of pink stem borer in late sown wheat.

Grain Yield

Significant difference in the grain yield of different wheat lines was observed (Table 1). The highest grain yield (43.75 q ha^{-1}) was recorded in the line AKAW-4627. Four wheat lines such as AKAW-4706, AKAW-3722, AKAW-4722 and AKAW-4734 were yielding in the range of 42.84 q ha^{-1} to 41.67 q ha^{-1}. The check line AKW-381 recorded 39.58 q ha^{-1} yields. Lowest yield was recorded by the wheat line AKAW-4697 i.e. 25.00 q ha^{-1}. The incidence of pink stem borer is in tillering stage and side tillers emerged after incidence of pink stem borer might have compensated some of the crop-loss. This might be one of the reasons for non-significant correlation in yield and the damage percent. Earlier, Jaipal *et. al.*, (2005) also reported compensatory tillering in pink stem borer infested wheat crop in Uchana (Haryana, India).

The results indicated that the lowest susceptibility was found in the line AKAW-4627, AKAW-4649 and NIAW-34. But the wheat line AKAW-4627 registered lowest per cent infestation as well as highest grain yield. Hence, considering the responses of wheat lines to infestation of *Sesamia inference* Walker and grain yield the cultivar AKAW-4627 is a valuable wheat line. Therefore it can be considered to include in breeding programme for developing of tolerant varieties.

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Table 1 : Per cent pod damage and yield of different wheat lines.

S.N.	Variety	% pod damage	% reduction over control	Yield kg/plot	Yield q ha^{-1}
1	AKAW-3722	11.89	-12.92	1.525	42.35
2	AKAW-4127	7.89	25.07	1.125	31.25
3	AKAW-4210-6	9.83	6.65	1.375	38.19
4	AKAW-4510	9.57	9.12	1.037	28.81
5	AKAW-4627	2.42	77.02	1.575	43.75
6	AKAW-4649	7.63	27.54	0.962	26.74
7	AKAW-4694	4.17	60.40	0.975	27.08
8	AKAW-4697	11.16	-5.98	0.900	25.00
9	AKAW-4705	10.09	4.18	1.237	34.37
10	AKAW-4706	11.45	-8.74	1.542	42.84
11	AKAW-4710	12.16	-15.45	1.087	30.20
12	AKAW-4719	12.05	-14.43	1.175	32.63
13	AKAW-4722	11.64	-10.54	1.500	41.67
14	AKAW-4723	10.97	-4.18	1.319	36.63
15	AKAW-4728	12.67	-20.32	1.200	33.33
16	AKAW-4734	10.79	-2.47	1.500	41.67
17	AKAW-4735	8.80	16.43	1.188	32.99
18	AKDW-4021	13.00	-23.46	1.175	32.63
19	NIAW-34	5.63	46.53	1.225	34.02
20	HD-2501	12.97	-23.17	1.275	35.41
21	HI-977	8.05	23.55	1.325	36.80
22	AKAW-3997	7.22	31.43	1.080	30.00
23	MACS-2826	10.08	4.27	0.981	27.26
24	AKW-381 (Check)	10.53	0.00	1.425	39.58
	F test	Sig.			Sig.
	SE (M)	1.05			0.74
	CD at 5%	3.23			2.28

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Effect of Feeding Soybean Straw on Dry Matter Intake and Milk Yield of Crossbreed Cows

Livestock depend on crop residues and grazing on uncultivable and fallow land. In India, the productivity of animal is very poor. As there is qualitative and quantitative shortage of feeds and fodder, there is deficiency of nutrient supply to the animals which may be major cause of low production. Cultivation of soybean crop in Maharashtra State increased in 2003-04 and contributes 65 per cent area production in Vidarbha region. Soybean has maximum nutritive value and it contains 20-21per cent oil, 40-42 per cent proteins and 20-30 per cent carbohydrates besides Vitamins A, B, complex vitamins, C, D, E, K and other essential amino-acid. The objective of this investigation is to study the effect of soybean straw on the quantity of milk of crossbreed cows.

The present study entitled was conducted at Livestock Instructional Farm, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola for a period 65 days from 26th December 2005 to 1st March 2006. Nine crossbred cows in 2nd and 3rd parity were selected having same lactation period. They were divided in 3 groups on the basis of nearness in milk yield and lactation period and subjected to feeding treatment. The treatment T_1 was 100 per cent. Jawar straw with sugrass concentrates. The treatment T_2 was 50 per cent jawar straw and 50 per cent soybean straw with Sugrass concentrates. The treatment T_3 was 100 per cent soybean straw with sugrass concentrates. The selected group was tested under different treatments by adopting "Switch over design". The animals were given feed of one treatment for a period on 15 days and shifted to next treatment before recording of observation of next treatment a gap of 7 days was given to eliminate the residual effect of previous treatments. The experimental crossbred cows were tied individually in conventional barn. The cows were examined for their health before the commencement of experiment. The normal routine management practices were followed as an when needed. Sufficient quantities of clean drinking water was provided thrice a day to all the cows. The crossbred cows were given measured quantity of feeds and fodder (2.5 kg 100 kg^{-1} body weight). The intake of feed and fodder was qualitatively monitored once in a week to assess the dry matter consumption by individual animal in the different treatments. Milk yield of individual cow was recorded daily in morning and evening from 1st day to final day of experimental period. The data were subjected to the statistical analysis by following the switch over design for testing their differences as per procedure described by Amble (1975).

The soybean straw, jawar straw and concentrate were provided to crossbred cows in different groups as per treatment. Daily feed intake of different feed stuff by the crossbred cows under different groups observed that the crossbred cows in T_1 group consumed 6.580 kg jawer straw while cows in T_2 group consumed 3.270 kg jawar straw and 3.270 kg soybean straw and cows in T_3 group consumed 6.410 kg soybean straw. Concentrate was fed to each cow in all groups @ 4 kg. On an average dry matter consumption of cows were 9.502, 9.450, 9.319 kg in T_1, T_2 and T_3 treatment, respectively.

Daily dry matter intake per day per cow was observed that DCP intake was 0.447, 0.601, 0.642 and TDN 4.751, 4.725 and 4.659 kg in T_1, T_2 and T_3 treatments, respectively. The intake of DCP was found lowest in T_1 and highest in T_3. Daily matter intake was 2.699, 2.684 and 2.687 kg 100 kg^{-1} body weight observed in T_1, T_2 and T_3, respectively. Similarly, Johri *et.al*., (1971) reported an intake of 2.56 and 2.60 kg DM 100 kg body weight in ruminant when soybean straw and green soybean were fed. Pachauri and Negi (1976) also observed higher intake of dry matter per kg was 0.75 on soybean straw based diet compared to wheat bhoosa.

The effect of feeding soybean straw on milk yield of crossbred cows of period was observed that the average milk yield of cows during experimental period was 118.222, 118.666 and 119.111 kg in treatment T_1, T_2 and T_3, respectively of crossbred cows. The average milk of yield was 7.881, 7.911 and 7.994 kg cow^{-1} day^{-1} in T_1, T_2 and T_3 treatment respectively. The milk yield was significantly highest in T_3 treatments, followed by T_2 treatment. The average milk yield of crossbred cows was different in different treatments. It indicated that feeding of soybean straw to crossbred cow was beneficial to increase milk production of cows.

Backer *et.al* (1986) reported that feeding of roasted whole soybean as a concentrate ingredient for lactating dairy cows increased milk yield. Schnogoethe

et. al. (1986) also observed that feeding of an extrude blend of soybean and soybean meal in diet containing maize silage, lucern hay and concentrate resulted in higher milk yield. Thus it is indicated that the milk yield of crossbred cow was increased by feeding of soybean straw. From the above investigation it could be concluded that the feeding of soybean straw to crossbred cows is beneficial to increase the milk yield of crossbred cows.

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Quality of Chhana Poda Prepared by Using Various Levels of Wheat Starch as Binding Material

The present investigation entitled "Quality of Chhana poda prepared by using various levels of wheat starch as binding material" was conducted to identify the acceptable level of wheat starch in chhana-poda and to determine the sensory and chemical qualities. Five different levels of wheat starch 0% (T_1), 2% (T_2), 4%(T_3), 6%(T_4) and 8%(T_5) was planned and studied. The data obtained was statistically analyzed by Randomized Block Design and the result revealed that fat, moisture and sugar content was decreased with increase the in rate of addition of wheat starch, total solids content was increased with increase in the rate of addition of wheat starch. The highest score for sensory attributes was obtained to the chhana poda prepared from blending of 6% wheat starch in respect to colour and appearance, flavor, body and texture, taste and overall acceptability.

"Poda" is a term purely spoken for 'burnt' product in dairy language. It is the only milk based indigenous delicacy prepared by baking. Mr.Kelu Behera in Pahel and Pratihari family in Puri were the first to prepare poda delicacy (Ghosh et al., 2002). This product has been served to Lord Jagannath in Puri as offering Prasad for hundreds of years. Chhana poda is made up of chhana and is famous in eastern part of India. It is a typical indigenous chhana cake manufactured by almost all sweet makers of Orissa (Ghosh et al., 1998). Chhana-poda is popularly known as poda throughout the state. It is very famous sweet and has regarded the same status as to Rasogolla in West Bengal and Laddu in Delhi. Rasogolla is known as the queen among the sweets in Bengal, chhana poda is the king of sweets (chhanapoda.com/society/yummy-chhana-poda/6-08-2011).Extensive work has been carried out on different aspects of chhana and chhana based sweetmeats. However, relevant literatures on chhana poda are scanty. Hence, the present investigation entitled "Quality of Chhana poda prepared

by using various levels of wheat starch as binding material" was conducted to identify the acceptable level of wheat starch in chhana poda.

Chhana prepared from cow milk of 3.5% fat, Cane sugar in crystalline (@25 %.), Baking powder (@2.5%) and wheat starch (as per treatments) purchased from the local market was used for Chhana-poda preparation. Five different levels of wheat starch 0% (T_1), 2% (T_2), 4%(T_3), 6%(T_4) and 8%(T_5) was planned and studied .Chhana - poda was prepared as per the procedure given by Ghosh et al. (2002).Fat was determined as per Soxhlet Method described by A.O.A.C. (1990). Total solids and moisture content of milk was determined by gravimetric methods as per IS: (1960).The Sugar content was determined as per ISI, Handbook of Food Analysis, SP:18, (Part XI) 1981. Chhana-poda prepared as per the treatments was judged for overall acceptability by a panel of judges with the help of 9.1 Hedonic scale as per procedure by Nelson and Trout (1964). The data obtained will be statistically analyzed by Randomized Block Design (RBD) as per the method suggested by Gomez and Gomez, (1984).

Fat content: The fat content of finished product for T_1, T_2, T_3, $T_4$and T_5 was 22.00, 21.54, 21.18, 20.68, and 20.60 respectively. The Fat content was noted to be lowest (20.60%) incase of 8 per cent wheat starch blended Chhana-poda (T_5) while the highest value (22.00%) in 0 per cent wheat starch blended Chhana-poda. Significant decreasing trend in fat content was noted due to increase in the rate of wheat starch blending.

Total solids content: Total solids were noted to be lowest (70.92%) in case of 0 percent wheat starch (T_1) in Chhana-poda, whereas the highest value (72.72%) in 8 percent wheat starch (T_4) treatment. It means TS increased due to increase in rate of addition of wheat starch. The results on TS content in Chhana-poda observed in present investigation is in agreement with that reported by Ghosh *et al.* (1998) which ranged between 67-70 percent. Similarly TS between 65.57 to73.23 per cent was also recorded by Dash et *al*.(1999).

Moisture content: The moisture content was lowest (27.28%) in case of 8 per cent Wheat Starch (T_5), while the highest value 29.08% was recorded in T_1 treatment (0%). For remaining treatments the moisture content was recorded as 28.68%, 28.24% and 27.50% in T_2, T_3 and T_4 respectively. Hence, this trend shows that moisture content was decreased due to increased in rate of addition of wheat starch. It might be due to presence of more TS in sugar and higher levels of wheat starch. Dash *et al* (1999) reported that moisture content of chhana-poda ranging between 26.71 to 34.43 percent. These findings are in close to the present study.

Sugar content: Sugar Content was noted to be lowest 25.72 per cent in case of 8 per cent Wheat Starch and highest 29.82 per cent in 0 per cent Wheat Starch. For remaining treatments the sugar content was recorded as 28.06, 27.36 and 26.84 in T_2, T_3, and T_4 respectively. Significant decreasing trend in sugar content was noted due to increase in the rate of wheat starch blending.

Sensory evaluation of Chhana-poda

It was observed that the effect of different levels of Wheat Starch on the various attributes of sensory evaluation of Chhana Poda was significant. Scores obtained for colour and appearance was 7.48, 7.55, 7.99, 8.56 and 7.70, for flavor 7.26, 7.47, 7.97, 8.38 and 7.67, for body and texture 7.54, 7.76, 8.20, 8.30 and 7.84 while for taste 7.44, 7.74, 7.92, 8.78 and 7.36, was recorded for T_1,T_2, T_3, T_4 and T_5 treatments' respectively. The mean score obtained for colour and appearance, flavour, body and texture, taste as well as overall acceptability was increased from T_1 to T_4 and then after decreased under T_5. The mean score of Overall acceptability from different levels of Wheat Starch were 7.43, 7.63, 7.97, 8.05, 7.64, in T_1, T_2, T_3, T_4, T_5 respectively. Thus, form the sensory evaluation studies it appears that 6 percent wheat starch produce acceptable and good quality Chhana Poda. Tambat *et al*. (1992) found that 4% maida was sufficient for preparation of Rasogolla. Addition of maida above 4% was caused rough appearance, hard body and coarse texture. Shelke *et al.* (2003) found that Rasogolla prepared by addition of 4% wheat starch got max., score and has better overall acceptability, these results are in supportive to the results of present investigation.

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