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SHORT NOTES

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Managementof *Spodoptera litura* in Organic Cauliflower Cultivation

S. K. Bhalkare[1], D. K. Shedge[2] and D. B. Undirwade[3]

ABSTRACT

Attempt to replace insecticides to which the *Spodoptera litura* had developed resistance have been made in present study of "Management of *Spodoptera litura*in organic cauliflower cultivation" to harvest the pesticide free produce. The experiment was laid in Factorial Randomized Block Design during *Rabi* season of 2020-21with twelve treatments replicated thrice. The treatments included were, Factor A with organic extracts viz., Triparni extract 10 per cent, PDKV organic formulation 10 per cent and PDKV botanical extract 10 per cent along with control. Wherein Factor B included incubation periods of organic extracts i.e. 7 days incubation, 15 days incubation and 30 days incubation. Finally, cauliflower curd yield was recorded in each of the net plot to compare the effect of different treatments against the major pests of cauliflower. The results revealed that among the treatments, minimum population of *S. litura* was observed in plots treated with 30 days incubated PDKV organic formulation (2.28 larvae plant^{-1}) followed by 30 days incubated PDKV botanical extract (2.68 larvae plant^{-1}) and 30 days incubated Triparni extract (2.85 larvae plant^{-1}). However, all these treatments were found at par with each other. Whereas, relatively maximum population of *Spodoptera* was recorded in untreated control (5.37 larvae plant^{-1}). However, the treatment of 30 days incubated PDKV organic formulation recorded highest cauliflower yield (22.06 t ha^{-1}). Therefore, these organic extracts could be incorporated in integrated pest management program of organically grown crops.

Cauliflower (*Brassica oleracea var. botrytis* Linn.) is one of the important cruciferous crop. India is the second largest cauliflower growing country in the world. In India, cauliflower is cultivated on an area of 452 thousand hectare with a production of 8668.22 thousand MT during 2017-18 (Anonymous, 2018).The production of cauliflower is hindered by the incidence of several insect pest, among them *Spodoptera litura* (Lepidoptera: Noctuidae) is polyphagous pest and feeds on crops of economic importance causing considerable damage by defoliation (Jat and Bhardwaj, 2005).

Insect pest management in cauliflower has traditionally been relied upon synthetic insecticides. The overzealous and indiscriminate use of most of the synthetic pesticides has created different types of environmental and toxicological problems. The biomagnification resulting in environmental pollution and fertile lands are acquiring infertility (Gill and Garg, 2014). Today due to the awareness about harmful effects of chemical pesticides, farmers are diverting towards the organic farming. Recently, in different parts of the world, attention has been paid towards exploitation of higher plant products as novel chemotherapeutants in plant protection. The popularity of botanical pesticides is once again increasing and some plant products are being used globally as green pesticides (Gurjar *et al*., 2012).

Pest management by using plant extracts can act as valuable input to make efficient use of natural resources and extends relevant support for sustainable agriculture. But there is a need to explore, verify, modify and scientifically validate these practices for their wider use and application. Therefore, the present study was planned to evaluate the organic extracts against *Spodoptera litura*on cauliflower.

MATERIAL AND METHODS

The present investigation withan object to evaluate the efficacy of organic extracts against *Spodpteralitura* on cauliflower was conducted during *Rabi* season of 2020-21. The experiment was laid in Factorial Randomized Block Design with twelve treatments replicated thrice. The treatments included were, Factor A with organic extracts viz., Triparni extract 10 per cent, PDKV organic formulation 10 per cent and PDKV botanical extract 10 per cent along with control. Wherein Factor B included incubation periods of organic extracts i.e. 7 days incubation, 15 days incubation and 30 days incubation. The transplanting of Cauliflower var. Tetris (Syngenta)

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was done on 6th December 2020 with 60 cm x 45 cm spacing in a gross plot size of 5.20 m × 4.40 m. In all two treatment sprays were applied at 15 days interval. The observations were recorded at an interval of 3, 7 and 14 days after spraying. Filtration of the organic extracts was done shortly before application in the field using muslin cloth. The stickiness and adherence of each of the organic extract was enhanced by the addition of 0.2 per cent detergent powder as surfactant. Cauliflower curd yield data was recorded from each of the net plot to find out most economical and effective treatment for the management of *S. litura* on cauliflower. As per Gomez and Gomez (1984) the data obtained during the present course of investigation was converted to appropriate transformation and was subjected to statistical analysis to test the level of significance.

RESULTS AND DISCUSSION

Efficacy of organic extracts against *Spodoptera litura* on cauliflower

The cumulative mean data presented in Table 1 revealed that all the treatments were significantly effective in reducing the larval population of *S. litura* at three days after spray. Among the treatments 30 days incubated PDKV organic formulation recorded minimum population of *Spodoptera* (2.06 larvae plant^{-1}). However, this treatment was found at par with 30 days incubated PDKV botanical extract, 30 days incubated Triparni extract and 15 days incubated PDKV organic formulation with population of 2.40, 2.45 and 2.64 larvae plant^{-1}, respectively. These were followed by treatment of 15 days incubated PDKV botanical extract (2.98),15 days incubated Triparni extract (2.98), 7 days incubated PDKV organic formulation (3.15), 7 days incubated PDKV botanical extract (3.25) and 7 days incubated Triparni extract (3.30).Whereas, maximum population of *Spodoptera* was recorded in untreated control plot (4.68 larvae plant^{-1}).

The results showed that at seven days after spray (Table 2) all the treatments found effective in reducing the population of *Spodoptera* as against untreated control. Among the treatments,30 days incubated PDKV organic formulation was found most effective in recording minimum population of *Spodoptera* (1.35 larvae plant^{-1}). However, this treatment was found statistically at par with 30 days incubated PDKV botanical extract (1.67 larvae plant^{-1}) and 30 days incubated Triparni extract (1.86 larvae plant^{-1}). The next in order of efficacy were the treatment of 15 days incubated PDKV organic

Table 1: Efficacy of organic extracts with different incubation periods against *S. litura* on cauliflower at three days after spray

Treatments	*Spodoptera* larvae plant^{-1}			Factor 'A' (Extract)
	Incubation period of extracts (in days)			
	7	15	30	
Triparni Extract 10%	3.30	2.98	2.45	2.91
	(1.82)	(1.72)	(1.57)	(1.72)
PDKV Organic Formulation 10%	3.15	2.64	2.06	2.62
	(1.77)	(1.62)	(1.44)	(1.62)
PDKV Botanical Extract 10%	3.25	2.98	2.40	2.88
	(1.80)	(1.72)	(1.55)	(1.69)
Control (water spray)	4.13	4.35	4.68	4.39
	(2.03)	(2.09)	(2.16)	(2.09)
Factor 'B'(Incubation Period)	3.46	3.24	2.90	
	(1.86)	(1.80)	(1.70)	
	Factor ' A'	Factor ' B'	Interaction (A×B)	
SE(m)±	0.05	0.04	0.07	
CD at 5 %	0.11	0.10	0.20	

Note: Figures in parentheses are corresponding square root transformation values.

Table 2: Efficacy of organic extracts with different incubation periods against *S. litura* on cauliflower at seven days after spray

Treatments	*Spodoptera* larvae/plant			Factor 'A'
	Incubation period of extracts (in days)			(Extract)
		7	15	30
Triparni Extract 10%	2.60(1.61)	2.23(1.49)	1.86(1.36)	2.23(1.49)
PDKV Organic Formulation 10%	2.40(1.55)	2.02(1.42)	1.35(1.16)	1.92(1.38)
PDKV Botanical Extract 10%	2.52(1.59)	2.15(1.47)	1.67(1.29)	2.11(1.45)
Control (water spray)	4.23(2.06)	4.52(2.13)	4.89(2.21)	4.55(2.13)
Factor 'B'(Incubation Period)	2.94(1.71)	2.73(1.65)	2.45(1.56)	
		Factor ' A'	Factor ' B'	Interaction (A×B)
SE(m)±		0.05	0.04	0.08
CD at 5 %		0.13	0.11	0.22

Note: Figures in parentheses are corresponding square root transformation values

Table 3: Efficacy of organic extracts with different incubation periods against *S. litura* on cauliflower at fourteen days after spray

Treatments	*Spodoptera* larvae/plant			Factor 'A'
	Incubation period of extracts (in days)			(Extract)
	7	15	30	
Triparni Extract 10%	3.67(1.91)	3.49(1.87)	2.85(1.69)	3.34(1.83)
PDKV Organic Formulation 10%	3.55(1.88)	3.40(1.84)	2.28(1.51)	3.08(1.75)
PDKV Botanical Extract 10%	3.69(1.92)	3.48(1.86)	2.68(1.64)	3.28(1.81)
Control (water spray)	4.77(2.18)	5.04(2.24)	5.37(2.32)	5.06(2.25)
Factor 'B'(Incubation Period)	3.92(1.98)	3.85(1.96)	3.30(1.82)	
	Factor ' A'	Factor ' B'	Interaction (A×B)	
SE(m)±		0.04	0.04	0.08
CD at 5 %	0.13	0.11	0.22	

Note: Figures in parentheses are corresponding square root transformation values.

Table 4: Effect of organic extracts on cauliflower curd yield

Treatments	Cauliflower curd yield (t/ha)			Factor 'A'
	Incubation period of extracts (in days)			(Extract)
	7	15	30	
Triparni Extract 10%	16.26	19.18	20.69	18.71
PDKV Organic Formulation 10%	18.19	20.47	22.06	20.24
PDKV Botanical Extract 10%	17.76	19.63	21.28	19.59
Control (water spray)	13.87	13.55	11.50	12.97
Factor 'B'(Incubation Period)	16.57	18.23	18.88	
		Factor ' A'	Factor ' B'	Interaction (A×B)
SE(m)±		0.57	0.49	0.98
CD at 5 %		1.67	1.44	2.89

formulation, 15 days incubated PDKV botanical extract, 15 days incubated Triparni extract, 7 days incubated PDKV organic formulation, 7 days incubated PDKV botanical extract and 7 days incubated Triparni extract recorded 2.02, 2.15, 2.23, 2.40, 2.52 and 2.60 larvae plant^{-1}, respectively. However, all these treatments were found at par among themselves. Whereas, maximum population of *S. litura*was observed in control plot (4.89 larvae plant^{-1}).

At fourteen days after spray (Table 3) minimum population of *S. litura* was observed in plots treated with 30 days incubated PDKV organic formulation (2.28 larvae plant^{-1}) followed by 30 days incubated PDKV botanical extract (2.68 larvae plant^{-1}) and 30 days incubated Triparni extract (2.85 larvae plant^{-1}). However, all these treatments were found at par with each other. Next in order of efficacy were treatment of 15 days incubated PDKV organic formulation (3.40), 15 days incubated PDKV botanical extract (3.48), 15 days incubated Triparni extract (3.49), 7 days incubated PDKV organic formulation (3.55), 7 days incubated Triparni extract (3.67) and 7 days incubated PDKV botanical extract (3.69). Whereas, relatively maximum population of *Spodoptera* was recorded in untreated control (5.37 larvae plant^{-1}).

The present findings pertaining to efficacy of organic extracts with different incubation periods against *Spodoptera litura*finds support in the work carried out by earlier workers. Ali *et al.* (2018) recorded 70-75 per cent *S. litura* larval mortality with *Nerium odorum*and *Parthenium hysterophorus*L. (leaf and flower) extracts when applied at 15 per cent concentration in addition to significant antifeeding effect.The present results are in conformity with the research work of Phambala *et al*. (2020) reported that in contact toxicity tests, the highest *Spodoptera frugiperda* larval mortality was obtained from *Nicotiana tabacum* (66 %). Similarly, Emeasor and Okpara (2019) reported that leaf extract of *Carica papaya* significantly reduced the population of flea beetles by 20.7 per cenrt and leaf defoliation by 57.7 per cent in okra which translated to better yield.

Effect of organic extracts on yield of cauliflower curds

The data presented in Table 4 regarding interaction effect of organic extracts with different incubation periods on cauliflower curd yield. All the treatments recorded significantly higher yield of cauliflower as compare to untreated control. Among the treatments 30 days incubated PDKV organic formulation recorded highest cauliflower yield (22.06 t ha^{-1}). However, this treatment was found at par with 30 days incubated PDKV botanical extract (21.28 t ha^{-1}), 30 days incubated Triparni extract (20.69 t ha^{-1}), 15 days incubated PDKV organic formulation (20.47 t ha^{-1}), 15 days incubated PDKV botanical extract (19.63 t ha^{-1}) and 15 days incubated Triparni extract (19.18 t ha^{-1}). The next effective treatments were 7 days incubated PDKV organic formulation (18.19 t ha^{-1}), 7 days incubated PDKV botanical extract (17.76 t ha^{-1}) and 7 days incubated Triparni extract (16.26 t ha^{-1}). Whereas, lowest yield of cauliflower was recorded in untreated control (11.50 t ha^{-1}).

The earlier researcher Chavada *et al*. (2020) in their field experiment on evaluation of different botanicals against cabbage aphid recorded 66.89 per cent increase in yield over control with treatment of tobacco decoction 2 per cent. The results of present studies finds support in the research work of Emeasor and Okpara (2019) evaluated different leaf extracts against okra Flea beetles, *Podagrica*spp. and harvested higher yield from the plots treated with *Carica papaya* extract. Murovhi *et al.* (2020) studied the efficacy of plant materials in controlling aphids on okra and reported that *Carica papaya* extract had the highest average yield (36.40 q ha^{-1}) followed by*Tobacco* extract (34.65 q ha^{-1}).

CONCLUSION

The treatments with 30 days incubated organic extracts and 15 days incubated organic extracts proved effective in combating the menace of pest of cauliflower and resulted into higher cauliflower curd yield. Thus, these organic extracts would be helpful in mitigating the pest in cauliflower which is alarming in the present situation and could be included in organic cauliflower production as a promising component.

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Nutrient and Water Use Efficiency, Nutrient Uptake and Yield of Rice as Influenced by Fertigation Levels and Weeds Management Practices

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ABSTRACT

A field experiment was conducted at AICRP on Weed Management Research Farm, Department of Agronomy, Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif* 2020-21. The experiment was laid out in split plot design with three replications and twenty treatment combinations having four different fertigation levels and five weed management practices. Experiment results revealed that, maximum rice grain yield (5103 kgha^{-1}), straw yield (7268 kgha^{-1}) and harvest index (41.25%) were substantially enhanced by drip fertigation with 125% RDNK in 5 splits than lower fertigation levels (75 and 100 per cent) and over conventional soil application with 100 per cent RDF. Nutrient use efficiency (NUE) was found better in drip fertigation at 75 per cent recommended dose of N and K per ha as compared to conventional soil application of fertilizers in rice crop. Among the herbicides, directed spray of Pretilachlor + Pyrazosulfuron Ethyl @ 0.615 a.i. kgha^{-1} PE *fb*. Bispyribac sodium @ 0.025 a.i kgha^{-1} at 25 DAS resulted in maximum rice grain yield (5231 kgha^{-1}) and also total nutrient uptake by crop and water use efficiency indicating the feasibility of using herbicides for effective weed management in rice and for enhancing NUE and WUE. The drip fertigation at 125% RDNK in 5 splits registered maximum GMR (^{1} 120353 ha^{-1}), NMR (^{1} 72924 NUE and WUE. The drip fertigation at 125% RDNK in 5 splits registered maximum GMR (^{1} 120353 ha^{-1}) and B:C ratio (2.54). The herbicidal application of Pretilachlor + Pyrazosulfuron Ethyl 0.615 kgha-1 PE fb. Bispyribac sodium 0.025 kgha^{-1} at 25 DAS registered maximum GMR (^{1} 128755 ha^{-1}), NMR (^{1} 81412ha^{-1}) and B:C ratio (2.72) among all herbicidal treatments, indicating the feasibility of using herbicides for effective weed management in rice.

Rice (*Oryza sativa*) is the most important cereal food crop in the world. It is the staple food for more than half of the world's population. In India rice was grown on 46 mha with production of 104.99 mt in the year 2022-23. Rice develops well in water, but recent developments demonstrate that rice can also be grown in dry soils under non-flooded conditions called "Aerobic rice". Aerobic rice cultivation saves water input and increases water productivity by reducing water use during land preparation and limiting seepage, percolation and evaporation. (Peng *et al*., 2012). Hence there is a need to develop and popularize innovative water saving technologies to "produce more rice crop from every drop" for a given specific locations. The injudicious use of irrigation water and improper weed management practices are the important reasons of low productivity of rice in India. Adoption of micro irrigation might help in increasing the irrigated area, productivity of crops and water use efficiency (Sivanappan, 2004). Soman (2018) reported that drip-fertigation offers clear advantage for increasing the productivity of rice with low water consumption in drip irrigation as compared to flood. Fertigation system assures precise application of nutrients through use of water-soluble fertilizers which are made available at the root zone along with water for its direct absorption by the crop. Drip fertigation significantly influenced the growth, yield, water productivity and nutrient use efficiency (NUE) in aerobic rice (Kombali *et al.,*2016). In fertigation methods, fertilizer use efficiency can increase upto 80 to 90 per cent.

Fertilizer application in wetland rice farming done manually through the soil application in split doses is imprecise and causes problems such as fluctuating nutrient supply and uneven fertilizer spread. This leads to various losses of nutrients under submerged cultivation. Besides loss of water and fertilizers through seepage and percolation, impounding water in paddy fields has an important environmental impact by contributing to global warming through considerable emission of methane. For effective weed management, improved weed control practices that include chemical weed control with newer formulations and herbicide mixtures and integrated cultivation need to be developed and refined. Malik *et al*.

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(2021) reported 57 per cent losses respectively due to weeds in rice in India. Addressing these issues requires an integrated approach to soil water-plant-nutrient management at the plant rooting zone. One of these technologies is fertigation, which is the direct application of water and nutrients to plants through a drip irrigation system. The introduction of simultaneous micro irrigation and fertilizer application (fertigation) opens new possibilities for controlling water and nutrient supplies to crops besides maintaining the desired concentration and distribution of nutrients and water into the soil. Drip fertigation offers the scope to increase the productivity of crops per unit land, time and input use in crop production. The hypothesis is that weeds can be controlled efficiently having no adverse effect on soil beneficial microorganisms and yield can be maintained at a lower rate of input practice by improving the weed management strategy. Introduction of new herbicides, chemical weed control with pre-mix combination of herbicide may result in effective weed control in rice. With this background, an effort was made to assess the suitability of split application of nutrients through fertigation and weed management practices on nutrient and water use efficiency, nutrient uptake and yield of Rice.

MATERIAL AND METHODS

A field investigation entitled "Nutrient and water use efficiency, nutrient uptake and yield of Rice as influenced by fertigation levels and weeds management practices" was conducted at AICRP on Weed management farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *kharif*, 2020-21 with an objective to assess the suitability of split application of nutrients through fertigation and weed management practices on rice yield, water and nutrient use efficiency and nutrient uptake in rice. The experiment was laid out in split plot design with three replications with 20 treatment combinations having 4 different fertigation levels and 5 weed management practices. The main plot treatments comprised of different levels of fertilizer in five splits at 75, 100 and 125 per cent of recommended dose of N and K fertilizers given through fertigation, however P was applied as basal and these treatments were compared with drip irrigation with 100 per cent soil application of fertilizers (N in 3 splits). Whereas, sub plot treatments comprised of five weed management practices viz.,Pendimethalin 1.0 kgha^{-1} PE *fb.* Bispyribac sodium 0.025 kg ha^{-1} at 25 DAS; Pretilachlor + Pyrazosulfuron Ethyl 0.615 kgha^{-1} PE *fb.* Bispyribac sodium 0.025 kg ha^{-1} at 25 DAS; Pretilachlor 0.75 kgha^{-1} PE *fb.* Bispyribac sodium 0.025 kgha^{-1} at 25 DAS; farmer practices - 2 HW at 15 20 days interval after sowing *fb.* 2 hoeing and weedy check.

The soil of experimental field was vertisol, low in available nitrogen (170.41 kg ha^{-1}), medium in phosphorus (18.94 kg ha^{-1}) and organic carbon (0.42 %), rich in available potassium (360.41 kg ha^{-1}) and slightly alkaline in reaction (7.65). Rice variety *Avishkar* was sown on 19th June, 2020 at a spacing of 20 cm×10 cm. The experimental site was established with inline drip irrigation system (16 mm) and 9 laterals were laid treatment^{-1} with emitter spacing of 50 cm and dripper discharge of 4 lph hr^{-1}. Irrigation water was applied through drip irrigation system on every alternate day based on cumulative pan evaporation and surface irrigation water was applied at 1.0 IW/CPE ratio at a depth of 6 cm. The drip irrigation water to be applied per plant was determined by the formula given by Michael (2008) [6]. The sources of nutrients were urea (46% N), single super phosphate (16% P_2O_5) and murate of potash (60% K_2O) for nitrogen, phosphorus and potash, respectively. The fertilizer was applied as per the treatments. The application of herbicide was done as per the treatments with manually operated knapsack sprayer attached with a flat fan nozzle. After calibrating the sprayer, water volume used was 700 l ha^{-1}. for PE and 500 l ha^{-1}. for PoE. Water use efficiency of rice crop was worked out for all treatments as the ratio of yield of marketable yield to the seasonal water requirement of rice. The plants removed for dry matter study at harvest were used for estimation of nitrogen, phosphorus and potassium content. These plants were dried, and nitrogen, phosphorus and potassium content in plant and grain were estimated by Kjeldahl method, di-acid extract by vanado-molybdate yellow colour method (Piper, 1966) and Flame photometer method respectively. Nutrient use efficiency was calculated by using following formula and expressed in per centage (Crasswell and Godwin, 1984.) Data on various parameters were analyzed by using statistical method of analysis of variance as per the standard procedure.

RESULTS AND DISCUSSION

Nutrient uptake

The data presented in Table 1 indicated that, uptake of nutrients by rice was differed significantly due to different fertilizer levels given through fertigation. The maximum uptake of nitrogen (133.93 kg ha^{-1}), phosphorus (26.99 $kgha^{-1}$) and potassium (137.34 kg ha^{-1}) by rice was recorded in drip fertigation with 125 per cent RDNK in 5 Splits which was at par with drip fertigation of 100 per cent RDNK in 5 Splits. The lowest uptake of 96.75 N $kgha^{-1}$, 19.25 P $kgha^{-1}$ and 107.29 K $kgha^{-1}$ was observed in drip irrigation with 100 per cent RDF through soil application (N in 3 Splits). 125 per cent RDNK showed 38.43, 40.21 and 28.01 per cent more N, P and K uptake respectively than 100 per cent RDF through conventional method of soil application. The concentration and availability of various nutrients in the soil for plant uptake depends on soil solution phase which is mainly determined by soil moisture availability. The higher available soil moisture was provided due to continuous water supply at alternate days under drip irrigation which led to higher availability of nutrients in the soil and thereby increased the nutrient uptake under drip fertigation levels in splits. An application of N and K given through fertigation not only stimulated vegetative growth and foraging capacity of roots, but also encouraged the absorption and translocation of more nutrients under higher drip fertigation levels. Reducing the fertilizer dose resulted in reduced availability of nutrients which might be the reason for lower uptake of nutrients by crop at lower doses of fertilizers as indicated in the present study (Table 1). In conventional method of soil application of fertilizers, application of large quantity of fertilizers as a single dose resulted in higher volatilization losses of nutrients and resulted lower the availability of nutrients during later growth stages of crop. This might be the reason for lower uptake of nutrients by crop, when fertilizers are applied by conventional soil application. Better availability of moisture and nutrients throughout the growth stages in drip system leading to better uptake of nutrients. Similar results were reported by Hebbar *et al*. (2004).

The uptake of nutrients by rice was differed significantly due to different weed management practices. The maximum uptake of nitrogen (123.25 kg ha^{-1}), phosphorus (24.68 kg ha^{-1}) and potassium (129.94 kg ha^{-1}) by rice was found in farmers practice of 2 HW at 15-20 days interval after sowing *fb*.2 hoeing which was found at par with Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kg ha^{-1} PE fb. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS with N-P-K 120.31 N $kgha^{-1}$, 24.40 P kg ha^{-1} and 125.91 K kg ha^{-1}). Among herbicidal treatments application of Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. $kgha^{-1}$ PE *fb*. Bispyribac sodium @ 0.025 a.i. $kgha^{-1}$ at 25 DAS showed 30.70, 31.04 and 23.32 per cent more N, P and K uptake respectively than weedy check. This might be due to reduced crop-weed competition favourably influenced growth, as there was favourable soil environmental condition which resulted in increasing soil nutrient mineralization and thereby increased in residual status of soil nutrient after harvest of rice crop. Similar findings are given by Sunil *et al*. (2010), Patel *et al*. (2018) and Saravanane *et al*. (2020).

Water use efficiency

In the present investigation, there was a positive relation among increasing drip fertigation level and rice grain yield. The highest WUE of 4.14 $kgha^{-1}$ mm was registered under drip fertigation with 125 per cent RDNK in 5 Splits followed by 3.86 $kgha^{-1}$ mm in drip fertigation with 100 per cent RDNK in 5 Splits. However, the lowest water use efficiency of 3.69 kg ha^{-1} mm in drip irrigation with 100 per cent RDF through soil application. Recommended dose of N and K registered 12.19 per cent more WUE than 100 per cent RDF through soil application. In case of drip fertigation with 125 per cent RDNK in 5 splits, the amount of carbon assimilated as biomass or grain produced per unit of water used by the rice crop was more resulted in increased the WUE. As in drip fertigation with 125 per cent RDNK in 5 Splits the rice grain yield was the highest one, for that the WUE was maximum in that treatment which was significant than the drip irrigation with 100 per cent RDF soil application (N in 3 Splits) where fertilizer was applied through soil application. This result was in accordance with results earlier reported by Deshmukh and Katake (2005), Jagadish *et al*. (2019) and Ashrafi *et al*. (2020)

The water use efficiency was higher in all other weed management practices than weedy check. The highest water use efficiency (4.37 kg ha^{-1} mm) was recorded

Table 1: Nutrient uptake, water use efficiency, nutrient use efficiency and availability of nutrients as influenced by different fertigation levels and weed management practices in rice

Treatments	Nutrient uptake ($kgha^{-1}$)			WUE(kg ha^{-1} mm)	NUE (kg kg^{-1})	Available nutrient ($kgha^{-1}$)		
	N	P	K			N	P	K
A) Fertigation Levels								
F_1 : Drip irrigation with 100% RDF soil application (N in 3 Splits)	96.75	19.25	107.29	3.69	18.63	175.79	19.13	362.68
F_2 : Drip fertigation with 75% RDNK in 5 Splits	104.38	21.29	111.59	3.75	23.67	178.24	19.55	366.02
F_3 : Drip fertigation with 100% RDNK in 5 Splits	119.22	24.72	127.49	3.86	19.83	181.52	20.60	369.33
F_4 : Drip fertigation with 125% RDNK in 5 Splits	133.93	26.99	137.34	4.14	17.91	185.38	21.15	374.15
SE (m)±	5.17	0.99	4.75	—	—	2.67	0.45	3.49
CD at 5%	17.91	3.42	16.44	—	—	8.38	1.54	10.64
B) Weed Management Practices								
W_1 : Pendimethalin 1.0 $kgha^{-1}$ PE *fb.* Bispyribac sodium 0.025 $kgha^{-1}$ at 25 DAS	114.72	23.66	122.28	4.06	20.85	180.31	19.23	364.49
W_2 : Pretilachlor+Pyrazosulfuron Ethyl 0.615 $kgha^{-1}$ PE *fb.* Bispyribac sodium 0.025 $kgha^{-1}$ at 25 DAS	120.31	24.40	125.91	4.24	21.80	189.84	19.92	369.83
W_3: Pretilachlor 0.75 kg a.i. ha^{-1} PE *fb.* Bispyribac sodium @ 0.025 a.i. $kgha^{-1}$ at 25 DAS	117.52	23.95	124.39	4.13	21.20	183.12	19.43	366.38
W_4 : Farmer practices- 2 HW at 15 20 days interval after sowing *fb.* 2 hoeing	123.25	24.68	129.94	4.37	22.45	195.22	20.85	373.01
W_5 : Weedy check	92.05	18.62	102.10	2.74	12.41	169.57	18.15	356.78
SE (m)±	5.40	1.27	5.00	—	—	3.51	0.31	3.80
CD at 5%	15.56	3.65	14.40	—	—	10.11	0.90	9.15
Interaction (F×W)								
SE (m)±	10.80	2.53	10.00	—	—	7.01	0.63	1.36
CD at 5%	—	—	—	—	—	—	—	—

Table 2: Grain yield, straw yield (kgha^{-1}), harvest index (%) and economics of rice as influenced by different fertigation levels and weed management practices

Treatments		Grain yield (kgha^{-1})	Straw yield (kgha^{-1})	Harvest Index (%)	GMR (₹ ha^{-1})	NMR (₹ ha^{-1})	B:C ratio
A) Fertigation Levels							
F_1 :	Drip irrigation with 100% RDF soil application (N in 3 Splits)	4471	6593	40.41	108407	62589	2.37
F_2 :	Drip fertigation with 75% RDNK in 5 Splits	4617	6724	40.71	111168	66639	2.50
F_3 :	Drip fertigation with 100% RDNK in 5 Splits	4760	6867	40.94	113871	68053	2.49
F_4 :	Drip fertigation with 125% RDNK in 5 Splits	5103	7268	41.25	120353	72924	2.54
	SE(m)±	28.37	45.57	—	536	536	—
	CD at 5%	101.00	160.30	—	1853	1853	—
B) Weed Management Practices							
W_1 :	Pendimethalin 1.0 kgha^{-1} PE *fb.* Bispyribac sodium 0.025 kgha^{-1} at 25 DAS	5004	7294	40.69	124479	75973	2.57
W_2 :	Pretilachlor+Pyrazosulfuron Ethyl 0.615 kgha^{-1} PE *fb.* Bispyribac sodium 0.025 kgha^{-1} at 25 DAS	5231	7603	40.76	128755	81412	2.72
W_3 :	Pretilachlor 0.75 kgha^{-1} PE *fb.* Bispyribac sodium 0.025 kg ha^{-1} at 25 DAS	5087	7402	40.73	126035	78062	2.63
W_4 :	Farmer practices- 2 HW at 15 20 days interval after sowing *fb.* 2 hoeing	5389	7656	41.31	131749	80229	2.56
W_5 :	Weedy check	2978	4350	40.64	56233	13287	1.31
	SE(m)±	46.29	72.51	—	874	874	—
	CD at 5%	134.00	212.20	—	2519	2519	—
Interaction (F×W)							
	SE(m)±	75.43	118.08	—	1748	1748	—
	CD at 5%	—	—	—	—	—	—

in farmer practices of 2 hand weeding at 15-20 days interval after sowing *fb*. 2 hoeing followed by Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kg ha^{-1} PE fb. Bispyribac sodium @0.025 a.i. kg ha^{-1} at 25 DAS with WUE of 4.24 kg ha^{-1} mm and the lowest WUE was recorded in weedy check (2.74 kg ha^{-1} mm). Among all herbicidal treatments application of Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kg ha^{-1} PE *fb*. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS showed 54.74 per cent more WUE than weedy check. Different weed management practices gave higher water use efficiency than weedy check, which might be due to less infestation of weeds in these treatments, which provide enough water for growth and development of rice crop. The similar results regards to WUE was reported by Kumaran *et al*. (2015), Mishra *et al*. (2018), Singh *et al*. (2018) and Ramesh and Rathika (2020).

Nutrient use efficiency

The data presented in Table 1 showed that, the highest NUE of 23.67 was registered under drip fertigation with 75 per cent RDNK in 5 Splits followed by drip fertigation with 100 per cent RDNK in 5 Splits (19.83), Drip irrigation with 100 per cent RDF soil application (18.63) and the lowest in drip fertigation with 125 per cent RDNK in 5 Splits (17.91). Nutrient use efficiency at 75 per cent RDNK was 37.68 per cent more than 100 per cent RDF through soil application. In case of drip fertigation there was efficient utilization and precise application of nutrients according to the nutritional requirements of the crop as compared to conventional soil application of fertilizers. Similar kind of result were reported by Modinat *et al*. (2014).

The nutrient use efficiency was higher in all other weed management practices than weedy check. The highest NUE was recorded in farmer practices i.e. 2 HW at 15-20 days interval after sowing *fb*. 2 hoeing (22.45 kg kg^{-1}) and the lowest NUE was recorded in weedy check treatment (12.41 kg kg^{-1}). Among all herbicidal treatments application of Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kg ha^{-1} PE fb. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS showed 75.66% more NUE than weedy check. In case of Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kgha^{-1} PE fb. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS), higher rice grain yield was obtained rather than other herbicidal applied treatments so NUE was maximum in this treatment after farmer practices i.e. 2 HW at 15-20 days interval after sowing *fb* 2 hoeing. Results shown by Singh *et al*. (2014) also supported maximum rice grain yield could be the reason for higher NUE.

Availability of major nutrients at harvest

The data of available N, P and K of soil at harvest is presented in Table 1 which indicated that, there was significant difference in the values of available N, P and K of soil as influenced by different fertigation levels and weed management practices after harvest. In case of available N, P and K at harvest, it was observed that maximum value of available N, P and K of soil was observed in treatment of drip fertigation with 125 per cent RDNK in 5 splits i.e.185.38, 21.15 and 374.15 kgha^{-1}, respectively and the and the lowest amount of available N, P and K of soil was observed in Drip irrigation with 100 per cent RDF through soil application i.e.175.79, 19.13 and 362.68 kg ha^{-1}, respectively. Significantly more nitrogen, phosphorus and potassium were remained in soil where higher level of fertilizer dose of 125 per cent RDNK ha^{-1} applied through fertigation. While minimum soil available nutrients were observed in soil application of 100 per cent RDF per ha due to leaching and evaporation losses of fertilizer. In case of drip fertigation, significantly higher nutrient content in upper soil layers compared to conventional soil application of fertilizers. While, among the weed management practices, farmer practices i.e. 2 HW at 15-20 days interval after sowing *fb*. 2 hoeing recorded maximum availability of N,P and K at harvest (195.22, 20.85 and 373.01 kg ha^{-1}, respectively) followed by Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kg ha^{-1} PE *fb*. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS and lowest availability of nutrients in weedy check. The great improvement in available nutrient status of soil after harvest can be described as the cumulative effect of added nutrient to the soil and indirect addition through leaf drop and root debris backed up by favorable soil microbial activity because of good soil moisture availability through drip irrigation throughout the crop growth which might have converted immobilized organically bound nutrients into inorganic available form. As the weed population was less in herbicidal treatment of Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kgha^{-1} PE *fb*. Bispyribac sodium @ 0.025 a.i. kgha^{-1} at 25 DAS so the available nutrients status was more in that after

harvest. These results are in conformity with the results reported earlier by Sunil *et al*. (2010), Patel *et al*. (2018) and Saravanane (2020).

Rice grain and straw yield

Each higher fertigation level of recommended dose of N and K significantly increased the grain, straw and biological yield kg ha^{-1}) over its lower levels and soil application with drip as indicated in Table 2. The grain yield and straw yield were influenced significantly due to split application of recommended dose of nitrogen and potash through fertigation. Grain yield (5103 kg ha^{-1}), straw yield (7268 kg ha^{-1}) and harvest index (41.25%) were observed at 125 per cent RDNK. The fertigation method offered an opportunity for precise application of water-soluble fertilizers and other nutrients to the soils at appropriate time with the desired concentration. Fertigation combined water and fertilizer which minimized the nutrient loss that helped in better grain yield, straw yield, biological yield and harvest index in rice.

Among herbicidal treatments the application of Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kg ha^{-1} PE *fb*. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS helped in preventing weed shift towards perennial nature and shifted the crop-weed competition in favour of crop. These all favored in maximum grain yield (5231 kg ha^{-1}), straw yield (7603 kg ha^{-1}) and harvest index of 41.25per cent . Whereas, in case of weedy check due to high weed population and high nutrient uptake by the weeds there was decrease in yield of rice crop. Pretilachlor was readily taken up by the hypocotyls, mesocotyls and coleoptiles and to a lesser extent by roots of germinating weeds; Pyrazosulfuron ethyl inhibited acetolactate synthase in weeds and Bispyribac sodium inhibited the amino acid formation in weeds. These results were in conformity with findings of Parthasarathi *et al*. (2018) and Patil *et al*. (2019).

Economics of fertigation and weed management practices

Among all the fertigation levels the highest gross monetary return (₹ 120353 ha^{-1}), net monetary return (₹ 72924 ha^{-1}) and B:C ratio (2.54) were obtained in the treatment receiving drip fertigation at 125 per cent RDNK kg ha^{-1}. (Table 2). Lowest GMR, NMR and B:C ratio were registered in the drip irrigation with conventional soil application of 100 per cent RDF (N in 3 splits). Adoption of drip fertigation is very much important as it gives higher B:C ratio by minimizing the cost of cultivation. In case of weedy check, GMR was lowest due to heavy weed infestation and very less rice yield. This might be reason behind the lowest B:C ratio in weedy check. Drip fertigation with 125 per cent RDNK was economically viable than other treatments as there more GMR was obtained. Similar types of result were found by the results reported by Nayak *et al*. (2016) and Parthasarathi *et al.* (2018). Among the herbicides, application of Pretilachlor + Pyrazosulfuron Ethyl @ 0.615 a.i. kg ha^{-1} PE fb. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS showed the highest gross monetary return (₹ 128755 ha^{-1}), net monetary return (₹ 81412 ha^{-1}) and B:C ratio (2.72). Weeds are main enemy of crops as they retarded the growth, development of a crop by competing with the crop for nutrients, water, solar radiation etc. Similar types of result were found by the results reported Upasani *et al.* (2012).

CONCLUSIONS

On the basis of the data, it could be concluded that application of drip fertigation with 125% RDNK in five splits and directed application of Pretilachlor + Pyrazosulfuron ethyl @ 0.615 a.i. kg ha^{-1} PE *fb*. Bispyribac sodium @ 0.025 a.i. kg ha^{-1} at 25 DAS found to be the best for enhancing the nutrient uptake, nutrient use efficiency, water use efficiency, availability of major nutrients at harvest and maximizing the yield and beneficial for increasing the productivity and economic returns of rice under different fertigation levels and weed management practices.

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Effect of Plant Geometry and Primary Nutrients on Growth and Yield of Newly Developed Groundnut (*Arachis hypogaea* L.) Variety TAG 73

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ABSTRACT

An investigation was undertaken with an objective to assess the response of plant geometry and NPK fertilizer on growth and yield of newly developed Groundnut *(Arachis hypogaea* L.) variety TAG 73" was undertaken during *summer* 2019 at Oilseeds Research Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola under irrigated condition. It is a Spanish bunch variety recommended for summer season cultivation. Three row spacing's of 45cm; 30cm and 15cm with common plant to plant spacing of 10cm were tested with three fertilizer levels of primary nutrients 75 per cent, 125 per cent and recommended dose which is 25:50:30 Kg NPK ha^{-1} applied at the time of sowing. The blanket application of Fe, Zn and Bo was applied as per recommendation. The experiment was conducted in factorial randomized block design with three replications. The full dose of fertilizers was applied at the time of sowing. Interaction effect between variety × spacing was significant with number of branches, yield attributes, yield and shelling percentage. Farmers are encouraged to grow TAG 73 groundnut variety using 30 × 10 cm spacing for highest yield and yield attributes. Among the treatments, sowing of groundnut with row spacing 30 x 10 cm with 125 per cent recommended dose of fertilizer (30:60:40 kg NPK ha^{-1}) recorded highest dry pod yield (2428 kg ha^{-1}), haulm yield (4450 kg ha^{-1}) with maximum benefit cost ratio of 3.02 from the cultivation of groundnut variety TAG 73.

Peanut (*Arachis hypogaea* L.) is one of the most valuable legumes of tropical and subtropical regions (Jadon *et al.* 2018). The groundnut (*Arachis hypogaea* L.) is one of the major oilseed crops of the country but its production and productivity needs to be significantly enhanced to meet the national shortage of availability of edible oil. The varieties which are suitable for *kharif* may not be suitable for summer due to differences in weather conditions coupled with varied growth habits of groundnut cultivars. Selection of suitable genotype and maintenance of plant population per unit area were found to be directly correlated with pod yield up to certain level in groundnut (Babu, 1991). Sub optimal plant stand in groundnut has been identified as one of the major constraints to realize full production potential. Hence, optimum plant population is required for better utilization of growth resources like light, moisture and nutrients, which consequently reduces the risk of yield reduction and ensures higher productivity and returns per unit area. Gopal (2004) revealed that crop sown under plant density of 3.33 lakh plants per hectare significantly improved dry matter production per plant at all the growth stages and yield attributes viz., pods per plants, weight of pods per plant and 100 seed weight over 4.44 lakh plants per hectare in groundnut. Similarly, Fertilizer management is another core factor in improving groundnut yield. The optimization of the mineral nutrients is the key to optimize the production of groundnut. Optimum plant population unit $area^{-1}$ for a given variety at specific situation not only reduces the cost of cultivation but also augment the full yield potential of the cultivar. The objective of this study was therefore to assess and compare the effects of spatial arrangement and nutritional requirement on the growth and yield of newly release genotype TAG-73 for Maharashtra.

MATERIAL AND METHODS

Experimental site

The field experiment was conducted during summer 2019 at the Oilseeds Research Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra), situated at 20°42' N latitude, 77°00' E longitude and at an altitude of 282 m above mean sea level. The research station comes under Western plateau and hills region, Maharashtra (IX). The soil type of the experimental site was medium black (Vertisols) and clayey in texture. The experiment was laid out in Factorial

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Randomized Block Design with twelve treatments comprising of main plot of row spacing (three) and fertilizer levels (three) with three replications. Spacing's include, S_1: 45cm × 10cm, S_2: 30cm × 10cm and S_3: 22.5 cm × 10 cm. Fertilizer levels: F_1: 75 per cent recommended dose (19:38:22 kg N: P_2O_5: K_2O ha^{-1}), F_2: 100 per cent RDF (25:50:30 kg N: P_2O_5: K_2O ha^{-1}), and F_3: 125 per cent RDF (30:60:38 kg N: P_2O_5: K_2O ha^{-1}). The sources fertilizer used were Urea, single super phosphate and muriate potash. The cultivar grown was TAG-73 (early maturing in character) and crop was planted on 8th February of 2019. The crop was harvested after attaining the physiological maturity (110 days). The crop was irrigated with sprinkler irrigation at 8 days interval.

The data collected were subjected to statistical analysis using Microsoft excel software programme of factorial randomized block design. The analysis of variance procedure was followed to determine whether differenced existed among treatments. Treatments were compared using the critical CD at 5 % probability level.

RESULTS AND DISCUSSION

Growth and yield attributes

From the data of table 1, it was revealed that, amongst the plant spacing, the plant height was significantly influenced with different row spacing and fertilizer levels. The highest plant height was recorded with row spacing 22.5 cm x 10 cm. Number of branches $plant^{-1}$ and number of mature pods $plant^{-1}$ were recorded significantly highest in plant spacing 30 cm x 10 cm, however highest shelling percentage recorded in row spacing 22.5 cm x 10 cm. However, the significantly highest plant height, Number of branches $palnt^{-1}$ and number of mature pods $plant^{-1}$ and shelling percentage recorded highest in 125% RDF (31:62:38 kg N: P_2O_5: K_2O ha^{-1}).

The interaction was found non significant in respect of plant height, number of immature pods and in shelling percentage. However, it was found significant in respect of number of branches and in number of number of mature pods $plant^{-1}$. From the interaction it was observed that, the spacing 30 cm x 10 cm with 125 per cent RDF recorded significantly highest number of branches $palnt^{-1}$ and number of pods $plant^{-1}$.

Giayetto *et al.* (1998) reported that the number of branching per plant was reduced with the increase of plant density. As plant density was decreased in per unit area, pod number per plant was increased. At low plant density, existing plants developed more branches and pegs because of reduced in competition. Donald (1963) reported that as the number of plants per unit area increased competition for growth resources such as nutrients, water and light also increased. Similar results were reported by others researches (Wright and Bell, 1992 and Konlan *et al.,* 2013).

Yield and Economics

From the table 2, it is revealed that, groundnut sown at plant spacing 30 cm x10 cm i.e. plant population @ 3.33 lakhs ha^{-1} with 125 per cent RDF (30:60:38 Kg NPK ha^{-1}) level recorded significantly highest dry pods yield, haulm yield with maximum economic return from groundnut genotype TAG-73. However, it was at par with plant spacing 22.5 cm x 10 cm. For this reason, the pod yield per hectare was increased when the plant density increased up to optimum level, however the pod yield per hectare decreased as density increased due to increase the crop-light and crop-nutrient competition. The same trends also found in respect of haulm yield also. These finding are in accordance with Elalyaraja and Singaravel (2010).

Significantly highest Gross Monetary Returns was found with plant spacing 30 x 10 cm (Rs. 100818/-) followed by spacing 22.5 cm x 10 cm (Rs. 97710/-). The highest B:C ratio recorded in spacing 30 cm x10 cm.

The significantly highest dry pods yield, haulm yield with maximum economic return found from groundnut genotype TAG-73 in the treatment 125 per cent RDF followed by 100 per cent RDF. The highest Gross Monetary Returns (Rs. 13727/-), Net Monetary returns (Rs. 76211/-) and B:C ratio (3.02) recorded in 125 per cenrt RDF.

The interaction effects were found significant in case of dry pod yield, haulm yield and economics. From the interaction, it was observed that, the spacing 30 cm x 10 cm with 125 % RDF recorded significantly highest dry pod yield (2811 kg ha^{-1}) followed by the spacing 22.5 cm x

Table 1: Growth and yield contributing characters of groundnut var. TAG 73 as influenced by different treatments during summer 2019 at Akola

Treatment	Plant Height (cm)	No. of branches plant^{-1} at harvest	No. of mature Pods plant^{-1} at harvest	No. of Imature Pods plant^{-1} at harvest	Shelling percentage
Planting geometry (P)					
45 cm x 10 cm	17.07	4.12	10.74	3.71	72.84
30 cm x 10 cm	18.09	4.30	11.79	4.67	73.32
22.5 cm x10 cm	18.42	3.72	10.02	4.72	73.40
SE m±	0.26	0.06	0.27	0.23	0.47
CD at 5%	0.78	0.17	0.81	0.67	NS
Fertility Levels (F)					
75 % RDF	16.89	3.90	9.90	4.10	72.31
100 % RDF	17.79	3.96	11.00	4.39	73.11
125 % RDF	18.90	4.27	11.64	4.61	74.13
SE m±	0.26	0.06	0.27	0.23	0.47
CD at 5%	0.78	0.17	0.81	NS	1.40
Interaction (P x F)					
SE m±	0.45	0.09	0.47	0.39	0.81
CD at 5%	NS	0.29	1.40	NS	NS

10 cm with 125% RDF. The same trend was observed in haulm yield, GMR and NMR also. However spacing 30 x 10 cm, was at par with 22.5 x 10 cm in respect of dry pod yield with 125 % RDF. These results are in agreement with the findings of Madkour *et al*. (1992), Patil *et al*. (2007) and Awal and Aktar (2015). The variability of row distances and plant spaces had statistically significant effects on pod weight per plant in this study.

CONCLUSION

The average pod yield was significantly affected by the row distance and plant spaces. From the result, it

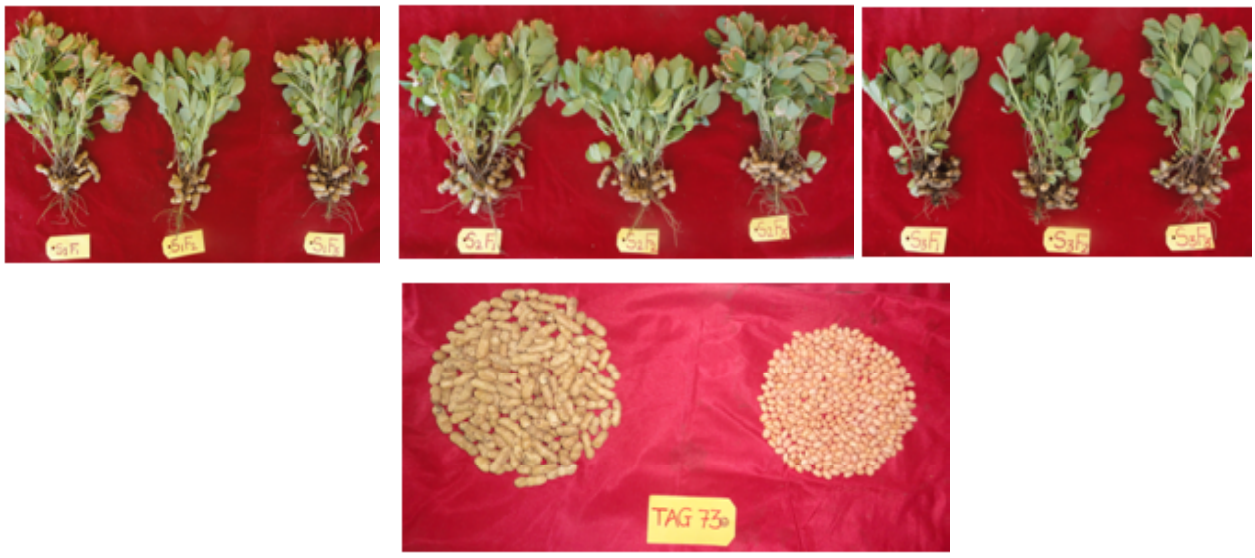

Table 2: Yield and economics of groundnut at harvest as influenced by different treatments during summer season (Summer 2019)

Treatments		Dry Pod yield(Kg ha^{-1})	Haulm Yield (Kg ha^{-1})	Cost of Cultivation (Rs ha^{-1})	Gross Monetary Return(Rs ha^{-1})	Net Monetary Returns (Rs ha^{-1})	B:C ratio
Planting geometry (P)							
P1	45cm x 10 cm	1781	2749	31901	69538	38870	2.26
P2	30cm x 10 cm	2582	3985	35725	100818	65093	2.81
P3	22.5cmx10 cm	2478	3777	43725	96710	52985	2.21
	SEm±	69.34	132.45	—	3250	3250	—
	CD at 5%	207.88	395.10	—	9744	9744	—
Fertilizer Levels (F)							
F1	75% RDF	1409	2609	36151	66009	29859	1.83
F2	100% RDF	1864	3452	37516	87330	50879	2.43
F3	125% RDF	2428	4450	37684	113727	76211	3.02
	SEm±	69.34	132	—	3250	3250	—
	CD at 5%	207.88	395	—	9744	9744	—
Interaction (P x F)							
	$P_1 \times F_1$	1181	2187	—	55320	25208	—
	$P_1 \times F_2$	1568	2904	—	73471	43059	—
	$P_1 \times F_3$	1704	3155	—	79822	48344	—
	$P_2 \times F_1$	1425	2639	—	66755	31585	—
	$P_2 \times F_2$	2220	4111	—	103994	68524	—
	$P_2 \times F_3$	2811	5206	—	131706	95171	—
	$P_3 \times F_1$	1621	3002	—	75952	32782	—

was concluded that, groundnut variety TAG-73 sowing with plant spacing 30 cm x10 cm i.e. plant population @ 3.33 lakhs ha^{-1} with 125 RDF (30:60:38 Kg NPK ha^{-1}) level recorded significantly highest dry pods yield, haulm yield with maximum economic returns. However, it was at par with row spacing 22.5 cm x 10 cm. Maintenance of optimum population per unit area of the field is essential to get maximum yield.

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Correlation Studies of Yield & Yield Attributing Traits in Safflower (*Carthamus tinctorius* L.)

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ABSTRACT

Safflower (*Carthamus tinctorius* L.), an oilseed crop is a member of the family Compositae. Carthamus is the latinized synonym of the Arabic word quartum, or gurtum, which refers to the colour of the dye extracted from the petals of safflower. There are 25 species in genus Carthamus out of which Carthamustinctorius is only under cultivation. Safflower oil is preliminary used for cooking purpose. It contains 78 per cent of PUFA (Linoleic Acid) which is useful for heart patients as it reduces blood cholesterol levels. It also contains 13 per cent monosaturated fatty acid (Oleic Acid) and only 8 per cent saturated fatty acid 1-10 per cent stearic acid, 1-10 per cent palmitric acid.

The correlation measures the degree of association between two variables. The genetic cause of correlation is chiefly pleiotropy though linkage is a cause of transient correlation. The study of correlated characters creates interest for three chief reasons. Firstly, in connection with the genetic causes of correlation through pleiotropic gene action of gene, secondly, in connection with the changes brought about by selection and thirdly, in connection with natural selection (Falconer, 1981). Association analysis between quantitative characters is important because it indicates the change brought out in them when selection pressure applied on one character even though the other character is not subjected to any selection. The measured relationship is vital in planning the efficient breeding programme for improvement of one or more economic characters which are known to be dependent on two or more metric traits.

The correlation provides the information on genetic association of yield and different yield attributing characters, which in turn are useful in developing breeding strategies. The present investigation therefore was planned to evaluate the genetic diversity and correlation studies in germplasm accessions of safflower.

MATERIAL AND METHODS

The set of 114 genotypes along with three checks 'A-1, AKS-207 & PKV Pink were evaluated in augmented block design with six blocks at the field of Oilseeds Research Unit, Dr. PDKV, Akola during rabi 2018-2019. The data was recorded on the characters viz., days to 50 per cent flowering, days to maturity, plant height (cm), number of branches per plant, number of capitula per plant, number of seeds per capitulum, volume weight (g/ 100 ml), 100 seed weight (g), oil content (%) and seed yield per plant (g).

Canonical root method suggested by Rao (1952) was followed. The matrix of variance and covariance (matrix A) was obtained by calculating the difference between group of sum of squares and sum of products from transformed variables (Y1, Y2, ……, Y10). Determination canonical variants was done by integration starting with trial vector (1,-1) each row of the matrix was multiplied and a derived vector which was better approximation was obtained. Same procedure was repeated until stable values of the vector were obtained. The highest value used in the last stage of division to obtain the final vector should be λ1, the first canonical root. The vector was standardized by dividing each element, by the square root of the sum of squares of all the elements. From the (ith, jth) element of the matrix A, the product, λ1Xith element, Xjth element of the first vector was subtracted to obtain the reduced matrix (matrix B). The procedure followed in the case of matrix A was repeated to obtain second, third, fourth and fifth canonical roots.

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Table 1:Simple correlation among ten yield contributing characters of safflower genotypes

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capitula plant^{-1}	No. of seeds capitulum^{-1}	100 seed wt.(g)	Volume wt. (g 100^{-1} ml)	Oil content (%)	Seed yield plant^{-1} (g)
Days to 50% flowering	**1.000**	0.474**	-0.002	-0.206*	-0.180*	0.011	0.224**	-0.001	0.435**	-0.383**
Days to maturity		**1.000**	-0.027	-0.114	-0.189*	-0.025	0.163	0.082	0.391**	-0.235**
Plant height (cm)			**1.000**	0.139	0.229**	0.010	-0.058	-0.172*	-0.020	0.023
No. of branches plant^{-1}				**1.000**	0.732**	0.051	-0.078	0.086	-0.066	0.815**
No. of capitula plant^{-1}					**1.000**	0.108	-0.020	0.119	-0.090	0.656**
No. of seeds capitulum^{-1}						**1.000**	-0.043	-0.009	-0.062	0.048
100 seed weight (g)							**1.000**	0.640**	0.115	-0.102
Volume weight (g 100^{-1} ml)								**1.000**	0.094	0.124
Oil content (%)									**1.000**	-0.189*
Seed yield plant^{-1} (g)										**1.000**

Note- * Significance at 5% level ** Significance at 1%level

RESULTS AND DISCUSSION

Present study revealed that the variation among the genotypes were significant for days to 50 per cent flowering, plant height, number of branches plant^{-1}, number of capitula plant^{-1}, number of seeds per capitulum, volume weight, seed yield plant^{-1} indicating the presence of wide genetic variability for these characters.

In order to know the magnitude of association of the seed yield with other yield influencing traits, correlation analysis is an effective tool. This will help in constructing a suitable plant type and combining desirable expression of different yield components.

The table 1 represents the correlation coefficients between the various characters with seed yield. It has been described in positive and negative directions. The character days to 50 per cent flowering had significant positive correlation with oil content (0.435**), Days to maturity (0.474**) and 100 seed weight (0.224**) whereas it had significant negative correlation with Number of branches per plant (-0.206*) and number of capitula per plant (-0.180*). Ahmadzadeh (2013)also obtained Days to 50 per cent flowering had positive and significant association with days to maturity.

Days to maturity was significantly and positively correlated with oil content (0.391**) whereas it had negative and non-significant correlation with plant height (-0.027), Number of branches per plant (-0.114) and number of seeds per capitulum (-0.025). Positive and significant association between days to maturity and oil content were obtained by Bagheri*et al.* (2001[b]).

Plant height had significantly and positively correlated with number of capitula plant^{-1} (0.229**). Number of branches plant^{-1} had significant positive correlation with seed yield per plant (0.815**), number of capitula plant^{-1} (0.732**). and non-significant negative correlation with Oil content (-0.066) and 100 seed weight (-0.078). Salunkhe (2014) also obtained positive and significant association of number of primary branches per plant with number of capitula per plant.

Number of capitula plant^{-1} showed significant and positive correlation with seed yield plant^{-1} (0.656**) while it was non-significantly and negatively correlated with 100 seed weight (-0.020) and oil content (-0.090). Mohtasham *et al.* (2012) also obtained positive and significant correlation of number of capitula per plant with seed yield per plant.Number of seeds per capitulum was non-significantly and negatively correlated with 100 seed weight (-0.043), Volume weight (-0.009) and Oil content (-0.062). In the findings of Salunkhe (2014), number of seeds per capitulum was non-significantly and negatively correlated with 100 seed weight.

100 seed weight showed significant positive correlation with volume weight (0.640**) and Days to 50 per cent flowering (0.224**) whereas, it had non-significant and negative correlation with seed yield per plant (-0.102). Non-Significant and negative association between 100 seed weight (-0.102) and seed yield per plant was also obtained by Murat and Vahdettin (2004).Volume weight had positive and significant correlation with 100 seed weight (0.640**) whereas, it had significant negative correlation with plant height (-0.172*). Volume weight was significantly and positively correlated with 100 seed weight in the results obtained by Pavithra (2013).

Oil content had positive and significant correlation with days to 50 per cent flowering (0.435**) and days to maturity (0.391**) while it had significant and negative correlation with seed yield per plant (-0.189*). Oil content was significantly and negatively correlated with seed yield plant^{-1} in the results obtained by Parameswarappa (1983).

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Effect of Crop Residue Mixture and Decomposing Culture on Physical, Chemical and Biological Properties of Compost

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ABSTRACT

An experiment entitled "Effect of crop residue mixture and decomposing culture on quality of compost." was undertaken at farm of COART, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year2020-21 with eight treatments replicated thrice in RBD. The compost is prepared in compost pit having dimension 1.5 x1.0 x 0.6 m^3. Results showed that highest final weight of compost (68.22 kg), maximum yield recovery of compost (45.48%), highest EC (1.52 dSm^{-1}), N (1.37%), P (0.87%), K (1.17%), ash content (60.34%), microbial population (Actinomycetes, bacteria and fugi) and lowest pH (7.24), total carbon (23.00%) and C:N ratio (16.79) and early maturity (107 days) were recorded with paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culture.

Compost is the natural process of 'rotting' or decomposition of organic matter by microorganism under controlled condition. Raw organic materials such as crop residues, animal waste, food garbage and weed species, enhance their suitability for application to the soil as a fertilizing source, after having undergone composting compost provides a stable organic matter that improves the physical, chemical and biological properties of soil, thereby enhancing soil quality and crop production.The composting process essentially occurs in three phases; a mesophilic phase during which microbial consortia multiply exponentially in the biomass to initiate the decomposition process, a thermophilic phase during which high rate decomposition occurs due to the increased growth of thermophilic microorganisms and the last phase maturation and cooling phase during which compost undergoes cooling, stabilization and maturation.

This huge amount of crop residue has economic value. Approximately 500-550 million tonnes (Mt) of crop residue are generated on-farm and off-farm annually from its productionof 110 Mt of wheat,122 Mt of rice,71 Mt of maize, 26 Mt of millets, 141 Mt of sugarcane, 8 Mt of fibre crops (jute, mesta, cotton) and 28 Mt of pulses. (Sunita Devi *et al.,* 2017).

Burning of crop residues causes' environmental pollution is hazardous to human health. It produces greenhouse gases causing global warming and results in loss of plant nutrients like N, P, K and S. Therefore, appropriate management of crop residues assumes a great significance. Hence, recycling of crop residues is an integral part of the strategies of plant nutrient management for sustaining soil health and crop yields.

The recycling of organic wastes for increasing soil fertility has gained importance in recent years due to the high cost of fertilizers and reduced availability of organic manures. The chemical inputs in crop production are becoming increasingly short in supply and prohibitively costly.

Hence it necessary to speed up the process of decomposition and to test feasibility of different crop residue and decomposing culture, hence the present investigation was undertaken.

MATERIAL AND METHODS

An experiment entitled "Effect of crop residue mixture and decomposing culture on quality of compost." was undertaken at farm of COART, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during the year 2020-21 with eight treatments *viz.*, T_1-paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culture, T_2- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + S-9 culture, T_3- paddy straw (40%) + soybean straw (20%) +

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gliricidialoppings (10%) + cowdung slurry (30%) + gauamrut culture, T_4- paddy straw (40%) + soybean straw (20%) + weed biomass (10%) + cowdung slurry (30%) + PDKV culture, T_5- paddy straw (40%) + soybean straw (20%) + weed biomass (10%) + cowdung slurry (30%) + S-9 culture, T_6- paddy straw (40%) + soybean straw (20%) + weed biomass (10%) + cowdung slurry (30%) + gauamrut culture,T_7- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) and T_8- paddy straw (40%) + soybean straw (20%) + weed biomass (10%) + cowdung slurry (30%) replicated thrice in RBD. The compost is prepared in compost pit having dimension 0.5 x1.0 x 0.6 m^3 in PDKV compost pit by above ground level was filled with crop residue mixture *viz*, paddy straw, soybean straw, gliricidialoppings and weed biomass with decomposing culture. Cover all the surface of bottom of pit with teak plant leaves and sprinkle cow dung slurry on the surface of teak leaves

At bottom, 10 kg of paddy straw was spread evenly and then spread 5 kg of soybean straw and then spread evenly 2.5 kg of weed biomass or gliricidialoppings in respective treatment. Then cow dung slurry of 25 liter prepared from mixture of 7.5 kg dung, 25 liter water and 17.5 gram decomposing culture. Likewise, total six layer were filled in compost pit . Last layer was plastered with thick slurry of 10 kg dung, 5 kg soil and 10-liter water. Compost was watered regularly when required to maintain moisture content up to 50-61%. Total 150 kg initial crop residues and weed biomass or gliricidialoppings was added in per compost pit.

Chemical analysis of Total N, P, K and Total Carbon of crop residues were determined by using Kjeldahl method, Spectrophotometer, Flame Photometer and Dry Combustion method respectively. The microbial population (bacteria, fungi and *actinomycetes*) in the compost sample was determined by using serial dilution plate method.

RESULTS AND DISCUSSION

Physical Properties of compost

The data presented in Table 1 revealed that significantly highest final weight (68.22 kg) of compost, percent yield recovery of compost (45.18%) and maturity of compost was earlier with treatment T_1- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culture which was significant over all other treatments and being at par with compost of T_3 and T_4. However, significantly lowest final weight (57.18 kg) of compost, lowest yield recovery (38.12 %) and late maturity w as recorded with treatment T_8- paddy straw (40%) + soybean straw (20%) + weed biomass (10%) + cowdung slurry (30%). In present investigation it is observed that higher final weight of compost and maximum yield recovery which might be due to addition of gliricidia lopping and decomposing culture helps increasing microbial population which ultimately enhance decomposition and also due to generation of humic acid in compost towards last stage of composting. The yield recovery maximumindicates that decomposition rate of PDKV decomposing culture was faster than other decomposing culture used in experiment. PDKV culture was matured significantly earlier *i.e.,*107 day due to the presence of humic acid (HA) in compost and greater activity of microbes it was consumed more carbon therefore decreasing of C:N ratio, hence faster decomposition process. Similar findings were reported by Laharia*et al.* (2000)), Verma*et al.* (2018) andPandule*et* al. (2019).

Chemical Properties of compost

The data presented in Table 2 revealed that chemical properties of compost.

pH and EC

At maturity, lowest pH (7.24) and highest EC was found with treatment T_1- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culture compost which was significant over all other treatments but being at par with T_3 and T_4. However, highestpH (7.48) and lower EC (1.27 dSm^{-1}) was recorded with treatment T_8- paddy straw (40%) + soybean straw (20%) + weed biomass (10%) + cowdung slurry (30%) compost. Lowest pH in compost might be due to formation of carbon dioxide gas and organic acid during organic matter decomposition.The increase in EC during composting might be due to loss of weight due to mineralization into soluble forms and subsequently become concentrated due to drying. The drying process enables

Table 1. Final weight, percent yield recovery and maturity of compost as influenced by different crop residue mixture and decomposing cultures

Treatment		Initial weight (kg)	Final weight (kg)	Per cent Reduction in weight	Per cent Yield recovery	Maturity (days)
T_1	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + PDKV culture	150	68.22	54.52	45.48	107
T_2	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + S-9 culture	150	61.98	58.68	41.32	115
T_3	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + Gauamrut culture	150	64.84	56.77	43.23	109
T_4	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%) + PDKV culture	150	64.33	57.11	42.89	112
T_5	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%) + S-9 culture	150	59.76	60.16	39.84	117
T_6	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%) + Gauamrut culture	150	60.30	59.80	40.20	114
T_7	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%)	150	59.10	60.55	39.45	120
T_8	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%)	150	57.18	61.88	38.12	122
	SE (m)±		1.31			3.11
	CD at 5%		3.96			9.44

accumulation of mineral salt such as phosphate and ammonium ions contributing to highest EC. Similar results were reported by Karanja*et al.* (2019), Pandule*et* al. (2019) andBarapatre*et al.* (2020).

Total carbon content and Ash cotnent

At harvest lowest total carbon content (23.00 %)and highest ash content (60.34 %) were observed in treatment T_1- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culture. Lowest total carbon content might be due to highest microbial population and their respiratory activity of microbes during composting. Carbon is a source of energy for microorganisms to build up cells. Almost all of the carbon is consumed by the microorganisms and transformed to CO_2 during the metabolism process of the cells thus lower the carbon content. Increased carbon content might be due to the decomposition of waste in a faster rate and the microbial assimilation was also performing the decomposition process in a good pace. The results are in conformity with the findings of SunitaDevi*et al.* (2012) and Gill *et al.* (2016) and Shukla *et al.* (2016).

Table 2 Chemical properties of compost at maturity as influenced by different crop residue mixture and decomposing culture

Treatments		pH	EC(dSm^{-1})	Total carbon content (%)	Ash content (%)	C:N ratio	Total N (%)	Total P (%)	Total k (%)
T_1	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + PDKV culture	7.24	1.52	23.00	60.34	16.79	1.37	0.87	1.17
T_2	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + S-9 culture	7.35	1.45	24.27	58.16	18.53	1.31	0.80	1.15
T_3	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + Gauamrut culture	7.29	1.50	24.36	58.01	18.18	1.33	0.85	1.16
T_4	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%) + PDKV culture	7.28	1.48	23.22	59.67	17.33	1.33	0.83	1.15
T_5	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%) + S-9 culture	7.42	1.42	24.26	58.18	18.96	1.28	0.76	1.12
T_6	Paddy straw (40%) + Soybean straw (20%) +Weed biomass (10%) + Cowdung slurry (30%) + Gauamrut culture	7.39	1.41	24.52	57.73	18.72	1.31	0.77	1.13
T_7	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%)	7.46	1.35	25.98	55.22	20.46	1.27	0.75	1.09
T_8	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%)	7.48	1.27	25.82	55.49	20.83	1.24	0.72	1.07
	SE (m) ±	0.03	0.03	0.36	0.40	-	0.01	0.02	0.02
	CD at 5%	0.09	0.08	1.08	1.21	-	0.03	0.06	0.06

Table 3. Microbial population in compost at maturity as influenced by different crop residue mixture and decomposing culture

	TREATMENTS	Bacteria (x 10^4 CFU g^{-1})	Fungal (x 10^6 CFU g^{-1})	Actinomycetes (x 10^3 CFU g^{-1})
T_1	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + PDKV culture	31.67	23.33	18.67
T_2	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + S-9 culture	28.33	20.67	16.67
T_3	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%) + Gauamrut culture	29.33	21.33	17.67
T_4	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%) + PDKV culture	30.33	21.67	18.33
T_5	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%) + S-9 culture	25.67	18.33	15.33
T_6	Paddy straw (40%) + Soybean straw (20%) +Weed biomass (10%) + Cowdung slurry (30%) + Gauamrut culture	26.00	19.33	14.00
T_7	Paddy straw (40%) + Soybean straw (20%) + Gliricidialoppings (10%) + Cowdung slurry (30%)	25.33	18.33	13.67
T_8	Paddy straw (40%) + Soybean straw (20%) + Weed biomass (10%) + Cowdung slurry (30%)	23.67	17.33	12.67
	SE (m) ±	0.50	0.61	0.67
	CD at 5%	1.50	1.84	2.04

Total NPK content

At maturity, total nitrogen, phosphorus and potassium content was significantly highest with the compost prepared by using treatment T_1- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culture.

The increase in nitrogen content may be due to high mineralization of organic matter by microbes by which N was retained in nitrate form. Higher total phosphorus content in compost was due to mineralization and mobilization of phosphorus as a result of microbial activity. Increase in potassium which might be due to addition of gliricidialoppings and acid production by the microorganisms which is important for solubalizing the insoluble potassium. These results are in conformity with similar results were were reported by Goyal and Sindhu (2011), Jusoh (2013), Viji (2015) and SheetalBarapatre (2020).

C:N ratio

Significantly lowest C:N ratio was recorded with treatment T_1- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culturecompost probably due to increased rate of decomposition and loss of organic carbon through oxidation in the form of CO_2 ultimatelydecrease in carbon and simultaneously increase in total nitrogen due to mineralization of organic residue and volatilization of nitrogen as ammonia. Hence, C:N ratio decreases. Similar results were reported by Devi *et al.* (2012) andKumari*et al.* (2016).

Biological properties

Microbial population

Highest fungal population (23.33x10^4CFU g^{-1}), bacteria (31.67 x10^4CFU g^{-1}) and *actinoycetes* population

(18.67 x 10^4CFU g^{-1})at maturity was observed in treatment T_1- paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culturecompost which might be due to the occurrence of the thermophillic, spore forming fungi at highest level and highest rate of decomposition and mineralization of complex substance into simple form. and (31.67x10^4CFU g^{-1})The increased *actinomycetes* population due to higher adoption of *actinomycetes*population in composting material due to porosity which enhances aeration, higher EC and neutral pH in composting material. Similar results were reported by Pandey *et al.* (2009), Sunita Devi *et al.* (2012) and Jagadabhi*et al.* (2019).

CONCLUSION

Compost prepared with paddy straw (40%) + soybean straw (20%) + gliricidialoppings (10%) + cowdung slurry (30%) + PDKV culture was significantly improved the quality of compost in terms of physical, chemical and biological properties.

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Development of Pulses Sprouter

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ABSTRACT

Sprouting is the practice of germinating seeds to be eaten raw or cooked. Sprouts can be germinated at home or produced industrially. The metabolic activity of resting seeds increases as soon as they are hydrated during soaking. Sprouting of grains is done using traditional method which includes overnight soaking of grains for minimum 8-10 h and then keeping overnight tightly covered in a cloth under ambient conditions for 24-72 h. The reduction of this time required in complete process is challengeable. Aim of the research was to overcome this drawback by the designing a sprouter to provide an easy and efficient way of sprouting of pulses. The sprouter provides essential temperature and relative humidity that are needed for breaking seed dormancy and making seed to grow into sprout. Sprouter works simply on the natural process germination which occurs in every seeds. In the designed sprouter, the water in the form of thin spray is applied to the pulses placed on the perforated tray. Submersible pump of capacity 18 watt is used to pump the water to the top four laterals of 16 cm on which have holes of 1.08mm diameter. The water from the perforation falls into the tub place below inside the sprouter. The recycling of water helps to provide pulses the heat during the sprouting. The continuous spray of water smoothens the seed coat and less energy is required by the sprout to come out of seeds. The length of sprout obtained is about 3 cm at temperature range about 24Ú C-25Ú C and high relative humidity of about 92%. The developedsprouter is able to produce the sproutes within 9 h. Inner side of box is lined with the double layer transparent plastic sheet (HDPE) & black plastic sheet (LDPE) to protect wood from moisture condensation on the sides of wood box. Sprouter provides natural condition of relative humidity and temperature required by the pulses at the time of germination. Sprouter uses grain heat which is generated by the respiration of grain itself.

India is the largest producer of chickpea and approximately 80-90 per cent supply of chickpea to the world is from India. In India Madhya Pradesh(production 2.69 kg ha^{-1} and productivity 711.93kg ha^{-1}) produces 33 per cent of India's chickpea production other top producing states includes Rajasthan, Maharashtra Karnataka, Andhra Pradesh and Uttar Pradesh (Anonymous, 2012).In Maharashtra the area under the total pulses was 3.38 million ha production 2.37 million tonnes and productivity 702 kg/ha .whereas in India in 2009-10, 23.38 million ha area was under these pulses with 14.66 million tonnes production and 630 kg ha^{-1} productivity(Anonymous, 2012).

Pulses belong to the family Leguminosae. Pulses provide protein and fibre, as well as vitamins and minerals, such as iron, zinc, folate, and magnesium. In addition, the phytochemicals, saponins, and tannins found in pulses possess antioxidant and anti-carcinogenic effects, indicating that pulses may have significant anti-cancer effects. Sprouting is the practice of germinating seeds to be eaten raw or cooked. Sprouts can be germinated at home or produced industrially. Normally bean sprouts need a week to grow to the state where they can be marketed or consumed, but developed sprouter can reduce this production time by 50% or more(Yoo, 1963). The metabolic activity of resting seeds increases as soon as they are hydrated during soaking. Sprouting grains causes increased activities of hydrolytic enzymes like lipase, improvements in the contents of total proteins, fat, essential amino acids, total sugars, B-group vitamins and starch digestibility, and decrease in phytates and protease inhibitors an increase in amino acid lysine is seen after sprouting, increase in proteolytic activity leads to hydrolysis of prolamins and increased lysine (Dipnaik and Bathere, 2017) .

The current era of speed and drastically advanced lifestyle food intake has become one of the major work being neglected and least preferred. This situation resulted in huge cases of protein deficiency and malnutrition. In the view of the above problems the current work aims to increase the protein content among the selected pulses with a focus on spouting of seedlings. The work can be of real use for those individuals who cannot afford to invest much on their diet. The proposed

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pulses can be substituted to the other nonnutritive foods that are much expensive. Based upon the above result the governments free food scheme for school students can be made more nutritive with minimum expenditure. Once the diet of the individual's is redesigned, this can be the first step to solve the nutritive problems faced today (Murugkar*et. al*.,2013).Protein content and transaminase activity are found to be highest in sprouted pulses. The sprouting increase the protein content for Chickpea, at raw stage 32±1.87gm%, at soaked stage 40±1.0 gm%, at sprouted stage 48±0.57gm% (Dipnaik and Bathere, 2017).

Sprouter and sprouting process is for growing sprouts as used in the meals served in restaurants, which are so popular in India. Normally, chickpea takes three to four days by traditional method to grow to the state of spouting where they can used in meals for preparation. Length of germination time followed by different heat treatments affect the nutritive value of leguminous sprouts. To optimize germination time and heat treatments for enhanced availability of iron from leguminous sprouts, three legumes namely, mungbean, chickpea and cowpea were germinated for three time periods followed by cooking of sprouts (Bains*et. al.*, 2014). Traditional method includes overnight soaking of grains for minimum 8-10 h and then keeping tightly covered in a cloth under proper conditions of temperature and RH for complete 24-48 h. The reduction of this time required in complete process is challengeable. Thus there is a need for development of a sprouter which will be able to produce the sproutes within noticeable short period. Thus the research study was undertaken for development of sprouter with the objective to develop the pulses (chickpea) sprouter and to reduce the sprouting time as compared to traditional method.

MATERIAL AND METHODS

Raw material selection

Mainly varieties of chickpeas like kabuli and desi were used. Kabuli are large sized, and beige-colored throughout, with a thin skin. This is the one referred to as: Bengal Gram, Kala Chana (meaning black chickpea) or Chola Boot. "Desi" chickpea is smaller, lighter to dark brown, with a thick, rough, seed coat. The word "Desi" means country or local in hindi. This chickpea is easily available in local market at the lower rates than other hybrid variety. Desi chickpeas have a markedly higher fibre content than other varieties and a lower glycemic index. The Desi chickpeas were procured from the local markets.

Traditional method

Normally, chickpea takes three to four days by traditional method to grow to the state of sprouting where they can used in meals for preparation. Traditional method includes overnight soaking of grains for minimum 8-10 h and then keeping tightly covered in a cloth under proper conditions of temperature and RH for complete 24-48 h. Following flow chart show the traditional method of sprouting:

Choose a jar and lid (Glass jar with mesh lid)

|

Rinse seeds Remove stones, debris, etc.

|

Soak seeds (Generally 24 hrs. for chickpea)

|

Drain seeds again rinse, drain (2-3 times)

|

Keep tightly covered with a cotton cloth

|

Sprouted seeds (48-72h)

Development of Sprouter

Components of the sprouter

1. Tubes for spraying

These are the plastic tubes with diameter 16mm with holediameter 1.08mm for spraying water. This drip tubes are called as laterals. The holes are made at distance of 1 cm each. The holes are manually made and are made such that the water is applied in the form of thin spray of water. Four laterals in cross pattern were used.

2. Drip Tube

Drip tubes of 16 mm diameter for conveying water to the top were used. This drip tube convey the water from the tub to the lateral. One end of the tube is connected to the pump in the tub and other to the laterals at top of sprouter.

3. Pump (18Watt)

Pump was used in system for recycling & pumping water. Submersible pump of capacity 18 watt was used to pump the water to the top four laterals of 16 cm diameter which have holes of 1.08mm diameter are made . The created pressure was required to create thin spray of water.

4. Water tub or storage tub

Metal tub of 55 cm x 55 cm was place at the bottom of the box to store water upto12 liter capacity. It reduces the chances leakage since plastic was linned throughout. The water was stored in the tub and recycled through pump. The sprouter includes specially designed drainage tub combined with improved water circulation similar to that of used by Poon, 1965. By recycling water, some of unknown growth factors released during germination can be resupplied and used for stimulation of growth. Recycling prevents the nutrients from washing away and helps to maintain constant temperature for sprouting and growing (Yoo,1963).

5. Perforated tray

Trays with perforations of diameter 2mm were used for holding pulses. The tray height was kept as 6cm from bottom except at front sidewere it was 3 cm. The dimension of tray were 48cm x 51cm.

6. Plywood box

Outer main frame was made of plywood sheet of 3 cm thickness. A rectangular box (60 cm x 60 cm) plywood box with door at front side for easy operation was fabricated and coated with double layer plastic sheet for controlling inside atmosphere. All the structure is made of plywood because it can be easily coated and also it act as insulator for temperature (do not transfer the heat to the outside environment). Inner side of box is lined with the double layer transparent plastic sheet (HDPE) & black plastic sheet (LDPE) to protect wood from moisture condensation on the sides of wood box.

7. Other components such as grommet, fourway, elbow, joiner were used for connections of such as pump with drip tube, drip tube with the laterals, laterals with main tube.

Assembly of sprouter machine

The dimension used and other functional detail of chickpea sprouter of capacity 5 Kg are as follows:

Plate 1: Designed pulses sprouter

Comparison of sprouting of chickpea with the traditional method

Sprouting using developed sprouter Sprouting using traditional method

At 0 h of sprouting

After 10 h of sprouting

After 13 hr

After 24 hr

Plate 2: Stages of sprouting from 0 hr to 24 h as compared to traditional method

Working of sprouter

Plate 3: Interior view of sprouter during sprouting of grains

Sprouter works simply on the natural process of germination which occurs in every seed when exposed to germination temperature and relative humidity conditions. In sprouter the pulses such as chickpea were firstly measured for their weight. Quantity taken should be 5 kg for the sprouter developed. After the beans are properly soaked a drainage was required merely unscrewing a drainage tub which has been placed at the bottom. The improved drainage system allows sprouts to grow in much larger mass. It was found unnecessary to use trays in some instances that have been proved commercially impractical by Poon, 1965. Then replace the water filled in the tub present at the bottom of the sprouter.Then by using pump of 18 watt the water was conveyed to the top of the sprouter through drip tube of length 50 cm. The pump pressure forces the water to come out through the holes on the laterals each of length 16 cm. The water comes out in the form of thin spray applied to the pulses placed on the perforated tray below. The water from the perforation falls into the tub placed below inside the sprouter. The recycling of water helps to provide the pulses the heat during the sprouting.

Sprouter provides natural condition of relative humidity and temperature required by the pulses at the time of germination (Sawant *et. al.,* 2019). Sprouter uses grain heat which is generated by the respiration of grain itself. After harvest, a seed separated from a plant goes into dormancy that is the period in which seed is not able to germinate. Very specific environmental condition are required to break the dormancy and grow the sprouts. High heat, prolonged rain and medium soil temperature are required to break the dormancy and after emerging from dormancy a seed is able to grow into sprouts (Sawant *et. al.,* 2019). During dormancy seed cannot make their own food because they lack of leaves. Therefore in order for a seed to stay alive or to grow it needs to use stored energy reserves and undergo cellular respiration. For this reason seeds have high calories and the seed will use those calories to survive during dormancy and to germinate. After harvest seed respires. Soaking of the seeds make the seed moist and moist seed should begin to break dormancy and have higher respiration rate than dry counterparts. Respiration involves the breakdown of carbohydrates, usually in the form of sugars,by the seeds itself for the growth and development.The general reaction for respiration is shown below:

$$C_6H_{12}O_6+6\,O_2=6CO_2+6\,H_2O+677kcal$$

Oxidation of sugar results in liberation of the carbon dioxide water and energy required for the growth of sprouts. Respiration is initiated by the enzymes and enzymes are catalyst that speed up the reaction and also their activity is optimal at temperature around 50^0C. Indirectly the temperature increases the enzymatic activity and which in terms increases the respiration rate which produces energy require for the growth of sprout or germination. In thesprouter, warm water unables to achieve the temperature for fast growth of sprouts. And continuous spray of water smoothens the seed coat and less energy is required by the sprout to come out of seeds (Yoo,1963).

Experimental Parameters measured

1. Initial moisture content of grains

25 - 30 g of sample was taken for estimation and

placedthe sample in ahotair oven at 105 ! temperature. The sample are kept in it for 72-96 hrs. Afterwards the sample are taken out from oven placed in desiccator to cool down to room temperature. Moisture content of sample is measured based on drop in weight from initial weight of sample.

$$\text{Moisture content (wb)} = W_2 - W_1 / W_1 \times 100$$

2. Temperature

It was calculated by using thermometer (in !).The reading for temperature was noted after every 30 minutes interval.Temperature determines the degree of hotness or the level of heat intensity of a body. Temperature is measured in degree Celsius.

3. Relative humidity

It was calculated by using digital hygrometer. It is the ratio of the actual vapour pressure of the moist air at given temperature to the saturation vapour pressure of the moist air at same temperature.

4. Final moisture content

It was calculated by using hot air oven method (direct method). Final moisture content of thepulses was measured when the sproutes were grown completely.

5. Sprout length

Sample of 10 chickpea was taken after interval of every half an hour and the length of each sprout was measured in cm using Vernier calliper.

RESULTS AND DISCUSSION

In the developed sprouter the temperature at time of sprouting was measured to be as 24.4!. Initially from every 5min the results for all the parameters such as temperature, RH, moisture content showed a gradual increase and then there was drastic increase observed. Relative humidity was measured by using digital hygrometer. For sprouter the relative humidity of 91.94 per cent was obtained. Moisture content of chickpea sample of 20 g before sprouting was 15 per cent and it changed to 30 per cent after sprouting. Sprout length increased and was measured to be 3 cm after 16 h for chickpea from 0 h of spouting to 24 h.

On comparison between traditional method of sprouting and developed sprouter there reduction in sprouting time was observed and it was about 24-48 h. Fig 1. shows the variation in temperature with time. Fig 2. Shows the variation in relative humidity with time. Fig 3. shows the growth in sprout length with time for grains sprouted using the developed sprouter.

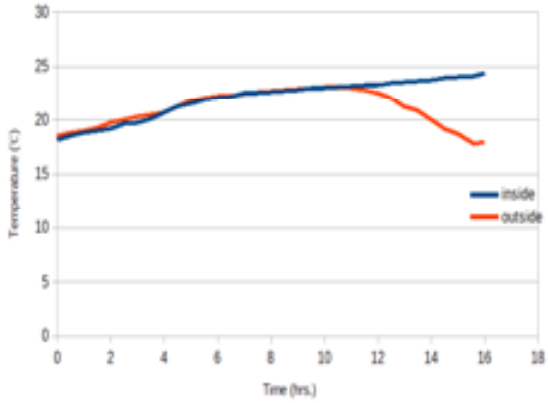

Fig. 1 Variation in the temperature with time

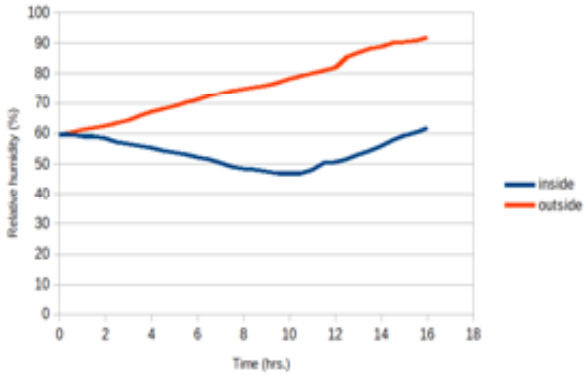

Fig. 2 Variation in the RH with time

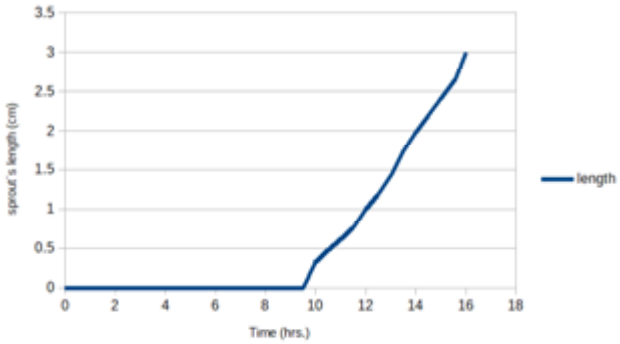

Fig. 3 Variation in the sprout's length with time

From the graph plotted for temperature against time it was observed that as the time passes the value of temperature inside the sprouter goes on increasing. From graph it is clear that thesprouter is able to maintain high relative humidity indicating the increasing value of relative humidity inside the sprouter which goes on increasing. Relative humidity of outer environment goes on decreasing with sun rise and goes on increases as sunset for the whole day. The graph shows that the sprout length increases as the time passes. For the first 8-10 h grains were soaked and then the germination of these soaked grains started after 10 h of soaking.

CONCLUSION

Normally, chickpea takes three to four days by traditional method for grow to the state of sprouting where they can used in meals for preparation. Traditional method includes overnight soaking of grains for minimum 8-10 h. and then keeping tightly covered in a cloth under proper conditions of temperature and RH for complete 24-48 h. The reduction of this time required in complete process is challengeable. The sprouter was able to produce the sproutes within 9 h and hence the time required in traditional method can be greatly reduced.

Development of chickpea sprouter provide an easy and efficient way of sprouting of pulses such as chickpea .The sprouts are grown in less time as compare to traditional method of sprouting. The sprouter provides essential temperature and relative humidity that are needed for breaking seed dormancy and making seed to grow into sprout. The length of sprout about 3cm was obtained if it was sprouted at medium temperature (about 24-25)and high relative humidity (of about 92%) condition.

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Performance Evaluation of Different Hand Tools for Shelling Fresh Sweet Corn Cob

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ABSTRACT

Sweet corn is a special maize variety popular for its tender and delicious kernels. Fresh sweet corn kernels aredirectly consumed in the forms of boiled or roasted forms and also added to many more dishes like salads, soups, pastas and fried rice etc. Apart from low shelling rate, handshelling of sweet corn is very tedious and exhausting task. Hence low costhand operated fresh sweet corn sheller was developed. But some small hand tools are also available in the market. Therefore the present the work was undertaken to compare the performance of a developed fresh sweet corn sheller with different hand tools available in the market for shelling the fresh sweet corn cob. Developed hand operated sheller and three hand tools namely Hand Tool A(Cylinder Type), Hand Tool B(Disc Type) and Hand Tool C (Mouse Type) were evaluated for its shelling efficiency (%), shelling capacity (kg/h), percentage of whole kernels and percentage of mechanical damage. Maximum shelling efficiency i.e. 97.61 % was found for cylindrical type hand tool (A) followed by developed hand sheller. But mechanically damaged kernels were highest in Mouse type hand tool and minimum (10.513 %) was observed for developed hand sheller.

Corn (*Zea mays* L.) is one of the most important staple crops in the world next to rice and wheat. Sweet corn is a variety of maize with high sugar content and also called Indian corn, pole corn or simply corn. Sweet corn has a sweeter taste than other corns due to more amount of sugar along with starch inits endosperm. It is distinguished from other corns by its high sugar content during the milky and early dough stages and kernels are wrinkled and translucent when dry (Geetha, et. al. 2017). Sweet corn has been widely cultivated as a valued crop in all countries due to its taste and nutritional value. It isconsumed as a healthy food because of its carotenoids content and is gluten-free cereal. Yellow sweet corn is the most commonly known variety of sweet corn. It has been reported to contain 75.7 percent moisture, 6.8mg/100g vitamin C, 2.0mg/100g calcium, 37mg/100g magnesium, 15.2mg/100g sodium on fresh matter basis (Aanchal Johari and Isha Kaushik., 2016). Although sweetness is the most important quality characteristic in sweet corn, the importance of other flavor components in consumer acceptance is also equally important (Evensen and Boyer, 1986).Sweet corn as a crop has multiple uses but it is mainly grown for human consumption in the forms of boiled or roasted forms. Sweet corn for processing is harvested at a relatively immature stage as compared to field corn. Sweet corn for the fresh market is generally harvested by hand or machine at higher moisture content of 70-80%.Sweet corn is commonly eaten as a vegetable, rather than a grain. The kernels are boiled or steamed to produce canned sweet corn and eaten as a side dish.

Hand shelling of sweet corn is very tedious, exhausting and time consumingtask. Also hand shelling of fresh sweet corn has very low shelling rate. Hence low cost hand operated fresh sweet corn sheller was developed. But some small hand tools are also available in the market. Therefore the present the work was undertaken to compare the performance of a developed fresh sweet corn sheller with different hand tools available in the market for shelling the fresh sweet corn cob.

MATERIAL AND METHODS

Freshly harvested sweet corns cobs were procured from local market of Parbhani. Sweet corn sheller was developed to shell fresh sweet corn cobs and separate the kernels from the cob.Three hand tools were purchased from the market and depending on its features named asHand Tool A(Cylinder Type), Hand Tool B (Disc Type) and Hand Tool C (Mouse Type).

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The trials of the machine were conducted on the sweet corn cobs with moisture content varied from 70 to76%. For each trial weight of shelled kernels (damage and whole), unshelled kernel and core (cob after shelling) were recorded. Developed hand operated sheller and three hand tools purchased from the market were evaluated for itsoperational parameters such as shelling efficiency (%), shelling capacity (kg h^{-1}), percentage of whole kernels and percentage of mechanical damage(Patil *et al* .,2016; Azeez *et al.,* 2017).

Shelling efficiency (%)

Shelling efficiency = (100 - Percent of unshelled kernel)

Shelling capacity(kg h^{-1})

$$\text{Shelling rate (kg/h)} = \frac{\text{Weight of shelled kernels (kg)} \times 60}{\text{Time (min)}}$$

Whole kernel (%)

$$\text{Whole kernel (\%)} = \frac{\text{Weight of whole kernels (kg)} \times 100}{\text{Weight of Total Shelled Kernels(kg)}}$$

Mechanically damagekernels %

$$\text{Mechanically damage kernels (\%)} = \frac{\text{Weight of broken kernels (kg)}}{\text{Weight of Total Shelled Kernels(kg)}} \times 100$$

RESULTS AND DISCUSSION

Shelling Efficiency per cent & Shelling capacity (kg h^{-1})

Hand tool A i.e. cylindrical type showed maximum shelling efficiency of 99.611 per cent followed by developed hand operated sheller i.e. 96.653 per cent, while minimum shelling efficiency was recorded for hand tool C i.e. mouse type. Disc type hand tool B recorded the 94.374 per cent shelling efficiency. Shelling capacity was observed maximum i.e. 15.382 kg h^{-1} for cylindrical type hand tool A whereas minimum of 7.965 kg h^{-1} shelling capacity was observed for developed hand operated fresh sweet corn sheller. Shelling capacity of 14.541 and 12.063 kg h^{-1} were recorded for disc type hand tool B and mouse type hand tool C respectively. 96.653 per cent.

Percentage of whole and mechanical damage of shelled kernels (%)

From Fig. 3 and 4, it is observed that showed that maximum percentage of whole kernel and minimum percentage of mechanical damage was recorded fordeveloped hand operated fresh sweet corn sheller as compare to all other hand tools. It was also observed that percentage of mechanical damage was highest for mouse type hand tool C i.e. 100 % followed by disc type hand tool B (87.551%). Mouse type hand tool C has to press the blade of tool against the cob while removing the kernels which ultimately resulted in highest percentage of mechanically damage kernels. Percentage of whole kernel of 70.830 and 87.551 % were recorded for Hand tool A i.e. cylindrical type and disc type hand tool B, respectively.

Table 1: Comparative evaluation of hand tools and developed sheller

Treatment	Shelling Efficiency (%)	Shelling Capacity (kg h^{-1})	% of Whole Kernels	% of Mechanically Damage Kernels
Hand Tool A (Cylinder Type)	97.611	15.382	30.270	70.830
Hand Tool B (Disc Type)	94.374	14.541	13.313	87.551
Hand Tool C (Mouse Type)	93.199	12.063	0.000	100.000
Hand Operated Sheller	96.653	7.965	88.497	10.513
Analysis of Variance				
C.D.	8.078*	1.940*	9.005*	5.668*
SE(m)	2.805	0.674	3.020	2.038
C.V.	21.176	2.228	291.083	9.782

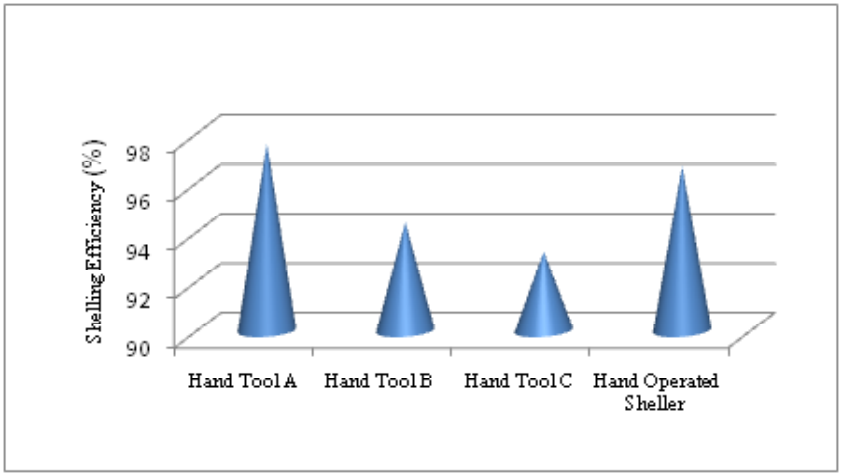

Fig. 1: Shelling efficiency fordifferent hand tools

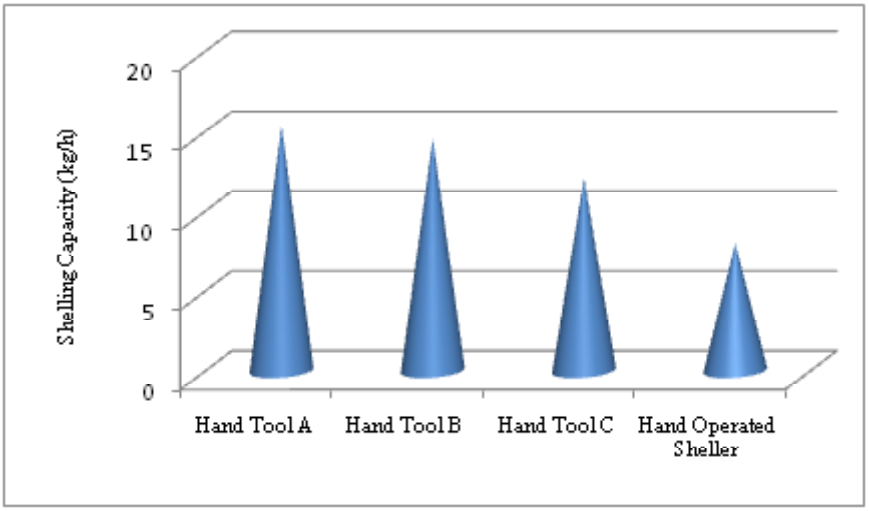

Fig. 2 : Shelling capacity fordifferent hand tools

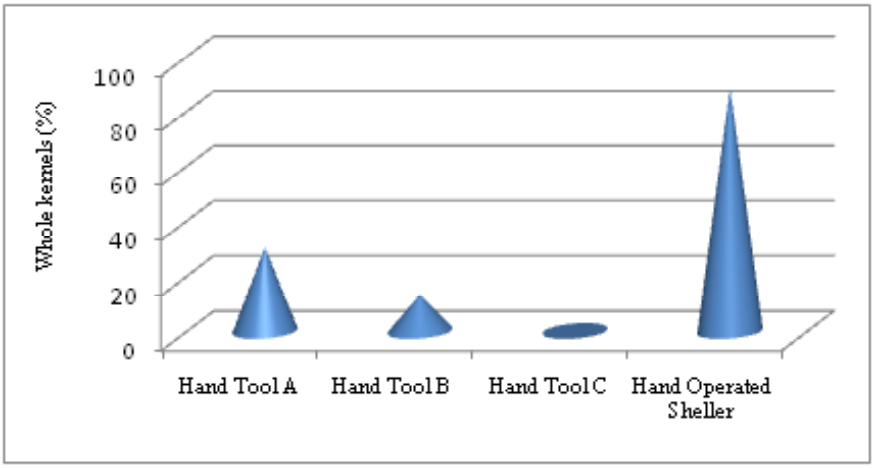

Fig. 3. Percentage of whole kernelfordifferent hand tools

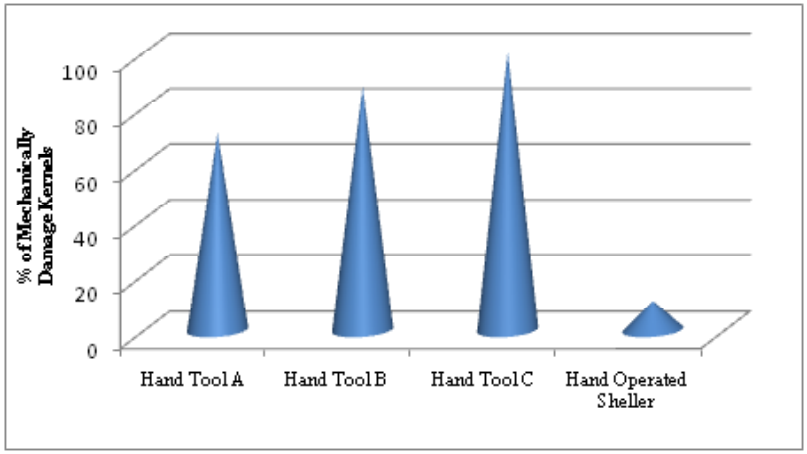

Fig. 4Percentage of mechanical damage fordifferent hand tools

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Comparative Study of Osmotic Dehydration and Conventional Drying on Quality Attributes of Plum

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ABSTRACT

Plum (*Prunus domestica*) is a seasonal fruitthat is rich in various functional nutrients such as vitamin C, antioxidants, total phenolic content, and minerals. Nowadaysresearchers areworking on different technologies for the retention of bioactive compounds during the processing of perishable fruits. In this work, the effect of osmotic dehydration and conventional drying on moisture content, acidity, vitamin C, total anthocyanin content, and total phenolic content of plumwere studied. Conventional drying of plum was carried out at 80°C for 5-6 hours and whole fruit osmotic dehydration was carried out at a different temperature of 45°C, 50°C and 55°C witha hypertonic solution concentration of 65°B, 70°B and 75°B at a constant contact time of 24 hours. This study found that the osmotically treated fruit gives more nutrient retention than conventionally dried fruit.The total phenolic content of fruit significantly increased with the increase ($p<0.05$ and CL 95%) in process temperature. However, vitamin C and total anthocyanin content of the fruit decreased significantly with process temperature and hypertonic solution concentration.

Plum (*Prunus domestica*) is one of the most important nutritional fruit in the human diet. Around 200 different varieties of the plum are available and few are commercially important (Birwal*et al*., 2017). Plum is an important source of bioactive compounds influencing human health and works as nutraceuticals. Plum is a vital source of bioactive compounds such as phenolic acids, anthocyanin, carotenoids, minerals, and pectin. For many decades plums have been used as medicine for the treatment of leucorrhea, irregular menstruation, and miscarriage (Birwal*et al*., 2017). Generally, plums are consumed as fresh. However, the processing of plumsincludes drying, juice preparation, and canning.

Dehydrationis one of the best techniques to extend the shelf of fresh produce. Dehydration involves the simultaneous application of heat and removal of moisture from foods, resulting in loss of heat-sensitive volatile components, like flavour, ascorbic acid, and oxidation of pigments. Simultaneously,changes in the texture of food are an undesirable cause of quality deterioration due to conventional drying methods. To minimize these dehydration losses osmotic dehydration is the most beneficial pretreatment.Osmotic dehydration is the movement of hypertonic solution through the semipermeable membrane. Generally, sugar is used in the preparation of hypertonic solutions for fruits. The osmotic dehydration process generally reduces the 30-50% moisture content of the fruits (Josephine *et al*., 2014).

Thus, the purpose of this research work is to compare the moisture, acidity, vitamin C, anthocyanin, and total phenolic content of conventional dried plum and osmodried plum. The objective of this study is to compare osmotic dehydration with conventional drying techniques and to understand the nutritional and other health benefits of osmodried plum.

MATERIAL AND METHODS

2.1.Sample preparation

Fresh fully ripened plums with outer dark red skin were procured from the Nagpur fruit market. The fruits were washed with chlorinated water to ensure the removal of surface adherents. Further blanching (100^0C) was carried out for removal of tissue gases, inactivation of enzymes, softening of tissue, and the facilitation of osmosis by rupturing the cell wall. The retention of colour was done by the addition of 1% citric acid and 0.5% NaCl in combination during blanching.

2.2.Osmotic Dehydration

Osmosis of whole blanched fruit was done with variant process conditions such as the temperature of 45^0C, 50^0C, and 55^0C with hypertonic solution (sucrose)

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of concentration (65°, 70° and 75°Bx) respectively at a constant contact time of 24 hours. The whole blanched fruitwith an initial moisture content of 87.63% and TSS 14°Bx was immersed into a hypertonic solution of sucrose maintaining fruit to hypertonic solution ratio of 1:6. After every treatment fruit was removed from the solution and kept at constant temperature for 15 min to drain the syrup, and thenfruits were gently blotted with tissue paper. Washing with water after osmosis may lead to a reduction in total TSS of fruit, thus it was avoided.

2.3. Conventional Drying of fruit

Conventional drying of whole fruit was carried out under a controlledtemperature of 80°C for 8 hours by using a hot air oven.

2.4. Physiochemical Analysis

2.4.1 Moisture content

The moisture content of all the samples was determined according to standard methods of AOAC. The sample (5 grams) of the sample was oven-dried at 110°C and the moisture content of the sample was calculated.

2.4.2. Total Acidity

Total acidity was determined by the procedure stated in Ranganna (2012). Standardization of NaOH (0.1N) was done by using analiquot (10ml) of oxalic acid (0.1N) and phenolphthalein as an indicator. Osmotically dehydrated plum was crushed in a mortar and homogenized with sterile distilled water. The extract was filteredusing Whatman filter paper no. 1.Further volume was made up to 100 ml with distilled water.The aliquotwas titrated against NaOH.The persistence of pink colour for at least 15 seconds indicates the completion of titration. Each determination was in triplicate.

2.4.3. Ascorbic Acid (Vitamin C)

Ascorbic acid of the osmotically dehydrated plum was determined by the 2,6-Dichlorophenol-Indophenol visual titration method (Johnson, 1948; Methods of Vitamin Assay, 1948) with modifications.Osmotically dehydrated plum was crushed in a mortar and homogenized with HPO_3.The extract was filtered using Whatman filter paper no. 1. Further volume was made up to 100 ml with HPO_3. The aliquot was titrated with 2, 6-Dichlorophenol-Indophenol. The endpoint was noted when the pink colourpersistedfor at least 15 seconds. All measure was in triplicate.

2.4.4. Total Anthocyanin content

The total anthocyanin content of the osmotically dehydrated plum was determined by using the method described by Fuleki, T. and F. J. Francis, (1968) with modification.Osmotically dehydrated plum was crushed in a mortar and homogenized with ethanolic HCl.Further, it was filtered on a Whatman filter paper no. 1 using a Buchner funnel. The residue was repeatedly washed with ethanolic HCl. For spectrophotometric (Labman Scientific Instrument) measurement aliquot (6.24 ml) was taken and made up to the volume of 25 ml with ethanolic HCl and then it was stored in a dark for 2 hours and absorbance was measured at 535 nm. Ethanolic HCl is used as a blank solution for UV visible spectrophotometric measurement. Each determination was in triplicate.

2.4.5. Total Phenolic Content

The total phenolic content of the sample was calculated by using Folin Ciocalteu's method described in Chuah *et al*. (2008) with some modifications. Osmotically dehydrated plums (5 grams) were crushed in a mortar with 80% ethanol and then the sample was stored for 2 hours under controlled refrigeration conditions (at 4°C). Then the sample was centrifuged at 3000 rpm for 20 min and filtered on a Whatman filter paper. 0.4 ml of osmotically dehydrated plum extract and the gallic acid solution were transferred to the test tube. 5ml water was added. Followed by this 0.5 ml Folin Ciocalteu's (FC) (10 fold) reagent was added. After 3 min 20% Na_2CO_3 was added to make up the volume to 10ml and shaken. The sample was then put into the water bath (100°C) for 1min. After cooling at room temperature absorbance was measured on UV visible spectrophotometer (Labman Scientific Instrument) at 640 nm. The Gallic acid (GA) calibration curve was plotted to compare the spectrophotometric absorbance. Results were expressed as mg GA $100g^{-1}$ osmotically dehydrated plum. All measures were done in triplicates.

2.4.6 Statistical analysis

The effect of temperature and sugar syrup concentration on each quality parameter was analyzed using Graphpad Prism 5.00.288 applying an analysis of variance (ANOVA). Differences in the mean values were analyzed using the least significant difference (LSD) test with a significance level of 0.05 and a confidence interval

of 95% ($P < 0.05$). In addition, the Bonferroni test included in the statistical program was used to compare the entire column with each other.

RESULTS AND DISCUSSION

Table 1 represents the mean values and standard deviation of the moisture content, acidity, vitamin C, total anthocyanin, and total phenolic content of conventional dried fruit with respect to different level operating parameters $p<0.05$ and (confidence level 95%) temperature (45^0, 50^0 and 55^0C) and hypertonic solution concentration (65^0, 70^0 and 75^0B), respectively.

From table no.1 it was observed that the acidity of the conventional dried fruit is not that much affected as compared to raw fruit. Vitamin C and anthocyanin content of the fruit was significantly decreased (Nadia *et al*., 2013. The total phenolic content of the fruit was more as compared to raw fruit (Nazmi *et al*., 2017). From this observation, it was found that the conventional drying process produces more losses as compared to other drying technology. Thus osmotic dehydration process is preferred for dehydration.

3.1. Moisture Content

The initial moisture content of raw fruit was presented in table no. 1 and osmotically dehydrated fruit moisture content was presented in figure no. 1. A significant decrease in moisture content was observed for osmotically dehydrated plum (figure no. 1) with respect to different operating parameters temperature (45^0, 50^0 and 55^0C) and sugar syrup concentration (65^0, 70^0 and 75^0B) at the level of $p<0.005$ and 95 per cent CL. Similar results for moisture content were reported by Yissleen*et al*., (2013) for osmotically dehydrated strawberry (*Fragaria vesca*).

Table no. 1: Raw and Conventional dried fruit analysis.

Sample / Parameters	Raw Fruit Analysis	Conventional Dried Fruit Analysis
	Wet Basis	Wet Basis
Moisture Content(%)	85.22 ± 0.52^b	7.77 ± 0.012^a
Acidity(%)	1.21 ± 0.05^a	1.30 ± 0.102^b
Vitamin C(mg/100gm)	50.22 ± 0.26^b	8.05 ± 0.05^a
Anthocyanin(mg/100gm)	112.2 ± 0.005^a	39.68 ± 0.025^a
TPC(mg GA /100 gm)	123.5 ± 0.087^a	1801.20 ± 0.002^a

The table represents mean ± standard deviation of triplicates (n=3) and values followed by the same letter in the same column are not signiûcantly different ($P < 0.05$).

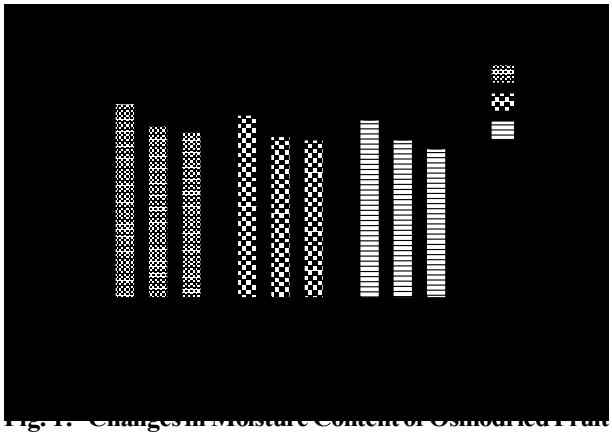

Fig. 1: Changes in Moisture Content of Osmodried Fruit with respect to temperature and sugar syrup concentration. Combined Bars represent the mean ± standard deviation of triplicates (n=3). Identical letters above the bars indicate no significant differences ($P < 0.05$).

3.2. Acidity

Figures no. 2a and 2bpresent the combined bar graph for acidity content (%) of both osmotically dehydrated plum and drain the syrup. From this, it was observed that there is no significant change in the acidity of the osmotically dehydrated plum (figure no. 2a). It was also observed that there is a significant increase (0.1-0.15%) in the acid content of drain syrup due to the addition of citric acid during syrup preparation for colour retention (figure no. 2b).

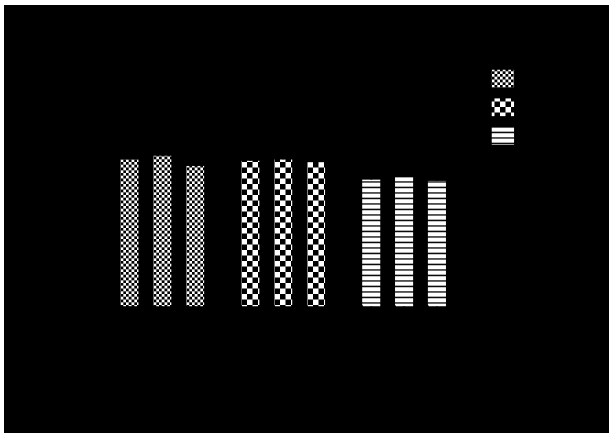

Figure no.: 2a

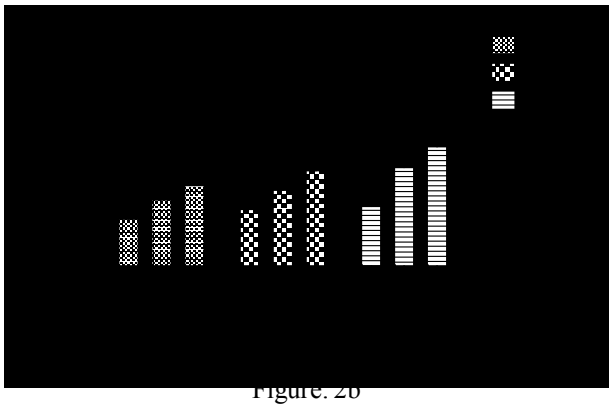

Figure: 2b

Fig. 2 (2a and 2b): Changes in Acidity of Osmodried Fruit and drain syrup with respect to temperature and sugar syrup concentration respectively. Combined Bars represent the mean ± standard deviation of triplicates (n=3). Identical letters above the bars indicate no significant differences (P < 0.05).

3.3. Vitamin C

Figure no.3a and 3b present the combined bar graph of sugar syrup concentration (^{0}B) versus ascorbic acid content (mg/100gm) at different temperatures (45^0, 50^0 and 55^{0}C) for the different samples of osmotically dehydrated fruit and drain the syrup. A significant decrease in vitamin C content was observed for osmotically dehydrated plum and drain syrup with respect to different operating parameters temperature (45^0, 50^0 and 55^{0}C) and sugar syrup concentration (65^0, 70^{0}and 75^{0}B) at the level of p<0.005 and 95% CL.Sample treated at 45^{0}C gives better vitamin C retention than samples treated at 50^{0}C and 55^{0}C. It was found that there is a 12 per cent reduction in ascorbic acid content in the case of osmotically dehydrated plum and 40% ascorbic acid reduction in the case of conventionally dehydrated plum. Ascorbic acid concentration decreases with processing temperature and hypertonic solution concentration (Nadia *et al*., 2013). Leaching is also one of the most important factors to consider in the decrease in ascorbic acid concentration in osmotically dehydrated fruit.

Vitamin C is highly heat-sensitive, is easily destroyed during processing (Wolbang,*et al,*. 2008). The decrease in ascorbic acid concentration with an increase in osmosis temperature shows its instability to the higher temperature (Solanke and Awonorin, 2002; Osundahunsi, 2008). However, some enzymes like cytochrome oxidase, ascorbic acid oxidase, and peroxidase found in fruits are also responsible for ascorbic acid degradation (Yissleen*et al.*, 2013) and Karim, *et al.*,(2009) for peach.

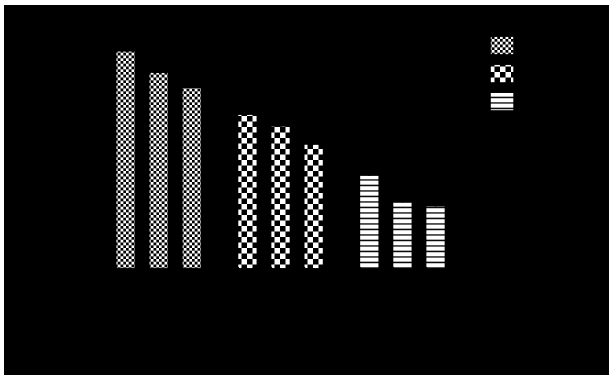

Figure No.: 3a

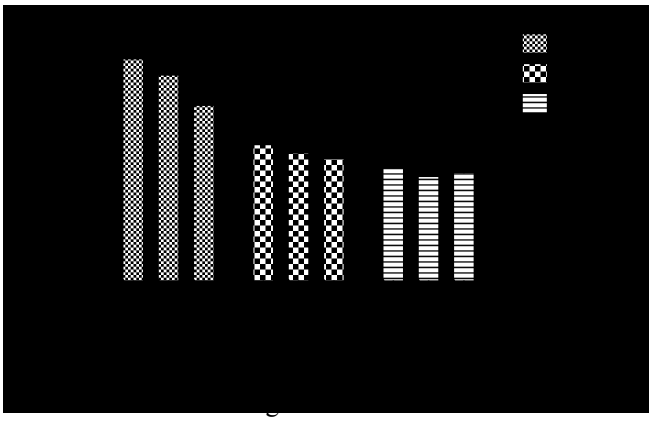

Fig. 3 (3a and 3b): Changes in Vitamin C content of Osmodried Fruit and drain syrup with respect to temperature and sugar syrup concentration respectively. Combined Bars represent the mean ± standard deviation of triplicates (n=3). Identical letters above the bars indicate no significant differences (P < 0.05).

3.4. Anthocyanin content

From figure 4a it was observed that a significant decrease in anthocyanin content of osmotically dehydrated plum with respect to different operating parameters temperature (45^0, 50^0 and 55^{0}C) and sugar syrup concentration (65^0, 70^{0}and 75^{0}B) at the level of p<0.005

and 95% CL. Sample processed at 45^0C and 65^0B gives more anthocyanin content (90.32 mg/100gm) than sample processed at 50^0C and 55^0C for osmotically dehydrated fruit. It was found that in the case of osmotically dehydrated plum 20-22% anthocyanin content losses and in case conventionally dehydrated plum more than 50% losses as compared to fresh plum fruit.

No significant change in total anthocyanin content of drain syrup was observed (presented in figure 4b) with respect totemperature (45^0, 50^0 and 55^0C) and sugar syrup concentration (65^0, 70^0 and 75^0B). Anthocyanin content of drain syrup was depending upon the amount of anthocyanin leaching out from fruit during 24-hour osmosis.

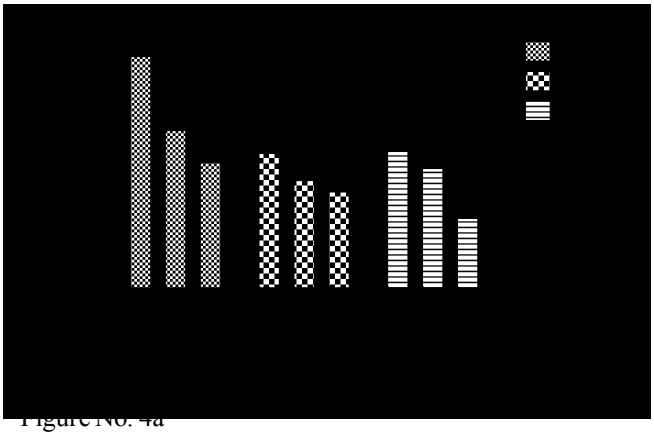

Figure No. 4a

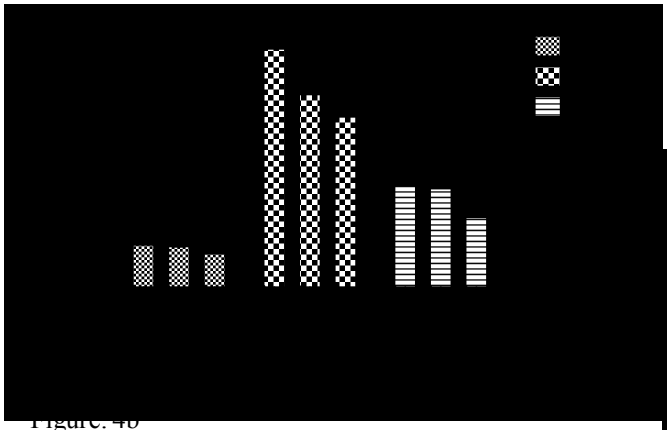

Figure. 4b

Fig4 (4a and 4b): Changes in Anthocyanin content of Osmodried Fruit and drain syrup with respect to temperature and sugar syrup concentration respectively. Combined Bars represent the mean ± standard deviation of triplicates (n=3). Identical letters above the bars indicate no significant differences (P < 0.05).

Sugar is one of the critical factors for anthocyanin stability (Ngo *et al.*,2007) reported that total anthocyanin in strawberries canned in 20^0B at room temperature. Similarly, the temperature and duration of blanching strongly affect anthocyanin. The study of Brownmiler*et al.*, (2008) observed that a higher temperature of blanching (95^0C for 3 min) resulted in 43% anthocyanin losses compared to the original level found in fresh fruit. Numbers of factors are responsible for anthocyanin degradation during processing such as heat, pH, light, oxygen,and duration of exposure of these factors to the product. Anthocyanin pigment is highly heat-sensitivedescribed byOancea, *et al.*, (2012) for the effect of extraction condition on total anthocyanin content from Vaccinium corymbosum. Pericles *et al.*,(1956) reported anthocyanin degradation with respect to temperature.

3.5. Total phenolic content (TPC)

Effect of processing temperature and hypertonic solution concentration on the total phenolic content of fruit was reported in Figures 5a and 5b. This figure showsa combined bar graph for change in the total phenolic content of the fruit and syrup. From it was observed that a significant increase in TPC content with increase in processing temperature and sugar syrup concentration. Similar results were reported by Nazmi *et al.*(2017) for osmotically dehydrated mango, The sample processed at 55^0C shows higher TPC content than the sampling process at 45^0C and 50^0C.

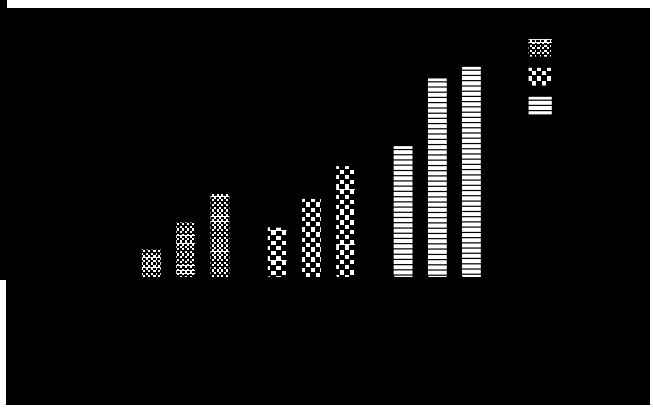

Figure. 5a

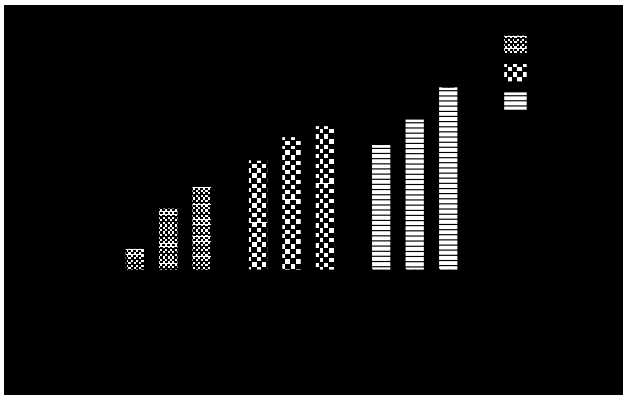

Figure: 5b

Fig. 5 (5a and 5b): Changes in the Total phenolic content of Osmodried Fruit and drain syrup with respect to temperature and sugar syrup concentration respectively. Combined Bars represent the mean ± standard deviation of triplicates (n=3). Identical letters above the bars indicate no significant differences (P < 0.05).

Various factors are responsible for TPC change like temperature, pH, sugar syrup concentration, enzymes, organic, acids, and many more. Polyphenol oxidase and other enzymes are responsible for TPC degradation during drying but higher processing temperature and longer exposure results in the inactivation of these enzymes (Nadia *et al.*, 2012). Que *et al.* (2008) reported that the formation of phenolic compounds occurs during drying because the precursor of phenolic compounds present in the fruits is converted into phenolic compounds with the help of non-enzymatic interconversion. Phenolic content of osmotically (NaCl as a hypertonic solution) pretreated grapes was increased on drying was reported by, Carranza-Concha *et al.* (2012). This might be due to structural changes in drying and skin damage due to the penetration of sugar molecules into fruit.

Besides, some researchersreported phenolic compounds are decreased during thermal processing of food products and some were reported there is no significant change in the TPC. TPC content of dried pears decreased significantly with an increase in temperature reported by, Nadia *et al.*(2012). Similar results for TPC decrease were reported by, Santos *et al.*(2014) for pear and Vega-Gálvez *et al.* (2012) for apple.

CONCLUSION

Comparison between osmotically dehydrated fruit (at different temperature and hypertonic solution concentration) and conventionally dehydrated fruit (80^0C for 5-6 hours) and drain syrup was represented in this research work. Vitamin C content and anthocyanin content of the fruit was significantly decreased whenthere was an increase in processing temperature. The total phenolic content of the fruit increased as the processing temperature increased. The osmotically treated fruit shows more vitamin, anthocyanin, acidity content retention than conventionally dried fruit. Thus osmotic dehydration is the best process for the preservation of fruits.

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Development and Quality Evaluation of Mango Leaves Fortified Ragi Biscuits

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ABSTRACT

Post pandemic, there has been increase in consumer interest and attention towards healthy and nutritious food products. Consumers are looking for food ingredients which not only provide nutrients but also improve their wellbeing. In this regard, the present study was conducted to develop convenient nutritious biscuits after incorporating mango leaves powder which is gaining significance as dietary supplement due to its proven multitudinous effects on human health. The mango leaves powder (MLP)is rich in essential minerals like calcium (1703 mg 100^{-1} g), iron (6.66 mg 100^{-1} g) and phosphorous (263 mg 100^{-1} g). Biscuits prepared using 6 per cent, 12 per cent and 18 per cent MLP were evaluated for their nutritional, antioxidant activities, phenolic content, sensory quality and shelf life studies. The macronutrients and antioxidant activities increased with increasing concentrations of mango leaves powder. The shelf life study showed negligible changes in nutritional and mineral content with no microbial growth for up to 21 days. Sensory studies of biscuits showed that 6 per cent and 12 per cent supplementation of mango leaves powder were most acceptable. Based on the results, it can be indicated that 12 per cent concentration of mango leaf powder incorporated in biscuits is organoleptically as well as nutritionally very acceptable.

Life styles of people all over the world have changed in the last century due to rise in income, increased leisure time and reduced physical activity. The new life styles have considerable impact on health. Consequently, there is a global rise in the incidence of diseases like obesity, cardiovascular diseases, diabetes mellitus and rheumatoid arthritis. As a parallel development there is a worldwide increase in health awareness and interest in herbal alternatives (Arvanitoyannis *et al.*, 2005). Functional foods have therefore, come up as an effective means for prevention of diseases (Roberfroid, 2008).Weight reduction, reduction of cholesterol, promotion of bone health, enhancement of disease resistance through immune system and improvement of digestive functions are the major health concerns that influence the purchase of functional foods. Functional foods are foods or food ingredients that provide a health benefit beyond their nutritive value (Ansari *et al.*, 2012). Fortification is achieved by adding the nutrien to the bakery products, which serves as a vehicle for carrying this nutrient. Biscuit is most popular bakery product worldwide and can be used as a functional food. They are high in carbohydrates, fat and calorie but low in fibre, vitamin, and mineral. Because of its acceptability in all age group, longer shelf life, better taste and its position as snacks it is consider as a good product for fortification and other nutritional improvement (Mishra *et al.*, 2012).

Herbs are generally used in fortification of food products. They can be any form of plant or plant product, including leaves, stems, flowers, roots and seeds. They generally have varied chemical compositions depending upon species. A good number of plants are known to be of economic and medicinal value. Those that are of medicinal value are often used as herbal remedy for the restoration and maintenance of good health. Some herbs have been considered as drugs and therefore generally safe and effective (Uboh, *et al.,* 2010).The major constituents of phytochemical consist of carbohydrates, aminoacids, proteins, and chlorophylls, while secondary metabolites consist of alkaloids, saponins, steroids, flavonoids, tannins, etc.

According to Ayurveda and indigenous medical systems, mango [*Mangifera indica* L. family Anacardiaceae] is a tropical fruit with a distinctive nutritional and phytochemical composition. Earlier

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literature recommends mango leaves, bark, seeds, flowers, and raw and ripe fruits for a myriad of medicinal, pharmacological and health benefits (Burton-Freeman BM. *et al.*, 2017).Research studies indicate that mango leaves and fruits exhibit antioxidant, anti-inflammatory, anti-diabetic, wound healing, anti-bacterial, anti-spasmodic, anti-carcinogenic, anti-microbial and anti-dysentry benefits, as well as hepatoprotective, gastroprotective and hypolipidemic effects (Imran *et al.*, 2017) (Gupta *et al.*, 2014). The present investigation was undertaken to evaluate the chemical, mineral composition and antioxidant properties of mango leaves and use it as an element in fortification of ragi biscuits at different concentrations.

MATERIALS AND METHODS

2.1.Material

Mango leaves were collected from gardens in Reliance Township, Lodhivali (Khalapur, Maharashtra). Ragi flour, whole wheat flour, Butter, sugar, vanilla essence, sodium bicarbonate, baking powder, milk and salt were purchased from local departmental store in Belapur CBD, Navi Mumbai. All chemicals and solvents used were of analytical grade obtained from Hi media.

2.2 Methods

2.2.1 Preparation of Mango Leaf Powder (MLP):

Mango leaves were sorted to reject over matured & insect affected portions and then washed with water, soaked in 2 per cent sodium hypochlorite solution (1ml L^{-1}) for 10 min and then dried in cabinet tray dryer at 60± 2 °C for 7-8 hours. The dried material was ground to powder using mixer and pass through a mesh (1mm) and dehydrated MLP was obtained. The powder was then packed in metallized polyester polyethylene laminate pouches and stored at room temperature for further chemical analysis and application studied

2.2.2. Preparation of MLP Supplemented Biscuits

Mango leaf Powder was supplemented at 6 per cent, 12 per cent, 18 per cent in ragi and wheat flour and dough was prepared using sugar, butter, sodium bicarbonate, baking powder, milk and salt.For preparing Biscuits, formulation given in Table1 was finalized after conducting a series of trials. Figure 1shows the procedure was followed for preparing biscuit.

2.2.3. Proximate analysis of biscuits

Moisture content, ash content, fat content, crude protein, crude fibre was analyzed by AOAC method.

2.2.4. Antioxidant assay

One gram grounded biscuit sample were extracted in 50ml of 60 per cent aqueous methanol at 40-50! in beaker. The mixture was shaken vigorously for 5min on magnetic stirrer & stand for 20min at room temperature. The mixture was centrifuge at 8000 rpm for 10min. the supernatant was collected for further analysis. Fresh samples were prepared for each extraction.

Table 1: Product formulation for control and MLP supplemented biscuits MB-6%, MB-12% and MB-18% biscuit

Ingredients	Control Biscuits	MLP Supplemented Biscuits		
		MB: 6%	MB: 12%	MB: 18%
Ragi Flour (gm)	40	37.6	35.2	32.6
Wheat Flour (gm)	60	56.4	52.8	49.2
Mango Leaf Powder (gm)	-	6	12	18
Butter(gm)	50	50	50	50
Sugar(gm)	45	45	45	45
Sodium Bicarbonate (gm)	1	1	1	1
Baking Powder(gm)	2	2	2	2
Salt (gm)	1	1	1	1
Vanilla Essence (ml)	2	2	2	2
Milk(ml)	40	40	40	40

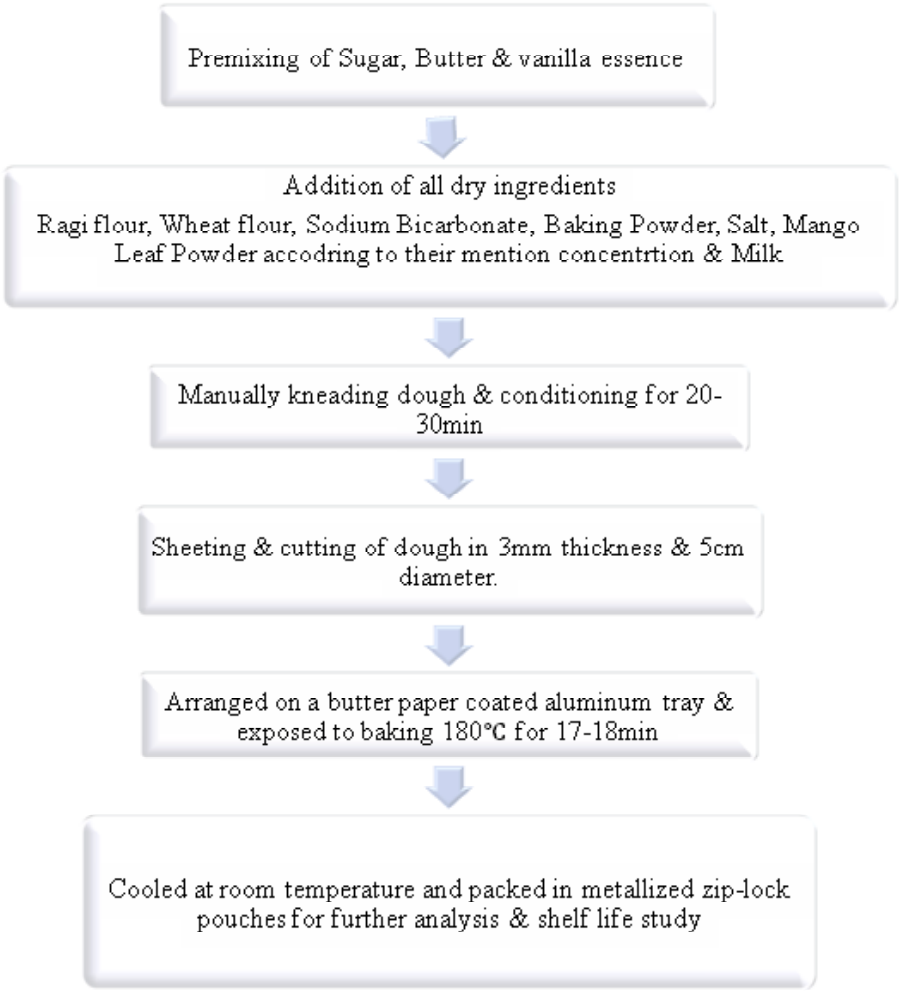

Figure 1: Flowchart depicting the unit operations for the preparation of Mango Leaves supplemented biscuits

A	B	C	D
Control	**MLP- 6%**	**MLP- 12%**	**MLP-18%**

Figure 2: Photographs of control and Mango leaves supplemented biscuits (MB-6%, 12%, 18%)

2.2.5. DPPH Assay

DPPH (2, 2-Diphenyl-1-picrylhydrzyl) radical activity of MLP, control biscuits and fortified biscuit samples were performed by following a procedure of Chakrabarty *et.al.* (2014).

2.2.6. Total Phenolic Content (TPC)

Total phenolic content was measured by following a protocol given byRavi Narayan Venkatachalam *et al.*, (2012).

2.2.7. Estimation of mineral content

Calcium, phosphorus and iron was estimated by AOAC method.

2.2.8. Sensory analysis

The Control Biscuits, MLP supplemented biscuits MB:6 per cent, MB:12 per cent, & MB:18 per cent were subjected to sensory evaluation to 15 panelists. The parameters evaluated such as appearance, aroma, texture, taste and overall acceptability. The sensory evaluation was collected on 9-point Hedonic scale (Bibiana, *et al.* 2014).

2.2.9. Microbiological analysis

The total microbial loads of biscuits were determined by the procedure described by APHA (2005).

2.2.10. Shelf life analysis

Shelf life study was carried out for 21 days at the interval of 0, 7, 14 and 21 days of storage period. The samples were stores in the metallized zip lock pouches for different storage intervals to check the efficiency of packaging. The samples were checked for the moisture content, mineral content, antioxidant activity, total phenolic content, texture and colour analysis organoleptic evaluation and microbiological analysis throughout the storage period.

RESULTS AND DISCUSSION

3.1. Nutritional and mineral composition

Nutritional composition of control ragi biscuits MB- 6-18 per cent is presented in Table 2. Increasing addition of mango leaves powder has shown good enhancement in protein, and fibre in biscuits as compared to control. The decrease in the fat content was seen as the concentration of the mango leaves powder in biscuits increased. The carbohydrate content in the given samples ranged from 67 -73 per cent and was highest in the control biscuits (73.22%). Highest energy value was recorded in control biscuit (497.4 Kcal) and lowest energy value was recorded for MB-18 per cent (491.9Kcal).The moisture content in the biscuits increased slightly with the increase in the concentration of MLP. All the samples were assayed for their mineral content which includes calcium, iron and phosphorous. The data is presented in Table 3. In MLP supplemented biscuits highest mineral content was found

Table 2: Nutritional composition of control ragi biscuits and MLP supplemented Ragi biscuits (MB)

Parameters	Control	MLP Supplemented Biscuits		
(%) / (g/g)		MB:6%	MB:12%	MB:18%
Moisture	1.13± 0.03	1.25±0.02	1.40±0.01	1.77.±0.03
Ash	0.25±0.16	0.85±0.13	1.7±0.10	2.0±0.11
Fat	21.90±0.13	21.98±0.05	21.60±0.04	21.18±0.03
Crude Protein	4.8±0.11	5.2±0.06	5.5±0.07	5.8±0.06
Crude Fibre	10±0.09	14.3±0.07	16.2±0.08	18.9±0.06
Carbohydrates	73.22±0.07	71.72±0.10	69.8±0.11	69.03±0.09

Table 3: Mineral composition of Mango leaves, control biscuits, MLP supplemented ragi biscuits

Parameters(mg/100gm)	MLP	Control	MLP Supplemented Biscuits		
			6%	12%	18%
Calcium	1703±0.27	166.3±0.57	400.8±0.3	801.6±0.4	1202.4±0.51
Iron	6.66± 0.8	9.1±0.1	10.5±0.5	11.5±0.10	12.5±0.5
Phosphorus	263±0.015	112.2±0.41	115±0.34	145±0.23	150±0.4

in MB-18 per cent i.e. Calcium 1202.4mg 100^{-1}gm, Iron 12.5mg 100^{-1} gm and Phosphorous 150mg 100^{-1} gm. Therefore from the obtained data it can be concluded that the supplementation with MLP has resulted in fortification with good amounts of minerals in ragi biscuits.

3.2. Sensory Analysis

Sensory evaluation results for Control and fortified ragi biscuits were obtained from group of panelistare shown in Table 4. In case of all attributes MB-6 per cent scored almost nearer to the control samples, when compared with other concentrations. In case of appearance all the fortified biscuits samples gained score which was almost similar to the control biscuits. Darkness in colour appearance in the samples increased with increase in MLP content of ragi biscuits. Supplementation with MLP had negligible effects on the textural properties of the biscuits. Flavour decreased slightly as the concentration of powder increased and slight bitterness was noticed as after taste in MB-18 per cent. In assessment of overall acceptability, highest score was gained MB-12 per cent as compared to other samples. The least overall acceptance was obtained by MB-18 per cent.

3.3. Effect of storage period on Sensory Attributes

The effect of different storage periods on taste score of MLP supplemented biscuits are clearly depicted in Table 4. In case of all attributes the scores were quite affected as days of the storage was increased. Appearance is one of the major factors the consumer uses to evaluate the qualit of food products. The appearance of a product as judged by its colour can often be used to determine the pigment content of a product, which in turn is often an index of quality. The sensory score was not affected for appearance even when products were stored for 21 days. Sensory score for aroma ranged from 7.39 to 8.11. The minimum score was obtained for sample MB-18%, maximum score was obtained for control biscuits. The sensory score did not showed significant difference during the storage days of 21 days in the aroma of the biscuits when compared to the fresh products.The decrease in taste score was recorded during storage period and it revealed that there

Table 4:Shelf life analysis of the Sensorial attributes of the Control and MLP supplemented biscuit (MB)

Sensorial attribute	Storage days	Control	6%MB	12%MB	18%MB
Appearance	**0**	8.66±0.15	7.99±1.03	7.61±1.36	7.40±1.23
	7	8.63±1.81	7.98± 1.11	7.59±1.03	7.38±1.33
	14	8.62±1.63	7.95±1.5	7.58±0.93	7.37±1.27
	21	8.60±1.06	7.93±0.81	7.56±1.26	7.35±1.56
Aroma	**0**	8.11±0.78	7.8±1.83	7.72±1.25	7.53±1.09
	7	8.08±1.73	7.78± 1.75	7.69±1.53	7.49±1.63
	14	8.05±1.12	7.74±1.63	7.65±0.77	7.42±1.27
	21	7.98±1.08	7.71±0.87	7.61±0.41	7.39±1.41
Taste	**0**	8.44±0.52	8.2±1.63	7.73±1.54	7.20±1.43
	7	8.43±0.33	8.20±0.36	7.71±0.49	7.17±0.85
	14	8.42±0.23	8.18±0.32	7.70±0.21	7.13±0.45
	21	8.41±0.68	8.17±0.45	7.69±0.85	7.09±0.31
Texture	**0**	8.67±1.08	8.60±1.46	8.53±1.46	8.45±1.55
	7	8.67±1.01	8.6±1.26	8.51±1.57	8.42±1.63
	14	8.66±1.23	8.57±1.36	8.49±1.25	8.38±1.74
	21	8.65±1.45	8.55±1.52	8.46±1.41	8.32±1.36
Overall acceptance	**0**	8.50±0.40	8.4±1.19	7.92±1.97	7.3±1.65
	7	8.48±0.32	8.38±0.65	7.89±0.36	7.28±0.37
	14	8.44± 0.49	8.36±0.46	7.86±0.25	7.26±0.29
	21	8.40± 0.35	8.33±0.24	7.81±0.34	7.23±0.53

was slight more decrease in the taste score of MB-18 per cent than compared to other samples. The score for texture of the biscuits was slightly decreased after 14 and 21 days when compared to the texture of the fresh products. The sample MB-18 per cent showed the lowest score for texture. The overall acceptability depends on colour, flavour and taste score of the products. Overall acceptability was slight highest for fresh products as compared to products stored till 21 days. The highest overall was acceptability score was for the control sample. The values presented in the table clearly indicates that the highest overall acceptability score was for sample control followed by MB-6 %, 12 per cent.

CONCLUSION

The use of MLP has been proven to be effective in increasing antioxidant, mineral and fibresource in biscuits at 8 and 12 per cent level, respectively. This ûnding highlighted the efficacy of these natural antioxidant sources to improve the nutritional values of biscuits. A reduction in fat content in the biscuits was achieved with increased addition of mango leaves. It is revealed in the work that the sensory score and the overall acceptability of the MLP supplemented biscuits were acceptable up to 12 per cent level. The data from shelf life studies revealed that the sensory scores did not decrease significantly up to 21 days. The results presented here indicate that MLP can be utilized as a remarkable food ingredient to formulate a wide range of products considering its valuable nutrient composition with noticeable amount of both macronutrients (carbohydrate, protein) and micronutrients (minerals and antioxidants). MLP have been reported to possess many pharmacological properties and therefore its inclusion in the diet as nutritional supplements or in the process of fortification of foods is highly promising.

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Impact of Agricultural Price Policy and its Deviation on Kharif Jowar in Maharashtra

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ABSTRACT

In Maharashtra state, the area under kharif jowar cultivation during 2020-21 was 2.75 lakh hectares with total production of 2.96 lakh tons and yield of 1.07tons^{-1}. The results raveled that, the area growth of kharif jowar decreased and also production growth was significantly declined during study period. Productivity growths were significantly dropped of kharif jowar. As the variability in WSPs were high in kharif jowar of the study, it denotes all the crops were volatile in terms of prices and also that large variability in MSP were observed of kharif jowar during study period. The compound growth rates of MSP were slightly higher than FHP and WSP of the study. It concluded that, significant gap between FHP/ WSP and MSP do not differ significantly. The impact of MSP on area is inferior in kharif jowar crop but there is lower impact of MSP on production and productivity. The impact of FHP on area is somewhat positive but there is subordinate impact of MSP on production and productivity and same results originate that in case of impact of WSP on area, production and productivity of kharif jowar in Maharashtra.

Agriculture policy is considered as the most important national economic policies through which the country can achieve the goal of improving the level of national agricultural income thus the economic and social standards for workers in the agriculture sector in particular and whole population in general (Shende, 2020). In Maharashtra state, the area under kharif jowar cultivation during 2020-21 was 2752.19 (00) hectares with total production of 2967.44 (00) tonnes and yield of 1078.21 kgs per hectares. Maharashtra ranks 1st in jowar production in country.About 50 per cent of the total area under jowar cultivation of India is in Maharashtra and the top producer state of this crop in India are Maharashtra, Karnataka, Andhra Pradesh and Tamil Nadu.

Jowar (sorghum) is one of the most important cereal crops in the world and is one of the four major food grains of our country. It is a staple food for millions of poor rural people in Asian and African countries. Besides being a major source of staple food for human beings, it also serves as an important source of fodder, animal feed and industrial raw material. Jowar is an important crop providing food, feed and fodder in the arid and semi-arid tropics of the world. It is a staple food for the rural poor in the country and African countries. It is primarily used as livestock feed and as industrial use in USA and other developed countries. Jowar is often referred to as "coarse grain". Though it is a traditional subsistence crop but now changes its role to commercial/semi-commercial crop. The demand for jowar for feed purpose is the maindriving force inrising the global production andinternational trade. It has also been used in theproduction of alcohol. The wholeplant is used for forage, hay or silage. The sweet stalked sorghum is emerging as apotential raw material to the industries producing ethanol, jaggery and paper making. It is grown as kharif, rabi and also as summer sorghum.

The Minimum Support Price (MSP)is announced by the government of India at a beginning of the sowing season for certain crops on the basis of the recommendation of the CACP. MSPsare prices fixed by government of India to protect the producer-farmers-against excessive fall in price during bumper production years. The MSP are the guarantee price for their produce from the government. If there is a fall in the prices of the crops, after a bumper harvest, the government purchases at the MSP and this is the reason that price cannot be below MSP so this directly help the farmers (Aditya *et al.,* 2017).

The farm harvest prices(FHP) are those which is prevail during a six to eight weeks immediately after the harvesting period and wholesale prices are those which

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prevail in the wholesale markets. Through, there are some years in between when the wholesale prices have fallen below FHP. WSP accordingly is the rate at which a relatively large transaction, generally for further sale, is effected price policy for agriculture produce is to set remunerative prices with a view to encourage higher investment and production.

MSP is not in line with the prices as well as demand and supply situation. This leads distortions and inefficiencies in the production patterns. The agricultural price policy (MSP) has outlived its utility and is being used more as a political tool than an economic tool. Therefore, it becomes imperative to examine the effectiveness of MSP in different regions of the country as well as its contribution towards growth (Ali*et.al.*, 2012). Since MSP policy is consider to have approved mostly the surplus states, its role and contribution towards production was examined for the Maharashtra state. Therefore this study was planed with the following objectives

1. To estimate the growth of area, production, productivity, MSP, FHP and WSP of kharif jowar in Maharashtra.
2. To study the gap between FHP and MSP, WSP and MSP of kharif jowar in Maharashtra.
3. To examine impact of MSP, FHP and WSP on area, production and productivity of kharif jowar in Maharashtra.

MATERIAL AND METHODS

The present study based on secondary data for the year 1990-91 to 2020-21 and the time series data on MSP, FHP, WSP, area, production and productivity of kharif jowar was collected from various official sources like Commission for Agricultural Prices and Costs (CACP), Directorate of Economics and Statistics, Department of Agriculture and Farmers welfare, Ministry of Agriculture and Farmers welfare, Government of India, *agmarknet.nic.in, www. Agricopp. nic.in,* etc. The data were complied and analysed using standard statistical tools.

Computation of growth rate

$$Y = ab^t$$

$$\text{Log } Y = \text{Log } a + t \log b$$

Where,

Y = area/ production /productivity

á = intercept

b = regression coefficient

t = time period in year

Compound growth rate (%) = $\{\text{Antilog } (\log b)^{-1}\} * 100$

Gap between FHP/WSP and MSP of kharif jowar in Maharashtra

The study based on the secondary data on FHP, WSP and MSP of kharif jowar crop in Maharashtra. To study effectiveness of the price policy during the harvest periods and wholesale prices periods, the deviations of farm harvest prices and wholesale prices from the minimum support prices were worked out and divided into positive and negative deviations examine, where market prices ruled higher or lower over the minimum support prices. The negative deviation reflected ineffectiveness of MSP policy for producers (Ritu *et al*, 2020). The formulae used for the mean absolute negative/positive deviation as follows:

$$\text{MAPD or MAND} = 1/n\ [\text{FHP/WSP} - \text{MSP}]$$

If FHP / WSP > MSP = Positive deviation (PD)

FHP / WSP < MSP = Negative deviation (ND)

Where, MAPD = Mean absolute positive deviation,

MAND = Mean absolute negative deviation,

FHP = Farm harvest prices

WSP = Wholesale prices

MSP = Minimum support price and

n = Frequency of positive or negative deviation

These deviations were adjusted with MSP in order to examine the degree of their deviation from MSP. The formulae used the adjusted mean negative/positive deviation was as follows:

$$\text{AMPD or AMND} = 1/n\ ([\text{FHPi}/\text{WSP}_i - \text{MSPi}] / \text{MSPi}) * 100$$

If FHP / WSP > MSP = Positive deviation (PD)

FHP/ WSP < MSP = Negative deviation (ND)

Where, AMPD = Adjusted mean positive deviation,

AMND = Adjusted mean negative deviation,

The significance gap between FHP/WSP and MSP of kharif jowar was tasted by two simple t test.

$$t = \frac{(\bar{x} - \bar{y}) - (\mu_x - \mu_y)}{s\sqrt{\frac{1}{n_x} - \frac{1}{n_y}}}$$

where,

$\bar{x}$ = mean of FHP/WSP of size n_x

$\bar{y}$ = mean of MSP of size n_y

$$s^2 = \frac{(n_x - 1)s_x^2 + (n_y - 1)s_y^2}{(n_x - 1) - (n_y - 1)}$$

Impact of Minimum Support Prices (MSPs) on kharif jowar crop in Maharashtra during 1990-2020

To study the impact of lagged minimum support prices (MPSs) on the acreage allocation, production, and productivity of kharif jowar in Maharashtra, linear and logarithmic, forms of equations have been fitted. The previousyear's MSPs generally influence the producer farmer's decision on acreageallocation for the current year (Ganga Devi*et.al*., 2016). The linear type of equation has been used as:

1. Linear regression equation:

$$At = a + b\ Pt - 1$$

$$Pt = a + b\ Pt - 1$$

$$Yt = a + b\ Pt - 1$$

The logarithmic type of equation has been used as:

2. Logarithmic regression equation:

$$\text{Log At} = \log a + b\ Pt - 1$$

$$\text{LogPt} = \log a + b\ Pt - 1$$

$$\text{LogYt} = \log a + b\ Pt - 1$$

Where,

At = Area of kharif jowar at (t)th period,
Pt = Production of kharif jowar at (t)th period,
Yt = Productivity of kharif jowar at (t)th period,
pt^{-1} = Minimum support Prices of food crops taken in per quintal at (t-1) th period

linear type of function found a better fit than logarithmic function.

Linear type of function found a better fit than logarithmic function. Hence it is used.

RESULTS AND DISCUSSION

Keeping in view the objectives of the study, the data were analysed using suitable techniques. The results obtained from this study have been presented and discussed.

Growth of area, production, productivity, MSP, FHP and WSP of kharif jowar crop in Maharashtra for the year 1990-91 to 2020-21.

The Minimum, maximum prices, coefficient of variation and compound growth rates of kharif jowar in Maharashtra during 1990-2020 was shown in table 1.

The maximum and minimum prices per quintal,

Table 1: Minimum, maximum prices, coefficient of variation and compound growth rates of kharif jowar in Maharashtra. Area in (000 ha.), Production (000 tonnes) and Productivity (Kg/ha)

	Minimum	Maximum	CV %	CGR
Area	275.20	2816.20	51.64	-5.53**
Production	273.07	5007.90	63.28	-7.90**
Productivity	594.00	1821.00	23.11	-1.54**

Note: **and* denotes significance at 1% and 5% level of significance.

coefficient of variation(%) and compound growth rates of kharif jowar is presented in table-1. It is observed from the table-1, that the maximum area of kharif jowar crop over a period of time of the study was 2816.20 thousand hectors, where as minimum area during study period was 275.20 thousand hectors. The CV (%) value for area of kharif jowar was 51.64 per cent and area under kharif jowar was decreased significantly by -5.53 per cent per annum during study period. In respect of production maximum production was 5007.90 thousand tonnes and minimum production was 273.07 thousand tonnes respectively. The variability in production was 63.28 per cent. The production of kharif jowar was decreased by -7.90 per cent per annum during study period. The variability in productivity in kharif jowar was 23.11 per cent and productivity was decreased by -1.54 per cent over the period of study. It is also observed from the table that, the growth rates of area, production and productivity under kharif jowar were decreased during 1990-2020.

Table 2: Growth rates of WSP AND MSP for the period 1990-91 to 2020-21

Crop	WSP CV (%)	MSP CV %	CGR of WSP	CGR of MSP
Kh. Jowar	78.71	81.26	8.91**	8.92**

Note: ** denotes significance at 1% level of significance.

The growth rates and variability in WSPs and MSPs of the kharif jowarwas presented in table-2. From the table 2 it is observed that, the variability in WSPs wasfound 78.71 per cent, it denotes all the crops were volatile in terms of prices. The variabilityin MSP of the kharif jowarwasobserved 81.26 per cent.The compound growth rates of WSP and MSP were significantly increased over a period of study, but the compound growth rates of MSP were slightly higher than WSP for the kharif jowarof the study.

Table 3: Growth rates FHP AND MSP for the period 1990-91 to 2020-21

Crop	FHP CV (%)	MSP CV %	CGR of FHP	CGR of MSP
Kh. Jowar	71.63	81.26	7.87**	8.92**

Note: ** denotes significance at 1% level of significance.

The growth rates and variability in FHP and MSP of the kharif jowarwas presented in table-3. From the table 3 it is seen that, the coefficient of variation (CV) value of FHP for the selected crops was found71.63 per cent, on the other hand CV value of MSP was observed81.26 per cent. Significantly positive growth rates were observed for FHP and MSP of kharif jowar.

Table 4 : Gap between FHPs and MSPs of kharif jowar.

Years	FHP (Rs. q^{-1})	MSP (Rs. q^{-1})	Gap Between FHP & MSP (Rs. q^{-1})
1990-91	228.75	180.00	48.75
1991-92	375.80	205.00	170.80
1992-93	299.00	240.00	59.00
1993-94	329.00	260.00	69.00
1994-95	340.00	280.00	60.00
1995-96	400.00	300.00	100.00
1996-97	369.00	310.00	59.00
1997-98	468.00	360.00	108.00
1998-99	473.65	390.00	83.65
1999-00	527.66	415.00	112.66
2000-01	542.19	445.00	97.19
2001-02	548.00	485.00	63.00
2002-03	543.00	485.00	58.00
2003-04	562.00	505.00	57.00
2004-05	587.00	515.00	72.00
2005-06	543.00	525.00	18.00
2006-07	611.00	540.00	71.00
2007-08	627.00	600.00	27.00
2008-09	890.00	840.00	50.00
2009-10	957.00	840.00	117.00
2010-11	1099.00	880.00	219.00
2011-12	1779.00	980.00	799.00
2012-13	1538.00	1500.00	38.00
2013-14	1507.00	1500.00	7.00
2014-15	1755.00	1530.00	225.00
2015-16	1763.00	1570.00	193.00
2016-17	1877.00	1625.00	252.00
2017-18	1690.00	1700.00	-10.00
2018-19	2447.00	2430.00	17.00
2019-20	2345.00	2550.00	-205.00
2020-21	2404.00	2620.00	-216.00

Table 5 : Gap between WSPs and MSPs of kharif jowar.

Year	Kharif jowar		
	WSP (Rs q^{-1})	MSP (Rs q^{-1})	Gap Between WSP & MSP (Rs q^{-1})
1990-91	318.73	180.00	138.73
1991-92	310.98	205.00	105.98
1992-93	322.37	240.00	82.37
1993-94	318.73	260.00	58.73
1994-95	310.98	280.00	30.98
1995-96	322.37	300.00	22.37
1996-97	316.08	310.00	6.08
1997-98	318.39	360.00	-41.61
1998-99	319.78	390.00	-70.22
1999-00	325.53	415.00	-89.47
2000-01	321.35	445.00	-123.65
2001-02	600.00	485.00	115.00
2002-03	551.45	485.00	66.45
2003-04	554.14	505.00	49.14
2004-05	587.00	515.00	72.00
2005-06	754.31	525.00	229.31
2006-07	640.47	540.00	100.47
2007-08	808.18	600.00	208.18
2008-09	1003.63	840.00	163.63
2009-10	923.63	840.00	83.63
2010-11	1030.62	880.00	150.62
2011-12	1633.39	980.00	653.39
2012-13	1988.12	1500.00	488.12
2013-14	1625.02	1500.00	125.02
2014-15	1922.72	1530.00	392.72
2015-16	2081.45	1570.00	511.45
2016-17	2174.44	1625.00	549.44
2017-18	2081.78	1700.00	381.78
2018-19	1998.26	2430.00	-431.74
2019-20	2874.23	2550.00	324.23
2020-21	2736.85	2620.00	116.85

Table 6: Significance of gap between FHP and MSP of kharif jowar during 1990-2020.

Crops	Mean FHP	Mean MSP	T value (t-cal.)	t table	D.f.
Kharif Jowar	981.45	890.48	0.50	2.00	60

Note : t cal < t tab that means H_0 is accepted at (5%) level of significance and conclude that the gap between FHP and MSP do not differ significantly.

Table 7: Significance of gap between WSP and MSP of kharif jowar during 1990-2020.

Crops	Mean FHP	Mean MSP	T value(t-cal.)	t table	D.f.
Kharif Jowar	1034.68	890.48	0.74	2.00	60

Note : t cal < t tab that means H_0 is accepted at (5%) level of significance and conclude that the gap between WSP and MSP do not differ significantly.

Table 8: Deviation of FHPs vis-a-vis MSPs of kharif jowar in Maharashtra during 1990-2020.

Crop	Negative deviation					Positive deviation				
	Freq-uency	MAND (Rs q^{-1})	Range (Rs q^{-1})	AMND (Rs q^{-1})	%	Freq-uency	MAPD (Rs q^{-1})	Range (Rs q^{-1})	AMPD (Rs q^{-1})	%
Kharif Jowar	3	-143.67	(-10) - (-216)	-5.62	9.68	28	116.11	7-799	20.7	90.32

Note : Zero deviation (FHP=MSP) were considerpositive deviation indicating success of theMSP policy Average = Average of the different of FHP from MSP (+ve or -ve) and % = Percentage of average positive or negative deviation over MSP.

Deviation of FHPs from MSPs of kharif jowar in Maharashtra from 1990-2020.

To examine the effectiveness of MSP policy of kharif jowar in Maharashtra, difference between its FHP and MSP was calculated for different year. kharif jowar experience positive deviation at 28 times in 31 years during 1990-2020. This means that the average FHP was very near to or ruled higher than MSP in 28 times out of 31 years. The adjusted difference (positive) between MSP and FHP was above 90 per cent of the MSP and the negative difference was very low. The adjusted different (positive) between MSP and FHP was as about 90.32 per cent of MSP and the negative difference was above 9.68 per cent.

Deviation of WSPs from MSPs of kharif jowar in Maharashtra.

To examine the effectiveness of MSP policy of kharif jowar in Maharashtra, difference between its WSP and MSP was calculated in different year. kharif jowar experience positive deviation at 26 times. This means that the average WSP was very near to or ruled higher than MSP in 26 times out of 31 years during 1990-2020. The adjusted difference (positive) between MSP and WSP was above 87 per cent of the MSP and the negative difference was very low. The adjusted different (positive) between MSP and WSP was as about83.87 per cent of MSP and the negative difference was observed 16.13 per cent in 31 years during 1990-2020.

Table 9 : Deviation of WSPs vis-a-vis MSPs of kharif jowar in Maharashtra.

Crop	Negative deviation					Positive deviation				
	Frequency	MAND (Rs q^{-1})	Range (Rs q^{-1})	AMND (Rs q^{-1})	%	Frequency	MAPD (Rs q^{-1})	Range (Rs q^{-1})	AMPD (Rs q^{-1})	%
Kharif Jowar	5	-151.34	(-41.61) - (-431.74)	-19.34	16.13	26	201.03	6.08-653.39	25.00	83.87

Note : Zero deviation (WSP=MSP) were consider positive deviation indicating success of the MSP policy Average = Average of the different of WSP from MSP (+ve or -ve) and % = Percentage of average positive or negative deviation over MSP.

Impact of Minimum Support Prices (MSPs) on kharif jowar in Maharashtra during 1990-2020

To study the impact of lagged MSP, FHP and WSP on the acreage allocation, production and productivity, linear and logarithmic form of equations had found a better fit than logarithmic function; the former had been presented here. The previous year MSP, FHP and WSP had been used here since these prices generally influence the farmer's decision on acreage allocation for the current year.

Impact of MSP on area, production and productivity of kharif jowar in Maharashtra.

Impact of MSP on area, production and productivity of kharif jowar in Maharashtra are presented in table-10. The numerical values of the liner function of kharif jowar indicates that R^2 is significant at 1 per cent level and supports the results that variation in area, production and productivity of kharif jowar is explained by the explanatory variables, i.e. previous years Minimum Support Prices (MSPs) of the kharif jowar. The result revealed that 75, 66 and 36 per cent variation in area, production and productivity of kharif jowar. The elasticity for these variables is significant at 1 per cent in case of area, production and productivity of kharif jowar. The value of elasticity has found all negative observation as - 0.948, -1.438 and -0.264 per cent indicating thereby that previous year MSP influences current year area, production and productivity of kharif jowar.

Table 10: Impact of MSP on area, production and productivity of kharif jowar.

	R^2	S.E. of R	Linear regression equation
Area	0.75	366.26	y = 2196.30 + (-0.948)x
Production	0.66	690.34	y = 3030.11 + (-1.438)x
Productivity	0.36	235.8	y = 1452.62 + (-0.264)x

y = area, production and productivity & x = MSP

Impact of FHP on area, production and productivity of kharif jowar in Maharashtra during 1990-2020.

Impact of FHP on area, production and productivity of kharif jowar in Maharashtra are presented in table-11. The numerical values of the liner function indicates that R^2 is significant at 1 per cent level and supports the results that variation in area, production and productivity of kharif jowar, is explained by the explanatory variables, i.e. previous years Farm Harvest Prices (FHPs) of the kharif jowar. 76, 65 and 33 per cent variation in area, production and productivity, is explained by independent variable i.e. lagged FHP. The elasticity for these variables is significant at 1 per cent in case of area, production and productivity of kharif jowar. The value of elasticity has initiateall negatively observation as - 0.950, -1.424 and -0.249 per cent indicating thereby that previous year FHP influences current year area, production and productivity of kharif jowar.

Table 11: Impact of FHP on area, production and productivity of kharif jowar in Maharashtra

	R^2	S.E. of R	Linear regression equation
Area	0.76	357.47	y = 2294.95 + (-0.950)x
Production	0.65	679.29	y = 3162.42 + (-1.424)x
Productivity	0.33	242.13	y = 1466.02 + (-0.249)x

y = area, production and productivity & x = FHP

Impact of WSP on area,production and productivity of kharif jowar in Maharashtra during 1990-2020.

Impact of WSP on area, production and productivity of kharif jowar in Maharashtra are presented in table 12. The numerical values of the liner function of kharif jowar indicates that R^2 is significant at 1 per cent level and supports the results that variation in area, production and productivity is explained by the explanatory variables, i.e. previous years Wholesale Prices (WSPs) of the kharif jowar. 77, 68 and 31 per cent variation in area, production and productivity, is explained by independent variable i.e. lagged WSP. The elasticity for these variables is significant at 1 per cent in case of area, production and productivity of kharif jowar. The all observed value of elasticity was found negative.

Table 12 : Impact of WSP on area, production and productivity of kharif jowar in Maharashtra.

Crops	R^2	S.E. of R	Linear regression equation
Area	0.77	352.98	y = 2217.07 + (-0.828)x
Production	0.68	675.98	y = 3060.09 + (-1.255)x
Productivity	0.31	245.71	y = 1438.12 + (-0.209)x

y = area, production and productivity & x = WSP

CONCLUSION

The area growth of kharif jowardecreased over a period of study, the production growth in the kharif jowar was significantly declined during study period. Productivity growths were significantly dropped of kharif jowar

As the variability in WSPs were high in kharif jowar of the study, it denotes all the crops were volatile in terms of prices and also that large variability in MSP were observed of kharif jowar during study period. The compound growth rates of MSP were slightly higher than FHP and WSP of the study.

It concluded that, significance gap between FHP/ WSP and MSP do not differ significantly. As about the deviation of FHPs/WSPs vis-à-vis MSPs, it was observed that, frequency of negative deviation occurred 3 and 5 times while about positive deviation it was 28 and 26 times of kharif jowar respectively. The adjusted difference (positive) between MSP and FHP was above as above 90 per cent and of the MSP and it was found above 83 per cent in between MSP and WSP while the negative difference was very low and the adjusted difference (positive) between WSP and FHP was above as above 83 per cent of the MSP and the negative difference was very low.

The impact of MSP on area is inferior in kharif jowar crop but there is lower impact of MSP on production and productivity.The impact of FHP on area is somewhat positive but there is subordinate impact of MSP on production and productivity and same results originate that in case of impact WSP on area, production and productivity of kharif jowar in Maharashtra.

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Impact of Front Line Demonstrations on Productivity of Black gram in Buldana District of Maharashtra

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ABSTRACT

Front line demonstration (FLD) a the long-term educational activity conducted by agricultural scientists in a systematic manner on farmers' field to show the worth of new practice/technology under the micro-farming situation. Keeping in view of an effective extension approach of FLDs for dissemination of technology FLDs on black gram were conducted by KVK, Jalgaon Jamod, district Buldana of Maharashtra was assessed. Thirty front line demonstrations were conducted on green gram crop i.e. black gram (AKU-15) plots covering an area of 12.0 hectare and latest production and protection technologies were exhibited for each year. The improved technologies consisting use of improved variety, seed treatment with rhizobium and PSB culture, sowing method, balanced fertilizer application and improved pest management techniques. The results of 3 years FLD indicated that improved varieties with improved package of practice recorded higher yield as compared to farmer's practice. It was observed that there was 22.67 to 30.47 per cent increase in grain yield over local check and the average benefit cost ratio was higher under demonstration as compared to control plots during the all years of study. The average technology gap was 3.91 q ha^{-1} and average extension gap was 1.30 q ha^{-1} during all three years. The economic of improved production practices under front line demonstration were estimated on the basis of prevailing market rates, average highest gross return of FLD's plots was Rs 24,276 ha^{-1} and average benefit cost ratio (2.32) was recorded. It can be concluded that the FLD is playing one of the important role in motivating the farmers for adoption of production technology resulting in increasing their yield and profit.

Pulses constitute very important dietary constituents for human and animal because of their richness with proteins (ranging from 20 to 24 per cent, depending upon the crop species) and essential minerals, vitamins and dietary fibers. The protein content of grain legumes is double that of wheat and three times that of rice. Therefore, pulses as a complement to cereals, make one of the best solutions to protein-calorie malnutrition. Keeping the cheapest source of protein, it is important to increase pulses production to increase balanced diet among the socially and economically backward classes. India is the largest producer (25% of global production), consumer (27% of world consumption) and importer (14%) of pulses in the World. Although, it is the world's largest pulses producer, India is importing 4-6 million tons (MT) and consumer (26-27 MT) of pulses every year to meet its domestic demand (Anonymou, 2018). India achieved a record 25.23 MT pulses production in 2017-18 with pigeon pea 21.10 per cent, chickpea 40.55 per cent, green gram 9.38 per cent, black gram 12.23 per cent and other pulses 16.77 per cent share in total production. Pulses are grown across the country with the highest share coming from Madhya Pradesh (23 %), Uttar Pradesh (18 %), Maharashtra (14%), Rajasthan (11 %) and Andhra Pradesh (09 %) (Anonymous, 2017). The traditional method of crop raising still dominates in pulses cultivation which causes low production of crops. In spite of agriculture modernization in pulse crops, farmers are still facing diverse technological gap in cultivation. Keeping in view the above facts, an intensive intervention such as cluster front-line demonstrations was conducted to transfer the generated farm technology through FLDs' in pulses under trail belt of Buldana dist., Maharashtra with the objectives of enhancing productivity, profitability narrowing in the extension yield gaps. Technological extension yield gaps under pulses in this comprehensive study are also presented in this paper for framing appropriate extension strategy for effective transfer of technology to target farmers in the district Buldana introduce and disseminate improved varieties of black gram (AKU-15)

MATERIAL AND METHODS

A front line demonstration (FLDs) is one of the most powerful tools of extension because farmers, in

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general, are driven by the perception that "Seeing is believing". The main objective of front line demonstrations is to demonstrate newly released crop production and protection technologies and its management practices in the farmer's field under the micro-farming situation. The front line demonstration on black gram for the year 2016-17, 2017-18 and 2018-19 in 10 villages of two blocks of Sagrampur and Jalgaon (Ja) tahsil of 30 ha area was considered for the studies, which were laid out in adopted villages by Krishi Vigyan Kendra, Jalgaon Jamod, dist. Buldana, Maharashtra. The soil of the district is generally sandy loam in texture. A total 36.0 ha area was covered under the front line demonstration (10.0 ha in each year). Front line demonstrations were conducted in five adopted villages at field of 25 farmers in the area of 0.4 hectare each. Soils of the FLD plots were low in N and medium in P and K availability. The primary data on grain yield farmer's practices was collected from the beneficiary farmers through crop cutting methodology followed by personal interviews. Before providing the critical input a training programme was arranged for farmers to educate about recommended technologies to be demonstration. In demonstration quality seeds of improved variety, seed treatment, recommended dose of fertilizers, rhizobium, PSB biofertilizer and plant protection management techniques were demonstrated on the farmer's field through front line demonstration at different locations. The conventional practices were maintained in case of local checks. All the important farm operations were performed under the supervision of KVK scientists by regular visits. The data were collected from front line demonstration's fields as well as from control field (farmer practices) and finally the technology gap, extension gap, technology index and corrected mortality of pod borer were calculated as formula given by Samui *et al.* (2000) and Henderson and Tilton (1955). The yield increase in demonstrations over farmers' practice was calculated by using the following formula:

Extension Gap (q ha^{-1}) = Demonstration Yield – Check Yield

Technology Gap (q ha^{-1}) = Potential Yield – Demonstration Yield

Technology Index (%) = Technology Gap / Potential Yield X 100

RESULTS AND DISCUSSION

Technologies undertaken in FLD's and practices adopted by farmers in control are presented in table 1 shows that farmers were not adopted a single recommended practices in black gram crop.

Grain yield

During *Kharif* 2016 to 2019, result of black gram (AKU-15) demonstrations conducted at farmers field revealed that there was 22.67 to 30.47 per cent increase in grain yield over local check. The table 2 shows that average yield in demonstrations varied from 3.84 to 9.25 q/ha during all three years and highest yield (9.25 q/ha) in demonstration was recorded during 2016-17 followed by 2017-18 (5.18 q ha^{-1}) and 2018-19 (3.84 q ha^{-1}), respectively. In local checks (Table 2), The average yield of green gram in FLD plots 6.09 q ha^{-1} as were much higher as compared to average yield of farmers practices i.e. 4.79 q ha^{-1}. The result indicated that the cluster front line demonstration have given good impact over farming community of Buldana dist. as they were motivated by the new agriculture technologies applied in CFLD plots. The finding is in collaborated with the finding of Singh et al (2020).

Extension & Technology Gap

Yield of the demonstration trails and potential yield of the crop was compared to estimate the yield gaps which were further categorized in to technology and extension gaps. The technology gap shows (Table 2) the gap in the black gram demonstration yield over potential yield and it was maximum (6.16 q ha^{-1}) observed during 2018-19 followed by 2017-18 (4.82 q ha^{-1}) and 2016-17 (0.75 q ha^{-1}), respectively. The overall average technology gap was 3.91 q ha^{-1} during all three years. The observed technology gap may be attributed dissimilarity in soil fertility status, rainfall distribution, disease and pest attacks as well as the change in the locations of demonstration plots every year (Choudhari *et al.,* 2009). Further, the maximum extension gap of 2.16 q ha^{-1} was recorded in black gram demonstrations during 2016-17 and The Overall average extension gap was 1.30 q ha^{-1} during all three years. The table 2 also revealed that the technology index varied from 7.50 to 61.60 per cent and

Table 1 : Difference between technological intervention and farmers practices for Black gram

S.N.	Particular	Front line demonstration practices	Farmers practices
1	Soil testing	Soil tested	Not tested
2	Variety	AKU-15	Local variety
3	Seed rate	10 kg	12 kg
4	Seed treatment	seed treatment with Rhizobium culture @ 250 ml/10 kg seed + PSB @ 250 ml/10 kg seed and Tricoderma 1.25kg /10 kg seed	No seed treatment
5	Time of Sowing	Last week of June to First fortnight of July	As per mansoon
6	Fertilizer dose	Urea 62.50 kg, SSP 250 kg and Zink sulphate 10 kg (on the basis of soil testing report) ha^{-1} in demo plot	use Graded fertilizer 20:20:0 @ 125 kg per ha and urea @62.50 kg per hectare
7	Method of fertilizer application	Fertilizer drilled at the time of sowing	Broadcasting
8	Insect-pest management	Need based spray of insecticide at Economic threshold level(ETL)	Overdoses/ unrecommended brand of insecticide

Table 2 : Grain yield and gap analysis of front line demonstration on Black gram

Year	Area (ha)	No. of farmers	Yield q ha^{-1}			% increase over farmer practices	Technology gap (q ha^{-1})	Extension Gap	Technology Index
			Potential	FLD plots	Farmer practices				
2016-2017	10	25	10	9.25	7.09	30.47	0.75	2.16	7.50
2017-2018	10	25	10	5.18	4.16	24.52	4.82	1.02	48.20
2018-2019	10	25	10	3.84	3.13	22.67	6.16	0.71	61.60
	Mean	**6.09**	**4.79**	**25.89**	**3.91**	**1.30**	**39.10**		

Table : 3 Economics analysis of demonstrated plots and farmers practices of Black gram

Year	Av. Cost of Inputs (Rs ha^{-1})		Av. Gross return (Rs ha^{-1})		Average net return (Rs/ha)		B:C ratio	
	Demo. Plots	Farmers practices	Demo. Plots	Farmers practices	Demo. Plots	Farmers practices	Demo. Plots	Farmers practices
2016-2017	21429	19294	71185	56442	49755	35377	3.4	2.9
2017-2018	13988	13271	32169	25835	18181	12564	2.3	1.95
2018-2019	17345	16303	22239	18129	4893	1826	1.25	1.11
Mean	**17587**	**16289**	**41864**	**33469**	**24276**	**16589**	**2.32**	**1.99**

overall average technology index was 39.10 per cent during all three years. The lower value is the value of technology index, the more is the feasibility of demonstrated where as Poor field establishment at early vegetative stage due to water stress under rainfed farming with uneven rainfall distribution, long dry spell and increasing pressure of diseases and insect pests are the possible reason for poor yields causing higher technology index. Hence, it can be concluded from the table 2 that increased yield was due to adoption of improved varieties

and conducting demonstration of proven technologies yield potentials of crop can be increased to greater extent.

Economic Return

The year wise economics of black gram production under demonstration were estimated and the result has been presented in table 3. The economic analysis of the data over the years revealed that black gram FLDs recorded higher gross returns (Rs. 41,864), net returns (Rs. 24,276) and B: C ratio (2.32) as compared to local check. Higher monetary return as well as B:C ratio through improved pulses production technologies have been reported by Kumar *et al.,* 2019 and Singh *et al.,* 2020.

CONCLUSION

It can be concluded that frontline demonstration conducted under the close supervision of scientists is one of the important tool for extension to demonstrate newly released crop production and protection technologies and its management practices in the farmers field under different agro-climatic regions and farming situations. On the basis of 3 years results of cluster front line demonstrations, the farmer were convince for adopting the precise technologies like improve variety, seed treatment, seed inoculation with rhizobium biofertilizers and plant protection measures were undertaken in a proper way. Hence, it was concluded that technologies disseminated for black gram was up to mark through there is scope to focus on improvement practices of green gram using recent technologies for enhancing the pulse productivity.

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SHORT NOTE

Effect of Different Plant Geometry and Bt Cotton Varieties on Nutrient Uptake and Soil Fertility

Cotton (*Gossypium hirsutum* L.) is one of the most ancient and important component crop next to food grains. In India during 2019-2020 around 360 lakh bales from 125.84 lakh hectares area with a productivity of 486 kg lint ha^{-1}. During the 2019-20, Maharashtra, Gujarat and Telangana were the major cotton growing states covering around 69.60 per cent (87.59 lakh hectare) area under cotton cultivation and 63.88 per cent (230 lakh bales) of cotton production in India. In Maharashtra total area under cotton was about 43.69 lakh ha and annual production of about 82 bales of 170 kg with Productivity 319 kg/ha, (Anonymous, 2019). Area under transgenic cotton is increasing year by year and new cotton genotypes are available for cultivation. Bt cotton is an exhaustive crop and needs heavy fertilization to achieve the higher yield. The nutrient removal is higher in Bt genotypes as compared to desi genotypes and American cotton cultivars. In general, a rainfed crop removes about 6-7 kg N, 2-2.5 kg P and 7-8 kg K 100^{-1} kg seed cotton (Blaise *et al.* 2014). Further, nutrient recommendation varies with crop response, genotypes, soil and climatic conditions.

A field investigation was carried out with objective to assess the "Influence of different plant geometry on growth, yield attributes and yield of Bt cotton genotypes". The experiment was conducted at Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India during *kharif* 2020-2021. Akola is situated in the Sub-tropical zone at the latitude of $22^{0}42'$ North longitude of 77^{0} 02' East. The altitude of the place is 307.41 meter above mean sea level. The soil of experimental plot was medium deep black with fairly uniform and levelled topography with slightly alkaline in reaction. The soil was having medium status of organic carbon, available nitrogen and phosphorous and fairly rich status of available potassium. The climate of Akola is semi-arid and characterized by three distinct season *viz.,* hot and dry summer from March to May, warm and rainy monsoon from June to October and mild cold winter from November to February. Most of the rain received from south-west monsoon during June to October with mean annual normal precipitation of 788.9 mm received in 43.7 rainy days (Average of 30 years, 1981-2010). Total rainfall of 774.1 mm was recorded during the crop growing season. At plant geometry 60 x15 and 60 x 30 cm the bollworm incidence was occured. Sap sucking pest infestations (aphids, jassids and whitflies) and bollworm attacks were controlled by undertaking timely plant protection measures. Four cotton plant geometry *viz.,* 60 x 15, 60 x 30, 90 x 15 and 90 x 60 cm with four Bt cotton genotypes viz., Suraj, PKV 081, Rajat and GJHV 374 were laid out in split plot design with three replications. The cotton crop was sown on June 24, 2020 and harvested in three pickings up to last week of December, 2020.

Yield studies

The plant geometry 60 x 15 cm recoded significantly higher seed cotton yield ha^{-1} over 90 x 15 cm and 90 x 60 cm, however, it was not significant with 60 x 30 cm, it might be due the higher number of plant per unit area, similar result reported by Sowmiya and Sakthivel (2018). Cotton stalk and biological yield per ha was significantly highest in 60 x 15 cm.

All the cotton varieties differed from each other for seed cotton yield. Rajat Bt registered significantly superior seed cotton yield compared to Suraj Bt, and GJHV 374 Bt, however, it was at par with the PKV 081 Bt. This might be due to the genetic ability and better photosynthetic efficiency through better source sink relations as reflected in harvest index. Similar result also reported by Singh *et al.* (2010), Parlawar *et al*. (2017) and Parihar *et al*. (2018). The Rajat Bt cotton registered higher cotton stalk and biological yield, which were significantly superior over GJHV 374 Bt and at par with PKV 081 Bt and Suraj Bt. The Cotton variety Rajat Bt recorded highest harvest index than the PKV 081 Bt followed by Suraj Bt and GJHV 374 Bt (Pise *et al.*, 2020).

Nutrient uptake

The influence of plant geometry on uptake of nitrogen, phosphorous and potassium was not

Table 1. Seed cotton yield, stalk yield, biological yield and harvest index influenced by plant geometry and varieties

Treatment	Yield (kg ha^{-1})			
	Harvest index (%)	Seed cotton	Stalk	Biological
A) Plant Geometry				
S_1 - 60 x 15 cm	1589	3530	5119	31.04
S_2 - 60 x 30 cm	1519	2875	4394	34.56
S_3 - 90 x 15 cm	1488	3143	4631	32.13
S_4 - 90 x 60 cm	1456	2545	4001	36.39
SE (m) ±	20	73	126	_ _
C.D. at 5%	68	252	435	_ _
B) Varieties				
G_1 - Suraj Bt	1505	3021	4526	33.25
G_2 - PKV 081 Bt	1562	3073	4636	33.69
G_3 - Rajat Bt	1608	3127	4735	33.95
G_4 - GJHV 374 Bt	1377	2871	4248	32.41
SE (m) ±	18	63	107	—
C.D. at 5%	51	184	311	—
C) Interaction (S X G)				
SE (m) ±	35	126	213	—
C.D. at 5%	NS	NS	NS	—

Table 2. Nutrient uptake influenced by plant geometry and varieties

Treatment	Nutrient uptake (kg ha^{-1})		
	N	P	K
A) Plant Geometry			
S_1 - 60 x 15 cm	61.26	8.51	30.90
S_2 - 60 x 30 cm	58.19	8.25	29.50
S_3 - 90 x 15 cm	55.95	7.69	28.13
S_4 - 90 x 60 cm	53.64	7.04	26.69
SE (m) ±	2.48	0.31	1.28
C.D. at 5%	NS	NS	NS
B) Varieties			
G_1 - Suraj Bt	58.81	7.82	29.85
G_2 - PKV 081 Bt	54.78	7.19	28.18
G_3 - Rajat Bt	61.49	9.41	31.66
G_4 - GJHV 374 Bt	53.96	7.07	25.53
SE (m) ±	2.04	0.68	1.53
C.D. at 5%	NS	NS	NS
C) Interaction (S X G)			
SE (m) ±	4.08	1.37	3.05
C.D. at 5%	NS	NS	NS

Table 3. Effect of plant geometry and varieties on available NPK after harvest of cotton

Treatment	Available nutrients (kg ha^{-1})		
	N	P	K
A) Plant Geometry			
S_1 - 60 x 15 cm	206	16.16	311
S_2 - 60 x 30 cm	207	16.83	316
S_3 - 90 x 15 cm	209	17.44	319
S_4 - 90 x 60 cm	211	18.54	322
SE (m) ±	1.74	0.47	4.20
C.D. at 5%	NS	NS	NS
B) Varieties			
G_1 - Suraj Bt	209	17.53	318
G_2 - PKV 081 Bt	206	16.10	314
G_3 - Rajat Bt	208	16.41	316
G_4 - GJHV 374 Bt	210	18.93	320
SE (m) ±	3.85	1.40	4.43
C.D. at 5%	NS	NS	NS
C) Interaction (S X G)			
SE (m) ±	7.71	2.81	8.86
C.D. at 5%	NS	NS	NS
Initial status	198	15.12	308

significant. The plant geometry of 60 x 15 cm recorded highest nitrogen uptake, following 60 x 30 cm, 90 x 15 cm and 90 x 60 cm. It might be due to high plant density and higher seed cotton yield ha^{-1}, the findings are inconformity with the findings of Manjunatha *et al.* (2010) and Devraj *et al.* (2011) reported significant effect of plant geometry on uptake of NPK.

The influence of cotton varieties on uptake of nitrogen, phosphorous and potassium was found to be not significant, numerically higher nitrogen uptake was registered with Rajat Bt, followed by Suraj Bt, PKV 081 Bt and GJHV 374 Bt, it might be due to higher seed cotton yield ha^{-1}, the findings were similar with Das and Reddy (2009) and Shukla *et al.* (2013) reported significant effect of plant geometry on NPK uptake.

Available NPK

The influence of plant geometry on available nitrogen, phosphorous and potassium was not significant. The plant geometry of 90 x 60 cm recorded highest available nitrogen, followed by 90 x 15 cm (209 kg ha^{-1}), 60 x 30 cm (207 kg ha^{-1}) and 60 x 15 cm (206 kg ha^{-1}). It might be due to low plant density under closer plant density and lower seed cotton yield ha1^{-1}. The findings were similar with the observations taken by Kalaichelvi (2008) and Shukla *et al.* (2014) they reported significant effect of plant geometry on available NPK.

The influence of varieities on available nitrogen, phosphorous and potassium was not significant. The genotypes GJHV 374 Bt recorded highest available nitrogen, followed by genotypes Suraj Bt , Rajat 081 Bt and genotypes PKV 081 Bt. It might be due to lower seed cotton yield per hectare, the results are closely associated with the findings of Patil (2012) and Shukla *et al.* (2014) they reported significant effect of plant geometry on available NPK.

CONCLUSION

The narrow plant geometry of 60 x 15 cm have given significantly highest seed cotton yield with highest uptake of NPK and with respect to cotton varieties it was highest with Rajat Bt.

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