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PDKV Rutuja


Lathyrus Dal Mill Plant


PDKV Rutuja


Biomass Hot Air Rotary Dryer

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RESEARCH JOURNAL

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RESEARCH NOTES

PKV Res. J. Vol. 44 (2), July 2020

Analysis of Farmer's Queries Received at Agriculture Technology Information Centre (ATIC)

Mohammad Khan Ebadi[1], V. S. Tekale[2] and S. D. Sarnaik[3]

ABSTRACT

The Agricultural Technology Information Centre (ATIC) provides a vital link between the technology developers and end users. ATIC is a 'Single Window' support System linking the various units of a research institution with intermediary users and end users (farmers) in decision making and problem solving experience. It provides real time information and advices to the farmer's queries with regard to agriculture and allied sciences. The present study was carried out at Agriculture Technology Information Centre (ATIC) Dr. PDKV, Akola to analyse farmers queries and its content, as well as to analyse trends of famers queries received at ATIC. The farmers from the different parts of the country visited ATIC as well as Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola round the year to know about recent advances, technology, implements, crop varieties, etc., generated by the University scientists after the enormous research. The farmers enquired their queries during their personal visit to ATIC as well as over the University Helpline Number. In order to get clear picture of the farmers queries received on University helpline number as per the records of ATIC, Dr. PDKV, Akola were used for the present study for the year 2014-2015 to 2018-2019. The findings revealed that 11,727 farmers were personally visited ATIC, while 27,646 farmer's queries were received at ATIC over telephone calls. With regard to the subject wise distribution of the queries, out of total queries received over telephone calls, the majority of the queries related to Agronomy (35.09%), Plant Protection (30.83%) followed by Horticulture (21.05%) and AHDS (9.78%), while 90.11 per cent queries were raised by farmers residing in Vidarbha region.

ATIC was established at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola in the year 2001, with financial support of ICAR, New Delhi, with prime objectives to serve for farming community as 'Single Window System' for farm information, technology, available inputs etc.(Dass, 2022). Personal contact, use of telephone or other electronic media, letters are the important sources utilized by the farmers to contact with any research institutes to know about the recent advances in field of agriculture sciences.

As Agriculture Technology Information Centre (ATIC), Dr. PDKV, Akola is an important reliable and trustworthy sources for the farming community in the region. The University also appointed the scientists from the different discipline to reply farmer's queries received on every Thursday, over the University Helpline number. Therefore it was felt necessary to evaluate the farmers queries received at ATIC with following objectives.

1) To analyze subject wise farmers' queries and its content received at ATIC
2) To examine trends of farmers' queries received at ATIC over period of time.

MATERIAL AND METHODS

The content analysis for the present research work was carried out at Agricultural Technology Information Centre, Dr. Panjabrao Deshmukh Krishi Vidyapeeth,Akola. The University providing technical support to the farming community through its 14 Krishi Vigyan Kendra, 19 Agriculture Research Stations, 26 AICRP's on different crops spread all over the region. ATIC was established at University head quarter in the year 2001with financial support of ICAR, New Delhi. ATIC has started telephone help line for farmers from July 2002. University Scientists i.e. Agronomist, Pathologist, Entomologist, Horticulturist, Representative of Seed Cell remain present in ATIC on every Thursday between 2.30 pm to 5.30 pm on phone no. 0724-2259262 to reply the questions asked by the farmers.

In order to get a clear picture of farmers queries received at the ATIC, the data with regard to the queries received on University Helpline number available as per the records of ATIC, Dr. PDKV, Akola were used for the present study. The content analysis for the queries received on University help line number over the period

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of last five years i.e. from the year 2014-15 up to 2018-19 were considered for the present research endeavour. The data were collected from the records available at Agriculture Technology Information Centre. The collected data were tabulated and analyzed by applying appropriate statistical tools.

RESULTS AND DISCUSSION

1. Year - wise trend of farmers visit

From the available data at ATIC, reveals year-wise trend of farmers visit at Agricultural Technology Information Centre, Dr. PDKV, Akola as well as number of telephone calls received from the farmers at ATIC, during the year 2014-2019 (Table 1).

From the above findings it is clear that number of queries received at ATIC over university helpline number is comparatively higher than the personal visit. Cellular phones are easily available at rural areas and ATIC is the reliable and trusted sources from the farmer's point of view therefore farmers usually contact with University scientists for technological guidance using helpline number.

The data further shows that 11727 farmers personally visited ATIC while 27646 farmers queries were received over University Helpline Number during the period of year 2014-15 to 2018-19. Out of the total queries over one forth (25.45%) and (27.33%) were recorded during the 2014-15 and 2015-16 respectively while 40.96 per cent farmers personally visited ATIC during the year 2014-15.The findings were in line with the findings as recorded by Sathiadhas and Immanuel (2003) and Sharma *et al.* (2008).

The trend of number of queries received from the farmers on telephone calls was observed in slightly decline form 19.13 per cent to 14.17 and 13.92 per cent during the year 2016-17, 2017-18 and 2018-19 respectively this might due to; farmers may use social media, WhatsApp groups, Personal Phone Calls to the University Scientists. If ATIC, use different social media sources to reach the farmers, the number of queries may increase and farmers will received the solution for their queries at an earliest from the University Scientists.

2. Subject - wise distribution of the farmers' queries

Agricultural Technology Information Centre is

Table 1. Year - wise trend of farmers visit at ATIC during 2014-15 to 2018-19

Particulars	2014-15	2015-16	2016-17	2017-18	2018-19	Total
Farmers personally visited the ATIC	4804	2222	738	1538	2425	**11727**
	(40.96)	(18.95)	(06.29)	(13.12)	(20.68)	**(100.00)**
Telephone calls received from farmers	7036	7557	5289	3917	3847	**27646**
	(25.45)	(27.33)	(19.13)	(14.17)	(13.92)	**(100.00)**
Total	**11840**	**9779**	**6027**	**5455**	**6272**	**39373**

** Figure in parenthesis indicate percentage*

Table 2. Subject-wise distribution of the farmers' queries received at ATIC,Dr. PDKV, Akola during 2014-15 to 2018-19.

Year	Agro-nomy	Horti-culture	Plant Protection	AHDS	Queries related to other discipline	Total
2014-15	2328	1014	1892	707	172	6113
2015-16	2028	1061	1214	328	73	4704
2016-17	1520	1059	1290	840	232	4941
2017-18	2268	1474	1740	558	79	6119
2018-19	1558	1212	2386	272	341	5769
Total	9702	5820	8522	2705	897	27646
Percent	**35.09**	**21.05**	**30.83**	**09.78**	**03.25**	**100.00**
Mean	**1940**	**1164**	**1704**	**541**	**179**	**5529**

supervised by the ATIC Manager/ Extension Agronomist with the technological support from the University Scientists representing different disciplines.

The total numbers of queries received on the University Helpline Number were separated in four major disciplines as maximum queries related to Agronomy, Horticulture, Plant Protection, Animal Husbandry and Dairy Science (AHDS) and queries related to other discipline(Table 2).

The Table 2 depicts the discipline wise queries received at ATIC over the period of time were 27,646 received during 2014-2019 to 2018-2019, out of which 9702 (35.09%) number of queries were related with the agronomical crops, as majority of the area under agronomical crops this might be the reason as large number of farmers quoted the agronomical queries, followed by, 8522 (30.83%) of the queries were from the Plant Protection discipline, while nearly one fifth (21.05%) of the queries were related to Horticulture discipline, the trend shows the area under Horticultural crops is increasing year by year, whereas one tenth (9.78%) of the queries were related to Animal Husbandry and Dairy Science discipline.

With regard to the per year average number of farmers queries received, the findings indicated that 1940 (Agronomy), 1704 (Plant Protection), 1164 (Horticulture), 541 (Animal Husbandry and Dairy Science) and 179 farmers queries were related to other disciplines. It is important to note that ATIC had registered over 5500 average number of queries per year.

3. Jurisdiction -wise distribution of farmers' queries

The queries received at the Agricultural Technology Information Centre, were separated into queries reported from the Vidarbha region and other parts excluding Vidarbha region.

Table 3. Distribution of the queries received at ATIC, Dr. PDKV, Akola from Vidarbha and rest of Vidarbha region during 2014-15 to 2018-19.

Queries received from	Agronomy	Horticulture	Plant protection	AHDS	Other Discipline	Total
Vidarbha	9032	4938	7692	2430	821	24913
	(93.09)	(84.85)	(90.26)	(89.83)	(91.53)	(90.11)
Rest of Vidarbha	670	882	830	275	76	2733
	(06.91)	(15.15)	(09.74)	(10.17)	(08.47)	(09.89)
Total	9702	5820	8522	2705	897	27646

** Figure in parenthesis indicate percentage*

Table 4. District - wise distribution of the queries asked by the farmers' under the jurisdiction of the University during 2014-15 to 2018-19 at ATIC.

Districts	Agronomy	Horticulture	Plant Protection	AHDS	Other discipline	Total	Per cent
Akola	3481	1303	2607	595	275	8261	33.16
Buldhana	1140	763	1672	215	132	3922	15.74
Nagpur	584	1020	924	206	49	2783	11.17
Amaravati	894	1117	875	226	85	3197	12.83
Washim	1245	219	617	287	143	2511	10.08
Yavatmal	426	113	546	313	32	1430	05.74
Wardha	412	134	175	163	33	917	03.69
Chandrapur	312	57	110	187	19	685	02.75
Bhandara	243	87	87	102	21	540	02.17
Gondia	169	79	58	87	19	412	01.65
Gadchiroli	126	46	21	49	13	255	01.02
Total	**9032**	**4938**	**7692**	**2430**	**821**	**24913**	**100**

The data (Table 3) revealed that majority (90.11%) of the queries received at University Helpline Number were asked by the farmers residing in Vidarbha region, while nearly one tenth (9.89%) of the queries were quoted by the farmers from the other parts of the country excluding Vidarbha region during the period 2014-15 to 2018-2019.

4. District - wise distribution of the farmers' queries

The University working in each and every district of the Vidarbha region and performing the need based research on different crops, at the same time University has engaged in research, education and extension activities in the region. Therefore the queries received from the farmers residing in the Vidarbha regions were further categorized according to the districts of Vidarbha from which it was enquired.

It was observed (Table 4) that, during the last five years 2014-15 to 2018-19, relatively higher proportion (33.16%) of the farmers queries received at ATIC, Akola were from Akola district, followed by Buldhana (15.74%), Amravati (12.83%), Nagpur (11.17%) and Washim districts (10.08%) respectively. Whereas, only 5.74 and 3.69 per cent queries were received from Yavatmal and Wardha districts respectively. The less queries were received from Chandrapur, Bhandara, Gondia and Gadchiroli districts of the Eastern Vidarbha region were in the range of 01.02 per cent to 02.75 per cent only.

The farmers participation from the Eastern parts was observed comparatively low than the Western part of the University jurisdiction. The University and the ATIC authorities need to concentrate on the farmers from the Eastern parts so that more number of queries should come from these districts. There is necessity to popularize the ATIC especially in the Eastern Vidarbha region.

5. Queries related with the Agronomical crops

The agronomical queries received from the farmers residing in Vidarbha region were further categorized on the basis of crops for which farmers seeks the advice of the University scientists (Table 5).

It was seen that, as cotton is the prominent cash crop of the region hence, higher proportion (19.43%) of the farmers queries were related to cotton crop, followed by 13.45 per cent of the queries received at ATIC were about the soybean crop. Among the other crop-wise queries 12.51 per cent were about wheat, groundnut (07.88%) 07.64 per cent about gram, udid (05.87%), maize (05.67%),04.62 per cent related to sugarcane, followed by green gram and black gram (04.35%), pigeon pea (04.32%), sunflower (03.44%),jowar (03.04%), paddy (02.83%), other crops (02.56%), and bajra (02.39%), respectively.

Table 5. Crop-wise distribution of the queries received at ATIC with regard to agronomical / field crops during 2014-15 to 2018-19

S. N.	Queries about crop	Frequency	Percentage
1	Cotton	1754	19.43
2	Soybean	1215	13.45
3	Wheat	1130	12.51
4	Gram	690	07.64
5	Sugarcane	417	04.62
6	Maize	512	05.67
7	Groundnut	712	07.88
8	Udid	530	05.87
9	Sunflower	311	03.44
10	Green gram and black gram	393	04.35
11	Jowar	275	03.04
12	Bajra	216	02.39
13	Pigeonpea	390	04.32
14	Paddy	256	02.83
15	Other	231	02.56
	Total	**9032**	**100.00**

6. Queries related with the Horticultural crops

It was observed from the data that around one fourth (25.30%) of the queries received were related to the Citrus crop, followed by 17.38 per cent of the queries were asked by the farmers pertaining to the acid lime, while 14.64 per cent of the farmers queries were enquired about the Pomogranate, whereas 12.94 and 09.13 per cent of the farmers queries were related to the Payapa and Sapota fruit crops respectively (Table 6).

The queries with regard to grape, watermelon and guava were comparatively low as compared to other fruit crops, the reason might be Citrus, Acid lime are the major fruit crops grown by the farmers in the Vidarbha region.

Saravanan (2008) studied information needs of tribal farmers and reported that most of the tribal farmers require information on different horticultural crops such as Khasi lemon, Aasam lemon, Mango, Pepper, etc.

Table 6. Crop-wise distribution of the queries received at ATIC with regard to horticultural crops during 2014-19.

S. N.	Fruit Crop	Frequency	Percentage
1	Citrus	712	25.30
2	Acid lime	489	17.38
3	Pomegranate	412	14.64
4	Papaya	364	12.94
5	Mango	68	02.42
6	Sapota	257	09.13
7	Aonla	163	05.79
8	Banana	143	05.08
9	Guava	105	03.73
10	Watermelon	63	02.24
11	Grape	27	00.96
12	Other	11	00.39
	Total	**2814**	**100.00**

7. Discipline wise distribution of Horticultural queries

The queries were further analysed on the basis of discipline as raisedby the farmers. The datra indicated that more than half i.e. 56.97 per cent of the queries raised by the farmers were related to the fruit crops whereas, nearly one third (32.66%) of the total queries were about the vegetable crops while nearly one tenth (10.37%) of the farmers queries were related to the floricultural crops (Table 7).This indicates that along with fruit crops vegetable and floriculture crops were also important from farmer's point of view.

Table 7. Discipline wise distribution of the queries received at ATIC with regard to horticultural crops during 2014-15 to 2018-19.

S. N.	Discipline	Frequency	Percentage
1	Fruit Crops	2814	56.97
2	Vegetable crops	1612	32.66
3	Floricultural crops	512	10.37
	Total queries related to Horticultural group	**4938**	**100.00**

8. Queries related with the Plant Protection

The farmers queries with regard to Plant Protection were further analysed for the crops on which the advice sought by the farmers. The data revealed that majority (56.06%) of the farmers queries with regard to Plant Protection were related to Agronomical crops, followed by slightly above one third (35.42%) of the farmers queries were related to fruit crops while 8.52 per cent of the queries were recorded for the vegetable crops grown in the region (Table 8). The findings were in line with the findings reported by Kavaskar *et al.* (2019)

Table 8. Discipline wise distribution of the queries related to Plant Protection discipline received at ATIC with regard to crops during 2014-15 to 2018-19.

S. N.	Discipline	Frequency	Percentage
1	Agronomical crops	4312	56.06
2	Fruit crops	2725	35.42
3	Vegetable crops	655	8.52
	Total	**4938**	**100**

9. Distribution of farmers' queries according to livestock and other enterprises

It was observed that farming community is much more interested in poultry farming as 22.94 per cent of the queries were related to poultry farming. The 18.45 per cent of the queries were received on sheep and goat rearing whereas, 13.51 per cent of the farmers were made queries on cow rearing. On an average 223 number of the queries received annually at the ATIC with regard to animal husbandry and dairy science discipline (Table 9).

The queries on the other components such as fodder management, dairy farming, establishment of dairy unit, cow and bullock management vermicomposting, fishery unit, Emu and piggy farming were received comparatively low. The findings were in line with the observations depicted by Rajmane *et al.,*(2010).

Table 9. Distribution of the queries received at ATIC with regard tolivestock and other enterprise during 2014-15 to 2018-19

S. N.	Particulars	Frequency	Percentage
1	Sheep and Goat rearing	452	18.45
2	Cow rearing	331	13.51
3	Poultry farming	562	22.94
4	Fodder management	152	06.20
5	Dairy farming	196	08.00
6	Establishment of dairy unit	220	08.98
7	Vermicomposting unit	191	07.80
8	Emu farming	89	03.63
9	Piggy farming	14	00.57
10	Fishery unit	102	04.16
11	Cow & Bullock management	141	05.76
	Total	**2430**	**100.00**

CONCLUSION

The ATIC working for the dissemination of the agricultural technologies evolved through the research system. It acts as a bridge between the farming community and the researcher. Large numbers of queries were received at the University Helpline Numbers and University scientists provide the need based solution for the queries raised by the farming community.The increasing trend of the farmer's queries was noticed as the available records of the Agricultural Technology Information Centre. Most of the queries received from Vidarbha region especially from Akola and Buldhana district and related to Agronomy, Horticulture and Plant Protection subject. On the basis of trends of queries asked, it is necessary to make popularity of ATIC especially in Eastern Vidarbha Region. As University is the most trusted and reliable source, the efforts need to be increased to disseminate the technology generated by the University, so that majority of the farming community adopt the same and gain the maximum returns from the farming enterprise.

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Effect of Foliar Nutrient Sprays on Summer Greengram (*Vigna radiata* L.) Under Sub Mountain Zone of Maharashtra

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ABSTRACT

An agronomic investigation to study the Effect of Foliar Sprays on Economics of Summer Greengram (*Vigna radiata* L.) was conducted at R.C.S.M. College of Agriculture, Kolhapur in randomized block design with seven treatments replicated thrice during *summer* season of 2017-18. The attributing characters like plant height, number of branches plant spread (cm), Leaf area and Dry matter were increased significantly due to application of foliar spray of 12:61:00 (1.5%) before flowering over other treatments. However,it was on par with foliar spray of DAP (1.5%) and 19:19:19 (1.5%). Yield contributing characters *viz*., number of pods, number of seeds, length of pods, test weight, grain and straw yield were increased significantly due to application of foliar spray of 12:61:00 (1.5%) before flowering over other treatments. However, it was on par with foliar spray of DAP (1.5%) and 19:19:19 (1.5%) before flowering.

Nutrient play a pivotal role in increasing the seed yield in pulses.foliar application of major plant nutrients like nitrogen and potassium was found tobe good as soil application (Subramanian and Planiaappan, 1981). According to Kalita *et al*., (1994), supplementing urea at the reproductive stage significantly enhanced the seed yield by delaying leaf senescence in mungbean.

Application of fertilizer to soil and due to formation of certain soil complexes the uptake of necessary element becomes difficult for the plants. The applied fertilizers are not fully utilized by the plants. In order to avoid or eliminate these situation foliar application of nutrients is important. (Velu and Srinivasan ,1984).

It is now well established fact that plants can utilize water soluble nutrients through their foliage,when applied in the from of foliar sprays . The nutrients enter in the cells by penetrating the cuticle of the leaf through stomata. When problem of excessive leaching of nutrients exits,foliar application constitutes the most effective means of fertilizer application .This practice may be useful to early maturing crops under rainfed conditions where moisture is limiting factor. Inorganic phosphatic fertilizers when added to soil undergo various reaction with soil constituents rendering some of the added phosphate unavailable to plants. Foliar application of nutrients using water soluble fertilizer is one of the possible way to avoid such loss of phosphatic fertilizer (Pandrangi *et al*., 1991).

MATERIAL AND METHODS

The field experiment was laid out in a randomized block design with three replications in summer, 2017. There were 7 treatments with foliar spray of fertilizers on summer greengram. The treatments were absolute control (No spray), urea (1.5%), DAP (1.5%), 13:00:45 (1.5%),19:19:19 (1.5%), 00:52:34 (1.5%) and 12:61:00(1.5%). The foliar spray of nutrients were applied just before flowering 32 DAS. The RDF 20:40:00 N:P:K kg ha^{-1} was applied uniformly to all treatments at the time of sowing. The soil of experimental field was sandy loam, neutral in reaction (pH 7.6) with low available nitrogen (257.75 kg ha^{-1}), medium in available phosphorous (16.17 kg ha^{-1}), high in available potassium (261.09 kg ha^{-1}) and medium in organic carbon (0.54%).The greengram crop was sown on 15 February, 2017 with spacing of 30 × 10 cm.

RESULTS AND DISCUSSION

Plant height

The highest plant height (68.73 cm) was observed at harvest due to foliar spray of 12:61:00 (1.5%) before flowering and it is on par with DAP (1.5%) and 19:19:19 (1.5%) before flowering. The lowest plant height was recorded in absolute control (51.97 cm). The plant height was increased due to proper application of nitrogen through irrigation at 8-10 days interval. Similar results were observed by Verma *et al*., (2011).

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Branches plant^{-1}

The highest number of branches plant^{-1} were observed due to foliar spray of 12:61:00 (1.5%) before flowering and it is on par with DAP (1.5%) and 19:19:19 (1.5%). The lowest branches plant^{-1} was recorded in absolute control. The rest of treatments were on par with each other. The increased number of branches plant^{-1} might be due to foliar application of nitrogen and phosphorus. Verma *et al*., (2011) also reported the same results.

Dry matter

The highest dry matter plant^{-1} was observed due to foliar spray of 12:61:00 (1.5%) before flowering and it is on par with DAP (1.5%) and 19:19:19 (1.5%) before flowering. The lowest dry matter was recorded in absolute control.The rest of treatments on par with each other. The increase in total dry matter production plant^{-1} may be ascribed to beneficial effect of foliar application of nitrogen and phosphorus on growth of plant. The results are in close conformity to Chandrasekhar and Bangarusamy (2003) and Selvi *et al.* (2004).

Leaf area plant^{-1}

The highest leaf area plant^{-1} was observed due to foliar spray of 12:61:00 (1.5%) before flowering and it is on par with DAP (1.5%) and 19:19:19 (1.5%) before flowering. The lowest leaf area plant^{-1} was recorded in absolute control.The rest of treatments on par with each other.The increase in leaf area may be due to the promotive effect of foliar application of N on leaf growth and in turn on leaf area (Kalita *et al*., 1994). Application of higher quantity of nitrogen has favoured rapid growth enlargement of tissue resulting higher leaf area .Similar result were observsed by Sritharan *et al*. (2005) and Mondal *et al*. (2011).

Plant spread

The highest plant spread was observed due to foliar spray of 12:61:00 (1.5%) before flowering and it is on par with DAP (1.5%) and 19:19:19 (1.5%) before flowering. The lowest plant spread was recorded in absolute control. The rest of treatments on par with each other. Application of nutrient through to foliar spray has favoured rapid growth resulting higher plant spread. Similar result were observsed by Mondal *et al*. (2011).

Pods plant^{-1}

The mean number of pods plant^{-1} was significantly influenced by different foliar spray of nutrients. The highest number of pods plant^{-1} (25.97) foliar spray of 12:61:00 (1.5%) before flowering and it is on par with DAP (1.5%) and 19:19:19 (1.5%) . The lowest number of pods plant^{-1} was recorded in absolute control (18.15). The rest of treatments on par with each other.The increase in pod yield was due to more nutrient supply to crop through foliar spray of 12:61:00. This might have caused more number of pods and efficient translocation of photosynthates from source to sink (Kuttimani and Velayutham, 2011).

Number of seeds pod^{-1}

The mean number of seeds pod^{-1} was significantly influenced by different foliar spray of nutrients.Foliar spray of 12:61:00 recorded the highest number of seeds pod^{-1} (10.78). The lowest number of seeds pod^{-1} was recorded in absolute control (8.51).

Weight of Seeds Plant^{-1}

The mean weight of seeds plant^{-1}was significantly influenced by different foliar spray of nutrients.Foliar spray of 12:61:00 recorded the highest number of weight of seeds plant^{-1} (7.92). The lowest weight of seeds plant^{-1} was recorded in absolute control (4.55). The similar results were found by Sarkar and Pal (2006) and Verma *et al*. (2011).

Length of Pod Plant^{-1}

Foliar spray of 12:61:00 before flowering recorded the highest number of length of pod plant^{-1} (7.93) before flowering. The lowest length of pod plant^{-1} was recorded in absolute control (6.27). The similar results were found by Sarkar and Pal (2006) and Verma *et al*. (2011).

Test Weight

The mean test weight (g) was significantly influenced by different foliar spray of nutrients.The foliar spray of 12:61:00 before flowering recorded the highest test weight (43.89g).The lowest test weight was recorded in absolute control (39.71g). The size of seeds might be increased due to the foliar application of proper quantity of nitrogen. The finding confirms the results of Kalita *et*

Table 1. Effect of foliar sprays on growth attributes of summer greengram

Treatments	Plant height (cm)	Branches plant^{-1}	Dry matter Plant^{-1}	Leaf area Plant^{-1} (dm^2)	Plant spread (cm)	Days to 50% flowering	Days to maturity
T_1 : Control (No spray)	51.97	6.28	25.33	5.99	46.74	38	70.17
T_2 : Urea (1.5 %spray)	62.64	6.46	25.56	7.07	50.19	38	69.50
T_3 : DAP (1.5% spray)	68.52	7.44	32.16	9.21	51.96	37	67.90
T_4 : 13:00:45 (1.5 %spray)	60.21	6.58	27.86	8.09	48.63	38	69.16
T_5 : 19:19:19 (1.5 %spray)	67.36	7.04	30.59	9.05	51.95	37	68.22
T_6 : 00:52:34 (1.5 %spray)	60.48	6.45	26.78	7.98	47.89	38	69.34
T_7 : 12:61:00 (1.5 %spray)	68.73	7.58	33.84	10.04	52.82	36	67.71
S.E (m) ±	1.67	0.10	1.16	0.40	0.11	0.64	1.30
C.D. at 5%	5.01	0.31	3.49	1.22	0.35	1.93	NS

Table 2.Effect of foliar sprays on yield attributing characters of summer greengram

Treatments	Number of pods plant^{-1}	Length of pod	Number of seeds pod^{-1}	Weight of seed plant^{-1}	Test Weight (1000 seeds)	Seed yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1 : Control (No spray)	18.15	6.27	8.51	4.55	39.71	11.29	25.39
T_2 : Urea (1.5 %spray)	20.52	6.41	9.83	5.90	40.66	12.23	26.87
T_3 : DAP (1.5% spray)	24.36	7.53	10.55	6.72	43.64	15.78	30.68
T_4 : 13:00:45 (1.5 %spray)	21.45	6.78	8.75	5.31	41.62	12.21	26.92
T_5 : 19:19:19 (1.5 %spray)	24.78	7.19	10.23	6.58	42.86	15.66	30.24
T_6 : 00:52:34 (1.5 %spray)	21.86	6.69	8.81	5.24	42.24	13.32	28.37
T_7 : 12:61:00 (1.5 %spray)	25.97	7.93	10.78	7.92	43.89	16.26	30.72
S.E (m) ±	0.42	0.05	0.20	0.51	0.06	0.96	1.04
C.D. at 5%	1.30	0.15	0.60	1.52	0.19	2.88	3.13

al. (1995), Godase *et al*. (2011), Verma *et al.* (2011).

Seed yield

The foliar spray of 12:61:00 before flowering recorded the highest seed yield (16.26 q ha^{-1}) and it was at par with foliar spray of DAP (15.78 q ha^{-1}) and 19:19:19 (15.66 q ha^{-1}**)**. The lowest seed yield was recorded in absolute control (11.29 q ha^{-1}). The yield was increased due to the increased dry matter production and efficient assimilate translocation to the developing sink lending to increased pods and higher seed yield (Dixit and Elamnthi 2007). The increase in yield was due to decrease in flower drop per plant imparted by the foliar application of nutrients. Mungbean, through produces more number of flower, most of them get abscised without forming pods. The retention of flower and pod can be increased by foliar application of nutrients as reported by Chandrasekhar and Bangarusam (2003).

Straw yield

The foliar spray of 12:61:00 recorded the highest straw yield (31.78 q ha^{-1}) and it was on par with foliar spray of, DAP (30.68 q ha^{-1}), 19:19:19 (30.24 q ha^{-1}) and 00:52:34 (28.37 q ha^{-1}). Lowest straw yield ha^{-1} was recorded in absolute control (25.39 q ha^{-1}).

The increase in straw yield might be due to increase in growth contributing characters like number of

leaves, leaf area, dry matter etc. There was increase in straw yield ha^{-1} which was due to increase in total dry matter production $plant^{-1}$.

Days to 50 Per cent Flowering

The significantly lower days required to 50 per cent flowering was recorded in treatment consisting foliar spray of 12:61:00 (1.5%) (36 DAS) and it was on par with foliar spray of DAP (1.5%) 37 DAS and 19:19:19 (1.5%). The mean number of days required to 50 per cent flowering was highest in treatments of urea (1.5%), 13:00:45 (1.5%), 00:52:34 (1.5 %) and control (1.5%) 38 DAS.

Days to Maturity

The mean number of days to maturity was 68.85. The mean day to maturity was statistically non-significant due to different foliar sprays of different nutrients. But lower days required to maturity was recorded in treatment consisting foliar spray of 12:61:00 (1.5%) days to maturity (67.71 DAS).

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Effect of Integrated Nutrient Management on Growth and Yield of Parching Sorghum

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ABSTRACT

A field experiment entitled "Effect of Integrated Nutrient Management on Growth and Yield of Parching Sorghum" was conducted to find out suitable combination of organic and inorganic nutrient sources with zinc for getting maximum yield of *Kharif* parching sorghum during *Kharif* season 2016-17 to 2018-19 at PDKV, Akola. The experiment was laid out in factorial randomized block design with three replications. The three different parching sorghum genotypes were tested for their performance with four nutrient managements. Three different genotype PKV- Ashwini (V_1) , Malkapur Wani (V_2) and PDKV- Kartiki (V_3) and four different nutrient management practices viz., 10 ton FYM (F_1) , 100 per cent RDF (F_2), 75 per cent RDF + 5 t FYM + 25 kg $ZnSO_4$ ha^{-1} (F_3) and 100 per cent RDF + $ZnSO_4$ 25 kg ha^{-1} (F_4). The genotype Malkapur Wani recorded significantly maximum plant height and 100 seed weight and was found superior to all other genotypes. The nutrient management with 75 per cent RDF + 5 t FYM + 25 kg $ZnSO_4$ ha^{-1} recorded significantly maximum plant height and it was found at par with application of 100 per cent RDF + $ZnSO_4$ 25 kg ha^{-1}. The pooled data revealed that significantly highest green hurda and biomass yield was obtained from parching sorghum genotype PDKV - Kartiki and combine application of organic manure with inorganic fertilizer and micronutrient viz. 75 per cent RDF + 5t FYM + 25 kg $ZnSO_4$ ha^{-1}.

Sorghum is gaining importance as 'health food' now a days, because of its higher dietary fiber carbohydrate, protein, mineral matter and rich source of amino acids along with vitamin-B complex specially niacin (Vitamin B6). The rich source of vitamins and minerals of sorghum perform different functions in our body to boost our immune response towards pathogens. They also play a good role in strengthening the immune system and building defenses against pathogens. Micronutrient deficiencies or 'hidden hunger' resulting from unbalanced diets based on starchy staple crops are prevalent among the population. There are many sources of foods that are known as immunity boosters and being a staple cereal, millets may prove to be a promising source, especially relevant to the times of Covid-19 virus pandemic situation.

The tender jowar grain in Marathi is called as "*hurda*" and in Gujarati it is called as "Ponk". Basically, *hurda* is roasted food product prepared from sweet sorghum on coal in mud pits which gives it an earthy taste. A comprehensive literature search revealed that INM enhances crop yields by 8 –150 per cent compared with conventional practices. It also increases water-use efficiency, and the economic returns to farmers, while improving grain quality, soil health and sustainability. It is well known that the organic sources cannot meet the total nutrients need to modern agriculture; integrated use of nutrients seems to be more appropriate. Incorporation of organic sources and later on its decomposition determines the availability of the nutrients. Zinc is an essential nutrient for human health Importance of application of zinc with INM can be highlighted for maintaining soil health and also for improving productivity of the sorghum at soft dough stage and getting this nutrient in to the crop. Therefore, the present study was undertaken with a view to find out the efficient combination of organic and inorganic fertilizers and zinc

MATERIAL AND METHODS

A three year field experiment was conducted at Sorghum Research Unit, Dr. PDKV, Akola, Maharashtra during *Kharif* season 2016-2018. The investigation was done with the objectives of study to know the yield and quality performance of *Kharif* parching sorghum

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genotypes with integrated nutrient management during three consecutive year of 2016-17 and 2018-19. The soil of the experiment plot was clay loam in texture with pH 8.3 indicating alkaline reaction, having low organic carbon content (0.53 %), low in available nitrogen (191 kg ha^{-1}), phosphorus (20.3 kg ha^{-1}) and marginally high in available potassium (317 kg ha^{-1}). The experiment was laid out in factorial randomized block design with three replications. The experiment was conducted with three parching sorghum varieties viz. PKV Ashwini (V_1), Malkapur wani (V_2) and PDKV Kartiki (V_3) and four Nutrient management treatments *viz.* 10 t FYM (T_1), 100 per cent RDF (T_2), 75 per cent RDF + 5 t FYM ha^{-1} + $ZnSO_4$ @ 25 kg ha^{-1} (T_3) and 100 per cent RDF + $ZnSO_4$ @ 25 kg ha^{-1} (T_4).

The sowing of parching Sorghum was done on dated 1st July, 13th July and 29th June during 2016, 2017 and 2018, respectively and harvested in October at its dough stage. Overall weather during crop growing season was quite satisfactory. The nutrient management was carried out through the FYM and applied to soil before sowing as per treatments. Recommended doses of inorganic fertilizers consisting of 80 kg N and 40 kg each of P_2O_5 and K_2O were applied to sorghum. For sorghum N was applied in 2 splits, half at sowing along with entire quantity of P_2O_5 and K_2O and remaining N was applied 30 days after sowing. Nitrogen, phosphorus, potassium and $ZnSO_4$ were applied through urea, single superphosphate, muriate of potash and Zinc Sulphate, respectively. The sorghum was sown using 7.5-10 kg ha^{-1} seed manually at spacing of 45 cm between rows and 15 cm between plants.

RESULTS AND DISCUSSION

Effect of different parching sorghum genotype

The pooled data (Table 1) revealed that, the parching sorghum genotype Malkapur Wani recorded significantly maximum plant height and was found superior over all other genotypes. It might be due to the varietal character of Malkapur wani. The lowest plant height was recorded with parching sorghum genotype PDKV- Kartiki.

Table 1: Growth and yield parameters as influenced by integrated nutrient management in *parching* sorghum (Pooled data: 2016-17 to 2018-19)

Treatments	Plant Height (cm)	Days to 50 % Flowering	100 Seed Weight of Hurda (g)	Grain Hurda per Panicle (g)	Days to soft dough stage	Panicle Length (cm)	Biomass Yield (kg ha^{-1})	Harvest Index (%)
Genotype								
PKV Ashwini	204	62.83	1.91	22.00	83.15	**18.63**	150	20.96
Malkapur Wani	253	70.42	2.39	21.58	93.51	**17.00**	157	19.14
PDKV Kartiki	169	61.28	2.27	26.45	84.96	**23.25**	144	24.25
SE(m)±	3.56	0.78	0.03	0.39	0.26	0.96	2.22	0.38
CD at 5%	10.39	2.31	0.10	1.14	0.76	2.69	6.49	1.10
Nutrient Management								
10 ton FYM	193	64.52	2.20	18.75	83.54	17.10	135	19.84
100% RDF	209	63.59	2.16	22.49	84.62	20.35	148	20.83
75% RDF + 5 t FYM + $ZnSO_4$ @ 25 kg ha^{-1}	221	62.67	2.20	27.46	86.22	24.55	172	22.48
100% RDF + $ZnSO_4$@25 kg ha^{-1}	213	63.26	2.21	24.67	87.11	23.19	145	22.65
SE (m) ±	3.11	0.91	0.05	0.45	0.18	0.52	2.57	0.43
CD at 5%	9.53	NS	NS	1.31	0.54	1.65	7.49	1.27
Interaction								
SE (m) ±	7.1	1.57	0.07	0.78	1.14	1.01	4.45	0.75
CD at 5%	NS	NS	NS	Sig.	NS	NS	NS	NS

The parching sorghum genotype PDKV- Kartiki recorded significantly lowest number of days to 50 per cent flowering and it was found par with PKV Ashwini. Days required to 50 per cent flowering were found to be non significant due to fertility levels. The 100 seed weight of hurda sorghum recorded significantly highest with parching sorghum genotype Malkapur Wani. However, the parching sorghum genotype PDKV-Kartiki recorded significantly superior green hurda per panicle as compared to genotype Malkapur Wani and PKV-Ashwini. This might be due to the vigorous growth habitats and adaptability of PDKV- Kartiki genotypes where it grown.

The pooled data revealed that, significantly highest green hurda yield and on hurda yield at dough stage was obtained from parching sorghum genotype PDKV- Kartiki. The lowest green hurda yield was recorded with Malkapur wani genotype.

Significantly superior fodder yield was recorded by parching sorghum genotype Malkapur Wani. The lowest fodder yield were obtained from parching genotype PDKV Kartiki . Interaction effects were found to be non significant. The performance of genotype might be due to the growth habitats and adaptability of genotypes where it grown. The results are in conformity with Ghorade *et. al.* (2009) and Shinde *et al.*(2016).

The economics analysis study of pooled data (Table 3) revealed that, significantly highest monetary advantage for green hurda at dough stage and biomass yield (hurda + fodder) in terms of gross monetary returns was found with the parching sorghum genotype PDKV-Kartiki. The values obtained for gross monetary was found significantly superior over all other treatments. The Similar trend was noticed with respect to the net monetary returns. The B: C Ratio for green hurda and biomass yield (hurda + fodder) found significantly highest with parching sorghum genotype PDKV Kartiki.

Effect of Integrated Nutrient Management:

The data pertaining to production traits as influenced by fertility levels are in Table 2 and 3. The Pooled data revealed that, nutrient management with

Table 2: Effect of genotypes and integrated nutrient management on green hurda and fodder yield of Parching sorghum (Pooled data: 2016-17 to 2018-19)

Treatments	Green Hurda Yield (Kg ha^{-1})				Green Fodder Yield (q ha^{-1})			
	2016-17	2017-18	2018-19	Pooled	2016-17	2017-18	2018-19	Pooled
Genotype								
PKV Ashwini	3340	3148	2974	3154	121	121	113	118
Malkapur Wani	3258	3075	2732	3022	130	133	118	127
PDKV Kartiki	3672	3432	3357	3487	114	112	100	109
SE (m) ±	42.60	75.22	125.07	54.24	2.02	2.71	5.17	1.91
CD at 5%	124.36	219.15	364.40	158.32	5.91	7.91	15.08	5.58
Nutrient Management								
10 ton FYM	2649	2568	2609	2639	114	114	99	109
100% RDF	3114	3081	2786	3064	121	120	110	117
75% RDF + 5 t FYM + $ZnSO_4$ 25 kg ha^{-1}	3925	3831	3778	3876	138	137	127	134
100% RDF + $ZnSO_4$ 25 kg ha^{-1}	3508	3393	2910	3304	114	118	106	112
SE (m) ±	49.19	86.60	144.18	62.65	2.33	3.13	5.97	2.21
CD at 5%	143.59	252.90	421.25	182.81	6.83	9.14	17.42	6.44
Interaction								
SE (m) ±	85.21	150.1	250.51	108.74	4.03	5.42	10.33	3.82
CD at 5%	Sig.	NS	Sig	Sig	NS	Sig	NS	NS

Table 3: Effect of genotypes and integrated nutrient management on economics of Parching sorghum (Pooled data: 2016-17 to 2018-19)

Treatments	GMR Hurda Yield	GMR Green Fodder Yield	MR Hurda + Green Fodder	NMR Hurda Yield	NMR Hurda + Green Fodder	B: C Ratio GMR Hurda Yield	B: C Ratio GMR Green Fodder Yield
			Rs ha $^{-1}$				
Genotype							
PKV Ashwini	235918	23664	259582	202680	226344	7.17	7.89
Malkapur Wani	226002	25428	251430	192765	218193	6.87	7.64
PDKV Kartiki	260895	21759	282655	227658	249417	7.94	8.60
SE(m)±	4068	407	4179	4068	4179	0.13	0.14
CD at 5%	11874	1189	12199	11874	12199	0.38	0.40
Nutrient Management							
10 ton FYM	197958	21785	219744	160558	182344	5.29	5.88
100% RDF	229808	23461	253269	200288	223749	7.78	8.58
75% RDF + 5 t FYM + $ZnSO_4$ 25 kg ha^{-1}	289048	26730	315778	253538	280268	8.14	8.89
100% RDF + $ZnSO_4$ 25 kg ha^{-1}	246939	22493	269431	216419	238911	8.09	8.83
SE(m)±	4697	470	4826	4697	4826	0.15	0.16
CD at 5%	13711	1373	14086	13711	14086	0.44	0.46
Interaction							
SE (m) ±	8136	815	8359	8136	8359	0.26	0.27
CD at 5%	NS	NS	NS	NS	NS	NS	NS

application of 75 per cent RDF + 5 t FYM + $ZnSO_4$ 25 kg ha^{-1} recorded significantly maximum plant height and it was found at par with application of 100 per cent RDF + $ZnSO_4$ 25 kg ha^{-1}. This might be due to higher availability of the nutrients as an effect of combine application of inorganic, organic and zinc. The plant height was mainly influenced by fertility status of soil and it directly influenced the growth parameter. Thus ample availability of nutrients during the crop growth resulted in optimum cell division and stem elongation and ultimately the height of the plant and dry matter.

Days required to 50 per cent flowering were found to be non significant with the different nutrient managements. The 100 seed weight of parching sorghum did not differ significantly with nutrient management treatments. However, the integrated nutrient management with 75 per cent RDF + 5 t FYM + $ZnSO_4$ 25 kg ha^{-1} recorded significantly superior green hurda per panicle as compared to all other nutrient management practices. This might be due to the INM practice show positive impact on plant height, which was mainly influenced by fertility status of soil and it directly influenced the growth parameter. Thus ample availability of nutrients during the crop growth resulted in optimum cell division and stem elongation and ultimately the height of the plant and dry matter. Above results are in conformity with Gangwar and Niranjan (1991) and Gangwar and Singh (1992). The application of chemical fertilizers in conjunction with organic manures increased the use efficiency of added chemical fertilizer which in turn increased the nutrient availability at later growth period ultimately resulted in increased dry matter accumulation. Similarly the Zinc

application increased metabolic activities as it is part of many enzymes which also increases availability of nutrients. Above results are in conformity with the results obtained by Kalibhavi *et al.,* (2001) and Balasubramanian and Ramamoorthy (1996).

The data compiled on parching sorghum green hurda yield at dough stage and dry grain yield (kg ha^{-1}) at maturity stage during 2016-17, 2017-18 and 2018-19. The data pertaining to production traits from pooled data revealed that, significantly highest green hurda yield and biomass yield was obtained from the combine application of Organic manure with inorganic fertilizer and micronutrient viz. 75 per cent RDF + 5 T FYM + $ZnSO_4$ 25 kg ha^{-1}, The results are in conformity with Arbad *et al.,* (2008), Satpal *et al.,* (2015), Singh *et al.,* (2016), Meena *et al.,* (2017) and Patidar (2004). The green hurda yield at dough stage and dry grain yield at maturity was found significantly superior over all other treatments within both the factors. Lowest green hurda and dry grain yield was recorded with 10 t FYM treatment. Interaction effects was found to be significant with *hurda* yield.

Significantly superior fodder yield was recorded by INM treatments viz. application of 75 per cent RDF + 5 t FYM + $ZnSO_4$ 25 kg ha^{-1}. The lowest fodder yield was obtained with application 10 t FYM ha^{-1}. Interaction effects were found to be non significant. The INM recorded significant values, this might be due to higher availability of the nutrients as an effect of combine application of inorganic, organic and zinc. The results are in conformity with Shinde *et al.,* (2016).

The economics worked out from the emerged data is presented in Table 4. The economics analysis study of pooled data revealed that, significantly highest monetary advantage for green hurda at dough stage, dry grain yield and biomass yield (*hurda* + fodder) in terms of gross monetary returns was found with the application of 75 per cent RDF + 5 T FYM + $ZnSO_4$ 25 kg ha^{-1}. The values obtained for gross monetary was found significantly superior over all other treatments. The Similar trend was noticed with respect to the net monetary returns, except in dry grain yield, it was found at par with treatment 100 per cent RDF and 100 per cent RDF + $ZnSO_4$ 25 kg ha^{-1}. The B: C Ratio for green hurda and biomass yield (*hurda* + fodder) found significantly highest with integrated nutrient management treatment and it was closely followed by 100 per cent RDF + $ZnSO_4$ 25 kg ha^{-1}.

CONCLUSION

Application of 5 t FYM + 75 per cent RDF + 25 Kg $ZnSO_4$ kg ha^{-1} is recommended for obtaining higher green hurda yield and monetary returns from PDKV Kartiki hurda sorghum.

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Effect of Temperature and Relative Humidity on Ripening of Custard Apple (*Annona squamosa* L.)

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ABSTRACT

The present study was undertaken to study effect of temperature and relative humidity on ripening of custard apple fruits. Ripening of custard apple fruits was carried out in ripening chamber and atmospheric conditions. Various physical and biochemical parameters like physiological loss in weight, days taken for ripening, fruit firmness, pH, total soluble solids, titrable acidity, sugars and ascorbic acid were estimated at an interval of 4 days during storage. Results showed that, fruits ripened at temperature 15°C and relative humidity 85 - 90 per cent recorded lowest physiological loss in weight and required maximum number of days to ripe (9 days), followed by fruits ripened at temperature 20°C and relative humidity 85-90 per cent required 6 days for ripening. Fruits ripened at temperature 20°C and relative humidity 85-90 per cent recorded value for pH (5.31), titrable acidity (0.27%), total soluble solids(22.17°Brix), reducing sugar (14.52%), total sugar (14.67%) and ascorbic acid (12.50%).

Custard apple (*Annona squamosa* L.) a member of the Annonaceae family, is a tropical and subtropical fruit tree which is widely distributed in Asia, Africa and the America. In India, Maharashtra leads the country in custard apple productionfollowed by Gujarat, Madhya Pradesh and Chhattisgarh. It is also grown in Assam, Bihar, Odisha, Rajasthan, Uttar Pradesh, Andhra Pradesh, Telangana and Tamil Nadu. The total area and production of custard apple in India is 43000 ha and 359000 MT during 2019-20, respectively (Anonymous, 2020).

The custard apple fruits are very delicate and highly perishable. Being climacteric in nature, the biochemical changes in the fruit after harvest occur at a faster rate and shows very short storage life at room temperature due to its fast ripening, high respiration rate and ethylene production (Prasanna *et al.* 2000). The mature fruits after harvest ripen quickly and become excessively soft within two to three days at ambient condition and become unfit for human consumption (Gholani and Bisen, 2012). Wills *et al.* (1984) studied the effects of low temperature on ripening of *Annona atemoya* and reported that there is delay in ripening at lower temperature, but fruits showed typical chilling injury symptoms.

The abundant supply of fruits in the market from the majority of orchard and forest area takes place in a short span, which causes glut in the market thereby, causing reduction in prices. This leads to loss in returns to the farmer. Also, many custard apple processing plant don't have capacity to process all the fruits at a time so, in peak season, they have to store fruits for some days. During this period fruits get spoiled if it is not properly stored. Therefore, there is necessity to study the ripening and storage conditions for custard apple fruits.

MATERIAL AND METHODS

The fruits (cv. Balanagar) of uniform size were procured from the farm of Citrus Research Station, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Fruits were harvested when fruit is in light green colour, yellowish white colour between the carpels and initiation of cracking of the skin between the carpels. Matured fruits of uniform size, firm, free from disease and injuries were directly picked from orchard and brought to the laboratory. The fruits were cleaned in running tap water to remove the adherent dirt material and then allowed to dry in shade.

Experiment was laid out in completely randomized design with nine replications. Each treatment containing fifteen fruitswere kept in ripening chamber at respective temperature and relative humidity conditions. For control, fruits were ripened at ambient conditions.For ripening of custard apple, ripening chamber (Mech-Air Industries) was used. The details of experiment conducted is shown in Table 1. Fruits were weighed when ripe to assess weight loss during storage (Batten, 1990). The physiological loss in weight (PLW) was recorded on weight basis. The number of days taken by each treatment to reach the fruits

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at eating stage were recorded. The lot considered ripened when more than 90 pe cent of fruits attain ripen stage. The progress of fruit ripening was observed manually by finger feel method on every day. The intensity of softening was worked out on 0 to 5 scale. The average score of softening of all fruits were recorded as described by Kumbhar and Desai (1986).

The pH of each sample of the custard apple pulp was directly recorded by sensor based digital pH meter. The total soluble solids (^{0}Brix) were determined by using ERMA hand refractometer. The titrableacidity of fruits ripened at different conditions was estimated by using method proposed by Ranganna (1986). Reducing sugars was estimated by using Nalson Smogyi method. Total sugars were determined by Dubois method. The ascorbic acid content was estimated by using the method described by Ranganna (1986). The overall sensory quality of the fruit and pulp after ripening, were assessed by a panel of five judges using 9-point Hedonic scale as described by Ahmad *et al.* (2005) and Shiva *et al.* (2014).

The treatment details of different temperature and relative humidity given to custard apple fruits are given in Table 1.

Table 1. Treatment details of experiment

Treatment	Temperature,°C	Relative Humidity, %
T_1R_1	15	65-70
T_1R_2	15	75-80
T_1R_3	15	85-90
T_2R_1	20	65-70
T_2R_2	20	75-80
T_2R_3	20	85-90
T_3R_1	25	65-70
T_3R_2	25	75-80
T_3R_3	25	85-90
C (Control)	-	-

RESULTS AND DISCUSSION

Physiological weight loss

The data pertaining to physiological loss in weight as affected by various temperature and relative humidity is given in Table 2. The physiological loss in weight of custard apple fruit increases with the increase in storage period.These results are in conformity with the findings of Kumhar *et.al.* (2014). This may be due to

Table 2. Effect of temperature and relative humidity on physiological weight loss of custard apple fruits during ripening

	Physiological Weight Loss (%)								
Treatment	**DAS**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
T_1R_1	1.57^e	2.67^e	3.59^e	4.42	4.74*				
T_1R_2	1.12^f	2.24^f	2.96^f	3.45	4.1	4.51*			
T_1R_3	0.43^h	0.99^h	1.43^j	1.89	2.52	3.19	3.84	4.69	5.34*
T_2R_1	0.62^g	1.22^g	2.56^g*						
T_2R_2	0.48^h	1.16^{gh}	1.78^h	2.56	3.46*				
T_2R_3	0.45^h	1.08^{gh}	1.57^i	2.1	2.94	3.4*			
T_3R_1	3.04^a	8.27^a	12.63^a*						
T_3R_2	2.30^b	4.34^c	6.77^c	9.34*					
T_3R_3	1.96^d	3.86^d	5.45^d	7.60	10.42*				
C (Control)	2.15^c	4.63^b	7.52^b*						
S.Em.±	0.01	0.01	0.01						
C.D. at 5%	1.20	0.17	0.09						
C.V.%	5.00	3.35	1.19						

Means within a column followed by different letters differ significantly at P<0.05

* Samples ripened

transpiration and respiration losses. Physiological loss in weight was higher in those fruits, which are ripened at higher temperature and low humidity conditions. After three days of storage period physiological loss in weightwas recorded highest (12.63%) under 25°C temperature and 65-70 per cent relative humidity and lowest (0.43%) in temperature 15°C and 85-90 per cent relative humidity.

Days taken for ripening

The data (Table 3) shows that fruits required maximum number of days *i.e.,* 9 days to reach ripen stage at temperature 15°C and 85 - 90 per cent relative humidity whereas other treatments and control required significantly less number of days (3 days) for ripening. Number of days taken to ripened was found to be increased with increase in the relative humidity of storage atmosphere and it was decreased with increase in the ripening temperature. This may be due to low temperature reduce the metabolic activities and the process of ripening by retarding the pre-climacteric respiration rate and ethylene production as reported by Tsay and Wu (1990), Boliver-Fernandez *et al.* (2009), Broughton and Tan (1979) and Bakane *et al.*(2016) in custard apple. Temperature and relative humidity had significant effect on the ripening of custard apple.

Table 3. Effect of temperature and relative humidity on days taken to ripe of custard apple fruits

Treatment	Days taken to ripe
T_1R_1	5^{bc}
T_1R_2	6^{b}
T_1R_3	9^{a}
T_2R_1	3^{de}
T_2R_2	5^{bc}
T_2R_3	6^{b}
T_3R_1	3^{e}
T_3R_2	4^{cd}
T_3R_3	5^{bc}
C (Control)	3^{e}
S.Em.±	0.40
C.D. at 5%	1.07
C.V.%	13.46

Fruit firmness (Softening score)

The data (Table 4) on progress of fruit softening score during course of ripening at various temperature and relative humidity conditions. It was found that with the advancement of storage period, fruit softening was increased irrespective of storage conditions. Fruit firmness of custard apple gradually decreased with increase in

Table 4. Effect of temperature and relative humidity on fruit softening (score) of custard apple fruits during ripening

	Fruit softening score								
Treatment	**DAS**								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
T_1R_1	4.5^{a}	4.2^{ab}	3.5^{b}	2.5	1.3*				
T_1R_2	4.5^{a}	4.0^{ab}	3.8^{ab}	3.2	2.5	1.3*			
T_1R_3	4.7^{a}	4.3^{a}	4.2^{a}	3.8	3.0	2.5	2.2	1.8	1.2*
T_2R_1	4.0^{ab}	3.0^{cd}	1.5^{d}*						
T_2R_2	4.2^{ab}	3.7^{abc}	3.3^{b}	2.5	1.5*				
T_2R_3	4.5^{a}	4.3^{a}	3.8^{ab}	3.2	2.3	1.3*			
T_3R_1	3.7^{b}	2.8^{d}	1.2^{d}*						
T_3R_2	4.2^{ab}	3.5^{bcd}	2.5^{c}	1.2*					
T_3R_3	4.5^{a}	4.2^{ab}	3.5^{b}	2.0	1.3*				
C (Control)	3.5^{b}	2.8^{ab}	1.3^{d}*						
S.Em.±	0.18	0.23	0.15						
C.D. at 5%	0.73	0.82	0.66						
C.V.%	10.15	13.11	13.51						

Means within a column followed by different letters differ significantly at P<0.05

* Samples ripened

ripening of fruits. The progress of fruit softening was faster in fruits ripened at 25°C temperature and 65-70 per cent relative humidity. However, progress of fruit softening was found to be slower in fruits ripened at 15°C temperature and 85-90 per cent relative humidity. This may be due to retardation of the bio-chemical changes and ripening process at low temperature. Similar observations were also reported by Vishnuprasanna *et al.* (2000) in custard apple.

The data revealed that pH, titrable acidity, total soluble solids, reducing sugars, total sugars and ascorbic acid of custard apple fruits were influenced by various temperature and relative humidity conditions (Table 5).

pH

The value of pH was found to be higher (5.42) of fruits ripened at lower temperature and low humidity conditions and lower (5.23) of fruits ripened at higher temperature conditions. The minimum value of pH could be due to retention of higher percentage of acidity under these conditions during storage period.

Total Soluble Solids (TSS)

The total soluble solidsof fruits were found to be increased with an increase in temperature and decrease in the relative humidity. This value was highest (25.67° Brix)of fruits stored at 25°C temperature with relative humidity 65-70 per cent, followed by ripening at ambient conditions. This is might be due to rapid ripening at dry conditions. Similar results were also reported by Vishnuprasanna *et al.*(2000) in Custard apple.

Titrable Acidity

Titrable acidity of the fruits werefound to be increased with increase in the ripening temperature and decrease in the ripening relative humidity. Titrable acidity was found highest (0.48%) in fruits ripened at 25°C temperature and 65-70 per cent humidity. Low acidity (0.27%) could be explained with the fact that organic acid might be utilized rapidly in respiration or conversion of acid into sugar from pre climacteric to post-climacteric stage at low temperature storage while higher acidity content might be due to high rateof respiration. This result is in agreement with the result of Jholgiker and Reddy (2007) in custard apple fruits.

Sugars

The fruits stored at 25° C temperature with 65-70 per cent relative humidity observed maximum reducing sugar content as compared to other treatments. This may be due to accumulation of reducing sugar is a function of starch metabolism which is higher in fruits stored at high temperature compared to store at low temperature which resulted in higher reducing sugar content. Fruits ripened at higher temperature and low humidity conditions showed higher accumulation of total sugars. This was might be due to high rate of respiration, oxidation and ripening at this temperature. Similar results were reported by Vishnuprasanna *et al.*(2000) and Jholgiker and Reddy (2007) in custard apple.

Ascorbic acids

Ascorbic acid content was found maximum (17.50%) in the fruits which were ripened at 25° C temperature and 65-70 per cent relative humidity conditions. However, it was minimum (12.50%) in fruits ripened at 15° C temperature and 85-90 per centrelative humidity conditions. Ascorbic acid content in custard apple fruits decreased as the days of storage increased. This might be due to advancement of storage period and breakdown of ascorbic acid into simpler compounds during storage period. Similar observations were reported by Vishnuprasanna (2000) and Patil (2016) in Custard apple.

Organoleptic Evaluation

The data pertaining to organoleptic evaluation of custard apple fruits ripened at various temperature and relative humidity conditions presented in Table 6.

Fruit and Pulp Color

Fruits ripened at 20°C and 15°C with relative humidity 75-80 per cent recorded highest (8.8) score for fruit colour and pulp color respectively. While, fruits ripened at ambient conditions recorded lowest score for fruit colour (6.2) and pulp colour (7.2).

Flavor and Taste

Fruits ripened at temperature 25°C with relative humidity 65-70 per cent recorded highest (8.4) score for flavor followed by control treatment. At same temperature and relative humidity highest (8.2) taste score was recorded.While, fruits ripened at 15°C with relative humidity 75-80 per cent and 85-90 per cent recorded lowest

Table 5. Effect of temperature and relative humidity on pH, titrable acidity, total soluble solids, reducing sugars, total sugars and ascorbic acid of custard apple fruits at ripening stage

Treatment	pH	Titrable Acidity (%)	TSS (°Brix) at ripening	Reducing stage sugars (%)	Total sugars (%)	Ascorbic acid (mg/100gm)
T_1R_1	5.35^{abc}	0.32^{bc}	23.33^{abcd}	13.38^{cd}	13.65^{cd}	15.00^{c}
T_1R_2	5.42^{a}	0.29^{c}	21.17^{d}	13.02^{d}	13.24^{de}	12.50^{d}
T_1R_3	5.38^{ab}	0.27^{c}	22.00^{cd}	11.85^{e}	12.36^{e}	12.50^{d}
T_2R_1	5.30^{bcd}	0.37^{abc}	23.67^{abc}	13.40^{cd}	13.88^{cd}	15.00^{c}
T_2R_2	5.29^{bcd}	0.37^{abc}	23.00^{bcd}	14.65^{b}	15.22^{ab}	13.50^{d}
T_2R_3	5.31^{bcd}	0.27^{c}	22.17^{cd}	14.52^{b}	14.67^{bc}	12.50^{d}
T_3R_1	5.25^{cd}	0.48^{a}	25.67^{a}	15.78a	16.10^{a}	17.50^{a}
T_3R_2	5.23^{d}	0.43^{ab}	23.00^{bcd}	14.31^{bc}	15.40^{ab}	15.50^{bc}
T_3R_3	5.24^{d}	0.37^{abc}	22.33^{bcd}	15.23^{ab}	15.92^{a}	15.00^{c}
C (Control)	5.27^{cd}	0.45^{a}	24.67^{ab}	14.41^{b}	14.52^{bc}	16.50^{ab}
S.Em.±	0.01	0.01	1.88	0.31	0.39	0.44
C.D. at 5%	0.11	0.13	2.33	0.95	1.07	1.13
C.V.%	1.23	20.53	5.94	3.98	4.35	4.55

Means within a column followed by different letters differ significantly at P<0.05.

Table 6. Effect of temperature and relative humidity on organoleptic score of custard apple fruits at ripening stage

Treatment	Fruit colour	Pulp colour	Flavour	Taste	Overall Acceptability
T_1R_1	7.6	7.8	7.6	7.8	7.7
T_1R_2	7.2	8.8	7.4	7.4	7.7
T_1R_3	7.4	7.6	7.4	7.0	7.4
T_2R_1	8.2	7.8	7.8	7.8	7.9
T_2R_2	8.8	7.4	7.6	7.8	7.9
T_2R_3	8.2	8.6	7.8	7.6	8.1
T_3R_1	7.8	6.6	8.4	8.2	7.8
T_3R_2	8.8	7.8	7.8	8.0	8.1
T_3R_3	7.2	8.6	7.6	7.8	7.8
C (Control)	6.2	7.2	8.2	7.8	7.4
S.Em.±	0.27	0.25	0.26	0.38	0.26
C.D. (0.05)	0.66	0.64	NS	NS	NS
C.V.%	6.71	6.40	6.57	7.98	7.32

NS - Non significant

(7.4) score for flavor and at 15°C with relative humidity 85-90 per cent recorded lowest (7.4) score for taste.

Overall Acceptability

The overall acceptability score of fruits was highest (8.1) stored at temperature 20°C and 85-90 per cent and at temperature 25°C and relative humidity 75-80 per cent while it was minimum in control (7.4) treatment.

CONCLUSION

From the present study it could be concluded that, custard apple fruits can be ripened at temperature 20°C and relative humidity 85 - 90 per cent for minimum physiological weight loss, more ripening period (6 days),

acceptable sensory score and desirable physicochemical properties. therefore 6 days period could be useful to avoid the losses of fruits during glut.

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Standardization of Plant Spacing and Fertilizer Dose for the Newly Developed Mungbean Variety AKM-12-28

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ABSTRACT

It is essential to know reliable information about agronomic management practices such as plant spacing and fertilizer doses to produce profitable and sustainable mungbean production and productivity. Therefore, this study aimed to determine the optimum plant spacing and fertilizer dose for the newly developed mungbean variety AKM 12-28. The experiment was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra), India, in 2018. The experiment was laid out in a randomized complete block design with two factors with three replications. There were four fertilizer doses (F_0: No fertilizers, F_1: 75% RDF, F_2: 100% RDF, and F_3: 125% RDF) and two plant spacing (S_1: 30 cm x 10 cm and S_2: 45 cm x 10 cm). The results revealed that the application of 125 per cent RDF resulted in taller plants with more branches and pods with significantly higher grain yield of mungbean variety AKM 12-28, and it was at par with the application of 100 per cent RDF. The effect of both spacings on these parameters was found non-significant.

India is the largest producer of pulses in the world, with a 24 per cent share in global production. The major pulse crops of the country are chickpea (48%), pigeonpea (15%), mungbean (7%), urdbean (7%), lentil (5%), and field pea (5%) (Anonymous, 2020[a]). The major pulse-growing states in the country are Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka and Andhra Pradesh, which account for about 80 per cent of the total production. Despite the increase in production, average pulse yields in India are much lower than the world average. The requirement for pulses has been projected to reach 32 million tonnes by 2050, considering the estimated population growth of 1.69 billion by 2050 (Anonymous, 2020[b]).

Mungbean [*Vigna radiata* (L.) Wilczek] is one of India's most ancient and extensively grown leguminous crops. Mungbean is an excellent source of high-quality protein. It contains about 25 per cent protein. It is primarily a rainy season crop, but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer seasons. It also contains high-quality lysine (4600 mg g^{-1} N) and tryptophan (60 mg g^{-1} N). The sprouted seeds of mungbean are rich in ascorbic acid (vitamin C), riboflavin, and thiamine (Kumar *et al*., 2013).

Appropriate use of fertilizers is of great importance to crop growth and productivity. However, mungbean growth and development have been seriously affected, and its yield and quality have declined due to low fertilization levels and imbalanced N, P and K fertilization (Yin *et al*., 2018). As a consequence of excessive fertilizer application, agricultural products have been affected, soil microecology has been altered, and soil-borne diseases have been amplified (Jain *et al*., 2007). Therefore, the balanced use of fertilizers can improve mungbean yield and quality.

In pulse crops, plant spacing is crucial as it is one of the most significant agronomic factors affecting the entity and the crop yield quality, with better quality at wider row spacing (Singh and Singh, 2021).

The spacing of mungbean plants in a field significantly affects the crop's yield, quality, and growth.Mungbean population studies were among the earliest and most common field experiments, which remain essential today. Rao *et al*., 2015, Muchira *et al*., 2018 and Birhanu *et al*., 2018.

More information is needed on the effects of the nutrient requirement and spatial arrangement of plants on the performance of the new mungbean variety AKM-12-28. Therefore, this study was designed to determine the optimal fertilizer dose and plant spacing for the newly developed mungbean variety AKM 12-28.

MATERIAL AND METHODS

A field experiment; was conducted at Dr. Panjabrao Deshmukh Krishi Vidyapeeth during the rainy season of 2018. The soil of the experimental plot was clayey

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(34.2 % sand, 25.1 % silt, 49.1 % clay) in texture, having a pH of 8.0, field capacity of 33.3 per cent, permanent wilting point of 14.5 per cent and bulk density of 1.43 Mg m^3. The soil has 0.43 per cent organic C, 193 kg ha^{-1} available N, 21 kg ha^{-1} 0.5 M $NaHCO_3$ extractable available P and 433 kg ha^{-1} NH_4OAc extractable available K. Most of the rainfall occurs in Akola during the South-West monsoon season, which begins in the middle of June. Monsoon season precipitation reaches 770 mm in about 40 to 45 rainy days from June to September. Mungbean crops received 759 mm of rainfall in 2018.

The experiment was laid out in a randomized complete block design with two factors (Fertilizer doses and Plant spacing) with three replications. Four fertilizer doses (F_1: 0 RDF, S_2: 75% RDF, S_3: 100% RDF, and S_4: 125% RDF) and two plant spacing [S_1: 30 cm x 10 cm (3,33,333 plants ha^{-1}) and S_2: 45 cm x 10 cm (2,22,222 plants ha^{-1})] were tested. The plot size was 3.0 m (length) x 3.6 m (width). The treatment S_1 consisted of twelve crop rows spaced at 30 cm, and S_2 consisted of eight crop rows spaced at 45 cm. The mungbean seeds of the genotype AKM 12-28 were densely planted (23rd June, 2018) and thinned to maintain the distance between plants of 10 cm. The fertilizers were applied as per the treatments.

The five representative plants were tagged from the net plot area to study mungbean growth and yield components (plant height, branches, pods, seed yield $plant^{-1}$ and seeds pod^{-1}). The harvesting was carried out successively when maximum percentage of mature pods turns brown. The mature pods were picked for final yield determination on 26th August 2018 and 3rd September 2018. The seeds were obtained manually by threshing the mungbean pods, and the final seed weight was recorded.

The statistical analysis of the data was performed using OPSTAT (Sheoran *et al*., 1998).

Rainwater use efficiency (RUE): The rainwater use efficiency was calculated by dividing seed yield (kg ha^{-1}) by cumulative rainfall (mm) from planting to harvest.

$$\text{Rainwater use efficiency (RUE)} = \frac{\text{Yield (kg ha}^{-1}\text{)}}{\text{Cumulative rainfall (mm)}}$$

Since the crop was grown entirely as rainfed and irrigation was not applied, rainwater use efficiency (RUE) would also indicate the water productivity or water use efficiency of treatment under rainfed conditions (Sharma *et al*., 2013).

RESULTS AND DISCUSSION

Effect of fertility levels on growth and yield contributing parameters and yield of mungbean

The effect of fertilizer levels on growth and yield contributing parameters of mungbean was found to be significant (Table 1). Applying 125 per cent, RDF recorded significantly taller plants, which was at par with the 100 per cent RDF. Application of 125 per cent recommended dose of fertilizer resulted in 15, 9 and 4 per cent taller plants compared to no fertilizer application, 75 per cent and 100 per cent recommended dose of fertilizers, respectively. A similar trend was noted for the number of branches and pods $plant^{-1}$. Application of 125 per cent recommended dose of fertilizer enhanced the pods $plant^{-1}$ by 57, 31 and 12 per cent than no fertilizer application, 75 per cent and 100 per cent recommended dose of fertilizer. The effect of different fertilizers doses on the number of seeds pod^{-1} was significant and clarified that the genetic characteristics do not influence by agronomic management.

The effect of fertilizer doses on the seed index of mungbean was significant (Fig.1). The treatment application of 125 per cent recommended fertilizer dose recorded a significantly higher seed index of mungbean variety AKM 12-28 (4.03g). The seed yield $plant^{-1}$ was also considerably influenced by the fertility levels, and treatment with a 125 per cent recommended dose of fertilizer recorded significantly more seed yield $plant^{-1}$. It was at par with the 100 per cent RDF. Similarly, the application of 125 per cent recommended fertilizer doses enhanced the mungbean yield $plant^{-1}$ (Fig. 2). The 125 per cent recommended dose resulted in 53, 35 and 5 per cent yield advantages over no fertilizer application, 75 per cent and 100 per cent application of the recommended dose of fertilizer. However, the application of 100 per cent recommended dose of fertilizer was at par with the 125 per cent.

The effect of fertilizer doses on the mungbean yield and rainwater use efficiency was significant. The application of 125 per cent RDF recorded a significantly higher grain yield (1350 kg ha^{-1}), which was at par with the 100 per cent RDF treatment (1291 kg ha^{-1}). The application

Table 1. Effect of fertility levels and spacing on the growth of mungbean AKM12-28.

Treatment	Plant height (cm)	No. of branches plant^{-1}	No. of pods plant^{-1}	No. of grains pod^{-1}
Fertility levels (F)				
F_0 (No fertilizers)	34.23	2.90	8.17	12.43
F_1 (75% RDF) (15:30:15 kg/ha N:P:K)	36.03	3.00	9.83	12.73
F_2 (100% RDF) (20:40:20 kg/ha N:P:K)	37.70	3.37	11.50	12.90
F_3 (125% RDF) (25:50:25 kg/ha N:P:K)	39.37	3.60	12.83	13.00
S.E. (m)	0.85	0.11	0.41	0.19
CD (P= 0.05)	2.50	0.33	1.21	NS
Spacing (S)				
S_1 (30 x 10 cm) (33 plant/m2)	37.13	3.18	9.42	12.68
S_2 (45 x 10 cm) (22 plants/m2)	36.53	3.25	11.75	12.85
S.E. (m)	0.60	0.08	0.29	0.13
CD at 5%	NS	NS	0.85	NS
F x S				
S.E. (m)	1.20	0.16	0.58	0.27
CD at 5%	NS	NS	NS	NS

Table 2. Effect of fertility levels and spacing on mungbean AKM12-28.

Treatment	Grain yield (kg/ ha)	Rainwater use efficiency (kg/ha/mm)
Fertility levels (F)		
F_0 (No fertilizers)	891	1.17
F_1 (75% RDF) (15:30:15 kg/ha N:P:K)	1004	1.32
F_2 (100% RDF) (20:40:20 kg/ha N:P:K)	1291	1.70
F_3 (125% RDF) (25:50:25 kg/ha N:P:K)	1350	1.78
S.E. (m)	39	-
CD (P= 0.05)	115	-
Spacing (S)	1141	1.50
S_1 (30 x 10 cm) (33 plant/m2)	1127	1.48
S_2 (45 x 10 cm) (22 plants/m2)	28	-
S.E. (m)	NS	-
CD at 5%		
F x S		
S.E. (m)	162	-
CD at 5%	-	-

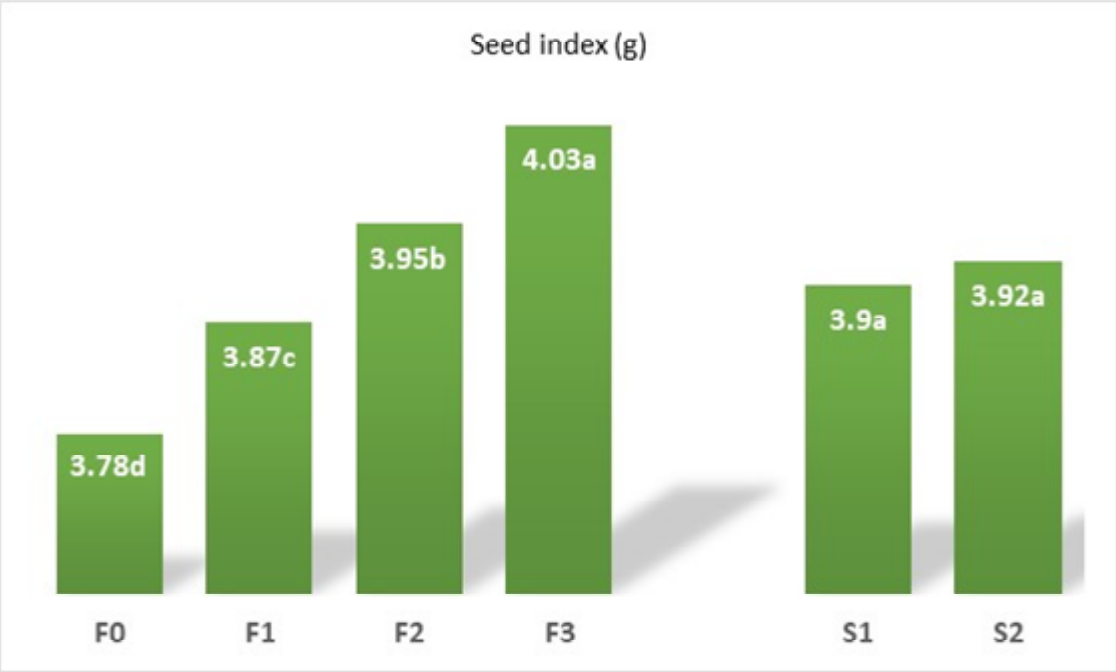

Figure 1. Effect of fertilizer doses and plant spacing on seed index of mungbean (g).

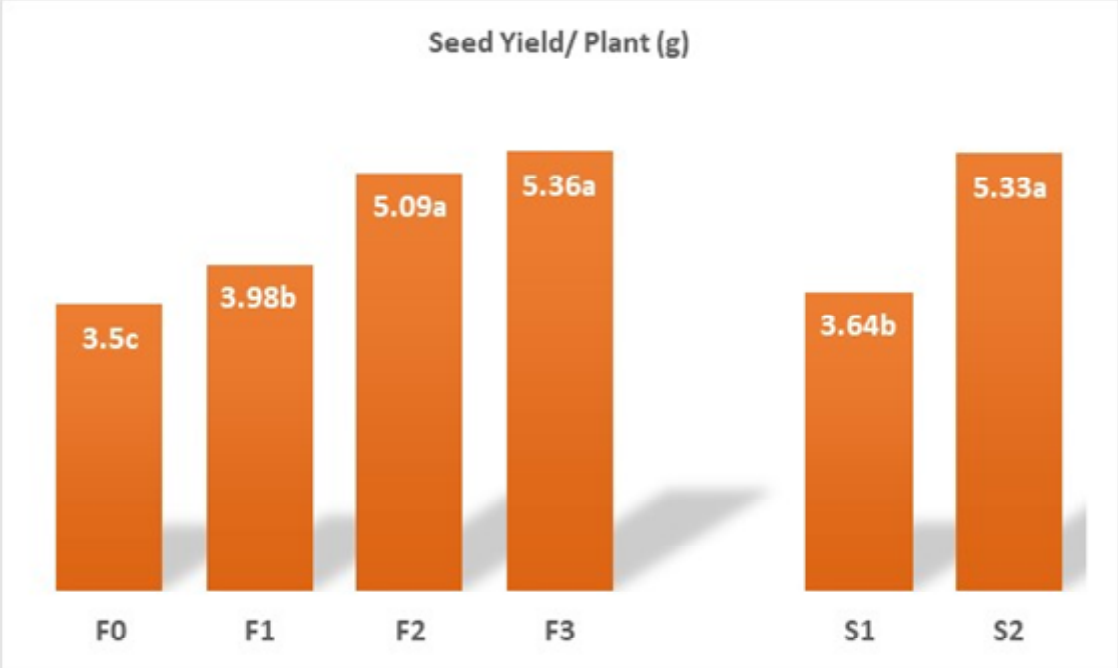

Figure 2. Effect of fertilizer doses and plant spacing on seed yield plant^{-1} of mungbean (g plant^{-1})

of a 125 per cent recommended dose resulted in 52, 34 and 5 per cent yield advantages over the treatments with no fertilizer, application of 75 per cent and 100 per cent recommended dose of fertilizer, respectively. Applying a recommended fertilizer dose resulted in the enhancement of the rainwater use efficiency of the mungbean crop. The highest rainwater use efficiency of 1.78 kg ha^{-1} mm^{-1} was observed with the treatment application of 125 per cent recommended dose of fertilizer. The best treatment application of 125 per cent recommended dose of fertilizer recorded 52, 35 and 5 per cent improvement in rainwater use efficiency over the treatment with no fertilizer, 75 per cent, 100 per cent recommended dose of fertilizer.

The nutrient requirement of pulse crops is comparatively lower than other field crops. Plant response was better with the addition of NPK due to the deficiency of nutrients in the soil, especially nitrogen (N). N fertilizer enhances cell division and cell elongation of mungbean. It promotes initial vegetative growth, which leads to enhanced plant height, increases in the branch $plant^{-1}$, pods $plant^{-1}$ and supports better seed yield. P stimulates early root growth, which helps better uptake nutrients and water from the soil. K fertilizer increases drought resistance. A balanced ratio of NPK helps in the good overall development of the plants and ultimately helps boost productivity. Our results align with the earlier results reported by Jain *et al*. 2007, Kumar *et al*. 2013, Yin *et al*. 2018 and Muchira *et al*., 2018.

Effect of plant spacing on growth and yield contributing parameters and yield of mungbean

Plant height, the number of branches $plant^{-1}$ (Table 1), and seed index (Fig. 1) was not affected by plant spacing. However, the number of pods $plant^{-1}$ (Table 1) was significantly higher with 45 cm x 10 cm plant spacing than with 30 cm x 10 cm. Planting the mungbean on 45cm x 10cm spacing resulted in 25 per cent more pods $plant^{-1}$ than the closer plant spacing of 30 cm x 10cm. The seed yield $plant^{-1}$ was also significantly influenced by the plant spacing (Fig. 2) and planting of mungbean crop at 45cm x 10 cm recorded significantly more seed yield $plant^{-1}$ than planting at 30 cm x 10 cm. Planting of mungbean at 45cm x 10 cm resulted in 25 per cent more $plant^{-1}$ yield than closer planting of 30 cm x 10 cm.

The plant spacing did not influence the grain yield (Table 2). However, closer plant spacing of 30 cm x 10 cm recorded numerically higher seed yield (1141 kg ha^{-1}) than the wider plant spacing of 45 cm x 10 cm (1127 kg ha^{-1}).

Plant spacing is a space between crops and the area required for a particular plant to thrive. The inadequately spaced crops compete for light, water, nutrients, and air. Competition of this type reduces both the quantity and quality of the produce. Obtaining reasonable yields requires appropriate plant spacing.

Results indicated that sowing mungbean at a closer (30 cm x 10 cm) or wider spacing (45 cm x 10 cm) does not influence the plant height, branches $plant^{-1}$ and seed index. However, wider spacing (45cm x 10cm) increased the number of mungbean crop pods $plant^{-1}$ and seed index characters. The planting distance did not influence the yield ha^{-1}. Though the yield $plant^{-1}$ was higher with the wider plant spacing (45cm x 10cm) than with the closer plant spacing (30 cm x 10 cm) due to a thirty-three percent increase in plant population at closer planting distance (30 cm x 10 cm) instead of a widely spaced mungbean crop (45 cm x 10 cm) both the plant spacing resulted in statistically similar yield. Similarly, (Rao *et al.* 2015) reported that the narrow row spacing resulted in 22 per cent higher shoot dry matter and 14 per cent more mungbean yield than the wide rows. Muchira *et al*. 2018 reported that 45 cm x 15 cm spacing had been determined to achieve the best yield for mungbean because it is the best spacing for the optimum plant population.

CONCLUSION

Results concluded that the newly developed mungbean variety AKM 12-28 performs equally well under row spacings of 30 cm x 10 cm and 45 cm x 10 cm plant spacing. Additionally, the newly developed variety responded to higher levels of fertility (25:50:25 kg ha^{-1} N:P:K).

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Chickpea Yields as Influenced by Tillage Management Practices and Varieties Under the Mungbean-Chickpea Crop Sequence

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ABSTRACT

A field experiment was carried out at the research field of Pulses Research Unit, Washim Road, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India, during the Rabi season of 2019-20, to study the tillage management in chickpea (*Cicer arietinum* L.) under mungbean-chickpea crop sequence. The result indicated that the values of growth attributes, yield attributes, and yield of chickpea crop were increased with tillage treatment tractor drawn cultivator + harrowing+ sowing + one hoeing + one hand weeding (T_1). The chickpea variety PDKV Kanak (V_2) recorded significantly higher plant height than the JAKI-9218 (V_1). Whereas, remaining growth and yield parameters namely branches plant^{-1}, dry matter plant^{-1}, pods plant^{-1} and seed yield plant^{-1} were not influenced considerably due to varieties. However, JAKI-9218 recorded a higher seed index and yield.

India is the largest producer of pulses in the world, with a 24 per cent share in global production. The primary pulse crops of the country are chickpea (48%), pigeonpea (15%), mungbean (7%), urdbean (7%), lentil (5%), and field pea (5%) (Anonymous, 2018[a]). In the country, the major pulse-growing states are Madhya Pradesh, Maharashtra, Rajasthan, Uttar Pradesh, Karnataka, and Andhra Pradesh, which account for about 80 per cent of the total production. Despite the increase in output, average pulse yields in India are much lower than the world average. The requirement for pulses has been projected to reach 32 million tonnes by 2050,considering the estimated population growthof 1.69 billion by 2050 (Anonymous 2018[b]).

Chickpea is one of India's most important winter pulse crops, grown under rainfed and irrigated conditions. In Maharashtra, chickpea is grown under conserved soil moisture and in irrigated situations. Moisture availability is the major constraint of rainfed chickpea in Maharashtra. Poor and erratic germination, weak seedlings, and less plant population is a significantcause of low chickpea productivity. Inadequate soil moisture has adverse effects on germination, seedling emergence, growth, flowering, pod set, and seed yield. Rapid germination and emergence are important factors for successfully establishing the crop (Giri *et al.*, 2022). The area under chickpea cultivation in Maharashtra in rabi 2018-19 was 1.69 million ha,with production of 1.39 million tonnes and productivity 825 kg ha^{-1} (Anonymous, 2020).

Mungbean-chickpea cropping system is popular in the Vidarbha region of the Maharashtra and is followed bya 0.1 million ha area (Anonymous, 2020). Tillage as a part of a cropping system is one of the primary agricultural operations because of its impact on soil properties, environment and crop growth.

The zero-tillage technology has been developed to reduce and minimize the turn around time and establish good crops without loss in yield. Moreover, zero tillage may advance the sowing of chickpea and consequently improve the grain yield compared to the conventional tillage system. The conventional method of sowing by giving repeated tillage delays the sowing and significantly minimizes the yield (Kumar *et al.,* 2005).

MATERIAL AND METHODS

A field experiment effect of tillage management practices and varieties on the growth and yield of chickpea under mungbean-chickpea sequence was carried out at the research field of Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India during the *Rabi* season of 2019-20. The soil of the experimental plot was clay loam in texture and slightly alkaline (pH 8.20) in reaction. The chemical composition of the soil indicated that the soil was low in available nitrogen (173 kg ha^{-1}), medium in available phosphorus (20 kg ha^{-1}) and high in potassium content (523 kg ha^{-1}). The total soluble salt content was normal (Electrical conductivity 0.18 dS m^{-1}). The experiment was laid out in strip plot design (Table 1). Four tillage practices in chickpea with two varieties (eight treatments) were replicated five times. The gross plot size was 10.0 m x 9.0 m, and the net plot size was 9.80 m x 8.40 m.

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Seed of chickpea variety JAKI9218 and PDKVKanak were sown @ 75 kg ha^{-1} with a spacing of 30 cm between rows and 10 cm between plants on 18th October 2019. The full recommended dose of fertilizers (25 kg N, 50 kg P_2O_5 and 30 kg K_2O ha^{-1}) was applied in all the treatments at the sowing time (basal application). Timely recommended plant protection measures for chickpea crop were followed to save the crop from pests and diseases. The chickpea crop was harvested manually. Different growth and yield components were recorded periodically. The data on various parameters recorded from experimental plots were statistically analyzed, as suggested by Panse and Sukhatme (1995) [9].

RESULTS AND DISCUSSION

Growth studies

Plant height (cm)

The effect of various tillage practices significantly influenced the plant height of chickpea (Table 2). Treatment tractor drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded significantly taller plants (57.88 cm) and it was at par with treatment rotavator immediately after the harvest of mungbean + sowing + one hoeing (55.48 cm). The lower plant height was recorded with application of glyphosate immediately after the harvest of mungbean+ sowing (51.06 cm). However, it was found to be at par with the treatment application of glyphosate immediately after the harvest of mungbean + sowing + pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (52.00 cm). Deep tillage treatments created a better root environment and enhanced crop height compared to shallow and no-tillage treatments. Our results are in line with the earlier results reported by Yau *et al.* (2010) and Deka *et al.* (2020). The effect of varieties on the plant height of the chickpea crop was found significant (Table 2). The chickpea variety PDKV Kanak recorded significantly higher plant height than the JAKI 9218. PDKV Kanak is a tall growing erect type, and JAKI- 9218 is a semi-spreading type of desi chickpea variety. Therefore, in the present investigation, chickpea variety PDKV Kanak recorded 11 per cent taller plants at harvest (56.89 cm) compared to JAKI 9218 (51.33 cm).

Number of branches $plant^{-1}$

The branches are important indicators of the sink. In the present investigation, tillage management practices did not significantly influence the number of branches/ plants in the chickpea crop (Table 2).The effect of both varieties on a number of branches $plant^{-1}$ were found non-significant.

Leaf area $plant^{-1}$ (dm^2) of chickpea

At the flowering stage, the maximum leaf area observed with the tillage treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding (24.00 dm^2 $plant^{-1}$) (Fig. 1), which was equivalent with the treatment rotavator immediately after the harvest of mungbean + sowing + one hoeing (22.94 dm^2 $plant^{-1}$). The lowest leaf area $plant^{-1}$ was observed with the treatment application of glyphosate immediately after the harvest of mungbean+ sowing (21.33 dm^2 $plant^{-1}$). The increase in leaf area $plant^{-1}$ may be attributed to the increase in the number of leaves $plant^{-1}$ with the treatment of tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding. An increase in the number of leaves $plant^{-1}$ increased the leaf area $plant^{-1}$ of the chickpea in the present investigation. Similar result was earlier reported by Khan *et al.* (2017). The leaf area of both the varieties

Table 1: Details of treatment and symbol used for the experiment

A	Main-plot (Tillage practices for chickpea crop)
T_1	Tractor drawn cultivator + rotovator + sowing + one hoeing + one hand weeding
T_2	Application of glyphosate immediately after the harvest of mungbean + sowing.
T_3	Application of glyphosate immediately after the harvest of mungbean + sowing + pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} + one hoeing
T_4	Rotovator immediately after the harvest of mungbean + sowing + one hoeing.
B	Sub-plot (Varieties of chickpea)
V_1	JAKI-9218
V_2	PDKV-Kanak (AKG-1303)

Note: Conventional tillage (Summer ploughing + harrowing+ sowing+ one hoeing) followed for the mungbean crop

was comparable.

Chlorophyll content (mg g^{-1})

The effect of tillage practices on chlorophyll content at the flowering stage was found to be non-significant (Fig. 2). At the pod development stage, treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded significantly higher chlorophyll content (1.59 mg g^{-1}). Which was similar with the treatment rotavator immediately after the harvest of mungbean + sowing + one hoeing (1.55 mg g^{-1}).The lowest chlorophyll content was observed with the treatment application of glyphosate immediately after the harvest of mungbean+ sowing (1.39 mg g^{-1}).The effect of varieties on leaf chlorophyll concentrations was found non-significant at all the stages.

Days to 50 per cent flowering

The effect of various tillage treatments on days to 50 per cent flowering was non-significant (Table 2). However, the maximum number of days required for 50 per cent flowering was found in treatment tractor drawn cultivator + harrowing + sowing + one hoeing + one hand weeding(53.30 days) followed by treatment rotavator immediately after the harvest of mungbean + sowing + one hoeing(52.50 days), application of glyphosate immediately after the harvest of mungbean + sowing + pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} (52.00 days). The lowest number of days to 50 per cent flowering was recorded with the application of glyphosate immediately after the harvest of mungbean+ sowing(51.60 days). The effect of varieties on days to 50 per cent flowering was found to be non-significant.

Dry matter accumulation $plant^{-1}$ (g)

The effect of tillage management practices on the chickpea dry matter accumulation (g $plant^{-1}$) was significant (Table 2). The treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded significantly higher dry matter accumulation $plant^{-1}$ (14.62 g $plant^{-1}$) and it was at par with the treatment rotavator immediately after the harvest of mungbean + sowing + one hoeing(14.11 g $plant^{-1}$). The lowest dry matter accumulation at harvest was recorded with the treatment application of glyphosate immediately after the harvest of mungbean+ sowing (13.36 g $plant^{-1}$). Improvement in growth parameters of chickpea due to tillage management practices may be because of beneficial effects of tillage practices on growth of chickpea and supported efficient translocation of photosynthates from source to sink resulted in improvement in yield attributing characters of chickpea and reflected in higher dry matter accumulation in chickpea crop. Arya *et al.* (2005) also observed that deep ploughing recorded significantly higher dry matter accumulation than the other tillage practices.The dry matter accumulation $plant^{-1}$ was not markedly influenced due to the varieties.

Yield attributing characters

Number of pods and seed yield ($plant^{-1}$)

Various tillage practices significantly influenced the number of pods $plant^{-1}$ (Table 2). Treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weedingrecorded considerably more pods (29.30 pods $plant^{-1}$). The lowest pods $plant^{-1}$ were observed with the treatment application of glyphosate immediately after the harvest of mungbean+ sowing (25.85 pods $plant^{-1}$); in treatment,tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded the highest number of pods $plant^{-1}$ due to the development of a deep root system, which resulted in easy access to greater soil nutrients as compared to other tillage practices. A similar response was observed by Arya *et al.* (2005).

The most important aspect of obtaining a higher seed yield per unit area is the seed yield $plant^{-1}$. In the present investigation, treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded significantly higher seed yield $plant^{-1}$ (7.35 g $plant^{-1}$) and it was at par with the treatment rotavator immediately after the harvest of mungbean + sowing + one hoeing (7.20 g $plant^{-1}$). The lowest seed yield $plant^{-1}$ was observed with the treatment application of glyphosate immediately after the harvest of mungbean+ sowing (6.14 g $plant^{-1}$). Treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded 20, 12 and 2 per cent more seed yield $plant^{-1}$ than the treatments application of glyphosate immediately after the harvest of mungbean + sowing, application of glyphosate immediately after the harvest of mungbean + sowing + pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} + one hoeing and rotovator immediately after the harvest of mungbean + sowing + one hoeing, respectively. The improvement in growth attributes, yield attributes, biochemical processes, and root growth increased seed yield $plant^{-1}$ of chickpea crop. A similar increase in seed yield $plant^{-1}$ was earlier noted by Arya *et al.* (2005) and

Table 2: Effect of tillage practices and varieties on growth attributes and yield attributes of chickpea

Treatments	Plant height (cm) at harvest	Branches plant^{-1} at harvest	Pods plant^{-1}	Seed yield plant^{-1} (g)	Seed index (g)	Days to 50% flowering	Dry matter (g) plant^{-1} at harvest
Tillage practices for chickpea crop (T)							
T_1 : tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding	57.88^a	7.16^a	29.30^a	7.35^a	21.52^a	53.30^a	14.62^a
T_2 : Application of glyphosate immediately after the harvest of mungbean + sowing	51.06^b	6.48^a	25.85^c	6.14^b	21.32^a	51.60^a	13.36^b
T_3 : Application of glyphosate immediately after the harvest of mungbean + sowing + pre-emergence application of pendimethalin @ 1.0 kg a.i./ha + one hoeing	52.00^b	6.50^a	25.90^c	6.56^b	21.41^a	52.00^a	13.97^b
T_4 : Rotavator immediately after the harvest of mungbean + sowing + one hoeing	55.48^a	6.66^a	27.16^b	7.20^a	21.43^a	52.50^a	14.11^a
S.E. (m)±	1.34	0.30	0.37	0.18	0.12	0.5	0.25
C.D. @5%	4.14	NS	1.14	0.57	NS	NS	0.77
Varieties (V)							
V_1: JAKI9218	51.33^b	6.79^a	27.08^a	7.04^a	22.26^a	52.55^a	14.19^a
V_2: PDKVKanak	56.89^a	6.61^a	27.03^a	6.59^a	20.58^a	52.15^a	13.84^a
S.E. (m)±	1.10	0.25	0.50	0.22	0.09	0.57	0.21
C.D. @5%	4.33	NS	NS	NS	0.36	NS	NS
T x V							
S.E. (m)±	2.21	0.49	1.00	0.43	0.18	1.14	0.41
C.D. @5%	NS	NS	NS	NS	NS	NS	NS

Means followed by the same letter do not differ significantly at the 0.05 probability level.

Table 3: Effect of tillage practices and varieties on seed, straw yield, and harvest index of chickpea

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Tillage practices for chickpea crop (T)			
T_1 : Tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding	2272^a	3088^a	42.36
T_2 : Application of glyphosate immediately after the harvest of mungbean + sowing	2018^b	2544^b	44.29
T_3 : Application of glyphosate immediately after the harvest of mungbean + sowing + pre-emergence application of pendimethalin @ 1.0 kg a.i./ha + one hoeing	2051^b	2659^b	43.57
T_4 : Rotavator immediately after the harvest of mungbean + sowing + one hoeing	2146^a	2857^a	42.92
S.E. (m) ±	61	75	-
C.D. @5%	187	231	-
Varieties (V)			
V_1: JAKI9218	2229^a	2918^a	43.33
V_2: PDKVKanak	2015^b	2656^a	43.25
S.E. (m) ±	45	74	-
C.D. @5%	177	NS	-
T x V			
S.E. (m) ±	90.20	147.67	-
C.D. @ 5 %	NS	NS	-

Means followed by the same letter do not differ significantly at the 0.05 probability level.

Billore *et al.* (2009).The effect of both the varieties on the pods plant^{-1} and seed yield plant^{-1} was found to be non-significant in the chickpea crop during the present investigation.

Seed index (g)

The effect of tillage practices on the seed index of the chickpea crop was found non-significant. The impact of varieties on the seed index of chickpea crop was found significant. The variety JAKI- 9218 produced the heavier seeds of chickpea and registered a significantly higher seed index (22.26 g) than PDKV Kanak (20.58 g) due to its bold seed size.

Seed, straw yield, and harvest index

The data regarding seed, straw yield (kg ha^{-1}) and harvest index (%) is presented in Table 3. The tillage treatment consisting of tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded significantly higher seed yield (2272 kg ha^{-1}) and it was at par with the treatment rotavator immediately after the harvest of mungbean + sowing + one hoeing(2146 kg ha^{-1}). The lowest seed yield was recorded in tillage treatment of the application of glyphosate immediately after the harvest of mungbean+ sowing (2018 kg ha^{-1}). Treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding recorded 13, 11 and 6 per cent more seed yield ha^{-1} than application of glyphosate immediately after the harvest of mungbean + sowing, application of glyphosate immediately after the harvest of mungbean + sowing + pre-emergence application of pendimethalin @ 1.0 kg a.i. ha^{-1} + one hoeing and rotovator immediately after the harvest of mungbean + sowing + one hoeing, respectively. The improvement in plant height, leaf area, dry matter accumulation, pods plant^{-1} and seed yield plant^{-1} cumulatively resulted in the increased seed yield of chickpea in the present investigation. A similar increase in seed yield ha^{-1} was earlier noted by Javed *et al.* (2012), and Deka *et al*. (2020). The effect of varieties on chickpea crop seed yield (kg ha^{-1}) was significant. The variety JAKI- 9218 recorded a significantly higher seed yield (2229 kg ha^{-1}) than the variety PDKV Kanak (2015 kg ha^{-1}). The variety JAKI 9218 recorded 11 per cent more seed yield ha^{-1} than the PDKV

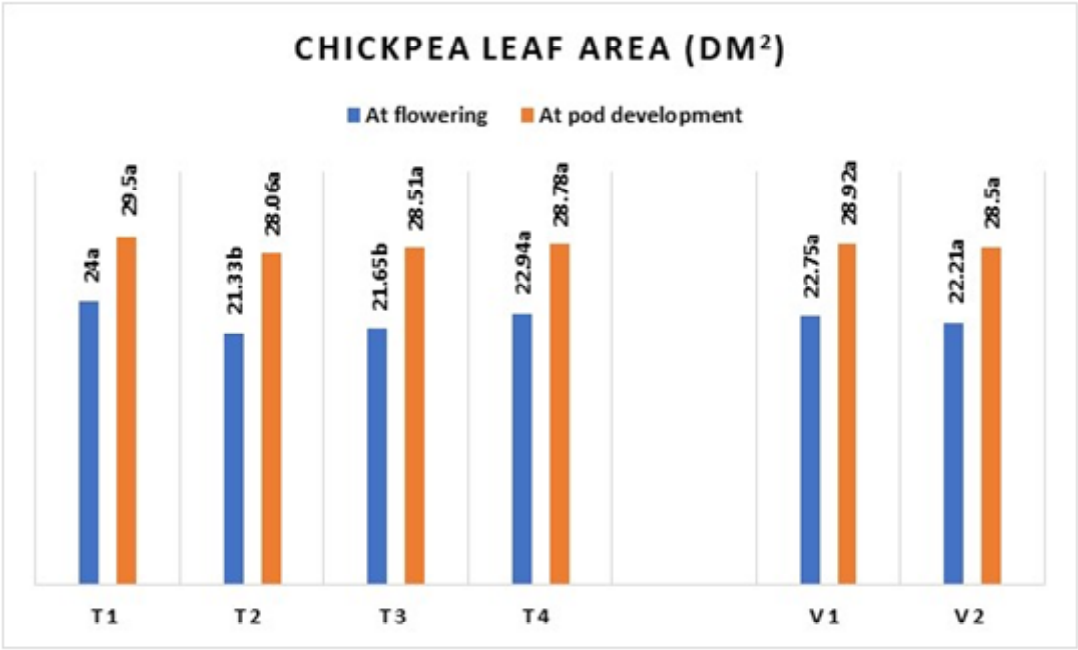

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Fig.1: Effect of different treatments on leaf area (dm^2) of chickpea at flowering and pod development stages of crop growth

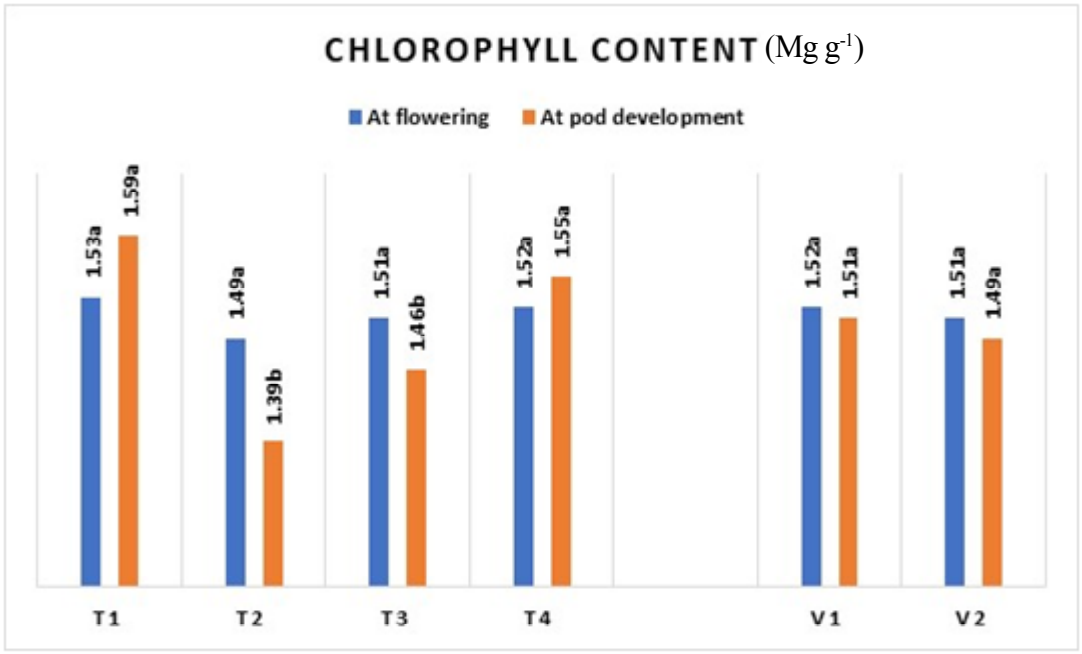

Fig.2: Effect of different treatments on leaf chlorophyll content (mg g^{-1}) of chickpea at flowering and pod development stages of crop growth

Kanak due to larger-sized grains.

Treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weedingrecorded significantly higher straw yield (3088 kg ha^{-1}). The lowest straw yield was observed with the treatment application of glyphosate immediately after the harvest of mungbean+ sowing(2544 kg ha^{-1}). Improvement in growth and yield contributing parameters of the chickpea crop resulted in a higher straw yield of chickpea with the treatment tractor drawn cultivator + harrowing + sowing + one hoeing + one hand weeding. A similar response to the straw yield of chickpea was also observed earlier by Ahmad *et al*. (2019), and Deka *et al*. (2020).The effect of both varieties on the straw yield (kg ha^{-1}) was found to be non-significant in the chickpea crop during the present investigation.

The effect of tillage treatment application of glyphosate immediately after the harvest of mungbean + sowing recorded a higher harvest index (44.29%). The lowest harvest index was observed with the treatment tractor-drawn cultivator + harrowing + sowing + one hoeing + one hand weeding(42.36%). Variety JAKI- 9218 recorded a slightly higher harvest index (43.33%) than the variety PDKV- Kanak (43.25%).

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Developing a Standard for Plant Spacing and Fertilizer Dose for the Recently Developed Desi Chickpea Variety AKG-1303

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ABSTRACT

To achieve sustainable crop production and productivity, reliable information about agronomic management practices is essential.This study determined the optimum fertilizer dose and plant spacing for the newly developed chickpea variety AKG-1303. The experiment was conducted at Pulses Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra), India, in 2018. The experiment was laid out in a factorial randomized block design with two factors with three replications. There were three plant spacing [S_1: 22.5 cm x 10 cm (4,44,444 plants ha^{-1}), S_2: 30 cm x 10 cm (3,33,333 plants ha^{-1}) and S_3: 45 cm x 10 cm (2,22,222 plants ha^{-1})] and three fertilizer doses [F_1: 75% RDF (18.75:37.50:22.50 kg N:P:K ha^{-1}), F_2: 100 % RDF (25:50:30 kg N:P:K ha^{-1}) and F_3: 125 % RDF (31.25:62.50:37.50 kg N:P:K ha^{-1})]. Our results indicated that sowing the newly developed desi chickpea variety AKG-1303 at a wider distance (45 cm x 10 cm) boosted the growth and yield contributing parameters of the chickpea crop. However, the yield per hectare was significantly higher, with a spacing of 30 cm x 10cm. The effect of fertilizer doses on the seed yield ha^{-1} was non-significant. However, the application of 25 per cent more fertilizer dose than the recommended dose of fertilizer improved the yield ha^{-1} of the newly developed desi chickpea variety AKG-1303.

Chickpea (*Cicer arietinum* L.) is the world's third most important pulse crop. In India, chickpea is a premier pulse crop occupying 8.17 million ha and contributing 7.47 million tonnes to the pulse basket. It accounts for 20 percent of the world's pulses production. India is the largest producer, with about 8 million tons, accounting for about 70 per cent of total world production (Range and Giri, 2020). In India, chickpea is grown almost in all of the country, mainly as a rainfed crop (68 % area). In the dry and the rainfed regions, the productivity is 911 kg ha^{-1}, which is much lower than those of the developed countries of the world, such as 2833 kg ha^{-1} in China, 1668 kg ha^{-1} in Canada, and 1488 kg ha^{-1} in the USA.

Rajasthan, Maharashtra, Uttar Pradesh, Andhra Pradesh, Karnataka, Chhattisgarh, Bihar, and Jharkhand contribute more than 95 per cent to the total chickpea production in the country (Anonymous, 2018)

Low crop yields are primarily caused by improper population. Too low and high plant population beyond a specific limit often adversely affects crop yield. The number of plants per unit area influences plants vegetative growth, yield components, and, ultimately, seed yield (Agajie, 2018). Aeration and light penetration into the plant's canopy are vital for optimizing photosynthesis through plant spacing in the field. Very little information is available on the relative contribution of various plant spacing towards yield and yield components and their interaction. Compared to 20, 40 and 50 cm spacing, 30cm row spacing increases chickpea yield (Agajie, 2018), while row spacing does not influence seed production (Parihar, 1996). Production and productivity of the crop are governed by the environmental, genotypic trait of the crop and crop management. Climate change and soil fertility have caused this spacing to be revised to enhance crop productivity.

Futher an adequate supply of chemical fertilizers is also closely associated with the growth and development of plants. As land and water resources shrink, scientific fertilizer application will increase the bulk of crop production (Kinekar, 2011). Among various reasons for low yield, insufficient and non-judicious use of fertilizer is of prime importance. To get the best results from fertilizer, combining fertilizer with other improved agricultural practices must be introduced simultaneously to make fertilizer a helpful input (Sandhya Rani and Krishna, 2016).

AKG 1303 is a variety of desi chickpeas developed by Dr. Panjabrao Deshmukh Krishi Vidhyapeeth, Akola, known for its high yields, erect growth habit, and profuse basal branching, this variety is resistant to major pests and diseases. The first pod appears 33 cm above ground level. Therefore, this variety is suitable for mechanical harvesting (combined harvesters).

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Currently, there is major information on the effects of spacing and nutrients on the performance of the AKG 1303 desi chickpea variety. Non-recommended plant spacing and suboptimal nutrient application could affect farm profitability and regional production targets. Therefore, this study was designed to determine the optimal plant spacing and fertilizer dose for the newly developed desi chickpea variety AKG-1303.

MATERIAL AND METHODS

The field based experiment was conducted at the Pulses Research Farm, Washim road, Dr. Panjabrao Deshmukh Krishi Vidyapeeth (Agricultural University), Krishi Nagar Post, Akola during the winter season of 2018-19. The soil of the experimental plot was clayey (34.1 % sand, 25.3 % silt and 49.2 % clay) in texture, having a pH of 8.2 field capaciper cent and bulk density of 1.42 Mg m^3. The soil has 0.45 per cent organic C 197 kg ha^{-1} available N, 22 kg ha^{-1} available P, and 417 kg ha^{-1} available K.

The experiment was laid out in a Factorial Randomized Block Design with two factors (plant spacing and fertilizer doses) with three replications. Three plant spacing [S_1: 22.5 cm x 10 cm (4,44,444 plants ha^{-1}), S_2: 30 cm x 10 cm (3,33,333 plants ha^{-1}), and S_3: 45 cm x 10 cm (2,22,222 plants ha^{-1})] and three fertilizer doses [F_1: 75% RDF (18.75:37.50:22.50 kg N:P:K ha^{-1}), F_2: 100 % RDF (25:50:30 kg N:P:K ha^{-1}) and F_3: 125% RDF (31.25:62.50:37.50 kg N:P:K ha^{-1})] were tested. The plot size was 3.0 m (length) x 3.6 m (width). The treatment S_1 consisted of sixteen crop rows spaced at 22.50 cm, S_2 consisted of twelve crop rows spaced at 30 cm, and S_3 eight crop rows spaced at 45 cm. The chickpea seeds of the genotype AKG 1303 were densely planted (14th November 2018) and thinned to maintain the distance between plants of 10 cm. The fertilizers were applied as per the treatments. Sprinkler irrigation immediately after the sowing of the chickpea crop was scheduled for uniform germination. Subsequently, two sprinkler irrigations were scheduled for entire experimental plots during the chickpea crop's flowering and pod development stages.

The five representative plants were bagged from the net plot area to study chickpea growth and yield components (plant height, branches, pods and seed yield $plant^{-1}$). The final harvesting was done the maximum percentage of mature pods turns brown. At maturity, the entire plants were harvested (1st March, 2019) by cutting the plant at the base close to the ground surface. The harvested plants were sun-dried in the field for two days and manually threshed for final yield.

The statistical analysis was performed using OPSTAT (Sheoran *et al.*, 1998).

RESULTS AND DISCUSSION

Effect of spacing on growth, yield contributing parameters and yield of chickpea

The plant height, branches $plant^{-1}$, pods $plant^{-1}$ and seed yield $plant^{-1}$ were significantly improved by the plant spacing. Closer plant spacing of 22.5 cm x 10 cm resulted in significantly taller plants (58.73 cm) compared to a wider spacing of 45 cm x 10 cm (54.89 cm). However, the wider spacing resulted in significantly more branches (9.69 branches $plant^{-1}$), pods (38.60 pods $plant^{-1}$) and seed yield $plant^{-1}$ (10.24 g $plant^{-1}$) than a relatively close-spaced plant spacing of 22.5 cm x 10 cm (5.64 branches $plant^{-1}$, 21 pods $plant^{-1}$ and 5.60 g $plant^{-1}$ seed yield) and 30 cm x 10 cm (8 branches $plant^{-1}$, 31 pods $plant^{-1}$ and 8.14 g $plant^{-1}$ seed yield). Sowing at a wider spacing of 45 cm x 10 cm resulted in 72 and 21 per cent more branches, 84 and 25 per cent more pods $plant^{-1}$ and 83 and 26 per cent more seed yield $plant^{-1}$ compared to 22.5 cm x 10 cm and 30 cm x 10 cm, respectively.

The sowing at a spacing of 30 cm x 10 cm resulted in a significantly higher seed yield of the newly developed chickpea variety AKG-1303 (2712 kg ha^{-1}) than a wider spacing of 45 cm x 10 cm (2278 kg ha^{-1}) and an ultra-narrow spacing of 22.5 cm x 10 cm (2507 kg ha^{-1}). Sowing at a spacing of 30 cm x 10 cm resulted in 8 percent more seed yield ha^{-1} compared to a narrow spacing of 22.5 cm x 10 cm and 19 per cent more seed yield ha^{-1} than the wider spacing of 45 cm x 10 cm.

The effect of plant spacing on the height of the first pod from the ground surface (Fig. 1) and seed index (Fig. 2) was non-significant.

The 33 per cent increase in plant population under 30 cm x 10 cm plant spacing instead of a widely spaced chickpea crop (45 cm x 10 cm) might explain the higher productivity per unit area. The results are in line with Chala *et al*. (2020).

Effect of fertility levels on growth, yield contributing parameters, and yield of chickpea

Application of 125 per cent recommended dose of fertilizers resulted in significantly taller plants (59.44

Table 1. Effect of plant spacing and fertility levels on chickpea

Treatment	Plant height (cm)	Branches plant^{-1}	Pods plant^{-1}	Seed yield plant^{-1} (g)
Plant spacings (S)				
S_1: (22.5 cm x 10 cm)	58.73^a	5.64^c	21.00^c	5.60^c
S_2: (30 cm x 10 cm)	57.13^a	8.00^b	31.00^b	8.14^b
S_3: (45 cm x 10 cm)	54.89^b	9.69^a	38.60^a	10.24^a
S.E. (m) $\pm$	0.65	0.20	0.72	0.11
CD at 5%	1.90	0.60	2.10	0.31
Fertility levels (F)				
F_1: (75% RDF)	54.18^c	7.36^b	28.00^b	7.77^b
F_2: (100% RDF)	57.13^b	7.71^a	30.11^a	7.93^b
F_3: (125% RDF)	59.44^a	8.27^a	32.49^a	8.28^a
S.E. (m) $\pm$	0.65	0.20	0.72	0.11
CD at 5%	1.90	0.60	2.10	0.31
Interaction (S X F)				
S.E. (m) $\pm$	1.30	0.41	1.43	0.21
CD at 5%	NS	NS	NS	NS

Means followed by the same letter do not differ significantly at the 0.05 probability level.

Table 2. Effect of plant spacing and fertility levels on seed, straw yield (kg ha^{-1}) and harvest index (%) of chickpea

Treatment	Seed yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Harvest index (%)
Plant spacings (S)			
S_1: (22.5 cm x 10 cm)	2507^b	2707^a	48.11^a
S_2: (30 cm x 10 cm)	2712^a	2987^a	47.76^a
S_3: (45 cm x 10 cm)	2278^c	2622^a	46.64^a
S.E. (m) $\pm$	55	102	0.79
CD at 5%	162	NS	NS
Fertility levels (F)			
F_1: (75% RDF)	2427^a	2620^a	48.17^a
F_2: (100% RDF)	2493^a	2737^a	47.73^a
F_3: (125% RDF)	2576^a	2958^a	46.61^a
S.E. (m) $\pm$	55	102	0.79
CD at 5%	NS	NS	NS
Interaction (S X F)			
S.E. (m)+	111	204	1.58
CD at 5%	NS	NS	NS

Means followed by the same letter do not differ significantly at the 0.05 probability level.

cm) compared to 75 per cent recommended dose of fertilizers (54.18 cm), However, it was at par with the recommended dose of fertilizers (57.13 cm). Similarly, the application of 125 per cent recommended dose of fertilizer resulted in more branches (8.27 branches plant^{-1}) and pods (32.49 pods plant^{-1}) than the application of 75 per cent recommended dose of fertilizers (7.36 branches plant^{-1} and 28 pods plant^{-1}). However, applying a recommended dose of fertilizers (7.71 branches plant^{-1} and 30.11 pods plant^{-1}) was at par with the 125 per cent recommended dose of

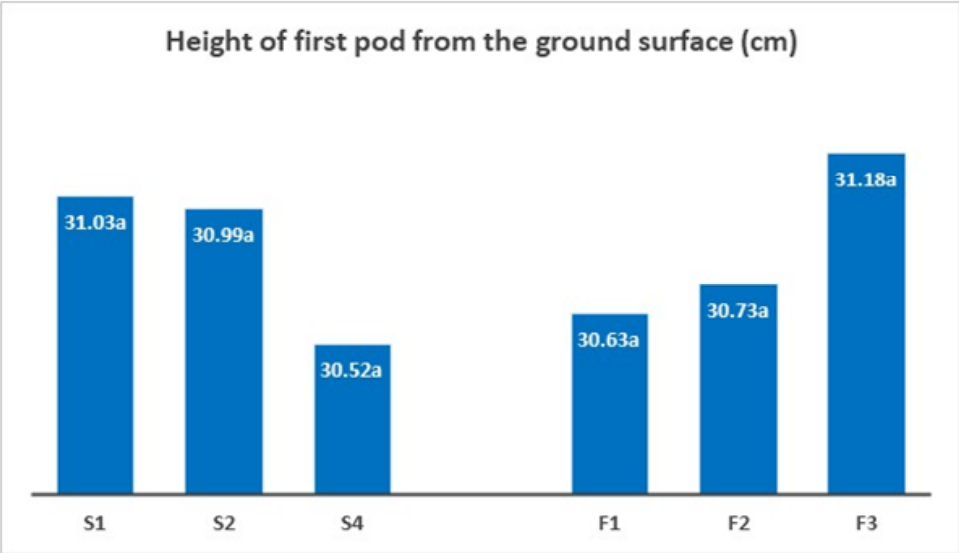

Fig. 1. Effect of plant spacing and fertility levels on the height of the first pod from the ground level in chickpea AKG- 1303.

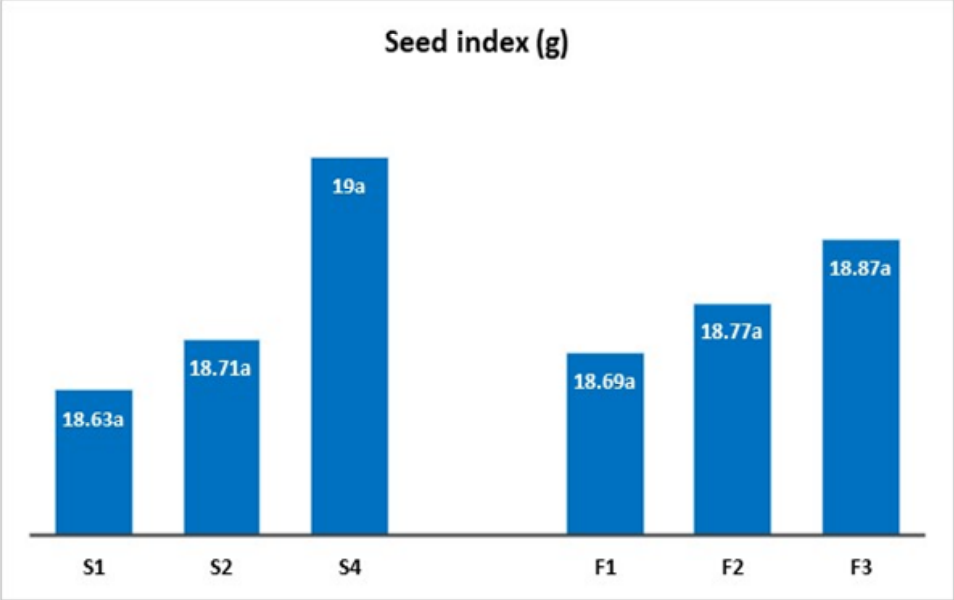

Fig. 2. Effect of plant spacing and fertility levels on the seed index (g) of chickpea AKG- 1303.

fertilizers.

Application of 125 per cent recommended dose of fertilizers also resulted in significantly higher seed yield/ plant of chickpea crop (8.28g plant^{-1}) compared to the application of 75 per cent of the recommended dose of fertilizers (7.77 g plant^{-1}) and 100 per cent recommended dose of fertilizers (7.93 g plant^{-1}). An improvement of 83 and 26 percent in seed yield plant^{-1} was observed with a 25 per cent higher recommended dose of fertilizers compared to 75 and 100 per cent recommended dose of fertilizers. The effect of fertilizer doses on the chickpea seed yield ha^{-1} was non-significant. Although the impact of fertilizer doses on seed yield ha^{-1} was non-significant, the 25 per cent higher dose than the recommended dose of fertilizer increased the seed yield of the desi chickpea variety AKG-1303 by 3 and 6 per cent compared to 75 and 100 per cent recommended dose of fertilizers.

The higher fertilizer dose increasing the dry matter production might have resulted in the more remarkable photosynthesis synthesis, contributing to an increase in the growth parameters of chickpea plants. Finally led to higher seed yield. Similar findings were reported by Singh

et al. (2000), Goyal *et al.* (2010), and Verma and Pandya (2003). All the interaction effects were found non-significant.

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Production and Export Performance of Spices in India

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ABSTRACT

India is traditionally known as the spice bowl of the world. "Out of the 109 spices listed by International Organization for Standardization (ISO), 63 are grown in India. 52 are under the Spices Board, Ministry of Commerce, India". There is no other country in the world that produces as many kinds of spices as India. The serving as culinary ingredients, Indian spices have medicinal properties too and are, hence, good for health. All over the world, the fast growing food industry depends largely on spices as taste and flavour makers. The objectives of this paper are to: estimate the growth of spices production and productivity in India; and estimate the instability of spices production and productivity in India. The data pertaining to all states have been collected for the period from 2000-01 to 2019-20. For that the time series data on Area, Production and Productivity of Spices and Export of Spices were gathered from the Web Site of Spices Board and the same were subjected to growth rate analysis.

The production of spices in India has increased substantially over the years due to the growing importance of the crop in both domestic and international.Non-Tariff Barriers to Trade is becoming a big constraint to many nations in respect of export of farm produce because of the restrictions towards maintaining food safety and standards for the health awareness. Due to this restriction, many of the export has become decreased in terms of its quantity and value and few of the commodities have performed well in respect of production and export. Red Chilli is one of the spice commodity performed well amidst different Non-Tariff Measures and hence this paper has presented the production and export performance that took place in a three decade of time and revealed that the production and export of spices found to be on the increasing phase.

India is actively following the Free Trade Agreements especially in Agricultural and Processed Food Products as enunciated by World Trade Organization. While Free Trade Agreements impose certainly a reduced tariffs, the gains from such free trade becomes limited in the presence of Non-Tariff Barriers which will be a different one from country to country based on their preferences and nature of transactions made.

The exports of Indian spices and spice products surged to Rs 21,515.40 crore (USD 3033.44 million) and a volume of 11,83,000 tonnes in 2019-20, sustaining their robust demand in International markets despite stiff competition.

The total number of spices and spice products exports stood at 215 in 2019-20 as against 219 items in the previous year. The Spices Board said chilli, mint products, cumin, spice oils and oleoresins and turmeric continued to be the major contributors in the spices basket contributing 80 per cent of the total earnings. Though the Indian spices are exported to 185 countries, China (24 %), USA (16 %), Bangladesh (6 %), Thailand (5%), UAE (6 %), Sri Lanka, Malaysia, UK, Indonesia, and Germany are the major buyers contributing over 70 per cent export earnings.

Chilli continued to be the most demanded spice in 2019-20 with exports of 4,84,000 tonnes amounting to Rs 6,221.70 crore, registering an increase of 15 per cent in value from the previous year. Cumin was the second-most exported spice, recording an increase of 16 percent in volume and 12 per cent in value. A total volume of 2,10,000 tonnes of cumin valued at Rs.3225 crore was exported from India in 2019-20.

The export for large cardamom escalated by 28 percent in volume and 11 per cent in value and 1,100 tonnes of the spice was exported crossing Rs 67.58 crores in value terms in 2019-20. Spice mixes have been in great demand in the foreign markets owing to their ready-to-use features.

The exports of curry powders and curry pastes

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ascended this year too with a value of Rs 834.10 crores and volume of 38,200 tonnes registering an increase of 12 percent and 13 per cent, respectively. India is the world leader in the supply of the higher-end value-added products of spices like spice extracts and mint and mint products.

MATERIAL AND METHODS

India has performed in respect of both the production and export of Spices and Chilli need to be assessed. For the purpose time series data on Area, Production of Spices and Export of Spices were gathered from the Web Site of Spices Board and the same were subjected to growth rate analysis. Compound growth rate (CGR) was used for the purpose utilizing the following formula. The form is,

$$Y = a\, b^{t} e$$

Where,

- Y = Dependent variable for which growth rate is estimated
- a = Intercept
- b = Regression co-efficient
- t = Time variable
- e = Error term

Then, compound growth rate (r) in per cent was computed by using the relationship

$$r = [(\text{Antilog of } b) - 1] \times 100.$$

RESULTS AND DISCUSSION

Area and Production of Major Spices:

The various developmental initiatives including establishment of Spices Parks in select state locations, the area and production of different spices found to be increased. These details are analyzed and the results are presented in Table 1.

The data revealed that the area and production of major spices in India when comparing the area during the year 2016-17 and 2019-20, the area under total spices found to be decreased to the tune of 2.82 per cent. The production figures in respect of total spices in India found 13.73 per cent increase during the year 2015-16 over the year 2016-17. Whereas, the area under Chilli (19.37 %) and Pepper (13.89 %) during the year 2019-20 is found to show a decreasing trend over the year 2016-17.

The decrease in area were taken away by the Coriander (30.56 %), and Fenugreek (41.90 %). The area were found to be increased in Cumin(31.63%) and Ginger (10.81%) and Garlic (10.28 %), respectively during the year 2019-20 over the year 2016-17. The results of Production of Ginger (72.52%) and Garlic (67.51%) were increased tremendously. Whereas, Fenugreek (36.36 %), Coriander (35.79 %), Chilli (19.37%), Pepper (13.89 %) and Turmeric (11.84 %) decreasing trend during the year 2019-20 over the year 2016-17. The production of Spices reduced during the year 2019-20. It might be mainly due to non-adoption of appropriate technology by the farmers.

Production performance of Red Chilli

The production performance of Red Chilli was assessed over a period of time by drawing time series data from 1988- 89 to 2016-17 by using Compound Growth Rate in respect of area, production and productivity of Chilli. These details are presented in Table 2.

The data revealed that the area under Red Chilli was found to decrease to the tune of 0.48 per cent per annum. During the year 2005- 06, India has witnessed a drastic reduction in area under Chillies to the tune of 2.35 lakhs ha. Later on, the area under Chilli found to be increased. The result are in comformity with Thamaraikannan, *et al* (2011). The increase in area between 2005-06 and 2016-17 might be due to the intervention of National Horticulture Mission, focusing Area Expansion component for spice and vegetable crops. In respect of production of Chilli, it is found to be growing constantly and reached a peak after 2009-10. The Production was found to grow at the rate of 3.13 per cent per annum.

The data on export of various spices from India revealed tha among the variety of spices, the largest quantity exported from India was chilli which was arrived at 6.84 lakh tonnes during the year 2019-20 (Table 3). When comparing the export figures of 2019-20 and 2016-17, the Chilli export was increased to the tune of 17.30 per cent in one year amidst the decrease in area under Chilli. It might be due to enhancement in the productivity of Chilli during these periods in certain pockets of India especially the

Table 1: Area and production of major Spices in India Area 000 ha, Production: 000 Tonnes

S.N	Name of the spices	2016-17		2017-18		2018-19		2019-20		Percentage change during 2019-20	
		Area (ha)	Production	Area (ha)	Production	Area (ha)	Production	Area (ha)	Production	Area (ha)	Production
1	Pepper	132	72	134	66	135	62	139	62	5.30	-13.89
2	Chilli	840	2096	752	2149	706	2386	721	1690	-14.17	-19.37
3	Ginger	168	1070	160	1118	175	1451	174	1846	3.57	72.52
4	Turmeric	222	1056	238	1133	246	1389	246	931	10.81	-11.84
5	Garlic	321	1693	317	1611	272	1505	354	2836	10.28	67.51
6	Coriander	674	883	532	710	641	756	468	567	-30.56	-35.79
7	Cumin	781	493	966	689	835	423	1028	608	31.63	23.33
8	Fennel	91	153	66	104	240	83	90	157	-1.10	2.61
9	Fenugreek	210	297	149	202	177	248	122	189	-41.90	-36.36
	Total	3439	7813	3314	7782	3427	8303	3342	8886	-2.82	13.73

(Source: Annonymous, 2016, Annonymous] 2019).

southern India. Similar to Chilli, enhanced export quantity is visible in certain spices, *viz.* Large Cardamom, Ginger,, Turmeric, Coriander Cumin, Powders and Spice Oils like Oleoresin. Similar results were reported Muthupandi *et al* (2018).

Table 2 : Compound growth rate of Red Chilli

S.N.	Year	Area in ha	Production in tonnes	Productivity (kg ha^{-1})
1	1988-89	805000	680400	845.21
2	1995-96	883700	809700	916.26
3	1999-2000	977530	1056000	1080.27
4	2005-2006	742200	1023128	1378.5
5	2010-11	792000	1223000	1544.19
6	2016-17	840000	2096010	2495.25
7	2018-19	721000	1690000	2343.96
CAGR in Per Cent (-)		0.483	3.13	3.61

(Source : Spices Board Annual Report 2018)

The decrease in export quantity during the year 2016-17 is visible in respect of Pepper, Short Cardamom, Coriander, Garlic, Fennel, Fenugreek and Nutmuge Mace. Among these, export of pepper was found to face a 107 per cent decrease during the year 2019-20 over the year 2015- 16.

Country wise export of Red Chilli

The export of Red Chilli from India has grown to certain extent in some of the countries in a decade of time which was arrived at and the results are presented in Table 4.

Table 4 revealed the details of export of Red Chilli to different nations during the year 2006-07 and 2016-17. Presentation of data on Red Chilli export in a decade of time is to highlight the decadal change in the export among different nations. Few of the countries are so friendly to India in receiving the increased consignments of Red Chilli regularly. Whereas, very few nations have started reducing their demand note with regard to import of Red Chilli from India. It might be due to the area expansion took place under Red Chilli in their own country and productivity would have been enhanced to meet their demand or the respective country would have imported the Red Chilli from some other nations because of Price and quality advantage of Red Chilli.

India is exporting Red Chilli to more than 20 countries across the world. Among these, Vietnam, Thailand, Sri Lanka, Bangladesh and Indonesia are the five top most nations importing the Indian Red Chilli considerably. Their import quantity during the year 2016-17 was found to be 70012, 60008, 51393, 39685 and 33394 tonnes, respectively. When one could compare the export data of 2016-17 with that of 2006-07, Vietnam is the only country has demanded the highest quantity of Red Chilli during the year 2016-17. Earlier the export data is not figured in respect of Vietnam revealed that the country is the new entry to the import of Red Chilli from India.

Thailand is the country which has imported very less quantity during the beginning of the decade (2006-07) and when we compare the data during the year 2016-17, the increase in the import is found to be 9472 per cent over the year 2006-07. Whereas, the Sri Lanka has imported the Indian Chilli to the tune of around 51393 tonnes which is accounted for 135 per cent increase over the year 2006-07. The countries which are showing much interest in importing the Indian Red Chilli to their destination are Thailand, Mexico, Indonesia, United Arab Emirate, Saudi Arabia and United Kingdom. The percentage increase in the export of Red Chilli during the year 2016-17 is found to be greater than 200 per cent over the year 2006-07. Though Nepal is a small country, its import statistics in respect of Red Chilli is also appreciable. The percentage increase in the import of Red Chilli to their destination is arrived at 170 per cent during the year 2016-17 over the year 2006-07. The overall increase in the Red Chilli export to different nations is accounted for 169 per cent.

Conclusion & Policy Implication

The production of spices in India was found to increase to the tune of 13.73 per cent during the year 2019-20 and the export of spices was found to increase to the tune of 19.97 per cent during the year 2019-20 showing that the production and export was in similar magnitude. Whereas, the export of Chilli alone to different destinations was found to increase to the tune of 169 per cent indicating that the demand is ever increasing to the Chilli and its

Table 3: Export of Spices from India (Quantity : Tonnes, Value : In Lakh)

S.N.	Name of the spices	Quantity Exported									
		2016-17		2017-18		2018-19		2019-20 (Est)		Percentage Change during 2019-20	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1	Pepper	17600	114312.6	16840	82078.48	13540	56868	16250	55187	-8.31	-107.14
2	Cardamom(L)	780	8265.45	760	5646.6	860	6106	1100	6758.5	29.09	-22.30
3	Cardamom(S)	3850	42150.33	5680	60908.15	2850	35625	2090	42629.5	-84.21	1.12
4	Chilli	400250	507075.63	443900	425632.74	468500	541117.5	484000	622170	17.30	18.50
5	Ginger	24950	25704.85	22605	21607.49	18150	19602	50410	44905	50.51	42.76
6	Turmeric	116500	124190.65	107300	103567.63	133600	141616	136000	121640	14.34	-2.10
7	Garlic	32200	30711.5	46980	30936.38	29500	17110	23350	17232.5	-37.90	-78.22
8	Coriander	30300	29208.5	35185	27274.96	48900	35208	50250	41110	39.70	28.95
9	Cumin	119000	196320.14	143670	241798.78	180300	288480	210000	322500	43.33	39.13
10	Fennel	35150	30875.93	34550	25906.35	26250	24412.5	23800	22288	-47.69	-38.53
11	Fenugreek	34680	18276.49	29280	12688.57	27150	13846.5	27660	16183.6	-25.38	-12.93
12	Other(Seed)	18100	15455.86	22175	16045.55	29740	18736.2	32700	19257	44.65	19.74
13	Nutmeg and Mace	5070	23641.65	5500	22094.31	3300	15015	2955	13630.75	-71.57	-73.44
14	Other spices	40210	50595	38305	65253.17	43300	61486	41050	66303	2.05	23.69
15	Curry powders/paste	28500	49910.43	30150	61619.55	333850	74470	38200	83410	25.39	40.16
16	Mint products	22300	252749.67	21500	322834.86	21610	374933.5	22725	383835	1.87	34.15
17	Spices Oils and Loeoresins	12100	245532.8	17200	266172.39	12750	219300	13950	264525	13.26	7.18
Total Export of Spices		**941540**	**1764977.48**	**1021580**	**1792065.96**	**1394150**	**1943932.2**	**1176490**	**2143564.85**	19.97	17.66

Table 4: Details of Export of Red Chilli from India to different nations.

S.N.	Name of the country	Quantity exported in tonnes during 2006-07	Quantity exported in tonnes during 2016-17	Percentage Change
1	Malaysia	43625.4	28791.87	-34.00
2	Sri Lanka	21822.4	51392.56	135.50
3	USA	13058.2	20792.36	59.23
4	UAE	12622.6	38318.37	203.57
5	Indonesia	6488.5	33393.85	414.66
6	United Kingdom	2279.4	6829.83	199.63
7	South Africa	1738.4	2022.64	16.35
8	Saudi Arabia	806.1	2426.7	201.04
9	Singapore	1285.6	3277.36	154.93
10	Nepal	3264.1	8812.2	169.97
11	Bangladesh	28424.6	39685.52	39.62
12	Mexico	1894.7	13105.64	591.70
13	Russia	870.7	0	-100.00
14	Australia	697.8	1587.35	127.48
15	Vietnam	0	70012.51	0.00
16	Thailand	626.9	60008.77	9472.30
17	Others	9512.8	19792.47	108.06
	Total	**149018.2**	**400250**	168.59

(Source: India Stat, 2016-17)

produce abroad and hence the Indian exporters and the traders involved in export has to contact the farmer clusters in producing the exportable product of Chilli further by making contractual arrangements with the producers following the traceability considerations.

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Assessment of the Fertility Status of Different Land Use Systems in Nagpur District

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ABSTRACT

The present study was undertaken to assess the fertility status of different land use systems for appropriate management in Nagpur district, Maharashtra during 2019-20. Four pedons were selected in different locations based on different variation. All the four pedons were described by their morphological features in the field and depth-wise samples were collected from 20 cm depth interval and analysed for physio-chemical properties. The bulk density of soil varied from 1.33 to 1.59 g cm^3.The soil was neutral to moderately alkaline in reaction and non-saline. The organic carbon content of the soil was low in content. The calcium carbonate in soil increased with depth and was moderately calcareous in nature. The available nitrogen was low to medium, phosphorus was medium to high, potassium was medium to high content and sulphur was low to medium. The exchangeable calcium and magnesium in soil ranged from 21.83 to 40 39 and 7.13 to 14.19 cmol (p+) kg^{-1}. Exchangeable sodium and potassium content varied from 0.14 to 0.62 and 0.35 to 0.95 cmol (p+) kg^{-1}, respectively. The DTPA extractable micronutrients in soil varied from low to medium for Fe, medium to moderately high for Cu, medium to moderately high for Mn and low to medium for Zn, respectively. The available boron content of soils varied from 0.37 to 0.81 mg kg^{-1}. The available molybdenum content was low to medium. The fractional distribution of Zn was found in descending order residual > oxide bound > carbonate bound > organic bound > exchangeable and water soluble Zn fraction. Extractable Zn concentrations of these soils were generally low because the stable fraction was the dominant form in soils.

Soil, a major component of the earth's ecosystem is the mixture of minerals, organic matter, gases, liquids and countless organisms that support plant life. Soil. cover is an important component in understanding the interactions of the human activities with the environment and thus it is necessary to simulate their changes. Soil is a valuable non-renewable resource, which provides essential support to ecosystems. Sustainable management of land resources is essential for food security, maintenance of environment and general well-being of the people. It is essential to enhance the soil productivity to meet the future demand. The characterization and mapping of different types of soils and their interpretation attains greater importance. Soil survey provides an accurate and scientific inventory of soils, their kind and nature, and extent of distribution so that one can make prediction about their characteristics and potentialities.

Soil resource information plays a critical role in the management of natural resources. To maintain, the present level of soil productivity and to meet the demand of the future, management of soil resources on scientific principles is very important. Therefore, increased emphasis is being laid on characterization of soils, accurate mapping of soils and developing rational and scientific criteria for land evaluation and interpretation of soils for multifarious land uses.

Micronutrients are important for maintaining soil health and soil fertility is the status of a soil with respect to its ability to supply elements essential for plant growth without a toxic concentration of any element. Macronutrients (N. P. K. Ca, Mg and S) and micronutrients (Zn, Fe, Cu and Mn) are important soil elements that control its fertility and also increasing productivity of crops (Yadav and Meena, 2009). Availability of micronutrients is influenced by their distribution in soil and other physico-chemical properties. However, knowledge about the status of micronutrients and their interrelationship with soil characteristics is helpful in understanding the inherent capacity of soil to supply these nutrients to plants.

MATERIAL AND METHODS

The present study was undertaken during the

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year 2019-20 to assess the fertility status for appropriate management. Four sites were selected based on different land use systems in Nagpur district. These four representative pedons were selected in four different locations of the study area covering all types of soils. The soil profile maximum upto 1.5 meters long, 1 meter wide and 1.5 meter deep were dug at all the sites. All the four pedons were described for their morphological features in the field and depth-wise samples collected from 20 cm depth interval and special observations regarding the depth of cracking were also recorded. The profile samples from the various depth of the exposed profile were collected for physical and chemical analysis. The soil samples were allowed to air dry in shade and then weighed soil aggregates were passed through 5, 2 and 0.5 mm sieve and used for laboratory analysis. The bulk density was determined by clod coating method (Black and Hartage, 1986). The soil pH and electrical conductivity was determined by digital pH meter using glass electrodes and conductivity meter (1:2.5) Soil: Water ratio as described by Jackson (1973). Organic carbon was determined by the Walkley and Black method as described by Nelson and Sommers (1982). The $CaCO_3$, content was estimated by rapid titration method described by Piper (1966). Water soluble and Exchangeable Zn fraction was determined by using 0.5 M Calcium nitrate method described by Miller and Marten (1986). Carbonate bound zinc fraction was determined by: using IM NaOAC method described by Elliot *et al.*, (1990). Iron- manganese oxide bound zinc fraction was determined by using 0.175 M Ammonium Oxalate and 0.1 M Oxalic acid, organically bound zinc fraction was determined by using 0.1M Sodium Pyrophosphate (1990), residual bound zinc fraction was determined by using Aqua Regia, methods described by Elliot *el al.* (1990).

RESULTS AND DISCUSSION

Physical properties of soil

Bulk density varied from 1.33 to 1.59 g cm^{-3} in (Table 1). The highest value of bulk density (1.59 g cm^{-3}) was observed in the 100-120 cm depth of pedon 3. Whereas, lowest value of bulk density (1.33 g cm^{-3} was observed in 0-20 cm of pedon 2. Similar results were also reported by Bharambe *et al.,* (1999), The higher bulk density values of soils were due to their coarse texture and in some cases due to the presence of calcium carbonate and low organic carbon content.

Table 1. Physico- Chemical characteristics of soil

Pedon	Depth (cm)	pH (1:2.5)	EC (dSm^{-1})	OC (%)	$CaCO_3$ (%)
P-1	0-20	7.45	0.25	6.5	5.75
	20-40	7.52	0.28	6.3	6.00
	40-60	7.65	0.30	6.0	6.75
	60-80	7.81	0.31	5.7	7.25
	80-100	7.97	0.32	5.3	7.75
	100-120	8.11	0.34	4.9	8.24
P-2	0-20	7.02	0.16	7.5	4.25
	20-40	7.11	0.14	6.7	4.75
	40-80	Weathered parent material			
P3	0-20	7.61	0.34	7.6	5.9
	20-40	7.72	0.32	7.1	6.41
	40-60	7.95	0.29	6.6	6.62
	60-80	8.04	0.34	6.1	7.75
	80-100	8.17	0.36	5.5	8.15
	100-120	8.23	0.34	5.2	8.81
P4	0-20	7.18	0.27	8.1	4.75
	20-40	7.33	0.36	7.5	5.25
	40-60	7.69	0.37	7.2	5.5
	60-80	7.81	0.34	6.7	6.25
	80-100	8.05	0.38	5.9	6.75

Chemical characteristics of soil

The pH of studied soil (1:2.5 soil water suspensions) ranged from 7.02 to 8.23, which indicated that soil was neutral to moderately alkaline in reaction (Table 1). The maximum pH was observed in 100-120 cm depth of pedon 3 (8.23) and minimum pH was observed in 0-20 cm depth of pedon 2 (7.02). The pH values were low in surface soils than in sub-surface soils in most of the pedons. This might be due to release of organic acids during decomposition of organic matter and these acids might have brought down the pH in the surface soils. Vadivelu and Bandyopadhyay (1997) observed similar results in soils of Minicoy Island in Lakshadweep. All Pedons showed an increasing trend with depth. The EC of the studied soils ranged from 0.14 to 0.38 dS m^{-1}which was well within the acceptable limit of EC range for normal soils (Richards, 1954). The range showed that these soils are non-saline in nature.

The organic carbon content (Table 1) in different pedons ranged from 4.9 to 8.1g kg^{-1} indicating low in organic carbon status. The highest value of 8.1 g kg^{-1} was

registered in pedon 4 and the lowest value was recorded in pedon 1. Pedons 1, 2, 3 and 4 exhibited a decreasing trend with depth. The organic carbon content decreased gradually with an increase with the depth, which is mainly due to the accumulation of plant residues on the soil surface and less movement down the profile due to rapid rate of mineralization at higher temperature and adequate soil moisture level. Similar results were observed by Sarkar *et al.,* (2001), Nayak *et al.,* (2001) and Rao *et al.,* (2008). The calcium carbonate content of the surface and subsurface depth of soil ranged from 4.28 to 8.81% indicating that these soils are moderately calcareous in nature. The highest $CaCO_3$, content was noticed in the pedon 3 and lowest in pedon 2. This might be due to high clay content which led to impeded leaching, consequently accumulation of $CaCO_3$, in the lower horizon. Similar results were reported by Prakash and Rao (2002) in soils of Krishna district, Andhra Pradesh.

The available nitrogen varied from 193.75 to 374.56 kg ha^{-1}(Table 2) and these soils were low to medium in available nitrogen. All the pedons exhibited a decreasing trend with depth. Available nitrogen found maximum in the surface horizons and decreased invariably with depth of the pedons, which might be due to decreasing trend of organic carbon with depth. Phosphorus is second most important major nutrient required by plants after nitrogen for proper growth and development. The phosphorus content varied from 15.51 to 37.71 kg ha^{-1} in all the pedons. The maximum content of available phosphorus was observed in soils of pedons I followed by soils of pedons 2, 3, and 4. The pedons 1, 2, 3 and 4 showed a decreasing trend with depth. These soils were medium to high in available phosphorus

The available potassium content varied from 250.67 to 368.10 kg ha^{-1}soil. Pedons 1, 2, 3, and 4 exhibited a decreasing trend with depth. This could be attributed to more intense weathering, release of labile K from organic residues, application of K fertilizers and ugward translocation of potassium from lower depths along with capillary rise of ground water. Similar results were reported by Basavaraju *et al.,* (2005) in soils of Chandragiri mandal of Chittoor district in Andhra Pradesh. The available sulphur content in the different pedons ranged from 7.83 to 18.96 mg kg^{-1}soil (Table 2). More or less all pedons showed a decreasing trend with increasing depth.

The DTPA extractable zinc varied from 0.39 to 0.80 mg kg soil which is deficient in soil. The DTPA extractable-Zn Pedons 1, 2 and 4 exhibited a regular decreasing trend with depth. The low DTPA extractable zinc was possibly due to high soil pH values which might be resulted in the formation of insoluble compounds of zinc or insoluble calcium zincate (Sarkar *et al.* 2000). Zinc deficiency was wide spread in the high pH, low organic matter and calcareous soils. The DTPA extractable iron varied from 6.00 to 14.18 mg kg^{-1} soil (Table 3). which was low to medium in category and its higher values were observed in pedon P3 and lowest value in pedon 1. According to the critical limit (4.5 mg kg^{-1}soil) of Lindsay and Norvell (1978) the soils were sufficient in available iron.

Table 2. Fertility Status of Soil

Pedon	Depth	Available nutrients(kg ha^{-1})			S (mg
	(cm)	N	P	K	kg^{-1})
P1	0-20	309.12	37.71	368.10	17.54
	20-40	297.22	33.34	359.45	14.42
	40-60	278.47	28.74	347.23	13.52
	60-80	265.81	25.62	316.00	10.07
	80-100	241..28	21.87	281.91	9.68
	100-120	225.67	19.45	274.41	8.54
P2	0-20	374.56	19.83	288.14	14.88
	20-40	316.89	17.28	264.26	12.76
	40-80	Weathered parent material			
P3	0-20	287.42	25.09	352.62	18.96
	20-40	271.36	22.18	345.87	16.57
	40-60	265.74	19.51	289.32	15.77
	60-80	241.93	20.09	263.31	15.29
	80-100	216.11	17.45	245.56	12.49
	100-120	193.75	15.84	241.84	10.55
P4	0-20	293.42	23.87	345.79	15.20
	20-40	278.14	20.45	291.66	12.36
	40-60	265.58	18.69	280.52	10.25
	60-80	242.26	19.25	268.42	9.87
	80-100	228.89	15.51	250.67	7.83

The DTPA extractable manganese varied from 5.32 to 14.88 mg kg^{-1} soil. which was found medium to moderately high in category and its higher values were observed in pedon 3 and lowest value in pedon 1. All pedons exhibited a decreasing trend with depth. The DTPA extractable copper varied from 0.83 to 2.71 mg kg^{-1}soil. All the pedons were found sufficient in available copper content.

The available boron content of the profile soils varied from 0.37 to 0.81 mg kg^{-1} (Table 3). These soils were low to medium in available boron. The available molybdenum content of the profile soils varied from 0.04 to 0.29 mg kg^{-1} and found highest 0.29 mg kg in pedon 4 and lowest 0.04 mg kg in pedon 3. These soils were found low to medium in available molybdenum. The available molybdenum in soil increased with increase in pH.

Table 3. Available Micronutrients in soil

Pedon	Depth	Available micronutrients (mg kg^{-1})					
	(cm)	Fe	Mn	Cu	Zn	B	Mo
P1	0-20	13.25	12.48	1.84	0.65	0.81	0.07
	20-40	10.42	11.78	1.73	0.59	0.78	0.10
	40-60	9.64	9.42	1.53	0.51	0.72	0.14
	60-80	8.04	7.85	1.28	0.48	0.64	0.19
	80-100	7.97	5.64	1.19	0.44	0.59	0.22
	100-120	6.00	5.32	0.84	0.39	0.46	0.25
P2	0-20	12.5	7.41	1.66	0.67	0.41	0.09
	20-40	8.20	6.00	1.54	0.63	0.37	0.14
	40-80	Weathered parent material					
P3	0-20	14.53	14.88	2.71	0.80	0.76	0.04
	20-40	13.85	12.71	1.64	0.76	0.74	0.07
	40-60	12.5	9.16	1.58	0.53	0.63	0.11
	60-80	10.45	7.75	1.32	0.58	0.58	0.15
	80-100	8.78	5.96	0.98	0.55	0.51	0.18
	100-120	7.32	5.37	0.86	0.49	0.45	0.21
P4	0-20	13.6	9.74	1.84	0.74	0.53	0.05
	20-40	10.25	7.25	1.62	0.62	0.57	0.09
	40-60	9.57	8.18	1.16	0.60	0.51	0.12
	60-80	7.35	6.59	0.94	0.43	0.48	0.18
	80-100	7.14	5.76	0.83	0.39	0.43	0.29

Zinc fractionation

The results revealed that water soluble and exchangeable zinc content was found to be least among the zinc fractions; it ranged from 0.33 to 0.81 mg kg^{-1} in the surface and subsurface soil profiles, respectively. The highest value of 0.81 mg kg^{-1} was registered in pedon 4 and the lowest 0.33 mg kg^{-1} value was recorded in pedon 3. The water soluble and exchangeable zinc fraction decreased with depth in all the profile samples (Table 4). This may be attributed to higher pH and $CaCO_3$ which leads to precipitation of water soluble fraction of zinc with $CaCO_3$.

The carbonate bound zinc fraction in these profile samples ranged from 0.48 to 1.27 mg kg^{-1} (Table 4). The highest value of 1.27 mg kg^{-1} was registered in pedon 3 and the lowest value was recorded in pedon 4. The organically bound zinc fraction in these profile samples ranged from 0.46 to 1.24 mg kg^{-1}. The highest value of 1.24 mg kg^{-1} was registered in pedon 4 and the lowest value 0.46 mg kg^{-1} was recorded in pedon 3. The organically bound zinc fraction decreased with depth. The iron and manganese oxides bound zinc ranged from 1.62 to 5.46 mg kg^{-1}. The iron and manganese oxides bound zinc fractions decreased with increasing in depth. Similar observations were noticed in all profile samples (Table 4), indicating that these fractions with depth is related to clay contents of soil (Prasad and Sakal, 1988).

The results revealed that, the residual bound zinc was found to be the major fraction among the zinc fractions: it ranged from 27.67 to 52.14 mg kg^{-1} in the soil profiles. The highest value of 52.14 mg kg^{-1} was registered in pedon 4 and the lowest value 27.67 mg kg^{-1} was recorded in pedon 1.

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Table 4. Zinc Fractionation of soil (mg kg^{-1})

Pedon	Depth (cm)	Water soluble & Exchangeable	Carbonate Bound	Fe-Mn bound	Organically bound	Residual bound
P1	0-20	0.79	0.62	4.86	0.71	47.12
	20-40	0.75	0.73	4.71	0.68	41.76
	40-60	0.64	0.98	3.89	0.65	43.52
	60-80	0.58	1.15	3.46	0.57	38.42
	80-100	0.49	1.18	2.68	0.51	31.25
	100-120	0.36	1.24	1.62	0.46	27.67
P2	0-20	0.59	0.68	3.21	0.89	51.16
	20-40	0.45	0.76	2.58	0.72	46.57
	40-80			Weathered parent material		
P3	0-20	0.65	0.46	5.46	0.87	48.11
	20-40	0.60	0.71	4.71	0.81	45.14
	40-60	0.54	0.93	3.95	0.74	40.22
	60-80	0.48	1.15	3.54	0.70	35.98
	80-100	0.37	1.22	3.12	0.72	31.25
	100-120	0.33	1.27	2.48	0.63	29.95
P4	0-20	0.81	0.48	4.33	1.24	52.14
	20-40	0.79	0.63	3.68	0.97	49.36
	40-60	0.72	0.87	3.28	0.86	43.15
	60-80	0.64	1.11	3.32	0.71	37.5
	80-100	0.56	1.18	1.81	0.65	32.78

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Morphological and Yield Parameters of Pigeonpea as Influenced by Plant Growth Regulators and Jeevamrut

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ABSTRACT

A field experiment was conducted during kharif season 2018-19 and 2019-20 at Experimental field of Department of Agricultural Botany., Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M.S.). The experiment was laid out in randomized block design with four replications. The eight treatments consists of two growth regulators i.e. GA_3 and NAA at various concentrations i.e. 25, 50 and 75 ppm 25, 50 and 75 ppm including jeevvmrut@ 500 L ha^{-1} and control. Plant growth regulators at different concentrations were applied through foliar spray at flower and pod initiation stages and soil application of jeevamrut was carried out at 30, 60, 90 and 120 DAS. Results indicated that two applications of 75 ppm GA_3 at flower and pod initiation stages recorded significantly more plant height, leaf area $plant^{-1}$, total dry matter $production^{-1}$ and yield and yield attributes followed by NAA-75 ppm and by soil application of jeevamrut @ 500 L ha^{-1}.

Pigeonpea is one of the major pulse crop cultivated in India. India is the largest producer and consumer of pigeonpea in the world. It is a widely adapted, hardy and drought tolerant crop with a large temporal variation (90-300 days) for maturity. In India, pigeonpea is grown on 45.22 lakh ha. with production of 38.51 lakh tons with a productivity of 859 kg ha^{-1} (Anonymous, 2020). Pre-mature abscission of flowers is one of the most serious problems in pigeonpea and other legumes. Pigeonpea produces large number of flowers, of which as much as 90 per cent are shed (Wasike *et al*., 2005). Therefore, the low yield of pigeonpea is due to poor pod set resulting from high flower and pod drops. Pigeonpea is an important legume food and drought tolerant crop and having potential to sustain productivity in drought prone areas. Being a legume, the residual nitrogen available to subsequent crop is estimated to around 40 kg ha^{-1} (Gore *et al.,* 2019)

The low yield in pigeonpea is also due to excessive vegetative growth, indeterminate growth habit, poor source-sink relationship, poor pod set resulting from high flower and pod drops. Therefore, it is very necessary to compensate the high degree of flower abscission in pigeonpea and increase the pod yield. Plant growth regulators (PGR's) are considered as new generation of agro chemicals after fertilizers, pesticides and herbicides to augment seed yield and quality. They are also known to enhance the source sink-relationship and stimulate the translocation of photo assimilates thereby resulting in better retention of flowers and fruits. The organic fertilizers composed of compost, leaf extract, rock phosphate and ash and during the process of decomposition of organic substrates leads to the production of several organic acids, such as malonic, fumeric, succinic acids.(Korde *et al.,* 2019) Indigenous liquid organic manures such as beejamrutha, jeevamrutha, panchagavya, amruthpani, liquid biodigester, biogas slurry etc., play major role in improving growth and yield of crops. These solutions are rich source of useful and effective microorganisms and also contain both macro nutrients and essential micro nutrients, many vitamins, essential amino acids, growth promoting substances like indole acetic acid (IAA), gibberellic acid (Palekar, 2006; Sreenivasa *et al*., 2010). Taking above view into consideration the present investigation was carried out with the objective to study the responses of plant growth regulators and jeevamrut on morphological and yield attributes in pigeonpea.

MATERIAL AND METHODS

The present investigation was conducted under field condition during *kharif* season 2018-19 and 2019-20 at Experimental field, Department of Agricultural Botany.,

1. Ph. D. Scholar, 2. Former Professor, 3. Assoc. Professor and 4. Professor, Department of Agricultural Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola.

Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (M. S.). The experiment was laid out in randomized block design with four replications using pigeonpea variety PKV Tara. The eight treatments consists of two growth regulators i.e. GA_3 and NAA at various concentrations i.e. 25, 50 and 75 ppm including jeevamrut and control. Spraying of growth regulators was done at flower initiation stage (stage 1) and pod initiation stage (stage 2) and soil application of jeevamrut was done at 30, 60, 90 and 120 DAS. The plot size was 4.6 m x 4.0 m. Seeds of pigeonpea were sown at spacing of 60 cm between rows and 20 cm between plants. After the emergence of seedling, only one healthy seedling was maintained per hill to obtain uniform planting density. N, P and K fertilizers in the form of urea, single super phosphate and murate of potash were applied @ 25 kg N + 50 kg P_2O_5 + 20 kg K_2O ha^{-1} to the gross plots. Half dose of N and a complete dose of P_2O_5 and K_2O were given as a basal dose at sowing while the remaining N was applied at 18 days after sowing. Plant protection measures were adopted as and when needed. Spray of quinalphos 25 EC @ 1000 ml ha^{-1} was done to reduce the infestation of pod borer for growth regulators treatments and for jeevamrut treatments spraying of decoction prepared form plant samples and cow urine was done to reduce the infestation of insects. Observations were recorded at different stages i.e., 60, 90, 120 DAS and at maturity. Harvesting in all treatments was undertaken after maturity of crop.

RESULTS AND DISCUSSION

Morphological parameters

In the present investigation plant height $plant^{-1}$, recorded substantial increase at 120 DAS and at maturity i.e. after the two foliar applications of 75 ppm GA_3 (208.66 cm) at flower and pod initiation stages (Table 1) followed by foliar application of NAA 75ppm (204.96 cm) at flower and pod initiation stages and soil application of jeevamrut @ 500 L ha^{-1} at 30, 60, 120 DAS (204.87 cm) as shown in Table 1.

The application of growth regulator also enhances the absorption and transport of nutrients. Hence, it facilitates fast availability of nutrients and growth of the plant. Increase in plant height may be due to the fact that GA_3 increased the growth of plant by increasing internodal length and due to cell division, cell enlargement and enhanced apical dominance indirectly by increasing auxin content and thus indirectly helped to increase the seed yield. Similar results were obtained by Giri *et al.* (2018) and Chinnmalwar *et al* .(2017) in pigeonpea.

Table 1: Effect of Plant Growth Regulators and Jeevamrut on Plant heightat maturity.

Treatments	Plant height (cm)		
	Kh-2018-19	Kh-2019-20	Pooled
T_1 - Control	173.95	192.35	183.15
T_2 - GA_3-25PPM	182.14	223.56	202.85
T_3 - GA_3 50PPM	184.46	225.18	204.82
T_4 - GA_3- 75PPM	188.60	228.71	208.66
T_5 - NAA-25PPM	183.62	222.05	202.83
T_6 - NAA-50PPM	184.37	223.78	204.07
T_7 - NAA-75PPM	185.27	224.65	204.96
T_8 - Jeevamrut @ 500 L ha^{-1}	179.51	230.23	204.87
Mean	182.74	221.31	202.03
SE (m) ±	0.969	0.999	0.725
CD at 5%	2.851	2.937	2.133

Data regarding leaf area was recorded at 30 days interval from 60, 90, 120 DAS and at maturity. It was observed that leaf area $plant^{-1}$ progressively increased up to 120 DAS, later on it decline towards the maturity (Table 2). At 60 DAS, the data regarding leaf area $plant^{-1}$ was found non significant. At 90 DAS significantly higher leaf area (36.533 dm^2) was noted by treatment (T_4) foliar application of GA_3-75ppm at flower initiation and pod initiation stages. However, at 120 DAS significantly superior leaf area $plant^{-1}$ (54.644 dm^2) was exhibited by the treatment (T_7) foliar application of NAA-75 ppm (54.644dm^2) at flower initiation and pod initiation stages followed by spraying of GA_3-75 ppm (T_4) treatment (49.851 dm^2) and T_8 treatment (44.795 dm^2) i.e., soil application of jeevamrut @ 500 L ha^{-1}. Similar results were obtained by Sutar *et al.* (2020) in pigeonpea and Korade *et al.* (2019) in wheat.

Total dry matter production rate $plant^{-1}$ progressively increased from 90 DAS up to maturity. At maturity the range of total dry matter was varied from 253.92 to 404.63 g. A marked increase in total dry

Table 2: Effect of Plant Growth Regulators and Jeevamrut on Leaf area of pigeonpea.

Treatments	Leaf area (d m^2)											
	Kh-2018-19				Kh-2019-2020				Pooled Means			
	60DAS	90DAS	120DAS	At maturity	60DAS	90DAS	120DAS	At maturity	60DAS	90DAS	120DAS	At maturity
T_1 - Control	14.547	27.155	36.339	24.094	14.793	28.638	38.566	26.036	14.670	27.896	37.453	25.065
T_2 - GA_3-25 PPM	14.348	29.241	40.154	27.921	14.448	30.102	41.253	29.171	14.398	29.671	40.703	28.546
T_3 - GA_3-50 PPM	14.852	29.497	41.960	31.004	15.835	42.897	42.160	34.501	15.344	36.197	42.060	32.752
T_4 - GA_3-75 PPM	14.621	30.906	49.897	38.306	14.944	42.160	49.805	45.542	14.783	36.533	49.851	41.924
T_5 - NAA-25 PPM	14.956	30.336	42.922	30.984	15.201	30.197	44.958	33.434	15.078	30.266	43.940	32.209
T_6 - NAA-50 PPM	15.710	29.197	45.583	34.507	15.098	29.397	42.897	35.452	15.404	29.297	44.240	34.979
T_7 - NAA-75PPM	14.668	30.086	54.019	36.742	15.741	30.611	55.269	41.714	15.204	30.348	54.644	39.228
T_8 - Jeevamrut @ 500 L ha^{-1}	14.686	29.561	41.931	31.031	15.017	30.548	47.659	41.593	14.852	30.054	44.795	36.312
Mean	14.799	29.497	44.101	31.824	15.135	33.069	45.321	35.930	14.967	31.283	44.711	33.877
SE(m)±	0.278	0.322	0.232	0.093	0.381	0.439	0.793	1.361	0.298	0.303	0.414	0.686
CD at 5%	NS	0.946	0.682	0.274	NS	1.292	2.333	4.004	NS	0.891	1.217	2.016

Table 3: Effect of Plant Growth Regulators and Jeevamrut on dry matter of pigeonpea.

Treatments	Dry matter plant^{-1}(g)											
	2018-19				2019-20				Pooled			
	60DAS	90DAS	120DAS	At maturity	60DAS	90DAS	120DAS	At maturity	60DAS	90DAS	120DAS	At maturity
T_1 - Control	27.67	139.66	200.88	254.49	28.92	141.16	203.19	254.49	28.07	140.32	202.33	253.92
T_2 - GA_3-25PPM	28.47	140.93	200.28	262.39	29.25	141.93	201.09	268.85	28.87	141.40	200.69	271.77
T_3 - GA_3-50PPM	28.55	140.68	247.17	329.90	29.11	136.68	248.42	314.62	28.75	138.64	247.79	334.47
T_4 - GA_3- 75PPM	28.46	140.93	257.96	403.48	28.61	141.68	260.46	405.84	28.55	141.40	259.21	403.22
T_5 - NAA-25PPM	28.14	140.38	242.51	314.38	29.14	141.13	246.74	314.40	28.64	140.67	244.62	314.63
T_6 - NAA-50PPM	28.18	140.57	247.43	322.58	29.18	142.07	247.94	323.33	28.68	140.67	248.24	326.71
T_7 - NAA-75PPM	28.15	140.61	298.11	402.13	29.16	141.86	309.11	405.07	28.65	140.89	298.10	404.63
T_8 - Jeevamrut @ 500 L ha^{-1}	28.60	139.70	247.34	359.43	29.14	137.20	249.09	359.43	29.07	137.89	248.21	357.02
Mean	28.28	140.43	242.71	331.10	29.06	140.46	245.44	330.75	28.66	140.22	248.04	333.30
SE(m)±	0.215	0.357	10.311	9.098	0.135	0.783	9.637	4.132	0.104	0.342	9.950	4.379
CD at 5%	NS	NS	30.326	26.758	NS	2.303	28.342	12.152	0.307	1.005	29.264	12.880

Table 4: Effect of Plant Growth Regulators and Jeevamrut on number of pods plant^{-1}, number of seeds pod^{-1} and 100 seed wt. of Pigeonpea

Treatments	2018-19					2019-20					Pooled Mean				
	No. of Pods Plant^{-1}	No. of seeds pod^{-1}	100 seed wt. (g)	Seed Yield q ha^{-1}	Harvest Index	No. of Pods Plant^{-1}	No. of seeds pod^{-1}	100 seed wt. (g)	Seed Yield q ha^{-1}	Harvest Index	No. of Pods Plant^{-1}	No. of seeds pod^{-1}	100 seed wt. (g)	Seed Yield q ha^{-1}	Harvest Index
T_1 - Control)	190.43	2.72	9.23	17.70	32.01	192.43	2.73	9.32	18.34	32.17	191.43	2.72	9.27	18.02	32.09
T_2 - GA_3-25PPM	208.23	3.31	9.31	18.48	33.51	230.41	3.41	9.33	19.33	33.45	219.32	3.36	9.32	18.90	33.49
T_3 - GA_3 50PPM	233.52	3.34	9.39	18.83	32.38	238.51	3.61	9.43	19.79	32.17	236.02	3.47	9.41	19.31	32.24
T_4 - GA_3- 75PPM	248.40	3.85	9.85	20.38	33.72	250.58	3.86	9.86	22.25	34.12	249.69	3.89	9.86	21.31	33.93
T_5 - NAA-25PPM	225.40	3.46	9.31	18.85	33.44	228.53	3.59	9.32	19.27	33.48	226.97	3.52	9.31	19.06	33.46
T_6 - NAA-50PPM	231.65	3.59	9.38	18.83	32.32	233.65	3.60	9.39	19.57	32.42	232.60	3.59	9.38	19.20	32.37
T_7 - NAA-75PPM	241.26	3.76	9.42	19.07	32.36	244.20	3.78	9.44	19.99	32.44	242.73	3.77	9.43	19.53	32.41
T_8 - Jeevamruth @ 500 L ha^{-1}	233.52	3.64	9.53	18.62	33.63	247.61	3.72	9.64	20.92	34.86	240.56	3.68	9.58	19.77	34.25
Mean	226.31	3.46	9.43	18.85	32.92	233.24	3.54	9.47	19.93	33.14	229.78	3.50	9.45	19.39	33.03
SE(m)±	1.22	0.07	0.08	0.064	0.16	1.37	0.09	0.08	0.209	0.14	0.88	0.06	0.06	0.101	0.12
CD at 5 %	3.59	0.21	0.22	0.188	0.48	4.04	0.26	0.23	0.615	0.43	2.58	0.18	0.20	0.297	0.34

production was observed after the foliar application of growth regulators at flower initiation and pod initiation stages and soil application of Jeevamrut at 30, 60, 90 and 120 DAS (Table 3). The foliar application of NAA-75 ppm (T_7) i.e. 404.63 g at flower initiation and pod initiation stages exhibited significantly higher total dry matter per plant followed by treatment (T_4) foliar application of GA_3-75 ppm (403.22 g) and by soil application of Jeevamrut- @ 500 L ha^{-1} (357.02 g) as compared to control (253.92 g) and rest of the treatments. Similar results were obtained by Upaydhyay and Rajan (2015) in soybean and Nabi *et al.* (2016) in cowpea.

Yield and yield parameters

Application of GA_3-75 ppm recorded significantly more number of pods $plant^{-1}$ and seeds pod^{-1} (249.69 and 3.89, respectively) followed by treatment (T_7), foliar application of NAA-75 ppm (242.73 and 3.77, respectively) at flower and pod initiation stages and by treatment (T8) soil application of jeevamrut@ 500 L ha^{-1} (240.56 and 3.68, respectively) at 30, 60, 90, and 120 DAS and as compared to control (191.43 and 2.72, respectively) and rest of the treatments. Application of GA_3-75ppm at flower and pod initiation stages recorded significantly highest 100 seed weight $plant^{-1}$ (9.86 g) followed by T_8 treatment soil application of jeevamrut@ 500 L ha^{-1} (9.58 g) and by treatment T_7, foliar application of NAA-75ppm (9.43 g) at flower and pod initiation stages as compared to control (9.27 g) and rest of the treatments.

Application of GA_3-75ppm (21.31 q) at flower and pod initiation stages recorded significantly highest seed yield ha^{-1} (q) followed by T_8 treatment, soil application of Jeevamrut @ 500 L ha^{-1} (19.77q) at 30, 60, 90, and 120 DAS and by treatment (T_7) foliar application of NAA-75ppm (19.53 q) at flower and pod initiation stages as compared to control (18.02 q) and rest of the treatments. However, in case of harvest index the soil application of jeevamrut- @ 500 L ha^{-1} (34.25 %) at 30, 60, 90 and 120 DAS recorded significantly highest harvest index (T_8) followed by treatment (T_4) foliar application of GA_3-75ppm (33.93 %) at flower and pod initiation stages as compared to control and rest of the treatments (able 4). Seed yield is combined effect of yield attributing characters and physiological efficiency of plant partitioning of assimilates in the plant during reproductive development is important for flower, fruit and seeds. Thus, crop yield can be increased either by increasing the total dry matter production or by increasing the proportion of economic yield (harvest index) or both (Gardner *et al.,* 1988).Similar findings were in agreement with Giri *et al.* (2018) and Jadhav *et al.* (2017) in pigeonpea. The positive response of organic formulations was also reported by Gowda *et al.* (2018) in groundnut.

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Population Dynamics of Fall Armyworm *(Spodoptera frugiperda)* and Its Natural Enemies on Maize

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ABSTRACT

Investigation on "Population dynamics of Fall Armyworm *Spodoptera frugiperda* and its natural enemies on maize" was conducted during *Kharif*, 2019-20 on the research field of Department of Agril. Entomology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola with objective to correlate the insect pest and natural enemies population with weather factors. Infestation of fall armyworm initiated from 29th SMW and its peak (45.0 %) during 31st SMW. Natural enemies, spider and ladybird beetle (LBB) reached their peak viz., (0.85) and (1.0) numbers plant^{-1}, respectively during 38th SMW, while carabid larvae population reached its peak (0.25) number plant^{-1} during 32th SMW. Minimum, maximum temperature and sunshine hour exerted significant positive impact on the infestation of fall armyworm. Positive correlation was noticed between fall armyworm and its natural enemy population i.e. carabid larvae. Population of spider and LBB showed significant positive correlation with morning relative humidity and maximum temperature had significant negative impact on LBB population. Abiotic factors did not show any significant influence on population of carabid larvae. Weather factor determines the seasonal activity and population build-up of fall armyworm and its natural enemies on maize crop and correlation studies indicates importance in predicting the insect pest incidence.

Important cereal crop after rice and wheat that provides food, feed and fodder grown throughout the year, predominantly *Kharif* crop with 85 per cent of the area under cultivation in the season, accounts for around 10 per cent of total food grain production in the country. In addition to staple food for human being and quality feed for animals, maize serve as a basic raw material as an ingredient to thousands of industrial products. Major maize growing states are Karnataka, Madhya Pradesh, Maharashtra, Rajasthan, Bihar, Uttar Pradesh, Telangana, Gujarat and Tamil Nadu.

The average productivity in India 109 kg ha^{-1} is much less than the U.S. 863 kg ha^{-1} in spite of increasing in the area under this crop. The productivity is still very low due to several reasons viz, environmental factor, less mechanization, pest and diseases etc. Insect pest are one of the major limitations of low yield of maize. The insect pest of maize inflicts serious losses both directly as borer, sap suckers, stem and root feeders etc. and as vectors to some diseases.The Fall Armyworm, *S. frugiperda* (J.E. Smith) (Lepidoptera: *Noctuidae*) is native to the Americas and it is key pest of maize (*S. frugiperda)* reported for the first time in 2018 in Africa, Nigeria, Sao Tome in Benin and Togo causing significant economic damage to maize crop and it has great potential for further spread. It has spread to 28 countries in Africa. In 2018, it began to spread widely in India (Deole and Paul, 2018). In India, *S. frugiperda* is recently reported in Karnataka Tamilnadu and Telangana infesting maize crop. It is also found in Maharashtra at Solapur district. (Sisodiya *et al*. 2018). Chormule *et al.* (2019) also identified on molecular basis that the insect pest creating the menace on maize was *S. frugiperda* and also reported in the month of September feeding on two months old sugarcane crop variety (Co 86032) at Ghogaon village, Sangli District of Maharashtra.

Fall army worm feeds on all growth stages of maize but most frequently in the whorl of young plant up to 45 days old. Larvae usually consume a large amount of foliage and sometimes destroy the growing point of the plant. Yield reductions in maize due to fall armyworm have been reported as high as 34 per cent. (Deole and Paul, 2018). Keeping this point in view the studies on abundance of *S. frugiperda* on maize and their natural enemies and correlation coefficients between *S. frugiperda* and their natural enemies with the existing weather parameters was conducted to know the abundance and to further formulate management strategies.

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MATERIAL AND METHODS

A field experiment was carried out during *Kharif* 2019-20 at research field of Department of Agril. Entomology, Post Graduate Institute, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola on the plot size 200 sq.mt area. The maize UDAY (Mahabeej 114) variety with spacing 60x20 cm^2 was sown on July 2019 and all the recommended cultivation practices were followed. Incidence of insect pests and natural enemies was assessed at weekly interval on 200 m^2 sown maize crop which was divided in four quadrate and ten plants were randomly selected for observing insect pests and natural enemies per quadrate. Per cent infestation by Fall army worm was assessed. For parasitoids five samples of pest stages from each quadrate were collected and were brought to the laboratory and were observed for parasitization if any and per cent parasitization were calculated and for Predators viz., coccinellids, carabid larvae and spiders were counted on 5 randomly selected plants in each quadrate.The population of insect pests, parasites and predators were correlated with weather parameters namely maximum temperature, minimum temperature, RH (morning and evening) and total rainfall. The periodicity of observations at weekly intervals was planned as per the standard weeks during the entire crop season. Correlation coefficients between pest population densities and abundance of their natural enemies with existing weather parameters during the period of experimentation were statistically analyzed by subjecting the per cent infestation and number of insects per plant and weather data to simple correlation coefficient by Karls Pearson's "r" value method (Gomez and Gomez, 1984). Weekly meteorological data was recorded on maximum and minimum temperature, sunshine hours, relative humidity (at 7 am and 2 pm) and total rainfall.

RESULTS AND DISCUSSION

Incidence of major pests of maize and their natural enemies

The incidence of fall armyworm first appeared in 29thstandard meteorological week (SMW)with (12.5%) infestation and last up to the 38th SMW during 2019. The pest infestation increased gradually and reached its peak during 31th SMW with (45%) infested plants (Table 1). Thereafter, pest infestation reduced gradually from 32nd SMW with (15%) damage plants and reached to its minimum (5%) infested plants on 36th to 38th SMW and there was no infestation observed on 39th SMW. The

Table 1: Per cent infestation of FAW and No. of natural enemies on maizein relation to weather factors

SMW	Month and Week	Predators			% Infestation FAW	Weather factors					
		No. of spiders plant^{-1}	No. of grubs and adults of LBB plant^{-1}	No. of Carabid larvae plant^{-1}		Max. Temp (ºC)	Min. Temp (ºC)	Sunshine hours	Morn. RH (%)	Eve. RH (%)	Total Rainfall (mm)
28	July-II	0	0	0	0	30.2	20	0.7	89	68	53.8
29	III	0	0	0	12.5	33.5	21.5	4.5	78	49	22.4
30	IV	0	0	0	40	34.9	21.8	7.1	79	48	27.3
31	Aug-I	0	0	0.1	45	31.6	20.9	4.7	88	69	106.1
32	II	0.1	0.2	0.25	15	27.6	19.6	0.7	92	82	118.7
33	III	0.15	0.4	0.2	15	29.9	20.1	2.2	90	73	79
34	IV	0.45	0.55	0.1	12.5	30.5	20.1	4.2	88	67	10.9
35	V	0.6	0.7	0	10	29.6	20	3.1	90	76	28.5
36	Sep-I	0.65	0.75	0	5	29.1	19.9	3.3	91	72	54.5
37	II	0.8	0.8	0	5	29.6	20.6	1.9	92	77	9
38	III	0.85	1	0	5	29	19.9	1.7	90	75	18.5
39	IV	0.7	0.65	0	0	30.3	19.4	2.8	94	70	118.1

weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 31.6^{0}C, 20.9^{0}C, 4.7 hrs, 88 per cent, 69 per cent and 106.1 mm, respectively.

The above findings on incidence are in close confirmation with Chormule *et al.,* (2019) who reported incidence of FAW on maize was up to 60 days and there after it gets reduced. Djaman *et al.* (2019) also reported the peak infestation of fall armyworm in the month of August during *Kharif* season of 2016, 2017 and 2018. Sundar *et al.,* (2018) reported that the infestation of *S. litura* started at 28 DAG, (2nd week of August) and peak infestation was during the last week of August, thereafter infestation abruptly decreased after 84 DAG. Murua *et al.* (2009) reported that larval populations of fall armyworm are more stable throughout the vegetative phase and decrease during beginning of the reproductive phase of corn.

Incidence of natural enemies

Spider population was found during 28th SMW to 31th SMW and started increasing in numbers (0.1) plant^{-1} in 32th SMW and followed by 33th SMW (0.15) number of spiders per plant. The abundance of these predators increased with the crop age along with corresponding increase in pest population. Spider peak population was observed at 38th SMW with (0.85) number of spiders per plant. However, on 39th SMW population decreased with (0.7) number of spiders per plant (Table 1). The weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 29^{0}C, 19.9^{0}C, 1.7 hrs, 90 per cent, 75 per cent, 18.5 mm, respectively.

No incidence of LBB (adult and grub) population was observed during 28th to 31th SMW and started increasing in numbers, (0.2) number of LBB per plant in 32th SMW. The abundance of these predator increased with the crop age along with corresponding increase in pest population. LBB reached its peak during 38th SMW with (1.0) number plant^{-1}. However, on 39th SMW the population decreased (0.65) number plant^{-1}. The weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 29^{0}C, 19.9^{0}C, 1.7 hrs, 90 per cent, 75 per cent, 18.5 mm, respectively. No incidence of carabid larvae was observed during 28th SMW to 30th SMW and started increasing (i.e.,0.1) number plant^{-1} in 31th SMW and reached its peak during 32th SMW with (0.25) number plant^{-1} (Table 1). However, from 33th SMW onwards the population started declining with (0.2) number plant^{-1} followed by 34th SMW with (0.1) number plant^{-1} and reached its minimum from 35th SMW to 39th SMW. Weather parameters viz., maximum temperature, minimum temperature, sunshine hours, morning relative humidity, evening relative humidity, total rainfall during the peak period of incidence were 27.6^{0}C, 19.6^{0}C, 0.7 hrs, 92 per cent, 82 per cent, 118.7 mm, respectively.

Present results are in agreement with those of the researchers viz., Kore *et al*. (2013) who reported lady bird beetle was active in the month of September and October. Andreas *et al.* (1999) concluded that beetles and spiders were the dominant predators of insect pests of maize and confirmed that ground beetles and spiders may play an important role in controlling herbivore populations in maize fields. Patra *et al*. (2013) who reported that total twenty-four insect pests and some natural enemies including seven coccinellid beetles and two predatory bugs and thirteen spider species were recorded in maize. Sahito *et al*. (2012) reported the predator, big-eyed bug (1.27) followed by seven spotted ladybird beetles (0.44), zigzag beetle (0.69), eleven spotted beetles (0.07), *Brumus* (0.50), green lacewing (0.78) plant^{-1}, respectively. Kris *et al.* (2006) reported high abundance of spider and ground beetle (Carabidae) was associated with lowered population of fall armyworm throughout the maize vegetative cycle.

Correlation coefficients of fall armyworm *(S. frugiperda)* with biotic and abiotic factors in maize during *Kharif*, 2019.

Correlation coefficient study (Table 2) revealed that the biotic factor *i.e.* carabid larvae (r = 0.251) indicated positive correlation, as fall armyworm population increases the population of predator also increases. In case of correlations between abiotic factors, per cent infestation of fall armyworm, it indicated that infestation was positively significant with maximum temperature (r = 0.581*), minimum

temperature (r = 0.661*) and sunshine hours (r = 0.701*). It indicated that as the maximum temperature, minimum temperature and sunshine hours increases, the pest infestation also increased. However, pest infestation had non-significant positive correlation with total rainfall (r = 0.158) and non-significant negative correlation with morning relative humidity (r = -0.507) as well as evening relative humidity (r = -0.410).

The above findings corroborate with Kumar *et al.,* (2020) who reported that maximum and minimum temperature had positive impact on infestation of fall armyworm while morning relative humidity, evening relative humidity and total rainfall had negatively correlated with the pest incidence. Hemchandra and Singh (2007) reported that higher temperature, lower relative humidity, lower total rainfall, longer duration of sunshine hours and higher wind speed seems to favour the pest population build up.Kris *et al.,* (2006) reported that high abundance of spider and ground beetle (Carabidae) was associated with lowered population of fall armyworm throughout the maize vegetative cycle.

Correlation coefficients between spiders and weather factors on maize during *Kharif*, 2019.

The correlation coefficient indicated that spider population was positively significant with morning relative humidity (r = 0.590*) (Table 3). The morning relative humidity increases, spider population was also increased. However, positively non-significant correlation between evening relative humidity (r = 0.504) and spiders' population. While, maximum temperature (r = -0.507), minimum temperature (r = -0.506), sunshine hours (r = -0.283) and total rainfall (r = -0.282) had non-significant negative influence on spider population.Thus, it indicates that the morning relative humidity influence population fluctuation of spider while, other weather parameters had no or less influence on population of Spider during *kharif* 2019.

The present findings are more or less in corroboration with Kumar *et al.,* (2020) who reported significant positive correlation with maximum and minimum relative humidity and rainfall with spider. In the present findings, except rainfall, rest of the abiotic factors exerted the same association, but were non-significant. It might be due to variation of location and different environment conditions or variety or plant age on which investigation was carried out. Similarly, Patra *et al.,* (2013) who reported thirteen spider species in maize crop.

Correlation coefficients between ladybird beetle and weather factors in maize during *Kharif*, 2019

The lady bird beetle predation was negative and significant correlation (Table 3) with maximum temperature (r = -0.586*). While, morning relative humidity (r = 0.611*) had positively significant correlation with population of ladybird beetle. Minimum temperature (r = -0.557), Sunshine hours (r = -335) and total rainfall (r = -0.281) had negatively correlated but there was no significant impact.

Table 2 : Correlation coefficient of fall armyworm, *S. frugiperda* with biotic and abiotic factors and natural enemies and abiotic factors on maize during *Kharif,* 2019.

Biotic factor:	% Infestation of fall armyworm (r values)	Spiders per plant (r values)	No. of grubs and adults of LBB plant^{-1} (r values)	No. of Carabid larvae plant^{-1} (r values)
Carabid larvae	0.251	---	---	---
Abiotic factors:				
Maximum. Temp (ºC)	0.581*	-0.507	-0.586*	-0.368
Minimum Temp (ºC)	0.661*	-0.506	-0.557	-0.256
Sunshine hours	0.701*	-0.283	-0.335	-0.272
Morning RH (%)	-0.507	0.590*	0.611*	0.233
Evening RH (%)	-0.410	0.504	0.572	0.388
Total Rainfall (mm)	0.158	-0.282	-0.281	0.541

No. of observations N=12, *: Significant at P=0.05critical value=0.576, **: Significant at P=0.01 critical value= 0.708

Positive but non-significant association of evening relative humidity (r = 0.572) with population of lady bird beetle was observed.Thus, it indicated that the maximum temperature and morning relative humidity influence on population fluctuation of ladybird beetle while, other weather parameters had no or less influence on population of ladybird beetle during *Kharif* 2019. The present findings are more or less tallies with the finding of Kumar *et al.,* (2020) who reported that maximum and minimum temperature which had negative effect on abundance of lady bird beetle while maximum relative humidity and minimum relative humidity had a significant positive correlation with population of ladybird beetle.

Correlation coefficients between carabid larvae and weatherfactors in maize during *Kharif*, 2019.

Among the weather parameters (Table 3), there was positively non-significant association between total rainfall (r = 0.541), morning relative humidity (r = 0.233) and evening relative humidity (r = 0.338) and number of carabid larvae per plant. Maximum temperature (r = -0.368), minimum temperature (r = -0.256) and sunshine hours (r = -0.272) had non-significant negative influence on carabid larvae population. It is indicated that there was no significant impact of weather parameters with population of carabid larvae.

CONCLUSION

Thus, the present studies concluded that weather factor determines the seasonal activity and population build-up of insect pest in maize crop and its natural enemies. The correlation coefficient studies indicated the importance of weather parameters in predicting the major pest incidence and these studies will be definitely helpful to farmers and extension workers for developing efficient pest management strategies for sustainable maize production.

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Management of Bollworms in Bt Cotton

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ABSTRACT

The study entitled 'Management of Bollworms in Bt Cotton' was carried out on the experimental field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The field was laid out in Randomised Block Design with eight treatments and three replications. Each treatment incurred the integrated approach with bioagent releases i.e; *Trichogrammachilonis*, Azadirachtin and chemical insecticides. From the present study it was observed that 4 releases of *T. chilonis* @ 1.5 lakh ha^{-1} at 50, 75, 100, 125 DAE and thiodicarb 75 WP @ 20 gm at 60 DAE, profenophos 50 EC @ 20 ml at 85 DAE, chlorantraniliprole 18.5 SC @ 3 ml at 110 DAE and fenevalrate 20 EC@ 8 ml at 135 DAE provided maximum protection from bollworms damage in *Bt* Cotton and found economical. This module was found at par with 5 releases of *T. chilonis* @ 1.5 lakh ha^{-1} at 10 days interval starting from 50 DAE followed by profenophos 50 EC @ 20 ml at 105 DAE, chlorantraniliprole 18.5 SC @ 3 ml at 120 DAE and fenevalrate 20 EC@ 8 ml at 135 DAE .

Cotton, *(Gossypium hirsutum)* plays an important role in providing lint, oil, protein, and fuel. Besides this, globally it provides employment opportunities to millions of people (Bhamare and Wadnerkar, 2018). Cotton occupies the place of pride in Indian agriculture and the economy by earning valuable foreign exchange. Major constraint in attaining high production of seed cotton is damage inflicted by insect pests. Among the various insect-pests infesting cotton, bollworm complex mainly *Helicoverpa armigera* (Hub.), *Eariasvittella* (Fab.) and *Pectinophora gossypiella* (Saunders) are serious pests and considered to be the major constraint to crop production in almost all cotton growing zones. These insect–pests are not only responsible for yield losses of seed cotton but also deteriorate seed and lint quality.Several approaches and strategies are being tried by researchers for effective control of these pests. One such approach is the application of a combination of insecticides, azadirachtin and trichogramma which has been reported to delay development of resistance and effective management of pests (Bhamare and Wadnerkar, 2018). In this context, the present investigation was carried out on the management of cotton bollworms with the releases of trichogramma in combination with subsequent application of neem-based insecticide and other chemical insecticides.

MATERIAL AND METHODS

The study was carried out on the field of Cotton Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during *Kharif* season 2019-20 to study the effect of different modules on bollworms infestation in *Bt* cotton.Experiment was laid out in Randomized Block Design with 8 treatments and 3 replications. Net plot size was 6.3 m × 6.0 m with inter replication spacing of 2 m and inter treatment spacing was 1m. The total layout size was 55.0 m × 22.9 m. PKV Hy.2 Bt BGII cultivar was used in present investigation. All the agronomic practices were carried out as per recommendations.Observation of bollworms damage was recorded at 50 Days after emergence of cotton crop. Firstly, the observation was recorded at weekly intervals up to the formation of bolls on fruiting bodies. Treatment Details are as follows

Treatments	Treatment details
T1	2 releases of *T. chilonis* @ 1.5 lakh/ha at an interval of 10 days starting at 50 DAE followed by thiodicarb 75WP @ 20 gm at 75 DAE, chloropyriphos 50EC @ 20 ml at 90 DAE, profenophos 50EC @ 20 ml at 105 DAE and fenevalrate 20EC@ 8 ml at 120 DAE.
T2	2 releases of *T. chilonis* @ 1.5 lakh/ha at an interval of 10 days starting at 50 DAE followed by chloropyriphos 50EC @ 20 ml at 75 DAE, thiodicarb 75WP @ 20 gm at 90 DAE, profenophos 50EC @ 20 ml at 105 DAE and fenvalrate 20EC @ 8 ml at 120 DAE.
T3	4 releases of *T. chilonis* @ 1.5 lakh/ha at an interval of 10 days starting at 50 DAE followed by thiodicarb 75WP @ 20 gm at 90 DAE, chloropyriphos 50EC @ 20 ml at 105 DAE, profenophos 50EC@ 20ml at 120

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	DAE and fenevalrate 20EC @ 8ml at 135 DAE.
T4	4 releases of *T.chilonis* @ 1.5 lakh/ha at an interval of 10 days starting at 50 DAE followed by chloropyriphos 50EC @ 20 ml at 90 DAE, thiodicarb 75WP @ 20 gm at 105 DAE, profenophos 50EC@ 20 ml at 120 DAE and fenevalrate 20EC @ 8 ml at 135 DAE.
T5	5 releases of *T. chilonis* @ 1.5 lakh/ha at 10 days interval starting at 50 DAE followed by profenophos 50EC @ 20 ml at 105 DAE, chlorantraniliprole 18.5SC@ 3 ml at 120 DAE and fenevalrate 20EC @ 8 ml at 135 DAE.
T6	4 releases of *T. chilonis* @ 1.5 lakh/ha at 50, 75, 100, 125 DAE and thiodicarb 75WP @ 20 gm at 60 DAE, profenophos 50EC @ 20 ml at 85 DAE, chlorantraniliprole 18.5SC @ 3 ml at 110 DAE and fenevalrate 20EC@ 8 ml at 135 DAE.
T7	4 releases of *T.chilonis* @ 1.5 lakh/ha at an interval of 10 days starting at 50 DAE followed by Azadirachtin 1500 ppm @ 10 ml at 90 DAE, profenophos 50EC @ 20 ml at 105 DAE, chlorantraniliprole 18.5SC@ 3 ml at 120 DAE and fenevalrate 20EC @ 8 ml at 135 DAE.
T8	Control

Observation on fruiting bodies i.e, squares, flowers and buds were recorded at weekly interval from five selected plants from each plot randomly. All the fruiting bodies of 5 plants were calculated from each plot and subsequently, per cent damage of each treatment was calculated as follows:

$$\text{Per cent damage} = \frac{\text{No.of fruiting bodies damaged by bollworms}}{\text{Total No.of fruiting bodies on five plants}} \times 100$$

Observation on cotton bolls and its loculi damage at 15 days interval was recorded from 90 days after emergence by randomly picking 10 bolls from each plot of each replication. The per cent damage of cotton bolls and its loculi damage were calculated asfollows:

$$\text{Per cent boll damage} = \frac{\text{No.of bolls damage in each treatment}}{\text{Total No.of bolls observed}} \times 100$$

$$\text{Per cent boll damage} = \frac{\text{No.ofloculi damage in each treatment}}{\text{Total No.of loculi observed}} \times 100$$

RESULTS AND DISCUSSION

The per cent green fruiting bodies damage by bollworms from 50 DAE to 105 DAE were ranged from 0.43 per cent to 1.51 per cent in which minimum mean green fruiting bodies damage was recorded in treatment T_6 (0.43%), whereas, maximum (1.51%) mean total fruiting bodies damage was observed in control T_8. The next best treatment was T_1 (0.62%) which was at par with T_2 (0.73%) followed by T_3 (0.75%), T_7(0.81%), T_5 (0.83%), T_4 (0.87%) and T_8 (1.51%). Sharma *et al.*, (1996) reported that both methomyl 40 SP and profenophos 50 EC were effective ovicides and methomyl (0.03 to 0.06%) recorded 74.97 to 80.96 per cent egg mortality, while profenophos (0.2 to 0.5%) recorded 81.61 to 98.50 per cent egg mortality.

The per cent mean green boll damage by bollworms from 90 DAE to 150 DAE was ranged from 14.66-32 per cent. Among the treatments, maximum 32 per cent mean green boll damage was observed in control treatment. The minimum per cent mean green boll damage was recorded in T_6 (14.66%) and it was statistically at par with T_5 (18.7%) and T_3 (19.3%). The next promising treatments were T_4 (21.33%), T_7 (22.6%), T_1 (24%) and T_2 (25.33%). Earlier worker Udikeri (2007) reported significant reduction in population of PBW larvae in the plots treated with thiodicarb 70 SP (3.29%) at 90 DAS, followed by all treatments including standard check.At 125 DAS also, it maintained its superiority with 4.35 larave/20 green bolls. At 155 DAS, thiodicarb (4.24) profenophos (5.10) and â-cyfluthrin (6.4) were on par with each other and were comparable to cyhalothrin (6.43) as far as larval population is concerned.

The per cent mean loculi damage by bollworm from 90 DAE to 150 DAE was ranged from 5.1-15.35 per cent. Among the treatments, maximum 15.35% mean loculi damage was observed in control treatment T_8. The minimum per cent loculi damage was recorded in T_6 (5.1%) and it was statistically at par with T_5 (6.35%) and T_3 (7.47%). The next promising treatment were T_4 (7.54%), T_7 (8.6%), T_1 (8.86%) and T_2 (9.95%). Patil *et.al.* (2009) reported that two season pooled results indicated superiority of thiodicarb 70 SP and profenophos 50 EC over untreated control (5.58 and 6.89 boll damage plant^{-1},

Table 1: Effect of different treatments on bollworm management and incremental cost benefit ratio

Tr. No.	Per cent green fruiting bodies damage	Per cent green bolls damage by bollworms	Per cent loculi damage by bollworms	Average per cent boll damage	Average per cent loculi damage	Seed Cotton Yield (q ha^{-1})	Total Costs Rs ha^{-1}	Yield	Increased yield over control	Increased yield over control (Rs ha^{-1})	Net Monetary Returns (Rs ha^{-1})	ICBR	Rank
	C Mean	C Mean	C Mean	C Mean	C Mean	Yield (q ha^{-1})	(A)	(q ha^{-1})	(q ha^{-1})	(B)	(B-A)		
T1	0.62	24.00	8.86	25.26	15.07	12.72	10350	12.72	3.28	18122	7772	1:0.75	
	(0.86)	(17.86)	(2.85)	(30.12)	(22.84)		VI						
T2	0.73	25.33	9.95	26.82	15.79	12.61	10350	12.61	3.17	17514.25	7164.25	1:0.69	VII
	(0.92)	(18.66)	(3.11)	(31.17)	(23.40)								
T3	0.75	19.30	7.47	23.75	12.60	16.34	11630	16.34	6.9	38122.5	26492.5	1:2.28	III
	(0.93)	(15.60)	(2.58)	(29.11)	(20.75)								
T4	0.87	21.33	7.54	23.97	12.73	16.00	11630	16.00	6.56	36244	24614	1:2.12	IV
	(0.98)	(17.15)	(2.68)	(29.26)	(20.89)								
T5	0.83	18.70	6.35	22.25	10.80	16.42	9595	16.42	6.98	38564.5	28969.5	1:3.01	II
	(0.95)	(15.60)	(2.38)	(28.12)	(19.17)								
T6	0.43	14.66	5.10	19.02	9.24	19.41	12980	19.41	9.97	55084.25	42104.25	1:3.24	I
	(0.77)	(14.16)	(1.95)	(25.73)	(17.67)								
T7	0.81	22.60	8.60	24.01	13.00	13.89	10460	13.89	4.45	24586.25	14126.25	1:1.35	V
	(0.95)	(17.40)	(2.79)	(29.31)	(21.10)								
T8	1.51	32.00	15.35	43.32	31.75	9.44		9.44					
	(1.19)	(21.32)	(3.65)	(41.14)	(34.28)								
SE(m)+	0.084	1.183	0.283	1.141	0.916	0.233							
CD at 5%	0.257	3.59	0.861	3.461	2.779	0.707							

Note: Fig in parentheses are *Arc sine* transformation, C Mean-cumulative mean.

1. Insecticides dose (ml ha^{-1}) Cost (Rs.)
   - Chloropyriphos 50 EC @20ml - 1000 ml ha^{-1} 600
   - Profenophos 50 EC @20 ml - 1000 ml ha^{-1} 590
   - Chlorantraniliprole 18.5 Sc @ 3ml - 150ml ha^{-1} 1950
   - thiodicarb 75 WP @20 g - 1000 gm h^{-1} 2800
   - Fenevalrate 20 EC @8ml - 400 ml ha^{-1} 180
2. labour charges=240 Rs labour^{-1}
3. 5 labours / treatment/ha and 1 labour per release for trichocard
4. Sale price of Cotton - 5525 Rs q^{-1}
5. Equipment charges - 25 Rs spray^{-1}
6. Trichocard of *Trichogramma chilonis*- 50 Rs card^{-1}

respectively). With respect to open boll damage also thiodicarb was found the most effective.

The mean per cent open boll damage by bollworms in all the treatments was ranged from 19.02 - 43.32 per cent. Treatment T_6 found consistently significant over rests of the treatments at the time of harvests. Among the treatments maximum mean per cent open boll damage was observed in control T_8. Significantly lower open boll damage was recorded in T_6 (19.02%) which was at par with T_5 (22.25%). The next promising treatments were T_3 (23.75%), T_4 (23.97%), T_7 (24.01%), T_1 (25.26), and T_2 (26.82%). The statistically highest open boll damage was in T_8 with 43.32 per cent open boll damage over the rest of the treatments. Treatment T_2 recorded 26.82 per cent open boll damage whichwas statistically significantly highest among the treatment imposed.

Different insecticides viz., Profenophos 50 EC @ 500 g a.i. ha^{-1}, quinalphos 25 EC g a.i. ha^{-1}, thiodicarb 70 SP @750 g a.i. ha^{-1}, ß-cyfluthrin 25 SC 18 g a.i. ha^{-1}, cyhalothrin 5 EC @25 g a.i ha^{-1} (check) against pink bollworm in cotton were studied and pooled results over the seasons indicated the superiority of thiodicarb 70 SP and profenophos 50 EC over untreated control recording 5.58 and 6.89 boll damage $plant^{-1}$, respectively (Nishantha *et al.*, 2008).

The mean per cent loculi damage at the time of harvests by bollworms in all the treatments were ranged from 9.24 per cent to 31.75 per cent. Among the treatments, maximum mean per cent loculi damage at harvests was observed in control treatment T_8 (31.75%). Significantly lowest loculi damage was recorded in T_6 (9.24%) which was statistically at par with T_5 (10.8%). The next promising treatments were T_3 (12.6%), T_4 (12.73%), T_7 (13.0%), T_1 (15.07%) and T_2 (15.79%).

Treatment with lambda-cyhalothrin 5 EC @ 100 g a.i ha^{-1} has proved to be highly effective against bollworm with locule damage of 11.92 per cent and produced the highest seed cotton yield 19.13 kg ha^{-1} and however, it was at par with indoxacarb 14.5 SC @ 75 g a.i ha^{-1}, spinosad 45 SC @ 75 g a.i ha^{-1} and profenofos 50 EC1000 g a.i ha^{-1} in which 12.72, 12.83 and 13.42 per cent locule damage was recorded (Ghure *et al.*, 2008).

The seed cotton yield in different treatments was ranged from 9.44 q ha^{-1} to 19.41q ha^{-1}. The highest seed cotton yield was recorded in T_6 (19.41q ha^{-1}). The next best treatment in which maximum seed cotton yield obtained was T_5 (16.42 q ha^{-1}) followed by T_3 (16.34 q ha^{-1}), T_4 (16 q ha^{-1}), T_7 (13.89 q ha^{-1}), T_1 (12.72 q ha^{-1}) and T_2 (12.61 q ha^{-1}). In control plot, the lowest seed cotton yield (9.44 q ha^{-1}) was recorded.The treatment Achook spraying at 45 DAS followed by thiodicarb spraying at 60 DAS, chloropyriphos spraying at 90 DAS and lambda-cyhalothrin at 120 DAS (T_{14}) were found effective against PBW followed by the treatment thiodicarb spraying at 60 DAS, chloropyriphos spraying at 90 DAS and lambda-cyhalothrin at 120 DAS. The lowest seed cotton yield loss (0.25 %) was recorded in T_{12} followed by T_{14} (Anonymous, 2019).

From the present study, it seems that treatment T_6 was most cost effective in order of merit with highest ICBR (1:3.24) and net monetary returns of Rs.42104.25 ha^{-1} followed by T_5 (1:3.01) with net monetary returns of Rs.28969.5 ha^{-1} and T_3 with ICBR (1:2.28) and net monetary returns of Rs. 26492.5 ha^{-1}. The next best treatments were T_4 with ICBR (1:2.12) and T_7 with ICBR (1:1.35). However, among the treatments T_2 recorded the lowest ICBR (1:0.69) with lowest net monetary returns of Rs.7164.25 and found least cost effective treatment.

From the present investigation, it was observed that 4 releases of *T. chilonis* @ 1.5 lakh ha^{-1} at 50, 75, 100, 125 DAE and thiodicarb 75 WP @ 20 gm at 60 DAE, profenophos 50 EC @ 20 ml at 85 DAE, chlorantraniliprole 18.5 SC @ 3 ml at 110 DAE and fenevalrate 20 EC@ 8 ml at 135 DAE provided maximum protection from bollworms damage in Bt Cotton and found economical which is at par with 5 releases of *T. chilonis* @ 1.5 lakh ha^{-1} at 10 days interval starting from 50 DAE followed by profenophos 50 EC @ 20 ml at 105 DAE, chlorantraniliprole 18.5 SC @ 3 ml at 120 DAE and fenevalrate 20 EC@ 8 ml at 135 DAE.

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Survey and Monitoring of Insecticide Resistance in Storage Insect Pests Infesting Seeds in Storage Godowns

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ABSTRACT

A laboratory experiment was carried out to monitor the insecticide resistance levels of Malathion and Deltamethrin against different populations of target insects viz., *Rhyzopertha dominica,Sitophilus oryzae, Tribolium castaneum, Callosobruchus maculatus* and *Callosobruchus analis* collected from the local godowns and warehouses of Akola district during the year 2019-20. The results revealed that the *Rhyzopertha dominica* populations tested for insecticide resistance showed resistance factor/Resistance Ratio (RF/RR) of 27.69 and 47.61 folds resistance, *Tribolium castaneum* showed resistance factor/Resistance Ratio (RF/RR) of 7.57 and 58.70 folds resistance, *Sitophilus oryzae*showed resistance factor/ Resistance Ratio (RF/RR) of 13.27 and 27.52 folds resistance, *Callosobruchus maculatus* showed resistance factor/ Resistance Ratio (RF/RR) of 12.50 and 26.67 folds resistance,and *Callosobruchus analis*showed resistance factor/Resistance Ratio (RF/RR) of 14.63 and 500 folds resistance when compared to the laboratory susceptible strains LC_{50} values supplied, against Malathion and Deltamethrin insecticides, respectively.

World population is facing many important challenges for food safety as human population keep on increasing day by day with tremendous effects of food resources depletions. During storages of grains mishandling along with other various environmental factors favours stored grains pests infestation (Upadhyay and Ahmad, 2011). Stored grains pests cause serious losses to storages commodities, by making grains unmarketable as well as uneatable due to decrease in nutritional values (Jood and Kapoor, 1994). Damaged grains lose their volume and average weight as well as seed germination badly (Nadeem *et al*, 2012). Red flour beetle, *T. castaneum* and lesser grain borer, *R. dominica* are considered major and serious pests of storage commodities. Both pests are a major cause of post harvest losses and contaminate or destroyed 5-10 per cent food after harvest over the worldwide. Small holder farmers experienced larger post harvest losses due to storage pests in developing countries with range 30-80 per cent causing major threats to food security (Kitinoja *et al*, 2011). These pests mainly feeds on kernels, contaminate grains with faeces, webbing, exuviae, pests' cadavers, and produces aflatoxins materials like uric acid, which promote micro floral growth causing nutritional losses and making food unfit for human consumption (Bhargava, 2007). Introducing proper storage techniques that are socially as well as economically practical and sound to small holder farmers can minimize the pest's related losses during storages (Ali *et al*, 2001). Deltamethrin is broad spectrum insecticides widely used to control storage insects pests (Kljajic and Peric, 2008). Many previous studies confirmed that Deltamethrin is effective grains protectants. Since last few decades, major insect pests of stored grains especially *T. castaneum* and *R. dominica* has developed resistance against plant derived synthetic pyrethroids. However very few researches documented resistance level of *T. castaneum* and *R. dominica* against commonly used grain protectants i.e., Deltamethrin. Due to these consequences current research was focused to survey and monitor the resistance level of different populations of target insects collected from the local godowns and warehouses of Akola district viz., *Rhyzopertha dominica,Sitophilus oryzae, Tribolium castaneum, Callosobruchus maculatus* and *Callosobruchus analis* against Malathion and Deltamethrin insecticides. Thus, a survey to verify the presence of resistance to Malathion and Deltamethrin insecticides is essential for further studies in order to evaluate their efficiency as well as to prepare management for strategies possible failures in insect control.

MATERIAL AND METHODS

Collection of the test insect: The surviving insects viz., *Rhyzopertha dominica,Sitophilus oryzae, Tribolium castaneum, Callosobruchus maculatus* and *Callosobruchus analis* collected from seed storage godowns of Akola district and also the information regarding insecticide application schedule was collected. The insects were reared in the laboratory and bioassay were conducted for determination of LC_{50} through probit analysis against Malathion and Deltamethrin insecticides for resistance. Bioassay were conducted by following film method. For film method, the Petri dish (5 cm diameter)

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were coated with one millilitre solution of insecticide on their inner sides through uniform spreading in the Petri dish by swirling it gently and then allowed it to dry up at room temperature prior to release of insects.

Batches of 20 insects were exposed (24h) to dosages of an insecticides. It was replicated at least four times. The batches of insects were so formed as to ensure that each batch a random sample of the population.

The dosages for testing were spaced as evenly as possible over the mortality range (20 - 80%). Since the toxicity is being tested with commercially available insecticides, different concentrations of insecticides were prepared using distilled water. One batch of insects was treated with water alone for untreated control.

Stock solution of one per cent concentration of corresponding test insecticides was prepared by weighing the required quantities of insecticides, by using acetone as solvent. The graded concentrations of the test insecticides were prepared with acetone as solvent by following serial dilution technique. The quantity of insecticidal solution required to coat the petri dish was determined and after coating the petri dishwere air dried. One day old insects were collected from the culture and kept under starvation for two hours. The starved beetles were transferred to the petri dishes containing insecticide @ 20 beetles/petri dish in four replications for each test insecticide. The insects were confined to the treated surface for 24 hours. Simultaneously, a control was also maintained with distilled water only.

Data Collection

Mortality was recorded at 24 hours after treatment (HAT). A preliminary experiment was conducted with wide range of concentrations followed by a narrow range to get mortality in the range of 20-80 per cent. There was no occurrence of the use of Abbott's formula since mortality was not recorded in control, because of the use of almost same age beetles and the experimentation conducted under controlled ambient conditions of 32^0 C temperature and 75 per cent relative humidity. In order to know the immediate toxicity of the chemical, the mortalities were recorded at 24 HAT.

Assessment of the Degree of Resistance The mortalities of adult beetles of *Rhyzopertha dominica,Sitophilus oryzae, Tribolium castaneum, Callosobruchus maculatus* and *Callosobruchus analis* collected against the test insecticides were subjected to probit analysis Statistical analysis data was analysed by using POLO Probit analysis software to calculate LC_{50}, heterogenety (c2), intercept: (a), slope of the regression line (b), regression equation and fiducial limits. The resistance factor was calculated by dividing the LC_{50} value of each population with the LC_{50} value of susceptible population supplied by the AICRP NSP centre.

RESULTS AND DISCUSSION

Toxicityof Malathion to different populations of store insect *R. dominica* recorded LC_{50} value as 0.461 at 24 HAT. The slope (b) value of log concentration probit (lcp) lines of malathion were 1.33 at 24HAT (Table 1).

The LC_{50} value obtained for malathion against *Tribolium castaneum*at 24 HAT was0.143. The slope (b) of log concentration probit (lcp) lines of malathion was1.424 at 24 HAT.

The LC_{50} value of 0.019 was obtained for malathion against *Sitophilus oryzae*at 24 HAT, (Table 1). The slope (b) values of log concentration probit (lcp) lines was 1.533 at 24 HAT.

The *Callosobruchus maculatus* population recorded (Table 1) the LC_{50} value of 0.003 to malathion at 24 HAT. The slope (b) of log concentration probit (lcp) lines for *Callosobruchus maculatus* was 1.440 at 24 HAT.

The *Callosobruchus analis* population showed the LC_{50} value as 0.006 at 24 HAT. The slope (b) values of log concentration probit (lcp) lines of malathion was 1.398 at 24 HAT.

Laboratory susceptible population: The LC_{50} values obtained for malathion against Laboratory susceptible population of *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and *Callosobruchus analis* which were supplied by AICRP NSP centre laboratory maintained in the at 24 HAT viz. 0.01665, 0.0189, 0.001432, 0.00024 and 0.00041, respectively(Table 3). The slope (b) values of log concentration probit (lcp) lines of malathion were 0.05, 3.507, 2.4005, 0.711 and 1.874 at 24 HAT, respectively.

Degree of resistance acquired by adults of *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and *Callosobruchus analis*to malathion at 24 HAT: The populations of *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and *Callosobruchus analis*were 27.69, 7.57, 13.27, 12.50 and 14.63 folds resistant

Table 1: Relative toxicity and Degree of resistance acquired by different populations collected from local godowns to malathion.

S.N.	Name of Insect	Strain name/location	Heterogeneity		Regression coefficient	LC_{50}	Fiducial limits		Resistance Ratio/ Resistance factor
			df	÷2					
1	*Rhyzopertha dominica*	Central Warehouse Akola	4	2.540	5.449+1.33x	0.461	0.357	0.613	27.69
2	*Tribolium castaneum*	SS Godown,Akola	4	0.034	6.201+1.424x	0.143	0.111	0.185	7.57
3	*Sitophilus oryzae*	Maharashtra State Warehousing, Akola	4	1.686	7.648+1.533x	0.019	0.014	0.024	13.27
4	*Callosobruchus maculatus*	Central Warehouse Akola	4	2.210	8.596+1.440x	0.003	0.002	0.004	12.50
5	*Callosobruchus analis*	Kalyx Warehousing	4	0.432	8.123+1.398x	0.006	0.004	0.008	14.63

at LC_{50} to malathion, respectively in comparison with Laboratory susceptible population (LC_{50} = 0.01665, 0.0189, 0.001432, 0.00024 and 0.00041, respectively (Table 1 &3).

Toxicity of Deltamethrin to different populations of store insect *R. dominica* recorded LC_{50} value as 0.209 at 24 HAT. The slope (b) value of log concentration probit (lcp) lines of Deltamethrin were 1.065 at 24 HAT (Table 2).

The LC_{50} value obtained for Deltamethrin against *Tribolium castaneum* at 24 HAT was 0.027. The slope (b) of log concentration probit (lcp) lines of Deltamethrin was 1.741 at 24 HAT (Table 2).

The LC_{50} value of 0.003 was obtained for Deltamethrin against *Sitophilus oryzae* at 24 HAT, (Table 2). The slope (b) values of log concentration probit (lcp) lines was 1.587 at 24 HAT.

The *Callosobruchus maculatus* population recorded the LC_{50} value of 0.002 to Deltamethrin at 24 HAT. The slope (b) of log concentration probit (lcp) lines for *Callosobruchus maculatus* was 1.667 at 24 HAT.

The *Callosobruchus analis* population showed the LC_{50} value as 0.006 at 24 HAT. The slope (b) values of log concentration probit (lcp) lines of Deltamethrin was 1.398 at 24 HAT.

Laboratory susceptible population: The LC_{50} values obtained for Deltamethrin against Laboratory susceptible population of *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and *Callosobruchus analis* which were supplied by AICRP NSP centre laboratory maintained in the at 24 HAT viz. 0.00439, 0.00046, 0.000109, 0.000075 and 0.000012, respectively (Table 3). The slope (b) values of log concentration probit (lcp) lines of Deltamethrin were 0.08, 0.836, 0.6712, 1.920 and 1.635 at 24 HAT, respectively.

Degree of resistance acquired by adults of *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and*Callosobruchus analis* to be Deltamethrin at 24 HAT: The populations of *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and*C. analis* were 47.61, 58.70, 27.52, 26.67 and 500 folds resistant at LC_{50} to Deltamethrin, respectively in comparison with Laboratory susceptible population (LC_{50}= 0.00439, 0.00046, 0.000109, 0.000075 and 0.000012, respectively (Table 2& 3).

Malathion has been in use as a common insecticide for postharvest insect control in the United States since 1958 (Anonymous,1958). Its use spread to several countries in the 1960s and its intensive use against stored grain insect pests (Badmin,1990 and Champ, 1976) resulted in the development of severe resistance in many insect species. Malathion resistance was earlier reported in the United States populations of lesser grain borer by (Badmin, 1990, Halliscakand Beeman, 1983 and Zettlerand Cuperus, 1990) several studies in the past have also shown that many OP insecticides including malathion resulted in the development of resistance in many insect species including lesser grain borer. Sub lethal doses of malathion greatly suppressed AcP (acid phosphatase) activity in resistant beetles, which might be due to inhibition of this enzyme under insecticidal toxicity and impairing of the lysosomal activity to hydrolyse the macromolecules and in turn limiting the ability of the resistant beetles to use energy rich compounds to obtain energy. The acquisition of resistance to Malathion in *Tribolium castaneum* was reported nearly three decades back (Bhatia et al, 1971), who found 38 folds resistance to malathion at Naraina in Delhi, whereas (Bhatia *et al*, 1990) reported13.33- and 51.28-folds resistance to Malathion in Charlapalli and Sanathnagar strains, respectively and 55.27 folds in Shillong strain of *T. castaneum*. The results are at par with (Ali *et al,* 2001) who reported that the adults of six populations of *R. dominica* behaved differently when exposed to Malathion under laboratory conditions. These populations showed different levels of resistance to Malathion. Multan (M) population was found to be the least resistant and Chichawatni population (C), the most resistant with 9.3 folds resistance than M population. In the present study, increased levels of resistance to Malathion in *R. dominica* was observed. The toxicity of most organophosphate insecticides applied as residual crack and crevice treatments to control insects in and around godowns, mills and processing plants is positively correlated with the temperature. Malathion being one of the oldest insecticides that has been registered nearly for more than five decades, its low cost, moderate toxicity to mammals and optimal residual activity in storage godowns are reasons of support for continuous and wide use in the control of the stored product insects and thus resulted in the widespread and increased level of resistance to *R. dominica* in the present study.

Development of resistance to Deltamethrin in *R. dominica* was earlier reported from Pakistan, wherein, the adults of six populations of the pest viz., Chichawatni (C), Karachi (K), Wazirabad (W), Sialkot (S), Lahore (L) and Multan (M) were treated with an organophosphate

Table 2: Relative toxicity and Degree of resistance acquired by different populations collected from local godowns to Deltamethrin.

S.N.	Name of Insect	Strain name/location	Heterogeneity		Regression	LC_{50}	Fiducial limits		Resistance Ratio/
			df	÷2	coefficient				Resistance factor
1	*Rhyzopertha dominica*	Central Warehouse Akola	4	2.397	5.723+1.065x	0.209	0.152	0.285	47.61
2	*Tribolium castaneum*	SS Godown, Akola	4	3.474	7.738+1.741x	0.027	0.021	0.034	58.70
3	*Sitophilus oryzae*	Maharashtra State Warehousing, Akola	4	4.360	8.987+1.587x	0.003	0.002	0.004	27.52
4	*Callosobruchus maculatus*	Central Warehouse Akola	4	3.742	9.532+1.667x	0.002	0.001	0.002	26.67
5	*Callosobruchus analis*	Kalyx Warehousing	4	1.603	8.123+1.398x	0.006	0.004	0.008	500.00

Table 3: Toxicity and LC_{50} value of susceptible strains to Malathion and Deltamethrin supplied by AICRP NSP centre given in the following table

S.N.	Insect	Insecticide	Strain	Heterogeneity		Regression	LC_{50}	Fiducial limits	
				df	÷2	coefficient/ equation		Min.	Max.
1	*Rhyzopertha dominica*	Malathion	S	4	2.991	1.204+0.05x	0.01665	0.01289	0.0215
		Deltamethrin	S	3	2.952	1.353+0.08x	0.00439	0.00296	0.00651
2	*Tribolium castaneum*	Malathion	S	4	0.8963	9.900+3.507x	0.0189	0.0159	0.0226
		Deltamethrin	S	4	6.5939	7.792+0.836x	0.00046	0.00026	0.00078
3	*Sitophilus oryzae*	Malathion	S	3	4.3897	10.802+2.4005x	0.001432	0.00111	0.00185
		Deltamethrin	S	5	5.3579	7.6606+0.6712x	0.000109	0.000056	0.00021
4	*Callosobruchus maculatus*	Malathion	S	4	5.101	3.233+0.711x	0.00024	0.000031	0.00045
		Deltamethrin	S	3	1.046	3.315+1.920x	0.000075	0.000001	0.000098
5	*Callosobruchus analis*	Malathion	S	3	4.876	0.102+1.874x	0.00041	0.00031	0.00053
		Deltamethrin	S	4	6.063	3.200+1.635x	0.000012	0.000009	0.000017

insecticides Malathion, and a synthetic pyrethroid, Deltamethrin (Decis). C population was found to be most resistant to malathion (LC_{50}, 115.50 ppm), whereas M population was least resistant (LC_{50} 12.40 ppm). On the other hand, M population was most resistant to deltamethrin (LC_{50} 10.55 ppm), whereas L population was most susceptible (LC_{50} 2.83 ppm). In the present research study, *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and *Callosobruchus analis* were 27.69, 7.57, 13.27, 12.50- and 14.63-folds resistant at LC_{50} to malathion and *Rhyzopertha dominica, Tribolium castaneum, Sitophilus oryzae, Callosobruchus maculatus* and *Callosobruchus analis* were 47.61, 58.70, 27.52, 26.67- and 500-folds resistant to Deltamethrin when compared with the susceptible population LC_{50}values supplied.

CONCLUSION

Best approaches to minimize resistance levels in stored products insects' pests is to know their geographical locations, control methods and storage techniques. The research was based on different locations of storages pests. The resistance levels in laboratory was observed against largely applied Deltamethrin and Malathion. Godowns collected strains were observed more resistant to Deltamethrin and Malathion as compared to susceptible strains LC_{50}values supplied. The study could be helpful for improvements in storages insect's pest management's strategies.

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Seasonal Effect of Azolla Powder Supplementation on Feed Consumption of Giriraja Poultry Birds

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ABSTRACT

The seasonal effect of Azolla supplementation on feed consumption of Giriraja poultry birds was carried out at Department of Animal Husbandry and Dairy Science, Dr. Panjabrao Deshmukh Krishi Vidypeeth, Akola with co-ordination of Poultry Science, PGIVAS, MAFSU, Akola, Maharashtra State. The chemical composition of Azolla powder was 21.56, 15.08 and 15.88 Crude Protein 21.56 per cent, crude fibre 16.66 per cent and ash 15.44 per cent on dry matter basis. The feed consumption during rainy season was recorded 715.73, 718.03, 728.70, 719.40 and 718.87 g bird. In winter season746.73, 749.03, 759.70, 750.40 and 749.87 g bird and in summer season 612.73, 615.03, 625.70,616.40 and 615.57 g bird in the treatment of T_1, T_2, T_3, T_4, and T_5 , respectively.The feeding of 5 per cent Azolla powder in all season in the diet of Giriraja birds without any adverse effect on growth performance. The better results were found in winter season as compare to rainy and summer season. Therefore the additional income can be generated in the winter season.

Poultry farming is an attractive economic activity as well, especially to women and poor population. It also creates job opportunities and self employment for the growing population of the country. Persons from low income group may also start the business on a small scale. The poultry is particularly important because it is the significant source of protein. Poultry industry has made a tremendous and remarkable progress evolving from a small scale backyard venture to the status of commercial, full fledge, self-sufficient and most progressive agro based industry and become an attractive enterprise particularly because of the small capital investment, increased returns, quick turn over, comparatively less risk involved, low land requirement, easy to production and high feed efficiency. Due to increasing demand for poultry meat, short supply of mutton and limited acceptability of beef and pork in some countries as considering of religious and cultural points like India.India has exported 278127.00 MT of poultry products to the world for the ward of Rs. 37650.00 Lacs during the year 2020-21 (Annonymous, 2020).

The most importance of backyard poultry is well recognized by Government of India and special programs are formulated for its promotion. Hence, efforts have been diverted into producing dual purpose native hybrids with improved production profiles. Azolla is a free floating water fern that floats in water and fixes atmospheric nitrogen in association with the nitrogen fixing blue green alge, Anabaenaazollae. Azolla is considered to be a potential bio-fertilizer in terms of nitrogen contribution to rice crop (Kannaiyan,1992). Long before its cultivation as a green manure, Azolla was used as a fodder for domesticated animals such as pigs and ducks.In recent days, Azolla is very much used as a sustainable feed substitute for livestock especially dairy cattle, poultry, piggery and fish. Azolla contains 25-35 per cent protein on dry weight basis and rich in essential amino acids minerals, vitamins and carotenoids including the antioxidant b carotene (Ivan *et al.,* 1989). Feed is by far the most important single factor under the environment which play a significant role, since it accounts more than two-thirds of total poultry production cost. Thus, the growth of feed industry is directly proportional to poultry population growth.

Recently, there is an increased emphasis in the use of aquatic plants in poultry rations because the protein and other nutrient content in them and are comparable to certain leguminous plants. Aquatic plants pieces accumulate secondary plant compounds and therefore offer greater potential than many other types of leaf protein sources (Balaji *et al.,* 2009). Among the aquatic plants floating fern *Azolla pinnata* can be used as unconventional high potential feed resource and it

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contains almost all essential amino acids, minerals such as iron, calcium, magnesium, potassium, phosphorus, manganese etc. apart from appreciable quantities of vitamin A precursor beta carotene and vitamin B_{12}. Azolla have symbiotic relationship with the nitrogen-fixing blue-green algae. The fern provides nutrients and a protective cavity in each leaf to Anabaena colonies in exchange for fixed atmospheric nitrogen and possibly other growth-promoting substances. It is this unique symbiotic relationship that makes Azolla, a wonderful "super plant" with high protein content, as it can readily colonize areas of fresh water and grow at great speed doubling its biomass every two to three days. It is also found to contain probiotics and biopolymers (Pillai *et al.,* 2005).

Important features of Giriraja poultry breed are multi-color feather pattern, immunity to disease, perform with less nutrition, grow faster and produce more eggs as well as meat, produce brown eggs like local hens. High nutritive value and rapid biomass production make Azolla a potential and effective feed substitute for livestock, particularly poultry birds. In view of this the research was conducted with the objective to study the feed consumption Giriraja poultry birds under different seasons.

MATERIAL AND METHODS

Experimental site and climate

The research trial was carried out at Veterinary Institute of Poultry Unit, Department of Poultry Science, Post Graduate Veterinary Institute, MAFSU, Akola in the coordination with Department of Animal Husbandry and Dairy Science, Dr.PDKV., Akola, Maharashtra State. In summer season the maximum temperature reached upto 42^0C to 45^0C with the humidity ranges from 11 to 16 %. With the annual rainfall of 750.0 to 900.0 mm. The experiment was conducted in three different seasons i.e. Rainy, Winter and Summer season.

Drying and preparation of Azolla Powder

Preparation of green azolla was collected from the demonstration unit of the department to dry in an air circulating oven at 50^0 C followed by 105^0 C until there were no further changes at these two temperatures. Grinded azolla powder sieved through 300 µm mesh and store at air tight cellophane bag as stock sample for further analysis.

Procurement of DOC

The 150 number of day old chicks of Giriraja Poultry birds were purchased from Private supplier through Government Hatchery, C.P.D.O., Seminary Hills, Nagpur

Immunization schedule

All the chicks were vaccinated as per the schedule

Treatments

The dietary treatment formulated were as below

The treatments were common in all season, as per experimental birds

T_1 - Standard ration (S.R.);
T_2 - S.R.+4% Azolla powder (AP);
T_3 - S.R.+5% Azolla powder (AP);
T_4 - S.R.+6% Azolla powder (AP) and
T_5 - S.R.+7% Azolla powder (AP)

Observation recorded

Weekly feed consumption

Weekly feed consumption was measured by the amount of feed offered on the beginning of week and deducted whatever left over at the end of the week. The cumulative feed consumption was work out for all the replicate under treatment groups.

Feed consumption = Feed offer – Feed left over

Weekly and cumulative feed efficiency

It was measured by using following formula

$$FE = \frac{\text{Feed consumption in week (gm)}}{\text{Gain in body Wt. in a week (gm)}}$$

RESULTS AND DISCUSSION

It was observed from the Table 1 that, azolla supplementation powder was containing 21.56, 15.08 and 15.88 per cent Crude Protein, crude fibre and ash on dry matter basis, respectively (Table1).

Table 1: Proximate composition of Azolla feed supplementation on percent (%)

Dry matter	89.91
Crude protein	21.56
Crude fat	3.37
Nitrogen Free extract	43.96
Crude fiber	15.08
Total Ash	15.88

Table 2: Composition of experimental Feed as per BIS standard

Ingredients	Pre-starter	Starter	Finisher
Maize grain	35.27	41.78	50
Rice bran	18.05	9.7	0
Wheat bran	5.58	10.97	15
Soybean meal	35.88	33.5	30.95
Methionine	0.25	0.25	0.25
Lysine	0.2	0.2	0.2
Limestone	1.5	1.2	1.2
Di-calcium Phosphate	1.8	1.5	1.5
Salt	1	0.5	0.5
Vitamin& Mineral mixture	0.47	0.4	0.4
Total	100.00	100.00	100.00

Feed consumption during the rainy season

The studies confirmed that weekly feed intake from birds of first week to seventh week and presented in the Table 3.

In the first week of the rainy season the feed consumption was 69.83, 71.57, 73.17, 71.97 and 70.87 bird^{-1} with the treatment of T_1, T_2, T_3, T_4, and T_5 respectively. These results were related to each others and was non significant.

During the second week the feed consumption was 188.63, 191.07, 201.07, 190.37 and 187.73 bird^{-1} with the treatment of T_1, T_2, T_3, T_4, and T_5 respectively. The maximum feed consumption was recorded with T_3 treatment. Whereas minimum feed consumption found in control group.In the third week the birds was recorded the feed consumption higher in AP 5 per cent treatment i.e. 288.13 bird^{-1} whereas lower in control group i.e. 274.67 bird^{-1}. During the fourth week of the birds the feed consumption was recorded 303.60, 311.97, 321.30, 312.50 and 317.67 with the treatment of T_1, T_2, T_3, T_4, and T_5 respectively. In the fifth week of the rainy season the feed consumption was found more in AP 5 per cent treatment i.e. 455.83 where as lower in control group. This means that the azolla powder support to feed consumption to the Giriraja poultry birds. During the sixth week of the season the feed consumption was recorded 634.87, 639.57, 644.93, 640.47and 638.17 with the treatment of T_1, T_2, T_3, T_4, and T_5 respectively.In the last week of the experimental trial the feed consumption was recorded 715.73, 718.03, 728.70, 719.40 and 718.87 with the treatment of T_1, T_2, T_3, T_4, and T_5, respectively. The maximum recorded in AP 5 per cent and minimum recorded in control group.

The nutrient intakes were estimated to 12 and 31 per cent of the nutrient intakes of confined growing of poultry birds. The environmental conditions affecting the performance and health productivity of chicken include temperature, relative humidity, light, sunshine prevailing at a given time, housing system and ventilation (Elijah and Adedapo,2006). Ambient temperatures significantly

Table 3 : Effect of Azolla powder supplementation on Feed consumption of Giriraja poultry birds during rainy season (g bird^{-1})

	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7
T_1	69.83	188.63^{c}	274.67^{d}	303.60^{d}	448.63^{e}	634.87^{c}	715.73^{c}
T_2	71.57	191.07^{b}	279.30^{c}	311.97^{c}	453.23^{d}	639.57^{b}	718.03^{b}
T_3	73.17	201.07^{a}	288.13^{a}	321.30^{a}	462.30^{a}	644.93^{a}	728.70^{a}
T_4	71.97	190.37^{b}	285.10^{b}	312.50^{c}	455.83^{b}	640.47^{b}	719.40^{b}
T_5	70.87	187.73^{c}	284.10^{b}	317.67^{b}	457.57^{c}	638.17^{b}	718.87^{b}
SEm (±)	0.95	1.28	1.01	1.09	1.02	0.89	0.92
CD at 5%	–	3.89	3.38	3.06	3.78	2.48	2.57

influence the survivability and performance of the poultry production.

Feed consumption during the Winter season

During the winter season the temperature was minimum and was12.89 ^{0}C lowest in this experimental period.

In the first week of the winter season the feed consumption was noted as 73.60, 75.47, 77.10, 76.00 and 74.77 g bird^{-1} with the treatment of T_1, T_2, T_3, T_4, and T_5, respectively. The results were non significant and maximum feed consumption was found in AP 5 per cent treatment (Table 4).

During the second week of the experiment the feed consumption was found 200.63, 203.07, 213.07, 202.37 and 199.73 g bird^{-1} with T_1, T_2, T_3, T_4, and T_5, respectively. The result of the third week of feed consumption was 291.67, 296.27, 305.50, 302.00 and 296.80 g bird^{-1} with the treatment in T1, T_2, T_3, T_4 and T_5, respectively. The fourth week of the treatment for feed consumption showed that 335.60, 344.00, 353.30, 344.50 and 349.67 g bird^{-1}. The Fifth week the feed consumption were found 475.63, 480.27,489.30, 482.87 and 484.60 g bird^{-1}. In the sixth week of the experiment the results of feed consumption were 666, .87, 671.57,676.93, 672.47 and 670.17. In the last week of the experiment the result were 746.73, 749.03, 759.70, 750.40 and 749.87 g bird^{-1} feed comsuption with the treatment in T_1, T_2, T_3, T_4, and T_5, respectively. In above results the AP 5 per cent was superior than the rest of the other treatments. The AP 5 per cent should the better feed consumption in the winter season which results the better body weight gain and has better performance in rearing of poultry birds.

In the winter season of the feed consumption was better in AP5 per cent treatment as the rest of the treatments. Bhadauria (2014) reported that during 55^0 to 75^0 F thermal neutral zone, the temperature range in which the bird does not need to alter its basic metabolic rate or behaviour to maintain its body temperature. It was noted that the temp ranges form 12.33 to 29.89 ^{0}C was the best for the feed consumption.

Feed consumption during the summer season

This was the most hot season in the Vidharbha region. The temperature ranges form 20.10 ^{0}C to 42.40 ^{0}C which was the hottest in this region. The work was done

Table 4: Effect of Azolla powder supplementation on Feed consumption of Giriraja poultry birds during Winter Season (g birds^{-1})

	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7
T_1	73.60	200.63^c	291.67^d	335.60^d	475.63^e	666.87^c	746.73^c
T_2	75.47	203.07^b	296.27^c	344.00^c	480.27^d	671.57^b	749.03^b
T_3	77.10	213.07^a	305.50^a	353.30^a	489.30^a	676.93^a	759.70^a
T_4	76.00	202.37^b	302.00^b	344.50^c	482.87^c	672.47^b	750.40^b
T_5	74.77	199.73^c	296.80^c	349.67^b	484.60^b	670.17^b	749.87^b
SE m (±)	0.96	1.29	1.82	1.09	1.02	0.89	0.92
CD a5 5%	-	3.89	5.35	3.06	2.85	2.48	2.57

Table 5 : Effect of azolla powder supplementation on feed consumption of Giriraja poultry birds during summer season (g birds^{-1})

	WEEK1	WEEK2	WEEK3	WEEK4	WEEK5	WEEK6	WEEK7
T_1	62.57	169.63^c	240.67^d	256.60^d	381.63^e	541.87^c	612.73^c
T_2	64.40	172.07^b	245.30^c	264.97^c	386.23^d	546.57^b	615.03^b
T_3	66.40	182.07^a	254.13^a	274.30^a	395.30^a	551.93^a	625.70^a
T_4	64.37	171.37^b	251.10^b	265.50^c	388.83^c	547.47^b	616.40^b
T_5	63.10	168.73^c	250.10^b	270.67^b	390.57^b	545.17^b	615.87^b
SE(±)	0.95	1.39	1.21	1.09	1.02	0.89	0.92
CD at 5%	NS	3.89	3.38	3.06	2.86	2.48	2.57

in April and May month and the results were presented in Table 5.

In the first week of the season the feed consumption was 62.57, 644.40, 66.40, 64.37 and 63.10 g bird^{-1} with the treatment of T_1, T_2, T_3, T_4, and T_5, respectively. During the second week the results were 169.63, 172.07, 182.07, 171.37 and 168.73 birds^{-1} and during the third week season the findings were 240.67, 245.30, 254.13, 251.10 and 250.10 g bird^{-1} feed consumption. In the fourth week, the feed consumption was 256.60, 264.97, 274.30, 265.50 and 270.67 g bird^{-1}. The fifth week was resulted 381.63, 386.23, 395.30, 388.83 and 390.57 bird^{-1} feed consumtpion. The sixth week resulted 541.87, 546.57, 551.93, 547.47 and 545.17 bird^{-1}. During the last week of the season the feed consumption was recorded 612.73, 615.03, 625.70,616.40 and 615.57 g bird^{-1} with the T_1, T_2, T_3, T_4 and T_5, respectively. The maximum feed consumption was recorded in the AP 5 per cent group as the rest of the treatments. In the first week of the season the results were non significant and the other weeks showed the significant results. From the data of the feed consumption during three season, the better performance was observed in the winter season followed by rainy season and summer season.

Correlation of feed consumption

The correlation of feed consumption was observed with three season i.e. rainy, winter and summer season (Table 6).

During rainy season the maximum temperature (T max) was positively correlated with Feed consumption of the birds, whereas, the minimum temperature (T min) was highly negatively correlated with feed consumption of the birds. The relative humidity (RH I) was negatively corelated and did not revealed statistically significant effect on feed consumption of the birds, but, the evening relative humidity (RH II) was significant negatively correlated with feed consumption of the birds.

In winter season of the feed consumption was negatively correlated to feed consumption and strongly significant in minimum temperature. The relative humidity (RH I) was positive correlated effect on feed consumption of the birds, but, the evening relative humidity (RH II) was strongly correlated in positive manner (p=0.05) with feed consumption of the birds.

In summer season the feed consumption was positively correlated in minimum and high temperature, Whereas, in relative humidity (RH I and RH II) was correlated in negative manner with the feed consumption.

From the above three seasons it was observed that the most best results were found in winter season. The similar results were found by Bhadauria *et.al.* (2014) reported that in the summer months, when daily temperatures reach at their extremes, it becomes critical for the birds to dissipate body heat to the surrounding environment. It was also reported that heat stress begins when the ambient temperature climbs above 80^0F and is readily apparent above 85^0F. When a bird begins to pant, physiological changes have already started within its body to dissipate excess heat.

The similar results were noted by Abalaka *et. al.* (2014) that majority (94 %) of respondent agreed to the climate changes affect the egg and the meat production pattern in the studied area, the same veins 78.4 per cent of the respondent agreed to that high temperature make the bird feeds less, this was because temperature reduced the

Table 6 : Correlation of Feed consumption on temperature and humidity.

Treat	Rainy				Winter				Summer			
	Tmax	Tmin	RH I	RH II	Tmax	Tmin	RH I	RH II	Tmax	Tmin	RH I	RH II
T_1	0.731	-0.977*	-0.216	-0.697	-0.355	-0.771**	-0.402	0.153	0.966*	0.980*	-0.472	-0.232
T_2	0.728	-0.977*	-0.222	-0.702	-0.360	-0.773**	-0.403	0.155	0.968*	0.982*	-0.480	-0.234
T_3	0.724	-0.978*	-0.232	-0.708	-0.361	-0.769**	-0.399	0.161	0.968*	0.982*	-0.483	-0.230
T_4	0.727	-0.975*	-0.223	-0.703	-0.363	-0.772**	-0.399	0.158	0.969*	0.982*	-0.481	-0.240
T_5	0.727	-0.976*	-0.227	-0.710	-0.369	-0.778**	-0.404	0.159	0.971*	0.984*	-0.484	-0.234

* 5% significant level ** 1% significant level

feed intake of poultry bird and more energy was needed to conserved the heat that caused by high temperature, hence, a decreased in the rate of feed intake.

The similar results were noted by Hyati (2007) showed that broiler birds raised in summer had lower cultural energy expended per unit of live weight (LB) and protein energy output than broiler raised in winter season. Hence broiler raised in summer had lower total CE expenditure and comparable growth rate, they had higher efficiency than broilers raised in winter.

CONCLUSION

Supplementation of 5 per cent azolla powder treatment was best over other treatment in all the season for achieving more feed consumption than the other treatments. The feed consumption was found better result in Winter season followed by the rainy season and summer season.

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Correlates with Yield of Selected Characteristics of Indo-Israel Technology Adopter and Non-adopter Mandarin Growers

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ABSTRACT

The research study was conducted in Nagpur and Amravati districtsin Maharashtra Stateon Indo-Israel technology adopter and non-adopter mandarin growers. The project was implemented in these districts on pilot basis. The experimental research design of social research was used for the present study. In all, 120 respondents were selected by random sampling method i.e. 60 adopter and 60 non-adopterof Indo-Israel technology in mandarin crop. The data were collected from adopter and non-adopter respondents by personal interview with them by means of interview schedule. The results pertaining to the yield of mandarin crop to the growers revealed that, more than fifty per cent of the adopter and non-adopter of Indo Israel technology mandarin growers have low yield level of mandarin crop. The correlation analysis undertaken for yield dimensions with selected characteristics revealed that,in case of adopter the characteristics viz. land holding, farming experience,area under mandarin cultivation, source of information, economic motivation and risk preference were found to be positive and highly significant with yield at 0.01 level of probability.However in case of non-adopter Indo-Israel technology mandarin growers, thecharacteristic area under mandarin cultivation was found to be positive and highly significant at 0.01 level of probability.

Fruits are of great importance in human diet. India is the second largest producer of fruits in the world. Its share in world's fruit production is 11.00 per cent. The major fruits grown in India are mango, banana, citrus, guava, pineapple, grape and papaya in tropics and subtropics and apple in the temperate region. Apart from these, sapota, aonla, ber, pomegranate, litchi, peach, pear plum and walnut are grown on a sizable area.

Mandarin is most common among the citrus fruit occupying nearly two-third of the world total area. The leading mandarin producing countries are United States, Brazil, Central and South America South Africa, Japan, China, India and Mediterranean country. Mandarin (*Citrus reticulata*) is most common among citrus grown in India. Mandarin (*Citrus reticulata* Blanco) is one of the premier commercial citrus grown in central India. It is grown in 92.2 thousand hectare with a total production of 11.2 lack tonnes and an average productivity 11.5 tonnes per hectare, Nagpuri mandarin was introduced in 1894 in Central India (Shrivastva and Singh, 2003).

A number of other fruits are also grown in different region, however the per capita availability of the fruits in the country is very less due to number of reasons (Anonymous, 2004). Mandarin is most common citrus fruit in Central India, but when we look forits productivity, it stands very low as compared to other countries. This is a challenging task for scientists and the farmers(Yadav *et. al*, 2013).

The Indo-Israel agriculture project based on the concept of establishing center of excellence which provide platform for a rapid transfer of technology to the farmers with the aim of increasing the productivity and improving the quality of produce (Wadhankar, 2020). Based on Israel's unique expertise in Agriculture, India and Israel have signed the Agreement for Agricultural Cooperation in 2006. This pilot project was implemented in Nagpur, Amravati and Wardha district inVidarbha region of Maharashtra State. It was therefore felt imperative to conduct the study in Nagpur and Amravati district having more area under mandarin crop.

MATERIAL AND METHODS

The present study was conducted in Warud Block in Amravati district and Katol and Kalmeshwar Block in Nagpur district of Vidarbha region in Maharashtra State, where Indo-Israel technology is being adopted by the mandarin growers. For selection of villages, the list of Indo-Israel technology adopted mandarin growers was obtained from Taluka Agriculture Officer of the respective block from Amravati and Nagpur district. From these

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selected villages the Indo-Israel technology adopter mandarin growers were purposively selected on random basis for collection of data. For comparison, the data was collected from no n-adopter mandarin growers from the same village selected for present study.The sample comprised of 60 adopter and 60 non-adopter mandarin growers from the purposively selected villages from Amravati and Nagpur district, respectively. Thus,a sample of 120 Indo-Israel technology adopter and non-adopter mandarin growers were considered as a respondent for the present study.The exploratory research design of social research was used for collection and analysis for the data of the present study.

RESULTS AND DISCUSSION

The results pertaining to the yield level of Indo-Israel technology adopter and non-adopter mandarin growers under present research study are given in Table 1.

Table 1: Distribution of adopter and non-adopter mandarin growers according to the yield of mandarin

S.N.	Yield	Adopter (n=60)		Non-adopter (n=60)	
	(t ha^{-1})	Frequency	Per cent	Frequency	Per cent
1.	Low	40	66.66	46	76.66
2.	Medium	16	26.66	12	20.00
3.	High	04	06.66	02	03.33
	Total	**60**	**100.00**	**60**	**100.00**

The data pertaining to levels of yield of mandarin (Table 1) revealed that, over half of adopter growers (66.66%) were having low yield of mandarin, it was followed by 26.66 percent and 6.66 per cent of adopters who were having medium and high levels of yield of mandarin crop, respectively. In case of non-adopter, it was found that 76.66 per cent were having low levels of yield of mandarin crop, followed by 20.00 per cent and 3.33 per cent of them having medium and high levels of yield, respectively. It might be due to the reason that, very high cost incurred initiallyfor adoption of Indo-Israel technology and fruitful results could bevisible over time after adoption of Indo-Israel technology as compared to the traditional mandarin growing practice.

The coefficient of correlation between the selected characteristics of adopter Indo-Israel technology and non-adopter mandarin growers with their yield of mandarin is presented in Table 2.

Table 2: Coefficient of correlation with yield of selected characteristics of Indo-Israel technology adopter and non- adopter mandarin growers

S. N.	Characteristics	'r' value	
		Adopter	Non-adopter
1.	Age	0.035	0.051
2.	Education	0.267*	0.209*
3.	Land holding	0.619**	0.745*
4.	Occupation	0.213*	0.016
5.	Farming experience	0.801**	-0.054
6.	Area under Mandarin cultivation	0.302**	0.890**
7.	Method of irrigation	0.221*	0.216*
8.	Source of information	0.353**	0.133*
9.	Economic motivation	0.291**	0.129
10.	Innovativeness	0.083	0.213*
11.	Perception towards Indo-Israel technology	0.299*	0.208*
12.	Risk preference	0.435**	0.449*

**Significant at 0.01 level of probability
*Significant at 0.05 level of probability

The data (Table 2) revealed that, the characteristics of adopter of Indo-Israel technology viz. land holding, farming experience, area under mandarin cultivation, source of information, economic motivation, and risk preference was found to be positively and highly significant with yield at 0.01 level of probability. The other characteristics viz. education, occupation, method of irrigation and perception towards Indo-Israel technology were found to be positively significant at 0.05 level of probability with yield of mandarin crop.

In case of non-adopter of Indo-Israel technology, it could be clearly observed that,the characteristics viz. area under mandarin cultivation was found to be positively and highly significant with yield at 0.01 level of probability. The characteristics viz.education,land holding, method of irrigation, source of information, innovativeness, perception towards Indo-Israel technology and risk preference were found to be positively significant at 0.05 level of probability with yield mandarin crop.

As regards the correlation analysis, it inferred that the characteristics of Indo-Israel technology adopter mandarin growers viz. land holding, farming experience,

area under mandarin cultivation, source of information, economic motivation, risk preference, education, occupation, method of irrigation and perception towards Indo-Israel technology contributed significantly for increasing the yield level of mandarin crop. Whereas, the characteristics of non-adopter of Indo-Israel technology viz. area under mandarin cultivation, education, land holding, method of irrigation,source of information, innovativeness, perception towards Indo-Israel technology and risk preference contributed significantly with the yield level of mandarin crop (Shah, 2012).

CONCLUSION

The findings of the research study concluded that, the yield level of mandarin growers in case of adopter of Indo-Israel technology were significantly correlated with the characteristics viz. land holding, farming experience, area under mandarin cultivation, source of information, economic motivation, and risk preference.Whereas in case ofnon-adopter of Indo-Israel technology mandarin growers yield level was highly significant with the characteristics area under mandarin cultivation under mandarin crop. Hence, it is necessary to consider and focus on these issue and characteristics for increasing the yield of mandarin crop.

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Response of Different Storage Packages on Oil Content in *Azadiractha indica* (A. Juss) Seeds Collected At Initial Stage

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ABSTRACT

Azadiractha indica A. Juss (Meliaceae) is a tropical and subtropical species locally found in Indian subcontinent commonly known as 'Neem' or 'Margosa'. Almost every parts of neem tree have medicinal values and also used as fuel wood, minor timber products, fodder in dry period. The kernels of Neem contain 40 to 50 per cent of oil. There are limitations in neem seeds to retain oil content for longer period of time; therefore, this study was conducted at IGKV, Raipur with aim-to identify the response of seed storage packages on variation of oil content in kernel of *Azadiractha indica,* when seeds were collected at initial stage *i.e.* during 1st to 15th June. The results revealed that, in kernel loss of oil content was minimum (4.19 %) in the treatment (A1B2D1) when seeds were dried in shade (D1) and kept in desiccators with cotton bag (B2) at room temperature (A1) 32°C ± 2, while maximum loss (7.58%) was observed in the treatment (A2B1D2) when sun dried (D2) seeds were kept at open in cotton bags (B1) and stored at low temperature (A2) 2°C ± 2.

Azadirachta indica A. Juss (Meliaceae) is a tropical and subtropical species indigenous to India and Southeast Asia commonly known as 'Neem' or 'Margosa'. It is an established fact that tree species with a wide geographical distribution exhibit considerable variation in anatomy, physiology, morphology and genetics to survive and reproduce under varying environmental conditions over generations (Antonovics, 1971) and (Nienstaedt, 1975). Neem trees are distributed in a diverse agro-ecological range in India and neighboring countries and large variations in morphological (e.g., seed weight, leaf shape and phenology) and biochemical characteristics (e.g., azadirachtin and oil content of kernels) have been reported by Tewari (1992), Oo (1987) and Ermel (1995). In kernels of neem contain 40 to 50 per cent of oil. There are limitations in neem seeds to retain oil content for longer period of time; therefore this study have been conducted at IGKV, Raipur, to evaluate the response of seed storage packages on variation of oil content in kernel of *Azadiractha indica*.

MATERIAL AND METHODS

The survey was conducted in Raipur district in the month of June covering wide range of fruiting period of tree, fruits were collected during fortnight of June i.e. 1st to 15th June, 2016. From different location total 175 trees were selected at random to ensure inclusion of local genetic variability. Within 24 hours of collection, fruits were de-pulped and seeds were washed thoroughly with tap water and some seed samples were air dried in shade at room temperature and other sample in full sunlight, both for 48–72 hours (Kaura, 1998). Thereafter, seeds were kept in cotton cloth bags and stored at room temperature and also at low temperature. These seeds kept in open mouth cotton bags were stored at humid conditions available in open and closed dedicator containing silica gel at room temperature of 32°C±2 and other seed samples in desiccator containing silica gel at low temperature of 2°C±2 in freezer. The treatment details i.e. storage packages were designed as storage temperatures (A) *viz*. room temperature 32°C ±2 (A1) and low temperature 2°C±2 (A2); storage conditions (B) *viz*. in bags at open (B1) and in desiccator with cotton bag (B2) and drying methods (D) *i.e.* in shade (D1) and in sun (D2). On the basis of storage temperature, condition and drying methods eight interactions (packages) of treatment was studied as A1B1D1, A1B1D2, A1B2D1, A1B2D2, A2B1D1, A2B1D2, A2B2D1 and A2B2D2. Twenty seed weight was recorded using five random samples. Initially, percent of oil content in kernels was extracted by standard distillation method of A.O.A.C., it was done by Soxhlet unit and measured (Medsen, 1976). There after oil content was measured regularly after storage treatment (DAT) at 30 days of interval till ten months (300 days). From each treatment the average oil content and its loss was recorded. Statistical tools were used for analysis of the data (Panse and Sukhatme, 1967).

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RESULTS AND DISCUSSION

The oil content was determined regularly after 30 days of interval till ten months of storage treatment (DAT). The result revealed that the loss of oil content in stored seed material was 1.77 (4.19%) to 3.20 (7.58%) in kernel during 300 days after treatment (Table 1). It was observed that the percentage loss of oil content was lower (4.19 %) in treatment (A1B2D1) i.e. when seeds were dried in shade (D1) and kept in desiccators (B2) at room temperature (A1), whereas it was recorded maximum loss (7.58 %) in the treatment (A2B1D2) when sun dried seeds (D2) were kept in cotton bags (B1) and stored at low temperature ($2^0C\pm2$) (A2).

The effect of storage temperature, storage and drying condition on oil content percentage in kernel of *Azadirachta indica* at 150 DAT and 300 DAT, was significant, while at other treatments period had no significant effect on the oil content. Seed oil content in most of the provinces was not consistently and significantly correlated with morphological parameters of seeds. Better fruits produce oils of higher quality and uniform plantations produce stable oils (Valenzuela, *et. al.* 2007).

Table 1 : Effect of storage temperature, storage and drying condition on oil content percentage in kernel of *Azadirachta indica* during 1st to 15th June (initial collection period)

Treatments (Storage Packages)	Oil content in kernel (%)									
	30 DAT	60 DAT	90 DAT	120 DAT	150 DAT	180 DAT	210 DAT	240 DAT	270 DAT	300 DAT
A1B1D1	42.17	42.06	41.96	41.86	41.40	41.10	40.39	40.58	40.15	39.99
A1B1D2	42.13	41.84	41.88	41.78	41.03	41.13	40.51	40.14	39.87	39.73
A1B2D1	42.20	42.18	41.02	41.89	41.81	41.62	40.59	40.90	40.55	40.43
A1B2D2	42.18	42.07	41.85	41.80	41.75	40.95	40.87	40.65	40.00	39.94
A2B1D1	42.30	42.10	41.44	40.54	40.57	40.06	39.09	39.90	39.27	39.19
A2B1D2	42.21	41.12	41..05	40.58	40.35	39.94	39.70	38.72	39.18	39.01
A2B2D1	42.47	42.03	41.07	42.00	41.59	41.42	40.98	40.97	40.25	40.02
A2B2D2	41.80	41.48	41.29	41.14	41.06	40.67	40.53	40.04	40.01	38.92
SE (m)±	0.27	0.13	0.06	0.09	0.09	0.16	1.82	0.68	0.20	0.02
CD (5%)	NS	NS	NS	NS	0.25	NS	NS	NS	NS	0.05

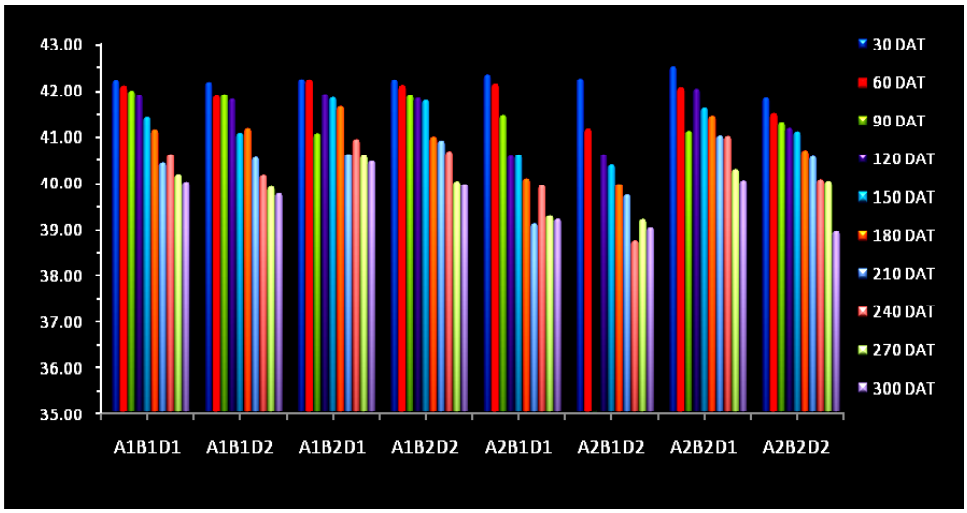

Fig. 1 : Treatment wise status of oil content in kernel at every 30 days of interval

Variation of oil content in kernel at the interval of 30 DAT:

The treatment wise status of oil content at every 30 days of interval in kernel was presented in fig.1 and it was observed that in kernel, the loss of oil content in stored seed material ranges from 4.19 to 7.58 per cent at 300 DAT. The average percent of oil content was highest (41.32%) in the treatment A1B2D1 followed by A2B2D1 (41.28%) and A1B2D2 (41.21%), whereas lowest measured in A2B1D2 (40.19%) followed by A2B1D1 (40.45%).By comparing, first150 DAT and later 150 DAT, the average oil content in treatment A1B1D2 showed similar trend i.e. 41.73% and 40.40% respectively. Average oil content during first150 DAT and later 150 DAT was found highest in A1B2D2 with 41.93 % and 40.98 % respectively. Similar trend of lowest average oil content was observed in A2B1D2 with 41.06% and 39.48 % in first150 DAT and later 150 DAT respectively.

While, comparing the average difference of loss of oil content in first150 DAT and later 150 DAT was observed lower in A1B2D1 (0.55%) followed by A2B2D1 (0.64%) and A2B2D2 (0.76%), while found highest in A2B1D2 (1.14%) and A2B1D2 (1.05%)

Intisar (22006) observed Az-content ranged from 1.08 to 2.3 mg/g of the seed kernel in the first season of (2001) and from 0.48 to 3.09 mg/g in the second season of (2002) whereas, the average content of the neem oil (N.O.) was 44.6 per cent in the neem seed kernel (NSK).

Status of average loss of oil content in kernel at 300 DAT : The observations presented in fig.2, revealed that after 300 days of treatment average percentage loss of oil content was lower (4.19%) in treatment (A1B2D1) i.e. when seeds were dried in shade (D1) and kept in desiccators (B2) at room temperature (A1) followed by A1B1D1 (5.17%) and A1B2D2 (5.31 %) and recorded maximum loss (7.58%) in the treatment (A2B1D2) when sun dried seeds (D2) kept in cotton bags at open (B1) and stored at low temperature ($2^0C\pm2$) (A2) followed by A2B1D1 (7.35 %) and A2B2D2 (6.89 %). The oil content was significantly affected by storage treatments (Intisar, 2006).

CONCLUSION

It was concluded that fresh neem fruits collected (June fortnight) and properly treated seed was effective under the storage package when seeds dried in shade (D1) and kept in desiccator with cotton bags (B2) at room temperature i.e. $32^oC\pm2$ (A1) was able to minimize the loss

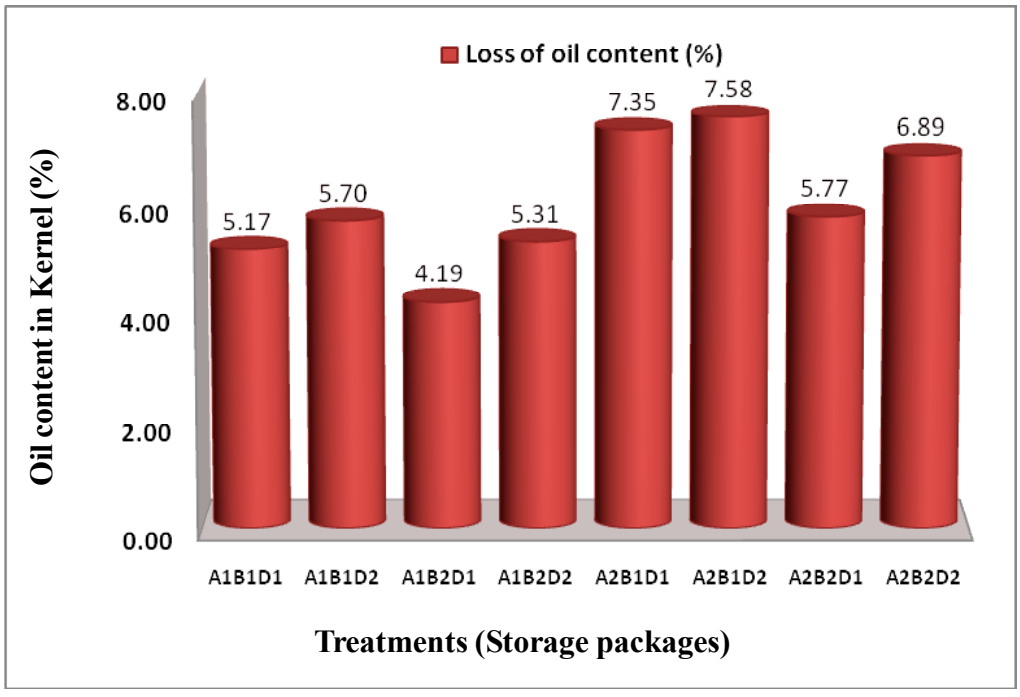

Fig. 2 : Average loss of oil content in kernel at 300 DAT

of oil content upto 4.19 per cent in the kernel during 300 days after treatment.

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SHORT NOTES

Response of Little Millet Varieties to Different Levels of Fertilizers Under Rainfed Condition

Little millet *(Panicum sumatrense* L.) is one of the minor millet, which belongs to family *Poaceae* and reliable catch crop in view of its earliness and resistance to adverse agro-climatic conditions of high drought as well as water logging. It is grown throughout India and a traditional crop of Karnataka. It is mostly cropped with other millets, pulses and oilseeds. It is generally consumed as rice and any recipe that demands staple rice can be prepared using little millet. It is described as a "quick growing, short duration cereal which withstands both drought and water logging". Doubtless this is a valuable crop in difficult situations. It occurs as wild crop in Northern India and South Eastern Asia. The crop is a balanced and staple food of tribal and economically poor section of the population. It provides low priced proteins, minerals and vitamins in the form of sustainable food. The stover is a good fodder for cattle.

Nitrogen is of vital importance to the physiology of little millet. It plays a critical role in the process of photosynthesis by which plants manufacture their own food from sunlight. Plants that are deficient in nitrogen grow poorly and develop yellowing leaves. Nitrogen is major component of amino acids and the building blocks of protein. Similarly phosphorus is an essential nutrient for animals and plants. Insufficient phosphorus in the soil can result in a decreased crop yield. It is involved in several key plant functions, including energy transfer, photosynthesis, transformation of sugars and starches, nutrient movement within the plant and transfer of genetic characteristics from one generation to the next. Traditionally, little millet is grown in low fertile soils without application or limited fertilizer application. However, experimental results indicated that the crop responds favorably to low fertilizer application.

The field experiment was laid out in a factorial randomized block design (FRBD) comprising eight treatment combinations replicated thrice *viz*. V_1-Phule Ekadashi, V_2-OLM 203, and four fertilizer levels F_1-75 per cent RDF, F_2-100 per cent RDF, F_3-125 per cent RDF,F_4-150 per cent RDF. The gross and net plot sizes were 4.50 x 3.0 m^2 and 3.90 x 2.40 m^2, respectively. Little millet crop was transplanted at row to row and plant to plant spacing with 30 cm × 7.5 cm.

The Post Graduate Research Farm, College of Agriculture, Kolhapur is geographically situated between $16^0$42' North latitude and $74^0$14' East longitude having elevation of 548 meters above the mean sea level. It comes under the Sub-montane zone of Maharashtra with average annual rainfall 1061 mm being received in 66 rainy days. Out of which 80 per cent rainfall receives from South West monsoon in June to September. Rest of the rainfall is received in the month of October and November from North East monsoon. The soil of experimental plot was sandy clay loam in texture, medium in available nitrogen and phosphorus and high in available potassium. It was slightly alkaline in reaction.

Growth contributing characters

Effect of varieties

The highest plant height was observed in Phule Ekadashi which was significantly superior over OLM-203 at all growth phases. The increase in height of Phule Ekadashi is genetically governed phenomena of harmonal balance, nutrient absorption capacity and conversion of radiant energy in presence of chlorophyll. All this process reflects in increase in plant height and all growth contributing characters. Similar results were reported by Bhomte *et al*., (2013), Patil *et al*., (2015), and Anonymous (2015).The mean number of tillers $plant^{-1}$and number of leaves were significantly higher in Phule Ekadashi over OLM-203. The Phule Ekadashi is significantly superior over OLM 203, it was observed that Phule Ekadashi has more genetical potential to enlarge the leaf size during growth period than OLM 203.

The dry matter accumulation was higher in Phule Ekadashi which was significantly superior over OLM-203. Dry matter accumulation is the result of all the growth and yield attributes namely plant height, number of tillers, number of leaves, leaf area etc. The Phule Ekadashi had high source sink relationship as compared to OLM-203. The dry matter production is largely function of photosynthetic surface which had favorably influenced

by Phule Ekadashi. Days to 50 per cent flowering and maturity did not differ significantly due to little millet varieties.

Effect of fertilizer levels

The significantly higher plant height of little millet was recorded as 150 percent RDF which was on par with 125 percent RDF and significantly superior over rest of the treatments. 125 and 150 per cent RDF provides sufficient nutrient to plant which leads to anatomical changes such as increase in size of cells, intercullar spaces, thinner cell walls and lower development of epidermal tissue resulted to increase in plant height.

The higher number of tillers plant^{-1}of little millet observed due to 150 percent RDF which was on par with 125 percent RDF and significantly superior over rest of the treatments. This might be due to luxuriant availability of nutrient for growth and development of auxillary bud from which tillers are emerged.These results are in corroborative with the findings of Sunitha *et al.,* (2004), Deshmukh (2007) and Pradhan *et al*. (2011).

The highest number of leaves plant^{-1} and leaf area plant^{-1}of little millet were influenced significantly due to different fertilizer levels. Application of 150 per cent RDF recorded highest number of leaves plant^{-1} and leaf area which was at par with 125 per cent RDF and significantly superior over rest of the treatments. This might be due to higher availability of nitrogen and phosphorus at vegetative and reproductive phases enables plants for promotion of cell division and expansion of leaves. Similar findings were reported by Deshmukh (2007).

Dry matter plant^{-1} was significantly higher due to 150 percent RDF which was at par with 125 percent RDF and significantly superior over rest of the treatments. These result are also supported by Ramamoorthy and Lourduraj (2002), Sunitha *et al.,* (2004), Deshmukh (2007) and Pradhan *et al*. (2011).

Interaction

All the interaction effects were found to be non-significant.

Yield attributing characters, yield and economics

Effect of varieties

The length of panicle, grain weight per panicle and test weight of little were influenced significantly due to different little millet varieties. The Phule Ekadashi variety of little millet was recorded significantly higher length of panicle, grain weight per panicle and test weight over OLM-203. The difference in these characters in little millet varieties might be due to inherent genetic potential of varieties.

The grain and straw yield of little millet was influenced significantly due to different little millet varieties. The Phule Ekadashi variety of little millet was recorded significantly higher grain and straw yield over OLM-203. The difference in grain and straw yield in little millet varieties might be due to inherent genetical potential of little millet varieties (Annonymous, 2015).

The net monetary returns had significantly influenced by the different little millet varieties. The Phule Ekadashi variety of little millet recorded significantly higher net monetary returns (Rs. 24695 ha^{-1}) over OLM 203 (Rs.9695 ha^{-1}). The Phule Ekadashi variety of little millet recorded higher B: C ratio (1.84) over OLM 203 (1.33).

Effect of fertilizer levels

The length of panicle of little was influenced significantly due to different fertilizer levels. The application of 150 percent RDF recorded significantly higher panicle length which was at par with 125 per cent RDF and significantly superior over rest of the treatments. This might be due to availability of nitrogen and phosphorus to plants resulted in higher accumulation of photosynthetic assimilates might be responsible for higher length of panicle.

The test weight of little millet was differed significantly due to different fertilizer levels. The application of 150 per cent RDF recorded significantly higher test weight which was at par with 125 per cent RDF and significantly superior over rest of the treatments. Higher source to sink relationship leads to higher values of test weight. Results are in agreement with those obtained by Ramamoorthy and Lourduraj (2002), Pradhan *et al*. (2011).

The grain weight panicle^{-1} of little millet was influenced significantly due to different fertilizer levels. The application of 150 percent RDF recorded significantly higher grain weight panicle^{-1} which was at par with 125 percent RDF and significantly superior over rest of the treatments. This might be due to reproductive phase reduce seed membrane integrity, embryo RNA content,

Table 1. Effect of varieties and fertilizer levels on growth contributing characters of little millet

Treatment	Plant height (cm)	Tillers plant^{-1}	Number of leaves plant^{-1}	Leaf area plant^{-1} (dm^{-2})	Dry matter plant^{-1} (g)	Days to 50% flowering	Days to maturity
Varieties							
V_1 – Phule Ekadashi	116.76	5.85	20.80	260.03	7.48	83	123
V_2 – OLM 203	110.94	4.89	16.48	253.57	6.34	85	125
SE (m) ±	1.20	0.13	1.17	1.60	0.16	1.20	1.71
C.D. at 5 %	3.60	0.37	3.51	4.82	0.49	NS	NS
Fertilizer levels							
F_1 – 75 % RDF	106.79	4.12	16.0	245.37	5.41	83	123
F_2 – 100 % RDF	109.09	45.21	16.56	253.54	6.74	84	124
F_3 – 125 % RDF	117.75	5.84	20.74	262.74	7.84	84	124
F_4 – 150 % RDF	120.81	6.32	21.26	265.17	8.22	85	124
SE (m) ±	1.71	0.15	0.05	2.21	0.27	1.27	1.51
CD at 5%	3.54	0.44	3.17	6.64	0.81	NS	NS
Interaction effect (V x F)							
S.E (m) ±	2.42	0.29	1.18	2.30	0.29	1.30	1.28
C. D. at 5 %	NS	NS	NS	NS	NS	NS	NS
General mean	113.85	5.37	18.64	256.70	7.01	84	124

Table2. Effect of varieties and fertilizer levels on yield contributing characters, yield and economics of little millet

Treatment	Length of panicle (cm)	Grain yield (g) panicle^{-1}	Test wt. (g)	Grain yield q ha^{-1}	Straw yield qha^{-1}	Net returns (Rs ha^{-1})	B:C ratio
Varieties							
V1–Phule Ekadashi	24.16	3.82	2.52	13.45	16.21	24695	1.84
V2 – OLM 203	19.20	2.91	2.19	9.70	12.83	9695	1.33
SE (m) ±	0.33	0.04	0.04	0.40	0.52	1600	-
C.D. at 5 %	1.00	0.13	0.12	1.21	1.56	4810	-
Fertilizer levels							
F1 – 75 % RDF	19.21	2.88	2.01	9.32	12.01	8643	1.30
F2 – 100 % RDF	21.24	3.10	2.26	11.0	14.10	15051	1.51
F3 – 125 % RDF	22.40	3.54	2.54	12.60	15.87	21139	1.72
F4 – 150 % RDF	23.87	3.86	2.63	13.40	16.10	24027	1.81
SE (m) ±	0.38	0.15	0.04	0.32	0.21	1280	-
CD at 5%	1.14	0.45	0.12	0.97	0.64	3840	-
Interaction effect (V x F)							
S.E (m) ±	0.42	0.18	0.06	0.33	0.27	1320	-
C. D. at 5 %	NS	NS	NS	NS	NS	NS	-
General mean	21.68	3.37	2.41	11.58	14.52	17215	

chlorophyll synthesis and dehydrogenase activity.

The grain yield of little millet was influenced significantly due to different fertilizer levels. The application of 150 percent RDF recorded significantly higher grain yield which was at par with 125 per cent RDF and significantly superior over rest of the treatments. This

might be due to high chlorophyll synthesis and dehydrogenase activity, also it affects source to sink relationship which reflects in higher yields. Similar result were observed in Bhomte (2013) and Anonymous (2015).

The straw yield of little millet was influenced significantly due to different fertilizer levels. The application of 150 per cent RDF recorded significantly higher straw yield which was on par with 125 per cent RDF and significantly superior over rest of the treatments. This might be due to better root activity, good source to sink relationship and high physiological activities which synthesized cytokinise. Similar result were reported by Deshmukh (2007) and Pradhan *et al*. (2011).

Application of 150 per cent RDF gave significantly higher net monetary returns (Rs. 24027 ha^{-1}), which was at par with 125 per cent RDF (Rs. 21139 ha^{-1}) and significantly superior over rest of the treatments *viz*. 75 and 100 per cent RDF. These results are also supported by Ramamoorthy and Lourduraj (2002) and Bhomte *et al*., (2013). Application of 150 per cent RDF recorded higher B: C ratio (1.81) followed by 125, 100 and 75 per cent RDF. Similar results were also reported by Ramamoorthy and Lourduraj (2002), Sunitha *et al.,* (2004) and Bhomte *et al*., (2013).

Interaction

All the interaction effects were found to be non-significant.

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Effect of Organic Sources on Yield of Wheat and Soil Fertility

With the increasing population the main goal of agriculture is to provide safe and quality food to the world. Many modern techniques are being adopted for the improvement of the agricultural production, this improvements not only depends on modern machineries and hybrids, but also on soil properties. The productivity and quality of the crop is controlled by many factors of which nutrition is the most important factor. Crops removes annually large quantities of plant nutrients from soil. On account of continuing world energy crisis and spiraling price of chemical fertilizers, the use of organic sources as a renewable source of plant nutrients is assuming importance. In this endeavor proper blend of organic fertilizer is important not only for increasing yield but also for sustaining soil health.

The imbalance use of chemical fertilizers can lead to soil acidification because of a decrease in organic matter in the soil. Continuous use of chemical fertilizers on soil depletes the soil of essential nutrients. So to counter the above mentioned problems and improve the soil properties, supply of nutrients for the growing crops can be done by applying different combination of organics.

The experiment was conducted in *rabi* season of 2020-21 on Wheat Research Unit, Dr PDKV, Akola, Maharashtra. The initial soil properties were slightly alkaline in reaction (8.01), non-saline (0.24 dS m^{-1}), medium in organic carbon (4.21 g kg^{-1}), moderately calcareous in nature (7.83%), low in available nitrogen (180.6 kg ha^{-1}), low in available phosphorus (14.73 kg ha^{-1}), medium in available potassium (296.45 kg ha^{-1}) and marginal in available S (11.26 mg kg^{-1}). The experiment was conducted in RBD with three replications.

Experiment consisted of 10 treatments, *viz* Control (T_1), 100 per cent RDF at sowing (T_2), Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5 per cent + Cow urine @ 2 per cent at 30-35 and 60-65 DAS (T_3), Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS (T_4), Compost @ 2.5 t ha^{-1} + spraying of Gibberllic acid (2.5 ml) at 30-35 and 60-65 DAS(T_5), Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5 per cent and Moringa leaf extract @ 5 per cent at 30-35 and 60-65 DAS(T_6), Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5 per cent + *Lantana camara* leaf extract @ 5 per cent + Pomegranate leaf extract @ 5 per cent at 30-35 and 60-65 DAS(T_7), Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5 per cent + Gibberllic acid 2.5 ml at 30-35 and 60-65 DAS (T_8), Compost @ 2.5 t ha^{-1} + Potassium humate @ 80 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS(T_9), Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10 per cent + Humic acid @ 20 per cent + sea weed extract @ 5 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS(T_{10}). Wheat was sown on 15th Dec, 2020 and harvested on 30th Mar, 2021.

Plot-wise soil samples (0-20 cm) were collected after harvest of wheat. The samples were analysed for pH (1:2.5 soil:water suspension), electrical conductivity by conductivity meter, organic carbon by Walkley and Black Method (Nelson and Sommers 1982), rapid titration method as described by Piper (1966) was used to determine calcium carbonate content of soil, available N was estimated by alkaline permanganate method (Subbiah and Asija 1956), intensity of colour was recorded using U.V. spectrophotometer as described by Watanabe and Olsen (1965), and DTPA-Zn, Fe, Mn and Cu were determined from soil extract with atomic absorption spectrophotometer as described by Lindsay and Norvell (1978).

The grain yield of the sun dried produce of the crop was recorded after threshing, sun drying and cleaning the grains separately for each plot. Straw yield was calculated by deducting grains weight from the weight of total harvested produce of the respective plots. Uptake of nutrients viz. N, P, K, S, Fe, Zn, Cu and Mn was calculated by considering grain and dry matter yield at harvest in the particular plot in relation to concentration of the particular nutrient in respective treatment.

Initial chemical properties of experimental soil at the start of experiment

S.N.	Particulars	Value
A	**Soil properties**	
1	pH (1:2.5)	8.01
2	EC (dS m^{-1})	0.24
3	Organic carbon (g kg^{-1})	4.21
4	Calcium carbonate ($CaCO_3$) (%)	7.83
B	**Fertility status**	
1	Available N (kg ha^{-1})	180.6
2	Available P_2O_5 (kg ha^{-1})	33.7
3	Available K_2O (kg ha^{-1})	296.45
4	Available S (mg kg^{-1})	11.26

Table 1. Yield of wheat as influenced by various treatments

	Treatments	Wheat yield(q ha^{-1})	
		Grainyield	Strawyield
T_1	Control	25.53	39.41
T_2	100% RDF	38.75	54.35
T_3	Compost @ 2.5 t ha^{-1} + spraying of compost extract @ 5% + Cow urine @ 2% at 30-35 and 60-65 DAS.	29.97	41.63
T_4	Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5% at 30-35 and 60-65 DAS.	30.42	42.58
T_5	Compost @ 2.5 t ha^{-1} + spraying of Gibberllic acid (2.5 ml) at 30-35 and 60-65 DAS.	28.93	41.50
T_6	Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5% and Moringa leaf extract @ 5% at 30-35 and 60-65 DAS.	27.92	41.08
T_7	Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5% + Lantana camara leaf extract @ 5% + pomegranate leaf extract @ 5% at 30-35 and 60-65 DAS.	29.68	42.55
T_8	Compost @ 2.5 t ha^{-1} + spraying of Compost extract @ 5% + Gibberllic acid 2.5 ml at 30-35 and 60-65 DAS.	29.23	42.58
T_9	Compost @ 2.5 t ha^{-1} + Potassium humate @ 80% + spraying of Compost extract @ 5% at 30-35 and 60-65 DAS.	33.28	46.89
T_{10}	Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10% + Humic acid @ 20% + sea weed extract @ 5% + spraying of Compost extract @ 5% at 30-35 and 60-65 DAS	33.97	47.56
	SE (m) ±	2.21	2.55
	CD at 5%	6.58	7.59

Table 2. Effect of organic sources on chemical properties of soil

	Treatments	pH (1:2.5)	EC (dS m^{-1})	OC (g kg^{-1})	$CaCO_3$ (%)
T_1	Control	7.95	0.23	4.17	7.83
T_2	100% RDF	7.92	0.30	4.32	7.86
T_3	Compost 2.5 t ha^{-1} + spraying of compost extract 5% + Cow urine 2% at 30-35 and 60-65 DAS.	7.79	0.24	4.48	7.81
T_4	Compost 2.5 t ha^{-1} + spraying of Compost extract 5% at 30-35 and 60-65 DAS.	7.77	0.24	4.51	7.81
T_5	Compost 2.5 t ha^{-1} + spraying of Gibberllic acid (2.5 ml) at 30-35 and 60-65 DAS.	7.81	0.26	4.51	7.79
T_6	Compost 2.5 t ha^{-1} + spraying of Compost extract 5% and Moringa leaf extract 5% at 30-35 and 60-65 DAS.	7.78	0.26	4.48	7.75
T_7	Compost 2.5 t ha^{-1} + spraying of Compost extract 5% + Lantana camara leaf extract 5% + pomegranate leaf extract 5% at 30-35 and 60-65 DAS.	7.79	0.24	4.39	7.82
T_8	Compost 2.5 t ha^{-1} + spraying of Compost extract 5% + Gibberllic acid 2.5 ml at 30-35 and 60-65 DAS.	7.75	0.26	4.38	7.76
T_9	Compost 2.5 t ha^{-1} + Potassium humate 80% + spraying of Compost extract 5% at 30-35 and 60-65 DAS.	7.73	0.26	4.52	7.81
T_{10}	Compost 2.5 t ha^{-1} + Fulvic acid 10% + Humic acid 20% + sea weed extract 5% + spraying of Compost extract 5% at 30-35 and 60-65 DAS.	7.81	0.26	4.53	7.77
	SE (m) ±	0.10	0.02	0.063	0.12
	CD at 5%	NS	NS	0.19	NS

Table 3. Effect of organic sources on available nutrient in soil

	Treatments	Available nutrients							
		N	P	K	S	Zn	Fe	Mn	Cu
		(kg ha^{-1})					(mg kg^{-1})		
T_1	Control	172.7	12.10	287.5	11.38	0.35	11.26	9.05	2.66
T_2	100% RDF	187.6	17.48	302.7	11.49	0.41	13.43	9.44	2.72
T_3	Compost 2.5 t/ha + spraying of compost extract 5% + Cow urine 2% at 30-35 and 60-65 DAS.	92.0	14.48	296.2	11.69	0.35	11.76	9.09	2.75
T_4	Compost 2.5 t/ha + spraying of Compost extract 5% at 30-35 and 60-65 DAS.	193.2	14.85	294.2	11.89	0.36	11.91	9.42	2.77
T_5	Compost 2.5 t/ha + spraying of Gibberllic acid (2.5 ml) at 30-35 and 60-65 DAS.	191.1	14.94	294.8	11.96	0.37	12.16	9.23	2.73
T_6	Compost 2.5 t/ha + spraying of Compost extract 5% and Moringa leaf extract 5% at 30-35 and 60-65 DAS.	194.1	14.44	294.7	11.78	0.37	12.63	9.31	2.70
T_7	Compost 2.5 t/ha + spraying of Compost extract 5% + Lantana camara leaf extract 5% + pomegranate leaf extract 5% at 30-35 and 60-65 DAS.	196.3	14.48	295.3	11.82	0.35	12.51	9.13	2.80
T_8	Compost 2.5 t/ha + spraying of Compost extract 5% + Gibberllic acid 2.5 ml at 30-35 and 60-65 DAS.	195.0	14.06	294.3	11.88	0.36	12.83	9.19	2.79
T_9	Compost 2.5 t/ha + Potassium humate 80% + spraying of Compost extract 5% at 30-35 and 60-65 DAS.	202.6	14.32	301.0	11.96	0.36	12.63	9.48	2.84
T_{10}	Compost 2.5 t/ha + Fulvic acid 10% + Humic acid 20% + sea weed extract 5% + spraying of Compost extract 5% at 30-35 and 60-65 DAS.	205.6	14.61	301.7	11.99	0.36	12.70	9.40	2.80
	SE (m) ±	3.81	0.75	2.63	0.69	0.02	0.62	0.17	0.05
	CD at 5%	11.32	2.23	7.81	NS	NS	NS	NS	NS
	Initial	180.6	14.49	296.45	11.26	0.32	11.07	9.02	2.63

5	DTPA extractable Zn (mg kg^{-1})	0.32
6	DTPA extractable Fe (mg kg^{-1})	11.07
7	DTPA extractable Mn (mg kg^{-1})	9.02
8	DTPA extractable Cu (mg kg^{-1})	2.63

Yield of wheat

The significantly higher grain yield (38.75 q ha^{-1}) of wheat (Table 1) was recorded with the application of 100 per cent RDF (T_2). Among all the organic sources, application of Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10 per cent + Humic acid @ 20 per cent + sea weed extract @ 5 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS (T_{10}) and Compost 2.5 t ha^{-1} + Potassium humate 80 per cent + spraying of Compost extract 5 per cent at 30-35 and 60-65 DAS (T_9) recorded the highest grain yield and they were found to give 33.06 and 30.36 per cent higher grain yield as compared to control, respectively.

Significantly highest straw yield (54.35 q ha^{-1}) of wheat was recorded with 100 per cent RDF (T_2).

It is emanated from the data that, among all the organic sources application of Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10 per cent + Humic acid @ 20 per cent + sea weed extract @ 5 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS (T_{10}) and Compost @ 2.5 t ha^{-1} + Potassium humate @ 80 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS (T_9) registered the highest yield. This might be due to the application of compost which increases the available nutrients in soil which became available to plants. Humic acid contains plant growth hormones mainly auxin which ensure increase in yield and addition of fulvic acid can improve nutrient availability in soils and potassium humate increases the nutrient content in soils. Similar results have been also reported by Atiyeh *et al*. (2002), Sarwar *et al*. (2008) and Kumar *et al*. (2019).

Chemical properties of soil

The pH of soil ranged from 7.73 to 7.95 indicating that the soil was slightly alkaline in reaction but not influenced statistically. The data in respect of electrical conductivity ranged from 0.23 to 0.30 dSm^{-1} which is normal and favourable for plant growth. The calcium carbonate content ranged from 7.75 to 7.86 per cent. However, the treatment wise variation in calcium carbonate was found to be non-significant (Table 2).

The significantly highest soil organic carbon (4.53 g kg^{-1}) was recorded with the application of Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10 per cent + Humic acid @ 20 per cent + sea weed extract @ 5 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS (T_{10}) and it was found to be on par with all the other organic treatments. The application of Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10 per cent + Humic acid @ 20 per cent + sea weed extract @ 5 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS (T_{10}) increased the organic carbon in soil by 8.63 and 4.86 per cent over control and 100 per cent RDF, respectively. The soil organic carbon was enhanced due to the application of various organic treatments which leads to addition of higher organic carbon directly through compost and other organic sources. Andrews *et al*. (2002) reported that the application of compost increased organic carbon as compared with conventional fertilized sites, Shelke (2001) reported that application of compost helps in liberation of organic acids during mineralisation and balanced C/N ratio which results in higher organic carbon in soil.

Available nutrients

The significantly highest available nitrogen (205.6 kg ha^{-1}) was observed with the application of Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10 per cent + Humic acid @ 20 per cent + sea weed extract @ 5 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS (Table 3). The increase in available nitrogen was 19.05 and 9.59 per cent over control and 100 per cent RDF respectively due to Compost @ 2.5 t ha^{-1} + Fulvic acid @ 10 per cent + Humic acid @ 20 per cent + sea weed extract @ 5 per cent + spraying of Compost extract @ 5 per cent at 30-35 and 60-65 DAS. Humic acid, compost, fulvic acid and sea weed extract increases the availability of nitrogen in soil as this substances enhanced the microbial activities in the soil. The increase in the available nitrogen in soil also might be due to the nature of humic substances to slow down the urease activity and also to inhibit the nitrification processes, therefore preventing the loss of nitrogen by leaching and volatilization. Similar findings are reported by Albaladejo *et al*. (2009), Muhammad *et al*. (2013) and Kumar *et al*. (2019).

The significantly higher available phosphorus (17.48 kg ha^{-1}) was observed in 100 per cent RDF. All the organic treatments recorded almost similar amount of available phosphorus in soil while treatment of Compost 2.5 t ha^{-1} + spraying of Gibberllic acid (2.5 ml) at 30-35 and

60-65 DAS recorded the highest available phosphorus in soil. The application of Compost 2.5 t ha^{-1} + spraying of Gibberllic acid (2.5 ml) at 30-35 and 60-65 DAS increased the available phosphorus status in soil by 23.47 per cent over control. Application of organic matter in soil increase the microbial activity in soil which leads to increase in release of phosphorus in soil. Similar findings were reported by Sarwar *et al*. (2008), Choudhary *et al* (2009). Ramadass *et al* (2007). reported that compost are rich in macro-nutrients so the application of compost in the soil acts as a source of slow-release nutrients.

The significantly highest available potassium (302.7 kg ha^{-1}) was observed in 100 per cent RDF. Among all the organic treatments the application of Compost 2.5 t ha^{-1} + Fulvic acid 10 per cent + Humic acid 20 per cent + sea weed extract 5 per cent + spraying of Compost extract 5 per cent at 30-35 and 60-65 DAS was recorded to be the highest. It increased the available potassium status in soil by 4.92 per cent as compared to control. The increase in available potassium in soil due to application of Compost 2.5 t ha^{-1} + Fulvic acid 10 per cent + Humic acid 20 per cent + sea weed extract 5 per cent + spraying of Compost extract 5 per cent at 30-35 and 60-65 DAS might be due to the application of humic substances and compost which results in release of various organic acids in soil. The hydrogen ions released from this organic materials are exchanged with the K ions on the clay micelle resulting in the increase of available potassium in soil. Similar findings are reported by Selvakumari *et al*. (2000) and Sarwar *et al*. (2008).

The soil was found to be marginal in available sulphur. This could be attributed to the application of organic treatments as well as fertilizers used in 100 per cent RDF which were low in sulphur content The effect of organic sources on available zinc, iron, manganese and copper of soil was found to be non-significant.

Hence it can be concluded that applying compost in the soil increases the availability of macro nutrients to the wheat crop and enhance the fertility of the soil.

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