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Effect of Rotational Speed and Feed Rate on Seed Damage During Ajwain Seed Extraction

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ABSTRACT

Spices seed extractor was developed to extract the seeds from ajwain flowers. The extractor is operated by 2 hp single-phase electric motor. The developed spices seed extractor consists of feeding hopper, extraction unit, sieve/cleaning unit, main frame and power transmission system. Machine and operational parameters were optimized for minimum seed damage during ajwain seed extraction. The optimized machine and operational parameters for minimum seed damage during ajwain seed extraction were found to be stud bolted type drum having rotational speed of 700 rpm and feed rate of 170 kg h^{-1}. The seed damage was found to be 2.84 per cent at optimized machine parameters.

Ajwain also known as carom seed (*Trachyspermum ammi* L.) belongs to the family Apiaceae which is a native from Egypt and popular seed spice crop in India. It is an annual herbaceous plant bearing small egg shaped grayish brown fruits. Plant parts usually consumed are herb, volatile oil and seeds. Seeds contain medicinal values specially for curing indigestion, stomach pain and elements concerning digestive system (Meena *et. al.,* 2010). Ajwain seed is an economic part which is used as spice. It is grown throughout country, mainly in plains, but flourishes equally well at higher altitudes, in plateaus and on hills. It is grown on a commercial scale in Rajasthan, Madhya Pradesh, Andhra Pradesh, Gujarat, Maharashtra, Uttar Pradesh and to considerable extent in Bihar and West Bengal.

Seed extraction/separation and cleaning is an important operation in a number of processes connected with the handling of seed after harvest. Traditional method of seed separation/extraction involve various operations like harvesting, sun drying, beating and winnowing. Operations being carried out manually, it takes more time and seed obtained by this method is of poor quality. Also presently no mechanical extractor is available for extraction and cleaning of ajwain seed. The spices seed extractor was developed for extraction of spices such as ajwain seeds mechanically. It was necessary to optimize the machine and operational parameters. Hence, the work was undertaken to optimize the machine and operational parameters for minimum seed damage during ajwain seed.

MATERIAL AND METHODS

The fully matured ajwain crop with well dried flowers of variety AA-01-19 available at the field of Chilli and Vegetable Research Unit, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola were used for conducting the experiments on ajwain seed extraction .

Spices seed extractor

The spices seed extractor was developed at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola and was used for the extraction of ajwain seeds. The spices seed extractor consisted of the following major units viz., i) Feeding hopper ii) Seed extraction unit iii) Sieve/Cleaning unit iv) Main frame and v) Power transmission system.

Optimization of parameters for minimum seed damage during extraction of ajwain seeds

Three types of extraction drums were fabricated for the experiments. The developed spices seed extractor was tested as per standard procedures for combination of various treatments. Based on feeler trials, some of the machine and operational parameters such as concave clearance, sieve aperture size and blower/fan speed were finalized for ajwain crop and were kept constant throughout the complete experimentation.

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Experiments were conducted to optimize the design parameters such as type of seed extraction mechanism (stud bolted drum, loop type drum, leather flap drum) and the operational parameters such as rotational speed and feed rate.

Ajwain crop samples each weighing 2 kg and having about 10 ± 0.5 % moisture content (w.b.) were used for extraction using the developed spices seed extractor. The variables of seed extraction experiments were optimized using Response Surface Methodology technique, since this is useful statistical technique for investigation of complex processes. (Box *et al.,* 1978 and Myers *et al.,* 2009). The studies of optimization have been carried out by various research workers (Pokharkar, 1994; Vijayan and *et al.*, 1995; Chowdhary *et al.*, 2000; Kar and Gupta, 2001; Liyana-Pathirana and Shahidi, 2005; Eren and Kaymak-Ertekin, 2007; Jain, 2007; Altan *et al.*, 2008; Corzo *et al.*, 2008; Mestdagh *et al.*, 2008; Shi *et al.*, 2008 and Borkar, 2011).

Optimization of Seed Extraction Unit

The type of seed extraction drum, rotational speed and feed rate were optimized for minimum seed damage during ajwain seed extraction.

Treatment Details

Independent variables

Categoric factors

Three types of seed extraction drums

i. Stud bolted drum ii. Loop type drum iii. Leather drum

Rotational speed of seed extraction drum (R), rpm

i. 600 ii. 650 iii. 700 iv. 750 v. 800

Feed rate (F), kg h^{-1}

i. 60 ii.120 iii. 180 iv. 240 v. 300

Dependent variables

i. Mechanical seed damage

The mechanical seed damage was calculated using the following formula.

$$\text{Mechanical seed damage (\%)} = \frac{\text{Quantity of damaged seeds collected at all outlets unit}^{-1}\text{ time, g}}{\text{Toral seed output unti}^{-1}\text{ time by weight, g}}$$

Optimization of seed extraction drum for ajwain seed extraction

Optimization of seed extraction drum for ajwain seed extraction is necessary so that maximum extraction efficiency and minimum seed damage could be achieved. Different types of seed extraction drums viz stud bolted drum, loop type drum and leather flap drum were tested for extraction of seeds out of which one drum was optimized based on maximum extraction efficiency. The experimental layout for two variable five levels response surface analysis as shown in Table 1 was used.

Extraction Data Analysis

Response Surface Methodology (RSM) was applied to the experimental data using Design-Expert version 9 (Statease Inc, Minneapolis, USA, Trial version, 2017).

Table 1. Levels of independent variables for ajwain seed extraction

Independent variables	Symbols		Levels	
	Coded	Decoded	Coded	Decoded
Rotational speed, rpm	X_1	X1	2	800
			1	750
			0	700
			-1	650
			-2	600
Feed rate, kg/h	x_2	X2	2	300
			1	240
			0	180
			-1	120
			-2	60

RESULTS AND DISCUSSION

The parameters such as type of seed extraction drum, rotational speed and feed rate were required to be optimized for maximum seed extraction efficiency and minimum seed damage. During preliminary experiments, extraction efficiency were found to be dependent on the machine and operational parameters.

Based on feeler trials, concave clearance and blower/fan speed were finalized and were kept constant

throughout the complete experimentation. Moisture content at the appropriate time of extraction was measured and was in the range of 10 $\pm$ 0.5 per cent on wet basis.

Effect of variables on seed damage during ajwain extraction

The results obtained for per cent seed damage during the experimentation on ajwain seed extraction using the developed spices seed extractor revealed that the seed damage was observed to be ranging from 1.41 to 3.98 per cent depending upon the extraction treatments. The maximum seed damage was observed in case of treatment having the combination of leather flap drum having rotational speed of 800 rpm and feed rate of 300 kg h^{-1}. The minimum seed damage was found for treatment having the combination of stud bolted drum having rotational speed of 700 rpm and feed rate of 180 kg h^{-1}. The ajwain seed damage was found to be dependent on the type of seed extraction drum, rotational speed and feed rate.

A second order polynomial equation fitted with the experimental data gives the predicted seed damage (%) as a function of drum rotational speed (R) and feed rate (F). This equation was obtained using step down regression method where factors with F-values less than one were rejected as described by Snedecor and Cocharan (1967). The data for seed damage were analyzed for stepwise regression analysis and the analysis of variance (ANOVA) is shown in Table 3. The response surface reduced cubic model was fitted to the experimental data and statistical significance for linear, interaction and quadratic effects were analyzed for seed damage which gives the effect of various parameters on seed damage. The R^2 value was calculated by least square technique and found to be 0.97 showing good fit of model to data.

For ajwain seed damage, the model F-value of 46.19 implies that the model is significant ($P<0.01$). The linear terms (R and F) are significant ($P<0.01$). The lack of fit F-value was non-significant, which indicates that the developed model was adequate for predicting the response. Moreover, the predicted R^2 of 0.87 was in reasonable agreement adjusted R^2 of 0.95. This revealed that the non-significant terms have not been included in the model. Therefore, this model could be used to navigate the design space. High value of coefficient of determination ($R^2 = 0.97$) obtained for response variable indicated that the developed model for extraction efficiency accounted for and adequately explained 97.40 per cent of the total variation.

Regarding the effect of independent individual parameter, from analysis of variance (ANOVA) given in Table 2, the drum type was having maximum effect followed by rotational speed and feed rate on seed damage of ajwain. The results showed that among linear effects drum speed had significant effect on seed damage ($P<0.01$) at 1 per cent level of significance followed by feed rate. The existence of quadratic terms indicates the curvy linear nature of response. It indicates that increasing the value of variable initially increased the response up to certain level of variable however further increase in the level of variable decreased the value of response.

The reduced cubic model data indicated the results as significant. The lack of fit was found to be non significant which indicates that the developed model was adequate for predicting the response. The coefficient of determination (R^2) was 0.97 for ajwain seed extraction which indicated that the model could fit the data for seed damage very well for both the variables, i.e. rotational speed and feed rate.

Effect of rotational speed and feed rate on seed damage

The effect of rotational speed and feed rate on seed damage is shown in Fig 1 to 3. The seed damage was found to be slightly increased with increase in rotational speed up to certain limit in all type of seed extraction drums. Fig. 1 to 3 shows that as the rotational speed increased, the seed damage slightly increased up to certain maxima and if rotational speed is further increased beyond this level, the seed damage was observed to be increased significantly. Significant effect of rotational speed was observed on seed damage. This might be due to the reason that at low feed rates, rubbing was insufficient. Clogging of seed was observed in the drum at lower speed which resulted in seed damage. At higher rotational speed, the friction between the rotating seed extraction drum and the seed was more than the required which resulted in increased seed damage.

From Fig. 1 to 3, the seed damage was found to be increased with increase in feed rate in all type of seed

Table 2. ANOVA for effect of extraction treatment variables on ajwain seed damage

Source	Sum of Squares	df	Mean Square	F-value	p-value	
Model	21.60	17	1.27	46.19	<0.0001	significant
A-Rotational Speed	0.3181	1	0.3181	11.56	0.0027	
B-Feed rate	0.8074	1	0.8074	29.35	<0.0001	
C-Type of extraction drum	18.46	2	9.23	335.52	<0.0001	
AB	0.0120	1	0.0120	0.4374	0.5156	
AC	0.0003	2	0.0002	0.0062	0.9938	
BC	0.1813	2	0.0907	3.30	0.0569	
A^2	1.01	1	1.01	36.55	<0.0001	
B^2	0.1735	1	0.1735	6.31	0.0203	
ABC	0.0429	2	0.0214	0.7792	0.4716	
A^2C	0.6214	2	0.3107	11.29	0.0005	
B^2C	0.0618	2	0.0309	1.12	0.3438	
Residual	0.5777	21	0.0275			
Lack of Fit	0.3404	9	0.0378	1.91	0.1464	not significant
Pure Error	0.2373	12	0.0198			
Cor Total	22.18	38				
Std. Dev.	0.1659	**R^2**		0.9740		
Mean	2.67	**Adjusted R^2**		0.9529		
C.V. %	6.21	**Predicted R^2**		0.8741		
PRESS	2.79	**Adeq Precision**		22.2014		

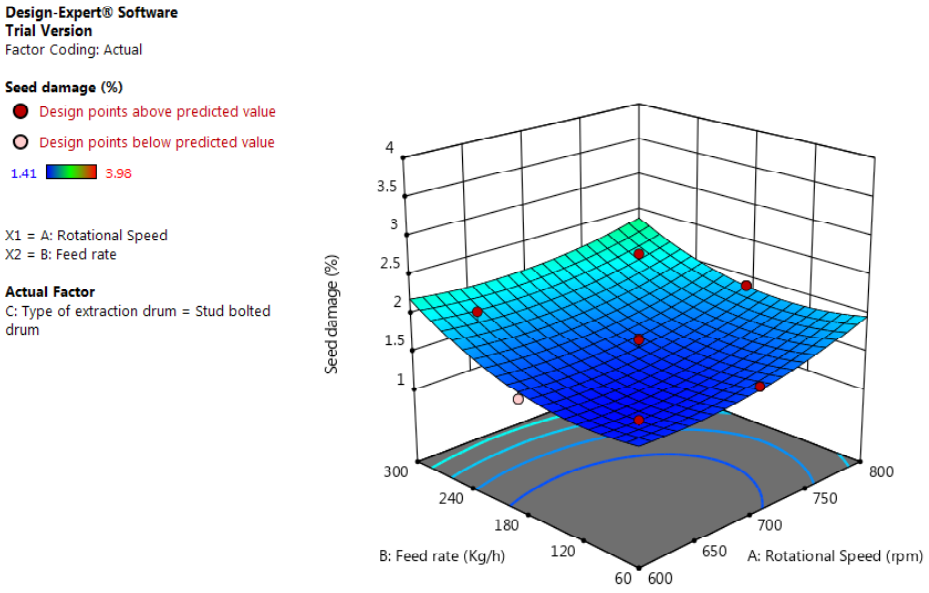

Fig. 1 Effect of rotational speed and feed rate on ajwain seed damage (Stud bolted drum)

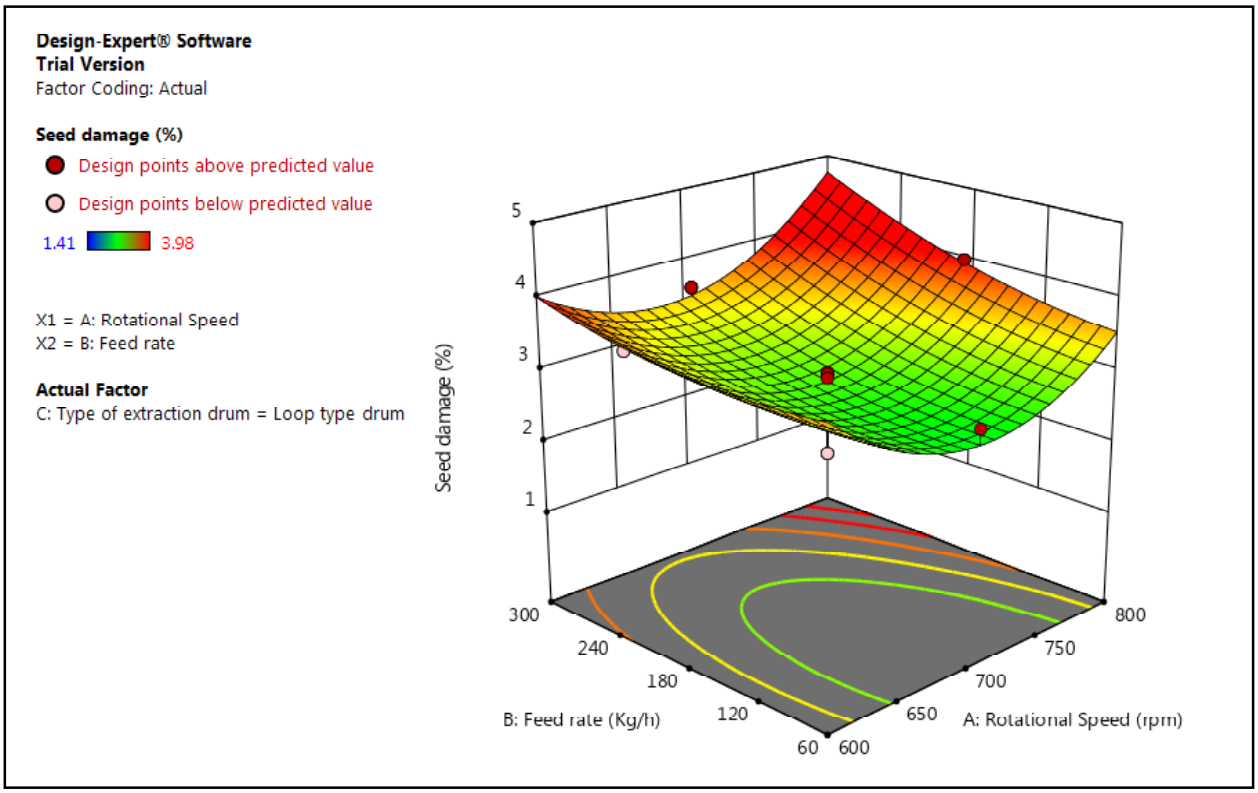

Fig. 2 Effect of rotational speed and feed rate on ajwain seed damage (Loop type drum)

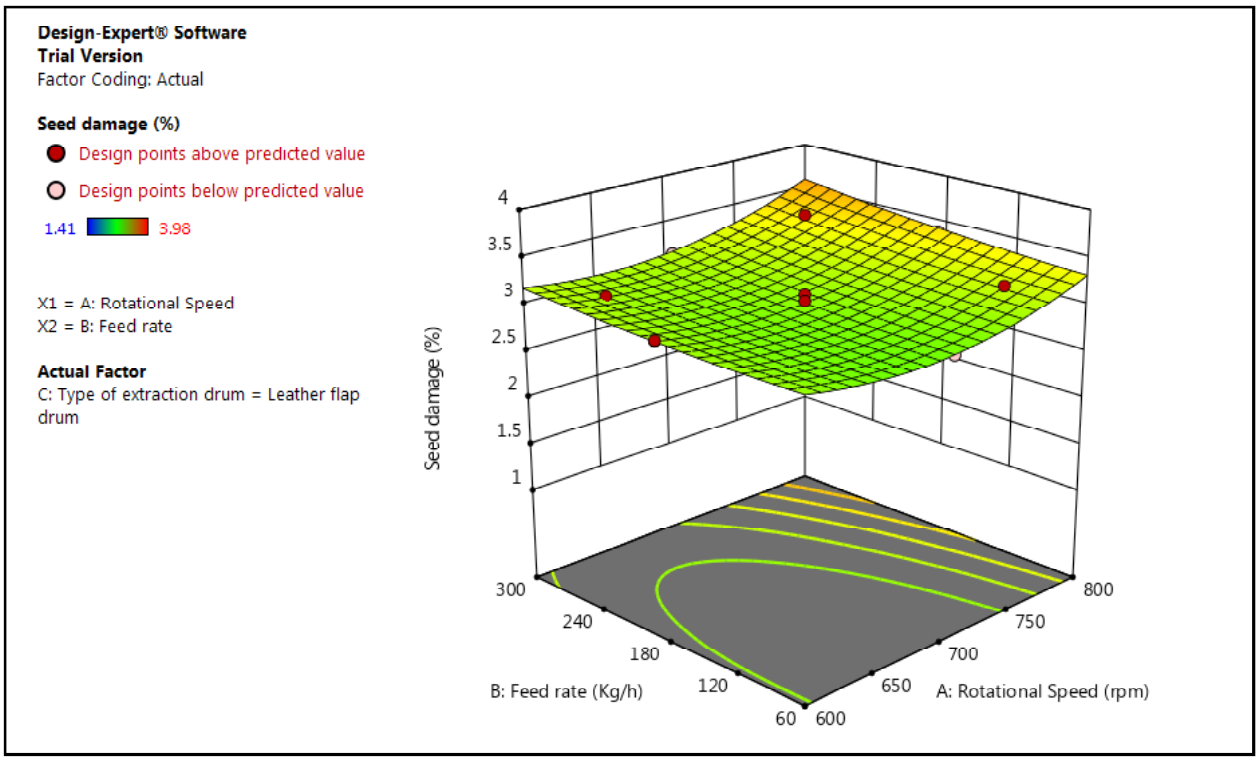

Fig. 3 Effect of rotational speed and feed rate on ajwain seed damage (Leather flap drum)

Table 3. Optimized solution generated by the software for ajwain seed damage

Number	Rotational drum speed, rpm	Feed rate, kgh^{-1}	Drum type	Seed damage, %	Desirability	
1	697.91	170.027	Stud bolted drum	1.53	0.958	Selected

extraction drums. Slight increase in feed rate resulted in reduced seed damage, further increase in feed rate resulted in increased seed damage. Increase in feed rate up to certain limit was found suitable for better seed extraction resulting in less seed damage. Further increase in feed rate beyond this limit resulted in higher seed damage, higher rubbing of seed was observed at higher feed rates, resulting in higher seed damage.

It was observed that the stud bolted drum was found to be most efficient for causing less damage to the seeds with respect to input parameters such as rotational speed and feed rate as compared to loop type drum and leather flap drum.

Considering the properties of seed, flower and stem, stud bolted drum was found better for extraction of ajwain seeds as compared to loop type and leather flap drum. The optimized input parameters for the minimum seed damage (Table 3) were found to be:

Rotational speed (rpm) = 697.91 ~ 700

Feed rate (kg h^{-1}) = 170.027 ~ 170

Type of drum = Stud bolted drum

Verification of the model for ajwain seed damage

Extraction of ajwain seeds (sample size 2 kg) was carried out at optimized input parameters (Rotational drum speed = 700 rpm, Feed rate = 170 kgh^{-1}) for testing the adequacy of model equations for predicting the seed damage response values.

Table 3 Predicted and experimental values of response at optimum process conditions for ajwain seed damage

Response	Predicted value	Experimental value	±SD
Seed damage, %	1.53	*1.69	±0.1424

*Average of three replications

The observed experimental values (mean of three experiments) and values predicted by the equations of the model are presented in Table 4. The experimental values were found to be very close to the predicted values for seed damage. Therefore, it could be concluded from above discussion that model equation 2 is quite adequate to assess the behavior of seed damage during ajwain seed extraction.

CONCLUSION

The optimized parameters for minimum seed damage during ajwain seed extraction were found to be stud bolted drum having rotational speed of 700 rpm and feed rate of 170 kg h^{-1}. The seed damage was found to be 1.53 per cent at optimized conditions.

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Correlation and Path Analysis studies in Sesame (*Sesamum indicum* L.)

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ABSTRACT

Sesame is one of most ancient oil crops known to mankind. It is also known as benniseed, gingelly, simsim and til. An experiment was carried out in *Kharif* 2019 at Experimental farm of Department of Agricultural Botany, Dr. PDKV, Akola to estimate the character association among yield and yield contributing traits in germplasm lines of sesame in rainfed conditions. The study was undertaken on fifty-one genotypes of sesame using randomized block design with three replications. The observation was recorded on eleven major morphological traits viz., days to 50 per cent flowering, days to maturity, plant height, number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, length of capsule, 1000 seed weight, seed yield plant^{-1}, harvesting index and oil content. Seed yield plant^{-1} was significant and positively correlated with number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, length of capsule, 1000 seed weight, harvesting index and oil content at both the genotypic and phenotypic level. While, the characters viz., days to maturity and plant height exhibited the positive but statistically non-significant association with seed yield plant^{-1}. The days to 50 per cent flowering was only character which was associated non-significantly with seed yield plant^{-1} in negative direction. Path coefficient analysis indicated positive direct effect days to maturity, number of capsule plant^{-1}, length of capsule and 1000 seed weight on seed yield plant^{-1}. Hence, these characters may be given consideration while formulating selection indices for the improvement program in sesame.

Sesame, scientifically referred to as *Sesamum indicum*, represents an ancient oilseed crop that is cultivated for its edible seeds and oil. It is characterized by short growth duration and can be grown throughout the year, serving as a key ingredient in various cuisines due to its rich, nutty flavor. India stands as one of the foremost producers of sesame seeds, and it is widely grown in tropical regions. Sesame is a member of the *Pedaliaceae* family, characterized by a chromosome count of (2n = 26). This annual crop features an upright, hairy, and branching stem, reaching heights of 0.60 to 1.20 meters. The leaves vary from ovate to lanceolate or oblong, with the lower leaves being tri-lobed and occasionally ternate, while the upper leaves are undivided and have irregularly pointed serrations (Felter and Lloyd, 1898). Some cultivars exhibit numerous branches, whereas others tend to be less branched (Kinman and Martin, 1954). The flowers are tubular, drooping, bell-shaped, and bilabiate, displaying colors ranging from pale purple or rose to white, measuring 1.9 - 2.5 cm in length. Furthermore, these flowers grow on short glandular pedicels, with a single flower emerging at each leaf axil. The lower flowers typically bloom two to three months post-planting, continuing to flower until the uppermost blooms are open (Martin and Leonard, 1967). The fruit, known as a capsule, is an oblong, mucronate, hairy structure that houses numerous small, oval seeds that can be yellow, white, red, brown or black. Sesame growth is indeterminate, and while the flowers are generally self-pollinated, they can also be cross-pollinated by insects (Oplinger *et al*., 1990).

Among the Indian states Uttar Pradesh is the highest sesame growing area followed by Rajasthan, Madhya Pradesh and West Bengal while, the West Bengal is rank first in sesame seed production having the productivity 951 kg ha^{-1}. Sesame is better known as "Queen of oilseeds" by virtue of its quality edible oil and protein content. As it seed contains 50 per cent oil, 23 per cent protein and 15 per cent carbohydrate (Ranganatha *et al*., 2012). Sesame seed contains significant amount of important minerals viz., Potassium, Phosphorus, Magnesium, Calcium and Sodium. Sesame oil has long shelf life and presence of antioxidants viz., sesamin, sesaminol, sesamol, sesamolinal also contains large level of polyunsaturated fatty acids. It is protein rich in sulphur

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containing amino acids (Methionine). It's really the poorman's substitute for 'Ghee', as 100 gm of seed provides 592 calories energy (Loumouamou *et al*., 2010). Sesame is cultivated all over India, demonstrating a wide array of variability and numerous distinct forms available throughout the country. In Maharashtra, there are several local varieties and improved types that are commercially grown in different areas.

The knowledge of interrelationship among its different components is necessary for effective selection and simultaneous improvement in yield. Such information can be obtained by studying the correlation between yield and its components. The phenotypic correlation coefficient is less reliable because phenotypic expression of characters changes with environment fluctuation. This difficulty can be overcome by estimating the genotypic correlation coefficient. The importance of genotypic correlation coefficient can be judged from the fact that it gives first-hand information regarding the heritable association between different yield components and also gives an idea regarding the importance of a particular character in a selection program for improvement in yield.

MATERIAL AND METHODS

The present has been conducted during *Kharif* 2019 at Experimental farm of Department of Agricultural Botany, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The data was recorded on five randomly selected plants, from each genotype in each replication. The characters studied were days to 50 per cent flowering, days to maturity, plant height, number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds per capsule, length of capsule, 1000 seed weight, seed yield plant^{-1}, harvesting index and oil content using fifty-one sesame germplasm lines obtained from National Bureau of Plant Genetic Resources (NBPGR). The experiment was laid down in randomized block design with three replication with all necessary management practices to grow healthy crop stand.

Analysis of variance for Randomized Block Design (RBD) was done based on following linear model as suggested by Panse and Sukhatme (1967). Whereas, the phenotypic, genotypic and environmental correlation among grain yield and its influencing characters was calculated according to procedure given by Miller *et al.* (1958). The technique of path coefficient analysis was developed by Wright (1921) as a means of separating direct and indirect contributions of various factors. Path coefficients analysis is a standard partial regression coefficient analysis and as such measures, the direct influence of one variable upon other and permits the separation of correlation coefficient into components of direct and indirect effects (Dewey and Lu, 1959).

RESULTS AND DISCUSSION

Analysis of Variance

The analysis of variance was carried out as per the standard statistical procedure to assess the variation in the genotype for all eleven quantitative characters viz., days to 50 per cent flowering, days to maturity, plant height, number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, length of capsule, 1000 seed weight, seed yield plant^{-1}, harvesting index and oil content under study and presented in Table 1. The significance was tested by applying 'F' test, the analysed data indicated that the treatment mean sum of squares found highly significant for all the eleven characters, indicating the presence of substantial genetic variation among the genotypes selected for study. Similar kind of result were also substantial by Ujjainkar *et al.* (2002), Jadhav and Mohrir (2012), Bharati *et al.* (2014), Haibru *et al.* (2018) and Singh *et al.* (2018) and Ujjainkar *et al.* (2022).

Correlation coefficient analysis

Yield is a complex character and it is governed by on many other morphological characters. Hence, it is necessary to know the relationship between the yield and its contributing characters.Correlation analysis is generally used to find out the mutual association between yield and its components. The estimation of phenotypic and genotypic correlation provides an effective way of predicting response to selection and isolating the desirable individuals from breeding population. The correlation studies helps to breeder to compute the required genetic make-up of the ideal genotype. The correlation coefficient was worked out among eleven characters to find out association of seed yield plant^{-1} with its components at genotypic and phenotypic levels. The results obtained

Table 1. Analysis of variance for mean sum of squares for eleven characters in fifty one sesame genotypes

S.N.	Characters	3 Mean Sum of Squares		
		Replications	Genotypes	Error
	Degree of freedom	2	50	100
1	Days to 50% flowering	2.52	795.35**	187.48
2	Days to maturity	6.13	816.01**	153.20
3	Plant height (cm)	188.61	11246.29**	3177.31
4	No. of branches plant^{-1}	1.75	85.53**	32.46
5	No. of capsules plant^{-1}	19.01	5022.36**	622.25
6	No. of seeds capsule^{-1}	29.62	2779.66**	534.24
7	Length of capsule (cm)	0.02	7.88**	1.04
8	1000 seed weight (g)	0.02	18.66**	0.39
9	Seed yield plant^{-1} (g)	0.61	116.33**	14.46
10	Harvesting index (%)	66.99	7731.66**	1369.70
11	Oil content (%)	6.72	1362.83**	223.63

*Significance at 5 per cent level, **Significance at 1 per cent level

on correlation coefficients between different pairs of characters are presented in Table 2 and Table 3. The data revealed that the genotypic correlation coefficient was relatively higher than their corresponding phenotypic correlation coefficients in most of traits. In the present investigation, the genotypic correlation coefficients were higher in magnitude over the respective phenotypic correlation coefficient except for the association in few pairs of characters indicating that genotypes superior but its expression was reduced under the influence of environment as reported by Shekhawat *et al*. (2013), Sopundharrya *et al*. (2017) and Singh *et al.* (2018).

In most of the cases the direction and magnitude of genotypic and phenotypic correlations between different characters remain same. This is very helpful to plant breeder because breeder can practice selection on the basis of phenotypic expression of the character for the improvement of end product i.e. seed yield. The phenotypic correlation coefficients in very few cases were higher than their corresponding genotypic correlation coefficients which might be due to non-genetic causes i.e. environmental influences. The study of genotypic correlation gives idea of the extent of relationship between different variables. This relationship among yield contributing characters as well as their association with yield provides information for exercising selection pressure for bringing genetic improvement in seed yield.

In the present study, seed yield plant^{-1} was found to be significant and positive correlated with number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, length of capsule, 1000 seed weight, harvesting index and oil content at both the genotypic and phenotypic level. Such positive and significant interrelationship between seed yield plant^{-1} and these attributes have also reported in sesame by several researchers. The association has been reported between seed yield plant^{-1} and number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsules^{-1} by Sumathi and Muralidharan *et al.* (2010) and Navaneetha *et al.* (2019). For number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsules^{-1}, length of capsule, 1000 seed weight by Patil and Lokesha (2018). Similar results were found by Khan *et al.* (2001), Solanki and Gupta (2003), Ismaila and Usman (2012), Navneet *et al.* (2019) and Umamaheswari *et al.* (2019) for length of capsule, 1000 seed weight, number of branches plant^{-1}, number of capsules plant^{-1}; harvesting index by Gidey *et al*. (2013) and Bamrotiya *et al*. (2016); oil content by Singh *et al*. (2018). Thus, on the basis of correlation, the outstanding characters influencing the yield seed yield in sesame and

Table 2. Genotypic correlation coefficient (r) for eleven characters in sesame

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capsule plant^{-1}	No. of seeds capsule^{-1}	Length of capsule (cm)	1000 seed weight (g)	Harvesting index (%)	Oil content (%)	Seed yield plant^{-1} (g)
Days to 50% flowering	1	0.504**	0.489**	0.222**	0.114	-0.271**	-0.324**	-0.078	-0.358**	-0.001	-0.024
Days to maturity		1	0.555**	0.270**	0.009	0.241**	0.100	0.108	-0.379**	0.418**	0.114
Plant height (cm)			1	0.390**	0.159*	-0.047	-0.067	0.048	-0.249**	0.347**	0.131
No. of branches per plant				1	0.416**	-0.016	-0.061	-0.219**	-0.200*	0.391**	0.245**
No. of capsule per plant					1	0.133	0.068	-0.022	0.408**	0.406**	0.894**
No. of seeds per capsule						1	0.964**	0.217**	0.224**	0.342**	0.440**
Length of capsule (cm)							1	0.257**	0.285**	0.266**	0.393**
1000 seed weight (g)								1	0.518**	-0.028	0.448**
Harvesting index (%)									1	-0.053	0.580**
Oil content (%)										1	0.429**
Seed yield per plant (g)											1

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

Table 3 . Phenotypic correlation coefficient (r) for eleven characters in sesame

Character	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capsule plant^{-1}	No. of seeds capsule^{-1}	Length of capsule (cm)	1000 seed weight (g)	Harvesting index (%)	Oil content (%)	Seed yield plant^{-1} (g)
Days to 50% flowering	1	0.355**	0.309**	0.087	0.094	-0.187*	-0.233**	-0.074	-0.281**	-0.053	-0.002
Days to maturity		1	0.418**	0.201*	0.015	0.213**	0.082	0.103	-0.273**	0.300**	0.084
Plant height (cm)			1	0.278**	0.109	-0.014	-0.029	0.049	-0.178*	0.268**	0.115
No. of branches per plant				1	0.293**	0.016	-0.036	-0.160*	-0.125	0.233**	0.174*
No. of capsule per plant					1	0.108	0.056	-0.012	0.355**	0.340**	0.791**
No. of seeds per capsule						1	0.796**	0.180*	0.174*	0.285**	0.377**
Length of capsule (cm)							1	0.235**	0.237**	0.226**	0.337**
1000 seed weight (g)								1	0.458**	-0.026	0.406**
Harvesting index (%)									1	-0.018	0.563**
Oil content (%)										1	0.353**
Seed yield per plant (g)											1

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

Table 4. Path coefficient analysis showing direct and indirect effects of different characters on seed yield in sesame

Characters	Days to 50% flowering	Days to maturity	Plant height (cm)	No. of branches plant^{-1}	No. of capsule plant^{-1}	No. of seeds capsule^{-1}	Length of capsules (cm)	1000 seed weight (g)	Harvesting index (%)	Oil content (%)	Seed yield plant^{-1} (g)
Days to 50% flowering	**-0.097**	-0.049	-0.047	-0.022	-0.011	0.026	0.031	0.008	0.035	0.000	-0.024
Days to maturity	0.032	**0.064**	0.036	0.017	0.001	0.015	0.006	0.007	-0.024	0.027	0.114
Plant height (cm)	-0.019	-0.022	**-0.039**	-0.015	-0.006	0.002	0.003	-0.002	0.010	-0.014	0.131
No. of branches per plant	-0.015	-0.018	-0.027	**-0.068**	-0.028	0.001	0.004	0.015	0.014	-0.027	0.245
No. of capsules per plant	0.117	0.009	0.162	0.424	**1.019**	0.136	0.070	-0.023	0.416	0.413	0.894
No. of seeds per capsule	0.006	-0.005	0.001	0.000	-0.003	**-0.022**	-0.026	-0.005	-0.005	-0.008	0.440
Length of capsule (cm)	-0.076	0.023	-0.016	-0.014	0.016	0.226	**0.234**	0.060	0.067	0.062	0.393
1000 seed weight (g)	-0.037	0.052	0.023	-0.105	-0.011	0.104	0.124	**0.481**	0.249	-0.014	0.448
Harvesting index (%)	0.065	0.069	0.045	0.036	-0.074	-0.041	-0.052	-0.094	**-0.181**	0.010	0.580
Oil content (%)	0.000	-0.009	-0.008	-0.009	-0.009	-0.007	-0.006	0.005	0.001	**-0.022**	0.429

Residual effect, R=SQRT(1 - 1.0822), *Significance at 5% level, **Significance at 1% level

need to be given due importance in selection to achieve higher seed yield. Further, the seed yield plant^{-1} also recorded positive non-significant correlation with days to maturity and plant height. Similar results were recorded for days to maturity by Ukaan and Ogbonna (2012), Bamrotiya *et al.* (2016) and Saxena and Bisen (2016); plant height by Sivaprasad *et al*. (2013) and Bamrotiya *et al.* (2016). Character days to 50 per cent flowering observed negative non significant correlation with seed yield per plant, similar result recorded by Ukaan and Ogbonna (2012).

The yield components exhibited varying trends of association among themselves. The days to 50 per cent flowering had positive and significant correlation at both genotypic and phenotypic levels with days to maturity; Thirumala *et al*. (2013) and plant height; Begum *et al.* (2012). The days to maturity had positive and significant correlation at both genotypic and phenotypic levels with plant height number of branches plant^{-1} number of seeds capsule^{-1} and oil content. Plant height had positive and significant correlation at both genotypic and phenotypic levels with number of branches plant^{-1} and oil content. Number of branches plant^{-1} had positive and significant correlation at both genotypic and phenotypic levels with number of capsule plant^{-1} and oil content. Number of capsule plant^{-1} had positive and significant correlation at both genotypic and phenotypic levels with harvesting index and oil content. Number of seeds capsule^{-1} had positive and significant correlation at both genotypic and phenotypic levels with length of capsule, 1000 seed weight, harvesting index and oil content. Length of capsule had positive and significant correlation at both genotypic and phenotypic levels with 1000 seed weight, harvesting index and oil content. 1000 seed weight had positive and significant correlation at both genotypic and phenotypic levels with harvesting index. The present results on correlation coefficient, revealed that number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, length of capsule, 1000 seed weight, harvesting index and oil content were the most important attributes and may contribute considerably towards higher seed yield. Thus, more emphasis should be given for improvement of these characters as to increase seed yield of sesame.

Path coefficient analysis

As in case of other crops, seed yield is a complex trait in sesame. When two or more variables are included in the correlation studies, it becomes difficult to determine which character is actually involved in enhancing the yield. The technique of path coefficient analysis overcomes this situation which partitions the forces of association and examines the relative contribution of direct and indirect effect of the independent variables on the dependent variable. Thus the path analysis gives a more realistic relationship of characters and helps to identify the effective component of seed yield plant^{-1}.

The path coefficient analysis revealed that days to maturity, number of capsule plant^{-1}, length of capsule and 1000 seed weight showed positive direct effect on seed yield plant^{-1} (Table 4). The positive direct effect of days to maturity on seed yield plant^{-1} has also been reported in sesame by Desawi *et al.* (2017) and Ramprasad *et al.* (2019); of number of capsules plant^{-1} by Sumathi and Muralidharan (2010), Goudappagoudra *et al*. (2011), Begum *et al*. (2012), Ibrahim and Khidir (2012), Bharathi *et al*. (2015), Bamrotiya *et al.* (2016) and Saxena and Bisen (2016) of length of capsule by Deepa Sankar and Ananda Kumar (2003), Bharathi and Vivekanandan (2009), Ramprasad *et al*. (2019) and Navaneetha *et al*. (2019); of 1000 seed weight by Sumathi and Muralidharan (2010), Goudappagoudra *et al.* (2011), Begum *et al.* (2012), Ibrahim and Khidir (2012), Desawi *et al.* (2017), Gogai and Sarma. (2019) and Navaneetha *et al.* (2019). The path coefficient analysis revealed that days to 50 per cent flowering, plant height, number of branches plant^{-1}, number of seeds capsule^{-1}, harvesting index and oil content showed negative direct effect on seed yield plant^{-1}. The negative direct effect of days to 50 per cent flowering and plant height on seed yield plant^{-1} has also been reported in sesame by Begum *et al*. (2012); of number of branches plant^{-1} by Sumathi and Muralidharan (2010) and Chandra Mohan (2011); of number of seeds plant^{-1} by Sumathi and Muralidharan (2010), Saxena and Bisen (2016) and Ramprasad *et al*. (2019); of harvesting index by Gidey *et al*. (2013) and Saxena and Bisen (2016); of oil content by Sumathi and Muralidharan (2010) and Gidey *et al.* (2013).

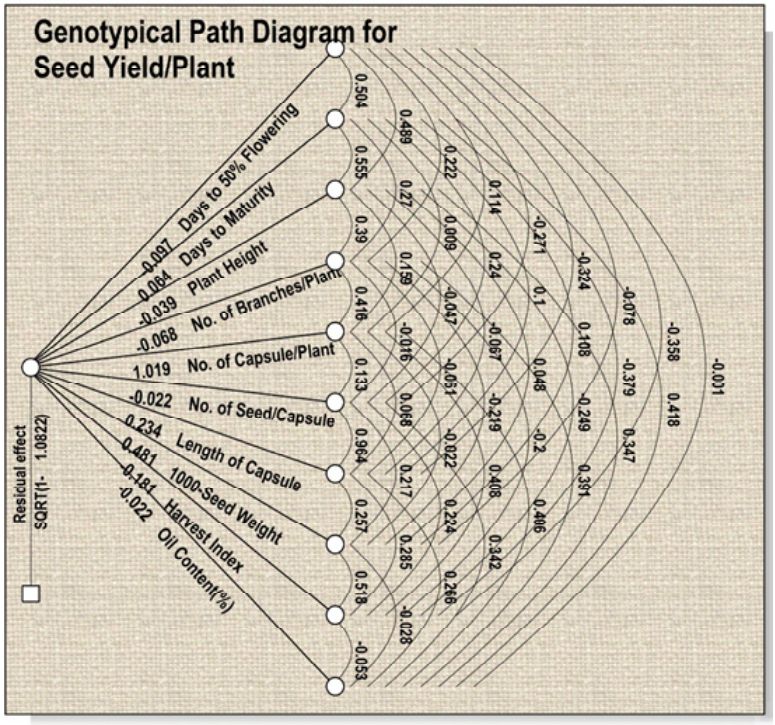

Fig. 1. Path diagram for seed yield per plant in sesame germplasm

The indirect effects between characters showed positive and negative effects with low magnitude on seed yield plant^{-1}. The indirect effects had not only supported the low magnitude direct effect but also resulted in high significant positive correlation with seed yield. It was clear from the path analysis that the days to maturity, number of capsule plant^{-1}, length of capsule and 1000 seed weight were manifested positive direct effect on seed yield plant^{-1} and hence, they may be considered as the most important yield contributing characters and due to emphasis should be given on these characters while sesame breeding for fulfilling the objective of high seed yield.

CONCLUSION

In the present study, the genotypic correlation coefficients higher than phenotypic correlation coefficients, indicating little masking effects of environment on the expression of the characters. The characters, seed yield plant^{-1} was found to be significant and positively correlated with number of branches plant^{-1}, number of capsules plant^{-1}, number of seeds capsule^{-1}, length of capsule, 1000 seed weight, harvesting index and oil content at both the genotypic and phenotypic level. Seed yield plant^{-1} also registered positive and non-significant correlation with days to maturity and plant height at both the genotypic and phenotypic level. The association studied, indicated that seed yield of sesame can be improved by selecting the genotypes having higher performances for the above-mentioned characters. The path coefficient analysis revealed that the characters viz., days to maturity, number of capsule plant^{-1}, length of capsule and 1000 seed weight exhibited positive direct effect on seed yield plant^{-1}. Therefore, these characters may be used as selection criteria to increase seed yield of sesame. While, the characters days to 50 per cent flowering, plant height, number of branches plant^{-1}, number of seeds capsule^{-1}, harvesting index and oil content showed negative direct effect on seed yield plant^{-1}.

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Biology of Bivoltine Silkworm Hybrids on V-1 Variety of *Morus alba*

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ABSTRACT

The experiment was carried out to study the "Biology of bivoltine silkworm hybrids on V-1 variety of *Morus alba"* at Sericulture Laboratory Department of Agril. Entomology, PGI, Dr. PDKV, Akola, during 2022-2023. The design used in the experiment was Completely Randomized Block Design with seven treatments and three replications. The hybrids *viz*., FC1×FC2, FC2×FC1, S8×CSR16, CSR16×S8, SK6×SK7, SK7×SK6 and TT21×TT56 procured from Central Sericulture Research and Training Institute, Mysore were used as test hybrids against mulberry variety V-1 in present investigation. Among the different hybrids reared, the bivoltine hybrid FC1×FC2 was performed better for characters like fecundity (564.22), hatching percentage (97.18 %), moth emergence (96.33 %) and effective rate of rearing (94.57 %). While the hybrid S8×CSR16 recorded lowest larval duration (22.92 days) and pupal duration (10.19 days).

The silkworm, *Bombyx mori* L. is a lepidopteran economic insect which is known for the production of mulberry silk aptly named as *"the Queen of Natural Fibers*" (Bobade *et al.,* 2019). The natural silk is obtained from four species of silkworm *viz*. Mulberry silkworm (*Bombyx mori)*, Tassar silkworm (*Antheracea mylitta)*, Muga silkworm (*Antheracea assamensis)* and Eri silkworm (*Philosemia ricini*). Mulberry silkworm, *Bombyx mori* L. is a monophagous insect, feeding exclusively on the mulberry leaves (*Morus spp*.) for its nutrition and produces the natural proteinaceous silk. Silkworm grows around 4-5 g in weight in its total larval life depending upon the mulberry leaf, environment and silkworm race/hybrid. It consumes about 15-20 g of leaf throughout its larval instars with 80-85 per cent of consumption in the last two instars. The leaf requirement also differs depending upon the age of the silkworms. Nutritional intake has a direct impact on the overall genetic architecture of larvae and cocoon characters, pupation, amount of silk production, and reproductive traits (Sajgotra *et al.,* 2018). In terms of productivity, one hectare of mulberry farming yields about Rs. 76,000 worth of silk, making it a highly profitable crop when compared to other commercial field crops. Additionally, it employs 12-13 people year^{-1} in mulberry cultivation, silkworm rearing, recycling, twisting, wearing, and garment production (Sangle *et al.,* 2022). The evolution of bivoltine breeds suited to farmer's condition, i.e. inferior management levels, poor quality mulberry leaves and fluctuating microclimatic conditions thus become necessary (Quadri *et al.,* 2013). Enrichment of silkworm hybrids have always been one of the important factors contributing to increase the productivity in sericulture sector. Continuous development, evaluation, renewal and change of existing hybrids with new superior varieties and their commercialization is the prime factor to improve silk quality and quantity with increase in production of cocoon as well as silkworm eggs. Keeping all these things in view, present investigation was undertaken to evaluate biology of bivoltine silkworm hybrids on V-1 variety of *Morus alba*.

MATERIAL AND METHODS

The present investigation was undertaken to study the biology of bivoltine silkworm hybrids on V-1 variety of *Morus alba* at Sericulture Laboratory Department of Agricultural Entomology, PGI, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, during September 2022 to December 2022. The experiment was conducted in Completely Randomized Block Design with seven treatments and three replications. Disease free laying (DFL) of silkworm hybrids (S8×CSR16), (CSR16×S8), (FC1×FC2), (FC2×FC1), (SK6×SK7), (SK7×SK6) and (TT21×TT56)

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procured from Central Sericulture Research and Training Institute, Mysore were used as test hybrids against mulberry variety V-1 in present investigation.

Disease free laying (DFLs) were placed into 7 different trays and covered by black piece of cloth and left undisturbed for 48 hours for uniform growth of embryo. Krishnswami (1978) described the improved technology of silkworm rearing and it was adopted in the present investigation. The newly hatched larvae of Silkworm hybrids were fed with chopped pieces of fresh tender mulberry leaves of V-1 variety. In the progression of rearing underweighted larvae were rejected periodically. The feeding was given for four times in a day. Moulting was completed in 20 to 30 hrs. After completion of each moult a bed disinfectant Vijetha @ 4 $kg100^{-1}$ DFLs was dusted to control the diseases and feeding was given after half an hour. Later bed cleaning was undertaken. After the worms have fully developed, the matured worms were identified, as they looked translucent with creamy color. The matured worms ceased to eat, crawled towards periphery of the trays and tried to spin the cocoons, were handpicked and put on the mount-ages for spinning cocoon. Larvae spun the cocoons within 48 to 72 hrs. The pupae remained inside the cocoon till emergence. The harvesting of cocoon was made on the fifth or sixth days of release of worms on mount-ages for spinning the cocoon. Randomly selected ten cocoons of each treatment were used for recording cocoon parameters observations.

The observations were recorded on Larval duration (days), ERR (%), Moth emergence (%), Hatching percentage (%), Fecundity (no.) and Pupal duration (days). The data obtained were analyzed and the percentage values were transformed to angular values and analyzed and the result obtained was interpreted.

RESULTS AND DISCUSSION

Highest hatching per cent was observed in hybrid FC1×FC2 (97.18 %) over rest of the hybrids which was followed by S8×CSR16 (94.56 per cent), FC2×FC1 (94.13 %), TT21×TT56 (94.01 per cent), CSR16×S8 (93.16 %) and SK6×SK7 (91.01 %) which were at par with each other. The lowest hatching percentage was recorded in hybrid SK7×SK6 (89.72 %). The findings are correlate with the findings of Thore *et al.* (2023) who observed that hybrids S8×CSR16 and FC1×FC2 recorded hatching percentage about (97.30 per cent) and (97.26 %) respectively. Attri *et al.* (2022) also observed that the hybrid FC1×FC2 recorded maximum hatching percentage of (96.11 per cent). Also, Bobade *et al.* (2019) observed highest hatching percent in the hybrid S8×CSR16 (97.48 per cent) which was significantly superior in their experiment. The results revealed that effective rate of rearing (ERR) ranged from 89.35 to 94.57 per cent. The highest ERR was observed in hybrid FC1×FC2 (94.57%) which was found significantly superior over rest of the hybrids. It was followed by hybrid FC2×FC1 (91.94%) which was at par with SK7×SK6 (91.87 %), TT21×TT56 (91.00%) and SK6×SK7 (90.95 %). Hybrid S8×CSR16 recorded (91.74 per cent) ERR. The lowest ERR was recorded by CSR16×S8 (89.35 %) bivoltine silkworm hybrid.

Significantly highest moth emergence was recorded by the hybrid FC1×FC2 (96.33 %) which was at par with S8×CSR16 (95.67 %) and FC2×FC1 (95.33 %). Next best hybrids were SK6×SK7 (94.17 %), CSR16×S8 (93.17 %) and TT21×TT56 (92.08 %) which were at par with each other. The lowest moth emergence was observed in SK7×SK6 (92.00) bivoltine silkworm hybrid. The findings regarding per cent moth emergence correlate with Attri *et al.* (2022). who observed that the hybrid FC1×FC2 recorded maximum moth emergence (94.86±1.24 per cent) over rest of the hybrids tested. Likewise, Thore *et al.* (2023) also reported that moth emergence of hybrids FC1×FC2 (95.50 per cent), FC2×FC1 (95.25 per cent) and S8×CSR16 (97.00 per cent). Also, Maske *et al.* (2020) observed moth emergence in hybrid S8×CSR16 (94.75 %).

Significantly maximum fecundity was observed in FC1×FC2 (564.22) bivoltine silkworm hybrid which was at par with FC2×FC1 (539.30) and TT21×TT56 (535.34). These were followed by CSR16×S8 (528.51), S8×CSR16 (517.77) and SK6×SK7 (498.97) which were at par with each other. The lowest fecundity was recorded in SK7×SK6 (493.11) bivoltine silkworm hybrid. Attri *et al.* (2022) observed the maximum fecundity of bivoltine hybrid FC1×FC2 (595 eggs). Also, Singh *et al.* (2020) recorded fecundity of bivoltine hybrid FC1×FC2 (576.67) studied during Autumn season (2^{nd} brushing) which was

significantly superior over other hybrids.

Data regarding larval duration revealed that hybrid S8×CSR16 showed shortest larval duration (22.92 days) and found significantly superior over rest of the hybrids which was followed by SK6×SK7(22.96 days) and SK7×SK6 (23.06 days) which were at par with each other. CSR16×S8 shown larval duration (23.95 days) followed by TT21×TT56 (24.03 days) which were at par with each other. Whereas FC1×FC2 had shown the longest larval duration (25.22 days) over FC2×FC1(24.93) which were at par with each other. The results are in close conformity with the findings of Singh et al. (2020) who recorded the shortest larval duration in hybrid S8×CSR16 (23.00 days) which was significantly superior than all other hybrids in their experiment. Also, Bobade *et al.* (2019) and Maske *et al.* (2020) recorded that the larval duration of hybrid S8×CSR16 (22.94 days) and (22.10 days), respectively.

The data revealed that pupal duration varies in the range of 10.19 to 11.91 days. Minimum pupal duration was observed in the hybrid S8×CSR16 (10.19 days) which was followed by SK6×SK7(10.21 days), SK7×SK6 (10.65 days) and CSR16×S8 (10.88 days) which were at par with each other. Maximum pupal duration was observed in FC2×FC1 (11.71 days) and FC1×FC2 (11.71 days). The present findings are in close conformity with the findings of Thore *et al*., (2023) who reported the minimum pupal duration of hybrid S8×CSR16 (10.00 days) and highest pupal duration was recorded by hybrid FC1×FC2 (11.75 days) among rest of the hybrids teste.

CONCLUSION

Among all the seven hybrids used for rearing, FC1×FC2 showed the best results for fecundity, hatching percentage, moth emergence and effective rate of rearing. While for the larval duration and pupal duration S8×CSR16 performed better over other hybrids. Based on overall performance it can be concluded that the bivoltine hybrid FC1×FC2 reared on mulberry variety V-1 was found to outperform over all hybrids under Vidarbha condition.

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S.N.	Treatments	Egg hatching (%)	ERR	Moth emergence (%)	Fecundity	Larval duration	Pupal duration
1	S8×CSR16	94.56 (76.52) *	91.74 (70.15) *	95.67 (78.01) *	517.77	22.92	10.19
2	CSR16×S8	93.16 (75.25)	89.35 (69.24)	93.17 (74.87)	528.51	23.95	10.88
3	FC1× FC2	97.18 (80.35)	94.57 (76.58)	96.33 (79.05)	564.22	25.22	11.71
4	FC2×FC1	94.13 (76.06)	91.94 (73.57)	95.33 (77.55)	539.30	24.93	11.91
5	SK6×SK7	91.01 (72.67)	90.95 (72.52)	94.17 (76.07)	498.97	22.96	10.21
6	SK7×SK6	89.72 (71.37)	91.87 (73.53)	92.00 (73.62)	493.11	23.06	10.65
7	TT21×TT56	94.01 (75.83)	91.00 (72.01)	92.08 (73.75)	535.34	24.03	10.96
	SE (m) ±	1.33	0.98	0.88	10.90	0.17	0.30
	CD at 5%	4.04	2.96	2.67	32.68	0.57	0.92
	CV (%)	3.06	2.31	2.00	4.11	1.35	4.80

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Comparative Study of Foliar Application of Nano Urea and Granular Urea fertilizers on Growth and Yield Performance of Blackgram and Greengram

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ABSTRACT

Comparative study of recommended 2 per cent urea solution and IFFCO newly introduced nano urea @ 2 / 4ml lit^{-1} through foliar spray at grand growth stages with basal dose of RDF on greengram and blackgram crop was conducted during *Kharif*, 2021-22 at Pulses Research Unit, Dr. PDKV, Akola (M.S.). Two separate experiments were laid out in RBD with eight treatments, replicated thrice. Foliar application of 2 per cent urea at flowering stage showed significant superior as regards of no. of pods and seed yield $plant^{-1}$ of blackgram and greengram, followed by 4 ml lit^{-1} nano urea two foliar spray at flowering and pod formation stage of crops. Significant effect on yield attributes reflected on significantly superior grain yield performance of blackgram (9.63 q ha^{-1}) and greengram (10.03 q ha^{-1}) under single foliar application of 2 per cent nano urea at flowering stage and which was followed by foliar spray of 4 ml lit^{-1} nano urea at flowering and pod formation stage blackgram (8.89 q ha^{-1}) and greengram (9.32 q ha^{-1}). The lowest values of growth and yield attributes were observed in absolute control. It can be concluded that, foliar application single dose of 2 per cent urea at flowering stage of blackgram and greengram was superior over two foliar spray of 4 ml lit^{-1} IFFCO nano urea. However, 2 per cent urea supplied 0.009 gm N lit^{-1} of spray solution and 4 ml lit^{-1} IFFCO nano urea supplied 0.074 gm N lit^{-1} of spray solution and results of one foliar spray of 2 per cent urea having very low concentration of nitrogen (0.009 gm lit^{-1}) in spray solution showed better performance over two foliar spray of IFFCO nano urea which has comparatively very high concentration of nitrogen (0.148 gm lit^{-1}). Hence, systematic crop wise experimentations will required before liberal use nano urea by farmers.

Green revolution led India to self-sufficiency in cereal food crops, however, is still lagging in case of pulses production and is dependent on their imports to fulfill the domestic needs of consumers. Indian productivity of the pulses is 764 kg ha^{-1} is far below the average productivity 848 kg ha^{-1} of the World. Indian pulses production during last four decades, virtually stagnant between 12 to 14 million tons from an area about 22 to 24 million ha. The slow rate of dry matter accumulation during the pre-flowering phase, onset of leaf senescence during the period of pod development and low partitioning efficiency of assimilates to grain were identified as the main physiological constraints for increasing yields (Pawar and Bhatia, 1980). Sinclair and de Wit (1975) reported that only 20 mg N of photosynthate would be available from soil to the developing seed as against the requirement of 26 mg N. It was apparent that blackgram / urd bean is not able to meet, the N demand of its seeds by uptake from the soil or by fixation. The exogenous supply of nitrogen, in the form of urea, would retard leaf senescence during pod development and contribute to increased seed yield. Thus, foliar fertilization is gaining importance in recent time for increasing crop yields.

Blackgram and greengram are important short duration *Kharif* leguminous crops in Maharashtra matured within 65 to 70 days. Apart from the nutritious food both the crops remain an integral part of subsistence cropping systems. They can be grown as sole crop, intercrop, catch crop, relay crop, cover crop and green manuring crop too. Foliar spray usually uses low amounts of fertilizer nitrogen. Foliar fertilization of 2 per cent nano urea at 30, 40 and 60 DAS with common RDF (20:50:20 kg ha^{-1} NPK) revealed significantly higher plant height, yield attibutes, N uptake and seed yield of blackgram (Reddy *et al.*, 2005). Urea can be used as foliar spray on plant with no scorching on leaves compared with fertilizers of salt nature (Mondal and Mamun, 2011). Three foliar application of 2 per cent urea at pre flowering + flowering + pod development stages showed significantly higher seed and

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stover yields, harvest index, as well as highest growth, productivity, profitability of greengram (Shafiqullah Bahadari *et al.,* 2020).

Nano-fertilizers are the important tools in agriculture to improve crop growth, yield and quality parameters, reduce wastage of fertilizers and cost of cultivation. Nano urea is a new Agri-input based on nanotechnology that supplies nitrogen to plants. Indian Farmers Fertilizer Corporation (IFFCO) recently developed and patented a novel urea nano fertilizer. The producer stated that it is possible to replace a bag of urea (45 kg urea or 20.7 kg N) by a 500 ml of 4 per cent w/v nano urea foliar fertilizer (43 gm urea of 20 g N). IFFCO- Nano urea is a long-term solution for farmers who wants to practise smart agriculture while also combating climate change. Because nano urea has a suitable size of 20-50 nm and a higher surface area (10,000 times that of a 1mm urea prill) and number of particles (55,000 nitrogen particles over 1 mm urea prill), it is bio-available to plants as a fertilizer. As a result, nano urea boosts crop availability by more than 80 per cent resulting in increased nutrient use efficiency (Yogendra Kumar *et al*., 2020). Nano urea liquid formulation will increase the production of crops with improved nutritional quality, cheaper than conventional urea, the new product also expected to reduce soil, water and air pollution caused by granular for fertilizers (Baboo, 2021).

MATERIAL AND METHODS

The field experiments on blackgram and greengram were carried out to study the effect of foliar application of IFFCO nano urea on growth and yield performance of crops at Pulse Research Unit, Washim road farm, Dr. PDKV, Akola during *Kharif* season 2021-22 in RBD with eight treatments and three replications. Treatments consists of T_1- RDF (20:40:20 kg ha^{-1} NPK), T_2- RDF + F.A. of 2% Urea (earlier recommendation of foliar spray), T_3- RDF + F.A. of nano urea @ 2 ml lit^{-1} at flowering stage, T_4- RDF + F.A. of nano urea @ 4 ml lit^{-1} at flowering stage, T_5- RDF + F.A. of nano urea @ 2 ml lit^{-1} at pod development stage, T_6- RDF + F.A. of nano urea @ 4 ml lit^{-1} at pod development stage, T_7- RDF + F.A. of nano urea @ 2 ml lit^{-1} at flowering and pod development stage and T_8- RDF + F.A. of nano urea @ 4 ml lit^{-1} at flowering and pod development stage. Blackgram (var. Black gold) and greengram (var. Green gold) were tested by using 15 kg ha^{-1} seeds, sowing at the spacing 30 x 10 cm and RDF was given through Urea, SSP and MOP fertilizers. Growth observations viz. plant height, no. of branches, triafoliate leaves, pods $plant^{-1}$, seed index, seed yield and dry matter yield was recorded. Leaf area is calculated by using leaf area meter (Pandey and Singh, 2011).

RESULTS AND DISCUSSION

Growth Performance

Foliar application of nano urea and 2 per cent urea solution to blackgram and greengram during grand growth stages showed non-significant improvement in plant height, trifoliate leaves, no. of branches and leaf area of the plant (Table 1). However, highest plant height (56.6 & 72.3 cm), trifoliate leaves(18.4 & 25.6 $plant^{-1}$), no. of branches(2.8 & 3.7 $plant^{-1}$) and leaf area (2665 & 2517 cm^{-2}) was recorded in the treatment received RDF + 2% urea foliar application at flowering stage to blackgram and greengram, followed by plant height (56.0 & 72.2 cm), trifoliate leaves(18.3 & 25.1 $plant^{-1}$), no. of branches(2.8 & 3.7 $plant^{-1}$) and leaf area (2645 & 2509 cm^{-2}) in the treatment RDF + foliar application of 4 ml lit^{-1} nano urea at flowering and pod development stage to both the pulse crops. Lowest values of all growth characters under study were observed under RDF alone (control) treatment. Senthil *et al*. (2008) also reported that, foliar application of 1 per cent urea at floral initiation stage and 15 days after flowering in black gram positively influenced higher growth, yield contributing characters and yield.

Yield Attributes

Data regarding pods per plant, seed yield $plant^{-1}$ and seed index of blackgram and greengram (Table 2), showed similar trend like growth performance i.e highest pods $plant^{-1}$, seed yield $plant^{-1}$ and seed index under RDF + F.A. of 2 per cent urea at flowering stage followed by RDF + F.A. of 4 ml lit^{-1} nano urea at flowering and pod development stage. Significantly highest pods (22.53) formation in greengram and seed yield) per plant of greengram (8.0 g) and blackgram (7.9 g) was observed in the treatment of RDF + single foliar spray 2 per cent urea at flowering stage and was at par to RDF+ two foliar

Table 1. Effect of foliar application of nano urea and 2% urea on growth performance of blackgram and greengram

Treatments	Blackgram				Greengram			
	Plant height (cm)	Trifoliate leaves (plant^{-1})	Branches (plant^{-1})	Leaf area (cm^2)	Plant height (cm)	Trifoliate leaves (plant^{-1})	Branches (plant^{-1})	Leaf area (cm^2)
RDF (20:40:20)	70.4	18.9	3.6	1868	55.2	17.3	2.7	2093
RDF+ F.A. of 2% Urea at flowering	72.3	25.6	3.7	2517	56.6	18.4	2.8	2665
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at flowering	70.7	19.9	3.7	1998	55.9	18.0	2.8	2514
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at flowering	71.7	21.2	3.7	2202	55.8	17.9	2.7	2502
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at pod development	70.8	20.9	3.6	2078	55.7	17.6	2.7	2402
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at pod development	71.5	19.3	3.6	1929	55.4	17.5	2.7	2298
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at Flowering & pod development	71.9	22.4	3.7	2317	55.9	18.2	2.8	2562
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at Flowering & pod development	72.2	25.1	3.7	2509	56.0	18.3	2.8	2645
SE (m) ±	1.11	2.22	0.12	215.5	2.11	0.51	0.13	231.5
CD at 5%	-	-	-	-	-	-	-	-

Table 2. Effect of foliar application of nano urea and 2% urea on yield contributing characters of blackgram and greengram

Treatments	blackgram			Greengram		
	Pods plant^{-1}	Seed yield plant^{-1}(g)	Seed index (g)	Pods plant^{-1}	Seed yield plant^{-1}(g)	Seed index (g)
RDF (20:40:20)	17.93	6.3	3.21	24.3	6.1	4.24
RDF+ F.A. of 2% Urea at flowering	22.53	8.0	3.27	28.7	7.9	4.30
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at flowering	19.33	6.5	3.23	26.7	6.2	4.26
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at flowering	20.33	7.2	3.24	26.9	6.3	4.27
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at pod development	19.33	6.5	3.22	26.9	6.3	4.27
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at pod development	19.07	6.6	3.24	25.8	6.4	4.29
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at Flowering & pod development	21.13	7.2	3.24	27.2	6.9	4.29
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at Flowering & pod development	21.47	7.6	3.26	27.5	7.4	4.29
SE(m)±	0.74	0.35	0.02	1.49	0.36	0.02
CD at 5%	2.18	1.04	-	-	1.05	-

spray of Nano urea 2ml lit^{-1} or 4ml lit^{-1} during flowering and pod development stages of both the pulse crops. Highest seed index of both crops was also observed under the F.A. of 2 per cent urea treatment but the improvement was non-significant. The lowest pods and seed yield per plant as well as seed index of blackgram and greengram was observed in absolute control treatment. Growada and Growada (1980) reported that, the number of pods per plant was increased with foliar application of NPK in mungbean and black gram. The foliage applied nitrogen and phosphorus at the initial stages might have been effectively absorbed and translocated to the pods resulting in more number of pods per plant. Hamid (1991) reported that foliar application of nitrogen increased seed number per pod in mungbean

Biological yield performance

Yield data (Table 3) showed the significant influence of foliar application of nitrogen fertilizers on the seed and straw yield of both greengram and blackgram crops. Significantly highest seed yield of greeengram (10.03 q ha^{-1}) and blackgram (9.63 q ha^{-1}) was observed in the RDF + F.A. 2 per cent urea at flowering stage and was statistically equal to seed yield of greeengram (9.32 q ha^{-1}) and blackgram (8.89 q ha^{-1}) under RDF+ F.A. of Nano urea @ 4ml lit^{-1} at Flowering and pod development stage treatment. Similarly, 2 per cent urea foliar spray at flowering stage with basal dose of RDF also showed significant straw yield over absolute control as regards of both pulse crops, but the performance was on par to all six treatments of nano-urea in the experimentation. Patel and Patel (1994) foliar application of 1.5 per cent urea and 0.5 per cent DAP significantly increased the seed yield in greengram. Similarly, Verma *et al.,* (2011) reported that, an increased grain yield was observed from 27.4 to 31.0 per cent due to foliar application of 2 per cent urea solution at 40 days after sowing in some black gram varieties. The foreign supply of nitrogen, in the form of urea or nano urea would stifle leaf senescence during pod development and contribute to higher seed yield. Seed yield was increased by foliar application of urea through retarding the decrement of chlorophyll and leaf nitrogen with tumid photosynthetic efficiency also revealed by Mitra *et at.*, 1987. The positive effect of nano nitrogen on seed yield of different legume crops was also reported by Drostkar *et al.*, 2016 and Gomma *et al.*, 2016.

CONCLUSION

Comparative study of recommended foliar application 2 per cent urea at flowering stage and foliar spray of IFFCO nano urea 2 / 4 ml lit^{-1} at flowering and pod development stage showed that, foliar application single dose of 2 per cent urea at flowering stage of blackgram and greengrm was superior over two foliar spray of 4 ml lit^{-1} IFFCO nano urea. However, 2 per cent urea supplied 0.009 gm N $lit.^{-1}$ of spray solution and 4 ml lit^{-1} IFFCO nano

Table 3. Effect of foliar application of nano urea and 2 per cent urea on biological yield performance of blackgram and greengram

Treatments	Blackgram (q ha^{-1})		Greengram (q ha^{-1})	
	Seed yield	Straw yield	Seed yield	Straw yield
RDF (20:40:20)	8.33	21.59	8.52	19.90
RDF+ F.A. of 2% Urea at flowering	9.63	24.78	10.03	22.35
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at flowering	8.46	23.24	8.89	21.25
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at flowering	8.61	23.52	8.95	20.51
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at pod development	8.52	23.36	8.86	20.33
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at pod development	8.64	23.04	8.92	20.14
RDF+ F.A. of Nano urea @ 2ml lit^{-1} at Flowering & pod development	8.80	24.42	9.14	22.01
RDF+ F.A. of Nano urea @ 4ml lit^{-1} at Flowering & pod development	8.89	24.66	9.32	22.30
SE(m)±	0.31	0.83	0. 29	0.81
CD at 5%	0.92	2.53	0.87	2.42

urea supplied 0.074 gm N lit^{-1} of spray solution and results of one foliar spray of 2 per cent urea having very low concentration of nitrogen (0.009 gm lit^{-1}) in spray solution showed better performance over two foliar spray of IFFCO nano urea which has comparatively very high concentration of nitrogen (0.148 gm lit^{-1}). Hence, systematic crop wise experimentations will required before its liberal use by farmers.

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Evaluation of Urdbean Production and Productivity Under Zinc and Iron Foliar Application

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ABSTRACT

This research paper investigates the effects of zinc sulphate and iron sulphate application on the bio-fortification and productivity of urdbean (*Vigna mungo* L.), a significant pulse crop in India. The study was conducted during the *kharif* season of 2023 at Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, on clayey, slightly alkaline vertisol soil. Various treatments involving foliar applications of zinc sulphate and ferrous sulphate at flowering and/or pod initiation stages were tested in a randomized block design. The results revealed that growth parameters such as plant height & branch number and yield were not significantly affected by zinc and iron application, but the notable improvement observed in the treatment involving the combined foliar application of zinc and iron at flower and pod initiation stages. This treatment also resulted in the highest seed yield and economic returns, demonstrating the beneficial effects of micronutrient application in improving the productivity and nutritional quality of urdbean. The study highlights the potential of zinc and iron fortification in addressing micronutrient deficiencies in rural populations through bio-fortified staple crops.

Urdbean [*Vigna mungo* (L.)] is one of the fourth prime pulses crop after chickpea, pigeonspea and mungbean. Being a self-pollinated grain legume possess high seed protein content (23-26 %) as well as ability to restore soil fertility through biological nitrogen fixation from atmosphere. In India urdbean is grown on an area of about 3.29 million ha with the production of 2.01 million tons and productivity of 469 kg ha^{-1} (Anonymous, 2017-18). The productivity of urdbean is low in farmer field as compare to experimental field. There are a number of biotic and abiotic factors to limit the potential yield of urdbean. Besides the major plant nutrients, micro nutrients viz: iron and zinc are playing an important role for boosting productivity of urdbean. The limited availability of these micro nutrients is also influencing the quality of seed. Frequent drought in the low rainfall semi-arid areas and water-logging in the high rainfall areas are caused considerable loss in urdbean production. It is of mature pods are picked 2 to 3 times because of non- synchronous and varieties or vegetative and reproductive sink, resulted flower and pod development.

Micronutrients are needed by plants in small amounts, but yet crucial to plant development. In plants, zinc is key constituent of many enzymes and proteins. It is essential in the formation of auxins, which help with growth regulation and stem elongation. Growth parameters were increased by zinc application regardless to its concentration and application method. Zinc application either through soil or foliar application, also increases the Zn content of shoot (Abbas and Zaynab, 2010). Foliar sprays fix the problem for the plant but they have don't fix the problem in the soil. Method of application of also depends upon the Zn fertilizer used.

Iron is very important to the growth of plants. It is a constituent of several enzymes and some pigments, and assists in nitrate and sulphate reduction and energy production within plant. Although iron is not used in the synthesis of chlorophyll but it is essential for its formation. Iron plays a significant role in various physiological and biochemical pathway in plants. In plants, iron is involved in the synthesis of chlorophyll and it is essential for the maintenance of chloroplast structure and function. Application of zinc and iron either foliar spray or basal application are fortified the seed quality of urdbean. Bio fortified staple crops, when consumed regularly, will generate measurable improvements in human health and nutrition. Bio fortified crops are also a feasible means of reaching rural populations who may have limited access to diverse diets or other micronutrients level interventions. Keeping, these points in view, the present investigation was undertaken to evaluate zinc and iron application on bio-fortification and productivity of urdbean.

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MATERIAL AND METHODS

A field experiment was carried out during *kharif* season, 2023 at Research Farm, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola (Maharashtra) located at a latitude of 20°70' and a northern longitude of 77°00' East, sits at an altitude of 316.41 meters above mean sea level. The soil in the experimental plot possessed a clayey texture and exhibited slightly alkaline characteristics with a pH of 8.34. Furthermore, it was classified as a vertisol. Chemical analysis indicated low levels of organic carbon (0.42%), deficient availability of nitrogen (161 kg ha^{-1}), moderate availability of phosphorus (19.16 kg ha^{-1}), and high availability of potassium (396 kg ha^{-1}). The total soluble salt content was within normal limits, as indicated by an electrical conductivity of 0.24 dSm^{-1}.

In this present investigation treatments included various combinations of zinc sulfate ($ZnSO_4$) and ferrous sulfate ($FeSO_4$) foliar applications at different growth stages, as RDF + Foliar application of 0.50 per cent $ZnSO_4$ at flower initiation (T1), RDF + Foliar application of 0.50 per cent $FeSO_4$ at flower initiation (T2), RDF + Foliar application of 0.50 per cent $ZnSO_4$ at pod initiation (T3), RDF + Foliar application of 0.50 per cent $FeSO_4$ at pod initiation (T4), RDF + Foliar application of 0.50 per cent $ZnSO_4$ + 0. 50 per cent $FeSO_4$ at flower initiation (T5), RDF + Foliar application of 0.50 per cent $ZnSO_4$ + 0. 50 per cent $FeSO_4$ at pod initiation (T6), RDF + Foliar application of 0.50 per cent $ZnSO_4$ + 0.50 per cent $FeSO_4$ at flower and pod initiation (T7), RDF + Foliar application of "PDKV Liquid Micro Grade X" at flower and pod initiation (T8), 75 per cent RDF + Foliar application of 0.50% $ZnSO_4$ + 0.50 per cent $FeSO_4$ at flower and pod initiation (T9), RDF (Control) (T10). The full recommended dose of fertilizers (20kg N, 40kg P_2O_5 and 20kg K_2O ha^{-1}) was applied in all the treatments at the time of sowing. along with control and other nutrient management practices were tried in a randomized block design with three replications.

Urdbean crop (Cv. PDKV blackgold) was sown on June 30, 2023 in a row spacing of 45 cm apart. Seed rate at 12 kg ha^{-1} was treated with thiram @ 2.5g kg^{-1} seed and inoculated with Rhizobium culture and PSB before sowing, Crop was fertilized at RDF of 20 kg N, 40 kg P_2O_5 and 20 kg K_2O ha^{-1}. Entire quantity of NPK was applied as basal below the seed uniformly in all treatments. Zinc sulphate and iron sulphate was applied 0.5 per cent foliar application at flower initiation and pod initiation separately and both the stages with 450 liters water per hectare was applied. Plant spacing of 10 cm was maintained by thinning operation. Pendimethalin @ 1 kg a.i ha^{-1} was sprayed next day of sowing for weed control in addition to one manual weeding on 25 days after sowing. Crop was raised under rainfed condition which received 497 Mm rainfall during cropping period out of an annual rainfall of 649 Mm. The crop was harvested on September 17, 2023. Important observations were taken at appropriate time and economics was calculated on the basis of prevailing market periods.

RESULTS AND DISCUSSION

Growth Characters

Growth characters of urdbean viz. plant height and branches $plant^{-1}$ were not affected by zinc and iron application. The mean plant height at harvest stages is 40.41 cm. There was increased plant height as the growth of the crops enhanced. The differences were not statistically significant at any stage of observation among treatments.

The observed increased growth over control might be attributed to the role of Zn foliar application, which aids in the synthesis of IAA, metabolism of auxins, biological activity, stimulation of enzyme activity, and enhancement of photosynthetic pigments, thereby promoting vegetative growth (internodal distance). The average number of branches 5.23 at harvest. In this study, the treatments applied did not significantly influence the number of branches $plant^{-1}$ at any observation stage in the urdbean crop. At the same time, the number of branches increased as the crop approached maturity.

Yield attributes

Yield attributes viz No. of Pods $Plants^{-1}$, Seed Index (g), Seed Yield $Plant^{-1}$ (g), Seed Yield (Kg ha^{-1}), Strover Yield (Kg ha^{-1}), Biological Yield (Kg ha^{-1}), Harvest Index (%) were not found significantly due to foliar spray of zinc sulphate and iron sulphate but have numerically higher values. Pods $plant^{-1}$ was observed higher in T7

Table 1: Effect of various foliar application on Growth and Yield parameters

	Treatment Details	Plant height (cm)	No. of Branches	No. of Pods Plants^{-1}	Seed Index (g)	Seed Yield Plant^{-1} (g)	Seed Yield (Kg ha^{-1})	Haulm Yield (Kg ha^{-1})	Biological Yield (Kg ha^{-1})	Harvest Index (%)
T_1	RDF + FA of 0.50% $ZnSO_4$ at FI	41.22	8.02	25.16	4.37	6.45	1431	2854	4285	33.9
T_2	RDF + FA of 0.50% $FeSO_4$ at FI	39.79	7.00	24.22	4.37	6.37	1415	2839	4254	32.6
T_3	RDF + FA of 0.50% $ZnSO_4$ at PI	41.12	7.54	24.83	4.30	6.41	1424	2853	4276	32.8
T_4	RDF + FA of 0.50% $FeSO_4$ at PI	39.92	7.10	24.79	4.30	6.41	1422	2844	4265	33.4
T_5	RDF + FA of 0.50% $ZnSO_4$ + 0.50% $FeSO_4$ at FI	43.24	8.10	25.30	4.13	6.47	1436	2868	4304	33.2
T_6	RDF + FA of 0.50% $ZnSO_4$ + 0.50% $FeSO_4$ at PI	43.37	8.38	25.49	4.27	6.57	1459	2873	4333	33.3
T_7	RDF + FA of 0.50% $ZnSO_4$ + 0.50% $FeSO_4$ at FI & PI	44.37	8.47	25.64	4.50	6.58	1462	2875	4337	33.2
T_8	RDF + FA of "PDKV Liquid Micro Grade X" at FI & PI	38.75	6.98	23.21	4.40	6.24	1385	2837	4222	33.1
T_9	75 % RDF + FA of 0.50% $ZnSO_4$ + 0.50% $FeSO_4$ at FI and PI	37.81	6.89	20.59	4.43	5.77	1310	2295	3575	33.7
T_{10}	RDF (Control)	38.52	6.95	21.82	4.20	5.97	1326	2760	4085	33.79
	S.E. (m)±	2.29	0.41	1.38	0.07	0.41	89.76	166	216	1.57
	CD at 5%	-	-	-	-	-	-	-	-	-
	CV	9.73	9.53	9.94	2.93	11.21	11.05	10.34	8.95	8.09

(RDF + foliar application of 0.5 per cent $ZnSO_4$ + 0.5 per cent $FeSO_4$ at flower and pod initiation stage) . Similarly, seed weight/plant was recorded numerically superior in T7 (RDF + foliar application of 0.5 per cent $ZnSO_4$ + 0.5 per cent $FeSO_4$ at flower and pod initiation stage). This shows that the use of zinc and iron in all the doses and stages of application enhanced metabolic process of plant which resulted better yield attributes.

Similar results were also obtained by Jain (2007), Sharma and Abraham (2010), Dubey *et al.* (2013), Jejal *et al*, (2024b), Jat *et al*. (2015). Singh and Aggarwal (1998) found that foliar application of zinc sulphate and ferrous sulphate at branching and flower bud initiation stages increased the number of flower plant^{-1}, pods plant^{-1}, seeds pod^{-1} and seed yield in green gram.

Yield and harvest index

Grain yield of urdbean was produced numerically superior by T7 (RDF + foliar application of 0.5 per cent $ZnSO_4$ + 0.5 per cent $FeSO_4$ at flower and pod initiation stage) closely followed by T6 (RDF + foliar application of 0.5 per cent $ZnSO_4$ + 0.5 per cent $FeSO_4$ at flower initiation stage) and T5 (RDF + foliar application of 0.5 per cent $ZnSO_4$ + 0.5 per cent $FeSO_4$ at pod initiation stage) This application enhanced seed yield by 9 per cent over control (RDF). It exhibited beneficial effect of zinc and iron in varying degree. Zinc and Iron is having the stimulatory effect on most of the physiological and metabolic processes and nitrogen metabolism, synthesis of chlorophyll, plant growth regulator, improves photosynthesis and assimilates transportation to sink resulted to enhanced seed yield of mung bean.

The foliar application of nutrients helps specially treatment of zinc sulphate and iron sulphate at flower initiation and bud initiation which might have also responsible for efficient translocation of photosynthate from source to sink, this cause higher number of pod formation and more dry weight plant. Similar results were reported by Jain (2007) Sharma and Abraham (2010) and Dubey *et al.* (2013). Stover yield was recorded significantly more in spray of 0.5 per cent $FeSO_4$ at FI and PI (2460 kg ha^{-1}) followed by 0.5 per cent $ZnSO_4$ +$FeSO_4$ at FI and PI (2387 kg ha^{-1}). This increase was associated with growth parameters due to application of zinc were also reported by Jain (2007), Sharma and Abraham (2010), Dubey *et al.* (2013) in different crop. Harvest index of urdbean was significantly increased due to foliar spray of $ZnSO_4$ and FeSO4. It was noted higher in T6 (RDF + foliar application of 0.5 per cent $ZnSO_4$ + 0.5 per cent $FeSO_4$ at pod initiation stage) This enhancement could be ascribed due to more increase in seed yield attributes as compare to growth parameters i.e. stover yield.

Economics

In this investigation, majorly cost of cultivation is fixed but variance is due to only foliar application inputs and frequency of spraying. Highest cost of cultivation is seen in T7 (RDF + Foliar application of 0.50 per cent $ZnSO_4$+ 0.50 per cent $FeSO_4$ at flower and pod initiation) due two frequency of spraying and two inputs used vis Zinc and

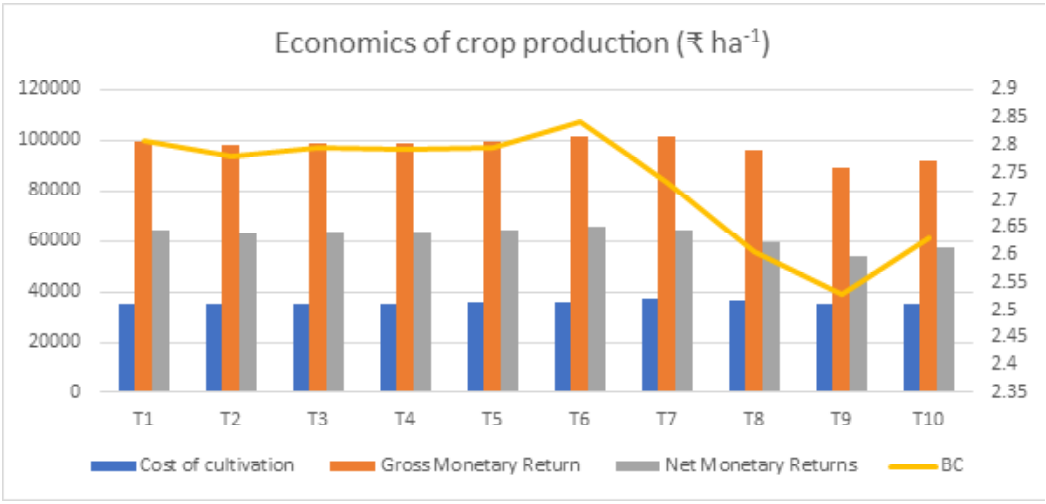

Fig 1. Economics of urdbean production under influence of zinc and iron sulphate foliar application

ferrous sulphate. While lowest is seen in control (T10)

The highest gross monetary returns (ha^{-1}) were recorded in T7 (RDF + Foliar application of 0.50 per cent $ZnSO_4$ + 0.50 per cent $FeSO_4$ at flower and pod initiation) at Rs. 1,01,574 ha^{-1}, due to the highest seed yield among all treatments. Net monetary returns from the urdbean crop were not significantly influenced by the various treatments in this investigation. The highest net monetary return was found in T6 (RDF + Foliar application of 0.50 % $ZnSO_4$ + 0.50 per cent $FeSO_4$ at pod initiation).

The maximum BC ratio was also observed in T6 (RDF + Foliar application of 0.50 per cent $ZnSO_4$ + 0.50 per cent $FeSO_4$ at pod initiation), which was 2.84, as the cost of cultivation was lower compared to other treatments. This similar result was shown in previous investigations conducted by Kavya *et al.* (2021), Dhaliwal *et al.* (2023), Barla *et al.* (2022), Rathod *et al*. (2022), Bahure *et al*. (2016) and Saini *et al*. (2017).

This could be associated because of high value of gross returns as compared to cost of cultivation. Result confirmed by the finding of Atul *et al.* (2017), Shivay *et al.* (2014), Jejal *et al*., (2024a) and Jat *et al.* (2015).

CONCLUSION

The present study revealed that foliar application of zinc and iron improves yield attributes and harvest index in urdbean. Among the treatments evaluated, the combination of 0.5 per cent $ZnSO_4$ + 0.5 per cent $FeSO_4$ at both flower and pod initiation stages proved to be the most effective in upscaling seed yield and improving economic returns. The results underscore the potential of zinc and iron foliar applications as a sustainable approach to boost urdbean productivity and contribute to the nutritional security of farmers and consumers.

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Temporal Changes in Cost and Returns of Tur in Vidarbha Region of Maharashtra

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ABSTRACT

Study of temporal changes in economics of tur production is helpful for farmers. It serves as a guideline to the cultivator to select appropriate crop. In deciding, what to produce? How to produce? and how much to produce? it is necessary to have some knowledge about the economics of production. Being the topic of such high importance from cultivators' point of view, the research topic has been selected i.e., "Temporal changes in Cost and Returns of Tur in Vidarbha region (M.S.)". The study was carried out with the main goals of determining the extent to study the temporal changes in input use, cost of cultivation and returns of tur crop and to estimate growth rates and instability of Input utilization, Cost and Returns of tur crop. The results of physical quantity of bullock labour, machine labour, seed and Nitrogen, Phosphorus, Potassium also increased for tur crop i.e. 96.40, 173.42, 37.91, 21.32, 84.46, 190.71 percentage change of 2020-21 to over 2000-01 respectively. The share of Cost 'A' in total cost was 57.98 per cent in 2000-01 and 56.86 per cent in 2020-21, which was lower than that in 2020-21. The share of human labour, seed, manure and fertilizer were decreased in total cost i.e. 23.53, 5.18, 3.15 and 6.51 per cent in 2000-01 to 14.20, 2.44, 1.34 and 2.82 per cent, respectively. The reasons of decreased in share of human labour is on account of substitution by machine labour. The cost of Production of tur has decreased from Rs.6443.93 q^{-1} in 2000-01 and Rs. 6178.55 q^{-1} in 2020-21, while the cost of production has recorded and decreased of 4.12 per cent during the period being study because farmers was adopting new technology and improved seed. The ha^{-1} yield of tur in 2000-01 was 7.06 quintals and 22.25 quintals in 2020-21 while the yield of tur crop has recorded an increase in 215.16 per cent over a period of time because farmers was aware the new technology and adopt the technology and farmers sowing used in high yielding varieties then increased the yield. The Cost 'A', Cost 'B' and Cost 'C' were increased of all three period i.e. Rs. 21147.61/-, Rs. 28206.38/- and Rs. 36472.64/- per hectare, in 2000-01, Rs. 36140.22, Rs. 61153.67/- and Rs. 66781.97/- per hectare in 2010-11 and Rs. 54906.21/-, Rs. 87950.29/- and Rs. 96570.73/- in 2020-21 respective cost. It was showing 159.63, 211.81 and 164.78 per cent at Cost 'A', Cost 'B' & Cost 'C' respectively percentage change of 2020-21 to over 2000-01 respectively.

The gross return was increased from Rs. 37118.45/- in 2000-01 to Rs.100547.02/- in 2020-21. It is increased from 301.73 percentage change of 2020-21 to over 2000-01. The net returns of Cost 'A' and Cost 'C' were observed that, Rs. 489.89 and Rs. 8036.00 per cent respectively in percentage change during 2020-21 to over 2000-01. The benefit cost ratio at Cost 'A' was 1:1.76, 1: 2.65 and 1: 1.72 in period I, period II and overall period, while at Cost 'C' the benefit cost ratio of was 1:1.02, 1: 1.43 and 1: 1.43 respective in period I, period II and overall period. It indicates that as adoption of technology increases the yield level of crop is increase and so that the net returns also increase.

Economics of crop production depends upon various factors. Among these. the important factors are level of input use and the prices of input and output. To study of cost of cultivation and its composition and the changes therein over the period is important in many ways. Such a study helps in knowing the relative importance of crops which helps in formulation appropriate price policy for their inputs. The study of productivity or ha^{-1} yield of crops and changes there in is important in devising policies regarding agricultural production.

As such the farmers need some objectives measures of these year-to-year variation based on past records. This may serve as a guide to the farmers in decision making. The farmer introduces new method and techniques to increase productivity. Farmers are moving towards superior is one of the most important forces which

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alter the structure of the agricultural production process. The technical advances may result in such development as evolution of new crop varieties, invention of new fertilizers and their use methods, improved rations new farm machinery use etc. Being the topic of such high importance from cultivators point of view, the research topic has been selected i.e., "Temporal changes in cost and returns of tur".

This study reveals the temporal changes in Input use, Cost of cultivation and returns of tur crop and Growth Rates and Instability of Input Utilization, Cost and Returns of Tur Crop.

MATERIAL AND METHODS

The study pertained to the time series data on cost and returns of tur crop was obtained from last 20 years i.e. from 2000-01 to 2020-21 and the data on costs and prices were collected from Agriculture Prices and Costs Scheme, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. In order to study the temporal changes of input use, cost, returns, growth of cost of input, trend in cost of production and factors affecting the cost of cultivation of tur crop were used. i.e. estimation of growth rates, trend curves and cobb Douglas function. The Crop was selected on Tur. It is the major pulse crop in Vidarbha region, therefore tur crop was selected for the present study.

To study the temporal changes in Input use, Cost of cultivation and returns of tur crop.

To accomplish the objectives of the study, input utilization, standard cost concept i.e. cost 'A', cost 'B' and cost 'C' were used to estimate the temporal changes of ha^{-1} cost of cultivation and returns of tur crop (Kale and Nikhale. 2021 and Monga and Sidana, *2020*).

Gross Return

Return obtained from the sale of crops output i.e. Main Produce and by-produce.

Net Return

Net returns were computed at different costs i.e. Cost 'A', Cost 'B', and Cost 'C' by deducting respective costs from the gross returns.

Benefit Cost Ratio

The Benefit cost ratio were worked out with reference to Cost 'A', Cost 'B' and Cost 'C'.

To estimate growth rates and instability of Input utilization, Cost and Returns of tur crop

Estimation of Compound Growth Rate

In this study, the Compound Growth Rates (CGR) of the costs, returns and input utilization of selected crop was worked out by fitting the exponential growth function.

$$Y = ab^t$$

Where,

Y = Dependent variable for which growth rate has to be estimated

a = Constant or intercept

b = Regression / trend coefficient

t = Period in year (1,2,3….n)

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

Compound growth rate was estimated by –

$$CGR = (\text{Antilog } (\log b - 1) \times 100$$

The function was fitted to see the difference in the growth rates of input, cost and return of tur. The growth rates was computed for the original data as well as data adjusted for inflation by converting them to constant prices using General Price Index prevailing during the selected base year. The function was fitted separately for both periods (i.e.) period (2000-01 to 2010-11) period II (2011-12 to 2020-21) as well as for the overall period (2000-2021) in order to see for differences in the rate of growth of average input and output prices of tur at current and constant prices .

Index number

An index no. is a statistical measure design to show the changes in variables or group of related variables or group of related variables with respect to time. The index no. will be calculated by choosing the 1st triannum average as a base year.

$$\text{Index Number} = \frac{\text{Current year value}}{\text{Base year value}} \times 100$$

Constant price

The original data of costs of inputs and prices were adjusted for inflation by using the general price index numbers gives the data at constant prices. The General Price Index numbers with the base yeas 2000-01 was selected.

Instability analysis

To measure the instability in Cost of cultivation and input utilization, an index of instability will be used as measure of variability. The coefficient of variation (CV) was calculated by the formula.

$$C.V.(\%) = \frac{\text{Standard Deviation}}{\text{Mean}} \times 100$$

RESULT AND DISCUSSION

Temporal changes in input use of tur crop

The details of input utilization of tur in Vidarbha region for the years 2000-01 to 2020-21 at triennium basis are given in Table 1.

Table 1 is revealed that, the use of male labour for tur in 42.36 days in 2000-01 which increased marginally to 45.42 days in 2020-21. However use of female labour increased form 37.42 in to 46.57 in 2000-01 to about 46.57 days in 2020-21. It means, male labour and female labour increased, 7.22 per cent and 24.45 per cent respectively. It is remarkable to note that the physical quantity of bullock labour, machine labour, seed and Nitrogen, Phosphorus, Potassium also increased for tur i.e. 96.40, 173.42 , 37.91, 21.32, 84.46, 190.71 percentage change of 2020-21 to over 2000-01 respectively. The per hectare yield of tur crop was increased from 7.06 quintal per hectare in 2000-01 to 22.25 quintal per hectare in 2020-21. This indicates an increase in yield is 215.16 per cent over a period of time. It is remarkable to note that, increased in yield of tur crop is obviously due to the increased use of inputs, particularly the chemical fertilizers. The same study was conducted by the Gurjar and Varghese, 2005 and found the same result are obtained more or less same.

Temporal changes in cost of cultivation and production of tur crop

Table 2, revealed that, the changes in the cost of cultivation of tur in Vidarbha region. The total cost of tur has gone up from Rs. 36472.64 per hectare in 2000-01 to

Table: 1 Temporal changes in Input use and Yield of tur

S.N.	Year	Unit	2000-01	2010-11	2020-21	Over all	Percentage change during 2020-21 to over 2000-01
1	Human labour						
	Male Labour	Daysha^{-1}	42.36	59.30	45.42	55.08	7.22
	Female Labour	Days ha^{-1}	37.42	55.54	46.57	64.21	24.45
	Total human labour	Days ha^{-1}	79.78	114.84	91.99	119.29	15.30
2	Bullock labour	Daysha^{-1}	8.60	15.99	16.89	13.05	96.40
3	Machine labour	Hr.ha^{-1}	9.82	24.21	26.85	21.61	173.42
4	Seed	Kg ha^{-1}	20.81	23.22	28.70	23.64	37.91
5	Manure	Qtl ha^{-1}	8.22	7.79	8.88	7.96	8.03
6	Fertilizer						
	N	kg ha^{-1}	26.92	30.04	32.66	30.55	21.32
	P	kg ha^{-1}	18.41	39.05	33.96	34.89	84.46
	K	kg ha^{-1}	4.63	3.50	13.46	9.48	190.71
7	Yield /ha	Qtlha^{-1}	7.06	15.30	22.25	16.22	215.16

Rs. 66044.28/- per hectare in 2020-21 depicting an increase by 164.78 per cent over a period of time. The increase has occurred in all major items of cost like hired human labour, family labour, bullock labour, machine labour, seed, fertilizer, manure, plant protection, rental value of land interest on working capital, cost of interest on fixed capital and depreciation cost. The cost of human labour, plant protection, incidental charges, seed and fertilizer has increased at a faster rate. Among the operational cost items, hired human labour(59.81 %) recorded the maximum share followed family labour(4.28 %) in the increased in cost of cultivation over a period of time.

The share of Cost 'A' in total cost was 57.98 per cent in 2000-01 and 56.86 per cent in 2020-21, which was lower than that in 2020-21. The comparison of the share of different items in the total cost for the period under study revealed that, there was an increase in the share of bullock labour, Machine labour and plant protection in total costi.e.9.39, 3.49 and 1.38 per cent in 2000-01 to 12.72, 4.36 and 5.97 per cent in 2020-21 respectively. The share of human labour, seed, manure and fertilizer were decreased in total cost i.e. 23.53, 5.18, 3.15 and 6.51 per cent in 2000-01 to 14.20, 2.44, 1.34 and 2.82 per cent respectively. The cost of Production of tur has decreased from Rs.6443.93 per quintal in 2000-01 and Rs.6178.55 per quintal in 2020-21, while the cost of production has recorded an decreased of 4.12 per cent during the period being study because farmers was adopting new technology and improved seed.

Temporal changes in Economics of Production of Tur

From the Table 3, the per hectare yield of tur in 2000-01 was 7.06 quintals and 22.25 quintals in 2020-21 while the yield of tur crop has recorded an increase in 215.16 per cent over a period of time because farmers was aware the new technology and adopt the technology and farmers sowing used in high yielding varieties then increased the yield.

The gross return was increased from Rs. 37118.45 in 2000-01 to Rs.100547.02 in 2020-21. It is increased from 301.73 per cent over a period of time.

The Cost 'A' , Cost 'B' and Cost 'C' were increased of all three period i.e. Rs. 21147.61/-, Rs. 28206.38/- and Rs. 36472.64/- per hectare, in 2000-01, Rs. 36140.22, Rs. 61153.67/- and Rs. 66781.97/- per hectare in 2010-11 and Rs. 54906.21/-, Rs. 87950.29/- and Rs. 96570.73/- in 2020-21 respective cost. It was showing 159.63, 211.81 and 164.78 per cent at Cost 'A', Cost 'B' & Cost 'C' respectively percentage change of 2020-21 to over 2000-01 respectively

The net returns of Cost 'A' and Cost 'C' were observed that, 489.89 and 8036.00 per cent respectively in percentage change during 2020-21 to over 2000-01.

The benefit cost ratio at Cost 'A' was 1:1.76, 1: 2.65 and 1: 1.72 in period I, period II and overall period, while at Cost 'C' the benefit cost ratio of was 1:1.02, 1: 1.43 and 1: 1.43 respective in period I, period II and overall period. It indicates that as adoption of technology increases the yield level of crop is increase and so that the net returns also increase.

Growth rate and Instability of cost & returns of tur crop

Growth rate at current and constant prices of cost and returns of tur crop

The rate of change in terms of various components of costs of production of tur crop expressed in terms of compound growth rates estimated through exponential function were examined for the period 2000-01 to 2010-11 (Period-I), 2011-12 to 2020-21 (Period-II) and 2000-01 to 2020-21 (Overall Period) are presented in table 4.

It can be seen from the table 4, during the first period 2000-01 to 2010-11 at current prices, the compound growth rate was found to be significant for all components of cost of production except fertilizer and per quintal cost. It means the growth rate were high during the first period for all input cost at current price i.e. hired human labour(10.80%), Bullock labour(14.26%), Machine labour(18.69%), Seed (9.14%), manures (7.59%), plant protection (20.94%), Cost 'A'(11.87%), Cost 'B'(11.97%) family labour(4.82%) and Cost 'C'(11.03%). But in second period i.e. 2011-12 to 2020-21, hired human labour(4.73%), bullock labour (15.03), seed (8.25%%), manures (9.30%), fertilizer (34.84%), Cost 'A'(8.92%), Cost 'B'(9.51%) shows significant growth rate in current prices. In the overall period compound growth rates were found to be significant except per quintal cost.

Table 2. Temporal Changes in cost of cultivation of tur

S. N.	Particulars	2000-01	2010-11	2020-21	Overall	Percentage change during 2020-21 to over 2000-01
1	Hired human labour	8581.83	14299.22	13714.33	14211.37	59.81
		(23.53)	(21.41)	(37.60)	(38.96)	
2	Bullock labour	3426.34	7262.95	12283.25	7050.41	258.49
		(9.39)	(10.88)	(33.68)	(19.33)	
3	Machine labour	1272.67	3410.56	4210.35	3265.94	230.83
		(3.49)	(5.11)	(11.54)	(8.95)	
4	Seed	1890.88	2280.21	2360.8	2252.93	24.86
		(5.18)	(3.41)	6(6.47)	(6.18)	
5	Manure	1148.76	1107.74	1289.38	1165.07	12.24
		(3.15)	(1.66)	(3.54)	(3.19)	
6	Fertilizer	2374.59	2196.77	2726.0	2820.9	
		(6.15)	(3.29)	4(7.47)	7(7.73)	14.80
7	Irrigation	0.00	0.00	1205.55	129.2	
		(0.00)	(0.00)	(3.31)	6(0.35)	-
8	Bio fertilizer	0.00	17.44	315.12	66.91	
		(0.00)	(0.03)	(0.86)	(0.18)	-
9	Plant protection	501.59	1877.92	5768.98	3730.58	
		(1.38)	(2.81)	(15.82)	(10.23)	1050.14
10	Incidental Charges	123.41	761.13	2091.17	917.73	
		(0.34)	(1.14)	(5.73)	(2.52)	1594.52
11	Repairing charges	214.38	377.39	1255.69	437.96	
		(0.59)	(0.57)	(3.44)	(1.20)	485.73
12	Growth regulator	0.00	0.0	1138.03	202.77	
		(0.00)	0(0.00)	(3.12)	(0.56)	-
13	Weedicide	0.00	257.72	827.88	332.20	
		(0.00)	(0.39)	(2.27)	(0.90)	-
14	Working capital	19534.45	33849.04	49186.63	36584.12	151.79
		(53.56)	(50.69)	(134.89)	(100.31)	
15	Interest on working capital	1135.69	1934.71	2951.20	2095.78	159.86
		(3.11)	(2.90)	(8.09)	(5.75)	
16	Depreciation	453.47	331.53	2748.36	651.21	506.07
		(1.24)	(0.50)	(7.54)	(1.79)	
17	Land revenue	23.99	24.94	20.02	27.00	-16.55
		(0.07)	(0.04)	(0.05)	(0.07)	
A	Cost 'A'	21147.61	36140.22	54906.21	39358.12	
		(57.98)	(54.12)	(150.54)	(107.91)	159.63

18	Rental value of land(1/6 of the Gross produce – Rental ` value of land)	6001.04 (16.45)	24358.86 (36.48)	22094.78 (60.58)	17634.02 (48.35)	268.18
19	Interest on fixed capital	1057.73 (2.90)	654.59 (0.98)	10949.30 (30.02)	1922.88 (5.27)	935.17
B	Cost 'B'	28206.38 (77.34)	61153.67 (91.57)	87950.29 (241.14)	58915.02 (161.53)	211.81
20	Family human labour	8266.26 (22.66)	5628.30 (8.43)	8620.45 (23.64)	7129.27 (19.55)	4.28
III	**Cost 'C' (A+B)**	36472.64 (100.00)	66781.97 (100.00)	96570.73 (100.00)	66044.28 (100.00)	164.78
	Cost/quintal	6443.93	6065.57	6178.55	6587.18	-4.12
	Yield	**7.06**	**15.30**	**22.25**	16.03	215.16

Note: Figures in parenthesis are percentages to the total cost

Table 3 : Temporal changes in Economics of Production of tur

	Particulars	**Units**	**2000-01**	**2010-11**	**2020-21**	**Overall**	**Percentage change during 2020-21 to over 2000-01**
I	Yield	Qtl	7.06	15.3	22.25	16.03	215.16
	Rate	Rs.	5096.05	6059.26	6504.32	6087.34	27.63
	Main produce	Rs.	35978.113	92706.678	144721.12	97580.06	302.25
	By produce	Rs.	1140.32	3009.69	4395.88	2966.96	285.50
	Gross produce	Rs.	37118.43	95716.37	149117.00	100547.02	301.73
II	Cost						
	Cost 'A'	Rs.	21147.61	36140.22	54906.21	37384.58	159.63
	Cost 'B'	Rs.	28206.38	61153.67	87950.29	87950.29	211.81
	Cost 'C'	Rs.	36472.64	66781.97	96570.73	95079.56	164.78
III	Net Return at Cost 'A'	Rs.	15970.823	59576.148	94210.79	63162.44	489.89
	Net Return at Cost 'B'	Rs.	8912.05	34562.70	61166.71	12596.73	586.34
	Net Return at Cost 'C'	Rs.	645.79	28934.40	52546.27	5467.46	8036.70
IV	B:C ratio at Cost 'A'	Rs.	1.76	2.65	2.72	2.69	54.73
	B:C ratio at Cost 'B'	Rs.	1.32	1.57	1.70	1.14	28.84
	B:C ratio at Cost 'C'	Rs.	1.02	1.43	1.54	1.06	51.73

The results of Constant prices at period one i.e. 2000-01 to 2010-11 manures, fertilizer, family labour were found non- significant. But in second period i.e. 2011-12 to 2020-21 machine labour(2.82%), seed (2.35%), Cost 'A' (3.57%), Cost 'B'(3.95%), family labour(1.96%), Cost 'C'(30.07%) were found significant.

The study of entire period i.e. 2000-01 to 2020-21, indicated that manure and per quintal cost of production were recorded non-significant growth rates at constant pries. On the other hand, growth rate of the cost of hired human labour (3.28%), bullock labour (6.56%), machine labour (4.67%), seed (1.02%), fertilizer (1.40%),

Table:4 Compound growth rate of Cost of inputs and returns of tur crop.

Particulars	Current prices			Constant prices		
	Period I 2000-01 to 2010-11	Period II 2011-12 to 2020-21	Overall period 2000 to 2021	Period I 2000-01 to 2010-11	Period II 2011-12 to 2020-21	Overall period 2000 to 2021
Hired human labour	10.8**	4.73*	10.8**	5.37**	-0.97	3.28**
Bullock labour	14.26**	15.03**	14.33**	7.54**	8.76	6.56**
Machine labour	18.69**	8.75	12.3**	11.72**	2.82**	4.67**
Seed	9.14**	8.25**	7.80**	2.73**	2.35*	1.02**
Manures	7.59**	9.30*	27.68**	1.26	3.34	0.47
Fertilizer	2.08	35.84**	104.59**	-1.04	-2.07	1.40*
Irrigation	-	175.01	116.65**	1.25**	2.43	106.05**
Plant protection	20.94**	5.29	25.25**	20.93**	2.1	25.24**
Cost 'A'	11.87**	8.92**	12.7**	5.56**	3.57**	5.25**
Cost 'B'	11.97**	9.51**	13.03**	6.42**	3.95**	5.90**
Family labour	4.82*	-0.57	11.22**	-1.33	1.96**	3.65**
Cost 'C'	11.03**	4.19	12.76**	5.27**	30.07**	5.58**
Yield per Ha	11.35**	4.19	14.19**	9.27**	4.3**	6.43**
Per quintal cost	4.19*	5.28**	7.42**	0.55	0.72	1.08**
B:C ratio at Cost 'A'	3.47*	7.59**	13.97**	3.55*	2.92	1.22*
B:C ratio at Cost 'B'	11.97**	-1.88	1.12	2.72*	4.10**	0.60*
B:C ratio at Cost 'C'	4.25**	-2.18	13.03**	3.83**	1.83**	0.91*
Net returns at Cost 'A'	4.34**	1.61**	2.14**	8.19**	3.03	1.03**
Net returns at Cost 'B'	1.79**	7.09**	5.65**	3.98**	1.01	1.15**
Net Retuns at Cost 'C'	1.63**	1.05*	6.42**	2.58**	1.01	1.60**

Note: * Significant at 5 per cent level, ** Significant at 1 per cent level

plant protection (25.24%), Cost 'A'(5.25%), Cost 'B'(5.90%), family labour (3.65%) and Cost 'C'(5.58%) were highly significantly increased at constant prices. The Sood et al., 2018 and Singh *et al.,* 2005 were studied the pulses but result was obtained different.

In general, it can be said that there was significant growth in most of the components of cost of production of tur crop. The comparative study of current prices and constant prices, the compound growth rate were high at current prices then at constant prices for tur crop. It can be concluded that the growth of cost of input at current prices and at constant prices were increasing trend.

Instability of cost & returns of tur crop:

The variations of costs of production of tur crop expressed in terms of coefficient of variation were estimated for the period 2000-01 to 2010-11 (Period-I), 2011-12 to 2020-21 (Period-II) and 2000-01 to 2020-21 (Overall Period) are presented in table 5.

As seen from the coefficient of variation at current prices was highest in B:C ratio at Cost B ie. 131.25 per cent during overall period (2000-2021) During first period (2000-01 to 2010-11), coefficient of variation it was highest in net return at cost C i.e 75.96 per cent while in second period (2011-12 to 2020-21) coefficient of variation

Table: 5: Variations of cost and returns of tur crop

S. N.	Particulars	Current Instability			Constant Instability		
		Period I 2000-01 to 2010-11	Period II 2011-12 to 2020-21	Overall 2000 to 2021	Period I 2000-01 to 2010-11	Period II 2011-12 to 2020-21	Overall 2000 to 2021
1	Hired human labour	40.78	19.97	85.88	18.81	37.28	167.64
2	Bullock labour	48.43	41.97	85.20	25.08	44.43	158.20
3	Machine labour	49.66	24.96	87.61	34.39	34.04	164.91
4	Seed	31.13	23.97	94.68	11.13	21.02	160.63
5	Manures	27.36	32.05	96.41	12.59	28.14	146.27
6	N	10.39	15.60	114.83	9.34	24.27	163.24
7	P	33.38	26.46	82.69	30.48	26.46	170.40
8	K	36.26	64.20	92.45	20.89	35.45	151.20
9	Fertilizer	17.96	24.88	89.68	13.03	32.18	165.98
10	Plant protection	73.28	28.17	87.38	73.28	43.90	163.06
11	Working capital	41.25	24.56	82.22	18.54	35.61	163.66
12	Interest on Working Capital	41.25	24.56	82.03	18.54	35.39	163.58
13	Cost 'A'	39.81	25.49	82.45	18.19	35.92	163.39
14	Rental value of land	51.58	23.08	81.14	31.63	34.08	166.86
15	Interest on fixed capital	32.97	93.82	112.17	32.97	103.16	149.22
16	Cost 'B'	40.83	27.59	82.35	21.18	36.05	163.72
17	Family labour	27.96	28.56	83.27	31.26	21.15	165.67
18	Total human labour	40.78	19.97	85.88	18.86	38.48	163.47
19	Cost 'C'	38.92	27.19	82.34	18.26	35.90	163.71
21	Yield per Ha	23.48	14.34	101.28	23.48	14.32	166.82
22	Per quintal cost	20.98	18.41	93.95	13.97	33.55	168.01
23	Gross Produce	51.30	23.02	81.21	31.56	34.12	166.87
24	B:C ratio at Cost 'A'	15.77	9.38	115.97	16.63	101.62	196.97
25	B:C ratio at Cost 'B'	25.28	36.61	131.25	12.54	114.42	229.17
26	B:C ratio at Cost 'C'	16.13	7.93	129.41	15.60	144.22	242.85
27	Net returns at Cost 'A'	11.48	-2.47	-1.25	13.37	-4.84	-4.05
28	Net returns at Cost 'B'	10.46	-4.58	-1.15	10.38	-5.48	-1.62
29	Net Retuns at Cost 'C'	38.92	27.19	82.34	13.31	-5.15	-2.22

it was highest in potassium i.e. 64.20 per cent. In case of coefficient of variation at constant prices was highest in B:C ratio at Cost 'C' 242.85 per cent during overall period (2000-2021). During First period (2000-01 to 2010-11), coefficient of variation it was highest in plant protection i.e. 73.28 per cent, while in second period (2011-12 to 2020-21) coefficient of variation it was highest in B:C ratio at Cost 'C' i.e 144.22.

CONCLUSION

As such the farmers need some objectives measures of these year to year variation based on past records. This may serve as a guide to the farmers in decision making. The farmer introduces new method and techniques to increase productivity. The present study leads to the conclusion that,

Tur is the most profitable crop in the Vidarbha region. Its per hectare yield increased significantly from 7.06 quintals in 2000–01 to 22.25 quintals in 2020–21, marking a 215.16% rise. This growth is largely attributed to the adoption of high-yielding varieties and modern agricultural technologies by farmers. During this period, there was a notable rise in the use of various inputs: bullock labour increased by 96.40%, machine labour by 173.42%, seed by 37.91%, nitrogen by 21.32%, phosphorus by 84.46%, and potassium by 190.71%. These changes reflect a shift towards recommended agronomic practices and increased mechanization.

Consequently, the share of human labour in total production cost declined from 23.53% in 2000–01 to 14.20% in 2020–21, mainly due to substitution by machines. Interestingly, the cost of production per quintal also decreased by 4.12%, from Rs. 6443.93 to Rs. 6178.55, owing to improved seeds and advanced techniques. Meanwhile, overall cultivation costs rose, with Cost 'A', 'B', and 'C' increasing by 159.63%, 211.81%, and 164.78%, respectively, indicating greater input investment.

Gross returns saw a substantial jump from Rs. 37,118.45 in 2000–01 to Rs. 1,00,547.02 in 2020–21, a 301.73% increase. Similarly, net returns based on Cost 'A' and Cost 'C' rose by Rs. 489.89 and Rs. 8036.00, respectively. The Benefit-Cost ratio at Cost 'C' improved from 1:1.02 to 1:1.43, underscoring increased profitability driven by technological advancements. Overall, tur cultivation has become more economically rewarding and efficient over time.

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Millet Knowledge Ambassador Pinpointing Through Competitive Mode in Tribal Areas of Rajasthan - The Sirohi

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ABSTRACT

International Year of Millet (IYOM2023) was celebrated to organize Millet Recipe Competition cum Millet Knowledge Ambassador Identification Initiative at KVK Sirohi Agriculture University Jodhpur and ICAR-ATARI Zone -II Jodhpur, Rajasthan. Small household survey was conducted before competition to know about millet cultivation and consumption pattern. Standardized questionnaire was provided by ICAR New Delhi. Data were collected by Interview method. TPI (Training Participation Index), TUI (Training Utility Index) and TEI (Training Effectiveness Index) were analyzed by standard methods. TUI, TEI and TPI revealed the participation, utility and effectiveness of the event, which was proved worth. Although farmwomen were not aware about IYOM2023 but they consumed and well versed by their ancient millet heritage and culinary practices. Nowadays Sorgum, Kodo, little millets have been disappeared by the time from of their food plates. *Meethe Pare, Churma, Laddu, Biscuit, Ghaat, Raab,Kheer, Suhali, Dhokla, Dhokli* etc were prepared and displayed for millet recipe competition for further evaluation. Preparations were evaluated liked moderately to liked extremely on nine-point hedonic scale by selected panel of judges. Selected farmwomen appreciated and awarded as "Millet Knowledge Ambassador" by KVK Sirohi. Identification of Millet knowledge ambassador was a step towards millet-based entrepreneurship for commercialization of millet technology.

Sirohi district is situated in south west of Rajasthan between parallels of 24degree 21' and 25degree17' North latitudes and 72degree 16' and 73degree 10' East longitudes. This district occupies prominent place in the agro-climatic zone IIb i.e. "Transitional Plain of Luni Basin" comprising three blocks of the district viz. Sheoganj, Reodar and Sirohi and Zone IVa i.e. "Sub humid southern plain and Aravali Hills comprising two blocks viz. Pindwara and Aburoad. It covers a total geographical area of 517947 ha accounting for 1.51 per cent of the total reported area of the Rajasthan State. The average rainfall of the district is 615.9 mm.Net sown area of the district is 1.35 lac (26.60%). The total population of the district is 8.51 lac. while 19.15 per cent of the total populations are SC and 24.79 percent ST. The main crop during Kharif season are Maize (25.97%), Pearl millet (11.56%), Sesame (8.59%), Castor (12.91%), Green gram (5.47%), Fennel (3.32%) & Cluster bean (12.53%). Major Rabi crops of the area are wheat (16.33%), mustard (13.61%) gram (3.4%), and cumin (1.11%). (https://sirohi.kvk2.in/district-profile) FAO and UN has recognized the year 2023 as International Year of Millets (IYOM2023) to create awareness of nutritional benefits of millets. Indian Government also recommended celebrating International Year of Millet 2023(Kumar 2023), because millets have high nutritional values and can be grown with minimum inputs. During IYOM 2023, various activities as training programmes, Kisan Gosthi, Awareness camps, workshops were organized in district as well as at KVK Sirohi to create awareness for millet consumption and recipe competition Agriculture University Jodhpur and ICAR-ATARI Zone II, Jodhpur and collaboration of Department of Agriculture Sirohi, Rajasthan. Millet preparations were served in Important occasions even marriages also. Recipe competitions are showcase of various traditional preparations and representation of rich culinary heritage. These activities strengthen the moral and confidence of homemakers. It is a channel to drag them in the common pathway for progress and prosperity.

MATERIAL AND METHODS

The present study was conducted under following mentioned steps.

Locale of the Study

Present Study was conducted in Sirohi district of Rajasthan. Locale of the study was selected based on millet cultivation and its diversified consumption pattern. The millet recipe competition was conducted at purposively selected villages Khambel (Sirohi Block) ,

1 &2. Subject Matter Specialist and Senior Scientist and Head, Farm Science Centre, Agriculture University, Jodhpur, Rajasthan

Krishnganj (Reodar block) and Mandaar (Reodar block). Total 100 farm women were approached and 82 farm women came forward meeting of Millet recipe competition.

Survey

A household survey was conducted to find out the cultivation practices and consumption pattern of millets. A Standardized questionnaire provided by ICAR New Delhi to collect the Information. Data was collected by Interview method. Farmwomen were assembled for meeting in collaboration with Department of Agriculture, Department of women and child development with the help of local public representatives.

Planning and preparation for Millet recipe competition

Established of linkages with Govt, local bodies and people, KVK officials visited the villages to establish collaboration with govt departments, NGO and local public representatives for successful execution of the competition.

Selection of the candidates for Competition

Willing candidates were selected for Millet Recipe Competition. All the participants signed formal Consent and discussed in detail about the Competition for successful execution of the event.

Evaluation of the Products

Interested candidates were selected for panel of judges .Standard method was selected for sensory evaluation of the products by using nine point hedonic scales. (Griswold1962)

RESULTS AND DISCUSSION

Results and Discussions are presented here as discussed in methodology under following steps.

Survey

Small household survey was conducted to collect the information regarding cultivation and consumption pattern of millet before conducting the Millet recipe competition. As per the findings of the survey, it was found that majority of the participants were literate. Participants were from local dialect. Their annual income was less than INR 50000/ Year. Only few were above INR 50000/Year. Majority of the participants had land holding of less than 1.5 ha, which was totally rain fed. Total land was used for Pearl millet cultivation. Farmwomen have habit of millet consumption from their childhood. They have learned millet preparations from their native places. Millet consumption was continued in their in-laws family. As per the Information regarding the status of millet consumption, Sorgum, Kodo, Kutki (little millets) have been disappeared from studied area. Both were consumed by the people in that area but by the passing, the time these were disappeared from their food plates. Now pearl millet, *Barti, Kurang* etc eaten in Krishnganj, Reodar block. In Reodar Tehsil of Sirohi Pearl Millet was consumed for whole year although in Sirohi block headquarters peal millet was consumed only in winter season. Bran yard millet is specially consumed during fasting state as *Ekadashi,Shivratri*, etc conditions. Area selected for the millet recipe competition has their own cultural and culinary heritage. Farmwomen were not aware about declaration of IYOM2023 and even the term millet /*chota anaz.* But they know availability of millet and their day to day utilization in different recipes. Although 80% respondents were prepared *chapati, Ghat , Rabri* and only 20-30 per cent prepared laddu, *Mattar, Churma, Dhokle* etc in the season. Nobody had prepared latest fusion preparations like millet Idli, Millet cake, Millet dosa etc. They were stick to their own traditional preparations those were consuming in that area. As per the Information regarding association of farmwomen to any Indigenous Institution, Farmwomen were the member of the self-help groups of RAJEEVIKA and Department of Women Empowerment Sirohi.

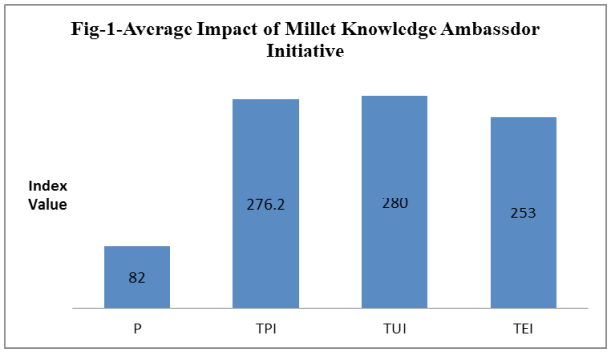
Evaluation of the Products

Total 100 Farm women were approached for Millet recipe competition .Only 82 were willing and 22 have prepared and displayed the products. Millet recipe contest's contestants were prepared various Pearl millet preparations as *Thepla, Bajara Biscuit, Sem Dhokli, Dal Dhokli ,Meethe pare,Sogra Kadhi, Gatte, Bajara Laddu, Matar,Churm etc.* Prepared products were evaluated from liked very much to liked extremely. Highest rated *products Laddu, Sogra, Suhali, Matar,Gatte,Meethe Pare Biscuits* were appreciated and respective farm women were awarded by certificates of" Millet Knowledge

Ambassador" by KVK Sirohi. Participants appreciated and awarded by Distt Collector Sirohi during district level workshop for IYOM 2023 Promotion and celebration organized by Department of Agriculture Extension, Department of Horticulture and KVK Sirohi jointly.

Impact of Millet Recipe Competition

As per the findings of Impact, assessment of Millet Recipe Competition cum Millet Knowledge Ambassador Identification Initiative revealed that Training Participation Index proved maximum presence and participation of the candidates. Training Utility Index determined the usefulness of the event. Training Programme was drawn between 88-96 Index values.(Fig.1.).



TPI-Training Participation Index, TUI-Training Utility Index, TEI-Training Effectiveness Index, P-participants, (Ray, 2017)

The present study was corroborated with the findings of Kartheek *et al*. (2024) that A cross-sectional study was carried out from 01 Aug 2023 to 15 Aug 2023 among housewives residing in a Military garrison in West Bengal. 209 respondents participated in the study of which, 33 per cent of the respondents belonged to 25-29 yrs age group. 52per cent of them were either graduates or postgraduates. There was a significant ($p<0.05$) association between level of education and knowledge level of health benefits of millets. Sustained efforts were required to create awareness and improve acceptance of use of millets amongst general population. Nanda and Janardan 2024 also motivated the consumption of millet and reported some facts in a study conducted on students that most of the students do not know what millet was, and many did not hear of their name, their local name, or their importance as food, fodder, or health benefits. The majority of the students lack knowledge about millet, which was directly linked to their non-consumption of millet at home and in hotels. The only millets' knowledge bank is their elders (grandparents and parents). So students and parents' gap must be resolve and especially next-generation citizens (students), should take responsibility for food security in their region. Swagata *et al.* (2024) also reported knowledge, attitude and practices of healthcare professionals regarding millet consumption. It was observed that, majority of participants (62 %) could identify different types of millets; 66.4 per cent participants consumed millet foods since childhood; 54 per cent were interested to make it part of therapeutic diets, but most of the participants were not had full knowledge about millets.

CONCLUSION

Based on the study it can concluded that TPI, TUI and TEI, because of millets are the miracle grain, which is easily grown in any environmental conditions. It is not only nutritious but also has its enriched culinary heritage. Millets are affordable and liked by every segment of the population. Now there is a need of awareness for its consumption in new generation and such kinds of events are not only to show the talent of homemakers but It can be a channel of millet popularity in interesting and enthusiastic manner. Identification of Millet knowledge ambassador Initiative was showcase for commercialization of shelf stable millet products for further development of millet-based entrepreneurship.

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Influence of Plant Growth Regulators and Jeevamrut on Microbial Population of Soil and Yield Parameters of Pigeonpea (*Cajanus Cajan* L.)

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ABSTRACT

Studies were undertaken to evaluate the impact of foliar application of plant growth regulators and soil application of jeevamrut on soil microbial population in pigeonpea. After two cycles, the soil microbial properties were significantly influenced due to soil application of jeevamrut followed by foliar application of plant growth regulators. Among the treatments soil application of jeevamrut at 30, 60, 90 and 120 DAS had the highest population of bacteria (44.34 and 22.51 x 10^5 cells g-1) at flowering and harvesting stage respectively followed by foliar application of GA_3-75ppm (43.17 and 21.63 x 10^5 cells g-1) at flower and pod initiation stages as compared to control. In case of fungal population, soil application of jeevamrut at 30, 60, 90 and 120 DAS had the highest population of fungi (7.46 and 3.75 x 10^5 cells g-1) at flowering and harvesting stage respectively followed by treatment (T_4) foliar application of GA_3-75ppm (7.19 and 3.68 x 10^5 cells g-1) at flower and pod initiation stages as compared to control. The population of bacteria and fungi decreased in higher proportion in control. 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 treatment (T_8) soil application of jeevamrut- @ 500 L ha^{-1} (34.25 %) at 30, 60, 90, and 120 DAS recorded significantly highest harvest index 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. The jeevamrut application treatment apart from providing sources of organic carbon also helped improving soil physical properties thereby built up of soil microbial population which resulted in higher seed yield.

Pigeonpea is one of the major pulse crop cultivated in India. This crop is widely grown in India and 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. Pre-mature abscission of flowers is one of the most serious problems in pigeonpea (Fakir, 1997) and other legumes (Wiebold *et al.,* 1981).

The low yield in pigeonpea is 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 known to improve photosynthetic ability as well as physiological efficiency of plants and offer a significant role in realizing higher crop yields. 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. Similarly, 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 (GA) (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 microbial population of soil and yield attributes in pigeonpea.

MATERIAL AND METHODS

The present investigation was conducted under field condition during kharif season 2018-19 and 2019-20

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at Experimental field of Department of Agricultural Botany., Dr. Panjabro Deshmukh Krishi Vidyapeeth, Akola (M. S.). The experiment comprised of single variety of pigeonpea i.e. PKV (TARA) laid out in randomized block design with four replications, provided with eight treatments of two growth regulators i.e. GA_3 -25, 50 and 75 ppm and NAA-25, 50 and 75 ppm concentrations including jeevvmrut 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.

RESULTS AND DISCUSSION

Application of plant growth regulators and jeevamrut significantly influenced the growth, yield and microbial population of pigeonpea as compared to without use of plant growth regulators and jeevamrut.

Microbial population of soil

In the present investigation among the plant growth regulators and jeevamrut treatments, soil application of jeevamrut @ 500 L ha^{-1} at 30, 60, 120 DAS significantly recorded higher bacterial population (44.34

Table 1. Bacterial population (X x 10^5 cells g^{-1}) as influenced by Plant Growth Regulators and Jeevamrut in pigeonpea

Treatments	2018-19		2019-20		Pooled	
	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage
T_1 - (Control)	30.67	18.00	33.34	17.66	32.01	17.83
T_2 - GA_3-25PPM	37.67	18.66	40.67	20.34	39.17	19.50
T_3 - GA_3 50PPM	40.00	20.35	42.00	21.34	41.00	20.85
T_4 - GA_3- 75PPM	43.00	21.67	43.67	21.67	43.17	21.63
T_5 - NAA-25PPM	39.67	19.35	41.03	21.00	40.35	20.17
T_6 - NAA-50PPM	40.00	19.68	41.06	21.00	40.53	20.34
T_7 - NAA-75PPM	42.33	21.33	42.33	21.35	42.33	21.34
T_8 - Jeevamrut @ 500 L ha^{-1}	44.67	22.68	44.02	22.34	44.34	22.51
Mean	39.75	20.21	41.01	20.84	40.36	20.52
SE(m)±	0.06	0.15	0.21	0.18	0.12	0.13
CD at 5%	0.18	0.43	0.61	0.54	0.34	0.38

Table 2. Fungal population (X x 10^5 cells g-1) as influenced by Plant Growth Regulators and Jeevamrut in pigeonpea

Treatments	2018-19		2019-20		Pooled	
	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage	Flowering stage	Harvesting stage
T_1 - (Control)	5.41	2.70	4.76	2.48	5.08	2.59
T_2 - GA_3-25PPM	6.28	3.23	6.47	3.23	6.38	3.23
T_3 - GA_3 50PPM	7.15	3.60	7.24	3.63	7.13	3.61
T_4 - GA_3- 75PPM	7.27	3.75	6.94	3.59	7.19	3.68
T_5 - NAA-25PPM	6.82	3.56	7.01	3.51	6.91	3.53
T_6 - NAA-50PPM	7.03	3.51	7.07	3.52	7.05	3.51
T_7 - NAA-75PPM	7.23	3.60	7.16	3.56	7.19	3.58
T_8 - Jeevamrut @ 500 L ha^{-1}	7.50	3.77	7.41	3.74	7.46	3.75
Mean	6.83	3.46	6.76	3.41	6.79	3.43
SE(m)±	0.14	0.05	0.04	0.08	0.07	0.04
CD at 5%	0.40	0.14	0.13	0.23	0.19	0.13

Table 3. Effect of Plant Growth Regulators and Jeevamrut on Seed yield q ha^{-1} and Harvest index (%) in Pigeonpea

Treatments	2018-19		2019-20		Pooled	
	Seed Yield q ha^{-1}	Harvest Index	Seed Yield q ha^{-1}	Harvest Index	Seed Yield q ha^{-1}	Harvest Index
T_1 - (Control)	17.70	32.01	18.34	32.17	18.02	32.09
T_2 - GA_3-25PPM	18.48	33.51	19.33	33.45	18.90	33.49
T_3 - GA_3- 50PPM	18.83	32.38	19.79	32.17	19.31	32.24
T_4 - GA_3-75PPM	20.38	33.72	22.25	34.12	21.31	33.93
T_5 - NAA-25PPM	18.85	33.44	19.27	33.48	19.06	33.46
T_6 - NAA-50PPM	18.83	32.32	19.57	32.42	19.20	32.37
T_7 - NAA-75PPM	19.07	32.36	19.99	32.44	19.53	32.41
T_8 - Jeevamruth- @ 500 L ha^{-1}	18.62	33.63	20.92	34.86	19.77	34.25
Mean	18.85	32.92	19.93	33.14	19.39	33.03
SE(m)±	0.06	0.16	0.20	0.14	0.10	0.12
CD at 5 %	0.18	0.48	0.61	0.43	0.29	0.34

and 22.51 x 10^5 cells g-1) at flowering and harvesting stage respectively followed by foliar application of GA_3-75ppm (43.17 and 21.63 x 10^5 cells g-1) at flower and pod initiation stages as compared to control (32.01 and 17.83 x 10^5 cells g-1) as shown in Table 1.

In case of fungal population, soil application of jeevamrut at 30, 60, 90 and 120 DAS significantly recorded highest population of fungi (7.46 and 3.75 x 10^5 cells g^{-1}) at flowering and harvesting stage respectively followed by treatment (T_4) foliar application of GA_3-75ppm (7.19 and 3.68 x 10^5 cells g-1) at flower and pod initiation stages as compared to control (5.08 and 2.59 x 10^5 cells g-1). The population of bacteria and fungi decreased in higher proportion in control as shown in Table 2. Devakumar *et al.*, (2008) in field bean, Shwetha (2007) in soybean and Swain *et al.* (2015) in chilli revealed that application of liquid manures (panchagavya, jeevamrut and beejamrut) promotes biological acitivity in soil and enhance nutrient availability to crops there by improve the growth and yield.

Yield and yield parameters

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 treatment (T_8) soil application of jeevamrut- @ 500 L ha^{-1} (34.25 %) at 30, 60, 90, and 120 DAS recorded significantly highest harvest index followed by treatment (T_4) foliar application of GA_3-75 ppm (33.93 %) at flower and pod initiation stages as compared to control and rest of the treatments as shown in Table 3. The increase in pod yield may be due to the presence of macro nutrients, essential micronutrients, many vitamins, essential amino acids, growth promoting substances like IAA, GA and beneficial microorganisms in the liquid organic manures (Jeevamrut) which might have resulted in better source-sink relationship i.e better vegetative growth, number of flowers and more number of fruits. These are in confirmative with Palekar (2006), Natrajan (2007) and Mathuvelu (2002) have also reported increase in yields of ladies finger, field bean and finger millet. Similar results were also reported by Kumbar and Devakumar (2016).

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Extent of Adoption of Dryland Technologies By The Farmers

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ABSTRACT

Dryland agriculture means cultivation of crops purely under rainfed conditions where soil moisture is limited for crop growth. Dryland farming is mostly followed in semi-arid regions. Dryland farming is improved system of cultivation maximum quantity of water is conserved by soil and water conservation management. The productivity levels are very low and unstable in drylands due to the vicissitudes of monsoon rainfall which is erratic, unpredictable and also higher fluctuating over years under different agro-climatic conditions. In such situation there is need of application of different useful dryland technologies. The research study was therefore conducted purposively to identify the extent of adoption of dryland technologies by the respondent farmers. The research study was conducted in Akola and Akot tehsils of Akola district in Vidarbha region of Maharashtra state because this area comes under dryland farming. Five villages from each tehsil were selected purposively to comprise sample of 120 farmers. The Data was collected by conducting personal interview of the respondent farmers through structured interview schedule. The findings revealed that, over half of the respondents (57.50 %) were found to be in medium level as regards adoption of dryland technologies.

Indian agriculture is mainly a rainfed agriculture under it consists both dry farming and dryland agriculture. Out of an estimated 143 million total cultivated area in the country, 101 million ha near about 70 per cent area under dryland agriculture. Dryland agriculture means cultivation of crops purely under rainfed conditions where soil moisture is limited for crop growth. Dryland farming is method of farming in which cultivation of crops under annual rainfall more than 750 mm. Dryland farming is mostly followed in semi-arid regions. The dryland areas of country contribute 42 percent of total food grain production. Most of the coarse grains like sorghum, pearl millet, finger millet and other millets are grown in dryland areas. It is characterized by the resource poor, small and marginal farmers, a poor infrastructure and low investments in technology and inputs. Although, the average productivity in dry regions is low. However, it contributes nearly half of the produce to the food basket of the nation and supports the life of a substantial chunk of the population.

Dry land technologies play a vital role in increasing crop production and productivity in through the use of different soil and moisture conservation practices. Soil and water conservation practices used to conserve soil moisture as well as reduce soil erosion. Soil and water are most precious natural resources, they are very important in human civilization. Soil being the major non-renewable natural resources is inelastic in nature.

It is estimated that by 2030, the total domestic food grain demand will be 350 million tons for growing populations. The total geographical area of our country is 329 million hectares. Inputs are very important resources in order to make farm productive. The productivity depends upon the availability and proper utilization of inputs and adoption of improved technologies. Sustainability of dryland farming is the survival of the farmer practicing with long term profitability. It depends upon transfer and adoption of appropriate technologies and availability and utilization of required inputs, in order to maintain long term productivity.

The study revealed the adoption of the dryland technologies by the farmers in Akola district. Hence this study is also helpful for identifying the adoption gap in crop cultivation and the constraints faced by the farmers in adoption of the dryland farming technologies.

In order to know the extent of adoption of dryland farming technologies by farmers. This study will be important to know personal, socio-economic, psychological characteristics of dryland farmers.

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Objectives of the study

1. To study the personal, socio-economic, situational, communicational and psychological characteristics of farmers
2. To study the extent of adoption of dryland farming technologies by the farmers
3. To find out the relationship between selected characteristics of farmers with their adoption of dryland farming technologies
4. To study the constraints faced by farmers in adoption of dryland farming technologies

MATERIAL AND METHODS

The study entitled "Adoption of dryland technologies by the farmers" was conducted in Akola and Akot tehsils of Akola district in Vidarbha region of Maharashtra state because this area comes under dryland farming. Five villages from each tehsil were selected purposively. Thus, 10 villages were selected and 12 farmers from each village i.e. total 120 farmer were selected for the study.

Exploratory research design of social research was used for the present study.

Table 1. Distribution of respondents according Personal and socio-economic Characteristics.

S. N.	Independent Variable	Frequency (n=120)	Percentage (100%)
	Age (Year)		
1	Young (Up to 35)	26	21.67
2	Middle (36 to 50)	63	52.50
3	Old (51 and above)	31	25.83
	Education		
1	Illiterate	0	0
2	Primary school (Up to 4th)	10	8.33
3	Middle school (5-7th)	20	16.67
4	Secondary school (8-10th)	42	47.50
5	Higher secondary school (11-12th)	31	29.17
6	College (above 12th)	14	11.67
	Land Holding		
1	Marginal (Up to 1.00 ha)	43	35.83
2	Small (1.01 to 2.00 ha)	36	30.00
3	Semi-medium (2.01 to 4.00 ha)	27	22.50
4	Medium (4.00 to 10.0 ha)	12	10.00
5	Large (Above 10.0 ha)	2	1.67
	Annual Income		
1	Up to Rs 150000	76	63.34
2	Rs 150001 to 300000	29	24.16
3	Above Rs 300000	15	12.50
	Cropping Pattern		
1	Kharif	94	78.33
2	Rabi	26	21.66
3	Summer	-	-
	Sources of Information		
1	Low (Up to 14)	25	20.83

2	Medium (15-21)	72	60.00
3	High (Above 21)	23	19.17
	Risk preference		
1	Low (Up to 17)	19	15.83
2	Medium (18-21)	78	65.00
3	High (Above 21)	23	19.17
	Innovativeness		
1	Low (Up to 13)	23	19.17
2	Medium (14-16)	72	60.00
3	High (Above 16)	25	20.83
	Knowledge		
1	Low (Up to 33.33)	25	20.83
2	Medium (33.33 to 66.66)	73	60.83
3	High (Above 66.66)	22	18.33

In Akola district, out of seven tehsils selection of Akola and Akot tehsils were done purposively because in these tehsils, maximum area comes under dryland farming

Random sampling method was used for the selection of villages. Twelve farmers were selected from each village randomly. Thus, total 120 farmers were selected for study.

RESULT AND DISCUSSION

Personal and socio-economic characteristics

The characteristics namely age, education, land holdings, annual income, cropping pattern were the variables studied under personal characteristics. The findings pertaining to distribution of the respondents on these characteristics are presented in the following table.

It was revealed that relatively higher proportion of the respondents i.e., 52.50 per cent were belonging to middle age group of 36 to 50 years. Majority of the respondents (47.50%) were educated up to secondary school level of education.

The study revealed that, 35.83 per cent of the respondents had possessed marginal land holdings and Majority of the respondent 63.33 per cent had annual income up to Rs 1,50,000/-.

It revealed that maximum number of respondents followed kharif cropping pattern i.e. (78.33%) and Majority of the respondents were found to be using various source of information about dryland technologies only to medium extent i.e. (60.00%).

Majority of respondents possessed medium level of risk preference with dryland technologies. (65.00%).

Majority that respondents were mostly from medium level of innovativeness. (60.00%)

Majority of the respondents 60.83 per cent belong to medium category of knowledge, followed by 20.83 per cent of the respondents were having low level of knowledge. Only 18.33 per cent of the respondents were observed in high knowledge category.

Adoption of dryland technologies

The practice wise adoption of the respondents about dryland technologies has revealed in table 2. According to categorization of technologies, in in-situ moisture conservation majority of the respondents were completely adopted deep ploughing after every 3 years 85.33 per cent, opening of furrow after every 2 rows at 30 days after sowing 66.67 per cent, ridges and furrow method 66.67 per cent, broad bed furrow method 62.50 per cent, contour cultivation 25.00 per cent and mulching 8.33 per cent. In crops and cropping system maximum respondents completely adopted sole cropping 71.67 per cent, sequence cropping 44.17 per cent, intercropping of soybean + pigeon pea (4:2) 33.33 per cent, intercropping of cotton + pigeon pea (6:2) 29.16 per cent, intercropping of cotton + sorghum

Table 2: Distribution of respondents according to practice wise adoption about dryland technologies

S.N.	Dryland technologies	Adoption		
		CA	PA	NA
A)	**In-situ moisture conservation**			
1.	Deep ploughing	103(85.83%)	15(12.5%)	3(2.5%)
2.	Mulching: crop residues, soil mulches	10(8.33%)	40(33.33%)	70(58.33%)
3.	Opening of furrows	80(66.67%)	00	40(33.33%)
4.	Broad bed furrow	75(62.5%)	00	45 (37.50%)
5.	Ridges and furrow method	80(66.67%)	00	40(33.33%)
6.	Contour Cultivation	30(25%)	00	90(75%)
B)	**Crops & Cropping systems**			
1.	Sole cropping	86 (71.67%)	00	34 (28.33%)
2.	Intercropping			
A	Cotton + black gram/ green gram (1:1)	68 (56.67%)	00	52 (43.33%)
B	Cotton + sorghum + pigeon pea + sorghum (3:1:1:1)	25 (20.83%)	00	95 (79.16%)
C	Pigeon pea + green gram/ black gram (1:2)	12 (10.00%)	00	108 (90.00%)
D	Soybean + pigeon pea (4:2)	40 (33.33%)	00	80(66.67%)
E	Cotton + pigeon pea (6:2)	35 (29.16%)	00	85(70.83%)
3.	Sequence cropping	53 (44.17%)	00	67 (55.57%)
C)	**Integrated nutrient management**			
1.	Application of FYM/ Compost/ Vermicompost	40(33.33%)	55(45.83%)	25(20.83%)
2.	Use of biofertilizer	20(16.67%)	80(66.67%)	20(16.67%)
3.	Foliar application	25(20.83%)	35(29.16%)	55(45.83%)
4.	Green manuring: glyricidia/ subabhul green leaves	02(1.67%)	08(6.67%)	110(91.67%)
D)	**Others**			
1.	Farm ponds	35 (29.16%)	00	85(70.83%)
2.	Protective irrigation	25(20.83%)	00	95(79.16%)
3.	High density planting	38(31.66%)	00	82(68.33%)
4.	Contingency crop planning under adverse condition: sowing pigeon pea, sunflower, bajra, sesamum, castor	20(16.67%)	40(33.33%)	60(50.00%)

+ pigeon pea + sorghum (3:1:1:1) 20.83 per cent, intercropping of Pigeon pea + green gram/ black gram (1:2) 10.00 per cent. In integrated nutrient management the respondents partially adopted the dryland technologies use of biofertilizer 66.67 per cent, application of FYM/ compost/vermicompost 45.83 per cent, foliar application: KNO3, etc. 29.16 per cent, green manuring 6.67 per cent. In other category of dryland technologies, the respondents completely adopted high density planting in cotton 31.66 per cent, farm ponds 29.16 per cent, protective irrigation 20.83 per cent and contingency crop planning under adverse condition: sowing pigeon pea, sunflower, bajra, sesamum, castor 16.67 per cent.

It observed that majority of respondents not adopting dryland technologies i.e. green manuring: glyricidia/ subabhul green leaves 91.67 per cent, intercropping of Pigeon pea + green gram/ black gram (1:2) 90.00 per cent, protective irrigation 79.16 per cent, intercropping of cotton + sorghum + pigeon pea + sorghum (3:1:1:1) 79.16 per cent, contour cultivation 75.00

per cent, farm ponds 70.83 per cent, , intercropping of cotton + pigeon pea (6:2) 70.83 per cent, sequence cropping 55.57 per cent, Contingency crop planning under adverse condition: sowing pigeon pea, sunflower, bajra, sesamum, castor 50.00 per cent, foliar application 45.83 per cent.

It observed that majority of respondents not adopting dryland technologies i.e. green manuring: glyricidia/ subabhul green leaves 91.67 per cent, intercropping of Pigeon pea + green gram/ black gram (1:2) 90.00 per cent, protective irrigation 79.16 per cent, intercropping of cotton + sorghum + pigeon pea + sorghum (3:1:1:1) 79.16 per cent, contour cultivation 75.00 per cent, farm ponds 70.83 per cent, , intercropping of cotton + pigeon pea (6:2) 70.83 per cent, sequence cropping 55.57 per cent, Contingency crop planning under adverse condition: sowing pigeon pea, sunflower, bajra, sesamum, castor 50.00 per cent, foliar application 45.83 per cent.

Table 3: Distribution of respondents according to their level of adoption of dryland technologies

S.N.	Adoption	Frequency (n=120)	Percentage
1	Low (Up to 33.33)	31	25.83
2	Medium (33.33 to 66.66)	69	57.50
3	High (Above 66.66)	20	16.67
		120	100.00

The data from Table 3 indicates that 57.50 per cent respondents had medium level of adoption of dryland technologies, followed by 25.83 per cent respondents had low level of adoption. Only 16.67 per cent respondents belonged to high adoption level of dryland technologies.

The similar results are in conformity with the findings of Kumar (2012), Khare *et.al* (2013), Gudadhe (2015), Kavhar (2019).

Relationship of selected characteristics of respondents with adoption

It was observed from Table 4 the relationship between Personal and socio-economic variables namely education, land holding, annual income, cropping pattern of the respondents were observed to be positive in relation with adoption of dryland technologies. However, age of the respondents found to non-significant with the adoption of dryland technologies.

Table 4: Coefficients of correlation between selected characteristics of respondents with adoption

S. N.	Variables	r' value
1.	Age	0.169NS
2.	Education	0.252**
3.	Land holding	0.189*
4.	Annual income	0.228**
5.	Cropping pattern	0.280**
6.	Source of information	0.272**
7.	Risk preference	0.124NS
8.	Innovativeness	0.229**
9.	Knowledge	0.232**

*Significant at 0.05 level of probability
**Significant at 0.01 level of probability
NS – non-significant

In case of communicational variables, source of information observed positive and significant in relation with adoption of dryland technologies.

In case of psychological characteristics such as innovativeness and knowledge possess positive and significant correlation with adoption of dryland technologies and risk preference was found to be non-significant in relation with extent of adoption of the farmers about dryland technologies.

Constraints in adoption of dryland farming technologies:

The unavailability of water for protective irrigation, unavailability of seeds of green manuring crops, lack of detail knowledge about high density planting in cotton, less adoption of farm pond due to small land holding, inconvenience in intercropping in contour sowing, lack of technical knowledge about soil and water conservation practices, lack of technical knowledge about soil and water conservation practices, lack of diversification of crops.

CONCLUSION

The study revealed that over half of the respondents (57.50%) were found to be in medium level of adoption of dryland technologies, followed by 25.83 per cent respondents had low level of adoption. Only 16.67 per cent respondents belonged to high adoption level of dryland technologies. However, personal and socio-economic variables namely education, land holding, annual income, cropping pattern of the respondents were observed to be positive in relation with adoption of dryland technologies. However, age of the respondents found to non-significant with the adoption of dryland technologies. In case of communicational variables, source of information observed positive and significant in relation with adoption of dryland technologies. In case of psychological characteristics such as innovativeness and knowledge possess positive and significant correlation with adoption of dryland technologies and risk preference was found to be non-significant in relation with extent of adoption of the farmers about dryland technologies.

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Correlation Analysis of Germination and Growth Characteristics in Red Sander (*Pterocarpus santalinus* Linn.)

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ABSTRACT

Pterocarpus santalinus, commonly known as Red Sander, Lal Chandan, Rakta chandan *etc*. recognized as "Pride of India." naturally found in the southern regions of the Eastern Ghats. The present study aimed to evaluate the germination behavior and early seedling growth of *P. santalinus* under the influence of various pre-sowing treatments. Fresh seeds were subjected to twelve different pre-sowing treatments, including plant growth regulators (GA*ƒ*), acid scarification (H, SO and HCl), cow dung slurry, and mechanical scarification. The experiment was conducted in polybags under nursery conditions using a Randomized Block Design (RBD) with three replications per treatment. Among all treatments, T3 (seeds soaked in solution of GA*ƒ* @300 ppm for 24 hours) resulted in the highest germination (71.67%) and maximum seedling survival rate (93.33%). Whereas, the correlation analysis among various germination and growth parameters revealed significantly positive relationships, indicating interdependence among traits such as days to emergence, days to final germination, germination percentage, and seedling survival with SVI-I and SVI-II.

P. santalinus is regarded as "State tree of Andhra Pradesh", an endangered and endemic tree found in Southern portions of the Eastern Ghats (Ahmed and Nayer, 1984; Jadav *et al*., 2001). In India, the natural range of *P. santalinus* used to be a very restricted in an area of 15,540 km^2 in the Southeast (Sarma, 1993). In India *P. santalinus* is only found in and is endemic to a small pocket of Andhra Pradesh spreading mainly in Kaddapa, Chittor, Nellore, Kurnool and Prakasam districts (Pandey, 2018). Red sandalwood or *P. santalinus* L., is a valuable timber species indigenous to the Deccan Plateau of India. Owing to heavy exploitation from its valuable wood and essential oil, the species is currently classified as endangered on the IUCN Red Data List. In order to meet the growing demand for *P. santalinus* wood and oil while preserving the remaining natural populations, efforts must be made to construct sustainable plantations of the species (Naidu *and Mastan,* 2001).

In *P. santalinus* poor seed germination was observed (Kalimuthu and Lakshmanan, 1995). One of the most practical methods for the ex-situ preservation of endangered tree species germplasm through seed (Rao *et al.,* 2004). Red Sanders have a long dormant period, poor germinability, low seed viability, and restricted distribution, which makes them difficult to naturally proliferate due to environmental degradation, illegal harvest, high demand for wood, and delayed regeneration. Prolonged germination, which can continue for up to 60 days after seeding, is the outcome of low germination speed (Kalimuthu and Lakshmanan, 1995). Traditional vegetative propagation techniques like grafting and air-layering cannot be used to reproduce this species on a wide scale, and the cuttings from these plants have inadequate root systems (Reddy and Sri Vasuki, 1990). While large-scale multiplication and conservation of many woody species can be achieved by tissue culture, the Fabaceae family finds in vitro culturing to be challenging. In contrast to stem cuttings, air layers have strong, vigorous roots, but they cannot be transplanted from the nursery to the main field due to a poor manipulation rate. Owing to the previously listed reasons, seeds are essential to the spread of this species (Rao and Raju, 2002).By considering the problem in seed germination and its heavy exploitation, the present study with aimed to evaluate the germination behaviour and early seedling growth of *P. santalinus* under the influence of various pre-sowing treatments was designed.

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MATERIAL AND METHODS

The present study was conducted at the Department of Forestry, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The seeds of *Pterocarpus santalinus* L. were procured from Andhra Pradesh for the experimentation. Seeds were sown in polybags of 200 mm gauge thickness which had filled with a standard potting mixture comprising soil, sand, and farmyard manure in the ratio of 2:1:1. The experiment was laid out in a randomized block design with twelve treatments and three replications per treatment. The treatments were designed as T_1 (Seeds soaking with 100 ppm GA_3 for 24 hours); T_2 (Seeds soaking with 200 ppm GA_3 for 24 hours); T_3 (Seeds soaking with 300 ppm GA_3 for 24 hours); T_4 (Seeds soaking with 1% H_2SO_4 for 20 minutes); T_5 (Seeds soaking with 3% H_2SO_4 for 20 minutes); T_6 (Seeds soaking with 5% H_2SO_4 for 20 minutes); T_7 (Seeds soaking with 1% HCl for 20 minutes); T_8 (Seeds soaking with 3% HCl for 20 minutes); T_9 (Seeds soaking with 5% HCl for 20 minutes); T_{10} (Seeds soaking with Cow dung slurry (1:1) for 48 hours); T_{11} (Separating seeds from pods with a sharp knife or scalpel and sown directly); T_{12} (Control *i.e.* untreated seeds). At nursery stage, the observations were recorded at two-day intervals from the date of sowing. The observations were recorded on various parameters *viz*. germination per cent, plant height, no. of leaves, collar diameter, shoot length, root length, fresh weight of seedling, dry weight of seedling, seedling vigour index-I (SVI-I), seedling vigour index-II (SVI-II) and survival per cent. The germination percentage was calculated based on the total number of seeds germinated from the first instance of germination until no further germination was observed. All recorded data were subjected to statistical analysis using appropriate methods, and the findings were interpreted to draw relevant conclusions special emphasized on correlation of various parameters, which are discussed in the subsequent sections of this paper.

RESULTS AND DISCUSSION

The observations were recorded at nursery stage for germination and its growth parameters in *P. santalinus* seeds which is presented in Table 1 & 2 and data was depicted in Fig.1 and Fig.2. The research findings were discussed below-

Seed germination (%)

Table 1 and Fig.1, revealed that the maximum germination percentage was observed in treatment T_3 (71.67 %) i.e. GA_3 @300 ppm for 24 hours followed by treatments T_2 (63.33%) i.e. GA_3 @200 ppm for 24 hours and T_9 (46.67%) *i.e.* HCl @3 per cent for 20 minutes. However, the minimum germination percentage was observed in T_{12} in Control (28.33%). The above results of germination are in conformity with Patel *et al*. (2018) their study revealed that, pre-soaking of red sander seeds in GA_3 @250 ppm solution for 24 hours, are advantageous for getting good germination.

Survival of germinated plants (%)

The maximum survival (93.33%) of plants from germinated seeds was recorded in T_3 treatment i.e. GA_3 @300 ppm for 24 hours which was followed by T_2 (91.67 %) *i.e.* GA_3 @200 ppm for 24 hours and T_{10} (90.00 %) i.e. seeds soak in cow dung slurry (1:1) for 48 hours, while minimum 55.00 per cent survival was recorded under T_{12} (Control) at 90 days after sowing (Table 1 & Fig. 2).

These results might be due to the overall performance in relation to growth parameters which ultimately increased the survival percentage. The observations are in conformity to the result reported by Patel *et al*. (2018) in *P. santalinus*; Masilamani and Dharmalingan (2002) in Silver Oak (*Grevillea robusta* A. Cunn.); Radhakrishnan and Renganayaki (2008) in Simaruba (*Simaruba glauca* Linn) and Rout *et al*. (2016) in *Delonix regia*.

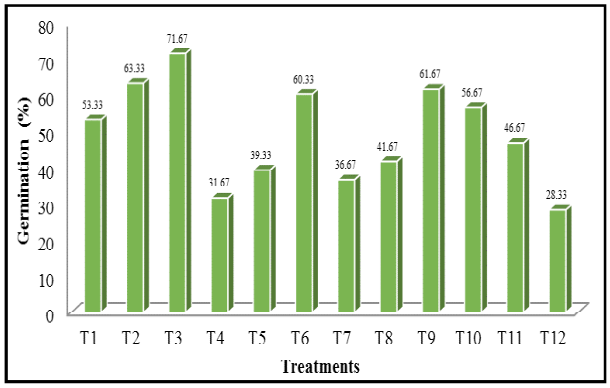

Fig. 1: Germination response of *P. santalinus* seeds to various pre-sowing seed treatments

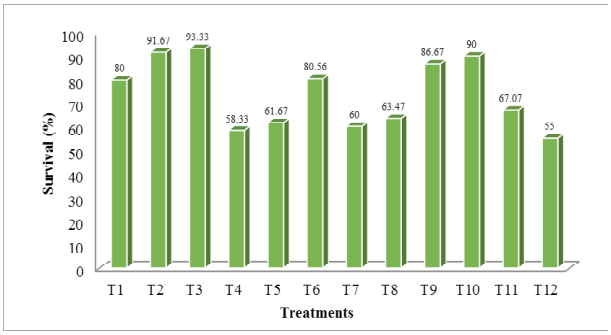

Fig. 2: Survival response of *P. santalinus* seeds to various pre-sowing seed treatments

Table 1: Germination and survival response of *P. santalinus* seeds to various pre-sowing treatments

Treatments	Germination (%)	Survival (%)
T_1 - 100 ppm GA_3 for 24 hours	53.33	80.00
T_2 - 200 ppm GA_3 for 24 hours	63.33	91.67
T_3 - 300 ppm GA_3 for 24 hours	71.67	93.33
T_4 - 1% H_2SO_4 for 20 minutes	31.67	58.33
T_5 - 2% H_2SO_4 for 20 minutes	39.33	61.67
T_6 - 3% H_2SO_4 for 20 minutes	60.33	80.56
T_7 - 1% HCl for 20 minutes	36.67	60.00
T_8 - 2% HCl for 20 minutes	41.67	63.47
T_9 - 3% HCl for 20 minutes	61.67	86.67
T_{10} - Cow dung slurry (1:1) for 48 hours	56.67	90.00
T_{11} - Separated seeds (Kernel) from pods	46.67	67.07
T_{12} - Control	28.33	55.00
'F' - Test	**Sig**	**Sig**
SE(m)±	0.46	3.50
C.D. at 5%	1.33	10.03
CV(%)	11.05	8.19

Correlation matrix for relationship between different parameters

In present study it has been found that all the germination and growth parameters were positively correlated. The germination percentage revealed very strong relationship with plant height, number of leaves, shoot length, root length, fresh weight, dry weight, SVI-I, SVI-II, survival percentage and strong relationship with collar diameter. Remaining all the parameters showed very strong relationship with each parameter except collar diameter showed strong relationship with shoot length, SVI-I, SVI-II and moderately strong relationship with survival percentage.

CONCLUSION

From this study, it is concluded that among different twelve pre-sowing seed treatments of *P. santalinus*; it is recommended treatment T_3 where seeds were soaked in solution of GA_3 @300 ppm concentration for 24 hours as it responded for higher seed germination (71.67%) along with higher survival rate (93.33%) of germinated seedlings. Whereas, it was observed that significantly positive correlation (0.778 to 0.999) exists between different germination and growth parameters of *P. santalinus* at 0.01 level of significance, from the correlation matrix for the dependency of various parameters.

(A) Pods of Red Sander

(B) Seeds separated from pods of Red Sander

Photo 1: Pods and seeds of *P. santalinus*

Table 2: Correlation among various germination and growth parameters in *P. santalinus*

Parameters	Germination (%)	Plant height	No. of leaves	Collar diameter	Shoot length	Root length	Fresh weight	Dry weight	SVI-I	SVI-II	Survival (%)
Germination (%)	1.000**										
Plant height	0.962**	1.000**									
No. of leaves	0.967**	0.997**	1.000**								
Collar diameter	0.844**	0.852**	0.850**	1.000**							
Shoot length	0.963**	0.990**	0.983**	0.894**	1.000**						
Root length	0.978**	0.981**	0.978**	0.905**	0.993**	1.000**					
Fresh weight	0.978**	0.981**	0.979**	0.903**	0.993**	0.999**	1.000**				
Dry weight	0.979**	0.981**	0.978**	0.901**	0.991**	0.999**	0.999**	1.000**			
SVI - I	0.990**	0.988**	0.990**	0.840**	0.983**	0.983**	0.984**	0.984**	1.000**		
SVI -II	0.993**	0.985**	0.987**	0.839**	0.980**	0.984**	0.985**	0.985**	0.999**	1.000**	
Survival (%)	0.964**	0.916**	0.921**	0.778**	0.897**	0.918**	0.918**	0.921**	0.944**	0.951**	1.000**

** = significant at p d" 0.01

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