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Evaluating the Role of Organically Extracted Humic Acids as a Nature Positive Agricultural Interventions for Sustainable Crop Performance

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ABSTRACT

The experiment was designed to evaluate the effects of humic acids (HA) extracted from different organics viz; FYM, phosphocompost, NPS compost, biogas slurry and vermicompost (VC). The extraction was carried out using the alkaline extraction method. The resulting humic acids were subjected to a comprehensive analysis, including chemical, elemental, and functional group analysis, as well as C:N ratio determination, FT-IR analysis, and spectral characterization. Based on comprehensive analysis, the HA prepared from VC was highly reactive as evidenced from functional and chemical analysis. The field experiment, conducted over multiple growing seasons from 2018-19 to 2023-24, focused on a variety of crops, including cotton, chili, brinjal, banana, and safed Musali, to assess the impact of foliar spraying and soil drenching with HA. In all, the experiment was conducted with different set of treatments in RBD. The results of the present experiment revealed that, the application of 100 per cent RDF + foliar spray of 0.5 per cent HA resulted improvement in seed cotton and stalk yield with higher nutrient uptake compared to 100 per cent RDF. The yield of brinjal was significantly increased with the application of 100 per cent RDF + NPS compost @ 2.5 t ha^{-1} + foliar spray of HA @ 1.5 per cent (41.24 tonnes ha^{-1}) followed by 100 per cent RDF + NPS compost @ 2.5 t ha^{-1} + foliar spray of HA @ 1.0 per cent (41.19 tonnes ha^{-1}). The yield of chilli was increased significantly with the application of 100 per cent RDF +foliar spray of 1 per cent HA. The results pertaining to the primary and secondary hardened banana plants indicates that, the application of HA extracted from cow dung showed promising results with substantial increase in dry matter accumulation in banana.

Humic acids are a group of organic compounds found in soils, sediments, and water, created through the decomposition of plant and animal matter. These substances are a major component of humus, the dark, fertile portion of soil that plays a vital role in supporting plant growth. Organically extracted humic acids are obtained through eco-friendly methods that aim to avoid harmful chemicals, thus promoting sustainable agricultural practices and enhancing soil health. Humic acids are widely used as soil amendments, fertilizers, and biostimulants in agriculture. The use of alkaline solutions, such as potassium hydroxide or sodium hydroxide, to extract humic substances from sources like leonardite and decomposed organic matter. This process is one of the most commonly used methods to obtain humic acids while maintaining natural properties (Stevenson, 1994). Their role in enhancing soil fertility, improving water retention, and increasing nutrient uptake is well-documented (Tan, 2003). Horticulture: In gardening and landscaping, humic acids are added to enhance soil quality and support plant growth, especially for stressed or nutrient-deficient plants. Environmental Remediation: Humic acids can play a role in the bioremediation of contaminated soils by binding heavy metals and organic pollutants, reducing their bioavailability and toxicity (Senesi, 1992).

Vermicompost is rich in various organic compounds, including humic substances, which are formed during the decomposition of organic matter in the digestive tract of earthworms. As earthworms excrete their waste (known as castings), the organic matter is further decomposed and stabilized, resulting in a high concentration of humic substances, including humic acids.

These humic acids formed during vermi composting are similar in structure to those found in natural soil and peat, making vermicompost an excellent and natural source of humic acids for agricultural use. The presence of humic acids in vermicompost significantly enhances the soil's ability to retain moisture, improve nutrient availability, and increase microbial activity.

The use of vermicompost for the preparation of humic acids offers an organic, sustainable method to

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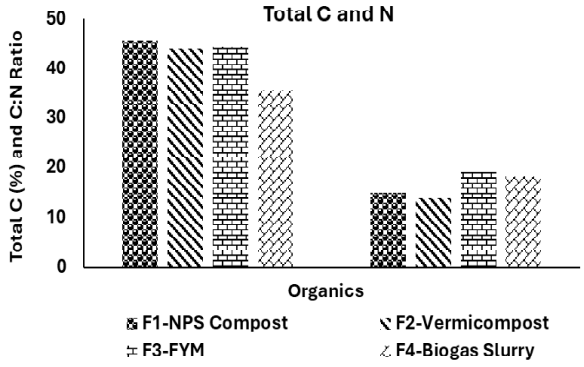
improve soil health, enhance nutrient availability, and promote plant growth. These experiments comprising different crops (cotton, chilli, brinjal, safed Musali and banana) were conducted comparing foliar spray and drenching of HA with chemical fertilizers. The parameters like plant growth, yield, quality, nutrient availability, photosynthetic pigments, etc were measured and compared. The experiment was designed to explore whether this eco-friendly and sustainable organically extracted humic acids can offer tangible benefits over applying chemical fertilizers.

MATERIAL AND METHODS

The experiment was conducted during 2018-19 to 2023-24 to extract the humic acids from various organics. The humic acids were extracted by alkaline extraction method. The extracted humic acids were subjected to elemental, functional, FT-IR and nutrient analysis. The HA extracted from different organics were optimized based on analysis. The optimized HA was used to test validity of application to the field crops. The field experiment was conducted to assess the effect of HA on growth, yield, quality and dry matter accumulation of cotton, Chilli, brinjal, safed Musali and banana. The crop wise experimental details are given in Table 1.

The extracted humic acids from different composts were subjected for elemental analysis (Fig. 1). The total N was significantly higher in HA extracted from vermicompost with different extractants, the C: N ratio was lower (13.87) in HA extracted vermicompost. The HA extracted from NPS compost with different extractant contains appreciably higher total P and S. However, the total K was higher in HA (0.86%) extracted from biogas slurry with different extractants.



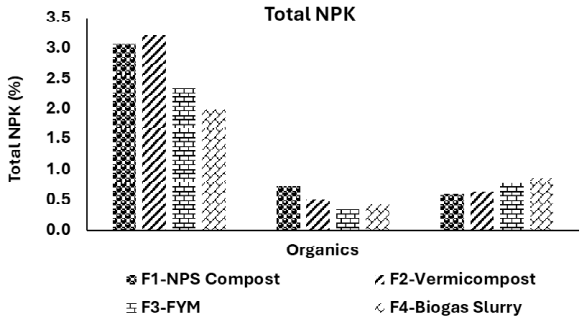


Fig. 1 : Elemental composition of humic acids extracted from vermicompost

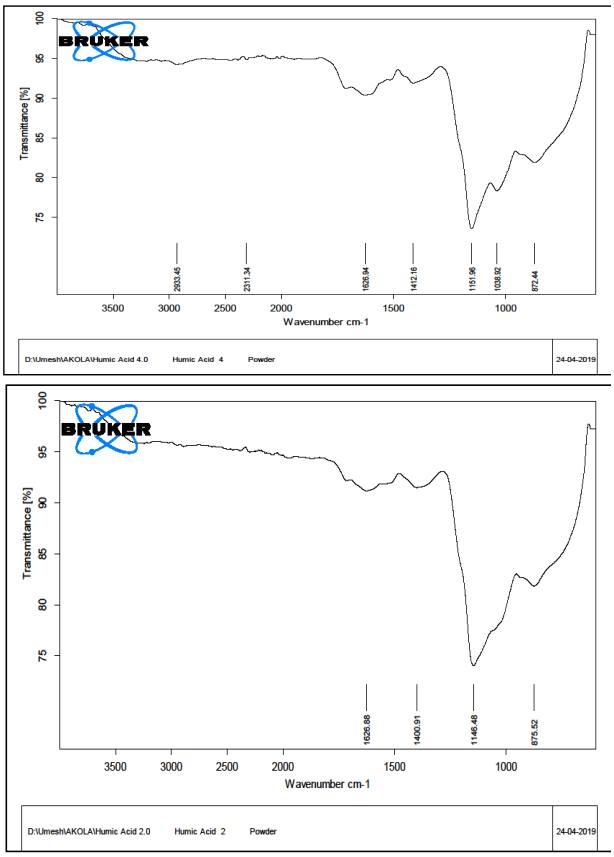


Fig. 2 : FTIR of HA extracted from vermicompost (a) and NPS compost (b) showing aliphatic group at 2933 wavenumber in HA of vermicompost and C=C double bond at 1412 wavenumber in HA of NPS compost.

Schedule of HA sprays on different crops

The spraying schedule of different crops are given below.

1. Cotton

- First spray at 20 days after sowing, thereafter at 20 days interval up to 80 days.

Table 1 Experimental details of different crops

Details	Crops			
	Cotton	Chilli	Brinjal	Safed Musali
Year of study	2021-22 to 2023-24	2020-21 to 2022-23	2021-22 to 2023-24	2019-20 to 2021-22
No. of treatments	09	07	07	07
No. of Replications	03	03	03	03
Variety	Ajit 155	Hirkani	Gaurav (F1 Hybrid)	Safed musali (Local)
RDF	120:60:60	150:50:50	200:150:100	Organics
Plot size				
Gross	5.4 x 4.5 m^2	6.00 X 3.60 m^2	5.4 x 4.5 m^2	2.10 × 3.00 m^2
Net	3.6 x 3.6 m^2	5.40 X 3.00 m^2	3.6 x 3.6 m^2	1.80 × 2.80 m^2
Spacing	90 x 45 cm	60 x 60 cm	90 x 60 cm	30 × 10 cm

- HA through drip at 20 days after sowing, thereafter at 20 regular intervals up to 80 days.

2. Chilli

- First spray at flowering
- Second spray at first fruit setting
- Third spray at 15 days after 1st picking
- Fourth spray at 15 days after 2nd picking
- Fifth spray at 15 days after 3rd picking
- Sixth spray at 15 days after 4th picking

3. Brinjal

- First spray at flowering
- Second spray at fruit setting
- Third spray at 10-15 days after first picking
- Fourth spray at 10-15 days after second picking

4. Safed Musali

- Two foliar sprays of 0.5 per cent humic acid were at 60 and 90 DAP.

RESULTS AND DISCUSSION

Yield of different crops

Cotton

The application of 75 per cent RDF through drip + EnHA @ 0.2 per cent through drip recorded significantly higher seed cotton yield 26.51 q ha^{-1} which was found at par with the application of 100 per cent RDF through drip, 75 per cent RDF through drip + HA @ 0.2 per cent through drip and 75 per cent RDF through drip + HA @ 0.2 per cent through drip. The lowest seed cotton yield was recorded in absolute control (Table 2).

The increase in seed cotton yield might be due to the application of humic acid along with RDF. Similar finding was reported by Basbag *et al.* (2008) that the application of humic acid had a significant impact on total seed cotton yield. Similar findings were noted by Haroon *et al.* (2010), who observed that the combined application

Table 2 Effect of different treatments on yield and uptake of nutrient by cotton

Treatments	SCY	CSY	Nutrient uptake (kg ha^{-1})		
			N	P	K
100 % RDF-drip	25.44	72.45	86.53	30.06	103.50
75 % RDF-drip + EnHA @ 0.2 %-drip	26.51	74.39	94.01	34.12	109.85
75 % RDF-drip + HA @ 0.2 % -drip	25.09	71.87	88.44	30.64	104.65
100 % RDF-soil	22.31	63.25	75.51	25.19	89.58
100 % RDF -soil + foliar spray of En HA @0.5%	24.97	69.33	87.23	30.98	104.30
100 % RDF-soil + foliar spray of HA @0.5%	24.02	67.38	82.65	29.06	99.66
Absolute control	16.31	51.66	56.25	19.11	70.41
CD at 5%	2.17	7.92	6.85	2.49	12.26

of humic acid with NPK had substantial additive benefits, resulting in a 19.0 per cent increase in seed cotton yield compared to NPK alone and up to a 41.1 per cent increase over the control. Singh *et al.* (2017) and Ahmad *et al.* (2014) also reported comparable results.

Chilli

The yield of chilli was increased significantly with the application of 100 per cent RDF + 6 spray of BS @ 1.5 per cent (Table 3). The increase in yield of chilli was to the extent of 8.97 per cent as compared to control, whereas it was 6.24 per cent higher as compared to RDF. The chlorophyll content was increased significantly with 100 per cent RDF along with six spray of BS @ 1.5 per cent. The results are close finding of Razek *et al*., 2012, they reported that, foliar and/or soil application of humic acid had a positive effect on yield.

Safed Musali

The significantly higher dry matter yield of Safed musali were recorded with application of NPS Compost @ 4.5 t ha^{-1} + two spray of HA @ 0.5 per cent (168 kg ha^{-1}) which was found at par with the application of NPS Compost @ 3.0 t ha^{-1} + 2 spray of 0.5 per cent HA (164 kg ha^{-1}) and NPS Compost @ 1.5 t ha^{-1} + two spray of HA @ 0.5 were found superior over control and other treatments (Table 4). The increase in dry matter yield of Safed Musali with the application of NPS Compost @ 4.5 t ha^{-1} + two

Table 3 Effect of foliar spray of humic acids on fruit weight and Green chilli yield

S.N.	Treatment Details	Fruit weight (g)	Green chilli Yield(q ha^{-1})			Pooled Mean	% Increase over RDF
			20-21	21-22	22-23		
T1	Absolute Control	1.84	227	213	204	215	-
T2	100% RDF (150:50:50 kg NPK ha^{-1})	1.89	245	241	226	237	-
T3	100% RDF +3 spray of HA @ 0.5 %	2.17	254	256	260	257	8
T4	100% RDF +3spray of HA @ 1.0 %	2.12	261	257	265	259	9
T5	100% RDF +3 spray of HA @ 1.5 %	2.23	261	258	267	262	10
T6	100% RDF +6 spray of HA @ 0.5 %	2.26	265	261	278	268	13
T7	100% RDF +6 spray of HA @ 1.0 %	2.30	274	280	283	279	17
T8	100% RDF +6 spray of HA @ 1.5 %	2.37	280	277	286	281	18
	SE (m) ±	0.03	4.01	2.34	2.51	1.93	—
	CD@ 5%	0.09	12.10	7.06	7.55	5.62	—

Table 4 : Effect of NPS compost and foliar application of humic acid on the Dry Leaves yield of Safed musali

Treatments	Dry matter yield of Safed musali (kg ha^{-1})				Percent increase in dry leaves yield over		
	2019-20	2020-21	2021-22	Pooled mean	Control	VC @ 5 t ha^{-1}	NPS @3 t ha^{-1}
Absolute control	107	117	122	115	-	-	-
Vermicompost @ 5 t ha^{-1}	142	142	150	144	25.60	-	-
NPS Compost @ 3 t ha^{-1}	149	148	155	151	31.01	3.91	-
Vermicompost @ 2.5 t ha^{-1} +FS of HA	125	127	132	128	11.21	-	-
Vermicompost @ 5.0 t ha^{-1}+ FS of HA	145	149	158	151	30.92	3.83	-
Vermicompost @ 7.5 t ha^{-1} + FS of HA	149	155	163	156	35.27	7.28	-
NPS Compost @ 1.5 t ha^{-1} FS of HA	140	142	145	142	23.67	-	-
NPS Compost @ 3.0 t ha^{-1} + FS of HA	158	163	170	164	42.51	13.03	3.02
NPS Compost @ 4.5 t ha^{-1} + FS of HA	161	168	175	168	46.09	15.86	5.81
CD at 5 %	12.5	17.20	24.75	15.44	-	-	-

spray of HA @ 0.5 per cent was recorded to the extent of 46.09, 15.86 and 5.81 per cent higher over control, Vermicompost @ 5.0 t ha^{-1}+ FS of HA and NPS Compost @ 3.0 t ha^{-1} + FS of HA, respectively.

Brinjal

The fruit yield and straw yield of brinjal as influenced by different treatments are presented in Table 5. The fruit yield of brinjal was influenced significantly with the application of 100 per cent RDF + NPS compost @ 2.5 t ha-1 + 4 spray of HA @ 1.5 per cent (40.23 tones ha^{-1}) followed by 100 per cent RDF + NPS compost @ 2.5 t ha^{-1} + 4 spray of HA @ 1 per cent (39.58 tones ha^{-1}). The yield of brinjal fruit was increased with the increase in the concentrations of foliar spray of humic acids, however the differences among treatments were non-significant. The yield of brinjal fruit was increased with the application of organics viz; FYM and NPS compost along with 100 per cent RDF. The lower yield of noted in the treatment of 100 per cent RDF.

The straw yield of brinjal as influenced by different treatments are presented in Table 3. The straw yield of brinjal was influenced significantly with the application of 100 per cent RDF + NPS compost @ 2.5 t ha^{-1} + 4 spray of HA @ 1.5 per cent (4.30 tones ha^{-1}) followed by 100 per cent RDF + NPS compost @ 2.5 t ha^{-1} + 4 spray of HA @ 1 per cent (4.28 tones ha^{-1}). The straw yield of brinjal was increased with the increase in the concentrations of foliar spray of humic acids, however the differences among treatments were non-significant. The straw yield of brinjal was increased with the application of organics viz; FYM and NPS compost along with 100 per cent RDF. The lower yield of noted in the treatments of 100 per cent RDF.

Biochemical attributes of different crops

The data related to anthocyanin content at 90 DAT revealed that application of NPS compost and foliar spray of humic acid showed non-significant differences. However, the highest anthocyanin content (0.40) was recorded with 100 per cent RDF + NPS compost @ 2.5 t ha^{-1} + 4 sprays of HA @ 1.5 per cent followed by application of 100 per cent RDF + NPS compost @ 2.5 t ha^{-1} + 4 sprays of HA @ 1 per cent, while lowest anthocyanin content (0.29) was recorded with application of 100 per cent RDF + NPS compost @ 2.5 t ha^{-1}(Table 5).

Flavonoid content in brinjal plant ranged from 0.64 to 0.80. However, statistically the flavonoid content was found significant. Highest flavonoid content (0.80) was recorded with application of 100 per cent RDF + NPS compost 2.5 t ha^{-1} + 4 sprays of HA @ 1.5 per cent while the lowest flavonoid content (0.64) was recorded with application of 100 per cent RDF.

The Nitrogen Balance Index (NBI) of brinjal as affected by application of organics and foliar spray of humic acid showed significant differences recorded during the 90 DAT. However, the highest nitrogen balance index (64.28) was recorded with application of 100 per cent RDF and lowest nitrogen balance index (53.21) was recorded

Table 5 Effect of organics and foliar spray of humic acid on yield and biochemical attributes of brinjal fruits

Treatment Details	Fruit Yield (t ha^{-1})	Chlorophyll Index	Anthocyanin content	Flavonoid content	NBI
RDF	31.74	25.65	0.37	0.64	64.28
RDF + FYM	33.28	26.80	0.33	0.69	58.99
RDF + NPS compost	36.11	27.33	0.30	0.74	55.73
RDF + FYM + foliar spray of HA (0.5 %)	35.51	27.73	0.34	0.73	56.34
RDF + FYM + foliar spray of HA (1%)	36.52	27.52	0.38	0.72	57.36
RDF + FYM + foliar spray of HA (1.5%)	36.86	27.41	0.35	0.74	56.67
RDF+NPS compost FS of HA (0.5 %)	38.00	27.67	0.36	0.79	53.69
RDF+NPS compost FS of HA (1%)	39.58	27.77	0.40	0.81	52.72
RDF+NPS compost FS of HA (1.5 %)	40.23	27.35	0.42	0.80	53.21
CD at 5%	1.95	0.98	NS	0.04	2.94

Note: FYM @ 5 t ha^{-1} , NPS compost @ 2.5 t ha^{-1}

with application of 100 per cent RDF + NPS compost 2.5 t ha^{-1} + 4 sprays of HA @ 1.5 per cent.

The total carbon content of cotton leaves indicated that effect of various treatments showed significant differences. However, the significantly highest total carbon (48.22%) was recorded with 75 per cent RDF through drip + EnHA @ 0.2 per cent through drip (Table 6). The lowest total carbon content was recorded in absolute control. Similar findings also reported by Reddy *et al.*,. (2023). The effect of various treatments have significant influence on the nitrogen content in leaves.

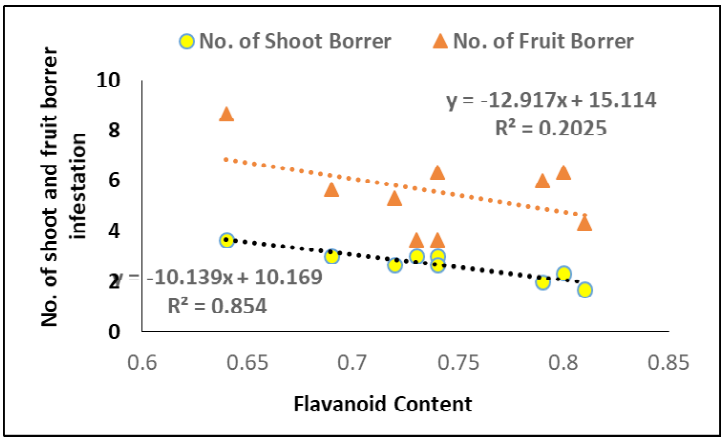


Figure 3 Correlation among flavanoids and number of shoot and fruit borer infestation

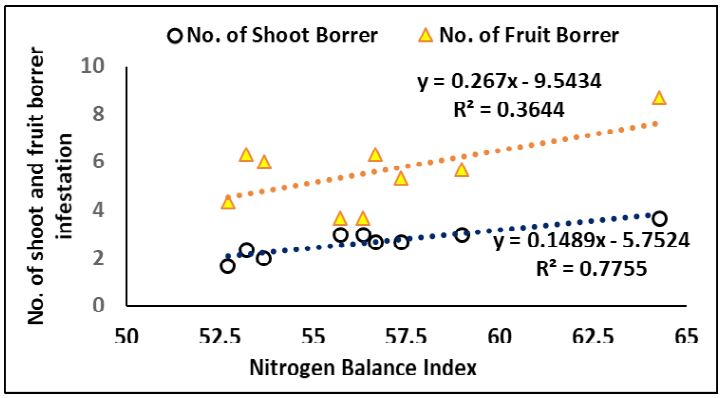


Figure 4 Correlation among nitrogen balance index (NBI) and number of shoot and fruit borer infestation

Table 6 : Effect of different treatments on biochemical attributes of cotton

Treatments	Total C (%)	Total N (%)	C: N Ratio	Chlorophyll index	Total Phenol (mg CLE/g FW)
100 % RDF-drip	46.91	0.98	45.87	36.40	0.55
75 % RDF-drip + EnHA @ 0.2 % - drip	48.78	1.07	45.59	39.97	0.59
75 % RDF-drip + HA @ 0.2 % - drip	48.17	1.00	48.18	36.75	0.57
100 % RDF-soil	47.94	0.99	48.46	35.33	0.55
100 % RDF -soil + foliar spray of En HA @ 0.5%	48.22	1.01	47.91	38.46	0.57
100 % RDF-soil + foliar spray of HA @0.5%	48.07	1.06	45.35	38.17	0.56
Absolute control	47.21	0.86	55.11	33.97	0.53
CD at 5%	0.98	0.037	1.79	2.25	-

Total nitrogen content was recorded significantly highest (1.07%) recorded with 75 per cent RDF through drip + EnHA @ 0.2 per cent through drip which was found at par with application of 100 per cent RDF through soil + foliar spray of HA @ 0.5 per cent. The maximum (55.11) C:N ratio was observed in control and lower C:N ratio was observed in 100 per cent RDF through soil + foliar spray of En HA @ 0.5 per cent. Total phenol content showed statistically significant over various treatments. The highest total phenol was recorded with 75 per cent RDF through drip + EnHA @ 0.2 per cent through drip which was found at par with application of 75 per cent RDF through drip + HA @ 0.2 per cent through drip and 100 per cent RDF through soil + foliar spray of EnHA @ 0.5 per cent.

Among various treatments, foliar spray of HA recorded higher chlorophyll content of cotton leaves compared to HA applied through drip (Figure 3). The higher chlorophyll content was noted with the application of RDF along with foliar spray of HA @1 per cent with concurrent improvement in the nitrogen balance index (NBI). However, the flavanoid content of cotton leaves were recorded lower in response to foliar application of HA. The application of HA either through foliar or drip did not have any significant change in anthocyanin content cotton leaves.

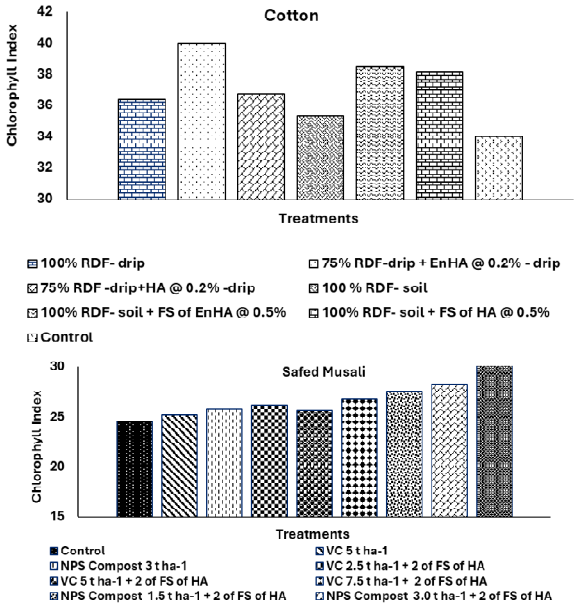


Fig. 5 : Effect of different treatments on chlorophyll content of cotton and Safed Musali

The significantly highest chlorophyll index was recorded in the treatment of 100 per cent RDF + 6 sprays of HA @ 1.5 per cent. However the chlorophyll index in all the HA spray treatment was found increased and on par with treatment 100 per cent RDF + 6 sprays of HA @ 1.5 per cent. The higher value of chlorophyll index of brinjal was recorded with the application of 100 per cent RDF along with NPS compost with foliar spray of HA @ 0.5, 1 and 1.5 per cent HA concentration. However, the higher chlorophyll index was measured with the application of 100 per cent RDF along with NPS compost with foliar spray of HA @ 1.5 per cent concentration.

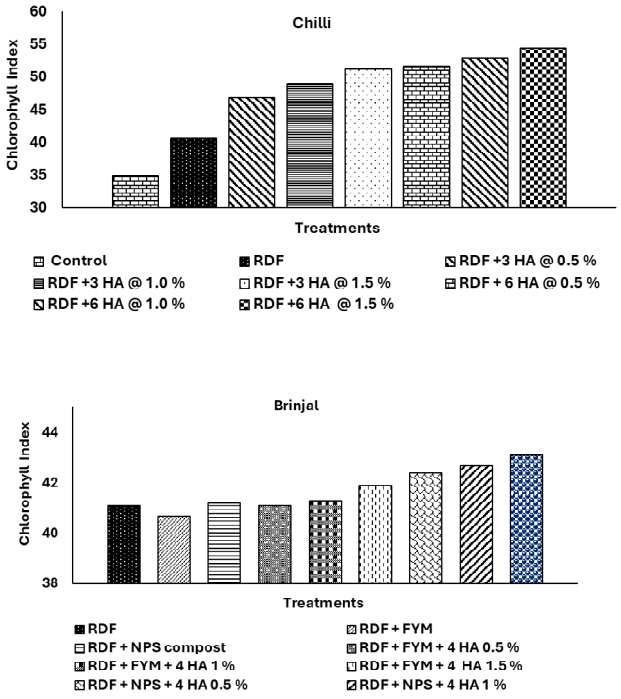


Fig. 6 : Effect of different treatments on chlorophyll content of Chilli and Brinjal

CONCLUSION

The humic acids (HA's) extracted from vermicompost have a higher nutrient content. The reactivity of these HA's was evaluated through functional group analysis and with FT-IR, revealing that, HA's extracted from vermicompost exhibited more prominent functional groups compared to those from other organic sources. The extracted HA's were tested for their effects on various crops. Cotton yield significantly increased when 100 per cent RDF was combined with a foliar spray of HA

at 0.5 per cent concentrations. Brinjal yield was enhanced through the application of RDF + NPS compost and a foliar spray of HA at 0.5 per cent concentrations. For green chili, foliar application of HA's at concentrations ranging from 0.5 to 1.5 per cent along with 100 per cent RDF resulted in a significant yield increase of 13, 17 and 18 per cent, respectively, compared to 100 per cent RDF alone. The foliar application of HAs at 0.5 per cent, combined with NPS compost, significantly boosted the yield of Safed Musali. Furthermore, chlorophyll and biochemical parameters (such as anthocyanin, flavonoids, and total phenols) were significantly higher with HA foliar sprays when compared to control and chemical fertilizers alone. This suggests that HA's play a role in enhancing crop resistance to insect pests, as demonstrated by the negative correlation between fruit and shoot borer infestations of brinjal and biochemical attributes (flavonoids and NBI) (Fig. 3 & 4).

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Promoting Balanced Nutrient Management for Enhancing Soil properties and Sustaining the Productivity of Soybean-Safflower under Vertisols

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ABSCTRACT

Long term fertilizer experiment was initiated in 2006-07 to investigate the impacts of inorganic fertilizers and manuring on soil health and productivity of soybean and safflower cropping system in Vertisols under climatic condition of Marathwada region of Parbhani Districts. The results emerged out at 19th crop cycle showed that soil pH (7.58), electrical conductivity (0.267 dSm^{-1}), organic carbon (8.33 g kg^{-1}), available nitrogen (276 kg ha^{-1}), phosphorous (20.64 kg ha^{-1}) potassium (751 kg ha^{-1}) and sulphur (36.87 kg ha^{-1}) were improved by balance application of 100% NPK+FYM @ 5t ha^{-1} over initial values of these parameters and imbalance application of 100% N, 100% NP and 50% NPK during the year 2023-24. Similarly, population of bacteria (55.63 cfu X 10^{-7} g^{-1} soil), actinomycetes (49.07 cfu X 10^{-6} / g soil), fungi (11.05 cfu X 10^{-4} / g soil) and enzyme activities were also enhanced by 100 per cent NPK+FYM under long term fertilization. The grain (24.42 and 19.66 q ha^{-1}) and straw (31.31 and 60.38 q ha^{-1}) yield of soybean and safflower was significantly highest in 100 per cent NPK+FYM @ 5 t ha^{-1} which was at par with 150 per cent NPK, 100 per cent NPK and lowest yield was observed in 100 per cent N, 100 per cent NP, 50 per cent NPK and control. The physical properties of soil and soil quality index were also enhanced due to application of inorganic fertilizers along with organic manure.

Long term fertilizer experiment was started in 2006-07 to study the impact of manures and inorganic fertilizers on yield and soil properties under soybean (*Glycene max* L.)– safflower (*Carthamus tinctorius*) prominent cropping system in climatic conditions of Marathwada. The area under these cropping system occupied by Rajasthan, Madhya Pradesh, Uttar Pradesh, Telangana, Karnataka and Maharashtra with average productivity of soybean and safflower is 317 kg ha^{-1} and 218 kg ha^{-1}, respectively for (Anonymous, 2023). Long-term experiments provides the valuable information to find out effects of continuous use of inorganic fertilizers in alone and in combination with organic manures and their effects on physical, chemical and biological properties of soil (Gil-Sotres *et al*. 2005). Integrated nutrient management sustain the productivity of soybean and safflower under long term fertilizer experiment in Vertisols of Marathwada region. Therefore, monitoring the changes in various physico – chemical and biological properties of soil offers a promise for better understanding of the nutrient availability, soil quality and productivity of soybean and safflower (Saini *et al*., 2005; Bhattacharyya *et al*., 2008; Mishra *et al*., 2008; Saha *et al*., 2008; Bedi *et al*., 2009), this information is lacking behind under Vertisols on soybean-safflower cropping system in Marathawada. Therefore, the present study was undertaken to examine the changes in physical, chemical and biological properties of soil due to long-term applications of chemical fertilizers and organic manuring on productivity of soybean-safflower cropping system in Vertisols at Parbhani of Marathwada.

MATERIAL AND METHODS

Experimental site

The long-term fertilizer experiment was started in 2006-07 at research farm of AICRP on Long Term Fertilizer Experiments, Department of Soil Science, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani. The soils of the experimental site was Vertisols, with dominant clay mineral are montmorillonitic, hyperthermic family of Typic Haplustert and clayey in texture. The application of nutrients were carried out urea, single super phosphate, muriate of potash and DAP where as Zinc was applied through $ZnSO_4$. H_2O for soybean and FYM is also applied in *Kharif* season prior to sowing. The recommended dose of fertilizer is applied to soybean and safflower was 30:60:30 and 60:40:00 kg N, P_2O_5 and K_2O ha^{-1}, respectively. The grain and straw yield of each crop was recorded and plot wise samples were collected after harvest of soybean

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and safflower during 2023-24. The mean annual rainfall for the year 2023-24 is about 716.10 mm, of which 80 to 90 per cent is received between June and September.

Experimental design and sowing

The long term fertilizer experiment was laid out in randomized block design with twelve treatments combinations were T_1 (50 % NPK), T_2 (100 % NPK), T_3 (150 % NPK), T_4 (100% NPK+ hand weeding, HW), T_5 (100% NPK+Zn), T_6 (100% NP), T_7 (100% N), T_8 (100% NPK+farm yard manure, FYM @ 5 t ha^{-1}), T_9 (100% NPK(-S) and T_{10} (farm yard manure, FYM @ 10 t ha^{-1}), T_{11} Control and T_{12} fallow (Table 1) and 13.5 m x 10 m plots size with four replications. The optimum fertilizer dose for soybean and safflower crop was 100 per cent NPK treatment represents the rate for each crop as determined from soil tests. Fertilizer doses and sources used at optimal NPK level (100% NPK) based on initial soil tests were 30 kg N ha^{-1} through urea 60 kg P ha^{-1} through single superphosphate and 30 kg K ha^{-1} through muriate of potash. The single superphosphate was not used to avoid S for treatment T9. Treatment T8 (100% NPK+FYM) received 5 t FYM ha^{-1} in soybean before the preparation of field. It was mixed in plough layer of soil (0–15 cm) by tillage. Full dose of N, P and K were applied at the time of sowing in *Kharif* season for soybean crop. The half dose of N and full dose of P and remaining half dose of N was applied after 30 days of sowing to safflower crop in *Rabi* season. Weeds in T_4 were controlled by hand weeding, whereas in other treatments chemical weed control was opted by pendimethaline in soybean immediate after sowing to control the pre-emergence weeds. Hand weeding was done twice in soybean at 20 and 35 days after sowing and at 15 and 30 days of sowing to safflower crop. The soybean cultivar MAUS-162 and safflower PBNS-12 were sown in 2023-24 by adopting recommended crop management practice for both the crops. (Singh *et al*., 2003). The harvesting of soybean and safflower were carried out in the month of October and safflower crop was harvested in the month of April during 2023-24, respectively. The harvested produce was sun dried for 3–4 days and weighed for recording biological yield. The grains were separated from the produce with mechanical thresher, cleaned, sun dried to approximately 11.0 per cent moisture and weighed for recording grain yield. The straw yield was recorded by subtracting the grain yield from the biological yield.

Soil sampling and analysis

The soil samples were collected from individual plots after the harvesting of soybean and safflower crops during three years of experimentations at 0-15 cm layer. The field moist soil samples were sieved through 2 mm sieve and stored in plastic bags at 4°C in deep fridge. The population of bacteria, fungi and actinomycetes in soil was determined by serial dilution pour plate method using Nutrient agar medium for bacteria, Ken Knight and Munaier's medium for actinomycetes and Martin's Rose-Bengal streptomycin agar medium for fungi (Wollum, 1982). soil organic carbon was estmited by using oxidation and

Table : 1 Details of fertilizer and manure treatments.

Treatments	Treatment details	Fertilizer source
T_1	50% NPK	N-Urea, P-SSP, K-MOP
T_2	100% NPK	N-Urea, P-SSP, K-MOP
T_3	150% NPK	N-Urea, P-SSP, K-MOP
T_4	100% NPK+Hand Weeding	N-Urea, P-SSP, K-MOP
T_5	100% NPK+Zinc	N-Urea, P-SSP, K-MOP, Zn -$ZnSO_4$
T_6	100% NP	N-Urea, P-SSP
T_7	100% N	N-Urea
T_8	100% NPK+FYM @5t ha^{-1}	N-Urea, P-SSP, K-MOP
T_9	100% NPK-Sulphur	N-Urea, P-DAP, K-MOP
T_{10}	Only FYM @10t ha^{-1}	—
T_{11}	Absolute Control	—

reduction procedure as given by Walkely and Black (1967), Soil dehydrogenase enzyme activity (EC 1.1.1.1) was determined by the reduction of 2,3,5-triphenyl-tetrazolium chloride to 1,3,5-triphenyl formazan (TPF) by the methods of Tabatabai (1994).

The acid (EC 3.1.3.2) and alkaline (EC 3.1.3.1) phosphatase enzymes activities were determined as per the method given by Tabatabai and Bremner (1969) by using p-nitrophenyl phosphate tetrahydrate solution of pH 6.5 for acid phosphatase and pH 11.0 for alkaline phosphatase enzymes and urease enzyme (EC 3.5.1.5) activity by the estimation of urea hydrolysis as described by Tabatabai (1994). All the estimated soil biological properties were calculated based on oven dry weight of soil.

Statistical analysis

All the data on grain and straw yield of soybean and safflower and also soil biological properties for three years were pooled and subjected to standard analysis of variance (ANOVA) following standard procedures for randomized block design (Gomez & Gomez ,1984). The F-test was used to compare significant differences between treatment means with the least significant difference (LSD) at 5 per cent level of probability by adopting the standard procedures given by (Deshpande *et al*., 1971)

RESULTS AND DISCUSSION

Grain and Straw yields of soybean and safflower

The grain and straw yields of soybean (24.42 and 31.33 kg ha^{-1}) and safflower (19.66 and 60.38 kg ha^{-1}) were highest in treatment of 100% NPK+FYM @ 5 t ha^{-1} after 19th years of crop cycle (Table 2) and this treatment was found to be statistically at par with 150 per cent NPK, 100 per cent NPK, 100 per cent NPK+Hand weeding, 100 per cent NPK+Zinc, respectively and lowest grain and straw yield of soybean and safflower was recorded by only 100 per cent N , 100 per cent NP, 50 per cent NPK and control treatment, respectively during the year 2023-24. This indicated that the balance application of inorganic fertilizers in combination with organic manure sustaining the productivity of soybean and safflower and yield was declined with the time due to imbalance application of inorganic fertilizers. Further, sulphur was also played important role in oil seeds crops and it was observed that 100 per cent NPK- S where sulphur is not applied also gave lowest yields of soybean and safflower than 100 per cent NPK+FYM @ 5 t ha^{-1}, 150 per cent NPK and 100 per cent NPK+Zinc. The integrated nutrient management added huge quantity of biomass in soil that resulted in higher grain yields reported by Vyas and Khandwe (2012).

Higher grain and straw yield due to inorganic fertilizers alone and in combination with organic sources might be due to substantial supply of nutrients supply and also as a result of better utilization of applied nutrients through improved microbial activity that involved in nutrient transformation, mineralization solubalisation and fixation. Increase in yield might be beneficial effect of FYM on nutrient availability. Shirale *et al*. (2014) and Arbad *et al*. (2011) have also reported similar results. The

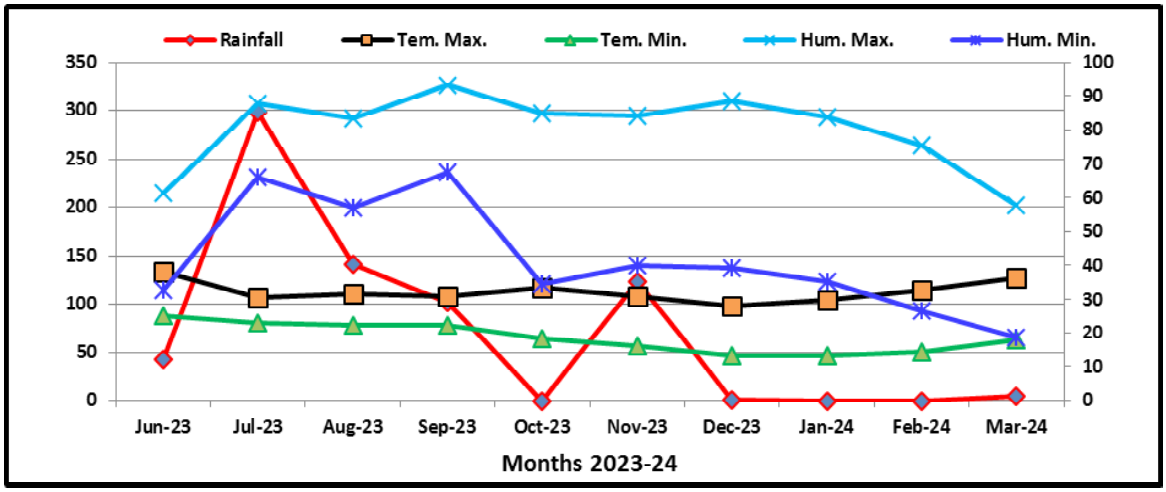

Fig. 1. Monthly weather condition at Parbhani during crop season 2023-24

Table 2. Effect of organic manuring and inorganic fertilizers on grain and straw yield of soybean and safflower under long terrm fertilizer experiment (2023-24)

Tretment Details	Soybean Yield(q ha^{-1})		Safflower Yield(q ha^{-1})	
	Grain	Straw	Grain	Straw
T_1 - 50% NPK	22.00	28.97	12.67	48.43
T_2 - 100% NPK	23.34	30.82	16.94	49.73
T_3 - 150% NPK	23.98	31.17	19.26	59.93
T_4 - 100% NPK + HW	23.17	30.87	17.28	52.34
T_5 - 100% NPK+Zn	23.48	30.78	17.59	55.47
T_6 - 100% NP	22.13	30.92	15.56	51.55
T_7 - 100% N	10.44	12.46	10.13	28.70
T_8 - 100% NPK + FYM @ 5 t ha^{-1}	24.42	31.31	19.66	60.38
T_9 - 100% NPK-Sulphur	23.13	29.91	15.28	51.95
T_{10}- Only FYM @ 10t ha^{-1}	21.85	27.92	13.76	52.53
T_{11}- Absolute Control	9.44	9.26	9.15	27.46
S.E. (m) ±	0.60	1.02	0.29	1.07
C.D. at %	1.73	2.94	0.84	3.10

imbalanced fertilizer treatments of 100 per cent N, 100 per cent NP and 100 per cent NPK (-S) were at par with 100 per cent NPK in soybean and safflower yields. It may be ascribed to adequate availability of P, K and S in soil due to continuous addition of above and below biomass crop residues in the form of roots stubbles rhizodeposition and leaf fall by soybean and safflower.

Microbial population status in soil

The data on microbial population (Table 3) indicated that highest bacterial (55.63 CFU X10^{-7} g^{-1} soil) and actinomycetes (49.07 CFU X10^{-4} g^{-1} soil) population) was found with 100% NPK+FYM @ 5 t ha^{-1} followed by only FYM @ 10 t ha^{-1} (52.38 CFU X10^{-7} g^{-1} soil and 40.57 CFU X10^{-4} g^{-1} soil) in soil, respectively. The significant variations were observed among the different treatments of long term fertilizer experiment. However, it was reduced by treatment fallow up to (28.88 CFU X10^{-7} g^{-1} soil and 28.57 CFU X10^{-4} /g soil) followed by absolute control (30.63 CFU X10^{-7} /g soil and 27.07 CFU X10^{-4} g^{-1} soil) at harvest of crop , respectively. Simillarly, fungal population was observed significantly highest in (13.75 CFU X10^{-4} g^{-1} soil) with application of FYM @ 10 t ha^{-1} at harvest. The lowest fungal population was found with absolute control (7.27 CFU X10^{-4} g^{-1} soil) and follow (7.45 CFU x 10^{-4} g^{-1} soil) treatment this could be due to continuous use of FYM over the years in combination with optimum chemical fertilizers supplied large amount of ready source of organic carbon in soil found to be maximum microbial population in comparison with application of inorganic fertilizers alone. The soil microorganisms, those are chemoheterotrophs, obtain organics a food for synthesis of cellular constituents and energy by the oxidation of organic substances for liveleness of soil micro organisms. Incorporation of organic matter improves the soil physical environment, making it more congenial for microorganisms (Tejada *et al*. 2009 and Khandare *et al*. 2015). It may be due to depletion in native pools of the plant nutrients in soil under these treatments which caused reduction in plant biomass (carbon substrate) production and addition in soil (Suresh *et al*. 1999).

Soil quality index (SQI)

Soil is a key natural resource and soil quality is the integrated effect of management of most of soil properties that determine crop productivity and sustainability. Good soil quality not only produces good crop yield, but also maintains environmental quality and consequently plant, animal and human health. A quantitative assessment of soil quality could provide

Table 3. Effect of organic manuring and inorganic fertilizers on soil microbial population and soil quality index under long terrm fertilizer experiment (2023-24).

Treatment		Bacteria(Xx 10^{-7})	Fungi(Xx 10^{-4})	Actinomycets(Xx 10^{-5})	SQI
T_1	- 50% NPK	31.38	8.50	32.32	1.78
T_2	- 100% NPK	33.88	9.50	33.07	1.80
T_3	- 150% NPK	35.88	11.00	40.57	2.15
T_4	- 100% NPK+HW	39.63	9.53	33.57	1.90
T_5	- 100% NPK+Zn	36.38	10.25	38.82	2.06
T_6	- 100% NP	32.63	8.53	32.57	1.71
T_7	- 100% N	30.88	8.00	29.32	1.63
T_8	- 100% NPK+FYM @ 5 t ha^{-1}	55.63	11.05	49.07	2.23
T_9	- 100% NPK-Sulphur	32.88	8.75	35.82	1.72
T_{10}	- Only FYM @ 10 t ha^{-1}	52.38	13.75	47.82	2.04
T_{11}	- Absolute Control	30.63	7.25	27.07	1.64
T_{12}	– Fallow	28.88	7.45	28.57	1.71
	S.E. (m) $\pm$	1.04	0.42	1.33	0.03
	C.D. at 5%	3.00	1.22	3.82	0.09

much needed information on the adequacy of the World's soil resource base in relation to the food and fiber needs of a growing World population. It is evident from table 3 stated the highest value of soil quality index (SQI) was observed with the application of 100 per cent NPK + FYM @ 5 Mg ha^{-1} and towards the quite improvement with the applications of inorganic fertilizer treatments as 150 per cent NPK and 100 per cent NPK +$ZnSO_4$ @ 25 kg ha^{-1} obtained from each of the 04 soil attributes. The highest total SQI (2.23) was contributed under treatment with the application of 100 per cent NPK + FYM @ 5 Mg ha^{-1} whereas, the total soil quality index (SQI) values considerably near were obtained in treatment 150 per cent NPK and 100 per cent NPK+$ZnSO_4$ @ 25 kg ha^{-1}. However, the soil quality index (SQI) values were low under absolute control treatment. Thus, treatment 100 per cent NPK + FYM @ 5 t ha^{-1} has taken I^{st} rank, because of the highest soil quality index (SQI) was obtained in same treatment as compared to all the other treatments reported by Jadhao *et al.* (2019) under long term fertilizer experiment.

Soil enzymatic activities

Soil enzymatic activity is an indicator of chemical reactions and continuous conversion of unavailable form of nutrients to available form. soil dehydrogenase, acid phosphatase and alkaline phosphatase enzyme activity were estimated after harvest of crop sequence and observed that all the three enzymes activity showed comparatively more values in the treatment 100% NPK+FYM @ 5 t ha^{-1} than rest of the treatments. Lowest enzyme activity was recorded in the control treatment fallowed by only 100 per cent N treatment. It is evident from (Fig. 2) significantly maximum dehydrogenase enzyme activity was observed by 100 per cent NPK+FYM @ 5 t ha^{-1} (97.00 ug TPF g $Soil^{-1}$) followed by 150 per cent NPK (65.20 ug TPF g $soil^{-1}$) and 100 per cent NPK+Zn (63.13 ug TPF g $soil^{-1}$). A relatively more pronounced effect of FYM on soil enzyme activities in comparison to the inorganic fertilizers has also been reported earlier by Chu *et al.* (2007) and Romero *et al.* (2010). The results are in closed with the findings of Bhattacharyya *et al.* (2008), who reported a four times increase in the dehydrogenase enzyme activity in soil due to the application of FYM in combination with NPK. Beneficial effects of S fertilization on the dehydrogenase enzyme activity in soil has also been reported by Niewiadomska *et al.* (2015), being an essential constituent of several amino acids and co-enzymes that play a role in microbial metabolism. The data on acid and alkaline phosphatase enzyme activity (Fig. 2) also revealed that the maximum acid phosphatase enzyme activity was

observed by 100 per cent NPK+FYM @ 5 t ha^{-1} (60.26 and 145 ug P-NP g^{-1} soil hr^{-1}) followed by 150 per cent NPK (54.65 and 140 kg P- NP g^{-1} soil this could be attributed to additional supply of N and C sources applied through FYM which supports microbial activity in soil. Garg and Bahl (2008) reported the increase in the alkaline phosphatase activity with combined application of FYM and inorganic fertilizers under long term fertilizer experiment. The activity of acid and alkaline phosphatases was found to correlate with organic matter in various studies (Aon & Colaneri 2001). The balanced application of inorganic fertilizer treatments of 100 per cent NPK also increased the acid and alkaline phosphatase enzyme activities over the control and imbalanced fertilization treatments of 100 per cent N, 100 per cent NP and 100 per cent NPK(-S). Mishra *et al*. (2008).

Soil Reaction (pH) and electrical conductivity

The data (Table 4) showed that the soil pH after harvest of safflower crop during 2023-24 showed significant variations under different treatments due to continuous use of organic manure and inorganic fertilizers and their combinations. It might be because of calcareous nature of soil which is having high buffering capacity. It was also observed that pH was declined with only FYM @ 10 t ha^{-1} treatment (7.56) followed by 100 per cent NPK+FYM @ 5 t ha^{-1} (7.58) over initial soil pH (8.10). It may be because of organic acids released during decomposition of FYM by microbes. It is observed from table 4 that higher electrical conductivity was observed in the treatments receiving continuously inorganic fertilizers like 150 per cent NPK, 100 per cent NPK and 100 per cent NPK+Zn treatments. This increase in EC might be attributed to the addition of salts through application of increased doses of inorganic fertilizers. It indicates that after fifteen years of experimentation EC of soil in most of the treatments was increased over initial value but only FYM @ 10 t ha^{-1} (0.249 dsm^{-1}) recorded lowest EC than rest of the treatments, looking to the above results Manna *et. al*. (2005) and Masto *et al*., (2007) also commented the similar results on soil reaction and soil pH positively and significantly impacte by organic and inorganic nutrient sources.

Soil Organic Carbon

The data pertaining to organic carbon content of soil (Table 4) revealed that highest soil organic carbon (8.33 g kg^{-1}) was noticed in the treatment receiving 100 per cent NPK+FYM @ 5 t ha^{-1} followed by only FYM @ 10 t ha^{-1} (8.08 g kg^{-1}) and 150 per cent NPK (6.60 g kg^{-1})

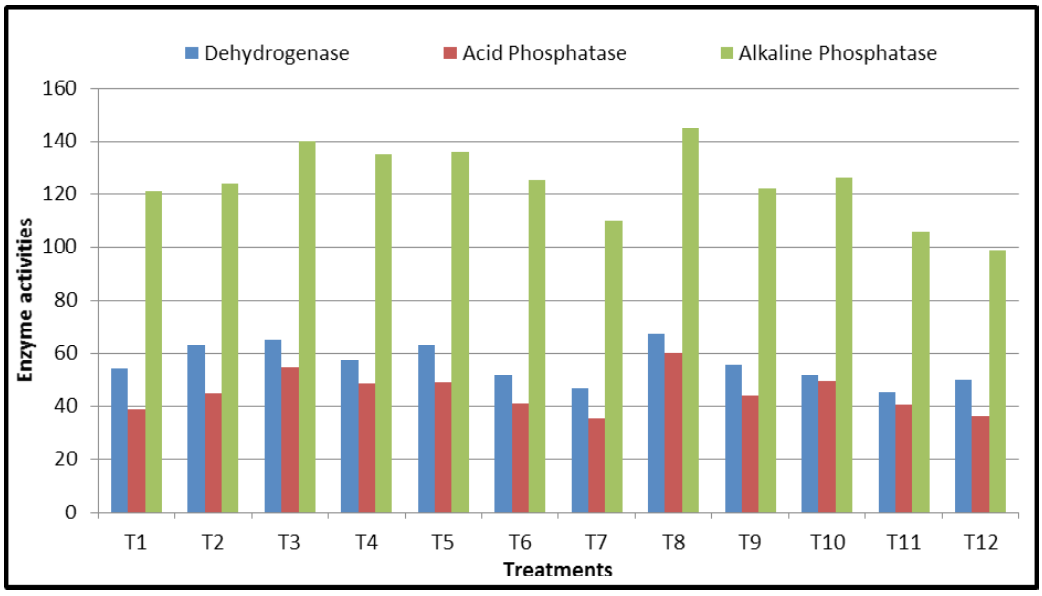

Fig. 2. Effect of organic manure & inorganic fertilization on soil enzyme activity Dehydrogenase activity (ug TPF g^{-1} soil 24hr^{-1}), Acid Phosphatase activity (ug P-NP g^{-1} soil hr^{-1}) and Alkaline Phosphatase activity (ug P-NP g^{-1} soil hr^{-1}) under soybean -safflower cropping sequence 2023-24.

treatments. This could be ascribed to the contribution from annual use of organic manure FYM during the period of experimentation and also due to increased levels of fertilizer application has helped in increasing the organic carbon content in soil and also due to the increased contribution from the roots, stubbles and other crop biomass. It was also observed that organic carbon content in soil was slightly increased in all treatments receiving different manure and fertilizers doses over initial status of soil except only 100 per cent N treatment. The variations in organic carbon content in soil were found to be relative to the total biomass production. The integrated use of FYM with fertilizers (100% NPK + FYM @ 5 t ha^{-1}) increased soil organic carbon level over control treatment (T_{11}). This may be attributed to the chelation effect of FYM in stimulating microbial growth, resulting in higher soil organic carbon content. Patil and Puranik (2001) reported the beneficial effects of the integrated use of inorganic fertilizers with FYM.

Available N, P and K

The highest build up of available nitrogen (Table 4) was recorded by the application of 100 per cent NPK+ FYM @ 5 t ha^{-1} (276 kg ha^{-1}). The magnitude of soil available N was always higher with balanced nutrient application. It was also noticed that the application of potassium 100 per cent NPK also improved available N content in soil. The available N content decreased continuously in control plot due to continuous removal of nutrients with continuous cropping without fertilizer application after nineteen years of experimentation it was observed that the available N status was not drastically reduced in any of treatments receiving manure or fertilizer application, similar results were reported by (Avte *et.al.,* 2021 and Meshram *et al.,* 2016). The data on available phosphorus status of soil (Table 4) during 2023-24 revealed that as compared to initial status (16.00 kg ha^{-1}) there were significant build up in available P status of soil (20.64 kg ha^{-1}) in 100 per cent NPK+FYM @ 5 t ha^{-1} treatment which found at par with 150 per cent NPK (19.05 kg ha^{-1}). It was also observed that imbalance use of fertilizer nutrients reduced the available P content in soil Katkar *et al.,* (2011) and khandale *et al*. (2019). The available K status in soil during nineteen years of experimentation (Table 4)

Table: 4. Effect of organic manuring and inorganic fertilizers on chemical properties of soil under long terrm fertilizer experiment (2023-24)

Treat.No.	Treatment Details	pH	EC(dSm^{-1})	SOC (g kg^{-1})	Available Nitrogen (kg ha^{-1})	Available Phosphorus (kg ha^{-1})	Available Potassium (kg ha^{-1})	Available Sulphur (kg ha^{-1})
T_1	50% NPK	7.71	0.275	6.10	247	15.08	699	29.40
T_2	100% NPK	7.72	0.309	6.40	251	17.22	712	31.18
T_3	150% NPK	7.69	0.370	6.60	265	19.05	742	33.95
T_4	100% NPK+HW	7.76	0.279	6.45	253	18.09	705	31.12
T_5	100% NPK+Zinc	7.88	0.330	6.23	256	18.16	711	32.47
T_6	100% NP	7.70	0.299	5.98	222	16.78	700	31.05
T_7	100% N	7.61	0.293	5.93	212	11.23	691	30.04
T_8	100% NPK+FYM @ 5 t ha^{-1}	7.58	0.267	8.33	276	20.64	751	36.87
T_9	100% NPK -Sulphur	7.67	0.288	6.15	241	15.47	701	29.13
T_{10}	Only FYM @ 10 t ha^{-1}	7.56	0.249	8.08	251	18.64	715	32.96
T_{11}	Absolute Control	7.81	0.263	5.65	211	10.69	689	27.05
T_{12}	Fallow	7.78	0.256	5.70	211	14.35	698	30.39
	SE ±	0.02	0.012	0.16	6.17	0.60	6.10	0.33
	CD at 5%	0.05	0.035	0.46	17.76	1.74	17.57	0.95
	Initial 2006-07	8.10	0.218	5.50	216.00	16.00	766.00	30.50

revealed that there was increased in available K status (751 kg ha^{-1}) of soil over initial status (766.00 kg ha^{-1}) was found with 100 per cent NPK+FYM @ 5 t ha^{-1} followed by 150 per cent NPK (742 kg ha^{-1}). The application of organic manure may have caused reduction in K fixation and consequently increased K content in soil due to interaction of organic matter with clay besides the direct addition to the available K pools of soil. As compare to initial available K status (766.00 kg ha^{-1}). The maximum decline in available K was observed in control treatment (644 kg ha^{-1}). Arbad *et al.,* (2014) reported the continuous application of N alone or NP showed depressive effect on available K content of soil which may be due to nutrient imbalance in the soil and which caused mining of its native pools that caused reduction in crop yields.

Available Sulphur

Application of organic manure, chemical fertilizers and their combinations also affected significantly the availability of sulphur in soil. The data (Table 4) clearly showed that continuous application of 100 per cent NPK+FYM @ 5 t ha^{-1} significantly increased the available S status of soil (36.87 kg ha^{-1}), over all the treatments. Continuous growing of soybean-safflower without application of S-containing fertilizers caused decline in available 'S' in the soil from its initial status 30.50 kg ha^{-1} in control 27.05 kg ha^{-1}, followed by fallow (30.39 kg ha^{-1}) and in 100 per cent N alone (29.15 kg ha^{-1}) treatments, respectively. It may be due to continuous use of diammonium phosphate (DAP) as P source which resulted decline in sulphur in 100 per cent NPK - S treatments causing reduction in crop yields as compared with single super phosphate application. It indicates that the trend of decrease in available 'S' status was lower where FYM was applied alone or in combination with sulphur containing fertilizers as well as where 150 per cent NPK dose was applied Arbad *et al*., (2014) and Katkar *et. al.* (2011) in long term fertilization

CONCLUSION

The INM treatment of 100 per cent NPK +FYM @ 5 t ha $^{-1}$ sustain the productivity of soybean - safflower cropping system and enhances the physical, chemical and biological properties of soil over initial status of soil at 19th crop cycle under long term fertilizer experiment. Therefore, it is concluded that balance application of inorganic fertilizers does not deteriorate the soil health.

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Tillage Dynamics Influence on Chickpea Under Rainfed Soybean-Chickpea Cropping System

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ABSTRACT

Tillage dynamics influence on chickpea under rainfed soybean-chickpea sequence cropping system was conducted at Agriculture Research Station, Achalpur (M. S.). Average rainfall and its distribution were found normal in all five years of the experimentation. The PCA of the five year rainfall shows not much variation in dimension. Experiment was conducted in Strip Plot Design with four main plot tillage treatments with two chickpea varieties as subplot treatment with five replications. Different tillage treatment recorded significant effect on soybean equivalent grain yield. Highest soybean equivalent grain yield (2005 kg ha^{-1}) was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea. However it was at par with treatment T_1 - Conventional Tillage (CT) - Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS. Non significant effect was observed with respect to varieties. Highest soybean equivalent grain yield was recorded with treatment V_2 - AKG- 1303 (1914 kg ha^{-1}) over treatment V_1. Interaction effect was found to be non significant. Different tillage treatment recorded highest benefit : cost ratio (2.56) was observed with the treatment T_2 - Zero Tillage (ZT) - application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea and with treatment V_2 - AKG- 1303 (2.33) over treatment V_1.

In order to fully exploit the advantages of conservation tillage, systems have to be adapted to the regional characteristics. Farmer's adoption of conservation tillage is still limited (Wang *et al.,* 2007). Conservation tillage in sub-tropical regions offers advantages over conventional tillage, but also poses significant challenges. To fully utilize conservation tillage, systems must be tailored to regional conditions. Despite its benefits, farmer adoption remains limited (Wang *et al.,* 2007). In subtropical regions, conservation tillage improves soil moisture and yield but presents challenges like planting and weed control (Wiedenfeld, 2006). No-tillage plots show slightly higher yields than conventional tillage, while reduced tillage yields are slightly lower (Yao *et al.,* 2004).Minimum tillage, an ecologically sound approach, reduces tillage frequency and intensity, using tools that loosen but don't invert or pulverize soil. It promotes sustainable cultivation with minimal degradation and supports optimal soil health and productivity. Conservation agriculture enhances water retention (Page *et al.,* 2019), soil quality (Somasundaram *et al.,* 2019), reduces erosion (Montgomery, 2007), and may increase yields and farm income (Pradhan *et al.,* 2018). It aims to balance productivity, profitability, and environmental conservation.

In India, chickpea leads pulse production (40 %), followed by pigeonpea, blackgram, and greengram. Major producers include Madhya Pradesh, Maharashtra, and Rajasthan. Though pulse productivity rose by 46 per cent from 1950–51 to 2013–14, the CAGR remains low at 0.64 per cent. India continues to be the largest pulse importer. Delayed sowing leads to moisture loss and poor germination, while timely sowing after harvest ensures better plant stand. However, long-duration varieties are vulnerable to terminal drought and rabi crops often face severe pest and disease pressure.

MATERIAL AND METHODS

This experiment was conducted for total five years from 2019 to 2023 on the farm of Agriculture Research Station, Achalpur, Dist Amravati, 444 805, comes under Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola Maharashtra State of India. Achalpur is situated in the subtropical region at $21^0 15'26''$ North latitude and $77^0 30'31''$ East longitude and at an altitude of 375 m above mean sea level. The soil of experimental plot was clayey in texture

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having 15.6 per cent sand, 30.7 per cent silt and 53.7 per cent clay (*Bouyoucos hyderometer* method - Piper, 1966). Soil was slightly alkaline in reaction having pH 7.90. Among nutrient status it ranged medium in organic carbon (0.42 %), low in available nitrogen (174.3 kg ha^{-1} by alkaline $KMnO_4$ method – Subbiah and Asija, 1956), very low in available phosphorus (12.21 kg ha^{-1} by alkaline Olsen's method – Olsen *et al.,* 1954) and very high in available potassium (412.74 kg ha^{-1} by Flame photometric method – Jackson, 1967). This experiment was conducted for total five years from 2019 to 2023. In the present investigation, healthy and viable seeds of soybean (Suvarna soya) in *Kharif* followed by chickpea (JAKI-9218 and AKG-1303) variety having 105-111 days duration in *Rabi* seasons were used with eight different treatments combinations with five replications. The treatment details as below.

Main Plot (A. Tillage)

T_1 : Conventional Tillage (CT) Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS

T_2 : Zero Tillage (ZT) Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea

T_3 : Minimum Tillage (MT) Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea + Pre emergence application of pendimethalin 30EC @ 1.0 kg a.i. ha^{-1} + hoeing at 25 to 30 DAS

T_4 : Reduced Tillage (RT) Rotovator immediately after harvesting of Soybean + sowing + One hoeing at 25 to 30 DAS

Sub Plot (B. Varieties)

V_1 : JAKI- 9218 (2007 released)

V_2 : AKG- 1303 - Kanak (2021 released)

Experiment was conducted with following objectives to study the effect of tillage practices on chickpea varieties and to assess the effect of tillage practices on economics of chickpea production.

Typology Construction

Selection of variables

Explored the differences in the treatment combination using typological analysis (Berre *et al.,* 2016). Typologies can be developed by using structural (Recourses) or functional (Yield) variables or both (Tittonell, 2014). Rainfall is perhaps the most important variable in the phenomenon of monsoon. The amount of rainfall in a given week, month or season varies from year to year over a wide range. This raises the question: is there an identifiable pattern in these variations, or is the variability purely random. Variability may be defined as a tendency of rainfall to fluctuate around a long-term average (normal) value. Studied first step in the dimensionality of the rainfall pattern and identified primary patterns and variability by applying Principal Component Analysis (PCA) using R (R 3.1.1 Core, 2014). The rainfall distribution was normal during the five years of experimentation. The four principle components (PCs) can explain more than 90 % of the total variances by the seasonality of rainfall.

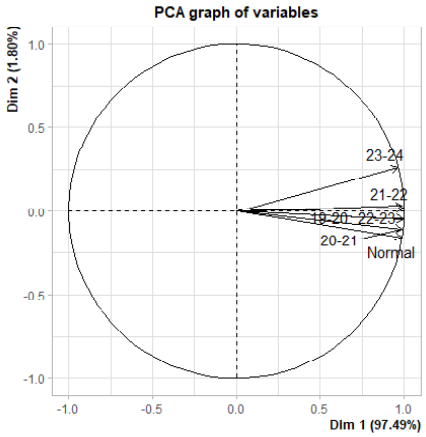

Fig. 1. Principle Component Analysis of rainfall obtained during five years of the experimentation.

PCA graph of variable shows 97.49 per cent similarity also ellipse analysis indicated similarity of rainfall data as shown in fig 2.

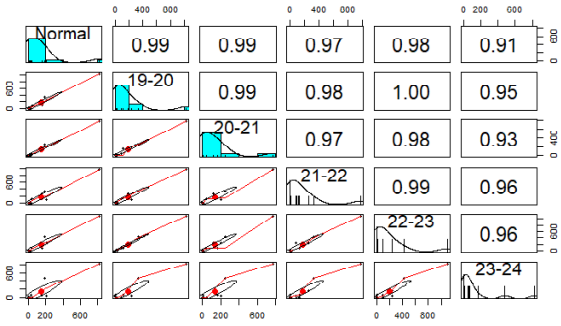

Fig. 2. Ellipse analysis for five years rainfall data along with normal rainfall.

RESULTS AND DISCUSSION

Five years pooled results showed that, different tillage treatment recorded non significant effect on grain and straw yield of soybean. Highest grain and straw yield of soybean (1162 and 1668 kg ha^{-1}) was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea. Non significant effect was observed with respect to varieties. Highest grain and straw yield of soybean was recorded with treatment V_2 - AKG- 1303 (1144 and 1643 kg ha^{-1}) and interaction effect was found to be non significant. No strong correlation was observed in the PCA with respect to tillage practices and varieties on soybean grain yield.

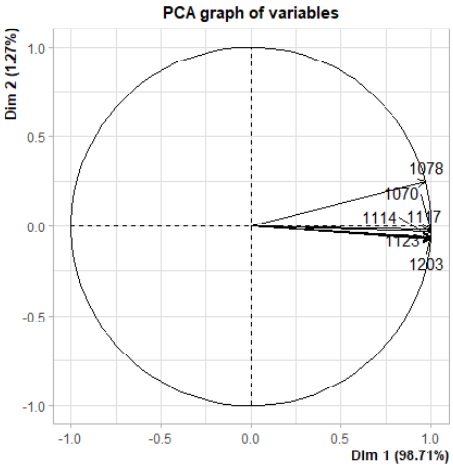

Fig. 3. Effect of tillage practices and varieties on Soybean grain yield (PCA)

Table 1: Effect of tillage practices and varieties on grain yield (kg ha^{-1}) of chickpea.

Treatments	2019- 20	2020-21	2021-22	2022-23	2023-24	Pooled
Main Plot (A) : Tillage						
T_1 - Conventional Tillage (CT)- Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS	1667	1412	1614	1614	1473	1556
T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea	1606	1459	1679	1679	1542	1593
T_3 - Minimum Tillage (MT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea + Pre emergence application of pendimethalin 30EC @ 1.0 kg a.i. ha^{-1} + hoeing at 25 to 30 DAS	1550	1256	1447	1466	1366	1417
T_4 - Reduced Tillage (RT) - Rotovator immediately after harvesting of Soybean + sowing + One hoeing at 25 to 30 DAS	1493	1215	1338	1283	1176	1301
SE (m) ±	73.4	32.3	57.5	61.7	56.3	55.70
CD at 5%	-	99.7	177.3	190.2	173.6	161.5
Sub Plot: (B) : Varieties						
V_1 - JAKI- 9218	1705	1266	1417	1393	1278	1412
V_2 - AKG- 1303 (Kanak)	1453	1404	1622	1627	1500	1521
SE (m) ±	46.3	22.1	51.2	50.6	55.2	49.4
CD AT 5%	181.9	66.3	200.8	126.5	216.8	128.4
Interaction (AxB)						
SE ± (m)	92.7	54.2	102.3	121.2	110.5	88.6
CD at 5%	-	-	-	373.5	340.4	225.4

Five years pooled results showed that, different tillage treatment recorded significant effect on grain yield of chickpea. Significantly highest grain yield (1593 kg ha^{-1}) was observed with the treatment T_2 - Minimum Tillage (MT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea over rest of the treatment but found at par with treatment T_1 - Conventional Tillage (CT) - Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS. Similarly, significantly highest grain yield of chickpea was recorded with treatment V_2 - AKG- 1303 (1521 kg ha^{-1}) over treatment V_1. Interaction effect was found to be significant.

Table 2: Interaction effect of tillage practices x varieties on grain yield (kg ha^{-1}) of chickpea.

Treatments	T_1	T_2	T_3	T_4	Mean
V_1	1472	1703	1317	1155	1412
V_2	1640	1482	1516	1446	1521
Mean	1556	1593	1417	1301	1467
SE (m) ±	88.6				
CD at 5%	225.4				

Five years pooled results showed that, the interaction effect of different tillage treatment and varieties recorded significant effect on grain yield of chickpea.

Table 3: Effect of tillage practices and varieties on soybean equivalent grain yield (kg ha^{-1})

Treatments	2019- 20	2020-21	2021-22	2022-23	2023-24	Pooled
Main Plot (A) : Tillage						
T_1 - Conventional Tillage (CT)- Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS	2191	1856	2085	1963	1708	1960
T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea	2110	1918	2167	2042	1788	2005
T_3 - Minimum Tillage (MT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea + Pre emergence application of pendimethalin 30EC @ 1.0 kg a.i. ha^{-1} + hoeing at 25 to 30 DAS	2036	1652	1868	1783	1585	1785
T_4 - Reduced Tillage (RT) - Rotovator immediately after harvesting of Soybean + sowing + One hoeing at 25 to 30 DAS	1961	1597	1727	1561	1364	1642
SE (m) ±	82.7	62.2	74.2	75.0	65.3	68.79
CD at 5%	-	191.9	228.9	231.3	201.3	199.5
Sub Plot: (B) : Varieties						
V_1 - JAKI- 9218	2240	1665	1830	1695	1483	1782
V_2 - AKG- 1303 (Kanak)	1909	1846	2094	1979	1740	1914
SE (m) ±	85.5	49.9	66.0	73.7	64.0	59.7
CD AT 5%	335.6	196.0	259.2	-	251.4	-
Interaction (AxB)						
SE ±(m)	170.9	99.8	132.0	147.4	128.1	124.5
CD at 5%	-	-	-	-	-	-

Significantly highest grain yield (1703 kg ha^{-1}) was observed with the treatment T_2 - Minimum Tillage (MT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea X V_1 - JAKI- 9218 over rest of the treatment but found at par with treatment combination T_1 x V_2 (1640 kg ha^{-1}), T_2 x V_2 (1482 kg ha^{-1}) and T_3 x V_2 (1516 kg ha^{-1}). Crop yields and water use efficiency have increased (with up to 35%) following the implementation of reduced tillage practices. In order to fully exploit the advantages of conservation tillage, systems have to be adapted to regional characteristics. Farmer's adoption of conservation tillage is still limited (Wang *et al.,* 2007). Conservation tillage in sub-tropical regions offers advantages over conventional tillage, but also poses significant challenges. New procedures and equipment modifications are required. Planting and weed control are difficult (Wiedenfeld, 2006). The average yield from the no-tillage plots was slightly higher than under conventional tillage, while a slightly lower yield was found under reduced tillage (Yao *et al.,* 2004).

Five years pooled results showed that, different tillage treatment recorded significant effect on soybean equivalent grain yield. Figure number 7 ellipse analysis shows strong correlation with respect to soybean equivalent grain yield. Highest soybean equivalent grain yield (2005 kg ha^{-1}) was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea. However it was at par with treatment T_1 - Conventional Tillage (CT) - Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS. Non significant effect was observed with respect to varieties. Highest soybean equivalent grain yield was recorded with treatment V_2 - AKG- 1303 (1914 kg ha^{-1}) over treatment V_1. Interaction effect was found to be non significant. Aulakh *et al.,* (2012) observed significantly higher uptake of N and P by soybean from crop residue amended treatments due to conservation of water in soil profile, resulting in higher soybean and wheat yield in conservation tillage than conventional tillage.

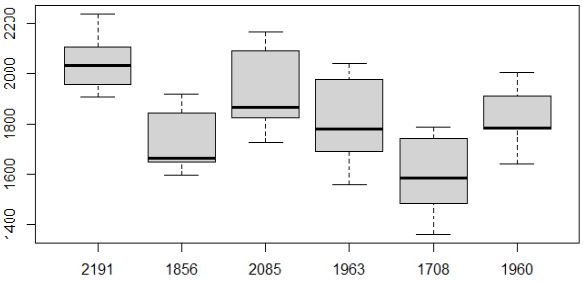

Fig. 4. Effect of tillage practices and varieties on seed equivalent grain yield.

Pooled results showed that, different tillage treatment recorded highest system cost of cultivation (68225 Rs ha^{-1}) was observed with the treatment T_1 - Conventional Tillage (CT) - Tractor drawn Cultivator + rotavator + Sowing of chickpea + one Hoeing + one hand weeding at 25 to 30 DAS. Highest system cost of cultivation was recorded with treatment V_2 - AKG- 1303 (62642 Rs ha^{-1}) over treatment V_1. Veronica *et al.,* (2012).

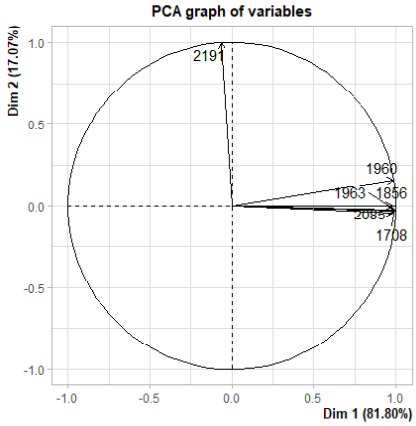

Fig. 5. PCA analysis of effect of different treatment on soybean equivalent yield.

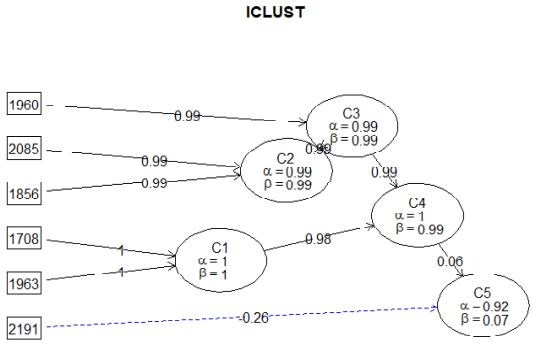

Fig 6. I cluster analysis of effect of different treatment on soybean equivalent grain yield

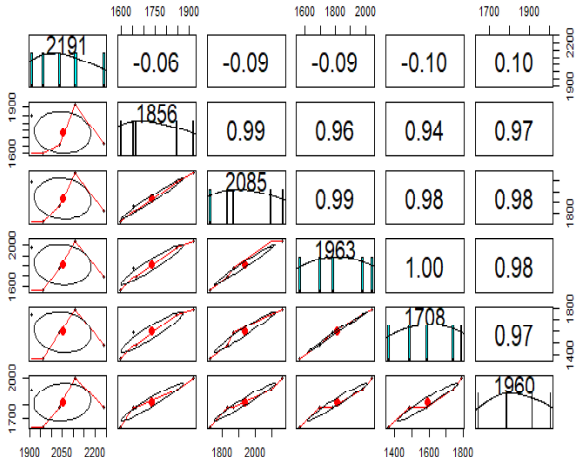

Fig. 7: Ellipse correlation analysis of soybean equivalent yield by different treatment.

From the present study, it can be concluded that the subsurface tillage (One Subsurface tillage at 90 cm horizontal distance + Two Tyne + blade harrow) practice showed the significant increase in the growth and yield attributing characters which showed ultimate increase in the grain and straw yield of the soybean crop. The subsurface tillage improved the moisture content of soil at 90 DAS of soybean crop.

Five years pooled results showed that, different tillage treatment recorded significant effect on gross and net monetary return of soybean-chickpea cropping system. Significantly highest gross and net monetary return (151788 and 92425 Rs ha^{-1}) was observed with the treatment T_2 - Zero Tillage (ZT)- Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea. Significant effect was observed with respect to varieties. Figure 7 indicated box plot presentation of NMR and GMR and fig 8 indicated ellipse analysis of GMR and NMR shows strong coorelation. Highest GMR and NMR of soybean-chickpea cropping system was recorded with treatment V_2 - AKG- 1303 (145650 and 83008 Rs ha^{-1}) over treatment V_1. Interaction effect was found to be non significant. Singh *et al.,* (2004) reported that conventional tillage for all soybean chickpea cropping sequence was found to be a better option for increasing the gross and net return compared to the reduced tillage, minimum tillage and zero tillage. Similar finding reported by Manjith and Angadi (2016), Chitale *et al.,* (2007).

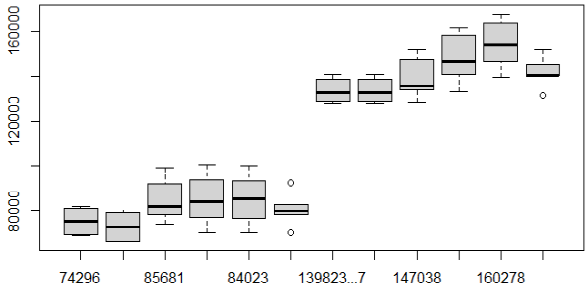

Fig 7. NMR & GMR of system as affected by tillage and varieties

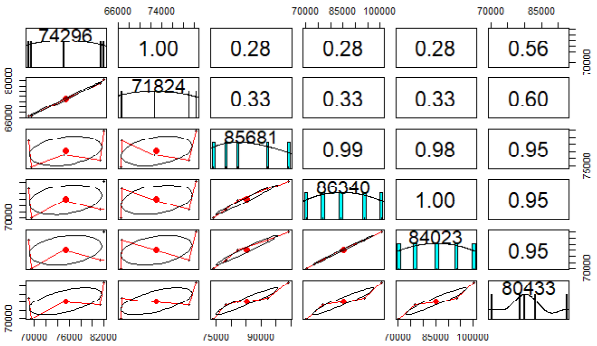

Fig 8. Ellipses analysis - NMR of system affected by tillage and varieties.

CONCLUSION

From pooled data over the five years revealed that, different tillage and varieties treatment recorded non significant effect on grain yield of soybean. Different tillage treatment recorded significant effect on grain yield of chickpea. Significantly highest grain yield (1593 kg ha^{-1}) was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea over rest of the treatment but found at par with treatment T_1 - Conventional Tillage (CT) - Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS. Similarly, significantly highest grain yield of chickpea was recorded with treatment V_2 - AKG- 1303 (1521 kg ha^{-1}) over treatment V_1. Interaction effect was found to be significant. Significantly highest grain yield (1703 kg ha^{-1}) was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea X V_1 - JAKI- 9218 over rest of the treatment but found at par with treatment

combination T_1 x V_2 (1640 kg ha^{-1}), T_2 x V_2 (1482 kg ha^{-1}) and T_3 x V_2 (1516 kg ha^{-1}). Similar observation recorded with respect to straw yield.

Five years pooled results showed that, different tillage treatment recorded significant effect on gross monetary return of chickpea. Significantly highest gross monetary return (91649 Rs ha^{-1}), highest net monetary return and benefit : cost ratio was was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea. However, it was at par with the treatment T_1 - Conventional Tillage (CT) - Tractor drawn Cultivator + rotavator + Sowing of chickpea+ one Hoeing + one hand weeding at 25 to 30 DAS. Significant effect was observed with respect to varieties. Highest gross monetary return of chickpea was recorded with treatment V_2 - AKG- 1303 (87808 Rs ha^{-1}) over treatment V_1. Interaction effect was found to be non significant.

Five years pooled results showed that, different tillage treatment recorded benefit : cost ratio (2.56) was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea. Highest benefit : cost ratio of soybean-chickpea cropping system was recorded with treatment V_2 - AKG- 1303 (2.33) over treatment V_1. Different tillage treatment recorded significant effect on soybean equivalent grain yield. Highest soybean equivalent grain yield (2005 kg ha^{-1}) was observed with the treatment T_2 - Zero Tillage (ZT) - Application of Glyphosate @ 1.0 kg a.i. ha^{-1} immediately after harvesting of Soybean + sowing of chickpea. However, it was at par with treatment T_1 - Conventional Tillage (CT) - Tractor drawn Cultivator + rotavator + Sowing of chickpea + one Hoeing + one hand weeding at 25 to 30 DAS. Non significant effect was observed with respect to varieties. Highest soybean equivalent grain yield was recorded with treatment V_2 - AKG- 1303 (1914 kg ha^{-1}) over treatment V_1. Interaction effect was found to be non significant.

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Bio-Efficacy Testing and Dosage Optimization of Pottasium Humate- A Humic Acid Based Bio Stimulant on Paddy Crop

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ABSTRACT

An agronomic investigation was undertaken during *Kharif* 2023-24 at Agronomy Farm, College of Agriculture, Nagpur to assess the bio-efficacy of humic acid (Pottasium humate) as soil application & foliar spray in paddy for supporting plant growth, yield enhancement and quality of grains. The experiment was laid out in randomized block design with replicated thrice. Seven treatments viz., Control (T_1), 100 per cent RDF (T_2), T_2 + 250 g humic acid per acre in soil at 7-10 DAT + 125 g humic acid acre^{-1} as foliar 28-30 DAT (T_3), T_2 + 500 g humic acid acre^{-1} in soil at 7-10 DAT + 125 g humic acid acre^{-1} as foliar 28-30 DAT (T_4), T_2 + 750 g humic acid acre^{-1} in soil at 7-10 DAT+ 125 g humic acid per acre as foliar 28-30 DAT (T_5), T_2 + 1.0 kg humic acid acre^{-1} in soil at 7-10 DAT + 125 g humic acid acre^{-1} as foliar 28-0 DAT (T_6) and T_2 + 1.5 kg humic acid per acre in soil at 7-10 DAT + 125 g humic acid acre^{-1} as foliar 28-30 DAT (T_7). The results revealed that, application of humic acid @ 1.5 kg acre^{-1} in soil at 7-10 days after transplanting and its foliar application at 125 g acre^{-1}, 28-30 DAT along with recommended dose of fertilizer (T7) recorded maximum plant height (94.1 cm) and longest root length (14.5 cm) at harvest; however, it remained at par with application of humic acid @ 1.0 kg acre^{-1} in soil at 7-10 days after transplanting and its foliar application at 125 g acre^{-1} 28-30 DAT along with recommended dose of fertilizer (T6). Similar trend was recorded with total number of tillers (12.6) and number of effective tillers hill^{-1} (12.0) at harvest. Similarly application of Humic acid (Pottasium humate) @ 1.5 kg per acre (3.75 kg ha^{-1}) in soil at 7-10 days after transplanting and its foliar application at 125 g acre^{-1} (312.5 g ha^{-1}), 28-30 DAT along with recommended dose of fertilizer (T_7) recorded significantly highest grain yield of 35.8 q ha^{-1}. However it was at par with application of humic acid of @ 750 g per acre (1.87 kg ha^{-1}) (T5) or 1.0 kg acre^{-1} (2.5 kg ha^{-1}) in soil at 7-10 days after transplanting + foliar application of 125 g acre^{-1} 28-30 DAT along with recommended dose of fertilizer (T_6) and these three treatments proved significantly superior over RDF 100: 50: 50 kg NPK ha^{-1} (T_2).

Rice (*Oryza sativa* L.) is the world's single most important crop, a primary food source for half of the world's population. Almost 25 per cent of the calories consumed by the entire world human population come from rice. Rice cultivation needs urgent emphasis regarding its revamp in productivity. The concernment of uplifting rice productivity is more prominent under the scenarios of increasing food demand in response to consistent population growth as well as agricultural land shrinkage. Moreover, in the present context of changing climate, unsatisfactory performance of rice crop is a major challenge which needs to be addressed with competent agro-technological interventions. India is the largest producer of rice in terms of area (43.79 million hectare) in the world with production. (Karennavar *et al.,* 2022)

In India, the area occupied under rice cultivation is 44 million hectares with production of 102.32 million tonnes and an average productivity of 2550 kg ha^{-1} (Anonymous, 2020[a]). In Maharashtra area under rice is 1.53 million hectares with production of 3.51 million tones with average productivity of 1873 kg ha^{-1} during 2019-2020.

Humic acid application can significantly benefit paddy crops by improving root development, enhancing nutrient uptake, boosting plant growth and increasing yield, primarily by improving soil structure and water retention capacity, making nutrients more readily available to the plant roots; essentially creating a more favorable environment for paddy cultivation.

Bio-stimulants have increasingly been considered as valuable advanced farming techniques used in worldwide agricultural production. They enhance crop health, quality and grower profitability and can effectively contribute to overcome the challenges posed by the increasing demand for food by the world's population in continuous growth. (Karennavar *et al.,* 2022).

MATERIAL AND METHODS

A field experiment was conducted at Agriculture Research Station, College of Agriculture, Nagpur, Dist.

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Nagpur, Maharashtra State (India) during *Kharif* - 2023 to assess the bio-efficacy of humic acid (Pottasium humate) as soil application & foliar spray in transplanted paddy (var. Sadhana) for supporting plant growth, yield enhancement & quality of grains.

The soil of experimental site was silty clay with pH of 7.8, electrical conductivity 0.35 dSm^{-1}, medium in available nitrogen (274 kg ha^{-1}), phosphorus (20 kg ha^{-1}) and high in potassium (394 kg ha^{-1}).The experiment was laid out in Randomized Block Design (RBD) with seven treatments and replicated three times. The treatments are given in Table 1. The recommended dose of fertilizers (100: 50: 50 kg N, P and K kg ha^{-1}) and other package of practices for paddy were imposed uniformly for all the treatments, except for control.

Table 1: Treatment details of the field experiment

SN	Treatments
T_1	Control
T_2	100% RDF (100: 50: 50 kg N: P : K kg ha^{-1})
T_3	T_2 + 250 g humic acid per acre in soil at 7-10 DAT + 125 g humic acid per acre as foliar, 28-30 DAT
T_4	T_2 + 500 g humic acid per acre in soil at 7-10 DAT + 125 g humic acid per acre as foliar, 28-30 DAT
T_5	T_2 + 750 g humic acid per acre in soil at 7-10 DAT+ 125 g humic acid per acre as foliar, 28-30 DAT
T_6	T_2 + 1.0kg humic acid per acre in soil at 7-10 DAT + 125 g humic acid per acre as foliar, 28-30 DAT
T_7	T_2 + 1.5 kg humic acid per acre in soil at 7-10 DAT + 125 g humic acid per acre as foliar, 28-30 DAT

RESULTS AND DISCUSSION

In paddy var. PDKV Sadhana, the plant growth and yield attributes as well as crop yields were highly influenced by application of humic acid based bio-stimulant.

Effect on Growth parameters

There was significance difference among the treatments for plant height, number of tillers $hill^{-1}$, number of effective tillers $hill^{-1}$ and root growth of rice crop.

Data pertaining to growth parameters of paddy, presented in Table 2, revealed that application of humic acid @ 1.5 kg $acre^{-1}$ in soil at 7-10 days after transplanting and foliar application of 125 g $acre^{-1}$, 28-30 DAT along with recommended dose of fertilizer (T_7) recorded maximum plant height (94.1 cm) at harvest; however, it remained at par with application of humic acid @ 1.0 kg $acre^{-1}$ in soil at 7-10 days after transplanting and foliar application of 125 g $acre^{-1}$ 28-30 DAT along with recommended dose of fertilizer (T_6) and both treatment proved significantly superior over rest of the treatments. Similar trend was recorded with total number of tillers (12.6) and number of effective tillers $hill^{-1}$ (12.0) at harvest. Increase in average number of tillers and effective tillers were as high as 57.5 and 64.3 per cent, respectively, when compared with 100 per cent RDF.

Application of humic acid @ 1.5 kg $acre^{-1}$ in soil at 7-10 days after transplanting and foliar application of 125 g $acre^{-1}$ 28-30 DAT along with recommended dose of fertilizer (T_7) recorded longest root length (14.5 cm) at harvest followed by application of humic acid @ 1.0 kg $acre^{-1}$ (T_6), 750 g $acre^{-1}$ (T_5) and 500 g $acre^{-1}$ (T_4) in soil at 7-10 days after transplanting and foliar application of 125 g $acre^{-1}$ 28-30 DAT along with recommended dose of fertilizer. The test weight was not influenced significantly by any of the treatments. Jayanta *et al*. (2017) reported that, application of bio-stimulant improved the yield attributing characters in rice crop.

Effect on grain yield

The grain yield of paddy showed significant difference among the various treatments compared to RDF. Application of humic acid (Pottasium humate) @ 1.5 kg $acre^{-1}$ in soil at 7-10 days after transplanting and foliar application of 125 g $acre^{-1}$, 28-30 DAT along with recommended dose of fertilizer (T_7) recorded significantly highest grain yield of 35.8 q ha^{-1}. However it was at par with application of humic acid @ 750 g $acre^{-1}$ (T_5) or 1.0 kg $acre^{-1}$ in soil at 7-10 days after transplanting and foliar application of 125 g $acre^{-1}$ 28-30 DAT along with recommended dose of fertilizer (T_6) and these three treatments proved significantly superior over RDF (T_2).

Significant impact of these humic substances on soil structure and plant growth was reported earlier by Ihsanullah and Bakhashawin (2013); El-Razek *et al.* (2012) and Fong *et al.* (2007). Humic acid in proper concentration can enhance plant and root growth (Ahmed *et al.,* 2013).

Table 2. Effect of Humic acid (Pottasium humate) on growth and yield of paddy

SN	Treatments	Plant height (cm)	Root growth (cm)	No. of tillers hill at harvest	No. of effective tillers hill^{-1} at harvest	Test wt. (g)	Grain yield (q ha^{-1})
T_1	No input	70.1	11.0	6.0	5.0	25.8	20.6
T_2	RDF 100%	79.0	11.0	8.0	7.3	26.2	28.4
T_3	T_2 + 250 g per acre in soil @ 7-10 DAT + 125 g per acre foliar 28-30 DAT	80.0	12.0	8.0	8.0	26.0	29.6
T_4	T_2 + 500 g per acre in soil @ 7-10 DAT + 125 g per acre foliar 28-30 DAT	82.7	12.4	9.7	8.1	26.4	33.1
T_5	T_2 + 750 g per acre in soil @ 7-10 DAT+ 125 g per acre foliar 28-30 DAT	84.0	13.7	10.6	8.9	26.8	34.8
T_6	T_2 + 1.0 kg per acre (in soil @ 7-10 DAT) + 125 g per acre foliar 28-30 DAT	90.2	14.0	12.3	11.0	27.2	35.5
T_7	T_2 + 1.5 kg per acre (in soil @ 7-10 DAT) + 125 g per acre foliar 28-30 DAT	94.1	14.5	12.6	12.0	27.5	35.8
	SE (m)±	3.0	0.7	0.6	0.5	0.5	1.8
	CD (0.05)	9.3	2.1	1.8	1.6	-	5.6

DAT : Days after transplanting

Humic substances (humic, fulvic acid) attracts positive ions, forms chelates with micronutrients and releases them slowly when required by plants.

CONCLUSIONS

Application of humic acid @ 750 g acre^{-1} (1.87 kg ha^{-1}) in soil at 7-10 days after transplanting and foliar application of 125 g acre^{-1} (312.5 g ha^{-1}) at 28-30 DAT along with recommended dose of fertilizer (100: 50: 50 kg NPK ha^{-1}) shown significant effect on root growth as well as yield contributing characters of transplanted paddy and was at par with application of humic acid @ 1.0 kg acre^{-1} (2.5 kg ha^{-1}) and 1.5 kg acre^{-1} (3.75 kg ha^{-1}) in soil at 7-10 days after transplanting and foliar application of 125 g acre^{-1} (312.5 g ha^{-1}) at 28-30 DAT along with recommended dose of fertilizer (100: 50: 50 kg NPK ha^{-1}).

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Effect of Organic Input on Yield and Economics of Minor Oilseed Crops

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ABSTRACT

The field experiment "Effect of organic input on yield and economics of minor oilseed crops "was carried out during 2023-24, at Agro-Ecology & Environment Centre Dr.Panjabrao Deshmukh Krishi Vidyapeeth, Akola, (M.S.), with the objectives to study the effect of organic inputs on growth, yield, and economics of minor oilseed crops. The experiment was laid out in Factorial Randomized Block Design with fifteen treatment combinations and three replications. Factor A comprises three levels of crops i.e. C1- Mesta, C2- Niger, and C3- Sesame and Factor B five levels of nitrogen management i.e. N1- 100% Nitrogen through Vermicomost, N2- 100% Nitrogen through Compost, N3- 75% Nitrogen through Vermicompost + Jivamrut, N4- 75% Nitrogen through Compost + Jivamrut, and N5- Absolute Control. The yield and yield attributes of Mesta, Niger and Sesame were recorded maximum intreatment, N 1 - 100% Nitrogen through Vermicompost followed by N 3 - 75 % Nitrogen throughVermicompost + Jivamrut. However, lowest values were recorded in N 5 - Control treatment.Mesta crop recorded significantly higher Sesame equivalent yield (kg ha -1), Gross monetary returns (Rs ha -1) over Niger and Sesame crop. The application of 100% nitrogen through Vermi-compost recorded higher values for all the yield contributing characters in Mesta, Niger andSesame crops. Among the three crops, Mesta crop observed economically beneficial when fertilized with 75% nitrogen through Vermicompost + Jivamrut with highest B:C ratio (3.26).

Oilseeds play a significant role in Indian agricultural economy next to cereals. India is one of the major growers and importers of edible oils. In India, nine annual oilseed crops (rapeseed and mustard, soybean, groundnut, sesame, sunflower, safflower and niger for edible oils; castor and linseed for industrial purposes) are grown in an area of about 26 million ha with an annual production of about 31 million tonnes of seeds. Of these, major portion of oilseed production [27.8 million tonnes (90.9%) from 22.3 million ha (86.7%)] is contributed by rapeseed & mustard, soybean and groundnut whereas the remaining 2.8 million tonnes is contributed by the minor oilseeds: sunflower, sesame, niger, safflower, castor and linseed from the area of 3.4 lakh ha (Anonymous, 2019-20). The minor oilseed crops viz. roselle, niger and sesame has its own importance as edible oil, nutritive, medicinal and industrial value, and potential to grow under organic inputs for sustainability.

Roselle (*Hibiscus sabdariffa* L.) locally called Mesta belongs to the Malvaceae family, recognized as tropical and sub-tropical shrub, found in India, Indonesia and Malaysia (Dhar *et al*., 2015). Roselle appears bright in colour and rich in nutrients such as anthocyanins, organic acids, pectin, phenolic compounds and vitamins that are important in reducing chronic diseases (Wu *et al*., 2018) as well as antispasmodic, hypertensive, antimicrobial and uterine muscle relaxation (Khalid *et al*., 2012). Roselle also could be consumed as juice, jam, beverages and foods (Rozan *et al*., 2017). Furthermore, it is cultivated for its stem as the source of pulp in paper industry (Aliyu & Tanmu, 1996). In addition to these crops have huge export potential.

Organic manures play a major role in supplying macro and micronutrients, besides improving the water retention in soil. Organic manures like farmyard manure, poultry manure, neem cake and Vermicompost helps to maintain the soil fertility, reduce the environmental pollution increases the yield and improves the quality of agricultural crops (Patidar and Mali 2004). Organic inputs are used to maintain the soil health and creating convenient environment for sustainable crop production. It improves soil physical, chemical and biological environment of soil for favorable crop growth and yield. Keeping in view the above facts, the present investigation was carried out at the Experimental Farm of Agro Ecology and Environment Centre, Dr. PDKV Akola with the objectives to study the effect of organic inputs on growth, yield, and economics of minor oilseed crops.

1. Post Graduate Student, 2 & 3. Associate Professor, 4. Chief Scientist, 5. Professor and 6. SRA, Department of Agronomy, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola

MATERIAL AND METHODS

The experiment was laid out in Factorial Randomized Block Design (FRBD) with fifteen treatments and three replications. Factor A comprises three levels of crops i.e. C_1- Mesta, C_2- Niger and C_3- Sesame and Factor B comprises five levels of nitrogen management i.e. N_1- 100% Nitrogen through Vermicomost, N_2- 100% Nitrogen through Compost, N_3- 75% Nitrogen through Vermicompost + Jivamrut, N_4- 75% Nitrogen through Compost + Jivamrut, N_5- Control. The varieties adopted were Local (Mesta), GNNIG-3 (Niger) and AKT-64 (Sesame). The other cultural practices were kept common, as recommended.

The soil of experimental plot was characterized as silty clay loam in texture and slightly alkaline in reaction (pH 7.9),low in available nitrogen, medium in available phosphorus, high in available potash and low in organic carbon content.

RESULTS AND DISCUSSION

Sesame Equivalent yield (kg ha^{-1})

Among the crops tested, Mesta recorded significantly highest Sesame equivalent yield 1638 kg ha^{-1} over Niger 1016 kg ha^{-1} and Sesame 627 kg ha^{-1}. It was due to higher calyx yield obtained in a Mesta crop. However, significantly lowest sesame equivalent yield was observed by sesame crop 627 kg ha^{-1}. As regard the nitrogen management, treatment 100% RDN through vermicompost recorded significantly highest sesame equivalent yield (kg ha^{-1}) over treatment 100% RDN through compost, 75% RDN through Compost + Jivamrut 10% and control. However it was at par with 75% RDN through Vermicompost + Jivamrut 10%. Significantly lowest sesame equivalent yield was recorded in control treatment. The interaction effect was found significant. The treatment combination (C_1xN_1) i.e. Mesta with 100% N through Vermicompost recorded higher sesame

Table 1: Sesame equivalent yield (kg ha^{-1}) ,GMR, COC, NMR (Rs ha^{-1}) and B:C Ratio as influenced by different nitrogen management treatments

Treatment	SYE (kg ha^{-1})	GMR (Rs ha^{-1})	COC (Rs ha^{-1})	NMR (Rs ha^{-1})	B:C Ratio
Crops					
C_1 (Mesta)	1638	196589	47215	149374	4.16
C_2 (Niger) 1016	121974	34564	87410	3.51	
C_3 (Sesame)	627	75274	43015	32259	1.75
S.E.m±	19.36	2322		2322	
CD at 5%	56.07	6728		6728	
N Management					
N_1 (100% RDN through Vermicompost)	1248	149768	47771	101996	3.14
N_2 (100% RDN through Compost)	1003	120439	38839	81600	3.08
N_3 (75% RDN through Vermicompost + Jivamrut 10%)	1179	141428	43239	98188	3.26
N_4 (75% RDN through Compost + Jivamrut 10%)	946	113482	36541	76940	3.07
N_5 (Control)	596	71558	26446	45111	2.66
S.E.m±	24.99	2998		2998	
CD at 5%	72.39	8686		8686	
Interaction (C x N)					
S.E.m±	43.28	5193		5193	
CD at 5%	125.38	15046		15046	

Table 1a. Sesame equivalent yield (kg ha^{-1}) as influenced by the crops x nitrogen management interactions

	N Management				
Crops	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**
C_1 (Mesta)	1879	1519	1757	1398	830
C_2 (Niger)	1153	922	1104	887	605
C_3(Sesame)	712	570	675	552	355
S.E.m±	43.28		CD at 5%	125.38	

Table1b. GMR (Rs ha^{-1}) as influenced by the crops x nitrogen management interactions

	N Management				
Crops	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**
C_1 (Mesta)	281798	227908	263557	209683	124441
C_2 (Niger)	172977	138300	165553	133041	90680
C_3(Sesame)	106854	85439	101245	82832	53221
S.E.m±	6492		CD at 5%	18807	

Table 1c. NMR (Rs ha^{-1}) as influenced by the crops x nitrogen management interactions

	N Management				
Crops	**N_1**	**N_2**	**N_3**	**N_4**	**N_5**
C_1 (Mesta)	227095	183923	214452	168616	95328
C_2 (Niger)	134869	105551	129844	101351	65367
C_3(Sesame)	56351	45654	56340	45965	28038
S.E.m±	6492		CD at 5%	18807	

equivalent yield over rest of the treatment combinations but it was at par with (C_1xN_3) i.e. Mesta with 75% nitrogen through Vermicompost and Jivamrut. Significantly lowest sesame equivalent yield was recorded in (C_3xN_5) combination. Similar findings were recorded by Takar *et al*. (2017), Babu Lal *et al*. (2017), Sudhakar *et al*. (2020), Choudhari *et al*. (2023).

Economics

The data pertaining to gross monetary returns (Rs ha^{-1}), cost of cultivation, net monetary returns (Rs ha^{-1}) and B:C ratio as influenced by different nitrogen management treatments are presented in the Table 1.

Mean cost of cultivation (Rs ha^{-1}) of Mesta, Niger and Sesame crop as influenced by different treatment was found to be 47215 (Rs ha^{-1}), 34564 (Rs ha^{-1}) and 43015 (Rs ha^{-1}) respectively. Among the different nitrogen management treatments, treatment 100% RDN through Vermicompost recorded highest cost of cultivation followed by 75% RDN through Vermicompost + Jivamrut 10%. The lowest cost of cultivation was recorded in control treatment.

Gross monetary returns (Rs ha^{-1}) was significantly influenced by different crops. Higher gross monetary returns was obtained with Mesta (196589 Rs ha^{-1}) which was significantly superior over Niger (121974 Rs ha^{-1}) and Sesame (75274 Rs ha^{-1}). It was due to higher calyx yield of Mesta. Gross monetary returns were significantly influenced by different nitrogen management levels. 100% nitrogen through Vermicompost recorded significantly the highest gross monetary returns (149768 Rs ha^{-1}) over 100% nitrogen through compost (120439 Rs ha^{-1}) and 75% nitrogen through compost +Jivamrut (113482 Rs ha^{-1}). However it was found at par with.75% nitrogen

through Vermicomost + Jivamrut (141428 Rs ha^{-1}). It was due to higher calyx yield with the application of 100% Vermicompost. The interaction effect between crop and nitrogen management was found significant. The treatment combination (C_1xN_1) i.e. Mesta with 100% N through Vermicompost recorded higher gross monetary return over rest of the treatment combinations however,it was at par with (C_1xN_3) i.e. mesta with 75% nitrogen through Vermicompost and Jivamrut.

Net Monetary return (Rs ha^{-1})

Net monetary return was significantly influenced by different crops. Among the crops higher net monetary returns was obtained with Mesta (149374 Rs ha^{-1}) which was significantly superior over Niger (87410 Rs ha^{-1}) and Sesame (32259 Rs ha^{-1}). It was due to higher calyx yield in Mesta. Net monetary returns were significantly influenced by different nitrogen management i.e. 100% nitrogen through Vermicompost recorded significantly the highest net monetary returns (101996 Rs ha^{-1}) over the 100% nitrogen through compost (81600 Rs ha^{-1}) and 75% nitrogen through compost +Jivamrut (76940 Rs ha^{-1}). However it was found at par with. 75% nitrogen through Vermicomost + Jivamrut (98188 Rs ha^{-1}). It was due to higher calyx yield with the application of 100% Vermicompost. The treatment combination (C_1xN_1) i.e. Mesta with 100% N through Vermicompost recorded higher net monetary return over rest of the treatment combinations but it was found at par with (C_1xN_3) i.e. mesta with 75% nitrogen through Vermicompost and Jivamrut.

B:C Ratio

Among the different nitrogen management treatments, treatment 75% RDN through Vermicompost + Jivamrut 10% recorded highest B:C ratio i.e 3.26 followed by 100% RDN through Vermicompost (3.14) and 75% RDN through Compost + Jivamrut 10% (3.07). The lowest B:C ratio was recorded in Control treatment (2.66).

CONCLUSIONS

The results revels that, Mesta crop recorded significantly higher Sesame equivalent yield (kg ha $^{-1}$), Gross monetary returns (Rs ha $^{-1}$) Net monetary return (Rs ha^{-1}) and B:C ratio over Niger and Sesame crop. Among the three crops Mesta crop was found economically beneficial when fertilized with 75% nitrogen through Vermicompost + Jivamrut.

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Effect of Incorporation of Pomegranate Juice on Physico-Chemical Properties of Shrikhand

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ABSTRACT

The present investigation entitled "Effect of incorporation of pomegranate juice on physico-chemical properties of Shrikhand was conducted at Department of Animal Husbandry and Dairy Science, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. An effort was made to standardize the optimum level of pomegranate juice in the preparation of shrikhand, with main objects to evaluate the product by sensory evaluation, determination of physico-chemical composition and to calculate cost of production. Some of the findings emerged from the present investigation are summarized as follows. In view of above objectives present study was carried out with five treatments including control T_1 and shrikhand prepared from buffalo milk chakka with different levels of pomegranate juice i.e. 3 per cent, 6 per cent, 9 per cent, and 12 per cent in treatment T_2, T_3, T_4 and T_5, respectively. In respect to physico-chemical composition of pomegranate juice added in shrikhand, it was observed that, the fat, protein, pH and titratable acidity content were slightly decreased with addition of different levels of beetroot juice. The moisture of shrikhand was significantly increased. The total solids and ash content of shrikhand was decreased with increase the level of pomegranate juice. From the present study it is concluded that, acceptable quality shrikhand can be prepared by adding 6 per cent of pomegranate juice.

The word 'Shrikhand' derives its name from the Sanskrit word "Shrikharini" meaning a curd preparation with added sugar, flavouring agent, fruits and nuts. Shrikhand is a delicious and delightful dessert of western India. It is made with chakka which is finely mix with sugar and flavouring agent. It has a nutritive goodness of fermented milk product like dahi, it is very refreshing particularly during summer month (Nigam *et al.,* 2009). Shrikhand can be prepared by using cow milk, buffalo milk or skim milk. The milk is pasteurized followed by cooling to room temperature. In such a way starter culture is added @ 1.5 per cent of milk and inoculated at 22 to 24^0 C for 14 to 16 hr to get dahi. The obtain dahi will be hang in muslin cloth to drain the whey and to get chakka. Sugar is then added at the rate of 40 to 60 per cent wt of chakka and kneaded in suitable equipment to get shrikhand. If skim milk is used, cream (40 % fat) is normally added at the later stage of production. This product contain 60 per cent total solid, 5 per cent fat, 42 per cent sugar and about 7 per cent protein (Aneja *et al.,*2002).

Pomegranate is a favorite fruit crop of tropical and subtropical region of the world. Pomegranate enjoy due to its health, dietetic and medicinal properties. It has a better keeping quality, better market price and good export potential. Edible portion of the pomegranate fruit is 52 per cent of the total fruit weight which contain 78 per cent juice and 22 per cent seed. Fresh juice contain 84 per cent moisture, 10.6 per cent total sugar,1.4 percent pectin, 0.19 per cent 100^{-1} ml acidity, 0.7 mg 100^{-1} ml ascorbic acid, 19.6 mg 100^{-1} ml free amino nitrogen and 0.05 g 100^{-1} ml ash. The hypothesis for present investigation is that fulfils the daily nutritional needs of Pomegranate and buffaloo milk would be the suitable combination.

MATERIAL AND METHODS

Whole, fresh, clean buffalo milk was collected from livestock instructional farm, Department of Animal Husbandry and Dairy Science (Dairy Science), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. Fresh pomegranate was purchased from local market of Akola and pomegranate juice was prepared in laboratory. Clean crystalline sugar purchased from local market and used as an ingredient of shrikhand as sweetening and thickening agent.

For preparation of shrikhand by using buffalo milk and Pomegranate Juice. The buffalo milk was heated at 80–85 ^{0}C for 15 minute and cool down to room temperature (37 ^{0}C). After cooling standard dahi culture

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was added in the milk and incubated at 37^{0}C for 8 hours. The curd was obtained after incubation was tied in muslin cloth. Then it was hanged in double folded muslin cloths to drain out of whey for 6-8 hours. The chakka was used as base material for preparation of shrikhand. Then Sugar was added by weight of chakka. Then prepared Shrikhand was divided into five different parts. In each parts of Shrikhand Pomegranate Juice were added as per the given Treatment i.e. T_1- control, T_2- 3 per cent, T_3- 6 per cent,T_4- 9 per cent, T_5-12 per cent. The proportion of sugar was reduced as the proportion of Pomegranate Juice increased. Finally proper mixing was done and packed shrikhand was kept at refrigerator condition for further study. The data were analyzed statistically by using Completely Randomized Design (CRD).

The product was subjected to chemical analysis of the fat by Gerber's method, (IS: 1224, Part I, 1977), total solids (IS: 1479 Part-II 1961), acidity (IS-1166, Part I, 1973), protein by macro-kjeldahl method, (IS: 1479, part II, 1961), ash (IS: 1167, 1967), pH (by digital pH meter) and moisture was determined by subtracting the total solid content from 100 in the sample. The treatment combinations are given below.

T - 100% Shrikhand
T_2 - 97% Shrikhand : 3% Pomegranate juice
T_3 - 94% Shrikhand : 6% Pomegranate juice
T_4 - 91% Shrikhand : 9% Pomegranate juice
T_5 - 88% Shrikhand : 12% Pomegranate juice
(Sugar was added at 80% by weight of chakka)

RESULTS AND DISCUSSION

The value added shrikhand was subjected for the proximate analysis viz., fat, protein, ash, acidity, pH, moisture, total solids. The results obtained on account of this parameter are presented in Table 1.

Fat (%)

It was observed that, the fat content in formulated product shrikhand ranged between 8.11 to 7.23 per cent. The largest fat content was listed for T_1 (control) 8.11 per cent and lowest fat percentage was in T_5 7.23 (12 % juice). The present observation clearly shows that, by addition of pomegranate juice in shrikhand decreased the level of fat in the product.

Protein (%)

The average mean of protein content in pomegranate juice added shrikhand were 10.94, 10.65, 10.36, 10.09, 9.80 per cent for treatments T_1, T_2, T_3, T_4 and T_5 respectively. The lowest protein score observed in T_5 (12 % juice) and highest protein content found in T_1 (control). From the present investigation revealed that, pomegranate juice suppresses the level of protein in shrikhand.

Ash (%)

The mean ash content in shrikhand under treatments T_1, T_2, T_3, T_4 and T_5 were 0.887, 0.886, 0.835, 0.834 and 0.800 per cent, respectively. The ash content was higher in T1, (0.887 %) and lowest ash content was

Table 1 Overall average physico-chemical attributes of shrikhand blended withpomegranate juice.

Treatments	Fat (%)	Protein (%)	Ash (%)	Acidity (%)	pH	Moisture(%)	Total solids (%)
T_1	8.11	10.94	0.887	1.26	3.649	41.20	58.80
T_2	7.86	10.65	0.886	1.22	3.388	42.56	57.44
T_3	7.64	10.36	0.835	1.20	3.387	43.94	56.05
T_4	7.42	10.09	0.834	1.16	3.386	45.33	54.66
T_5	7.23	9.80	0.800	1.13	3.386	46.72	53.28
S.E.(m) ±	0.010	0.010	0.010	0.010	0.070	0.010	0.010
C. D. at 5%	0.211	0.235	0.214	0.230	0.192	0.023	0.027

observed in T_5 (0.800 %) as shrikhand prepared from addition of 3.0 per cent pomegranate juice. These differences might be due to less ash content of pomegranate juice.

Titratable acidity (%)

The average titratable acidity content of shrikhand were 1.26, 1.22, 1.20, 1.16, and 1.13 per cent in treatments T_1, T_2, T_3, T_4, and T_5 respectively. The titratable acidity content was higher in treatment T_1 i.e. 1.26 per cent, shrikhand prepared from buffalo milk with addition of 0 per cent pomegranate juice. Lowest titratable acidity content in shrikhand was observed in treatment T_5 (1.13) i.e. shrikhand prepared from buffalo milk with 12 per cent pomegranate juice.

pH

The scores for pH content were 3.649, 3.388, 3.387, 3.386, 3.386 for treatments T_1, T_2, T_3, T_4 and T_5, respectively. The highest pH observed in control T_1 (3.649) and lowest pH T_5 (3.386) this was due to increase in the acidity of shrikhand as compared to decrease in the pH content due to addition of pomegranate juice.

Moisture (%)

The mean moisture content in shrikhand under treatments T_1, T_2, T_3, T_4 and T_5 were as, 41.20, 42.56, 43.94, 45.33, 46.72 per cent, respectively. The moisture content was higher in T_5 (42.72) per cent i.e. shrikhand prepared from buffalo milk with 12 per cent pomegranate juice. Lowest moisture content in shrikhand was observed in T_1 (41.20) per cent. It was also found that the addition of pomegranate juice had significant effect on moisture content of shrikhand. It was observed that increases the level of pomegranate juice increased the moisture content in shrikhand.

Total solids (%)

The mean average values for total solids were 58.80, 57.44, 56.05, 54.66, and 53.28 per cent for treatments T_1, T_2, T_3, T_4 and T_5, respectively. The highest total solids content in T_1 (58.80 %) and lowest observed in T_5 (53.28 %). In all over result it revealed that, total solids reduced significantly. The present observation found that increased the percentage moisture declined the percentage of total solids by the addition of pomegranate in shrikhand.

CONCLUSION

It is concluded from the present study that in respect to physico-chemical composition of shrikhand i.e. fat, protein, total solids, titratable acidity, ash, moisture and pH were decreased with increases in the levels of pomegranate juice, while moisture were increased with increases in the levels of pomegranate juice in shrikhand preparation.

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Utilization of Wood Apple Pulp for Preparation of Kalakand from Cow Milk

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ABSTRACT

The present investigation was carried out in the Department of Animal Husbandry and Dairy Science, Dr. PDKV, Akola (M.S). The objectives of the present investigations were to study the overall acceptability, physico-chemical properties and self-life of wood apple kalakand. Kalakand was prepared in the proportions of cow milk chhana and wood apple pulp as 100:00 (T_1) 90:10 (T_2), 85:15 (T_3), 80:20 (T_4) and 75:25 (T_5), respectively. The data obtained was statistically analyzed by CRD. Overall acceptability were observed that the treatment T_1, T_2, T_3, T_4 and T_5 were 7.60, 7.80, 8.60, 7.60 and 7.40, respectively. The chemical qualities of kalakand i.e. fat, protein, total sugar, ash, total solids and SNF were decreased with increases the level of wood apple pulp, while moisture and titratable acidity increases with increased the level of wood apple pulp for kalakand preparation. The physico-chemical properties of accepttable kalakand prepared from 85 parts of cow milk chhana and 15 parts of wood apple pulp with 30 percent sugar as moisture,fat, protein, total sugar, ash, TS, SNF and acidity were 30.23, 18.42, 14.92, 34.04, 2.39, 69.77 51.35 and 0.84 per cent, respectively. According to FSSAI (2015) the total SPC and yeast and mould count should not more than 150000 g^{-1} and 50 g^{-1}, respectively. Therefore, the acceptability of kalakand having 15 per cent wood apple pulp from the day of preparation was 5 to 6 and 15 to 20 days at room and refrigerated storage condition, respectively. The coliform count for optimized product was analyzed and it was found Nil.

Dairying in India is diversified and agriculture based and a stepping stone towards socio-economic progress. The interdependence of Dairy & Food Industries is known since ancient times. This is due to the fact that no single food provides all the nutrients in the right quantity for good health. It has been an established fact that the use of improper food perhaps the root cause of every disease. Still, despite good nutritional and medicinal significance, some fruit based milk delicacies remain confined to the domestic kitchen segment. There is an ever increasing variety of milk products being introduced in the market with an increased palatability and fascinating forms. Milk has a high nutritive value hence it is an ideal food. It supplies body building protein, bone forming minerals, health giving vitamins and furnishes energy providing lactose and milk fat. All this properties make milk an important food for every age of human being. Today, India is world's largest and fastest growing country for milk and milk products. The value addition and variety in the availability in milk product are on everybody's agenda .There is an increasing demand for new products and processes. India is crossed 239 million tonnes, out of which 44 per cent is consumed as liquid milk and about 50-56 per cent of the total milk produced in India is converted into traditional milk products (BASH, 2024).

Wood apple has promising therapeutic value because of the presence of various phyto constituents such as tannins, alkaloids, steroids, flavonoids, terpenoids, fatty acids and vitamins. Wood apple include relief from constipation, indigestion, peptic ulcer, piles, respiratory problems, diarrhoea, and dysentery. It also boosts the immune system, fights off bacterial and viral infections, reduces inflammation and various inflammatory conditions, prevent cancer, increases milk production for nursing mothers, cures diabetes, increases ocular health, and helps prevent various sexual dysfunctions. In general there is a considerable scope for standardizing the process of kalakand preparation incorporated with wood apple pulp in order to improve its quality and also to enhance consumer preference. Wood apple is the most popular choice of fruits of the tropics because of its palatability, excellent taste, pleasant aroma and nutritive value (Prafull Kumar & Shiv B. Singh, 2017). The nutritional value of wood apple pulp as moisture, protein, fat, carbohydrate, ash, calcium, phosphorus, iron and tannins are 74.0, 8.0, 1.45, 7.45, 5.0, 0.17, 0.08, 0.07 and 1.03 per cent, respectively (C. Sivakkolindu and Loganthan, 2016).

In the present study, the effort was made to combine nutritional value, over all acceptability of kalakand prepared from cow milk chhana and wood apple pulp.

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MATERIAL AND METHODS

The present investigation was carried out in the Department of Animal Husbandry and Dairy Science, Dr. PDKV, Akola (M.S). The objectives of the present investigations were to study the overall acceptability, physico-chemical properties and self-life of wood apple kalakand. Treatments were planned for kalakand preparation in the proportions of cow milk chhana and wood apple pulp as 100:00 (T_1) 90:10 (T_2), 85:15 (T_3), 80:20 (T_4) and 75:25 (T_5), respectively. Fresh, clean cow milk and fresh ripened wood apple was received from Instructional Dairy Farm and Department of Horticulture, Dr. PDKV, Akola for preparation of kalakand. The method was used for preparation of kalakand suggested by Aneja (1977) with slight modification. In all treatments sugar was used @ 30 per cent by wt. of mix. The overall acceptability of kalakand blended with wood apple pulp was measured by sensory evaluation in respect of flavour, body and texture, colour and appearance and overall acceptability of the product by panel of judg with the help of 9 point hedonic scale (Pal and Gupta, 1985). Moisture, fat, protein and ash were determined as per procedure of BIS standards (ISI Handbook of Food Analysis-Dairy Products, 1981), while the refractometric method described by Akinsanya (1998) was used to determine the total sugar. SNF was obtained by subtracting the percent of fat from percent of total solids in kalakand. The data obtained was statistically analyzed by CRD as per the procedure described by Amble (1975). The production cost per kg of kalakand under various treatments was calculated by considering the prevailing market price of various ingredients like, milk, wood apple pulp, sugar, fuel, electricity charges and labour charges etc.

RESULTS AND DISCUSSION

It was observed that, cow milk used for preparation of kalakand was good quality and contained 3.83 per cent fat, 3.41 per cent protein, 4.85 per cent lactose, 0.70 per cent ash, 12.79 per cent total solids. The present results are closed related to the researcher Kadam Snehal (2014) reported that the average chemical composition of cow milk. The chemical values of wood apple pulp used for preparation of kalakand contained water, fat, protein, ash, total solid, acidity and pH was 74.88, 1.30, 7.45, 6.0,

Table 1: Chemical composition of cow milk, chhana and wood apple pulp (per cent)

S.N.	Constituents	Cow milk	Chhana	Wood apple pulp
1	Moisture	86.66	54.30	69.8
2	Fat	3.83	22.70	0.24
3	Protein	3.41	18.25	1.75
4	Ash	0.70	2.15	1.28
5	lactose	4.85	2.60	—
6	Total solids	12.79	45.70	30.2

Table 2: Sensory evaluation of wood apple kalakand (9-point hedonic scale)

Treatment	Flavour	Body and texture	Colour and appearance	Overall acceptability
T_1 (Control)	7.40	7.20	7.60	7.60
T_2 (90:10)	7.40	7.60	7.80	7.80
T_3(85:15)	8.60	8.60	8.40	8.60
T_4(80:20)	7.40	7.40	7.40	7.60
T_5(75:25)	7.20	7.20	7.20	7.40
SE(M)±	0.310	0.224	0.227	0.237
CD at 5%	0.914	0.673	0.680	0.698

(Avg. of five replications)

25.12, 0.14 and 4.23 per cent, respectively. The present findings are in aggrement with Sharma and Deen (2017).

Sensory evaluation of wood apple kalakand

The effect of fifferent levels of wood apple pulp on mean score values of different parameters of overall acceptability of kalakand was tabulated in Table 2.

From the Table 2 indicated that, the variation in the score of flavour. Body and texture, colour and appearance and overall acceptability were observed statistically significant due to effect of wood apple pulp on various treatments of kalakand. The mean score of flavour, Body and texture, colour and appearance and overall acceptability for highly acceptable treatment T_3 were observed 8.60, 8.60, 8.40 and 8.60, respectively. It was observed that mean score of overall acceptability of wood apple pulp blended kalakand for treatment T_1, T_2, T_3, T_4 and T_5 were 7.60, 7.80, 8.60, 7.60 and 7.40, respectively. The treatment T_3 was significantly superior over T_1, T_2, T_4 and T_5 treatments. The treatment T_1, T_2, T_4 and T_5 was observed at par. The significantly highest score for overall acceptability was obtained in kalakand prepared with 15 per cent wood apple pulp, while the lowest score was obtained in kalakand prepared by addition of 25 per cent wood apple pulp. Flavour, body & texture, colour and appearance and overall acceptability of kalakand prepared with 15 part of wood apple pulp and 85 part of cow milk chhana (T_3) was observed sweet and slightly acidic, soft, smooth and grainy, moderate brown and highly acceptable, respectively. The observations of present investigation is in agreement with Shalini *et al.,* (2015), Nagar *et al.* (2017), Manohar *et al.* (2018) reported, the overall acceptability score for kalakand prepared by addition of papaya pulp.

Physico-chemical properties of experimental kalakand

It is observed from table 3 that, the following physico-chemical properties mentioned as below.

Moisture

The average moisture content of kalakand prepared from cow milk chhana and different levels of wood apple pulp was found as 22.67, 27.02, 30.23, 32.98 and 35.87 in treatment T_1, T_2, T_3, T_4 and T_5. The moisture content was significantly higher in T_5 (35.87 %). The lowest moisture content in kalakand was observed in T_1 (22.67 %). Moisture content of kalakand was recorded significantly increased with increases the level of wood apple pulp in kalakand preparation. The present results are in agreement with Thakur *et al.* (2017) and Verma *et al.* (2018).

Fat

Fat content in kalakand blended with wood apple pulp showed decreasing tread with increases level of wood apple pulp. This might be due to less fat content in wood apple pulp. The average mean value of fat content in kalakand were 21.68 (T_1), 19.84 (T_2), 18.42 (T_3),17.32 (T_4) and 16.32 (T_5). The fat content of kalakandwas significantly higher in T_1 (21.68 %) while fat content in kalakand was observed lowest in T_5 (16.32 %). Kumar *et al.* (2017) and Tidake (2020) studied on preparation of wood apple kalakand and reported that, increased the level

Table 3: Effect of wood apple pulp on chemical quality of kalakand (%)

Treatment	Moisture	Fat	Protein	Total sugar	Ash	Total Solids	SNF	Titratable Acidity
T_1 (Control)	22.67	21.68	16.90	36.06	2.69	77.33	55.65	0.59
T_2 (90:10)	27.02	19.84	15.68	34.92	2.54	72.98	53.14	0.76
T_3 (85:15)	30.23	18.42	14.92	34.04	2.39	69.77	51.35	0.84
T_4 (80:20)	32.98	17.32	13.98	33.42	2.30	67.02	49.70	0.95
T_5 (75:25)	35.87	16.32	12.88	32.74	2.19	64.13	47.81	1.14
SE(M)±	0.181	0.111	0.138	0.126	0.022	0.181	0.168	0.029
CD at 5%	0.537	0.329	0.413	0.377	0.065	0.537	0.498	0.086

of wood apple pulp blended with whole milk decreased the fat.

Protein

The average mean values of protein content in kalakand were16.90, 15.68, 14.92, 13.98 and 12.88 per cent in T1, T2, T3,T4 and T5treatment, respectively. The treatment differences were statistically significant at 5 per cent level of significance indicating that there was a significant decrease in protein content of kalakand prepared from cow milkchhana blended with wood apple pulp. The protein content was significantly more in T1 (16.90 %) and lowest in T5 (12.88 %). The above results are nearly closed with the results reported by Shalini *et al.,* (2015) and Tidake (2020).

Total sugar

The average total sugar content of kalakand was 36.06, 34.92, 34.04, 33.42 and 32.74 in treatment T_1, T_2, T_3, T_4 and T_5, respectively. The total sugar content was significantly higher in T_1 (36.06 %) and lowest total sugar content was observed in T_5 (32.74 %). This is might be due to low sugar content of wood apple pulp. Therefore, decreasing trend was observed in kalakand prepared from cow milk chhana and different level of wood apple pulp. Similar observation was made by researchers like Thikare *et al.* (2020) and Tidake (2020)

Ash

The average total ash content of kalakand was 2.69, 2.54, 2.39, 2.30 and 2.19 in treatment T_1, T_2, T_3, T_4 and T_5, respectively. The ash content was significantly higher in T_1 (2.69 %) and lowest was observed in T_5 (2.19 %). The ash content of kalakand was significantly affected with increases the level of wood apple pulp because ash content in wood apple pulp was lower than cow milk chhana.

Total Solids

Total solids content in kalakand blended with wood apple pulp was observed significantly decrease with increases the level of wood apple pulp. This might be due to less total solids content in wood apple pulp than cow milk chhana. The average total solids content of kalakand were 77.33 (T_1), 72.98 (T_2), 69.77 (T_3), 67.02 (T_4) and 64.13 (T_5). The total solids content was higher in T_1 (77.33 %) treatment and lowest in T_5 (64.13 %). The above results are closely related with the results reported by Shalini *et al.* (2015) and Tidake (2020).

Solids Not Fat

Solids not fat content in kalakand blended with wood apple pulp showed decrease in tread with increases level of wood apple pulp. The average solids not fat content of kalakand was 55.65, 53.14, 51.35, 49.70 and 47.81 in T_1, T_2, T_3, $T_4$and T_5 treatments, respectively. The solids not fat content was significantly higher in T_1i.e. 55.65 per cent and lowest in treatment T_5 (47.81 %). Blending of wood apple pulp with cow milk chhana was significantly affected the SNF content in kalakand. The above result is closely related with the result reported Tidake (2020).

Titratable Acidity

Titratable acidity content in kalakand prepared from cow milk chhana and different level of wood apple pulp was significantly increased with increases the level of wood apple pulp. This might be due to more titratable acidity content in wood apple pulp. The average mean values titratable acidity of kalakand were 0.59 (T_1), 0.76 (T_2), 0.84 (T_3), 0.95 (T_4) and 1.14 (T_5). The titratable acidity content in kalakand was significantly affected due to addition of wood apple pulp. The result of the study was agreement with Kumar *et al.* (2017) and Thikare *et al.* (2020).

Self-life of wood apple kalakand

The parameters used under microbial analysis of different treatments of wood apple kalakand under storage period for standard plate count (SPC), yeast & mould count and coliform. The SPC on 20th day of storage at refrigerated temperature was 15.70 to 14.00 (X10^{4}cfu g^{-1}) for treatments T_1 to T_5. The observation of SPC was discontinued on 20th day storage at room as well as refrigerated temperature due to crossing the limit of microbial standards. The SPC was numerically increased with increase days of storage of kalkand. According to FSSAI (2015) the total SPC should not more than 150000 g^{-1}. The YMC on the 20th day of storage at refrigerated condition was 11.25 to 8.40 (cfu g^{-1}) for treatments T_1 to T_5. The yeast and mould count was found decrease in trend by using the wood apple pulp in kalakand preparation. The observation was discontinued due to crossing the limit of SPC. According to FSSAI (2015) the total YMC should not more than

50 g^{-1}. Hence, the acceptability of kalakand having 15 per cent wood apple pulp from the day of preparation was 5 to 6 and 15 to 20 days at room and refrigerated storage condition, respectively. The coliform count for optimized product was analyzed and it was found to be absent. The above results are closely related with the results reported by Shalini *et al.* (2015) and Verma *et al.*(2018).

Cost of Production

The cost of production of different level of wood apple pulp kalakand (kg^{-1}) for treatment T_1, T_2, T_3, T_4 and T_5were Rs. 268, 255, 246, 238 and 231, respectively. Wood apple pulp blended with cow milk chhana proportionally reduced the cost of production. The cost of production of blended kalakand could be lowered further if the same was manufactured on large scale. The level of wood apple pulp increased found decreases the production cost of kalakand. However, the best treatment selected by judges was T_3 treatment (where addition of 15 per cent wood apple pulp for kalakand preparation) and the cost of production of wood apple kalakand was found as Rs. 246 kg^{-1} which was about 9 per cent less than the without wood apple pulp blended kalakand (Rs 268 kg^{-1}). The above result is closely related with the result reported Tidake (2020) and Thikare *et al.* (2020).

CONCLUSION

For going results and discussion leads to concluded that, according to sensory evaluation, kalakand prepared from blending of 15 % wood apple pulp was found superior. The chemical qualities of kalakand i.e. fat, protein, total sugar, ash, total solids and SNF were decreased with increases the level of wood apple pulp, while moisture and titratable acidity increased with increases level of wood apple pulp for kalakand preparation. Keeping quality of kalakand prepared blended with 15 % wood apple pulp was acceptable up to 5 to 6 days at room and 15 to 20 days at refrigerated temperature. The cost of production was reduced with increases the level of wood apple pulp. The cost for acceptable wood apple kalakand (blended with 15% pulp) was calculated as Rs.246 kg^{-1}, which was about 9 per cent less than the plain kalakand (Rs. 268 kg^{-1}).

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Effect of Different Levels Ginger Juice and Turmeric Powder on Sensory Evaluation and Cost of Production of Value Added Kulfi

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ABSTRACT

In the present investigation, the efforts were made to combine nutritional and medicinal value as well as natural flavoring and coloring agent i.e. ginger and turmeric respectively to overcome problem against less preferring the product kulfi especially in rural areas due to throat infection problems like cold. The main objectives studied were to evaluate acceptable level of ginger juice and turmeric powder and to estimate the cost structure. All kulfi samples were prepared with slight modification in the method as prescribed by De and Ray (1982). The research work was carried out with Step-I : Acceptable level of ginger juice was evaluated first (as 0%, 2%, 4%, 6%, 8%, blends) by sensory evaluation in kulfi after acceptable level was fixed it was used as base for further blending of ginger juice. Step-II: Acceptable level of 4% ginger juice blend was used as base to evaluate the level of turmeric (as 0.0%, 0.2%, 0.4%, 0.6 %, 0.8% blends) by sensory evaluation in *Kulfi*.

The data revealed that, score secured for colour and appearance, flavour, body and texture, Melting point and score for overall acceptability was maximum recorded for T_3 treatment i.e. 14.60, 42.00, 32.40, 4.60 and 93.60, respectively, followed by T_1, T_2, T_4 and T_5. It means 4 per cent ginger juice and 0.4 per cent turmeric powder blended Kulfi was highly accepted by panel of judges. Cost of production of Kulfi was not influenced with rate of addition of turmeric and ginger juice further herbal kulfi was also enriched in respect to value addition and acceptability of final product, so we can increase its market price up to Rs. 15 /- kulfi^{-1} and increase the profit ratio.

Kulfi is traditionally prepared by evaporating sweetened and flavoured milk via slow cooking, with almost continuous stirring to keep milk from sticking to the bottom of the vessel where it might burn, until its volume is reduced by a half, thus thickening it, increasing its fat, protein, and lactose density. The semi-condensed mix is then frozen in tightly sealed moulds often kulhars with their mouths sealed that are then submerged in ice mixed with salt to speed up the freezing process. The ice/salt mix, along with its submerged kulfi moulds, is placed in a matka or an earthen pot that provides insulation from the external heat and slows down the melting of ice. Kulfi prepared in this manner is hence called *Matka Kulfi*. Kulfi, thus prepared by fast freezing, also renders a unique smooth mouth feel that is devoid of ice crystals (De and Ray, 1982).

Ginger root contains many note-worthy plant derived chemical compounds that are known to have disease preventing and health promoting properties. Ginger root slices boiled in hot water with added lemon or orange juice and honey is a popular herbal drink in ayurvedic medicine to relieve common cold, cough and sore throat. Turmeric (*Curcuma longa*) has been used in traditional medicine as a household remedy for various diseases, including biliary disorders, anorexia, cough, diabetic wounds, hepatic disorders, rheumatism and sinusitis. Preclinical study showed that combination of both Turmeric and ginger substances gave a better result compared to their individual usage. Spice such as Turmeric is being used to a limited extent as, colouring and flavouring in ice cream by small scale ice cream manufactures. However there is a need to standardize certain parameters involved in manufacture of 'Turmeric ice cream'. The medicinal properties of Turmeric are well documented for instance, in preventing cough and cold (Karkhele, 2003 and Singh *et al.,* 2003).

In the present investigation, the efforts were made to combine nutritional and medicinal value as well as natural flavoring and coloring agent i.e. ginger and turmeric respectively to overcome problem against less preferring the product kulfi especially in rural areas due to throat infection problems like cold with main objective to find out the sensory quality and cost of production if herbal kulfi..

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MATERIAL AND METHODS

All *Kulfi* samples were prepared with slight modification in the method as prescribed by De and Ray (1982). The research work was carried out with Step- I : Acceptable level of ginger juice was evaluated first (as 0%, 2%, 4%, 6%, 8%, blends) by sensory evaluation in kulfi after acceptable level was fixed it was used as base for further blending of ginger juice. Step-II : Acceptable level of 4% ginger juice blend was used as base to evaluate the level of turmeric (as 0.0%, 0.2%, 0.4%,0.6 %, 0.8% blends) by sensory evaluation in kulfi. Sensory evaluation was made by using 9 point hedonic scale as described by Nelson and Trout (1964). The cost of manufacturing of herbal kulfi was worked out by considering the prevailing market prices of ingredients and cost of processing of the product. The observations recorded were analyzed as per the randomized block design using analysis of variance (Amble, 1975).

RESULTS AND DISCUSSION

Phase I: During first phase of experiment sensory evaluation was done to find out the acceptable level of ginger juice (0%, 2%, 4%, 6%, 8% blends) and the data obtained for overall acceptability of kulfi was tabulated and presented in Table 1.

From Table 1, it was observed that the overall acceptability score of Kulfi was significantly affected by blending of different levels of ginger juice. The average score worked out from the score given by judges for different characters like colour and appearance, body and texture, flavor and taste of final product. Kulfi obtained from T_3 treatment secured maximum score of 8.59 fallowed by T_4 (8.24) T_1 (8.15), T_2 (8.12) and T_5 (7.93). It means 4% ginger juice blending level was highly accepted by panel of judges, hence same level was used as base and then after different levels of turmeric powder were evaluated as per treatments for further studies.

Sensory evaluation of Kulfi blended with Ginger juice and Turmeric powder

The data obtained in respect to sensory evaluation of Kulfi blended with 4% ginger juice and different levels of turmeric powder was done from trained judges by using score card as given by Pal and Gupta (1985) and the data obtained was tabulated and presented in Table 2.

From Table 2, it was observed that different levels of turmeric powder blended with 4% ginger juice significantly affect the sensory evaluation of kulfi. Score secured for colour and appearance, flavour, body and texture, Melting point and score for overall acceptability was maximum recorded for T_3 treatment i.e. 14.60, 42.00, 32.40, 4.60 and 93.60, respectively, followed by T_1, T_2, T_4 and T_5. It means 4 per cent ginger juice and 0.4 per cent turmeric powder blended Kulfi was highly accepted by panel of judges. These results were also supported by the results of other research workers as, Pinto *et al.,* (2006) observed that Ice cream with 4 per cent ginger juice level was Superior over all other treatment for body and texture. Manoharan and Ramasamy (2013) reported that increased level of inclusion of (herbal) Aloevera ice cream with

Table 1: Effect of various levels of ginger juice on sensory evaluation of Kulfi (Score as per 9 point hedonic scale)

Treatments	Replications				Mean
	I	II	III	IV	
T_1	8.17	8.15	8.16	8.13	8.15
T_2	8.13	8.12	8.10	8.12	8.12
T_3	8.56	8.64	8.58	8.56	8.59
T_4	8.22	8.19	8.28	8.26	8.24
T_5	7.94	7.90	7.92	7.94	7.93
SE(M) ±		0.01			
CD at 5%		0.07			

Table 2. Sensory evaluation of harbal Kulfi blended with 4% Ginger juice and different levels of Turmeric powder.

(Pooled Mean)

Treatments	Colour & appearance (Max.Score15)	Flavour (Max.Score 45)	Body and texture (Max. Score35)	Melting point (Max. Score 05)	Overall acceptability (Max. Score 100)
T_1	13.40	36.80	28.80	3.80	82.80
T_2	13.20	39.00	29.60	4.20	86.00
T_3	14.60	42.00	32.40	4.60	93.60
T_4	14.00	34.20	28.60	3.80	80.60
T_5	12.40	28.40	23.80	3.40	68.00
SE(m)	0.248	0.311	0.279	0.230	0.579
CD at 5%	0.699	0.875	0.784	0.647	1.626

natural colour beetroot for strawberry flavour in different artificial sweeteners reduced the standard plate count. David (2014) has reported that ginger juice improve the taste of ice cream and also observed that decreases standard plate count was significantly due to increase in rate of addition of ginger juice. Ghodekar *et al.,* (2016) also highlighted that herbal softy icer cream prepared eith ginger juice and turmeric poder improve sensory quality. Solanki *et al.* (2022) also reported that score for sensory attributes of herbal kulfi improved with use of herbles like Tulsi, Ginger and Clove.

Effect on cost of production of Kulfi

Considering the prevailing cost of inputs and cost of production of experimental trials as per treatment cost structure on the basis of commercial production for each treatment for Kulfi preparation was calculated and presented in Table 3.

It is observed from Table 3, that cost of production of Kulfi was not influenced with rate of addition of turmeric and ginger juice further kulfi was also inriched in respect to value addition and acceptability of

Table 3 : Cost of herbal kulfi production

Ingredients	Rate kg^{-1} or lit.(Rs.)	Treatments Quantity gm or ml $Cost^{-1}$ (Rs.)				
		T_1	T_2	T_3	T_4	T_5
Cow milk (ml)	50.00	2000(100/-)	2000(100/-)	2000(100/-)	2000/(100/-)	2000/(100/-)
Sugar (g)	40.00	150g6.00/-	150g6.00/-	150g6.00/-	150g6.00/-	150g6.00/-
Ginger juice (g)	120.00	-	40ml4.80/-	40ml4.80/-	40ml4.80/-	40ml4.80/-
Turmeric powder	200.00	—	2g0.40/-	4g0.80/-	6g1.20/-	8g1.60/-
Miscellaneous gas, electric, etc cost (Rs.)	-	30.00	30.00	30.00	30.00	30.00
Labour charges (Rs.)	280 .00 Rs/day.	35.00	35.00	35.00	35.00	35.00
Total production cost per liter	—	171.00	176.20	176.6	177.00	177.40
No. of. kulfi (50g each)		23	24	24	24	24
Cost per kulfi		7.43	7.34	7.36	7.38	7.39
Market cost/kulfi		10.00	10.00	10.00	10.00	10.00
Input Output Ratio		1:1.35	1:1.36	1:1.36	1:1.36	1:1.35

final product, so we can also increase its market price upto Rs. 15 /- kulfi^{-1} and increase the profit ratio. David (2014), Ghodekar *et al.,* (2016), Solanki *et al.,* (2022) also reported that the cost of production of respectively for Ice cream, softy ice cream and kulfi was compairable with control but it gives more return due to more demand the high market rate of herbal products, which supports the present findings.

CONCLUSION

On the basis of results recorded in the present investigation it is concluded that, Highest acceptable quality recorded for herbal kulfi prepared from 4 per cent ginger juice and 0.4 per cent turmeric powder (T_3). The cost of herbal kulfi was slightly increased with increase in the rate of addition of turmeric and ginger juice.

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Effect of Different Treatment Modules for Disease Management of Soyabean

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ABSTRACT

The present investigation carried out in *Kharif* season for the year 2023-2024 on field of Oilseed Research Unit, Dr. PDKV Akola M.S. As soybean crop affected by various number of pest and diseases. Amongst diseases major diseases are Alternaria leaf spot and Pod blight were taken in consideration for this research experiment. Module basis which comprises application of insecticides and fungicides in tank mix condition. Seed treatment of Azoxystrobin 2.5 per cent + Thiophanate Methyl 11.25 per cent + Thiomethoxam 25 per cent FS (ready mix) @ 10 ml kg^{-1} of seed given at time of sowing to all research plot accept control plot. And two fungicides along with insecticides sprayed 60DAS and 75DAS after sowing. Present study summarized that amongst tested eight modules treatment module M3(Chlorantraniliprole 18.50 per cent SC followed by Thiamethoxam12.60 per cent + Lambda cyhalothrin 9.50 per cent ZC (combi product) + Propiconazole 25 % EC) recorded maximum yield 23.71 q ha^{-1} with an increase of 13.78q ha^{-1} yield over control which was statistically at par with treatment module M1(Indoxacarb 15.80 per cent followed by Chlorantraniliprole 9.30 per cent + lambda cyhalothrin 4.60 per cent ZC (combi product) + Propiconazole (25% EC) recorded yield of 22.22 q ha^{-1}. This same treatment module M1 found effective for management of Alternaria leaf spot and Pod blight.

Maharashtra ranks first in soybean production in India 45 lakh MT and its area is 40.39 lakh ha. Madhya Pradesh ranks second with an area of 58.541 lakh ha and production of 41.774 Lakh MT. In Maharashtra soybean is mainly cultivated as rain fed crop from June to November. Satara, Sangli, Kolhapur, Solapur, Pune, Ahmednagar, etc. are major soybean cultivating districts of Maharashtra state. (Anonymous, 2020)

In Vidarbha region since 2003-04 onwards soybean emerged as the major *Kharif* crop by replacing sorghum totally and cotton partially. Being a short duration legume crop and as consisting medicinal and soil replenishment properties/qualities befitted in the cropping pattern in Vidarbha especially in crop sequence and intercropping too. Particularly in Vidarbha climatic condition is most suitable for soybean crop therefore only Vidarbha contributed 48.23 per cent area of soybean in Maharashtra (Anonymous, 2017). The area under soybean is consistently increasing every year in Vidarbha region. However, due to continuous monocropping, same variety use, seed material exchanges becoming routine and found contributing for increasing severity of foliar diseases of soybean and yield losses year after year.

Annual yield losses by disease in soybean have been reported to the tune of 10-30 per cent (Hartman *et al.,* 1999). Several phyto-pathogens are responsible for foliage, stem and root damages these include *Fusarium oxysporum, Fusarium soani, Fusarium equesetii, Colletotrichum trumcatum, Macrophomina phaseolina, Rhizoctonia solani, Sclerotinia sclerotiorum, Sclerotium rolfsii* (Wrather *et al.,* 1997, Fenille *et al.,* 2002, Shrivastava *et al.,* 2002). A number of seed borne pathogen such as *Alternaria alternata, Aspergillus niger, Aspergillus flavus, Cercospora kikuchii, Colletotrichum dematium, Fusarium oxysporum, Phoma medicaginis, Macrophomina phaseolina, Myrothecium roridum and Penicillium sp.* have been reported from the different part of India (Bhale *et al.* 2003, Sarbhoy and Agarwal, 1983).

Pod blight disease complex was observed in Vidarbha region of central India during kharif affecting pod and quality of seeds (Gaikwad *et al.,* 1993). Epiphytotic conditions were recorded at Indore, Madhya Pradesh (Singh *et al.,* 1994). The fungal infection leads to leaf spot, pod blight. Losses up to 90 per cent were observed due to premature defoliation, improper pod filling and loss in chlorophyll (Singh and Shrivastava, 1996).

MATERIAL AND METHODS

The field experiment was undertaken on field of Oilseed Research Unit, Dr. PDKV Akola for *Kharif* season 2023-2024 with RBD design (8x3). For management of major

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pest of soybean. All standard crop raising practices followed. Seed treated with Azoxystrobin 2.5 per cent + Thiophanate Methyl 11.25 per cent + Thiomethoxam 25 per cent FS @ 10 ml Kg^{-1} of seeds. Followed by spray application of treatment modules at 35th & 75 DAS. Treatment modules comprise

$$\text{Per cent disease incidence} = \frac{\text{Number of plants infected}}{\text{Total number of plants examined}} \times 100$$

Yield - The grain yield data in all treatment modules recorded at the time of threshing. Economics of various treatments was also calculated.

RESULTS AND DISCUSSION

Mean effect of different treatment modules on per cent disease incidence of Alternaria leaf spot on soybean

The data presented in (Table 2) and illustrated (Fig .1) showed mean effect of different treatment modules on incidence of Alternaria leaf spot. Among the treatment module M1 (Indoxacarb 15.80% followed by Chlorantraniliprole 9.30 per cent + lambda cyhalothrin 4.60% ZC + Propiconazole 25 % EC) significantly superior over rest of treatment and recorded incidence of 24.02 per cent followed by M6 (Chlorpyriphos 50 % + Cypermethrin 5 % EC followed by Novaluron 05.25 % + Indoxacarb 04.50 % SC + Hexaconazole 5 % EC) and M2 (Profenofos 50 % EC followed by Beta-cyfluthrin 8.49% + Imidacloprid19.81 % OD + Hexaconazole 5% EC) recorded incidence 25.93 and 26.75 per cent, respectively. The next better treatment module found for reduction of *Alternaria* leas spot was M5 (Emamectin benzoate 5 % SG followed by Chlorantraniliprole 9.30 % + lambda cyhalothrin 4.60 % ZC + Propiconazole 25 % EC) recorded incidence of 27.95%.

The next effective treatment was M4 (Profenofos 50 per cent EC followed by Thiamethoxam12.60 per cent + Lambda- cyhalothrin 9.50 per cent ZC + Hexaconazole 5%EC) recorded incidence of 28.31 per cent. The next treatment module M3 was comparatively less effective (Chlorantraniliprole 18.50 per cent SC followed by Thiamethoxam12.60 % + Lambda- cyhalothrin 9.50 per cent ZC + Propiconazole 25% EC) recorded incidence of 28.80%. The treatment module was M7 (Profenofos 50 per cent EC followed by Thiamethoxam12.60% + Lambda- cyhalothrin 9.50% ZC + Propiconazole 25% EC) recorded incidence of 29.45 per cent. Maximum incidence was recorded in treatment module M8 i.e. control (43.53%). All these

Table1: Mean effect of different treatment modules on per cent disease incidence of pod blight on soybean

Treatment modules	Application of insecticides	
	First sprayVegetative stage(25-35 DAS)	**Second sprayPodding stage(60-75 DAS)**
M1	Indoxacarb 15.80% EC	Chlorantraniliprole 9.30%+ lambda cyhalothrin 4.60% ZC (Combi Prod) + Propiconazole 25% EC
M2	Profenofos 50 % EC	Betacyfluthrin8.49% + Imidacloprid19.81% WWOD (Combi Prod) +Hexaconazole 5%EC
M3	Chlorantraniliprole 18.5% SC	Thiamethoxam12.60% + Lambda- cyhalothrin 9.50%ZC (Combi Prod) + Propiconazole 25% EC
M4	Profenofos 50 % EC	Thiamethoxam12.60%+ Lambda- cyhalothrin 9.50%ZC (Combi Prod) + Hexaconazole 5%EC
M5	Emamectin benzoate 5% SG	Chlorantraniliprole 9.30%+ lambda cyhalothrin 4.60% ZC (Combi Prod) + Propiconazole 25% EC
M6	Chlorpyriphos 50% + Cypermethrin 5% EC	Novaluron 05.25% + Indoxacarb 04.50 % SC (Combi Prod) + Hexaconazole 5%EC
M7	Profenofos 50 % EC	Thiamethoxam12.60% + Lambda- cyhalothrin 9.50%ZC (Combi Prod) + Propiconazole 25% EC
M8	Untreated control	Untreated control

treatment modules tested for phytotoxicity on soybean crop, but none of treatment module shown phytotoxicity.

As all modules recorded 0 grade for phytotoxicity reaction for all tested treatment modules.Similar results obtained by Zade *et al.* (2018) that propiconazole and hexaconazole showed 100 mycelial inhibitions of Alternaria fungus in vitro. Muliya *et al.* (2024) tested bio efficacy of propiconazole alone or in combination with the other fungicides against *Alternaria alternata* causing leaf blight in cowpea observed. The maximum 100 per cent mean growth inhibition was recorded in Propiconazole 25 per cent EC.

The data presented in (Table 3) and illustrated (Fig. 2) showed mean effect of different treatment modules on incidence of Pod blight. Among the treatments module M1 (Indoxacarb 15.80 % followed by Chlorantraniliprole 9.30%+ lambda cyhalothrin 4.60 % ZC + Propiconazole 25%EC) (19.02%) recorded significantly less incidence

Table 2: Effect of different treatment modules on per cent disease incidence of Alternaria leaf spot and pod blight on soybean

M. No.	Treatment modules	Alternaria Leaf Spot			Pod Blight		
		60 DAS	75 DAS	Mean	60 DAS	75 DAS	Mean
M1	Indoxacarb 15.80 % EC Fb Chlorantraniliprole 9.30%+ lambda cyhalothrin 4.60% ZC (Combi prod) + Propiconazole 25% EC	21.62 (4.60)	26.42 (5.13)	24.02 (4.87)	14.18 (3.69)	23.86 (4.86)	19.02 (4.27)
M2	Profenofos 50% EC Fb Betacyfluthrin8.49% + Imidacloprid19.81% WWOD (Combi prod) + Hexaconazole 5%EC	24.79 (4.98)	28.70 (5.36)	26.75 (5.17)	22.83 (4.71)	27.24 (5.21)	25.03 (4.96)
M3	Chlorantraniliprole 18.50 % SC Fb Thiamethoxam12.60% + Lambda- cyhalothrin 9.50%ZC (Combi prod) + Propiconazole 25% EC	26.99 (5.20)	30.61 (5.53)	28.80 (5.37)	26.14 (5.11)	29.24 (5.40)	27.69 (5.26)
M4	Profenofos 50% EC Fb Thiamethoxam12.60%+ Lambda- cyhalothrin 9.50%ZC (Combi prod) + Hexaconazole 5%EC	26.95 (5.19)	29.67 (5.44)	28.31 (5.32)	25.12 (5.02)	28.09 (5.29)	26.61 (5.16)
M5	Emamectin Benzoate 5% EC Fb Chlorantraniliprole 9.30% lambda cyhalothrin 4.60% ZC (Combi prod) + Propiconazole 25% EC	26.45 (5.14)	29.46 (5.43)	27.95 (5.29)	23.70 (4.87)	27.93 (5.21)	25.82 (5.08)
M6	Chlorpyriphos 50% + Cypermethrin 5% EC Fb Novaluron 05.25 % + Indoxacarb 04.50 % SC (Combi prod)+ Hexaconazole 5 % EC	24.12 (4.91)	27.73 (5.27)	25.93 (5.09)	20.28 (4.51)	26.25 (5.12)	23.27 (4.81)
M7	Profenofos 50% EC Fb Thiamethoxam12.60 % + Lambda- cyhalothrin 9.50%ZC(Combi prod) + Propiconazole 25% EC	27.17 (5.21)	31.73 (5.60)	29.45 (5.41)	26.75 (5.18)	29.76 (5.43)	28.26 (5.31)
M8	Untreated control	39.40 (6.28)	47.66 (6.88)	43.53 (6.58)	40.40 (6.36)	46.69 (6.83)	43.55 (6.60)
	SE (m)±	0.25	0.29	0.27	0.27	0.30	0.29
	CD at 5%	0.75	0.87	0.81	0.82	0.91	0.86
	CV%	8.21	8.91	8.56	9.46	9.60	9.49

Figures in parentheses are square root transformation. DAS - day after sowing. Fb- followed by 1st spray

followed by M6 (Chlorpyriphos 50% + Cypermethrin 5% EC followed by Novaluron 05.25% + Indoxacarb 04.50 % SC + Hexaconazole 5%EC) (23.27%) and M2 (Profenofos 50% EC followed by Beta-cyfluthrin 8.49% + Imidacloprid19.81% OD + Hexaconazole 5%EC) (25.03%). The next effective treatment module for reduction of pod blight was M5 (Emamectin benzoate 5% SG followed by Chlorantraniliprole 9.30%+ lambda cyhalothrin 4.60% ZC + Propiconazole 25%EC) recorded incidence of 25.82%. The treatment module M4 (Profenofos 50% EC followed by Thiamethoxam12.60% + Lambda- cyhalothrin 9.50% ZC + Hexaconazole 5%EC) recorded incidence of 26.61%. The next treatment module followed by was M3 (Chlorantraniliprole 18.50 % SC followed by Thiamethoxam12.60% + Lambda- cyhalothrin 9.50% ZC + Propiconazole 25%EC) recorded incidence of 27.69%. The treatment module was M7 (Profenofos 50% EC followed by Thiamethoxam12.60% + Lambda- cyhalothrin 9.50% ZC + Propiconazole 25%EC) recoded incidence of 28.25%. Maximum incidence was recorded in treatment module M8 i.e. untreated control (43.55%).

All these treatment modules tested for phytotoxicity on soybean crop, but none of treatment module shown phytotoxicity. As all modules recorded 0 grade for phytotoxicity reaction for all tested treatment modules tested. The similar results obtained by Kale and

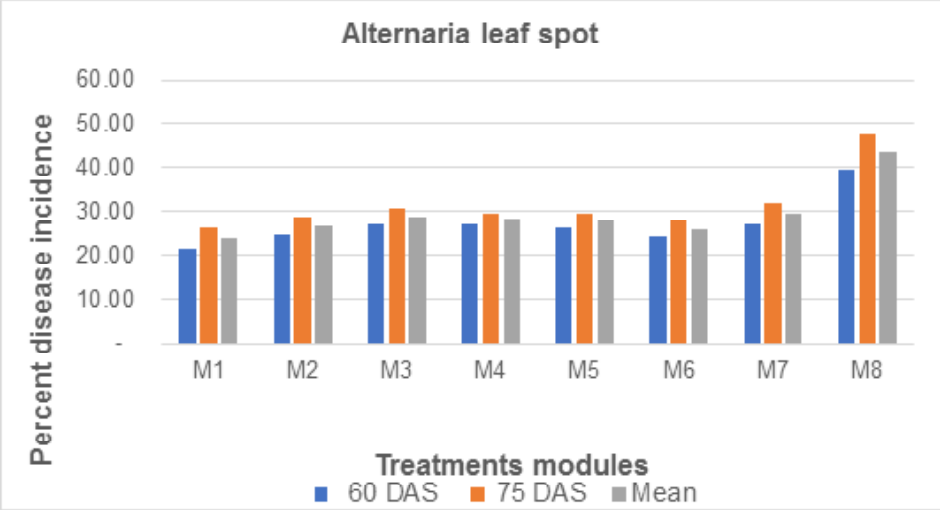

Fig 1: Effect of different treatment modules on per cent disease incidence of Alternaria leaf spot on Soybean

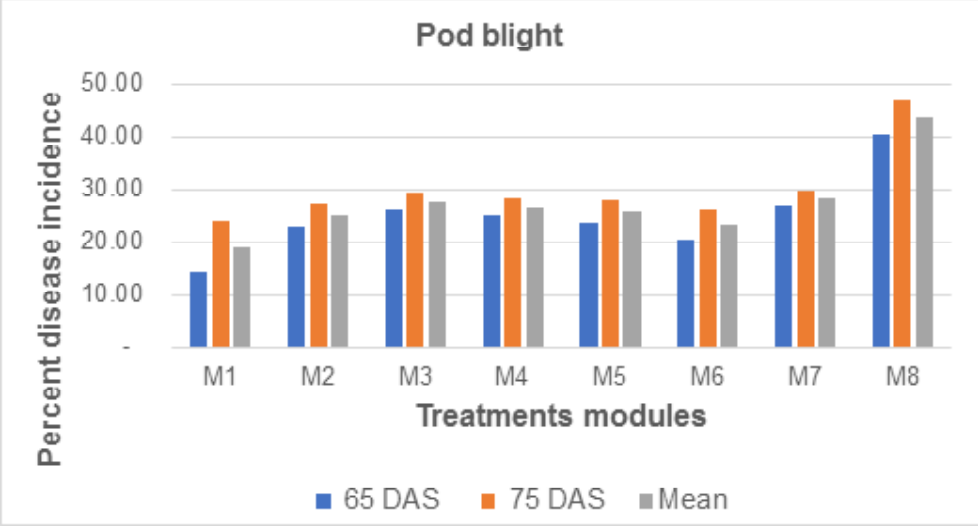

Fig 2: Effect of different treatment modules on per cent disease incidence of Pod blight on Soybean

Barhate (2016) for in vitro evaluation fungicide against *Colletotrichum truncatum* hexaconazole (84.44), chlorothalonil (80.00) and propiconazole (78.15) which recorded mean colony diameter of test pathogen.

Effects of different treatments modules on yield of soybean.

The treatment module M3 (Chlorantraniliprole 18.5 % SC followed by Thiamethoxam12.60% + Lambda-

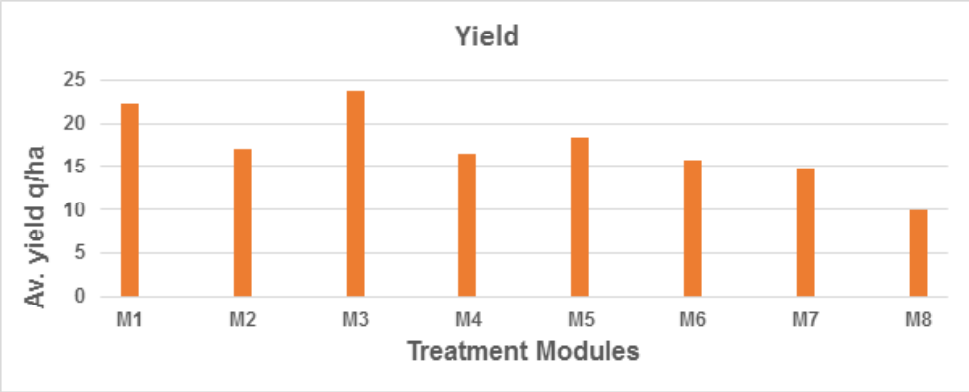

Fig 3: Average yield of various treatment modules in soybean

Table 3. Effect of different treatment modules on soybean yield.

M. No.	Treatment modules		Yield	Av. Yield
	Vegetative stage (25-35 DAS)	**Podding stage(60-75 DAS)**	**kg plot^{-1}**	**(q ha^{-1})**
M1	Indoxacarb 15.80 % EC	Chlorantraniliprole 9.30% + lambda cyhalothrin 4.60% ZC + Propiconazole 25% EC	2.08 (1.45)	22.22 (4.72)
M2	Profenofos 50% EC	Betacyfluthrin8.49% +Imidacloprid19.81% WWOD + Hexaconazole 5% EC	1.60 (1.27)	17.09 (4.14)
M3	Chlorantraniliprole 18.5% SC	Thiamethoxam12.60% + Lambda- cyhalothrin 9.50%ZC + Propiconazole 25% EC	2.22 (1.46)	23.71 (4.87)
M4	Profenofos 50% EC	Thiamethoxam12.60%+ Lambda- cyhalothrin 9.50%ZC + Hexaconazole 5% EC	1.54 (1.25)	16.45 (4.06)
M5	Emamectin benzoate 5%SG	Chlorantraniliprole 9.30% lambda cyhalothrin 4.60% ZC + Propiconazole 25% EC	1.72 (1.31)	18.37 (4.27)
M6	Chlorpyriphos 50% + Cypermethrin 5% EC	Novaluron 05.25% + Indoxacarb 04.50 % SC+ Hexaconazole 5% EC	1.47 (1.22)	15.70 (3.97)
M7	Profenofos 50% EC	Thiamethoxam12.60%+ Lambda cyhalothrin 9.50 % ZC+ Propiconazole 25 % EC	1.39 (1.18)	14.85 (3.80)
M8	Untreated Control	Control	0.93 (0.97)	9.93 (3.09)
	SE (m) ±		0.08	0.22
	CD at 5%		0.23	0.66
	CV%		10.47	9.17

cyhalothrin 9.50 % ZC + Propiconazole 25% EC) recorded maximum yields of 23.71 q ha^{-1} with an increase of 13.78 q ha^{-1} yields over control. And found at par with treatment module M1 (Indoxacarb 15.80 % EC followed by Chlorantraniliprole 9.30 %+ lambda cyhalothrin 4.60 % ZC + Propiconazole 25% EC) recorded yield of 22.22 q ha^{-1} and treatment module was M5 (Emamectin benzoate 5%SG followed by Chlorantraniliprole 9.30% lambda cyhalothrin 4.60% ZC + Propiconazole 25% EC) recorded yields of 18.37 q ha^{-1}. All this treatment modules M3, M1 and M5 are statistically similar and found at par with each other.

These results corroborate with the finding of Bhamare *et al.* (2021), who obtained highest yield of soyabean (34.87q ha^{-1}) in the treatment Chlorantraniliprole 0.04 percent documented highest incremental cost benefit ratio. Similarly, Shobarani *et al.,* (2019) received maximum seed yield recorded in indoxacarb 14.5 per cent SC (14.87q ha^{-1}). Patel *et al.,* (2019) Obtained highest B:C ratio (1:10.7) was recorded with Thiamethoxam +Lambda Cyhalothrin. Similarly with the earlier finding of Kambrekar *et al.* (2020) who reported that maximum yield of soybean obtained in Chlorantraniliprole 9.3 per cent + Lambda Cyhalothrin 4.6 per cent ZC 17.57 q ha^{-1} and 18.65 q ha^{-1} @ 150 ml ha^{-1}. The next finding Chand and Gaur (2015) who reported the maximum yield of soybean obtained in Beta cyfluthrin 8.49 per cent + Imidacloprid 19.81 per cent 300 OD @ 350 ml ha^{-1}.

CONCLUSION

For management of Alternaria leaf spot and pod blight disease the most effective treatment found was M1 (Indoxacarb 15.80 % EC followed by Chlorantraniliprole 9.30 %+ lambda cyhalothrin 4.60% ZC + Propiconazole 25% EC) recorded a yield of 22.22 q ha^{-1}. The treatment module M3 (Chlorantraniliprole 18.5% SC followed by Thiamethoxam12.60 % + Lambda- cyhalothrin 9.50 %ZC + Propiconazole 25% EC) recorded maximum yields of 23.71 q ha^{-1}. And found at par with treatment module M1 (Indoxacarb 15.80 % EC followed by Chlorantraniliprole 9.30%+ lambda cyhalothrin 4.60% ZC + Propiconazole 25% EC) recorded yield of 22.22 q ha^{-1} and treatment module was M5 (Emamectin benzoate 5%SG followed by Chlorantraniliprole 9.30% lambda cyhalothrin 4.60% ZC + Propiconazole 25% EC) recorded yield of 18.37 q ha^{-1}. All this treatment modules M3, M1 and M5 are statistically similar.

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Analysis of Morphological Variation in *Pterocarpus marsupium* from Seed Sources in Maharashtra and Gujarat, India

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ABSTRACT

Pterocarpus marsupium, a valuable deciduous tree species with medicinal and ecological significance, exhibits considerable morphological variation across different seed sources. This study aimed to assess the morphological diversity of *P. marsupium* from selected seed sources in Maharashtra and Gujarat, focusing on tree height and diameter at breast height (DBH) parameters. Five seed sources from each state were evaluated, and morphometric data were statistically analyzed. Significant variation in tree height was observed among seed sources in Gujarat ($p < 0.05$), with GJ-PM-4 exhibiting the highest mean height (41.25 m) and GJ-PM-5 the lowest (12.79 m). In contrast, tree height variation in Maharashtra was not statistically significant, with values ranging from 29.60 m (OS-PM-3) to 32.85 m (OS-PM-4). DBH analysis revealed significant differences among Gujarat seed sources ($p < 0.05$), with GJ-PM-4 having the largest DBH (75.77 cm) and GJ-PM-5 the smallest (27.46 cm). In Maharashtra, DBH values ranged from 45.56 cm (OS-PM-3) to 58.60 cm (OS-PM-4), but the variation was not statistically significant. Seed sources such as GJ-PM-4, which exhibited superior height and DBH, could be prioritized for afforestation and conservation programs. However the observed morphological diversity may suggest genetic and environmental influences on growth traits. Further research related to molecular study is needed to confirm the genetic variation.

Tree height and diameter at breast height (DBH) are fundamental parameters in evaluating forest productivity and assessing the growth potential of tree species. *Pterocarpus marsupium*, a tree of significant ecological and economic importance, is renowned for its medicinal and timber properties. This species belongs to the genus *Pterocarpus*, which is part of the subfamily Papilionoideae within the Fabaceae family. The genus includes several species that hold both economic and ecological value, such as *P. marsupium*, *P. santalinus*, *P. dalbergioides*, *P. macrocarpus*, and *P. indicus* (Gupta, 1969; Troup, 1921). Among these, *Pterocarpus marsupium* stands out due to its distinctive winged, one-seeded fruits and is particularly valued in forestry. This species is not only known for its high-quality timber but also for the bioactive compounds found in its heartwood and stem bark, which are used in a range of medicinal applications. The genus *Pterocarpus* is widespread, with 15 to 70 species globally (Allen & Allen, 1981; Hooker, 1879; Brandis, 1907), and five species recorded in India (Gamble, 1922; Troup, 1921; Pearson & Brown, 1932). *P. marsupium*, also referred to as Indian Malabar Kino, Indian Kino, or Bijasar, is a medium to large deciduous tree found at altitudes of 200 to 500 meters. However, its population in the wild is currently declining due to overexploitation and slow growth rates, which have led to its listing as a "Near Threatened" species in the Red Book (Waeber *et al.*, 2019). Despite its high timber value, *P. marsupium* is less familiar to farmers and under-researched in terms of its phenology and the performance of its various provenances. The conservation and sustainable management of this species require a deeper understanding of its growth potential across different geographical locations. Given its ecological and economic importance, *P. marsupium* is considered a prime candidate for afforestation and reforestation programs aimed at conservation (Sukhadiya *et al.*, 2019). This study focuses on analyzing the morphological variation in tree height and DBH of *P. marsupium* across selected seed sources from the states of Maharashtra and Gujarat, India. By assessing the growth potential of various provenances, this research aims to provide insights into the variation of morphological parameters, which can inform the selection of superior genotypes for sustainable forestry and conservation efforts.

2,3,4,5&7. Assistant Professor, 1,6,8 &10. Assistant Professor, 9. Associate Dean, College of Forestry, Dr. PDKV, Akola (M.S.)

MATERIAL AND METHODS

The study was carried out during 2021 and 2022 across two states in India: and survey was conducted purposefully for *Pterocarpus marsupium* in Gujarat (GJ) and Maharashtra, this location (States) has rich sources of species in natural forest and in plantation, hence these regions were selected purposively based on resource availability. In each state, five locations were chosen as seed sources. The treatments (seed sources) were prepared as, for *Pterocarpus marsupium* seed sources from Gujarat (GJ) as GJ-PM-1, GJ-PM-2, GJ-PM-3, GJ-PM-4, GJ-PM-5, whereas for Other state (OS) i.e. Maharashtra as OS-PM-1, OS-PM-2 OS-PM-3 OS-PM-4 OS-PM-5. The treatment detail given in Table 1.

Sampling Method

A multistage random sampling method was employed to select trees (5 trees from each seed sources) from five seed sources across the two states for *Pterocarpus marsupium* from Gujarat and Maharashtra. Data collection was carried out directly in the field (Panse and Sukhatme, 1985).

Data collection and analysis

The height and diameter at breast height of the selected trees was measured using a measuring tape and expressed in meters. The height and DBH was recorded. The collected data were processed and analyzed statistically. The results are presented in tabular form, and conclusions were drawn based on the statistical inferences.

The Gujarat state falls in the sub-tropical climate zone and experiences sub-humid climate in southern Gujarat (South of River Narmada), moderately humid climate in central Gujarat (between Narmada and Sabarmati rivers), humid and sultry climate in the coastal region (south facing coastal region of Saurashtra), dry climate in regions of central Gujarat (north of Ahmadabad and part of central Saurashtra) and arid and semi-arid climate in north Gujarat and Kutch.

In Maharashtra, climate is of tropical monsoons as it receives a heavy rainfall during the monsoon season with the summers being hot and winters being chilly. Majority of the forests are in the eastern and Sahyadri regions of the state.

RESULTS AND DISCUSSION

Tree height (m)

Tree height is one of the major growth parameters that differed at locations. In *Pterocarpus marsupium*, the details are presented visually in Figure 1 and shown in Table 2 and 3. It is evident from the data presented in Table 2 and 3 that, tree height of *P. marsupium* from different seed sources varied significantly within GJ locations. Whereas, the tree height was found non-significant at seed sources within Maharashtra location. When comparing the tree height (m) of *P. marsupium* at two locations, it showed significant variation. In case of tree height variation of *P. marsupium* within GJ seed sources, GJ-PM-4 recorded maximum tree height (41.25 m) which was followed by GJ-PM-2 (32.73 m) whereas minimum tree height registered in GJ-PM-5 (12.79 m). Among all seed sources of *P. marsupium* irrespective of its locations, maximum tree height was observed in GJ-PM-4 (41.25 m), followed by OS-PM-4 (32.85 m) and GJ-PM-2 (32.73 m) and minimum tree height was found in GJ-

Table 1: Treatment (Seed source) details at different locations of *Pterocarpus marsupium.*

Gujarat (GJ) seed sources		*Maharashtra (MH) seed sources*	
GJ-PM-1	Navsari, Gujarat	OS-PM-1	Pindkepar, Maharashtra
GJ-PM-2	Sunthwad, Gujarat	OS-PM-2	Papala Khurd Maharashtra
GJ-PM-3	Khaparda, Gujarat	OS-PM-3	Bolde, Maharashtra
GJ-PM-4	Waghai, Gujarat	OS-PM-4	Bortekadi, Maharashtra
GJ-PM-5	Rajpipala, Gujarat	OS-PM-5	Kawatha, Pratapgad, Maharashtra

Where, *GJ: Gujarat State & OS: Maharashtra state*

PM-5 (12.79 m) and GJ-PM-3 (24.43 m) (Table 2 & Fig.1). While comparing the tree height variation in *P. marsupium* of different seed sources and locations, it was observed that there was significant variation in tree height between locations with highest tree height (31.64 m) recorded in Maharashtra locations and lowest tree height (28.27 m) noted in Gujarat location. However, the tree height of *P. marsupium* varied from 12.17 m to 48.43 m (Table **3**) with mean height of 29.96 m.

Diameter at breast height (DBH)

One of the key growth factors, DBH of a tree represents the diameter at breast height of each individual tree in a stand. The data in relation to variation in DBH of *Pterocarpus marsupium* at various seed sources are presented in Table 2 & 3, and graphically depicted in Figure 2. The data presented in Table 2 & 3 revealed that, DBH of *P.* from different seed sources varied significantly within Gujarat location, while, it showed non-significant difference in Maharashtra location. In case of Gujarat seed sources of *P. marsupium*, the maximum DBH was recorded in GJ-PM-4 (75.77 cm) which was followed by GJ-PM-1 (51.66 cm) which was at par with GJ-PM-2 (46.69 cm) whereas minimum DBH was noted in GJ-PM-5 (27.46 cm). There was no noticeable difference noted when it came to the seed sources from Maharashtra location. Among all seed sources of *P. marsupium* irrespective of its locations, the maximum DBH was registered in GJ-PM-4 (75.77 cm), followed by OS-PM-4 (58.60 cm) and OS-PM-2 (58.51 cm) whereas minimum DBH was observed in GJ-PM-5 (27.46 cm) (Table **2**). When comparing DBH variation between *P. marsupium* irrespective of their seed sources and locations, it showed significant variation between two locations and it was observed that there was significant variation in DBH with maximum DBH (53.93 cm) observed in Maharashtra location as compare to DBH (47.61cm) found in Gujarat locations. The DBH of *P. marsupium* varied from 26.20 cm to 98.68 cm, (Table 3).

Table 3: Comparison of tree height (m) and diameter at breast height (cm) of *P. marsupium* at two locations.

	GJ	MH	GJ	MH
	Height (m)		DBH (cm)	
Mean (m)	28.27	31.64	47.61	53.93
t - test	-1.55		-1.46	
P(T< t)	0.127		0.152	
Range (m)	12.17 - 48.43		26.2 - 98.68	
Mean (m)	29.96		50.77	

Note: ** Two sample t-test assuming equal variance*

Variation in morphological parameters might be due to the geographical variation or due to genetical constituent or better environment of the particular place. This variability might be substantially influenced by parental as well as environmental conditions. Such variability was earlier reported by many researchers (Modi *et al.*, 2018). This morphological variability might be substantially influenced by parental as well as environmental conditions. Such variability was earlier

Table 2 : Morphological variation in tree height (m) and diameter at breast height (cm) across different seed sources of *Pterocarpus marsupium*.

Gujarat			Maharashtra		
Seed Sources	**Tree height (m)**	**DBH(cm)**	**Seed Sources**	**Tree height (m)**	**DBH(cm)**
GJ-PM-1	30.16^{bc}	51.66^{b}	OS-PM-1	32.48	52.05
GJ-PM-2	32.73^{b}	46.69^{bc}	OS-PM-2	31.90	58.51
GJ-PM-3	24.43^{c}	36.45^{cd}	OS-PM-3	29.60	45.56
GJ-PM-4	41.25^{a}	75.77^{a}	OS-PM-4	32.85	58.60
GJ-PM-5	12.79^{d}	27.46^{d}	OS-PM-5	31.39	54.94
S.Em.±	2.94	6.20	S.Em.±	1.63	6.49
C.D. at 5 %	6.12	12.93	C.D. at 5 %	NS	NS
C.V.%	16.42	20.59	C.V.%	8.12	19.03

Note: *The mean values with the same letter are not significantly different*

reported by Goba *et al.* (2019), Zhang *et al.* (2019) in *Pterocarpus* species, while Twinkle Patel (2022) in *Ficus* species, Essid *et al.* (2017) in Fig, Takuathung *et al.* (2012) in *Senna siamea (Lam.)*, Kallaje (2000) in *Garcinia indica*, Kapoor (2001) in *Saraca asoca* etc. this finding verified our studied results of present investigation and some significant parameters are discussed below.

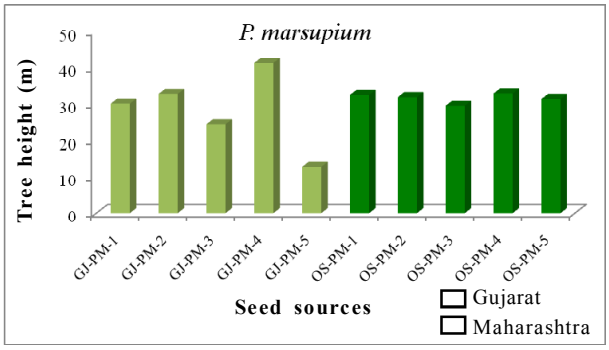

Fig. 1

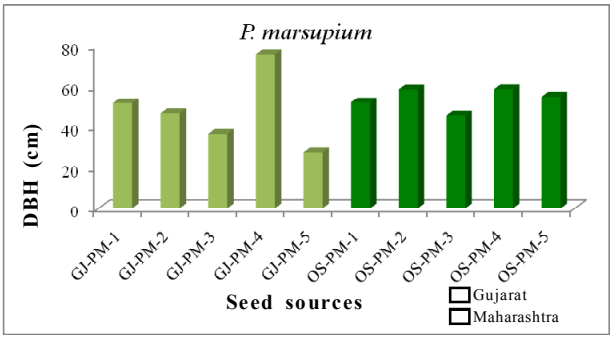

Fig. 2

Fig. 1 & 2 : Variation in Tree height and DBH (cm) of *P. marsupium*, among different seed sources of two locations

Plate 1: Tallest tree of *P. marsupium* from Waghai, Gujarat seed sources

The present morphological analysis of *Pterocarpus marsupium* revealed significant variation in tree height and diameter at breast height (DBH). The observed tree height ranged from 12.17 m to 48.43 m, while the DBH varied from 26.2 cm to 98.68 cm. These findings are consistent with previous studies, though they highlight the broader range observed in the current analysis. For instance, Gopikumar *et al.* (2003) described *P. marsupium* as one of the largest trees in deciduous forests, with a typical height of about 30 m, a figure also reported by Ahmad *et al.* (2022) and Chalise (2021). Conversely, Mohammad *et al.* (2022) documented a tree height range from 5.0 m to 48 m for the species, which corroborates the present study's results.

Regarding DBH, Gopikumar *et al.* (2003) reported a diameter of about 2.2 m, a similar value found by Ahmad *et al.* (2022). However, Mohammad *et al.* (2022) recorded a broader range of DBH, from 45.0 cm to 345.0 cm, under favorable growing conditions. This disparity in observed values can likely be attributed to the varying environmental and geographical conditions influencing growth, as well as the different populations sampled.

In line with these reports, the present study observed a large variation in both tree height and DBH. This variation in morphometric traits has also been highlighted by Mohammad *et al.* (2022), who identified considerable differences in the studied traits across populations. Such variation is not unexpected, as *P. marsupium* is known to exhibit plasticity in response to environmental factors, such as soil type, rainfall, temperature, and altitude. Shambharkar *et. al*, (2024) also found vast variations in crown spread of *Pterocarpus marsupium* and *P. santalinus*, across north-south aspects and diverse seed sources in India.

It is important to note that these findings underline the influence of geographical location and specific environmental conditions on the morphological traits of *P. marsupium*. While the general trends of height and DBH observed in the current study align with the existing literature, the ranges observed in Maharashtra and Gujarat may differ due to the unique conditions in these regions, such as soil fertility, water availability, and climatic variations.

Furthermore, these inconsistency in the reported values emphasize the importance of studying morphometric variation within specific populations, as these traits are crucial for conservation and management efforts. A comprehensive understanding of the factors driving such variation can enhance the implementation of strategies for sustainable utilization and protection of *P. marsupium* across its distribution range.

CONCLUSION

The study revealed significant variations in morphological traits at the seed source level of *Pterocarpus marsupium*. Particularly, seed sources from Gujarat ($p < 0.05$) outperformed those from Maharashtra in terms of key morphological parameters. Among the Gujarat seed sources, GJ-PM-4 demonstrated superior performance, with a tree height of 41.25 m and DBH of 75.77 cm, followed closely by OS-PM-5. These findings underscore the substantial differences in tree height and DBH across various seed sources within Gujarat, whereas Maharashtra exhibited relatively uniform growth patterns across its seed sources. These results emphasize the importance of seed source selection in influencing the growth and development of *P. marsupium*. The study enhances our understanding of the species morphological diversity and suggests that the genetic and environmental conditions associated with different seed sources can play a key role in determining tree growth. Further research, including genetic and environmental studies, is needed to identify superior genotypes that could support more effective conservation and management strategies for *P. marsupium* in both locations.

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