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RESEARCH PAPER

Yield attributes and nutrient uptake of organic safflower (*Carthamus tinctorius* L.) in drylands of Maharashtra

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Abstract : A field experiment on 'organic farming' in safflower was conducted at Dry Farming Research Station (DFRS), Solapur for five years (2009-10 to 2013-14) with the objective to explore the possibilities of substituting chemical inputs through organic source and to evaluate its effect on nutrient uptake. Well decomposed farm yard manure, vermicompost, neem seed cake, *Azotobacter, Tricoderma* and neem seed kernel extract were used as organic inputs. While, urea, SSP, dimethoate and arbendezim were used as synthetic sources of inputs. Significantly higher seed yield (1189 kg ha^{-1}) of safflower was recorded under RDF (50:25:0 NPK kg/ha + chemical control). Treatment with application of FYM @ 5ton/ha + BF+ biopesticide (Neem cake @ 200kg/ha, *Trichoderma* seed treatment @ 5 g / kg seed + spray of NSKE 5%) and treatment FYM alone @ 6.5 ton/ha were at par with RDF (50:25:0) NPK kg/ha + chemical control. Numerically higher values of test weight (5.87 g) were recorded under (FYM @ 2.5 ton/ha + biofertilizer) and T_8 (FYM (equal to 50 kg N) = 6.5 ton/ha). Higher volume weight (722 g lit^{-1}) was recorded under the treatment T_3. Significantly higher uptake of nitrogen was recorded under T_9 *i.e.* RDF (50:25:0) NPK kg/ha + chemical control and it was at par with T_3 *i.e* FYM @ 5ton/ha + BF + biopesticide in respect of P_2O_5 and K_2O.

Key Words : Biofertilizer, LAI, Safflower, NSKE, TDM, Uptake

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INTRODUCTION

Safflower (*Carthamus tinctorius* L.) is an oldest oilseed crop cultivated in India, mainly for cooking oil and dyes. Besides, safflower is a multipurpose crop species used in preparation of medicines, cosmetics, salads and margarine production (Balasubramanian and Palaniappan, 2005). Safflower seed contains 28-34 per cent of oil, flavourless and colourless and nutritionally having enough amount of linoleic acid (78%), which is very useful for reducing blood cholesterol content (Kadu and Ismail, 2008). India ranks first in area (41%) and production (29%) of the safflower grown across the world. In India, safflower is grown in 1.78 lakh ha and production is 1.44 lakh tons (Anonymous, 2015). In Maharashtra, safflower is grown in 1.07 lakh hectares with a production of about 61,000 tons and productivity of 570 kg ha^{-1} (Anonymous, 2015). It is 60.11 and 53.5 per cent of India's area and production, respectively.

Green revolution technologies, supported by policies, and fuelled by agrochemicals, machinery and irrigation, propelled India towards self-sufficiency in food production. With increase in cost of production inputs,

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inorganic fertilizers became increasingly more expensive (Reddy, 2010). But, the small farmers of scarcity areas, who by cash flow definition are short of cash, are, therefore, found to lag behind large farmers in the adoption of technologies (Anonymous, 2005). Among the different agronomic management practices, use of organics is of prime importance under rainfed farming situations. Better yields of safflower and sustainability in its production can be obtained with better fertility management practices especially with organic farming practices (Sowmya, 2014). Organic farming in recent years gaining impetus due to realization of inherent advantages, it confers in sustaining crop production under aberrant rainfed farming situations and also maintaining dynamic soil nutrient status and safe environment. Use of either farmyard manure (FYM) and vermicompost along with other organic amendments like neem seed cake; and bio-fertilizers and bio-pesticides etc., in rainfed safflower, found advantageous for sustainable crop production (Sharma and Goyal, 2000). Further, integration and incorporation of organic manures (farmyard manures/ vermicompost) in the agricultural system helps to improve soil structure, soil microbial activity and soil moisture conservation which in tern helps to stabilize the production and productivity of the crops in rainfed farming situations (Bhattacharyva and Chakraborty, 2005). Hence, a field investigation was carried out at the DFRS with the objective to explore the possibilities of substituting chemical inputs through organic source and to evaluate its effect on nutrient uptake.

MATERIAL AND METHODS

A field experiment was conducted with an objective to study the effect of application of organics on the productivity of safflower in Vertisols (Medium black soil) under scarcity zone of Maharashtra at DFRS, Solapur under Mahatma Phule Krishi Vidyapeeth, Rahuri for consecutive five years (2009-10 to 2013-14). The chemical test values of soil were 7.8 pH, 0.45 per cent organic carbon, 252 kg available N/ha, 11.90 kg available P_2O_5/ha, 697.60 kg available K_2O/ha, The experiment consisted of ten treatments *viz.*, T_1: application of well decomposed farm yard manure (FYM) @ 5ton ha^{-1}, T_2: FYM @ 5ton/ha + biofertilizer (*Azotobacter* was used as a source of biofertilizer), T_3: FYM @ 5ton/ha + BF + biopesticide (T_2 + 5 % neem seed kernel extract, HNPV and seed treatment with *Trichoderma*) were applied, T_4: FYM @ 2.5 ton/ha, T_5: FYM @ 2.5 ton/ha + biofertilizer, T_6: FYM @ 2.5 ton/ha + biofertilizer + biopesticide, T_7: FYM (quantity equal to 50 kg N) = 6.5 ton/ha, T_8: Vermi compost application @ 3 t ha^{-1}, T_9 : Inorganic farming involves seed treatment with captan (3 g/kg seed), application of recommended dose of inorganic fertilizers (50 kg N, 25 kg P_2O_5 and 0 kg K_2O/ ha) and chemical pesticides as per need to safflower in all the years and T_{10} was kept absolute control. Neem cake and vermicompost were applied in the seed rows at the time of sowing. The seeds were hand dibbled at planting geometry of 45 cm ×20 cm. All the agronomic practices as per the recommendations of MPKV, Rahuri were adopted to raise the crop satisfactory. The safflower crop was harvested between 114 to 121 days after sowing during all the years of experimentation. The dried plants from each plot and seeds were separated by threshing and seed yield/plot was recorded. Well dried seeds of safflower were taken in a flask of capacity one litre and the weight was measured on electronic balance to determine the volume weight. The leaf area at 50 per cent flowering in present investigation was determined by direct method using leaf area meter of LAI -3050C canopy analyser (Li-COR, Inc., Lincoln, NE). The leaves were detached from the uprooted plant and then the leaf area was measured in cm^2. The leaf area index was calculated by using formula :

LAI= Leaf area (cm^2)/ Ground area (cm^2)

For nutrient uptake analysis, the observational plants were collected at harvest and used for chemical analysis. The dried samples of seed and plant were ground and passed through Willey mill (20 mesh) and about 20 g of representative samples from each powdered material were stored in plastic bag suitably labeled and used for estimation of nitrogen, phosphorus and potassium separately. Nitrogen, phosphorus and potassium content of seed and plant were calculated by multiplying per cent N, P and K to their respective yields.

RESULTS AND DISCUSSION

The pooled data of five years on yield, yield contributing characters and uptake of nutrients are presented in Tables 1-3. Perusal to the data, it was noticed that, significantly higher seed yield (1189 kg ha^{-1}) of safflower was obtained under T_9, wherein, the crop was fertilized with RDF (50:25:0 NPK kg ha^{-1}) with chemical fertilizer *i.e*. through urea and single super phosphate (SSP) and the need based plant protection

Table 1: Seed yield and yield attributes of safflower as influenced due to various treatments (Data of five years, 2009-10 to 2013-14)

Sr. No.	Treatments	Seed yield (kg/ha)	Biological yield	HI (%)	Test wt. (g)	Volume wt.(g/lt)
1.	FYM @ 5ton/ha	845	3443	24.5	4.62	718
2.	FYM @ 5ton/ha + biofertilizer *(Azotobacter*)	902	3658	24.7	5.10	716
3.	FYM @ 5ton/ha + BF + biopesticide	1094	3985	27.5	5.47	722
4.	FYM @ 2.5 ton/ha	824	3537	23.3	5.23	705
5.	FYM @ 2.5 ton/ha + biofertilizer	870	3720	23.4	5.41	711
6.	FYM @ 2.5 ton/ha + *Azotobacter* + biopesticide	963	3916	24.6	5.87	708
7.	FYM (equal to 50 kg N) = 6.5 ton/ha	1036	4005	25.9	5.87	721
8.	Vermicompost application @ 3 t ha^{-1}	917	3926	23.4	5.52	729
9.	RDF (50:25:0) NPK kg/ha + chemical control	1189	4568	26.0	5.25	718
10.	Absolute control	575	3068	18.7	4.14	712
	S.E. ±	47.2	135.4	1.13	0.68	4.02
	C.D. (P=0.05)	135.4	388.5	3.26	NS	NS

NS=Non-significant

Table 2 : Yield contributing characters of safflower as influenced by different organic components (Data of five years, 2009-10 to 2013-14)

Sr. No.	Treatments	Leaf area index at 50 % flowering	Number of capituala ($plant^{-1}$)	TDM at harvest (g $plant^{-1}$)
		Mean	Mean	Mean
1.	FYM @ 5ton/ha	0.59	22.9	27.4
2.	FYM @ 5ton/ha + biofertilizer (*Azotobacter*)	0.64	24.2	30.5
3.	FYM @ 5ton/ha + BF + biopesticide	0.72	29.5	32.9
4.	FYM @ 2.5 ton/ha	0.53	21.4	28.3
5.	FYM @ 2.5 ton/ha + biofertilizer	0.59	23.7	33.6
6.	FYM @ 2.5 ton/ha + *Azotobacter* + biopesticide	0.65	26.9	36.4
7.	FYM (equal to 50 kg N) = 6.5 ton/ha	0.72	25.4	31.6
8.	Vermicompost application @ 3 t ha^{-1}	0.61	24.6	30.2
9.	RDF (50:25:0) NPK kg/ha + chemical control	0.79	30.7	37.9
10.	Absolute control	0.54	16.9	21.4
	S.E. ±	0.036	0.13	2.13
	C.D. (P=0.05)	0.11	4.6	6.5

Table 3 : Nutrient uptake (at harvest) of safflower as influenced by different organic components (Data of five years 2009-10 to 2013-14)

Sr. No.	Treatments	N uptake	P uptake	K uptake
		Mean	Mean	Mean
1.	FYM @ 5ton/ha	44.29	8.82	37.02
2.	FYM @ 5ton/ha + biofertilizer (*Azotobacter*)	45.10	9.98	37.10
3.	FYM @ 5ton/ha + BF + biopesticide	56.19	13.82	46.95
4.	FYM @ 2.5 ton/ha	41.13	8.60	35.62
5.	FYM @ 2.5 ton/ha + biofertilizer	47.68	10.60	39.65
6.	FYM @ 2.5 ton/ha + *Azotobacter* + biopesticide	51.55	10.89	44.63
7.	FYM (equal to 50 kg N) = 6.5 ton/ha	55.01	12.10	46.21
8.	Vermicompost application @ 3 t ha^{-1}	48.10	11.34	40.15
9.	RDF (50:25:0) NPK kg/ha + chemical control	60.69	14.01	48.10
10.	Absolute control	27.85	4.12	18.90
	S.E. ±	6.24	3.11	3.43
	C.D. (P=0.05)	2.09	1.04	1.15

measures were undertaken through the synthetic pesticides. The treatment T_3 (FYM @ 5ton/ha + BF+ biopesticide (Neem cake @ 200kg ha^{-1}, seed treatment with *Trichoderma* @ 5 g / kg seed + spray of NSKE 5%) and treatment T_7 (application of FYM (equal to 50 kg N) = 6.5 ton/ha) were at par with T_9. The seed yield recorded under these treatments was 1094 kg ha^{-1} and 1036 kg ha^{-1}, respectively. Biological yield and test weight were found significantly higher under T_9. The respective figures under T_9 were 4568 kg ha^{-1} and 5.87 g. In case of leaf area index at 50 per cent flowering, number of capitula per plant and total dry matter per plant were found significantly higher under T_9- RDF (50:25:0) NPK kg/ha + chemical control. The values of these parameters were 0.79, 30.7 and 37.9, respectively. Second in order was T_7 in LAI (0.72), T_6 (FYM @ 2.5 ton/ha + *Azo.* + biopesticide) in number of capitulas and TDM (26.9 $plant^{-1}$ and 36.4g $plant^{-1}$, respectively) (Table 2).

Nitrogen and phosphorus are the two essential nutrients for safflower growth and development, therefore, optimization of their rates can strongly increase the seed yield and oil content in safflower. Timely application of nutrients has a vital role in early and vigorous plant growth especially under scarcity areas. Balanced application of fertilizers at the time of sowing led to higher plant growth. Proper application of nitrogen might have increased the chlorophyll content of the leaves and photosynthesis. N application through urea was also found to play a significant role in assimilation rate, stomatal conductance of water vapour (Dordas and Sioulas, 2008.). Under T_3, application of FYM @ 5ton/ha and Neem cake @ 200kg/ha, seed treatment with *Trichoderma* @ 5 g / kg seed + spray of NSKE 5%) for five years found at par results in terms of yield ha^{-1}. This might be due to the continuous application of N and P for longer time. The superiority in yield attributes was mainly due to improvement in growth parameters. Application of organic manure has increased the total dry matter production and its accumulation into various plant parts. The significant improvement in leaf area and dry matter accumulation in leaf was noticed with application of organic manure which resulted in greater assimilation of photosynthates and their accumulation in yield components. Organic matter contents in soil with the application of organic manure were significantly improved which had favorable effect in modifying the soil environment to hold more moisture and nutrients. Better aeration and microbial activity have direct influence on the uptake of nutrients and improvement in growth and yield components and ultimately yield of safflower (Naik *et al*., 2007). Numerically higher values of test weight (5.87 g) were recorded under T_5 (FYM @ 2.5 ton/ha + biofertilizer) and T_7 (FYM (equal to 50 kg N) = 6.5 ton/ha). Whereas, higher volume weight (722 g $lit.^{-1}$) was recorded under the treatment T_3. More or less similar results were also obtained by Dhamak *et al*. (2011) ; Chikshe *et al.* (2013); Shirale *et al*. (2014) and Gawande *et al.* (2015).

Uptake studies :

The data pertaining to nutrient uptake of safflower are presented in Table 3. Significantly higher nitrogen (60.69 kg ha^{-1}), phosphorus (14.01 kg ha^{-1}) and potassium (48.10 kg ha^{-1}) uptake by seed and plant of safflower was observed with application of RDF (50:25:0) NPK kg/ha + chemical control (T_9) and it was significantly superior over rest of the treatments except T_7 and T_4 in nitrogen and phosphorus uptake while, it was at par with T_7 and T_3 in case of K uptake. This might be due to improved nutrient availability pattern of soil, reflecting biological yield and ultimately nutrient content and uptake of nutrients. Similar results were also reported by Kadu and Ismail (2008); Raju *et al.* (2013) and Durgude *et al.* (1996).

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