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Integrated Nutrient Management in Non-Spiny Safflower on Inceptisol under Dryland Condition

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ABSTRACT: A field experiment was conducted during 2008-09 to 2012-13 on deep soil (Inceptisol) at Zonal Agricultural Research Station farm to evaluate the effect of integrated nutrient management in non-spiny safflower (cv. NH-1) under dryland conditions of scarcity zone of Maharashtra. Application of 50 kg N + 25 kg P_2O_5/ha through integrated nutrient management (50% through organics + 50% through chemical fertilizers) and pest and disease control by IPM recorded significantly higher grain, straw and petal yield (1250, 3025 and 119 kg/ha, respectively), total N uptake (45.84 kg/ha) and oil content (31.9%) with highest gross (₹ 104977/ha), net returns (₹ 83664/ha) and 4.93 benefit:cost ratio. The improvement of soil fertility observed with respect to available N, P and K was prominent with the application of 50 kg N + 25 kg P_2O_5/ha through integrated nutrient management (50% through organics + 50% through chemical fertilizers) and pest and disease control by IPM. The soil organic carbon and soil biological properties in terms of total bacteria, fungi, actinomycestes, N fixer and P solubilizer were increased with the application of 50 kg N + 25 kg P_2O_5/ha adjusted through FYM, neem cake and *leucaena* loppings, PSB + *Azotobacter* seed treatment for pest and disease control by *Tricoderma* seed treatment + neem oil sprays thrice at 15, 30 and 45 DAS followed by INM.

Key words: Safflower, integrated nutrient management, yield, soil fertility and economics

The productivity of safflower (*Carthamus tinctorius* L.) was low in India (511 kg/ha) and in Maharashtra (472 kg/ha). As this is cultivated under rainfed conditions, inadequate and imbalanced fertilizer use and emergence of multiple-nutrient deficiencies are the major factors responsible for low productivity of the crops (Tiwari, 2002). Under these circumstances, integration of chemical and organic sources and their management have shown promising results not only in sustaining the productivity but have also proved to be effective in maintaining soil health and enhancing nutrient use efficiency (Thakur *et al.,* 2011). In view of shrinking land resources for cultivation, short supply and escalating cost of chemical fertilizers, environmental pollution and ill effects on soil, animals and human health, there is a need to adopt integrated nutrient management concept for achieving the objectives of environmentally and economically sustainable agriculture. Present study was conducted to evaluate the effect of combined application of inorganic fertilizers with organic manures on productivity of safflower and soil fertility status of Inceptisol soils for scarcity zone of Maharashtra.

Materials and Methods

A field experiment was carried out in *rabi* season during 2008-09 to 2012-13 at the All India Coordinated Research Project for Dryland Agriculture, Solapur, Maharashtra. Safflower (*Carthamus tinctorius* L.) Cv. NH-1 was grown on Inceptisol soil. The soil of the experimental field was *Vertic Haplustepts*, clayey and had pH 7.90, EC 0.29 dS/m, organic carbon 0.42%, available N 141 kg/ha, available P 9.45 kg/ha, available K 689 kg/ha, moisture at FC 304 mm and PWP 155 mm. The treatments comprised of T_1: control (no inputs); T_2 : recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5/ha through chemical fertilizers + pests and diseases control by chemicals (RDF); T_3: recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5/ha (50% through organic sources + 50% through chemical fertilizers), pests and diseases control by IPM (INM); T_4: recommended dose of fertilizer (50 kg N + 25 kg P_2O_5/ha through FYM + neem cake + *Leucaena* loppings + PSB + *Azotobacter* seed treatment). The N and P_2O_5 were adjusted through FYM, neem cake and *Leucaena* loppings. For pest and diseases control, *Trichoderma* seed treatment + neem oil spray thrice at 15, 30 and 45 DAS was done (organic). The treatments were replicated five times in a randomized block design outlined by Panse and Sukhatme (1967). The rainfall data received during the five years are given in Table 1. The N and P were applied through urea and single super phosphate, respectively. The FYM, *Leucaena* loppings and neem seed cake were used as organic sources. The information on the N and P_2O_5 content in various chemical fertilizers and organic manures used in the study is given in Table 2. The chemical fertilizers were applied as basal at the time of sowing whereas the organic manures were applied three weeks before sowing of safflower. The data on crop yield, total N uptake economics, seed oil content, moisture use efficiency (MUE) of grain were recorded at harvest of safflower. The MUE was computed as ratio of grain yield (kg/ha) to that of cumulative soil moisture stored in the soil (mm) at the time of sowing plus rainfall during *rabi* cropping period. After harvest of crop, soil samples were collected (0-15 cm) and analysed for organic carbon (wet oxidation method), available N (0.32% alkaline $KMnO_4$ oxidizable), available P (0.5 M $NaHCO_3$ extractable, pH 8.5) and K (Neutral normal ammonium acetate extractable) following the procedures described by Page *et al.* (1982). The colony forming units of total bacteria fungi, actinomycetes, N fixer and P solubilizer microorganisms were counted in standard media following serial dilution techniques as outlined by Dhingra and Sinclair (1993). The oil content of safflower seed was estimated by Nuclear Magnetic Resonanance (NMR).

Table 1 : Year wise seasonal distribution of rainfall (2008-09–2012-13)

Season	2008-09		2009-10		2010-11		2011-12		2012-13	
	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days	Rainfall (mm)	Rainy days
Pre-season	72.8	07	62.5	5	60.7	6	91.7	7	32.7	4
Kharif	499.2	25	475.3	20	609.5	38	514.4	29	318.3	23
Rabi	124.9	09	288.4	11	117.1	14	155.6	7	183	11
Total	693.2	41	790.2	36	787.3	58	761.7	43	534.0	38
Normal	721.4	-	721.4	-	721.4	-	721.4	-	721.4	-
+ / -	- 28.2	-	+ 68.8	-	+ 65.9	-	+ 40.3	-	- 187.4	-
% (+ / -)	- 3.9	-	+ 9.53	-	+ 9.13	-	+ 5.54	-	- 26.0	-

Normal rainfall-721.4 mm, pre-monsoon-70 mm, *kharif*- 420 mm, *rabi*- 230.3 mm

Table 2 : Contents of N and P_2O_5 in fertilizer and manures used

Fertilizer/manures	Nutrient content (%)	
	N	P_2O_5
Urea	46.0	-
Single super phosphate	-	16.0
FYM	0.58	0.37
Leucaena loppings	3.00	0.18
Neem seed cake	5.00	1.05

Results and Discussion

Yield

The pooled data on grain, stover and petal yield of safflower differed significantly due to different treatments (Table 3). Application of recommended dose of fertilizers @ 50 kg N + 25 kg P_2O_5/ha (50% through organic and 50% through chemical fertilizers), pest and disease control by IPM (INM) treatment recorded significantly highest grain, straw and petal yield (1250, 3025 and 119 kg/ha). However, stover and petal yield was on par with T_4 i.e. organic: recommended dose of fertilizers @ 50 kg N + 25 kg P_2O_5/ha through FYM, neem cake and *Leucaena* loppings, PSB + azotobacter seed treatment, pest and disease control by *Trichoderma* seed treatment + neem oil spray thrice at 15, 30 and 45 DAS. While lowest was recorded in control treatment i.e. no inputs. Grain yield of safflower increased significantly with INM, organic and RDF over control with yield response of 72, 48 and 31%, respectively. Benefits accruing from the integrated use of chemical fertilizers with organics might be attributed to better conservation of moisture, nutrient supply through incorporation of organics along with conductive physical environment leading to better root activity and higher nutrient absorption, which resulted in better plant growth and superior yield attributes responsible for high yields. The results with significant effects of organics and chemical fertilizers are in agreement with others (Srinivasa Rao, 2011 and Basak *et al.,* 2012).

N-uptake, oil content and MUE for grain

Significant increase in total N uptake by safflower was observed with application of chemical fertilizers and organic manures applied either alone or in combination over control (Table 3). It was evident that application of recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5/ha (50% through organics and 50% through chemical fertilizers), pest and disease control by IPM (INM) was found superior in increasing total N uptake (45.84 kg/ha) to other treatments. Higher N uptake by safflower in treatments receiving integrated source of nutrients may be attributed to better translocation of N from soil to plant due to its release from organic amendments over a longer period of time. It is also evident from the present study that when either

Table 3 : Safflower yield, economics, MUE, N uptake and seed oil content as influenced by different treatments (pooled mean)

Treatment	Yield (kg/ha)			Cost of cultivation (₹/ha)	Gross returns (₹/ha)	Net returns (₹/ha)	B-C ratio	MUE for grain (kg/ha/mm)	Total N uptake (kg/ha)	Oil content (%)
	Grain	Straw	Petal							
Control (T_1)	728	1862	74	17170	63539	46333	3.69	2.83	25.76	31.2
RDF (T_2)	954	2512	104	18720	86446	67726	4.62	3.63	34.77	31.6
INM (T_3)	1250	3025	119	21313	104977	83664	4.93	4.62	45.84	31.9
Organic (T_4)	1070	2794	115	25833	96354	70521	3.73	3.94	39.70	32.0
SEm±	51	117	4.20	--	2792	2792	--	--	1.66	0.17
CD (P=0.05)	156	362	12.96	--	8602	8602	--	--	5.14	0.53
C.V %	11.28	--	--	--	--	--	--	--	--	--

organic manures or chemical fertilizers are applied alone, the performance in term of crop yield and N uptake was less as compared to integrated use of 50% through chemical fertilizers + 50% through organic manures indicating that integrated use of manures and chemical fertilizers is effective in substituting nutrients. This may be due to direct as well as residual effect of manures and chemical fertilizer applied to the crop. This corroborates the findings of Kaur *et al.* (2008). However, application of manures alone failed to meet the demands of the crop because of slow rate of release of nutrients, particularly N. Our results showed that substantial increment of N uptake was recorded under integrated application of organic manures in combination with chemical fertilizers.

The oil content of safflower seed was improved with integrated nutrient management and recorded significantly highest oil content (32.0%) with the application of recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5/ha through organics i.e. FYM + neem seed cake + *Leucaena* loppings with PSB and *Azotobacter* seed treatment, for pest and disease control *Trichoderma* seed treatment + neem oil sprays at 15, 30 and 45 DAS and need based use of botanicals which was on par with T_3 (INM) and T_2 (RDF) treatments. The results are in accordance with those reported by Sharma and Dixit (1987). Fertilizer use as per INM i.e. recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5/ha (50% through organics and 50% through chemical fertilizers), pest and disease control by IPM numerically registered highest (4.62 kg/ha/mm) MUE for grain while lowest was recorded in control (2.83 kg/ha/mm).

Soil fertility

The soil organic C, available N, P and K were significantly influenced due to different treatments after harvesting of safflower are presented in Table 4. The application of recommended dose of fertilizer @ 50 kg/ha N + 25 kg/ha P_2O_5 through (FYM + neem cake + *Leucaena* loppings + PSB + *Azotobactor* seed treatment), pest and diseases control by *Trichoderma* seed treatment + neem oil spray thrice at 15, 30 and 45 DAS and need based use of botanicals recorded significantly higher soil organic carbon content (0.57%) which was on par with T_3 treatment i.e. recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5/ha (50% through organic + 50% through chemical fertilizers), pest and disease control by IPM. The least soil organic carbon content (0.36%) was recorded in control treatment. However, the maximum values of soil available N (163 kg/ha), P (11.20 kg/ha) and K (775 kg/ha) were recorded under the treatment T_3 comprising of recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5/ha (50% through organic + 50% through chemical fertilizers) + pest and disease control by IPM which were significantly superior over control. Similar beneficial effects of organic sources as well as integration of different sources of nutrients on soil fertility were also recorded by Reddy (2005), Akbari *et al.* (2011) and Basak *et al.* (2012).

Soil biological properties

The biological properties in terms of population of bacteria, fungi, actinomycetes, N fixer and P solubilizer are presented in Table 5. The results revealed that the microbial count was the highest at the time of sowing. At sowing, pooled mean for the total bacteria, fungi, actinomycetes, N fixer and P solubilizer count was 14.5 x 10^5, 5.5 x 10^3, 8.1 x 10^3, 5.3 x 10^5 and 5.2 x 10^4 cfu/g soil, respectively irrespective of treatments. The count reduced at flowering and harvesting stage of the crop due to moisture stress. Among the treatments, total organic treatment i.e. T_4 – Organic farming: recommended dose of fertilizer @ 50 kg N/ha + 25 kg P_2O_5/ha through FYM + neem cake and *Leucaena* loppings, PSB + *Azotobactor* seed treatment for pests and disease control *Trichoderma* seed treatment and neem oil spray thrice at 15, 30 and 45 DAS and need-based use of botanicals supported higher population of bacteria, fungi, actinomycetes, N fixer and P solubilizer followed by T_3 (INM) and T_2 (RDF) treatment. Addition of organic residues, balanced fertilization, integrated nutrient management have all been shown to improve soil biological properties. Similar results were also reported by Tilak (2004), Biedebeck *et al.* (2003) and Tamboli *et al.* (2011).

Economics

Application of recommended dose of fertilizer @ 50 kg N + 25 kg P_2O_5 /ha (50% through organic + 50% through chemical fertilizers), pest and disease control by IPM (Treatment T_3) resulted in highest gross (₹ 104977 /ha) and net returns (₹ 83664/ha) with 4.93 benefit:cost ratio (Table 3). This was followed by INM (T_3) and organic treatment (T_4). Similar results were reported earlier by Sandeep Singh and Jag Pal Singh (2012).

Table 4 : Soil chemical properties as influenced by different treatments at harvest of Safflower (pooled mean)

Treatment	Organic carbon (%)	Available nutrents (kg/ha)		
		N	P	K
Control (T_1)	0.36	136	5.57	732
RDF (T_2)	0.50	154	9.70	769
INM (T_3)	0.54	163	11.20	775
Organic (T_4)	0.57	160	10.17	770
SEm±	0.010	1.82	0.29	6.65
CD (P=0.05)	0.031	5.62	0.89	20.5

Table 5 : Soil biological properties as influenced by different treatments at different growth stages of safflower (pooled mean)

Treatment	Bacteria (x 10^5 cfu/g soil)				Fungi (x 10^3 cfu/g soil)				Actinomycets (x 10^3 cfu/g soil)				N fixer (x 10^5 cfu/g soil)				P Solubilizer (x 10^4 cfu/g soil)			
	S	F	H	Mean	S	F	H	Mean	S	F	H	Mean	S	F	H	Mean	S	F	H	Mean
Control (T_1)	11.7	7.0	2.2	6.9	302	1.7	0.9	1.9	5.4	3.0	1.1	3.2	2.9	1.7	1.0	1.9	3.8	1.6	1.1	2.2
RDF (T_2)	11.4	8.3	3.1	7.6	3.0	1.9	1.1	2.0	6.1	3.7	1.2	3.7	4.7	3.1	1.11.5	3.1	3.4	1.8	1.8	2.3
INM (T_3)	16.8	10.0	4.2	10.3	7.4	4.1	2.4	4.6	8.9	5.1	2.8	5.6	6.1	3.3	2.1	3.8	6.2	2.4	2.2	3.6
Organic (T_4)	18.1	12.0	4.1	34.2	8.5	4.5	2.4	5.1	11.8	6.5	2.6	6.9	7.3	4.5	2.5	4.8	7.3	3.7	2.5	4.5
Mean	14.5	9.3	3.4	-	5.5	3.1	1.7	-	8.1	4.6	1.9	-	5.3	3.2	1.8	--	5.2	2.4	1.9	--

S = Sowing, F = Flowering, H = Harvesting

Conclusion

From the results, it may be concluded that the maximum grain, straw and petal yield of safflower, net profit, B:C ratio were obtained in scarcity zone of Maharashtra under dryland conditions with integrated use of 50 kg N + 25 kg P_2O_5/ha (50% through organics + 50% through chemical fertilizers) in non-spiny safflower grown on deep soil (Inceptisol). There is a considerable improvement in N uptake and oil content in safflower under integrated nutrient management practices. The status of organic carbon, available N, P and K in soil improved considerably after the harvest of safflower crop under the INM treatment.

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