Economic efficiency and nutrient balance sheet as influenced by integrated nutrient management in hybrid sunflower (helianthus annuus l.)

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ABSTRACT

Field experiment was carried out at the Annamalai University, Experimental Farm, Department of Agronomy, Annamalai Nagar, Tamil Nadu to study the economic efficiency and nutrient balance sheet as influenced by integrated nutrient management in hybrid sunflower (*helianthus annuus* l.) during February – May 2013. The experiment was laid out in randomized block design (RBD) with eleven treatments *viz*., Control - (T_1) 100 % RDF - (T_2), 75 % RDF + FYM vermicompost @ 2.5 t ha^{-1} (T_3), 75 % RDF + Pressmud vermicompost @ 2.5 t ha^{-1} (T_4), 75 % RDF + Sewage sludge vermicompost @ 2.5 t ha^{-1} (T_5), 75 % RDF + Water hyacinth vermicompost @ 2.5 t ha^{-1} (T_6), T_2 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_7), T_3 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_8), T_4+ foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_9),T_5 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS- (T_{10}) and T_6+ foliar spray of $ZnSO_4$ @ 0 .5% + Borax at 0.2% on 40 and 60 DAS – (T_{11}). The treatments were replicated thrice. The results of the experiment revealed that crop raised with pressmud vermicompost registered higher values of seed yield, net income, return per rupee invested and maximum soil net gain and nutrient balance (NPK) in post harvest soil. From the above experimental results, it could be concluded that with application of pressmud vermicompost @ 2.5 t ha^{-1} along with 75% RDF + foliar spray of $ZnSO_4$ @ 0.5 % + Borax @ 0.2% on 40 and 60 DAS not only resulted in higher yields but also superior in respect of nutrient balance in post harvest soil and maximum return per rupee invested under hybrid sunflower cultivation.

Keywords: Hybrid sunflower, Seed yield, Nutrient (NPK) balance, Soil net gain, Net income and Return per rupee invested.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) is an important oilseed crop and is native to southern parts of USA and Mexico. At present the annual edible oil requirement for India is about 18.24 MT of which only 8.04 MT is met by local production and rest of the oil requirement about 9.34 MT is being imported. To provide oil seeds to the exploding population, it is obligatory to produce double the present oil seed production of the country. Hence there is an urgent need to augment oilseed production on sustainable basis to meet out the needs of the expanding demand. Sunflower is cultivated on an area of 23.70 million hectares with an annual production and productivity of 31.33 million tonnes and 1322 kg per hectare, respectively in the world (Hegde, 2012). Even though sunflower cultivation has more advantages, the productivity is still lower in India when compared other countries in the world. Lower sunflower productivity could be attributed to highly varying factors and management practices mainly low soil fertility status. Exploiting the production potential of high yielding sunflower varieties through agronomic management is one of the alternatives to satisfy the ever rising population. For this, fertilizers have contributed substantially to the spectacular increase in sunflower yield. However, growing crop with indiscriminate use of fertilizers has resulted into degradation of lands owing to low yields with poor quality of produce. Thus, more and more emphasis is being given towards integrated

nutrient management. INM practices are a holistic management system, which promotes sustainable agriculture and enhances agro-ecosystem health. The organic manures like FYM, pressmud and water hyacinth serve as good raw material for vermicomposting (Shweta *et al*., 2010). Vermicomposting is a simple process of composting with certain species of earthworms to accelerate the process of waste conversion and to get a better end product.

Foliar nutrition is a simple and cheaper technology which ensures the supply of nutrients to the crops directly where they are needed without spending energy for their transport, application and without any losses in transit. Among micronutrients, boron plays important roles in most of the crops e.g. cell wall strengthening, development, cell division, fruit and seed setting, sugar translocation, and hormonal development. (Ahmad *et al*., 2009). Zinc is another micronutrient, plays multiple important role in various physiological and metabolic processes of plants. It is known to activate more than 300 enzymes in plants and involved in auxin biosynthesis, protein synthesis etc. Combined application of B and Zn were found effective increasing chlorophyll content, NPK content in dry matter and seed and oil and protein content in seeds of sunflower (Gitte *et al.,* 2005). Although research work on organic manure with inorganic fertilizer in sunflower is available, vermicompost made from different organic sources along with foliar nutrition in sunflower is almost meager. Therefore, the present investigation was planned to develop a sustainable nutrient management concept to achieve a highly productive and remunerative sunflower hybrid crop under tail end area of Cauvery deltaic zone of Tamil Nadu.

MATERIALS AND METHODS

Field experiment was carried out at the Annamalai University Experimental Farm, Department of Agronomy, Annamalai Nagar, Tamil Nadu to study the economic efficiency and nutrient balance sheet as influenced by integrated nutrient management in hybrid sunflower (*helianthus annuus* l.) during February – May 2013. The experimental soil was deep clay, low in available soil nitrogen (198 kg ha^{-1}), medium in available soil phosphorus (23 kg ha^{-1}) and high in available soil potassium (282 kg ha^{-1}). The experiment was laid out in randomized block design (RBD) with eleven treatments *viz*., Control - (T_1) 100 % RDF - (T_2), 75 % RDF + FYM vermicompost @ 2.5 t ha^{-1} (T_3), 75 % RDF + Pressmud vermicompost @ 2.5 t ha^{-1} (T_4), 75 % RDF + Sewage sludge vermicompost @ 2.5 t ha^{-1} (T_5), 75 % RDF + Water hyacinth vermicompost @ 2.5 t ha^{-1} (T_6), T_2 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_7), T_3 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_8), T_4+ foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS - (T_9),T_5 + foliar spray of $ZnSO_4$ @ 0.5% + Borax at 0.2% on 40 and 60 DAS- (T_{10}) and T_6+ foliar spray of $ZnSO_4$ @ 0 .5% + Borax at 0.2% on 40 and 60 DAS – (T_{11}). The treatments were replicated thrice.Vermicompost was prepared using heap method. After 3 months, matured vermicompost was applied to experimental plots as per the treatment schedule. The sunflower hybrid (sunbred) was chosen for the study. The recommended seed rate for sunflower hybrid @ 4 kg ha^{-1} was adopted and seeds were dibbled at a depth of 3 cm with a spacing of 60 cm x 30 cm. A recommended fertilizer schedule of hybrid sunflower *viz.*, 60 kg N, 90 kg P_2O_5 and 60 kg K_2O ha^{-1} was adopted. Nitrogen, phosphorus and potassium were applied as per treatment schedule. 50 per cent of recommended N was applied as basal and the remaining 50 per cent was applied at 30 DAS. Entire dose of P_2O_5 and K_2O were applied as basal. As per treatment schedule, Zinc (0.5%) and Borax (0.2%) was sprayed at 40 and 60 DAS by using of hand operated knapsack sprayer. All other improved recommended package of practices were followed to sunflower hybrid as per the Crop Production Guide. The sunflower heads from the each treatment plot were harvested, threshed, sun dried to attain 14 per cent moisture, weighed and the seed yield was expressed in kg ha^{-1}.

Plant analysis

The plant samples after estimation of dry matter were chopped and powdered by using a Willey mill and were analysed for N, P and K contents. Analytical methods employed for plant were as under

Particulars	Author(s)	Method
N content	Humphries, 1956	Micro Kjeldahl method
P content	Jackson (1973)	Spectro photometer using triacid digestion method
K content	Jackson (1973)	Flame photometer using triacid extract

Soil analysis

The post harvest composite soil samples were collected after the harvest of sunflower and analysed for post harvest available nutrients. Analytical methods employed for soil/manure were as under

Particulars	Author(s)	Method
Available N	Subbiah and Asija (1956)	Alkaline permanganate method
Available P	Olsen *et al.* (1954)	Colorimeter method
Available K	Stanford and English (1949)	Flame photometric method

Nutrient balance in sunflower hybrid

The soil nutrient balances in the sunflower hybrid cultivation were computed for different treatments as per the procedure suggested by Sadanandan and Mahapatra (1973).

Net input (I_{net}) of nutrients

The I_{net} reflects the net intake of nutrients from sources other than fertilizer and was calculated as per the procedure given by Palaniappan and Siddeswaran (1994).

$$I_{net} = \text{Final soil nutrient Level} - \text{Initial soil nutrient Level} - \text{Added fertilizer nutrient} - \text{Nutrient removed by crop}$$

Economic analysis

Gross return

Gross return was calculated using seed yield of sunflower on market price and expressed in Rs ha^{-1}.

Net return

Net return was calculated by deducting the cost of cultivation from gross returns as detailed below and presented in Rs ha^{-1}.

Net return = Gross return – total cost of cultivation

Return $rupee^{-1}$ invested

Return $rupee^{-1}$ invested was calculated based on gross returns and cost of cultivation as given.

$$\text{Return rupee}^{-1}\text{ invested} = \frac{\text{Gross return (Rs. ha}^{-1})}{\text{Cost of cultivation (Rs. ha}^{-1})}$$

The data on various studies recorded during the investigation were subjected to statistical scrutiny as suggested by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Effect of INM treatments on seed yield

All the treatments exerted significant influence on the seed yield of sunflower hybrid. Among the treatments, pressmud vermicompost @ 2.5 t ha^{-1} along with 75% RDF + foliar spray of $ZnSO_4$ @ 0 .5% + Borax @ 0.2% on 40 and 60 DAS (T_9) significantly registered the higher seed yield of 2241 kg ha^{-1}, which was 258.74 per cent higher than T_1 (control) and 86.35 per cent over 100% RDF (T_2). This might be due to the fact that pressmud vermicompost offer a balanced nutritional release pattern to plants, providing nutrients such as available N, soluble K, exchangeable Ca, Mg and P that can be taken readily by plants (James Pitchai *et al*., 2009) and greater microbial diversity and activity resulting in higher seed production. Being the key component in photosynthesis (Patil *et al.,* 2006) boron might have improved the physiological activity of plant resulting in enhanced synthesis photosynthates. Studies have revealed that boron not only improved the nutrients uptake, it also augmented the conversion, translocation of starch to sink region. Similarly, zinc and sulphur being the prime requisite nutrient for formation of several amino acids might have involved in protein synthesis in higher plants. Hence, the availability of these nutrients with this treatment might have enhanced the effective translocation and storage of photosynthetic assimilates which inturn increased seed yield of sunflower. The findings of Gitte *et al.* (2005) lend support to the present results. The next order of ranking was T_8 (75% RDF + FYM vermicompost @ 2.5 t ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS). The least yield was registered under T_1 (control).

Effect of INM treatments on Nutrient Balance (NPK) In Post Harvest Soil Of Sunflower Hybrid

The computed balance was higher with T_4 (75% RDF + pressmud vermicompost @ 2.5 t ha^{-1}), which recorded a higher N balance of 215.38 kg ha^{-1}, P balance of 142.87 kg ha^{-1} and K balance of 303.38 kg ha^{-1}. The least computed balance of NPK registered under T_1 (control).The higher soil net gain N of 15.84 kg ha^{-1} , P of 4.85 kg ha^{-1} and K of 22.64 kg ha^{-1} was recorded under T_4 (75% RDF + pressmud vermicompost @ 2.5 t ha^{-1}). The next best order of ranking was T_9 (75% RDF + pressmud vermicompost @ 2.5 t ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS) and T_3 (75% RDF + FYM vermicompost @ 2.5 t ha^{-1}), which is mainly due to sustained release of N, P and K from vermicompost and also could be attributed to higher biomass addition of the crop. The higher net loss N of -22.28 kg ha^{-1} , P of -6.91 kg ha^{-1} and K of -21.08 kg ha^{-1} was recorded under T_1 (control). The variation in the computed balance and net gain of nutrients was noticed in different imposed treatments. This variation could be due to variable content of nutrients in different organic manures and their availability in soil and supplemental addition of inorganic fertilizer under sunflower besides inherent capacity of the crop to absorb nutrients. Higher actual balance and net gain of nutrients in the combined application of vermicompost and inorganic fertilizer could be due to the limited or reduced nutrient losses through various mechanisms like volatilization, de-nitrification, leaching and fixation (Babu Mathew, 2001).

ECONOMICS

Effect of INM treatments on Gross and net returns

The ultimate aim of any agricultural technology is to realize maximum returns per rupee invested. This also gives a clear idea about the optimum level of input that could be
used to obtain higher net profit. Any farming technology to be adopted under farmer situations should have a sound economic viability in terms of higher net returns or benefit: cost ratio. The maximum gross return (Rs. 78446.80), net return of Rs. 58099.41 was recorded in T_9 (75% RDF + pressmud vermicompost @ 2.5 t ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS). This was followed by T_8 (75% RDF + FYM vermicompost @ 2.5 t ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS) which registered a gross return of Rs 74752.31 and net return of Rs. 54404.92. The lowest gross return of Rs. 21867.30 and net return of Rs. 7242.30 was noticed in T_1 (control).

Effect of INM treatments on Return rupee^{-1} invested

The maximum Return rupee^{-1} (Rs. 3.01) was recorded in T_9 (75% RDF + pressmud vermicompost @ 2.5 t ha^{-1}+ foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS). This was followed by T_8 (75% RDF + FYM vermicompost @ 2.5 t ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS), which registered a return rupee^{-1} 2.82. The lowest return rupee^{-1} was noticed in T_1 (control) with Rs. 1.50. Higher level of biomass accumulation and efficient translocation to the reproductive parts due to supply of adequate nutrients might be responsible for the production of elevated yield attributes, which resulted in higher monetary returns and B:C ratio. These results are in accordance with Jakhar (2006) and Patil *et al.* (2006).

Conclusion

In nut shell, the results have proved sustainability in productivity and soil fertility in sunflower hybrid with INM practices using different sources of vermicompost. Adoption of the integrated nutrient management practices to sunflower hybrid, consisting of 75% RDF + pressmud vermicompost @ 2.5 t ha^{-1} + foliar spray of $ZnSO_4$ @ 0.5% + Borax @ 0.2% on 40 and 60 DAS will hold an ecofriendly, agronomically sound and economically viable for tail end areas of Cauvery Deltaic Zone of Tamil Nadu.

Table 1. Effect of INM practices on nitrogen (N) balance sheet (kg ha^{-1}) in hybrid sunflower cultivation.

Treatments	N applied	N added through organics	Total N added	N removed by sunflower	Computed balance	Final soil N	Soil net gain
T_1	0.00	0.00	0.00	26.17	171.83	173.72	-22.28
T_2	60.00	0.00	60.00	54.99	203.01	184.87	-11.13
T_3	45.00	50.25	95.25	79.43	213.82	205.32	9.32
T_4	45.00	54.50	99.50	82.12	215.38	211.84	15.84
T_5	45.00	48.50	93.50	78.21	213.29	200.21	4.21
T_6	45.00	45.00	90.00	75.76	212.24	195.72	-0.28
T_7	60.00	0.00	60.00	63.22	194.78	181.86	-14.14
T_8	45.00	50.25	95.25	89.26	203.99	203.97	7.97
T_9	45.00	54.50	99.50	92.85	204.65	209.54	13.54
T_{10}	45.00	48.50	93.50	87.84	203.66	198.74	2.74
T_{11}	45.00	45.00	90.00	85.44	202.56	193.86	-2.14

Initial soil available N = 198.0 kg ha^{-1} Not analysed

Table 2. Effect of INM practices on Phosphorus (P_2O_5) balance sheet (kg ha^{-1}) in hybrid sunflower cultivation

Treatments	P_2O_5 applied	P_2O_5 added through organics	Total P_2O_5 added	P_2O_5 removed by sunflower	Computed balance	Final soil P_2O_5	Soil net gain
T_1	0.00	0.00	0.00	6.01	17.19	15.89	-6.91
T_2	90.00	0.00	90.00	10.77	102.43	19.57	-3.23
T_3	67.50	41.75	109.25	15.55	116.90	25.82	3.02
T_4	67.50	68.25	135.75	16.08	142.87	27.65	4.85
T_5	67.50	43.50	111.00	15.31	118.89	24.27	1.47
T_6	67.50	41.25	108.75	14.83	117.12	22.81	0.01
T_7	90.00	0.00	90.00	12.38	100.82	18.03	-4.77
T_8	67.50	41.75	109.25	17.47	114.98	25.28	2.48
T_9	67.50	68.25	135.75	18.18	140.77	27.12	4.32
T_{10}	67.50	43.50	111.00	17.20	117.00	23.68	0.88
T_{11}	67.50	41.25	108.75	16.73	115.22	22.21	-0.59

Initial soil available P_2O_5 =23 kg ha^{-1} Not analysed

Table 3. Effect of INM practices on Potassium (K_2O) balance sheet (kg ha^{-1}) in hybrid sunflower cultivation

Treatments	K_2O applied	K_2O added through organics	Total K_2O added	K_2O removed by sunflower	Computed balance	Final soil K_2O	Soil net gain
T_1	0.00	0.00	0.00	22.75	259.25	252.92	-21.08
T_2	45.00	0.00	45.00	43.64	283.36	269.77	-4.23
T_3	45.00	46.00	91.00	71.44	301.56	291.85	17.85
T_4	45.00	50.25	95.25	73.87	303.38	296.64	22.64
T_5	45.00	41.00	86.00	70.35	297.65	286.53	12.53
T_6	45.00	36.50	81.50	68.14	295.36	281.79	7.79
T_7	60.00	0.00	60.00	56.87	285.14	264.33	-9.67
T_8	45.00	46.00	91.00	80.29	292.71	289.91	15.91
T_9	45.00	50.25	95.25	83.51	293.74	294.88	20.88
T_{10}	45.00	41.00	86.00	79.01	288.99	284.83	10.83
T_{11}	45.00	36.50	81.50	76.85	286.65	279.92	5.92

Initial soil available K_2O = 282.0 kg ha^{-1} Not analysed

Table 4. Economics of hybrid sunflower

Treatments	Seed yield (Kg ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Gross return (Rs. ha^{-1})	Net return (Rs. ha^{-1})	Return rupee^{-1} invested
T_1	624	14625.00	21867.30	7242.30	1.50
T_2	1202	21481.52	42097.30	20615.78	1.96
T_3	1849	25892.39	64721.65	44954.26	2.50
T_4	1926	25517.39	67433.45	47666.06	2.64
T_5	1813	26017.39	63481.25	43713.86	2.44
T_6	1742	25392.39	61001.50	41234.11	2.40
T_7	1422	22061.52	49796.77	27735.25	2.26
T_8	2135	26472.39	74752.31	54404.92	2.82
T_9	2241	26097.39	78446.80	58099.41	3.01
T_{10}	2096	26597.39	73368.19	53020.80	2.76
T_{11}	2021	25972.39	70747.74	50400.35	2.72

Not analysed

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