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Studies on site specific nutrient management (SSNM) on hybrid sunflower seed production in Southern Karnataka

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Abstract: A field experiment was conducted at the Main Research Station, University of Agricultural Sciences, Hebbal, Bangalore, to know the effect of Site Specific Nutrient Management (SSNM) on growth (plant height (cm), Leaf area (cm^2), leaf area index (LAI) and dry matter production (g $plant^{-1}$) and yield (capitulum diameter (cm), No. of filled seeds, 1000 seed weight (g) and seed yield (kg ha^{-1}) of hybrid sunflower seed production. The study indicated that significantly higher growth parameters *viz*., plant height (155.4 cm), leaf area (1293.10cm^{-2}), leaf area index (0.69) and total dry matter accumulation (88.16 g $plant^{-1}$) were recorded with SSNM for 1.2 tons ha^{-1} + Farm Yard Manure (FYM) as compared to recommended practice (Recommended Dose of Fertilizer 62.50:75:62.50 kg NPK ha^{-1}). The application of fertilizers based on SSNM for a target yield of 1.2 t ha^{-1} + FYM resulted in significantly higher yield and yield attributes compared to the only application of RDF + FYM. The important yield parameters recorded that were significantly higher were *viz.,* head diameter (19.89 cm) number of filled seeds per head (353.24), seed weight per plant (19.76 g), 1000 seed weight (43.72 g), hybrid seed yield (1003 kg ha^{-1}).

Keywords: Growth, Productivity, Site specific nutrition, Sunflower, Yield

INTRODUCTION

Sunflower is an introduced oilseed crop which has made much impact and is gaining more importance in recent years. In India, it is cultivated over an area of 4.7 lakh hectares producing 4.3 lakh tons with a productivity of 697 kg ha^{-1} (Anonymous 2016-17). The major states that grow sunflower include are Karnataka, Andhra Pradesh, Maharashtra and Tamil Nadu. Globally it is cultivated on 250 lakh hectares with a production of 340 lakh tons having the productivity of 1391 kg ha^{-1} (Rai *et al*. 2016) World major sunflower production comes from Ukraine, Russia, European Union, Argentina and china. Sunflower is a drought tolerant crop due to its deep tap root, which makes it the best substitute for all rain fed crops. Sunflower crop being a short duration (95-100 days), it is adaptable to different conditions. It can be grown in all the seasons (*kharif*, *rabi* and summer) with medium fertile to high fertile soils. Besides, it yields high quality oil. The productivity of sunflower has decreased from 737 kg ha^{-1} (2014 - 15) to 697 kg ha^{-1} (2015-16) inspite of using the higher levels of inputs like better genotypes, fertilizers and pesticides (Anonymous, 2015). The average crop yields in farmers' fields are much lower compared to potential yield. The lower productivity of sunflower is mainly due to non availability of good quality seeds, technological constraints in crop husbandry, nutritional constraints, crop protection constraints and socio economic constraints as reported by Kannan *et al*. (2011), Deshpande (2012) and Komol Singh *et al*. (2015). Out of these, availability of best quality genotype and better crop nutrition are very important for higher yield. Among the various approaches for crop nutrition, the targeted yield approach has been found to be highly popular in India. As the production potential of sunflower crop is much higher than the present average on the farmers' field, there is a scope to increase the production by matching with balanced nutrition through soil testing and crop demand. The optimal N, P and K doses (Recommended Dose of Fertilizer 62.50:75:62.50 kg NPK ha^{-1}) based on soil testing would help not only in attaining desired target yields but also to maintain soil health over a period of time. In view of above situation, a field experiment was planned to develop a schedule for better nutrient management to maximize the hybrid sunflower seed yield based on soil test values for attaining different yield targets under rainfed Alfisols of Karnataka.

MATERIALS AND METHODS

The field experiments were carried out for two seasons during 2013 and 2014 at the Main Research Station,

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University of Agricultural Sciences, Hebbal, Bangalore. The experiment was laid-out with Randomized Complete Block Design (RCBD). There were nine treatments and three replications. Composite soil samples were collected from the experimental field before sowing, and they were analyzed for important physical and chemical characteristics (coarse sand, fine sand, silt, clay, pH, EC, bulk density, organic carbon, available N, available P_2O_5, available K_2O, available S, available Zn and available B. The results of the analysis and the methods followed are presented in table 1. The textural class of the experimental site was red sandy loam having medium fertility status. The soil was neutral in pH and free from excess salts, medium in organic carbon, low in available nitrogen, medium in available phosphorous and potassium. Based on these soil test values by following the principles of site specific nutrient management, the chemical fertilizers were applied. Irrigation was provided to the crop once in 15 days based on the need for the crop. The FYM was applied as per the treatment before two weeks of sowing. Both male and female parents (CMS 234 A and RHA 6D-1) were obtained from AICRP on sunflower scheme, Zonal Agricultural Research Station, Gandhi Krishi Vigyan Kendra, Bangalore and were sown separately. At the time of flowering, male sunflower heads were covered with cloth bags to avoid pollen theft by insects. In the morning pollen was collected in the petriplate from each sunflower head and with the help of brush hand pollination was done to individual flowers in female parent (234 A). The process was continued till flowering and seed setting was complete. Plant biometric parameters viz., plant height, leaf area, leaf area index, dry matter production, days to fifty percent flowering, days to maturity, capitulam diameter, the total number of seeds, number of filled seeds, percent seed filling, 1000 seed weight, hybrid seed yields were recorded at regular interval. Yield attributes were recorded at the time of harvest. The results were analyzed by using standard procedures.

Criteria for deciding SSNM levels: International plant Nutrition Institute (IPNI) developed standards for Nutrient removal by each crop. According to IPNI, the nutrient removal by groundnut is 58.1:19.6:30.1 NPK kg t^{-1} (Anonymous, 2006). Therefore Nutrient to be applied for groundnut considering the above removal for 2.5 tha^{-1} is as: N: 58.1 X 2.5 = 145.25 kg ha^{-1}; P_2O_5 : 19.6 X 2.5 = 49.00 kg ha^{-1}; K_2O : 30.1 X 2.5 = 75.25 kg ha^{-1}. Further taking the supply factor into consideration, (1) if soil nutrient rating is medium - apply exactly removal quantity, (2) If soil nutrient rating is low - apply 30 % more and (3) If soil nutrient rating is high - apply 30 % less.

Table 1. Physico-chemical properties of soil in the groundnut and sunflower experimental field at Main Research Station, Hebbal, Bangalore.

Particulars	Methodology of Measurement	2013	Status
I. Mechanical composition			
1. Coarse sand (%)		54.19	--
2. Fine sand (%)		26.03	--
3. Silt (%)	International pipette method (Piper, 1966)	9.16	--
4. Clay (%)		10.62	--
5. Soil type		Sandy loam	--
II. Chemical properties			
1. pH (1:2.5)	Buckman's Zerb metric pH meter(Piper, 1966)	6.7	Neutral
2. EC (1:2.5) (dSm^{-1})	Conductometry (Jackson, 1967)	0.23	Low
3. Bulk density (g/cm^3)	Core sampler method (Piper, 1966)	1.39	-
4. Organic carbon (%)	Walkley and Black Wet digestion method (Jackson, 1973)	0.66	Medium
5. Available N (kg ha^{-1})	Alkaline permanganate method (Subbaiah and Asija, 1959)	239.6	Low
6. Available P_2O_5(kg ha^{-1})	Olsen's method (Jackson, I973)	22.30	Medium
7. Available K_2O (kg ha^{-1})	Neutral normal ammonium acetate method (Jackson, 1973)	190.54	Medium
8. Available S (kg ha^{-1})	Turbidometry (Jackson, 1973)	14.69	Medium
9. Available Zn (ppm)	DTPA extractant method (Lindsay and Norvell, 1978)	0.53	Low
10. Available B (ppm)	Carmine red method (Hatcher and Wilcox, 1950).	0.46	Low

The standard values for classification of nutrients as neutral, low and medium are as under.

Particular	Range of values for classification		
	Low	Medium	High
Organic carbon	0.5	0.5-0.75	> 0.75
2. Available N (kg ha^{-1})	280	280-560	> 560.0
3. Available P_2O_5 (kg ha^{-1})	22.5	22.5-55.0	>55.0
4. Available K_2O (kg ha^{-1})	144	144-336	>336.0
5. Available S (kg ha^{-1})	< 10	10-20	>20.0
6. Available Zn (ppm)	< 0.6	0.6-1.2	>1.2
7. Available B (ppm)	< 0.33	0.33-1.0	> 1.0

Table 1. Growth parameters of sunflower as influenced by site specific nutrient management (SSNM) under irrigated condition.

Treatments	Growth parameters											
	Plant height (cm)			Leaf area (cm^{-2})			Leaf area index			Dry matter production ($g\ plant^{-1}$)		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
T_1 - RDF + FYM	145.4	140.1	142.7	1036.92	978.00	1007.46	0.57	0.54	0.56	73.22	77.90	75.56
T_2- SSNM for 0.6 t ha^{-1}	134.1	129.2	131.6	837.77	792.00	814.89	0.47	0.44	0.45	62.22	67.96	65.09
T_3- SSNM for 0.8 t ha^{-1}	142.0	136.8	139.4	947.65	894.00	920.82	0.52	0.50	0.51	63.98	75.56	69.77
T_4- SSNM for 1.0 t ha^{-1}	150.0	144.2	147.1	1170.06	1104.00	1137.03	0.65	0.61	0.63	80.41	82.19	81.30
T_5- SSNM for 1.2 t ha^{-1}	154.5	150.4	152.4	1270.40	1200.00	1235.20	0.68	0.67	0.68	85.78	87.13	86.46
T_6 - SSNM for 0.6 t ha^{-1} + Rec. FYM	142.4	137.0	139.7	999.87	943.00	971.44	0.56	0.53	0.54	64.43	76.02	70.23
T_7 -SSNM for 0.8 t ha^{-1} + Rec. FYM	148.0	142.6	145.3	1091.85	1026.00	1058.93	0.61	0.57	0.59	67.04	78.56	72.80
T_8- SSNM for 1.0 t ha^{-1} + Rec. FYM	150.3	144.8	147.6	1194.86	1131.00	1162.93	0.66	0.64	0.65	81.67	83.11	82.39
T_9 -SSNM for 1.2 t ha^{-1} + Rec. FYM	157.3	153.5	155.4	1332.20	1254.00	1293.10	0.69	0.70	0.69	87.51	88.82	88.16
S.Em.+	3.17	2.73	2.88	55.067	52.122	53.37	0.031	0.0284	0.03	3.18	2.90	2.97
C.D. (P=0.05)	9.50	8.2	8.28	165.1	156.27	153.40	0.09	0.08	0.09	9.52	8.68	8.52
C. V.	10.3	8.6	9.45	12.4	9.5	10.95	8.9	11.2	10.05	8.5	10.8	9.65

RDF – 62.50:75:62.50 kg NPK ha-1; SSNM for 0.6 t ha-1 – 49.37:11.46:33.72 kg NPK ha-1; SSNM for 0.8 t ha-1 – 65.83:15.28:44.96 kg NPK ha-1; SSNM for 1.0 t ha-1 – 82.30:19.11:56.21 kg NPK ha-1; SSNM for 1.2 t ha-1 – 98.75:22.92:67.44 kg NPK ha-1 ; FYM – 7.5 t ha-1

Table 2. Days to fifty percent flowering and days to maturity of sunflower as influenced by site specific nutrient management (SSNM) under irrigated condition.

Treatments	Days					
	50% flowering			Maturity		
	2013	2014	Pooled	2013	2014	Pooled
T_1 - RDF + FYM	61.39	63.85	62.62	99.36	103.33	101.35
T_2 - SSNM for 0.6 t ha^{-1}	59.36	61.73	60.55	96.61	100.47	98.54
T_3 - SSNM for 0.8 t ha^{-1}	60.15	62.56	61.35	99.01	102.97	100.99
T_4 - SSNM for 1.0 t ha^{-1}	62.89	65.41	64.15	101.59	105.65	103.62
T_5 - SSNM for 1.2 t ha^{-1}	63.53	66.07	64.80	102.35	106.44	104.40
T_6 - SSNM for 0.6 t ha^{-1} + Rec. FYM	60.48	62.90	61.69	99.42	103.40	101.41
T_7 - SSNM for 0.8 t ha^{-1} + Rec. FYM	61.58	64.04	62.81	99.73	103.72	101.72
T_8 -SSNM for 1.0 t ha^{-1} + Rec. FYM	63.21	65.74	64.48	101.73	105.80	103.77
T_9 - SSNM for 1.2 t ha^{-1} + Rec. FYM	63.61	66.15	64.88	102.69	106.80	104.75
S.Em.±	0.66	0.69	0.65	0.86	0.89	0.85
C.D. (P=0.05)	1.97	2.05	1.87	2.57	2.67	2.43
C. V.	10.5	12.8	11.65	12.6	11.9	12.25

RDF – 62.50:75:62.50 kg NPK ha-1; SSNM for 0.6 t ha-1 – 49.37:11.46:33.72 kg NPK ha-1; SSNM for 0.8 t ha-1 – 65.83:15.28:44.96 kg NPK ha-1; SSNM for 1.0 t ha-1 – 82.30:19.11:56.21 kg NPK ha-1; SSNM for 1.2 t ha-1 – 98.75:22.92:67.44 kg NPK ha-1 ; FYM – 7.5 t ha-1

Table 3. Capitulum diameter, total number of seeds, number of filled seeds and percent seed filling of sunflower as influenced by site specific nutrient management (SSNM) under irrigated condition.

Treatments	Yield parameters											
	Capitulum diameter (cm)			Total no. of seeds head^{-1}			No. of filled seeds			Per cent seed filling		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
T_1 - RDF + FYM	16.32	18.05	17.19	444.94	477.59	461.27	223.31	251.47	237.39	50.11	52.37	51.24
T_2- SSNM for 0.6 t ha^{-1}	14.63	16.09	15.36	406.85	414.22	410.54	152.54	165.86	159.20	37.02	40.06	38.54
T_3- SSNM for 0.8 t ha^{-1}	15.34	16.87	16.11	438.50	472.88	455.69	183.93	230.73	207.33	41.78	48.43	45.11
T_4- SSNM for 1.0 t ha^{-1}	17.57	19.33	18.45	489.36	513.97	501.66	286.75	304.96	295.85	58.65	59.37	59.01
T_5- SSNM for 1.2 t ha^{-1}	18.35	20.19	19.27	509.52	548.43	528.98	315.12	353.05	334.08	61.84	64.36	63.10
T_6 -SSNM for 0.6 t ha^{-1} + Rec. FYM	16.02	17.62	16.82	439.98	473.44	456.71	187.12	239.02	213.07	42.46	49.92	46.19
T_7 -SSNM for 0.8 t ha^{-1} + Rec. FYM	16.13	18.08	17.10	445.33	476.59	460.96	235.00	256.02	245.51	52.74	53.73	53.24
T_8-SSNM for 1.0 t ha^{-1} + Rec. FYM	17.75	19.41	18.58	491.07	514.15	502.61	293.87	310.70	302.28	59.63	60.33	59.98
T_9 - SSNM for 1.2 t ha^{-1} + Rec. FYM	18.94	20.83	19.89	524.76	564.64	544.70	332.13	374.35	353.24	63.30	66.38	64.84
S.Em.±	0.51	0.64	0.57	12.53	19.73	16.57	24.07	25.65	26.27	3.4356	2.41	2.89
C.D. (P=0.05)	1.56	1.90	1.63	37.56	59.14	47.63	72.15	76.89	75.49	10.3	7.21	8.30
C. V.	8.3	10.4	9.35	12.1	10.6	11.35	12.3	10.6	11.45	11.2	9.4	10.3

RDF – 62.50:75:62.50 kg NPK ha-1; SSNM for 0.6 t ha-1 – 49.37:11.46:33.72 kg NPK ha-1; SSNM for 0.8 t ha-1 – 65.83:15.28:44.96 kg NPK ha-1; SSNM for 1.0 t ha-1 – 82.30:19.11:56.21 kg NPK ha-1; SSNM for 1.2 t ha-1 – 98.75:22.92:67.44 kg NPK ha-1 ; FYM – 7.5 t ha-1

Table 4. 1000 seed weight, hybrid seed yield, stalk yield and harvest index of sunflower as influenced by site specific nutrient management (SSNM) under irrigated condition.

Treatments	Yield parameters											
	1000 Seed weight (g)			Hybrid seed yield (kg ha^{-1})			Stalk yield (kg ha^{-1})			Harvest index		
	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled	2013	2014	Pooled
T_1 - RDF + FYM	39.77	41.42	40.60	825	769	797	1712	1715	1714	0.32	0.31	0.32
T_2- SSNM for 0.6 t ha^{-1}	38.53	40.01	39.27	709	633	671	1544	1547	1546	0.31	0.29	0.30
T_3- SSNM for 0.8 t ha^{-1}	38.63	40.2	39.42	787	726	757	1621	1624	1623	0.33	0.31	0.32
T_4- SSNM for 1.0 t ha^{-1}	41.6	42.64	42.12	894	897	895	1771	1774	1772	0.33	0.33	0.33
T_5- SSNM for 1.2 t ha^{-1}	43.41	43.35	43.38	964	969	966	1856	1860	1858	0.34	0.34	0.34
T_6 - SSNM for 0.6 t ha^{-1} + Rec. FYM	39.26	40.24	39.75	810	744	777	1635	1638	1637	0.33	0.31	0.32
T_7 - SSNM for 0.8 t ha^{-1} + Rec. FYM	41.33	41.34	41.34	834	779	806	1750	1753	1752	0.32	0.31	0.31
T_8- SSNM for 1.0 t ha^{-1} + Rec. FYM	42.12	42.91	42.52	918	921	920	1807	1811	1809	0.34	0.34	0.34
T9 - SSNM for 1.2 t ha-1 + Rec. FYM	43.8	43.63	43.72	993	1013	1003	1882	1886	1884	0.34	0.35	0.35
S.Em.±	0.78	0.51	0.66	35.11	39.97	36.43	36.21	43.655	39.05	0.01	0.021	0.02
C.D. (P=0.05)	2.35	1.50	1.89	105.27	119.80	109.30	108.57	130.88	112.23	NS	NS	NS
C.V.	8.6	10.5	9.55	11.2	10.9	11.05	10.4	12.6	10.5	12.6	14.3	13.45

RDF – 62.50:75:62.50 kg NPK ha-1; SSNM for 0.6 t ha-1 – 49.37:11.46:33.72 kg NPK ha-1; SSNM for 0.8 t ha-1 – 65.83:15.28:44.96 kg NPK ha-1; SSNM for 1.0 t ha-1 – 82.30:19.11:56.21 kg NPK ha-1; SSNM for 1.2 t ha-1 – 98.75:22.92:67.44 kg NPK ha-1 ; FYM – 7.5 t ha-1

RESULTS AND DISCUSSION

Growth components of sunflower: Application of SSNM for a target yield of 1.2 t ha^{-1} + FYM (T_9) recorded significantly higher plant height (155.4 cm) over recommended package (T_1:RDF+ FYM) which recorded significantly lower plant height (142.7 cm). There was 8.9 per cent increase in the plant height due to the application of fertilizers based on SSNM compared to a recommended package. This increase in plant height may be due to greater availability of nutrients that helped in the metabolic processes of the plant leading to greater cell division, elongation and dry matter production there by increasing the plant height. Similar results have been reported by Ram *et al.* (1992) in sunflower and Anand (2010) in sunflower and maize. The results are also in line with the findings of Biradar *et al.* (2016) in rice, Indu Bala (2016) in maize, Neha Sahu (2017) in maize, Sinha (2016) in maize and Anand *et al.* (2017) in maize crops.

Significantly higher leaf area (1293.10 cm^{-2}) of sunflower (28.4 per cent increase) was obtained with application of SSNM for a target yield of 1.2 t ha^{-1} + FYM (T_9) over recommended package (T_1:RDF+ FYM) which indicated significantly lower leaf area (1007.46 cm^{-2}). Significantly lower leaf area index was obtained in T_2 (0.45). Significantly higher leaf area index was obtained with T_9 (SSNM for 1.2 t ha^{-1} + FYM) (0.69) over other treatments. Application of SSNM for 1.2 t ha^{-1} + FYM (T_9) recorded significantly higher total dry matter production (88.16 g $plant^{-1}$) compared to T_1 (75.56 g $plant^{-1}$). The extent of increase in dry matter production was 16.67 per cent over T_1. Leaf area index is the green leaf area available per unit ground surface area. LAI is used to predict and measure the photosynthetic production area of plant system, evapotranspiration and as a reference tool for crop growth. LAI plays an essential role in plants food synthesis. A plant should have higher leaf area index for higher productivity. Higher the leaf area higher is the photosynthesis and higher crop productivity (Breda, 2003). The favourable effect of optimum nutrition on higher dry matter distribution in leaf, stem and capitulum has resulted in higher total dry matter production. This increase could also be attributed to the positive effect of farm yard manure along with NPK in increasing the nutrients uptake leading to higher dry matter production. Similar results have been reported by Ram *et al.* (1992) in sunflower, Shivaprasad *et al.* (1996) in sunflower Sarmah *et al*. (2000) in sunflower, Thavaprakash (2000) in sunflower and Anand (2010) in sunflower and maize.

Application of SSNM for 1.2 t ha^{-1} + FYM (T_9) recorded significantly (P=0.05) more number days to 50 per cent flowering (64.88 days) and days to maturity (104.75 days) compared to T_1 (RDF + FYM) (62.62 and 101.35 days to 50 per cent flowering and maturity respectively). In the present study under irrigation, the supply of optimum and balanced nutrients along with FYM created a favourable environment for plant growth which enabled the plant to grow luxuriantly and put up maximum vegetative growth before they enter the reproductive phase. Thus, under assured nutrition environment extending the vegetative phase by putting better growth and delaying flowering as well as translocation of assimilates to sink by delaying maturity. Similar results have been reported by Tripathi and Kalra (1981) in sunflower, Tomar *et al.* (1997) in sunflower, Thavaprakash (2000) in sunflower, Singh *et al*. (2016) in rice, Singh *et al*. (2017) in rice and wheat and Basavanneppa *et al.* (2016) in Bt cotton.

Yield components of sunflower: In the present study, application of SSNM for target yield of 1.2 t ha^{-1} + FYM (T_9) produced significantly (P=0.05) higher hybrid seed yield (1003 kg ha^{-1}) and stalk yield (1883 kg ha^{-1}) over recommended package (T_1:RDF+ FYM) which gave significantly lower seed yield (797 kg ha^{-1}) and stalk yield (1714kg ha^{-1}**)**. The yield increase in T_9 over T_1 was in the magnitude of 25.83%. This was mainly due to the application of a balanced and optimum quantity of nutrients at the root zone enabled the crop to utilize and put higher total dry matter accumulation which translocated in seeds (Mahesh *et al.,* 2017 and Qureshi *et al*. (2016) in rice and wheat crops. This might have contributed to the increase in the yield attributes. Favourable influences on the yield attributes, in turn, contributed to the significant increase in hybrid seed yield. Similar reports of an increase in yield were noticed by Mishra *et al.* (1995), Reddy and Sudhakarababu (1997) and Biradar *et al*. (2016).

An analysis of yield attributing characters revealed that application of SSNM for a target yield of 1.2 t ha^{-1} + FYM (T_9) produced significantly (P=0.05) higher yield attributing characters compared to T_1 (RDF + FYM). Significantly higher head diameter (19.89 cm) and a number of filled seeds (353.24) were recorded with the application of SSNM for a target yield of 1.2 t ha^{-1} + FYM (T_9). Thus higher per cent of seed filling (64.84) and thousand seed weight (44.72 g) were recorded with T_9 compared to T_1. Thus the significant difference in the performance of yield attributes was observed due to the differential application of nutrients to different treatments based on SSNM approach. Thus there was the optimum quantity of nutrients at the root zone of the crop (T_9) with SSNM approach making it available to plants and subsequent assimilation leading to better translocation of photosynthates from vegetative to reproductive parts. Similar results on yield attributing parameters have been reported by Tamak *et al*. (1997) in sunflower, Devidayal and Agarwal (1999) in sunflower, Singh *et al*. (2016) in rice and Anand *et al*. (2017) in maize. The harvest index (HI) did not differ significantly due to the application of fertilizers based on SSNM treatment which may be

due to the proportionate production of seed and stalk yields in sunflower. The results are in line with Anand *et al*. (2017) in maizeand Mahesh *et al*. (2017) in rapeseed and mustard crops.

The economic evaluation of SSNM in sunflower revealed that maximum net returns were obtained in application of SSNM for a target yield of 1.2 t ha^{-1} (T_5 : Rs. 64480 ha^{-1}). Higher B: C ratio was also obtained with application of SSNM for a target yield of 1.2t ha^{-1} (T_5 : 3.28) due to higher economic yields obtained in these treatments. But the application of Rec. NPK + FYM (T_1) recorded lowest B: C ratio (2.34). The cost incurred on FYM application reduced the net returns and B : C ratio in this treatment. Similar economic benefits have been reported by Prasad and Singh (2002) in sunflower, Thavaprakash and Malligawad (2002) in sunflower, Reddy *et al*. (2002) in sunflower and Anand (2010) in chickpea and maize.

Conclusion

The present study concluded that application of fertilizers based on SSNM for a target yield of 1.2 t ha^{-1}+ Recommended FYM recorded significantly higher growth parameters viz., plant height (155.4 cm), leaf area (1293.1 cm^2), leaf area index (0.69), dry matter production (88.16 g $plant^{-1}$). The yield parameters included capitulam diameter (19.89 cm), total number of seeds (544.7), number of filled seeds (353.24), per cent seed filling (64.84), thousand seed weight (43.72 g) and hybrid seed yield of sunflower (1003 kg ha^{-1}) as compared to recommended dose of fertilizer. Thus, the application of FYM along with SSNM in sunflower improved the yield and quality of sunflower. Higher seed yield, net returns and B: C ratio of sunflower were realized with application of fertilizer based on Site Specific Nutrient Management. The application of fertilizer based on SSNM approach would not only increase crop yield but also help in reducing excess fertilizer use.

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