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Performance of summer sunflower (*Helianthus annuus* L.) hybrids under different nutrient management practices in coastal Odisha

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Abstract: The field experiment was conducted at Department of Agronomy, College of Agriculture, OUAT, Bhubaneswar during *summer* 2014 to find out appropriate hybrids and nutrient management practices for summer sunflower. Application of recommended dose of Fertiliser(RDF) i.e. 60-80-60 kg N, P_2O_5-K_2O ha^{-1}+ $ZnSO_4$ @ 25 kg ha^{-1} recorded the maximum capitulum diameter (15.60cm), seed yield (2.17 t ha^{-1}), stover yield (4.88 t ha^{-1}) and oil yield (0.91 t ha^{-1}), while application of RDF + Boron@ 1 kg ha^{-1} recorded the highest number of total seed (970) and filled seed per capitulum (890) with the lowest unfilled seed (80) and sterility percentage (9.0%). The hybrid 'Super-48' recorded the highest seed and oil yield of 2.17 and 0.91 t ha^{-1}, respectively, at recommended dose of fertiliser + $ZnSO_4$ @ 25 kg ha^{-1}. Experiment was conducted in evaluating the new hybrids in addition to evaluate the response of variety to different nutrient management practices.

Keywords: Boron, Economics Fertility levels, Sulphur, Sunflower

INTRODUCTION

Sunflower is one of the most important high quality oilseed crop widely cultivated all over world after soybean, palm and rapeseed. In India sunflower covers an area of 0.83 M ha, production with 0.54 Mt and with average yield of 655 kg ha^{-1} (Agricultural statistics at a glance 2014, GOI, Ministry of Agriculture). In Odisha, sunflower is cultivated in an area of 17.1 thousand hectares with a production and productivity of 16 thousand tons and 904 kg ha^{-1}, respectively. Non-availability of seeds of hybrid and high yielding varieties suited for different agro climatic areas, improper nutrient managements, bird damage and incidence of several diseases and insect pests lead to poor crop growth, yield attributing characters and seed yield. Yield of sunflower greatly varies due to varying genotypes/ Hybrids perform better as compared to varieties due to their better nutrient uptake and growth and vigour. Several scientists have reported about varying growth parameters , total seeds , number of filled grain oil and seed yield due to different varietal selection (Sheoran *et al*., 2014). Sustainability in production requires proper nutrient management. Sulphur is considered as the fourth most important essential element after N, P and K for crop production and it is actively involved in plant growth, flowering, pollen germination and fruiting as a whole affecting the seed and oil yield and also protein synthesis in addition to improved quality of produce owing to its role in enzymatic and metabolic processes (Roche *et al*., 2004 and Hussain *et al*., 2011). Appropriate dose of boron at sowing affect positively the inner tissues of plant which lead to head seed filling due to better development of pollen tubes, Silva *et al.* (2011) and Shekhawat and Shivay (2008).Since the environmental and health problems arising from chemical fertilizers usage, attention has been drawn to the application of biological fertilizers in agriculture. Biological fertilizers or biofertilizers contain useful microorganisms, which could colonize the rhizosphere and promote plant growth through increasing the supply or availability of essential nutrients to the plants (Vessey, 2003). Sunflower has vast potential of improving seed and oil yield, it has high quality of oil which demanded most now–a–days. More research work is needed on sunflower to explore its production. Considering above in mind a field experiment was conducted at Agronomy main research farm, College of Agriculture, OUAT, Bhubaneswar to evaluate better hybrid and nutrient management practices.

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MATERIALS AND METHODS

A field experiment was conducted at Agronomy Research Farm, Department of Agronomy, OUAT, Bhubaneswar during summer, 2014. The experimental site lies at 20^0 15'N latitude and 85^0 52'E longitude, with an altitude of 25.9 m above the mean sea level under the Agro-climatic zone of East and South Eastern Coastal Plains Zone. The experiment was laid out in split plot design with four main plot treatments viz., N_1 - P_2O_5- K_2O @ 60-80-60 kg ha^{-1} (RDF); N_2- RDF + $ZnSO_4$ @ 25 kgha^{-1}; N_3 - RDF+ Boron @ 1 kg ha^{-1} and N_4 - RDF + *Azotobacter* + *Azospirillum* + PSB (1:1:1) and four varieties V_1 – Super -48, V_2 – Super -90, V_3 – Super- 86 and V_4–Morden and replicated three times. The soil was sandy loam in texture with pH values of 5.76, EC of 0.133dS m^{-1} and organic carbon of 0.52%. The values of available nitrogen, phosphorus, potassium and sulphur were 235.7, 32.4, 120.4, 25.3 kg ha^{-1}, respectively and available boron status was 0.334 mg kg^{-1}. Well decomposed FYM was incorporated into the soil at final ploughing @ 5t ha^{-1}. Inorganic fertilizers @ 60: 80:60 kg N, P_2O_5 and K_2O ha^{-1} were applied to all the plots through urea (46-0-0), DAP (18-46-0) and MOP (0-0-64).Full P and K and a half of N were applied as basal, while the rest were top dressed at 30 days after sowing. Application of $ZnSO_4$ (25kg ha^{-1}), Boron (1 kg ha^{-1}) and *Azotobacter* + *Azospirillum* + Phosphorus solubilising bacteria (1:1:1) @ 4kg ha^{-1} each was done as basal at the time of final land preparation.

RESULTS AND DISCUSSION

Nutrient management practices

Number of seed capitulum^{-1}: The highest total seeds capitulum^{-1} (970.2) and filled seeds capitulum^{-1} (890.0) were noticed under application of RDF + Boron@ 1 kg ha^{-1} and RDF + $ZnSO_4$ was at par with the corresponding values of 955.2 and 870.7, respectively (Table 1). Increase in number of seeds due to application of boron was due to its influence on flowering, pollen germination, fertilization, cell division and improved water relationship. It increases pollen-producing capacity, anthesis and pollen grain viability. The increase in number of achene per head might be due to the role of boron in pollen tube germination. These results coincided with the findings of Ghani et al. (2000); Khan et al. (2000) they gave the evidence of positive effects of B application on number of achene in sunflower crop. Parkash and Mehra (2006) also found that boron application significantly enhanced the number of achenes per head. Application of RDF + Boron recorded 2.21, 29.26 and 58.27% higher filled grain than application of RDF+ $ZnSO_4$, RDF+ Biofertilizers and RDF alone, respectively. Application of RDF + Boron @ 1 kg ha^{-1} also resulted in lowest sterility percentage followed by application of RDF+ $ZnSO_4$ @ 25 kg ha^{-1} while the highest was recorded with application of recommended dose of fertilizer alone.

Head diameter: Application of RDF + $ZnSO_4$ @ 25 kg ha^{-1} recorded the maximum head diameter of 15.60cm and RDF + Boron @ 1 kg $ha^{-1}$with head diameter of 15.10cm was at par it. This increase may be attributed to application of sulphur leading to stimulated photosynthetic activity and contributing to growth and development of head (Hassan *et al.,* 2007).

Head dry weight (g capitulum^{-1}): Application of RDF + $ZnSO_4$ @ 25 kg ha^{-1} (80.1g capitulum^{-1}) recorded the maximum head dry weight and RDF+ Boron @ 1 kg ha^{-1} (79.8g captulum^{-1}) was statistically at par with it. This might be due to the highest values of head diameter and total seeds associated with these treatments. Similar results of increased head dry weight was also reported by Patra *et al.* (2013).

1000-seed weight: Weight of 1000 seeds was the highest under application of RDF + $ZnSO_4$ @ 25 kg ha^{-1} (49.9g) and application of RDF + Boron @ 1 kg ha^{-1} (48.3g) was statistically at par with it. Increased photosynthetic activity and protein synthesis due to sulphur application resulted in higher test weight. While boron application increased test weight through enhanced activities of dehydrogenase and phosphatase enzyme and better translocation. The lowest sterility percentage was recorded with boron application due to enhanced seed filling activity. Higher 1000 seed weight with sulphur application was in accordance with Khan *et al.* (2003).

Yield

Seed yield: Application of RDF + $ZnSO_4$ @ 25 kg ha^{-1} (2.17t ha^{-1}) resulted in the highest seed yield, which was on par with that of RDF+ Boron @ 1 kg ha^{-1} (2.12 t ha^{-1}), while the lowest was recorded under only RDF application (Table 2). This increased yield might be due to significant increase in yield attributes and better partitioning of photosynthates from source to sink. Application of RDF+ $ZnSO_4$ @ 25 kg ha^{-1} recorded in 2.5 and 11.43% increase in yield over RDF+ Boron @1 kg ha^{-1} and RDF + Biofertiliser, respectively. Treatment containing RDF+ $ZnSO_4$ @ 25 Kg ha^{-1}, RDF+ Boron @ 1 kg ha^{-1} and RDF+ Biofertiliser recorded 20.05, 17.12 and 7.73% increase in yield over RDF, respectively. Kumar and Tenua (2010) also reported increased seed yield upto 40 kg ha^{-1} from 0 kg ha^{-1}, 10kg ha^{-1} and 20 kg ha^{-1} which conformed that sulphur application increases the seed yield because sulphur deficiency affect yield and quality of crops, as it is involved in protein and enzyme synthesis as well as it is a constituent of the amino acids methionine, cystine and cysteine (Hassan *et al.,* 2007).

Stover yield: Application of RDF + $ZnSO_4$ @ 25 kg ha^{-1} produced the highest stover yield (4.88 t ha^{-1}) and RDF + Boron @ 1 kg ha^{-1} (4.82 t ha^{-1}) was statistically at par (Table-2). Application of RDF+ Biofertiliser

Table 1. Yield attributing characters of sunflower hybrids as influenced by nutrient management practices.

Treatment		Total no. of seeds	Head diameter (cm)	Head dry weight (g)	Filled grain	Unfilled grain	Test weight (g)	Sterility (%)
Nutrient management								
N_1	RDF N,P_2O_5-K_2O 60-80-60 kg ha^{-1}	676	12.61	70.5	562	110.5	45.0	16.3
N_2	RDF +$ZnSO_4$ @ 25 kg ha^{-1}	955	15.60	80.1	871	84.5	49.9	9.7
N_3	RDF + Boron @ 1 kg ha^{-1}	970	15.10	79.8	890	80.2	48.3	9.0
N_4	RDF + Biofertiliser	783	13.40	75.1	689	94.2	46.5	13..6
SEm±		24	0.19	2.1	11	1.6	0.6	-
CD (P=0.05)		71	0.66	3.2	38	5.4	1.7	-
Variety								
V_1	Super 48	981	18.83	79.5	903	77.5	49.0	8.5
V_2	Super-90	845	12.10	75.6	756	89.2	47.2	11.3
V_3	Super-86	911	13.10	76.5	812	98.2	47.5	12.1
V_4	Morden	649	12.51	71.9	540	108.5	46.0	20.0
SEm±		21	0.40	0.8	10	1.7	0.3	-
CD (P=0.05)		63	1.17	2.5	29	5.1	0.8	-

Table 2. Yield (t ha^{-1}), Harvest index, and oil content as influenced by nutrient management practices and hybrids.

Treatment		Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index	Oil content (%)	Oil yield (t ha^{-1})
Nutrient management						
N_1	RDF N,P_2O_5-K_2O 60-80-60 kg ha^{-1})	1.81	4.54	0.28	40.2	0.73
N_2	RDF +$ZnSO_4$ @ 25 kg ha^{-1}	2.17	4.88	0.30	42.1	0.91
N_3	RDF + Boron @ 1 kg ha^{-1}	2.12	4.82	0.30	41.9	0.89
N_4	RDF + Biofertiliser	1.95	4.68	0.29	40.9	0.80
SEm±		0.067	0.64	-	-	0.033
CD (P=0.05)		0.20	0.19	-		0.10
Variety						
V_1	Super 48	2.250	5.100	0.31	42.0	0.95
V_2	Super-90	2.020	4.730	0.30	41.3	0.83
V_3	Super-86	2.150	4.890	0.30	41.5	0.89
V_4	Morden	1.630	4.190	0.28	40.3	0.66
SEm±		0.03	0.065	-	-	0.02
CD (0.05)		0.09	0.19	-	-	0.06

(4.68 t ha^{-1}) recorded significantly less stover yield. Application of recommended dose of fertilizer alone (4.54 t ha^{-1}**)** produced the lowest stover yield. Treatments containing RDF + $ZnSO_4$, RDF+ Boron and RDF+ Biofertiliser recorded 7.55, 6.14 and 3.06% increase in stover yield over RDF alone, respectively.

Harvest index: Harvest index is a measure of determining productivity of a crop. Both RDF + $ZnSO_4$ and RDF+ Boron resulted in higher harvest index (0.30), which might be due to their ability for effective translocation of photosynthates towards the reproductive part rather than the vegetative parts of the

Table 3. Economic analysis (Rs. ha^{-1}) of sunflower hybrids as influenced by nutrient management practices.

Treatment		Cost of cultivation	Gross return	Net return	B- C ratio
Nutrient management					
N_1	RDF N,P_2O_5-K_2O 60-80-60 kg ha^{-1})	28000	67875	39875	2.42
N_2	RDF +$ZnSO_4$ @ 25 kg ha^{-1}	29250	81488	52238	2.79
N_3	RDF + Boron @ 1 kg ha^{-1}	29100	79500	50400	2.73
N_4	RDF + Biofertiliser	28800	73125	44325	2.53
SEm±			1286.4	838.1	0.03
CD(P=0.05)			3780	2439	0.06
Variety					
V_1	Super 48	29100	84375	55275	2.89
V_2	Super-90	29100	75750	46650	2.60
V_3	Super-86	29100	80625	51525	2.77
V_4	Morden	27500	61125	33625	2.22
SEm ±			1349.8	940.6	0.02
CD(P=0.05)			3982	2756	0.07

Table 4. Interaction of nutrient management practices and hybrids in relation to seed yield.

	V_1	V_2	V_3	V_4	Mean (t ha^{-1})
N_1	1.95	1.84	1.90	1.55	1.81
N_2	2.55	2.11	2.32	1.70	2.17
N_3	2.38	2.11	2.30	1.68	2.12
N_4	2.12	2.01	2.07	1.59	1.95
Mean (t ha^{-1})	2.25	2.02	2.15	1.63	
	Fixed main plot			**Fixed sub plot**	
SEm±	0.12			0.10	
CD	0.36			0.30	

Table 5. Interaction of nutrient management practices and hybrids inrelation to oil yield.

	V_1	V_2	V_3	V_4	Mean(t ha^{-1})
N_1	0.87	0.71	0.73	0.61	0.73
N_2	1.03	0.94	0.98	0.70	0.91
N_3	1.00	0.90	0.96	0.69	0.89
N_4	0.90	0.78	0.88	0.63	0.80
Mean (t ha^{-1})	0.95	0.83	0.89	0.66	
	Fixed main plot			**Fixed sub plot**	
SEm±	0.057			0.052	
CD	0.159			0.149	

plant. These results are in conformity with the reports of Silva *et al.* (2011) who reported increased harvest index due to application of Boron and Patra *et al* (2013) who reported increased harvest index due to sulphur application over control.

Oil content and oil yield: The highest oil content and oil yield were recorded with RDF + $ZnSO_4$ @ 25 kg ha^{-1} (42.1% and 0. 91 t ha^{-1}) and RDF + Boron @ 1 kg ha^{-1} (41.9 % & 0.89 t ha^{-1}) were at par with it. This might be due to synthesis of higher amount of sulphur containing amino acids and fatty acid (conversion of acetyl Co-A to malonyl Co-A) resulting from increased activity of thiokinase enzyme due to S supply. Application of 20 kg S/ha in sunflower (*Helianthus annuus*) resulted in 6.9% higher seed yield over its yield obtained without S application, which is in conformity with the results of Sheoran *et al.* (2013).

Higher oil content in case of boron application was due to pollination and better seed set leading to formation of protein and oil synthesis thereafter as reported earlier by Mekki *et al.* (2015).

Effect of hybrid: Performance of genotypes depends upon its genetic constituents and growth and yield attributing characters. Hybrids performed better than cultivars. Hybrid Super-48 recorded the highest head diameter (18.8cm) and capitulum dry weight (79.5g $capitulum^{-1}$). The highest number of total seeds (980.5) and number of filled grain (903.0) with the lowest unfilled seeds (77.5) and sterility percentage (8.5) was recorded in Hybrid Super -48. The variation in yield attributing characters was due to hybrids and varieties in sunflower (*Helianthus annuus*) were in accordance with Bakht *et al.* (2005) Ceyhan *et al.* (2008) and Zaidi *et al.* (2012). Yield is the combined effect of all yield attributing characters. The hybrid 'Super- 48' recorded the highest seed yield (2.25 t ha^{-1}), the highest stover yield (5.10 t ha^{-1}) and the highest harvest index (0.31). The sunflower hybrids cv. Super-48 when applied with RDF + $ZnSO_4$ @ 25 kg ha^{-1}, the maximum yield of 25.5 q ha^{-1} was recorded, (table-4) which was followed by application of RDF + Boron @ 1 kg ha^{-1} (23.8 q ha^{-1}). The hybrid 'Super-48'also recorded the highest oil yield (0.95 t ha^{-1}) which was attributed to the highest seed yield (table-5) and the highest oil content (42.0%). The hybrid 'Super- 48'recorded 14.18, 6.74 and 43.99% higher oil yield over 'Super-90', 'Super-86' and 'Morden', respectively. The hybrids viz. 'Super-90' and 'Super-86' recorded 26.06 and 34.84% higher yield, respectively, over Morden. The hybrid 'Super-48' recorded the maximum oil yield with application of RDF + $ZnSO_4$ @ 25 kg ha^{-1} (1.03 t ha^{-1}). The increased seed and oil yield in hybrids over local varieties of sunflower (*Helianthus annuus*) was also reported by Kaya and Kolsarici (2011) and Khan *et al.* (2013).

Economics: Among different nutrient management practices, the maximum gross returns, net returns and benefit-cost ratio were found to be the maximum with RDF + $ZnSO_4$@ 25 kg ha^{-1}.(Rs.81488 ha^{-1},Rs.. 52238 ha^{-1} and 2.79, respectively) and RDF+ Boron with corresponding values of Rs. .79500 ha^{-1}, Rs . 50400 ha^{-1} and 2.73 was at par with it (Table 3). This was due to higher seed and oil yield in these treatments. Application of RDF alone recorded the least gross return, net return and benefit-cost ratio due to lower seed and oil yield. Sulphur application resulted in better returns as compared to without S application (Table 5). The net monetary benefit of 3572/- and 4396/- with incremental cost benefit ratio (ICBR) of 13.3 and 7.3 per rupee invested was obtained with application of 20 and 40 kg S/ha, respectively in comparison to without S application in sunflower (*Helianthus annuus*) (Sheoran *et al* 2013), which is in conformity with our results. Among different test cultivars, the maximum gross returns (Rs. 84375 ha^{-1}), net returns (Rs. 55275 ha^{-1}) and benefit-cost ratio (2.89) were obtained with the hybrid 'Super-48' which was significantly superior to 'Super-86' and 'Super-90'. The lowest gross returns, net returns and benefit-cost ratio were observed with cv. 'Morden'. This was due to the variability among the cultivation for the seed yield and oil yield.

Conclusion

For better result and performance of sunflower in coastal Odisha condition , Hybrid -48 may be preferred due to its potential ability of yield exploitation in combination with fertiliser management with application of $ZnSO_4$ @ 25 kg ha^{-1} or boron at 1 kg ha^{-1} with recommended fertiliser dose of 60-80-60 kg ha^{-1} N, P_2O_5 and K_2O. Super-48 recorded maximum oil yield production with application of RDF +$ZnSO_4$ @ 25 kg ha^{-1} (10.3 q ha) and RDF + Boron @ 1 kg ha^{-1} (10.09 q ha^{-1}).

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