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Effect of Microbial Inoculants on Growth and Yield Parameters in Sunflower *(Helianthus annuus*)

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Sunflower *(Helianthus annuus*) is an annual species crop for its edible oil and edible fruits used as bird food, as livestock forage as meal or silage plant, and in some industrial applications. Application of *Azotobacter chroococcum, Bacillus megaterium, Trichoderma viride* as soil application with 100 per cent NPK and Foliar spray of *Trichoderma viride* has showed maximum germination percentage, increased plant height, number of leaves, stem girth and less number of days to 50 per cent flowering at all the four stages of plant growth viz., 30, 60, 90 DAS and at harvest. Similar trend was also noticed in head diameter, seed yield per hectare, 100 seed weight, and seed volume weight, oil content and residual NPK status of soil. The results of this study has clearly recorded that conjunctive use of *Azotobacter chroococcum, B. megaterium* and *T. viride* as soil application and foliar spray of *T. viride* is advantageous for the growth of Sunflower and to obtain higher crop yields.

Key words: Sunflower, Foliar spray, microbial inoculants.

Sunflower (*Helianthus annuus*), is belonging to the family of Compositae, is a major oilseed, used for the production of edible oil. At present in India, it is grown in an area of 7.22 lakh hectares with a annual production of 5.00 lakh tones having productivity of 692 kg/ha. Sunflower oil is a source of fatty molecules that can be used as reagents for chemical modifications. Sunflower oil also has excellent nutritional properties. It is practically free of significant toxic compounds and has a relatively high concentration of linoleic acid. This polyunsaturated fatty acid is an essential fatty acid (not synthesized by humans), and is the precursor of gamma-linolenic and arachidonic acids (Seiler 2007).The composition of fattyacids is a main determinant of the oil quality in sunflower. Organic agricultural practices aim to enhance biodiversity, biological cycles and soil biological activity so as to achieve optimal natural systems that are socially, ecologically and economically sustainable (Samman *et al*. 2008).

Soil microbes play an important role in many critical ecosystem processes, including nutrient cycling and homeostasis, decomposition of organic matter, as well as promoting plant health and growth as bio-fertilization (Han *et al*., 2007). In recent years, biofertilizers have emerged as a promising component of integrating nutrient supply system in agriculture. Our whole system of agriculture depends in many important ways, on microbial activities and there appears to be a tremendous potential for making use of microorganisms in increasing crop production. Microbiological fertilizers are an important part of environment friendly sustainable agricultural practices (Bloemberg *et al*., 2000).

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MATERIALS AND METHODS

The effect of biofertilizers on growth, yield and availability of nutrients in soil in Sunflower was studied at All India Co-ordinated Research Project (AICRP) on sunflower, at Zonal Agricultural Research Station (ZARS), University of Agricultural Sciences, Gandhi Krishi Vignana Kendra (GKVK) campus, Bengaluru during *Kharif* season 2012.

The experimental study we selected variety of KBSH-44 and field site was located at 12p 58 North latitude, 77p 35 East longtitude with an altitude of 899 meters above mean sea level. The experimental soil was red sandy loam in texture with initial available nitrogen (165.4 Kg/ ha), available phosphorus (26.6 Kg/ ha) and available potassium (65.7 Kg/ ha) and initial soil population was analyzed using serial dilution plate count method. The field experiment was laid out in Randomized Complete Block Design (RCBD) which had 12 treatments and three replications. Treatments T1: 100 % NPK, T2: 75 % NP +100 % K, T3: T1 + S.A of *A. chroococum* + PSB + *T. viride* + F.S of *T. viride*,T4: T2 + S.A of *A. chroococum* + PSB + *T. viride* + F.S of *T. viride*,T5: T1 + S.A of *A. chroococum* + PSB + *T.viride* + F.S of *S. griseus* T6:T2 + S.A of *A. chroococum* + PSB + *T.viride* + F.S of *S. griseus*,T7: T1 + S.A of *A. chroococum* + PSB + *B. subtilis* + F.S of *T. viride*,T8: T2 + S.A of *A.chroococum* + PSB + *B. subtilis* + F.S of *T.viride*,T9: T1 + S.A of *A. chroococum* + PSB + *B. subtilis* + F.S of *S. griseus*

T10:T2 + S.A of *A.chroococum* + PSB + *B. subtilis* +F.S of *S. griseus*, T11: T1 + Mancozeb spray at 0.3 %, T12: T1 + Propiconozole spray at 0.1 %.

Note: S A- Soil application and F S- Foliar spray

1. FYM is common to all the treatments as basal application at recommended dose (7.5 t ha^{-1}).
2. 50% Urea was applied as basal dose and 50% as top dressing.
3. Biofertilizers as soil treatment: Applied to soil 7 days after sowing.

The microbial inoculants used in the experiment were obtained from Biofertilizer scheme of Department of Agricultural Microbiology. The microbial inoculants used in the study were, *Azotobacter chroococcum* as N fixer, *Bacillus megaterium* as P-solubilizer , *Trichoderma viride, Bacillus subtilis, Pseudomonas fluorescens* and *Streptomyces griseus* as bioagents.

Microbial inoculants were mass multiplied under laboratory condition using respective media like *A. chroococcum* on Ashby's broth, *Bacillus megaterium* on Pikovoskaya's broth, *T. viride* on *Trichoderma* specific medium and *Pseudomonas fluorescens* on King's B broth. After attaining desirable population, the culture was mixed aseptically in pre-sterilized charcoal powder which was neutralized with calcium sulphate. The mixing proportion was 1: 0.6: 2.5 (1 litre broth: 600g CaSo4: 2.5kg charcoal), and was used in the field study as soil application at the rate of 10 kg ha^{-1}.

The observations on crop growth parameters (per cent germination, plant height, number of leaves, stem girth, days to 50 per cent flowering) were recorded at 30,60, 90 days after sowing and at harvest stage, yield parameter (head diameter, seed yield per plot and hectare, oil content and oil yield) and seed quality parameters (hundred seed weight and volume weight,) were recorded after crop harvest.

The experimental data was analyzed statistically by Fischer's method of analysis of variance as given by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Growth parameters

The combined application of organic and inorganic fertilizers in combination with biofertilizers has significantly influenced the growth parameters in Sunflower hybrid KBSH 44. Among the treatments, biofertilizer treated plants showed significantly superior plant growth over plants not treated with biofertilizers at all the stages of plant growth (30, 60, 90 DAS and at harvest stage).

The highest germination percentage was recorded treated with microbial consortia of *Azotobacter chroococcum, PSB, Trichoderma viride* and foliar spray of *Trichoderma viride* with 100% NPK (T3) showed maximum germination (96.39%) which was statistically on par with the next best treatment combinations of *Azotobacter chroococcum, PSB, Trichoderma viride* and foliar spray of *Streptomyces griseus* with 100% NPK (T5) (96.11%). The treatment T_2 showed the lowest

Table 1. Effect of microbial inoculants on Growth parameters of sunflower hybrid KBSH 44

Treatments	Germination	Plant height (cm)				Number of leaves/plants				Stem Girth (cm)				Days
	(%) at 10 DAS	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	30 DAS	60 DAS	90 DAS	At Harvest	to 50%
T_1	90.94	19.81	120.71	168.80	168.97	12.60	22.13	11.80	10.13	1.15	1.65	1.75	1.70	66.67
T_2	87.77	17.90	118.40	163.37	164.15	11.33	20.67	10.87	9.80	1.10	1.49	1.71	1.57	67.00
T_3	96.39	25.16	146.95	189.33	189.60	12.67	30.13	24.53	16.07	1.25	1.90	2.31	2.07	64.33
T_4	94.39	23.60	140.07	182.60	182.92	11.93	26.87	21.87	13.20	1.21	1.63	2.01	1.87	65.00
T_5	96.11	24.90	145.07	187.13	187.39	12.53	29.07	23.87	14.40	1.23	1.81	2.25	2.01	64.67
T_6	94.33	23.47	139.40	180.07	180.37	11.80	26.47	21.47	13.07	1.19	1.60	2.07	1.81	65.33
T_7	92.33	21.63	133.73	173.60	173.87	12.53	28.13	23.73	14.40	1.23	1.67	2.13	1.99	64.67
T_8	90.33	20.99	130.67	171.24	171.31	11.80	26.27	20.00	12.07	1.22	1.65	2.02	1.79	66.00
T_9	92.00	21.45	133.20	173.57	173.78	12.53	26.73	22.10	14.13	1.21	1.63	2.04	1.81	64.67
T_{10}	90.67	20.63	130.36	170.93	170.99	11.67	25.33	19.73	11.27	1.19	1.65	1.91	1.80	66.33
T_{11}	88.50	19.12	119.61	164.93	164.59	11.33	21.67	10.93	9.67	1.11	1.58	1.68	1.60	66.00
T_{12}	89.33	19.53	120.77	165.67	165.91	12.47	21.73	11.20	10.20	1.13	1.62	1.73	1.65	66.33
F- test	*	*	*	*	*	NS	*	*	*	NS	*	*	*	NS
S.Em±	1.15	0.93	4.42	5.25	5.45	-	1.05	0.82	0.53	-	0.06	0.08	0.09	-
CD at 5%	3.36	2.71	12.97	15.39	15.60	-	3.09	2.42	1.57	-	0.17	0.23	0.26	-

Table 2. Effect of microbial inoculants on yield parameters of sunflower hybrid KBSH 44

Treatments	Head diameter (cm)	Seed yield per plot (kg)	Seed yield (kg ha^{-1})	100 seed Weight (g)	Volume seed weight (g/100 ml)	Oil content (%)	Oil yield (kg ha^{-1})
T_1	20.07	1.44	1603.32	5.81	53.52	37.18	596.88
T_2	18.67	1.31	1458.24	5.61	53.41	37.00	540.92
T_3	24.33	2.04	2276.64	7.19	56.80	37.64	844.69
T_4	22.07	1.72	1919.52	6.10	55.05	37.26	722.43
T_5	24.20	2.00	2235.72	7.10	56.05	37.50	840.22
T_6	21.47	1.74	1941.84	6.30	54.15	37.29	729.54
T_7	22.87	1.75	1953.00	7.09	55.72	37.43	734.01
T_8	21.93	1.71	1908.36	5.94	54.91	37.16	715.64
T_9	22.20	1.74	1938.12	6.19	55.37	37.32	721.94
T_{10}	21.60	1.73	1926.96	5.84	54.84	37.14	714.63
T_{11}	19.80	1.37	1525.20	5.66	53.58	37.07	564.30
T_{12}	20.11	1.40	1562.40	5.78	53.94	37.10	567.97
F- test	*	*	*	NS	NS	NS	*
S.Em±	0.68	0.09	100.79	-	-	-	38.04
CD at 5%	1.99	0.26	295.61	-	-	-	111.57

germination percentage (87.77%) having 75%NP + 100% K (Table 1). The application of microbial consortia resulted in better seed germination and enhanced plant growth. These beneficial microorganisms are known to secrete biologically active, plant growth promoting substances like IAA, gibberellins, cytokinins, vitamins, etc., which enhances seed germination, seedling vigour and root growth of plants, thus improving the yield of crops (Moeinzadeh *et al.*, 2010). Many earlier research studies have also showed that combined use of organic manures and biofertilizers along with mineral fertilizers improve soil fertility and productivity (Reddy *et al.*, 2005; Iraj *et al.*, 2009). The plant height was significantly higher in plants treated with consortial application of *Azotobacter chroococcum*, *PSB*, *Trichoderma viride* and foliar spray of *Trichoderma viride* with 100% NPK (T3) (25.16 cm, 146.95 cm, 189.33 cm and 189.60 cm at 30, 60, 90 DAS and harvest stage respectively) (Table.1 & Fig.1). The lowest plant height was recorded in the treatment of 75%NP + 100%K (T2) (17.90 cm, 118.40 cm, 163.37cm and 164.15 cm). The plant height was significantly increased due to microbial inoculation at all the stages of plant growth viz., 30, 60, 90 DAS and at harvest, which is due to better supply of nitrogen by biological means and efficient solubilization of unavailable P to available P form. The production of biologically active substances by these microorganisms might have helped in better nutrient uptake for the plant growth. These results are in conformity with the findings of many research workers who reported such increased plant height was due to biofertilizers application in crops like canola (Megawer and Mahfouz, 2010; Khan *et al.*, 2010), soybean (Ramamurthy et al., 2001), black gram (Rathi *et al.*,2009) and sunflower (Zehra Ekin, 2011).

More number of leaves were obtained in the plants inoculated with *Azotobacter chroococcum*, *PSB*, *Trichoderma viride* and foliar spray of *Trichoderma viride* with 100% NPK at all the stages of plant growth viz., 30, 60, 90 DAS and at harvest (12.67, 30.13, 24.53 and 16.07 respectively) (Table 1).

The stem girth increased in all the growth stages i.e., 30, 60, 90 DAS and decreased at hatvest

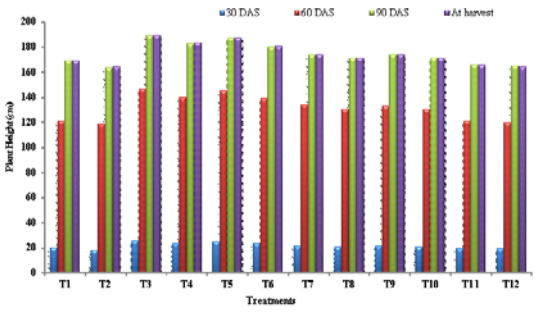

Fig.1. Effect of microbial inoculants on Plant height in sunflower

(Table 1). The highest stem girth was observed in plants supplemented with *Azotobacter chroococcum, PSB, Trichoderma viride* and foliar spray of *Trichoderma viride* with 100% NPK (1.25cm,1.90 cm, 2.31 cm and 2.07 respectively). These results correlate with the findings of Mohsen Javahery *et al*. (2011) who studied the effects of biofertilizer application on phenology and growth of sunflower (*Helianthus annuus L.*).

Seed quality parameters

Good seed is the basis for successful crop production programme. The quality seed are ensured with uniform germination, rapid root and shoot development (seedling vigour) to obtain healthy and robust seedlings for increased yield per unit area. The seed quality parameters like 100 seed weight and volume weight yield differed significantly due to treatments. combined application of microbial inoculants *viz., A. chroococcum, B. megaterium, T. viride* and foliar spray of *T. viride* with 100 per cent NPK has recorded significantly higher 100 seed weight (7.19 g) and volume weight (56.08 g 100 ml^{-1}) compared to other treatments (Table 2). The improvement in seed quality parameters may be attributed to the nutrition of sunflower crop due to the accumulation of higher quantities of seed reserves like protein and carbohydrates. These results are in agreement with the findings of Seshasailasree (2005) who reported that the combined inoculation of *Azotobacter* and *Azospirillum* could enhance the yield of rainfed sunflower to an extent of 37.9 per cent, compared to control.

Yield and yield parameters

The highest head diameter (24.33 cm) was recorded (Table.2,Fig.2&3) in plants treated with (T3) 100% NPK + *Azotobacter chroococcum* + *PSB* + *T.viride* + Foliar spray of *T.viride* which was superior over all other treatments and the lowest head diameter was found in (T2) 75%NP +100%K (18.67 cm). These findings are in accordance with the findings of Sanaz Shoghi Kalkhoran *et al.,* (2010) who studied integrated use of chemical, organic and biofertilizer (*Azotobacter* and *Azospirillum*) and with the results earlier obtained in sunflower by Mallikarjuna *et al.,* (2000) and Ram *et al.,* (1992).

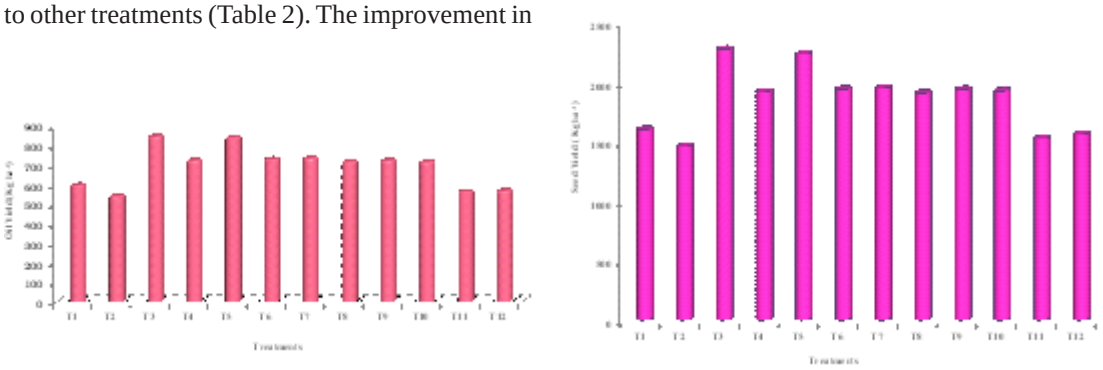

Fig. 2-3. Effect of microbial inoculants on oil yield & seed yield in sunflower

The combined inoculation of *A. chroococcum, B. megaterium, T. viride* and foliar spray of *T. viride* with 100 per cent NPK has resulted in higher seed yield of sunflower per plot (2.04 kg/plot), seed yield per hectare (2276.64 kg ha^{-1}), oil yield (844.69 kg ha^{-1}) and oil content (37.64%). These results are in accordance with the results obtained by earlier research workers in sunflower (Nanjundappa *et al*., 2001; Ramamurthy and Shivashankar, 1995 and Mallikarjuna *et al*., 2000) and Ahmed *et al*., (2011) who reported the effect of bio-N-P fertilizer on the growth, yield and some biochemical components of two sunflower cultivars i.e.,Vedock and Hy-sun 35.

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