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Effects of Phosphorus Solubilizing Biofertilizers on Plant Growth and Seed Yield in Seed Parent of Sunflower (*Helianthus annuus* L.) Hybrid KBSH-44

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ABSTRACT One of the major causes for low productivity of sunflower is poor seed setting which is due to insufficient nutrient (phosphorus) supply to the sink. Dual inoculation of phosphorus solubilizing biofertilizers, *i.e.* either *B. megasterium* or *P. striata* with *G. fasiculatum*, 60 or 90 days from sowing (DFS), significantly increased plant growth characters, *viz.* plant height, number of leaves, leaf area, stem girth, early flowering and decreased the days to maturity as compared to either uninoculated control or single inoculation. Likewise, significantly higher seed yield, *viz.* higher head diameter, seed filling % were recorded. A significant increase of raw seed yield (21.25%), seed recovery (%) and processed seed yield (20.67%) were also recorded in dual inoculations. Application of 100% recommended doses of phosphorus fertilizer (RDPF) showed significantly higher yield and yield attributes as compared to 50% RDPF.

Key words: Sunflower, productivity, nutrient supply, phosphorus, plant growth, seed yield

Low productivity of sunflower is due to poor seed setting and high per cent of chaffy seeds in the capitulum. One of the major causes for poor seed setting is insufficient nutrient supply to the sink. Among the important nutrients, phosphorus is considered as most important because more than two-thirds of native phosphates are unavailable to the plants and applied P fertilizers are also unavailable within a short period due to chemical fixation in the soil. The role of phosphorus solubilizing biofertilizers (PSB) is unique since it makes the fixed soil-P available to the plants. Mycorrhizae, a symbiotic fungus helps the plants in mobilization of phosphorus and certain other micro elements such as Zn, Cu, Mn and Fe, *etc.* through its extensive network of hyphae.

MATERIALS AND METHODS

A field experiment was conducted during *rabi* season at the main research station, Hebbal, University of Agricultural Sciences, Bangalore. The soil of experimental field is red sandy loam with neutral pH (6.8), electrical conductivity 0.46 dS m^{-1} and the organic carbon 0.38 per cent. The available nitrogen, phosphorus and potash of the soil were 245, 21 and 240 kg/ha, respectively. The recommended dose of fertilizers for the crop was 60 : 90 : 60 kg NPK/ha. The 50 per cent dose of N and full dose of P and K was applied as basal, and remaining 50 per cent N was applied after 30 days from sowing as topdressing. Nitrogen in the form of urea and potassium in the form of muriate of potash (MOP) were applied equally to all the plots. Phosphorus was applied at two levels, *viz.* 50 and 100 per cent of the recommended dose in the form of single super phosphate (SSP) as per the treatment schedule. The study included 2 factors, *viz.* levels of P fertilizer at 2 levels, *viz.* 50 and 100 per cent recommended dose of phosphatic fertilizers (RDPF) and biofertilizer inoculations at 6 levels, *viz.* control, *Bacillus megaterium*, *Pseudomonas striata*, *Glomus fasciculatum*, *B. megaterium* + *G.*

fasciculatum and *P. striata* + *G. fasciculatum*. Biofertilizers used in the study were obtained from the Biofertilizer Scheme of Department of Agricultural Microbiology, UAS, GKVK, Bangalore.

Nucleus seed of 'A' and 'B' lines, *viz.* CMS 17 A and CMS 17 B obtained from Breeder of AICRP on sunflower, UAS, GKVK, Bangalore, were treated with PSB @ 4 g/100 g of seeds. The VAM was applied to soil @ 1 q/ha at the time of sowing. Treated seeds were sown @ 2 seeds per hill in individual plots measuring 3 m x 1.8 m, and each treatment was replicated thrice in completely randomized block design. For recording various biometric observations, five randomly selected plants were tagged at vegetative stage in each treatment.

RESULTS AND DISCUSSION

Growth parameters

At early stage of plant growth, *i.e.* 30 days from sowing (DFS), no significant increase in plant height and number of leaves was observed due to the inoculation of P solubilizing biofertilizers. However, at 60 and 90 DFS, dual inoculation of either *B. megaterium* or *P. striata* with *G. fasciculatum* increased plant height and number of leaves significantly as compared to either uninoculated control or single inoculation. Single inoculation increased number of leaves significantly at 90 DFS. Application of 100 per cent recommended dose of phosphatic fertilizer (RDPF) showed significantly higher plant height and number of leaves at all stages of growth as compared to 50 per cent RDPF.

The increase of plant height and number of leaves in sunflower due to inoculation with P solubilizing biofertilizers has been shown by Jones and Sreenivasa [1], Gadagi and Alagawadi [2], and Chinnamuthu and Venkatakrishnan [3]. The increase in plant height and number of leaves with dual inoculation of P solubilizing biofertilizers was due to enhanced nutrient uptake, especially phosphorus, by plants due to synergic interaction of these organisms through solubilization of unavailable P either by *B. megaterium* or *P. striata* as well as increased P nutrient through *G. fasciculatum*. It was attributed to the production of plant growth promoting substances in the vicinity of roots, by inoculated biofertilizers as most of the P solubilizers are known to produce IAA, GA and cytokinins like substances [4]; whose role in shoot and root elongation as well as plant growth is well established [5].

Leaf area was significantly increased with dual inoculations as well as 100 per cent RDPF at 30, 60 and 90 DFS. Leaf area was increased due to single inoculation of either *B. megaterium* or *P. striata* or *G. fasciculatum* only at 60 and 90 DFS. However, leaf area was maximum with dual inoculation of either *B. megaterium* or *P. striata* with *G. fasciculatum*, suggesting synergistic interaction between these organisms. Increased cell elongation and multiplication due to enhanced nutrient uptake especially P and production of plant growth substances by P solubilizing biofertilizers resulted in increased leaf area. Increased leaf area due to inoculation with P solubilizing biofertilizers was also reported by Jones and Sreenivasa [1] and Nandagopal *et al.* [6].

Stem girth at 90 DFS was significantly higher only with dual inoculation of either *B. megaterium* or *P. striata* with *G. fasciculatum*. Application of 100 per cent RDPF showed significant increase of stem girth as compared to 50 per cent RDPF. Increased cell elongation and multiplication due to enhanced P uptake had contributed to the increased stem girth as P was known to stimulate meristematic growth. Similar increase in stem girth with dual inoculations was observed by Jones and Srinivasa [1] in sunflower.

Days to 50 per cent flowering and maturity

Early flowering occurred with dual inoculation of either *B. megaterium* or *P. striata* with *G. fasciculatum* as well as due to 100 per cent RDPF. The PSB and VAM fungi are known to produce cytokinins [7] due to which flowering was advanced in dual inoculation treatment. Similar observations on early flowering in sunflower due to dual inoculation with *P. striata* and *G. fasciculatum* in sunflower was reported by Jones and Sreenivasa [1]. Observations made on

Table 1. Effect of levels of phosphorus and phosphorus solubilizing biofertilizers on plant gowth in seed parent of sunflower hybrid KBSH-44

Treatment	Plant height (cm)			Number of leaves			Leaf area (cm^2)			Stem girth (cm)	Days to 50% flowering	Days to maturity
	30 DFS	60 DFS	90 DFS	30 DFS	60 DFS	90 DFS	30 DFS	60 DFS	90 DFS			
Phosphorous (kg/ha)												
50	22.41	122.43	123.96	12.27	22.42	3.73	122.56	329.4	71.08	4.02	62.00	89.55
100	24.84	130.39	132.35	13.81	26.39	6.43	129.49	385.22	98.2	4.55	59.94	87.22
CD (p=0.05)	1.24	2.67	2.76	0.68	2.10	0.41	2.12	16.85	4.47	0.22	0.74	1.00
Phosphorus solubilizing biofertilizers												
Uninoculated (control)	22.82	121.77	123.03	12.38	21.68	3.32	123.59	321.32	69.57	3.95	62.16	90.16
B. megaterium	23.75	125.62	127.53	13.05	24.02	5.01	125.44	352.56	79.15	4.23	61.33	88.83
P. striata	23.46	125.32	127.36	12.83	23.75	4.6	125.28	346.55	77.96	4.16	61.50	89.00
G. fasciculatum	23.38	126.44	128.15	12.96	24.85	5.31	124.90	356.37	85.44	4.32	61.00	88.00
B. megaterium + *G. fasciculatum*	24.41	130.00	131.59	13.62	26.30	6.26	129.01	387.59	98.36	4.58	59.83	87.00
P. striata + *G. fasciculatum*	24.06	129.31	131.28	13.42	25.83	5.97	127.92	379.46	97.37	4.50	60.00	87.33
CD (P=0.05)	NS	4.62	4.78	NS	3.64	0.71	3.67	29.19	7.74	0.38	1.29	1.73

days to maturity showed that dual inoculation of either *B. megaterium* or *P. striata* with *G. fasciculatum* significantly decreased the days to maturity. This trend support to the long held view that increased uptake of phosphorus hastens the plant maturity [8].

Seed yield and yield attributes

Application of 100 per cent RDPF showed significantly higher seed yield and yield attributes as compared to 50 per cent RDPF. Significantly higher head diameter, number of filled seeds, seed filling per cent and lesser number of unfilled seeds were recorded due to single and dual inoculations. However, these were highest with dual inoculation of either *B. megaterium* or *P. striata* together with *G. fasciculatum*. Increased plant height, number of leaves and leaf area due to dual inoculations contributed for more production and translocation of photosynthates to sink (seeds).

Moreover, 'p' is the major key element necessary for the synthesis of amino acids, proteins and nucleic acids. The high supply of which due to dual inoculations, resulted in more seed filling, good seed development, leading to production of more number of filled seeds. The increase in number of filled seeds and seed filling per cent due to inoculation with P solubilizing biofertilizers was reported by several workers [2, 6, 9 and 10].

Table 2. Effect of levels of phosphorus and phosphorus solubilizing biofertilizers on seed yield parameters in seed parent of sunflower hybrid KBSH-44

Treatment	Capitulum diameter (cm)	Seed yield/ plant (g)	No. of filled seeds	No. of unfilled seeds	Seed filling (%)	Raw seed yield (kg/ha)	Processed seed yield (kg/ha)	Seed recovery (%)
Phosphorus kg/ha								
50	15.26	37.63	639.94	160.94	79.83 (63.39)	1460.6	1154.8	78.98 (62.72)
100	17.20	43.90	720.80	127.76	84.70 (67.03)	1716.0	1408.8	82.03 (64.93)
CD (p=0.05)	0.33	1.60	23.84	7.15	0.70	42.2	54.7	0.73
Phosphorus solubilizing biofertilizers								
Uninoculated (control)	15.29	37.33	629.33	164.52	79.02 (62.78)	1449.4	1145.1	78.85 (62.64)
B. megaterium	16.04	40.17	676.56	149.78	81.67 (64.73)	1563.4	1253.2	80.01 (63.46)
P. striata	15.96	39.96	670.83	153.07	81.29 (64.54)	1552.3	1242.2	79.88 (63.36)
G. fasciculatum	16.27	40.63	684.75	143.58	82.54 (65.39)	1581.0	1276.3	80.59 (63.88)
B. megaterium + *G. fasiculatum*	17.11	43.58	714.00	124.90	84.88 (67.18)	1697.5	1392.3	81.89 (64.84)
P. striata + G. fasiculatum	16.71	42.94	706.75	130.26	84.19 (66.63)	1686.4	1381.8	81.80 (64.78)
CD (p=0.05)	0.581	2.77	41.30	12.39	1.22	73.2	94.9	1.26

Figures in parantheses are transformed values

A significant increase in seed yield/plant was observed with dual and single inoculations. However, seed yield/plant was highest with dual inoculation of either *B. megaterium* or *P. striata* together with *G. fasciculatum*. Seed yield/plant is the manifestation of yield-contributing characters, like head diameler, number of filled seeds/head and seed filling per cent. Hence, a significant increase in all these characters, due to inoculations, lead to significant increase in seed yield/plant. Increased seed yield/plant due to single or dual inoculations with *P. striata* and *G. fasciculatum* was well established by Jones and Sreenivasa [1] in sunflower. Increased seed yield/ plant in sunflower due to inoculation with P solubilizing biofertilizer was reported by several workers [6, 10-12].

A significant increase in raw seed yield, seed recovery per cent and processed seed yield was recoded in case of both dual and single inoculations. However, highest raw seed yield, seed recovery per cent and processed seed yield were observed with dual inoculations of either *B. megaterium* or *P. striata* with *G. fasciculatum*. The increase in processed seed yield was 21.25

and 20.67 per cent, respectively with dual inoculations of *B. megaterium* or *P. striata* with *G. fasciculatum*. This was due to increased seed yield/plant and good seed development with inoculation. Increase of seed yield/ha due to inoculation with P solubilizing biofertilizers was documented by Renugadevi and Balamurugan [10] in sunflower. Similar increase in seed yield was reported by several workers [3, 6, 10-12]. In conclusion, dual inoculations of P solubilizing bacteria *B. megaterium* or *P. striata* with *G. fasciculatum* was more beneficial than individual inoculation to obtain higher seed yield in sunflower.

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