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EFFECTS OF PHOSPHORUS LEVELS, PHOSPHATE SOLUBILIZING BACTERIA APPLICATIONS AT VARYING DOSES AND TECHNIQUES ON PLANT STAND, OIL CONTENT AND YIELD OF SUNFLOWER (*HELIANTHUS ANNUS* L.)

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ABSTRACT

A field experiment was conducted to study the effect of different doses and method of phosphate solubilizing bacteria (PSB) application and the phosphorus levels on sunflower during *Rabi*, 2020 at College of Agriculture, PJTSAU, Rajendranagar, Hyderabad, Telangana, India. The experiment was laid out in Randomized Block Design, comprising eleven treatments with three replications. Initial soil parameters of experimental site indicated that the soil belongs to sandy loam texture, with alkaline in soil reaction, non-saline, and low in organic carbon (OC), low in available nitrogen, medium in available phosphorus, available potassium and available sulphur. The results showed that the sunflower growth parameters were not markedly influenced by either PSB or Phosphorus levels when applied alone but had significantly improved the growth of sunflower. Combined application of PSB and reduced P levels had significant effect on the sunflower seed yield. The study indicated that application of Phosphorus @ 67.5 kg ha^{-1} along with soil application of PSB @ 6kg ha^{-1} produced the highest seed yield of 23.79 q ha^{-1} over all the other treatments and also highest oil yield (925.81 kg ha^{-1}) than the other treatments. The above study indicated that combined application of PSB with reduced P levels could help in saving fertilizer dose to the extent of 25%.

Key words : Phosphate Solubilizing Bacteria, Phosphorus levels, Yield attributes, Yield, Oil yield.

Introduction

Sunflower (*Helianthus annus* L.) belongs to the family *Asteraceae* and is characterized by considerable decor ability, as production of heads varying in the different cultivars by size and colour of the flower, from cream to yellow. It is a potential source of edible oil, ranges with 48 - 52% of good quality edible oil (FAO). The global sunflower seed, oil and meal production in the year 2018-19 was estimated at 51.41 mt, 19.45 mt and 20.90 mt. In India during *Rabi* 2018-19 sunflower had occupied 1.145 lakh hectares area, while in Telangana 2030 ha. In Telangana, Siddipet with an area of 1226 ha is the major sunflower producing district. Since introduction of this crop in India during 1970s, productivity has remained low as compared to world average productivity though the area under this crop has increased markedly (Krishnamurthy *et al*., 2011). Phosphorus (P) is the second most abundantly required plant nutrient element after nitrogen to crop plants. Phosphorus positively affects the sunflower growth and productivity by increasing photosynthetic rate and the radiation use efficiency and consequently the availability of assimilates (Rodriguez *et al*., 1998). The potential for improving seed set and filling in sunflower also seems to be mainly associated with increased assimilates ratio (Karadogan *et al*., 2009) and higher phosphorus uptake can increase seed sets and improve yields (Zubillaga *et al*., 2002). Seed composition is also affected by phosphorus supply,

which particularly increased oil content in the seed. Thus, the general findings of researchers show that the most effective method to increase seed or oil yield of sunflower is adequate P supply (Zubillaga *et al*., 2002).

Phosphate solubilizing bacteria (PSB) play an important role in enhancing phosphorus availability to plants by lowering soil pH by microbial production of organic acids and mineralization of organic phosphorus. Introduction of PSB in the rhizosphere of crop also increases the efficiency of phosphate fertilizers (Gaur, 1990). Most of the soils in Telangana are low in available phosphorus status, farmers are using high amount of DAP fertilizer, to reduce the cost on fertilizer and also to increase the availability of phosphorus, present study has been investigated.

Materials and Methods

The experiment was conducted during *Rabi*, 2020 and the geographical location of the experimental site was 17° 32' N Latitude, 78° 40' E Longitude with an altitude of 477 m above mean sea level. Agro-climatologically the area is classified as Southern Telangana Agro Climatic Zone of Telangana state.

The experimental soil was sandy loam in texture, alkaline in soil reaction, non - saline, low in OC and available nitrogen, medium status of available phosphorus, available potassium and available sulphur. The experiment was laid out in RBD comprising eleven treatments with three replications. The experimental details is given in Table 1.

To sunflower (KBSH –78) hybrid RDF of 60:90:30 kg ha^{-1} NPK was applied. Uniform dose of N and K was applied to all the treatment. While P was applied as per the treatments given in Table 2. PSB was applied as soil application and drenching at the time of sowing. Lignite based powder form with two doses @ 3 and 6 kg per hectare was properly mixed with vermicompost @ 1 t ha^{-1} was applied to soil in the sowing line. The liquid PSB @ 8 L per hectare was drenched in the sowing line.

Table 1 : Experimental details.

Technical details	Experiment
Season	*Rabi*, 2020
Design	Simple RBD
Replication	03
Treatments	11
Varities	KBSH – 78
Seed rate	5 kg ha^{-1}
Spacing	60 × 30 cm
Duration	98 days
RDF	60:90:30 kg ha^{-1} NPK
Gross plot size	4.8m × 3 m
Net plot size	3.6m × 2.4 m

Table 2 : Treatment details.

Treatment	Treatment detail
T_1	100% NPK , (RDF)
T_2	No P
T_3	No P + PSB-D
T_4	No P +PSB-SA_1
T_5	No P + PSB-SA_2
T_6	75 % P + PSB-D
T_7	75 % P+ PSB-SA_1
T_8	75 % P + PSB-SA_2
T_9	50% P + PSB-D
T_{10}	50% P+ PSB-SA_1
T_{11}	50% P + PSB-SA_2

D = Drenching @ 50 ml L^{-1} or 8 L ha^{-1}.
SA_1 = Soil application of PSB @ 3 kg ha^{-1}
SA_2 = Soil application of PSB @ 6 kg ha^{-1}.

Plant stand

The plant stand was recorded using a meter square quadrant and no. of plants per meter square was counted and the mean was calculated for each plot by taking five point observation in each plot.

Test weight

Random hundred seeds were selected from net plot produce and weight was recorded for each plot and average was calculated and expressed in grams.

Seed yield

The net yield was recorded after drying of the economic produce. The final yield was reported as quintal per hectare.

Quality analysis

Oil content

Seed sample was drawn from each net plot procedure, for oil estimation. The oil content of seed for each treatment was determined by using continuous type pulsed Nuclear Magnetic Resonance (NMR-oxford MQC) at Bio-chemistry Laboratory, ICAR-IIOR as suggested by Tiwari *et al*. (1974) and there by oil present in the seed was recorded directly.

Oil yield

The oil yield (kg ha^{-1}) was estimated by multiplying oil content with the seed yield.

$$\text{Oil yield (Kg ha}^{-1}) = \frac{\text{Seed yield (Kg ha}^{-1}) \times \text{Oil content (\%)}}{100}$$

The data was statically analyzed by adopting the standard methods for Randomized block design as suggested by Panse and Sukhatme (1978) with the help of computer software (CVSTAT).

Results and Discussion

Yield parameters

The results indicated that application of PSB and P levels independently had a non-significant effect on the growth parameter of sunflower *viz.*, Plant stand and test weight (Table 3). However, the combined application of reduced P levels with PSB had produced prominent effect on yield as given below.

Plant stand

From the Table 3, there was a non-significant effect on the plant stand with PSB and P levels. Among, all the treatments, Highest plant stand was noticed in the treatment T_5 (9.22), due to No P + PSB-SA_2 and the lowest was observed with the T_2 (7.55), No P.

Test weight (100 seeds) (g)

From the results, there was a non-significant effect of PSB and P levels on test weight of sunflower. Among, the treatments highest was obtained in T_8 (5.02 g) with 75% P+ PSB – SA_2 and the lowest was noticed in T_6 (4.20 g) treated with 75% P + PSB-D. Almost similar trend was observed by Arif *et al*. (2003), who found that by increasing NP levels in sunflower, had increased 100-seed weight was also increased.

These results were supported by the findings of Zafar *et al.* (2011) and Bera *et al.* (2014). The increase in head diameter might be due to more leaf area index and more nutrients uptake by the crop from root zone. Inoculation with PSB led to overall increase in chlorophyll content, nitrogen and phosphorus content of plant as compared to un-inoculated treatment (Neenu *et al*., 2014; Pramanik and Bera, 2012 and Bhattacharjee and Sharma, 2012).

Seed yield (q ha^{-1})

The results pertaining to the effect of different doses and methods of PSB application and P levels on seed yield of sunflower has been presented in Table 4 and Fig. 1. There was a significant effect of PSB and P levels on seed yield of sunflower. The highest seed yield (23.79 q ha^{-1}) of sunflower was recorded in treatment T_8 (*i.e*, application of phosphorus @ 67.5 kg/ha along with PSB as soil application @ 6kg ha^{-1}) this was at par with treatment T_7 (23.05 q ha^{-1}). The lowest seed yield (16.38 q ha^{-1}) was observed in T_2 treatment, where no phosphorus was applied.

Table 3 : Effect of different doses and methods of PSB application and P levels on yield attributes of sunflower.

Treatment	Treatment details	Plant stand	Test weight (g)
T_1	100% NPK, (RDF)	8.4	4.8
T_2	No P	7.5	3.5
T_3	No P + PSB-D	8.1	4.4
T_4	No P +PSB-SA_1	8.4	3.7
T_5	No P + PSB-SA_2	9.2	3.8
T_6	75% P + PSB-D	8.0	5.2
T_7	75% P+ PSB-SA_1	8.7	4.7
T_8	75% P + PSB-SA_2	8.7	5.1
T_9	50% P + PSB-D	7.6	5.3
T_{10}	50% P + PSB-SA_1	7.9	5.9
T_{11}	50% P + PSB-SA_2	7.9	5.6
	SEM ±	0.45	0.5
	CD (0.05)	NS	NS

Table 4 : Effect of different doses and methods of PSB application and P levels on seed yield (q ha^{-1}) of sunflower.

Treatment	Treatment detail	Sunflower (q ha^{-1})
T_1	100% NPK, (RDF)	19.53
T_2	No P	16.38
T_3	No P + PSB-D	17.31
T_4	No P +PSB-SA_1	17.49
T_5	No P + PSB-SA_2	18.79
T_6	75 % P + PSB-D	20.83
T_7	75 % P+ PSB-SA_1	23.05
T_8	75 % P + PSB-SA_2	23.79
T_9	50% P + PSB-D	19.34
T_{10}	50% P+ PSB-SA_1	19.71
T_{11}	50% P + PSB-SA_2	20.27
	SEM ±	0.86
	CD (0.05)	2.54
	CV (%)	7.59

The significant increase in the seed yield with the application of PSB might be attributed to solubilization of native soil P by bacteria as well as due to availability of soluble P from applied P source in soil and thus enhanced P availability to the plants. These results are in similarity with the findings of Zehra ekin *et al*. (2011) and Rashmi *et al.* (2011).

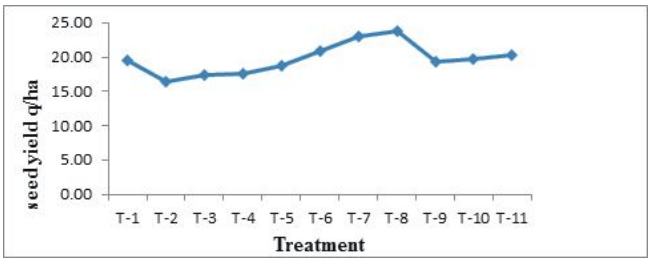

Fig. 1 : Seed yield of sunflower.

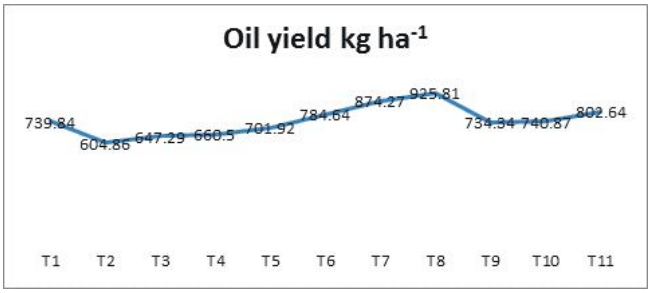

Fig. 2 : Oil yield of sunflower.

Table 5 : Effect of different doses and methods of PSB application and P levels on oil content (%) and oil yield (kg ha^{-1}) of sunflower.

Treatment	Treatment detail	Oil content (%)	Oil yield kg ha^{-1}
T_1	100% NPK, (RDF)	37.89	739.84
T_2	No P	36.91	604.86
T_3	No P + PSB-D	37.39	647.29
T_4	No P + PSB-SA_1	37.80	660.50
T_5	No P + PSB-SA_2	37.37	701.92
T_6	75 % P + PSB-D	37.67	784.64
T_7	75 % P + PSB-SA_1	38.07	874.27
T_8	75 % P + PSB-SA_2	38.87	925.81
T_9	50% P + PSB-D	37.97	734.34
T_{10}	50% P + PSB-SA_1	37.54	740.87
T_{11}	50% P + PSB-SA_2	39.59	802.64
	SEM ±	0.71	35.92
	CD (0.05)	NS	105.95
	CV (%)		8.32

Oil content (%)

The data pertaining to the effect of different doses and methods of PSB application and P levels on oil content of sunflower was reported in Table 5.

From the data in Fig. 2 revealed that there was a significant effect on oil yield. There was an increase in the oil content with increase in phosphorus levels. The oil yield of sunflower crop with variety (KBSH -78) varied in the range of 604.86 to 925.81 kg ha^{-1}. Highest oil yield was obtained in T_8 (925.81 kg ha-^{1}) treated with application of P levels with 75% P + PSB-SA_2 followed by T_7 (874.27 kg ha^{-1}) with 75% P + PSB-SA_2 which was at par to each other. As source of P levels is SSP which contains Sulphur which has a significant effect on oil yield.

Increased oil content in seeds of sunflower with the application of phosphorus (Jones and Sreenivasa, 1993 and Mishra *et al.*, 1994). Increase in oil content by Sulphur application might be attributed to involvement of Sulphur in the biosynthesis of oil. Sulphur is involved in the formation of glucosides and glucosinolates and sulphydril-linkage and activation of enzymes, which aid in biochemical reaction within the plant. The higher oil yield by Sulphur application was obviously because of higher seed yield and oil content.

Conclusion

The application of PSB along with reduced P levels significantly influenced the yield attributes and yield in sunflower. The combined application of Phosphorus increased the yield of sunflower by 21-81% over 100% RDF. The application of PSB along with increase in phosphorus availability also increases the nutrient availability of soil. Due to combined application of the PSB and P fertilizer leads to the saving of the 25% of the phosphorus fertilizer in sunflower.

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