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EFFECT OF INTEGRATED PHOSPHORUS MANAGEMENT ON GROWTH AND YIELD OF SUMMER SESAME (*Sesamum indicum* L.)

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ABSTRACT

A field experiment was conducted during summer season of the year 2018. The treatments were 25 kg P_2O_5 ha^{-1} (100 % RDF) (T_1), FYM @ 5 t ha^{-1} (T_2), Vermicompost @ 2 t ha^{-1} (T_3), 12.5 kg P_2O_5 ha^{-1}(50 % RDF) + PSB @ 5 mL kg^{-1}(seed treatment) (T_4), FYM @ 2.5 t ha^{-1} + PSB @ 5 mL kg^{-1} (seed treatment) (T_5), Vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} (seed treatment) (T_6), 12.5 kg P_2O_5 ha^{-1} (50% RDF) + FYM @ 2.5 t ha^{-1} (T_7), 12.5 kg P_2O_5 ha^{-1} (50 % RDF) + Vermicompost @ 1 t ha^{-1} (T_8), FYM @ 2.5 t ha^{-1} + Vermicompost @ 1 t ha^{-1} (T_9) and FYM @ 2.5 t ha^{-1} + vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} (seed treatment) (T_{10}). Result revealed that among the ten treatments, application of 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1} to sesame significantly increased the growth, yield attributes and seed yield (881 kg ha^{-1}) over rest of the treatments but remained at par with application 12.5 kg P_2O_5 ha^{-1} + FYM @ 1 t ha^{-1}. The highest net realization (Rs. 43932 ha^{-1}) was also recorded with 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1} followed by 12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1}.

Keywords: Farmyard manure, Phosphorus, Phosphate solubilizing bacteria, Sesame, Vermicompost.

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Sesame (*Sesamum indicum* L.) is known to be one of the earliest domesticated edible oilseeds used by the mankind. India is considered as the secondary centre of origin and is believed that the cultivated type, *Sesamum indicum,* originated in India (Ogasawara *et al.,* 1988).

Phosphorus fertilization occupies an important place amongst the non-renewable inputs in modern agriculture. Crop recovery of added phosphorus seldom exceeds 20 per cent and it may be improved by the judicious management. As the concentration of available P in the soil solution is normally insufficient to support the plant growth, continual replacement of soluble P from inorganic and organic sources is necessary to meet the P requirements of crop (Tisdale *et al*., 2010). The major constraint, limiting the growth and development of sesame is the poor fertility status of Indian soils. Most of the soils of Gujarat are low in organic carbon. The organic matter content in the soils can be improved with addition of organic manures. Addition of organic manures has shown considerable increase in the yield of sesame and has exerted a significant influence on physical, chemical and biological properties of the soil. Phosphate solubilizing bacteria (PSB) are a group of beneficial bacteria capable of hydrolyzing organic and inorganic phosphorus from insoluble compounds and make it available to the plant. Reddy *et al.* (2014) have reported 10-30% increase in yield of crop.

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The present experiment was conducted to study the effect of organic and inorganic sources with and without PSB inoculation on summer sesame.

MATERIALS AND METHODS

The present experiment was carried out during summer, 2018 on loamy sand soil of Anand (Gujarat) under irrigated condition with 10 treatments in 4 replications in a randomized block design. The soil of the experimental field was neutral in pH (7.5) and EC (0.6 dSm^{-1}) loamy sand in texture, low in organic carbon (0.34%), low in available nitrogen (183.4 kg N ha^{-1}), medium in both available phosphorus (28.1 kg P_2O_5 ha^{-1}) and available potash (281.6 kg K_2O ha^{-1}). The treatments were 25 kg P_2O_5 ha^{-1} (100 % Recommended dose of phosphorus (RDP)) (T_1), FYM @ 5 t ha^{-1} (T_2), Vermicompost @ 2 t ha^{-1} (T_3), 12.5 kg P_2O_5 ha^{-1}(50 % RDP) + PSB @ 5 mL kg^{-1}(seed treatment) (T_4), FYM @ 2.5 t ha^{-1} + PSB @ 5 mL kg^{-1} (seed treatment) (T_5), Vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} (seed treatment) (T_6), 12.5 kg P_2O_5 ha^{-1} (50% RDP) + FYM @ 2.5 t ha^{-1} (T_7), 12.5 kg P_2O_5 ha^{-1} (50 % RDP) + Vermicompost @ 1 t ha^{-1} (T_8), FYM @ 2.5 t ha^{-1} + Vermicompost @ 1 t ha^{-1} (T_9) and FYM @ 2.5 t ha^{-1} + Vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} (seed treatment) (T_{10}). The composition of FYM and vermicompost used in the experiment are 0.5:0.2:0.5 and 2.01:1.10:0.50 NPK respectively.

Application of 50 kg N ha^{-1} in two splits (25 kg at sowing and 25 kg at one month after sowing) was made through urea (46% N) as common dose, Phosphorus

through SSP (16 % P_2O_5 and 12 % sulphur), FYM, vermicompost and PSB was applied as per treatments. Sesame variety Gujarat Til 3 was sown in 4.5m x 5.0m plot having spacing of 45 cm between the rows. Plant population m^{-1} row length was recorded at 30 days after sowing (DAS) and at harvest. Plant height, number of branches $plant^{-1}$ and dry matter were recorded by five randomly selected tagged at 30 DAS, 60 DAS and at harvest. Number of capsules $plant^{-1}$, seeds $capsule^{-1}$, seed and stalk yields, test weight, harvest index, net realization and Benefit: cost ratio (BCR) were recorded after harvest of the crop.

The crop from ring area of each treatment was harvested first where most of the capsules on plants had matured. Thereafter, the crop of net plots was harvested and kept in the threshing yard for 5 days in erect position for sun drying as per treatments. The seeds were separated after drying by threshing twice at 5 and 8 days after harvesting. The produce so obtained was cleaned, weighed and recorded plot-wise and at the same time the stalk yield was recorded separately for each treatment. Thereafter, the yield was converted into hectare basis.

The statistical analysis of the various growth, yield and quality characters studied during the course of investigation was carried out by using statistical methods appropriate to Randomized Block Design at the Computer Centre, Department of Agricultural Statistics, B. A. College of Agriculture, AAU, Anand as per the procedure described by Cochran and Cox (1957). The variance of different sources of variation in ANOVA was tested by "F" test and compared with the value of F-table at 5% level of significance. To elucidate the treatment effect, summary tables along with S.Em. ±, and C.D. at 5% are given in the bottom of the tables.

In order to evaluate the most effective and remunerative treatment, the relative economics of each treatment was computed. For each treatment, the gross realization in terms of rupees per hectare was worked out taking into consideration the prevailing market price of seeds and stalk. Likewise, the cost of cultivation was also worked out by considering the expenses incurred for cultural operation from tillage to harvesting including threshing, winnowing and cost of input *viz*., seeds, irrigation, fertilizer etc. The cost of cultivation was then deducted from the gross realization to work out net realization under each treatment and recorded accordingly. The BCR was calculated on the basis of the following formula:

$$BCR = \frac{\text{Gross realization (Rs. ha}^{-1})}{\text{Total cost of cultivation (Rs. ha}^{-1})}$$

RESULTS AND DISCUSSION

Growth attributes

Treatments differed significantly for growth attributes *viz.,* plant height, number of branches $plant^{-1}$ and dry matter production $plant^{-1}$ at different growth stages (Table 1). Application of 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1} resulted in highest plant height, number of branches $plant^{-1}$ at and dry matter production $plant^{-1}$ at all growth stages (30 and 60 DAS and maturity) which were at par with application of 12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1} and significantly higher than all other treatments. Similarly, plant height, number of branches $plant^{-1}$ and dry matter production $plant^{-1}$ at all these growth stages with application12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1} were at par with the application of 12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1}. Application of FYM @ 5 t ha^{-1} alone resulted in significantly lower

Table 1. Effect of different treatments on growth of summer sesame

Treatment	Plant height (cm)			No. of branches $plant^{-1}$			Dry matter $plant^{-1}$ (g)		
	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest	30 DAS	60 DAS	At harvest
T1	13.8	62.9	84.1	1.9	3.3	4.0	2.4	10.8	14.6
T2	10.6	57.6	78.9	1.5	2.9	3.2	1.9	9.6	11.3
T3	13.4	60.5	81.8	1.6	3.0	3.9	2.1	10.0	13.5
T4	13.5	61.8	83.1	1.8	3.0	4.1	2.2	10.7	13.6
T5	11.9	58.6	79.8	1.5	3.0	3.8	1.9	9.8	11.9
T6	12.4	58.9	80.1	1.6	3.2	3.6	2.0	10.0	12.4
T7	15.8	70.8	92.1	2.2	3.2	4.4	2.7	12.1	15.9
T8	16.8	72.0	93.0	2.3	3.6	4.7	2.8	12.2	16.3
T9	14.4	63.4	84.7	2.0	3.4	4.2	2.4	11.3	14.6
T10	15.6	64.0	85.2	2.2	3.3	4.2	2.6	11.4	15.5
S.Em. ±	0.6	2.1	2.1	0.1	0.2	0.3	0.1	0.4	0.5
C.D. at 5%	1.8	6.1	6.1	0.3	0.4	0.8	0.4	1.2	1.6
C.V. %	8.9	6.7	5.1	12.0	9.2	12.9	12.0	7.4	7.8

*DAS: days after sowing

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Table 2. Effect of different treatments on yield attributes and yield of summer sesame

Treatment	No. of capsule plant^{-1}	No. of seeds capsule^{-1}	Test weight (g)	Harvest index (%)	Seed yield (kg ha^{-1})	Stalk yield (kg ha^{-1})
T1	35.3	64.9	3.4	28.6	753	1883
T2	30.8	52.6	3.1	28.0	632	1623
T3	34.9	64.6	3.3	27.3	656	1748
T4	35.0	64.6	3.4	27.8	714	1857
T5	33.5	58.5	3.1	28.1	643	1647
T6	34.8	64.2	3.2	27.6	653	1718
T7	37.7	65.6	3.8	26.6	794	2192
T8	37.7	67.2	4.0	27.1	881	2377
T9	36.7	65.4	3.5	26.5	754	2075
T10	37.2	65.8	3.6	27.0	778	2113
S.Em. ±	1.9	1.5	0.2	1.2	39	78
C.D. at 5%	NS	4.25	NS	NS	112	228
C.V. %	10.7	4.6	12.0	8.8	10.6	8.2

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yield which could be due to slow and delay release of nutrients at the time of active growth phase. The increase in growth attributes with application of 12.5 kg P_2O_5 ha^{-1} along with vermicompost @ 1 t ha^{-1} or FYM @ 2.5 t ha^{-1} could be attributed to better proliferation of roots due to increased phosphorus availability. Phosphorus encourages formation of new cells, promotes plant vigour and hastens leaf development, which helps in harvesting more solar energy and better utilization of nitrogen, which help towards higher growth attributes (Ansari, 2008). This may be due to balanced fertilization and availability of nutrients throughout the growth period specially at critical growth periods which results in better uptakes of nutrients by crop. The results are in conformity with those of Ghosh and Mohiuddin (2000), Jaishankar and Wahab (2005), Muhamman and Gungula (2008), Hafiz and El-Bramawy (2012), Muhammad *et al*. (2016) and Chaudhary *et al*. (2017).

Yield attributes and yield

Different treatments containing inorganic phosphatic fertiliser, organic manures and PSB inoculation, and their integration had a significant impact on yield attributes and yield of summer sesame *viz.,* number of capsules plant^{-1}, number of seeds capsule^{-1}, test weight, harvest index, seed yield and stalk yield. However, number of capsules plant^{-1} and number of seeds capsule^{-1} were not affected by the different treatments (Table 2). Highest number of seeds capsule^{-1} (67.2), seed yield (881 kg ha^{-1}) and stalk yield (2377 kg ha^{-1}) were obtained with the application of 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1} which were at par with application of FYM @ 2.5 t ha^{-1} + vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1}, 12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1}, FYM @ 2.5 t ha^{-1} + vermicompost @ 1 t ha^{-1}, 25 kg P_2O_5 ha^{-1} 12.5 kg P_2O_5 ha^{-1} + PSB @ 5 mL kg^{-1}, vermicompost @ 2 t ha^{-1} and

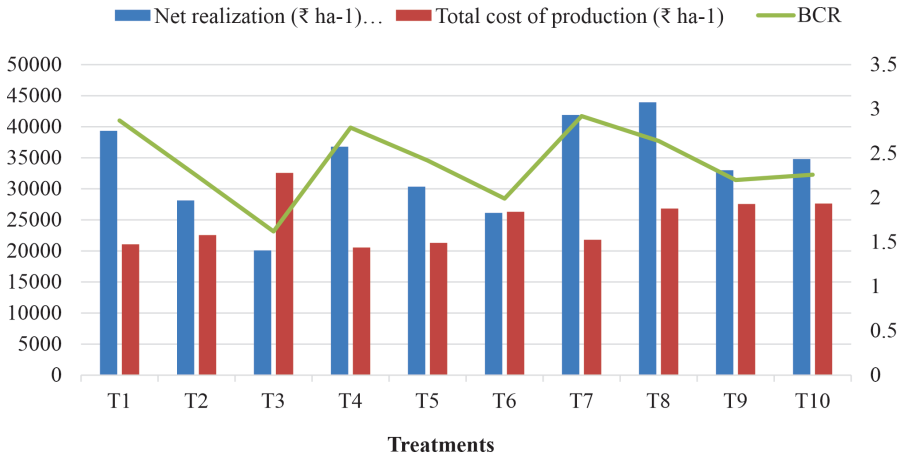

Fig. 1. Cost of cultivation, net realization and BCR of sesamum as influenced by different inorganic phosphatic fertilizer, organic manures and PSB treatments

vermicompost @ 1 t ha^{-1}+ PSB @ 5 mL kg^{-1} for number of seeds $capsule^{-1}$. Seed yield with application of 12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1} and FYM @ 2.5 t ha^{-1} + vermicompost @ 1 t ha^{-1} + PSB @ 5 mL kg^{-1} and 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1} was statistically similar. Stalk yield obtained with the application 12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1} and 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1} was statistically. Application of FYM @ 5 t ha^{-1} alone resulted in significantly lower seed yield (632 kg ha^{-1}) and stalk yield (1623 kg ha^{-1}) than all other treatments.

The increment in yield attributes and yield under treatments T_8 (12.5 kg P_2O_5 ha^{-1} + Vermicompost @ 1 t ha^{-1}) and T_7 (12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1}) was due to increase in growth characters *viz*., plant height, number branches $plant^{-1}$ and dry matter $plant^{-1}$. Integration of chemical source chemical source of phosphorus along with FYM and vermicompost might have also supplied other macro and micro nutrients. The increase in the yields may also be due to the increase in P availability through solubilization of phosphate rich compound. Similar results were reported by Purushottam and Hiremath (2005), Chaurasia *et al.* (2009), Wayase *et al*. (2014), Ali (2017), Parewa *et al.* (2018) and Nouri *et al*. (2019).

The highest net realization (Rs. 43,932 ha^{-1}) was obtained with the application of 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1} with BCR value of 2.64, followed by application of 12.5 kg P_2O_5 ha^{-1} + FYM @ 2.5 t ha^{-1} (Rs. 41,894) with the highest BCR value of 2.92. The lowest value (Rs. 20,089) was obtain with the application of vermicompost @ 2 t ha^{-1}.

To conclude, for higher yield and returns from sesame during summer season, apply 12.5 kg P_2O_5 ha^{-1} + vermicompost @ 1 t ha^{-1}.

Authors' contribution

Conceptualization of research work and designing of experiments (ACS); Execution of field/ lab experiments and data collection (LPR); Analysis of data and interpretation (ACS, LPR); Preparation of manuscript (LPR, ACS)

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