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Rachana
Ph.D Scholar, SHUATS, Allahabad, Uttar Pradesh, India

Vikram Singh
Associate Professor (Agronomy) Allahabad School of Agriculture, SHUATS, Allahabad, Uttar Pradesh, India

Prasad Mithare
Assistant Professor (C) Agronomy, Dept of ILFC, KVAFSU, Bidar, Karnataka, India

Correspondence
Prasad Mithare
Assistant Professor (C) Agronomy, Dept of ILFC, KVAFSU, Bidar, Karnataka, India

Effect of different levels of phosphorus and biofertilizers (PSB and VAM) on growth and yield of hybrid maize (*Zea mays* L.)

Rachana, Vikram Singh and Prasad Mithare

Abstract

The field experiment was conducted during kharif season of 2015 at Crop Research Farm SHUATS, Allahabad. The experiment was carried out to find the performance of different Levels of phosphorus and biofertilizers (PSB and VAM) on Growth and Yield of Hybrid Maize, which laid out in Randomized Block Design (RBD) & replicated thrice. The experiment finding revealed that the treatment T_9 (80 kg ha^{-1} P + PSB+VAM) significantly performed better than all other treatments viz; Plant height (187.08 cm), Number of leaves (10.58), while treatment T_6 (60 kg ha^{-1} P + PSB+VAM) performed better than all other treatments viz; Dry weight (51.72 g), Cob length (18.94 cm), Cob weight (241.08 g), Grain yield (4.95 t ha^{-1}), Straw yield (7.45 t ha^{-1}), Test weight (28.10 g) and Harvest index (39.98%). While the same treatment T_6 (60 kg ha^{-1} P + PSB+VAM) recorded highest gross return (65653.75 Rs ha^{-1}), net return (38416.75 Rs ha^{-1}) and B: C ratio (1.41), however treatment T_3 (40 kg ha^{-1} P + PSB+VAM) was found statistically at par with treatment T_6 (60 kg ha^{-1} P + PSB+VAM).

Keywords: vesicular arbuscular mycorrhizae (VAM), phosphate solubilizing bacteria (PSB), ppm

Introduction

Maize is the third major cereal crop after Wheat and Rice that occupies about 8.71 million hectares producing 22.23 million tonnes with an average productivity of 2.5tonnes ha^{-1} during 2012-13 and belongs to Gramineae family. Maize is considered as native to Central America and Mexico. In India maize accounts for about 7.89 million ha^{-1} which accounts for about 18.96 million/ha ton food grain of total area in content. Among cereals maize ranks 5th in total area and 3rd in total production and productivity in India. In India, it is cultivated in about 1943 million hectares with a production of 24.35 million tonnes and productivity of 2583 kg ha^{-1} GOI, 2014 [1]. Maize (*Zea mays* L.) is considered as economically important cereal crop, used as food, feed and other products. It assumes an important role next to rice and wheat in the farming sector and macro-economy of the agrarian countries. The low productivity of maize is attributed to many factors like frequent occurrence of drought, declining of soil fertility, poor agronomic practice, limited use of fertilizers, technology generation, disease, insect, and pests CIMMYT, 2004 [2]. Phosphorus is an important plant nutrient, next only to nitrogen. P is important in cell division and development of new tissue. It is responsible for utilization of sugar and starch, photosynthesis, nucleous formation and fat and albumin formation, cell organisation and the transfer of heredity. The soils acidic in nature, which have high P-fixing power due to excessive presence of Fe and Al ion resulting into low availability of phosphorus to crop plants. VAM (Vesicular arbuscular mycorrhizae) develop both Intra and extra material hyphae that extend into P available zone and far areas away from the roots and increase the absorptive surface area of the mycorrhizae root system VAM improve the P uptake in many crop plants like maize.

Similarly Phosphate Solubilizing Bacteria (PSB) converts insoluble phosphates into soluble forms through acidification, chelating, exchange reactions and production of organic acids resulted in improved growth, yield and P uptake in several crops.

Materials and Methods

A field experiment was conducted during kharif 2015 at Crop Research farm, Department of Agronomy, Allahabad School of Agricultural, Sam Higginbottom University of Agriculture Technology and Sciences, Allahabad. The experiment site lies between 25- 27° N latitude, 8.5°E Longitude and 98 meters altitude. The climate is characterized by the alternate hot rainy season from late June to early September with mean temperature of 38°C. The soil was sandy loam in texture having a pH (7.34), EC (0.13 dSm^{-1}), organic carbon (0.36%), available N (240 kg ha^{-1}), P (13.05 kg ha^{-1}), K (312 kg ha^{-1}), S (17.70 ppm), and Zn (0.50 ppm) during the experimental year. The experiment was laid down in randomized block design (RBD) with 9 treatments and 3 replications. The planting was carried out in main field on 08-08-2015 conventionally at a spacing of 60 x 30 cm. The crop was fertilized with recommended dose of NPK 100:60:40 kg ha^{-1} was applied. The (100%) full dose phosphorus and potassium whereas (50%) of Nitrogen was applied at the time of planting as basal dose and the remaining Nitrogen was applied in two equal split doses as top dressing at active (35 DAS & 55 DAS) respectively. Irrigation was scheduled at 6-8 days interval during vegetative growth; however other normal cultural practices were followed timely as; weeding at 30 DAT & 45 DAT. One quadrate (1 m^2) was harvested in every plot for the determination of results and data was subjected to statistical analysis separately by using analysis of variance technique. The difference among treatment means was compared by using least significant difference test at 5% probability levels. The treatment consisted of T_1: (40 kg ha^{-1} P + PSB), T_2: (40 kg ha^{-1} P + VAM), T_3: (40 kg ha^{-1} P + PSB+VAM), T_4: (60 kg ha^{-1} P + PSB), T_5: (60 kg ha^{-1} P + VAM), T_6: (60 kg ha^{-1} P + PSB+VAM), T_7: (80 kg ha^{-1} P + PSB), T_8: (80 kg ha^{-1} P +VAM), T_9: (80 kg ha^{-1} P + PSB+VAM).

Results and Discussion

Growth attributes

Plant height (cm)

Plant height is not a yield component especially in grain crops but it indicates the influence of various nutrients on plant metabolism. Significantly maximum plant height (187.08 cm) was recorded in treatment T_9 at 60 DAS, however treatment T_6 and T_3 were statistically at par with treatment T_9 respectively (Table 1) and (Fig 1). The increase in plant height might be due to the genetic makeup of the variety. Increase in plant height might be due to application of phosphorus + PSB+VAM seed inoculation might be due to increase in Auxin production by PSB and increased supply of phosphorus by PSB and VAM. These findings are reported by Amanullah *et al.*, 2013 [3] and Ojaghloo *et al.*, 2007 [4].

Number of leaves

The observations regarding Number of Leaves are being presented and were observed significant difference between the treatments at 40 DAS. Maximum Number of Leaves (10.58) was recorded in treatment T_9 where as treatment T_6 and T_3 were found statistically at par with treatment T_9, while minimum Number of Leaves (8.83) was recorded in treatment T_5 at 40 DAT (Table 1) and (Fig 1). The probable reason for recording higher No. of leaves $plant^{-1}$ under treatment T_9 (80 kg ha^{-1} phosphorus + PSB+VAM) seed inoculation might be due to increase in nitrogen fixing and phosphate solubilizing microorganisms to enhance growth and yield of maize crop and have possibility of substituting a part of demand of chemical fertilizers of the crop. Findings are reported by Amanullah *et al.*, 2013 [3].

Plant dry weight (g)

The observations regarding plant dry weight are being presented and were observed significant difference between the treatments. Maximum plant dry weight (51.72 g) was observed in treatment T_6 where as treatment T_4, T_8 and T_9 were found statistically at par with treatment T_6, while minimum plant dry weight (49.69 g) was recorded in treatment T_1 at 60 DAS (Table 1) and (Fig 1). The increase in plant dry weight (g) might be due to more assimilatory surface leading to higher dry matter production coupled with effective translocation and distribution of photosynthates from source to sink. These results are confirmed by Asghar *et al.*, 2010 [5].

Crop growth rate (g m^{-2} day^{-1}) and relative growth rate (g g^{-1} day^{-1})

Maximum CGR (9.88) and RGR (0.1785) were recorded in treatment T_8 at 60-80 DAS. While minimum CGR (9.65) and RGR (0.1773) was recorded in treatment T_4 (Table 1) and (Fig 1). The percentage increase in CGR and RGR is due to prevelance of low temperature coupled with less humidity at the reproductive stage and also application of phosphorus + VAM as seed inoculation might be due to synergistic action of organisms which increased the phosphorus uptake. These findings are confirmed by Surrender and Sharanappa 2000 [6].

Yield attributes

The yield attributes of hybrid rice, viz., Cob length (cm), Cob weight (g), number of grains Cob^{-1} were significantly influenced by genetic potential of the variety and also may be due to synchronized availability of essential plants nutrients to the crop especially NPK for a longer period during its growth & reproductive stages. The maximum cob length (18.94 cm) and cob weight (241.08 g) was recorded in Treatment T_6 (60 kg ha^{-1} P + PSB+VAM) whereas minimum cob length (16.39 cm) and Cob weight (213.83 g) was recorded in treatment T_7 and T_2. Similarly treatment T_9 (80 kg ha^{-1} P + PSB+VAM) has recorded maximum number of grains cob^{-1} (592.22), while minimum number of grains cob^{-1} (430.33) was recorded in treatment T_6 respectively (Table 2) and (Fig 2). In several maize hybrids, the effect of increased cob length (cm), cob weight (g), number of grains cob^{-1} may have helped in increasing the photosynthetic area for photosynthesis in plant. The probable reason for recording higher cob length under treatment T_6 (60 kg ha^{-1} P + PSB+VAM) might be due to increase availability of NPK which are essential nutrients required for the promotion of the meristematic and physiological activities such as leaf spread, root development, plant dry matter production, leading to efficient absorption and translocation of water and nutrients and interception of solar radiation. These activities promote higher photosynthetic process which is translocate to assimilates into various sink and producing components like cob length, cob weight, number of grains cob^{-1}. These findings are confirmed with Singh and Nepalia 2009 [7]. Similar findings are reported by Hassen *et al.*, 2005 [8].

Yield

Maize hybrid had a significant effect on the yield parameters with Levels of Phosphorus and Biofertilizers (PSB and VAM). Significant and highest grain yield (4.95 t ha^{-1}), straw yield (7.45 t ha^{-1}), Test weight (28.10 g) and Harvest index (39.98%) was recorded in treatment T_6 (60 kg ha^{-1} P + PSB+VAM), while lowest grain yield (3.68 t ha^{-1}), straw yield (7.0 t ha^{-1}), Test weight (21.45 g) and Harvest index (34.46%) was recorded in treatment T_1 (40 kg ha^{-1} P + PSB) however T_9 and T_3 were found statistically at par with treatment T_6 (Table 3) and (Fig 3).. This might be due to genetic ability of the plant attributed to higher biomass accumulation coupled with effective translocation and distribution of photosynthates from source to sink, which in turn resulted into elevated stature of yield attributes. The probable reason for recording higher grain yield under treatment T_6 (60 kg ha^{-1} phosphorus + PSB+VAM) might be due to phosphorus application because phosphorus was directly related to the vegetative and reproductive phases of the crop and attributes complex phenomenon of phosphorus utilization in plant metabolism. It also helped in the efficient absorption and utilization of the other required plant nutrients which ultimately increased the grain yield. These findings are in confirmed with Girma *et al.*, 2006 [9] and Parvez *et al.*, 2009 [10]. Similar results were also reported by Singh and Khan 2003 [11].

Economics

The highest gross return (65653.75 Rs ha^{-1}), net return (38416.75 Rs ha^{-1}) and B:C ratio (1.41) was observed in treatment T_6 (60 kg ha^{-1} P + PSB+VAM), while lowest gross return (48804.17 Rs ha^{-1}), net return (22754.77 Rs ha^{-1}) was observed in treatment T_1. However T_9 and T_3 were found statistically at par with treatment T_6 (Table 3) and (Fig 4). The probable reason for recording higher economic sunder treatment T_6 (60 kg ha^{-1} phosphorus+ PSB+VAM) might be due to use of biofertilizers plus half a dose of organic and chemical fertilizers have resulted in highest gross return and net return.

Table 1: Effect of different levels of phosphorus and biofertilizers (PSB and VAM) on growth attributes plant height (cm), plant dry weight (g), number of leaves $plant^{-1}$, CGR (g m^{-2} day^{-1}) and RGR (g g^{-1} day^{-1}).

	Treatments	Plant height (cm)	Plant dry Weight (g)	No. of leaves $plant^{-1}$	CGR (g m^{-2} day^{-1})	RGR (g g^{-1} day^{-1})
T_1	40 kg ha^{-1} P+ PSB	169.58	49.69	10.25	9.70	0.1776
T_2	40 kg ha^{-1} P + VAM	177.33	50.39	10.33	9.82	0.1782
T_3	40 kg ha^{-1} P + PSB+VAM	170.50	51.47	9.91	9.66	0.1774
T_4	60 kg ha^{-1} P+ PSB	171.50	51.65	9.83	9.65	0.1773
T_5	60 kg ha^{-1} P + VAM	162.08	51.35	8.83	9.79	0.1780
T_6	60 kg ha^{-1}P + PSB+VAM	151.16	51.72	9.58	9.67	0.1774
T_7	80 kg ha^{-1} P+ PSB	154.91	50.37	8.91	9.76	0.1779
T_8	80 kg ha^{-1} P+VAM	168.91	51.38	10.41	9.88	0.1785
T_9	80 kg ha^{-1} P + PSB+VAM	187.08	51.07	10.58	9.79	0.1780
F-test		S	S	S	NS	NS
S.Ed(±)		5.86	0.59	0.32	0.15	0.5085
CD (P=0.05)		12.42	1.24	0.67	-	-

Table 2: Effect of different levels of phosphorus and biofertilizers (PSB and VAM) on yield attributes viz, cob length (cm), cob weight (g), number of grains Cob^{-1}

	Treatments	Cob length (cm)	Cob weight (g)	Number of grains Cob^{-1}
T_1	40 kg ha^{-1} P+ PSB	16.95	227.96	492.78
T_2	40 kg ha^{-1} P + VAM	17.61	213.83	462.33
T_3	40 kg ha^{-1} P + PSB+VAM	16.67	240.20	463.89
T_4	60 kg ha^{-1} P+ PSB	17.33	228.93	478.11
T_5	60 kg ha^{-1} P + VAM	16.89	223.41	465.55
T_6	60 kg ha^{-1}P + PSB+VAM	18.94	241.08	430.33
T_7	80 kg ha^{-1} P+ PSB	16.39	228.67	475.78
T_8	80 kg ha^{-1} P+VAM	16.61	217.84	496.00
T_9	80 kg ha^{-1} P + PSB+VAM	17.05	237.92	592.22
F-test		S	S	S
S.Ed(±)		0.51	6.38	27.75
CD (P=0.05)		-	13.52	58.83

Table 3: Effect of Different Levels of Phosphorus and Biofertilizers (PSB and VAM) on Grain yield, Straw yield, Test weight (g), Harvest Index (%), Gross return, Net return and B: C ratio

	Treatments	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Test weight (g)	Harvest Index (%)	Gross return (Rs ha^{-1})	Net return (Rs ha^{-1})	B: C ratio
T_1	40 kg ha^{-1} P+ PSB	3.68	7.0	21.45	34.46	48804.17	22754.77	0.87
T_2	40 kg ha^{-1} P + VAM	4.43	7.20	23.87	38.11	58785.83	32621.23	1.24
T_3	40 kg ha^{-1} P + PSB+VAM	4.70	7.41	26.53	38.82	62358.92	36069.52	1.37
T_4	60 kg ha^{-1} P+ PSB	3.92	7.01	21.87	35.83	51940.00	24942.60	0.92
T_5	60 kg ha^{-1} P + VAM	4.50	7.26	24.40	38.26	59633.83	32521.63	1.19
T_6	60 kg ha^{-1}P + PSB+VAM	4.95	7.45	28.10	39.98	65653.75	38416.75	1.41
T_7	80 kg ha^{-1} P+ PSB	3.87	7.08	23.47	35.29	51277.50	23362.58	0.83
T_8	80 kg ha^{-1} P+VAM	4.07	7.33	25.73	35.71	53971.67	25941.55	0.92
T_9	80 kg ha^{-1} P + PSB+VAM	4.79	7.44	27.37	39.14	63467.50	35312.58	1.25
F-test		S	S	S	S	-	-	-
S.Ed(±)		1.42	6.41	0.53	0.77	-	-	-
CD (P=0.05)		3.01	1.36	1.06	1.62	-	-	-

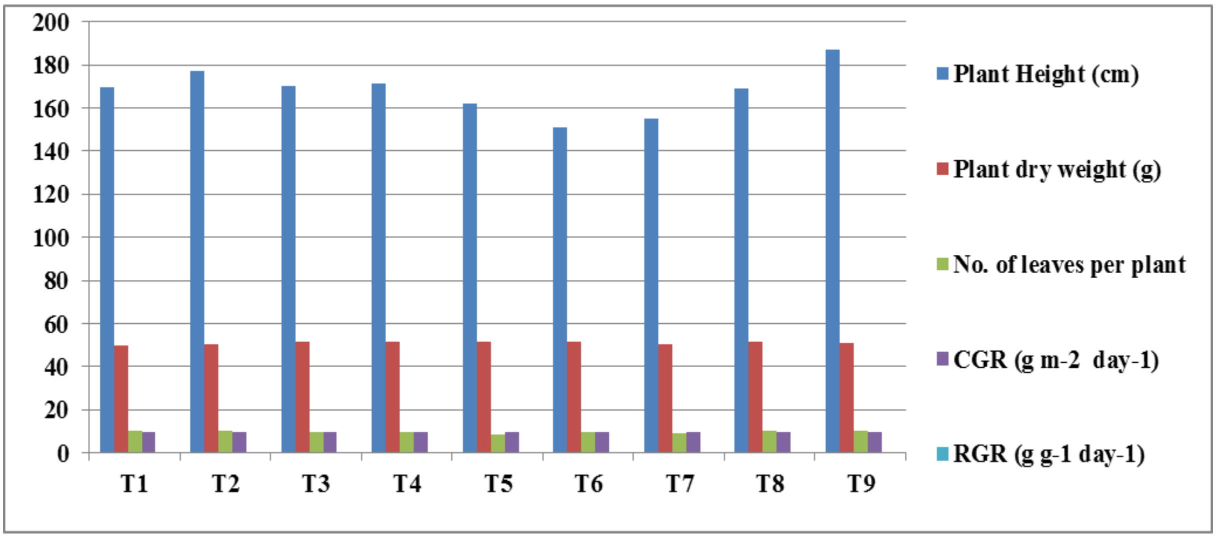

Fig 1: Effect of Different Levels of Phosphorus and Biofertilizers (PSB and VAM) on Growth Attributes viz, Plant height (cm), Plant dry weight (g), Number of leaves plant^{-1}, CGR (g m^{-2} day^{-1}) and RGR (g g^{-1} day^{-1}).

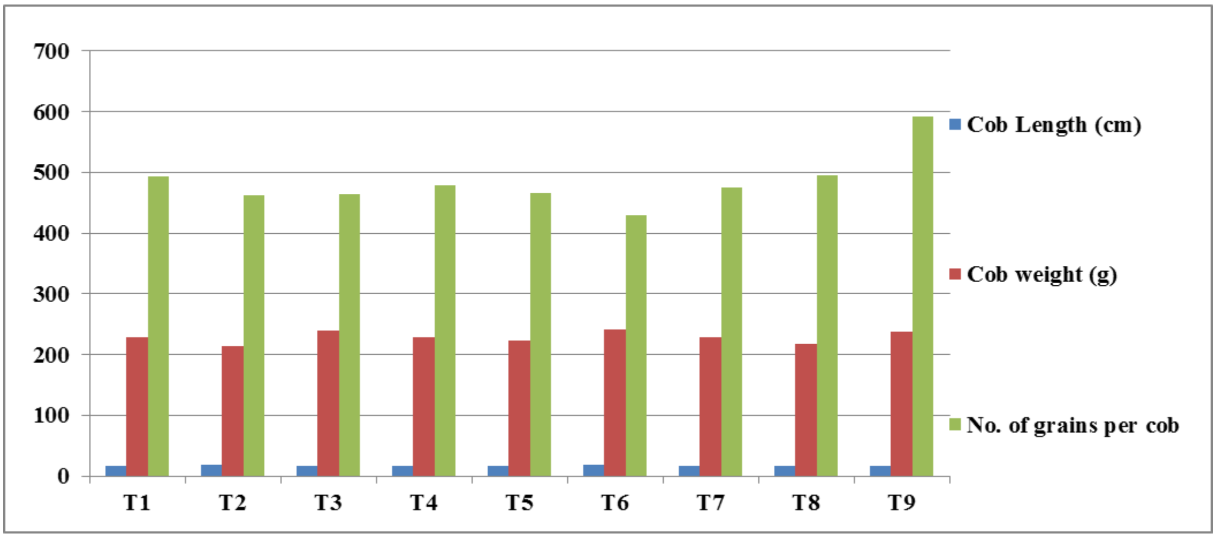

Fig 2: Effect of Different Levels of Phosphorus and Biofertilizers (PSB and VAM) on Yield Attributes viz, Cob length (cm), Cob weight (g), number of grains Cob^{-1}

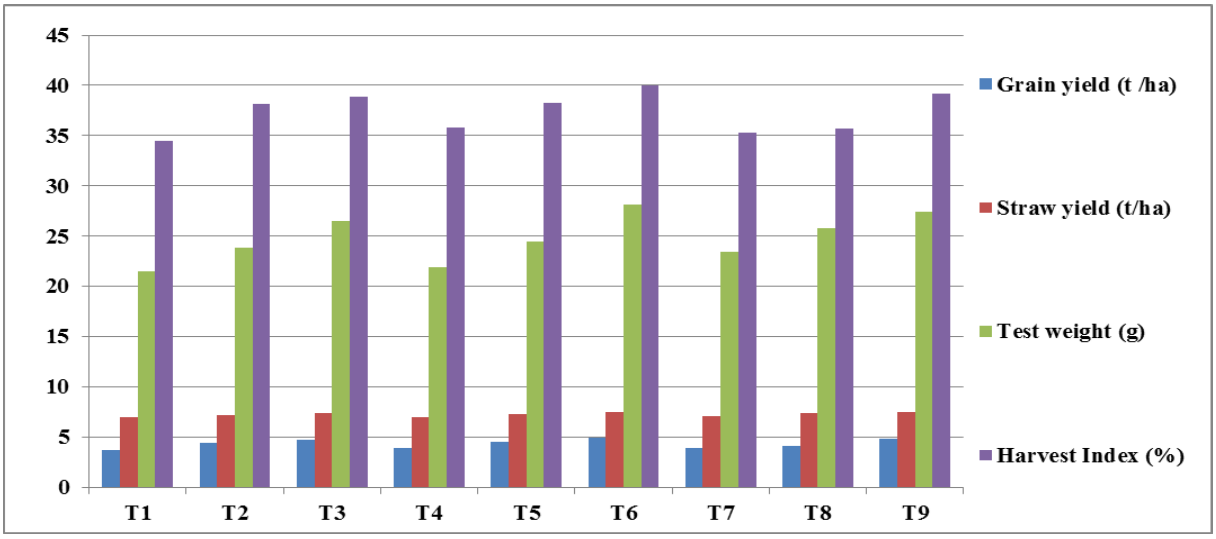

Fig 3: Effect of different levels of phosphorus and biofertilizers (PSB and VAM) on grain yield, straw yield, test weight (g), harvest index (%)

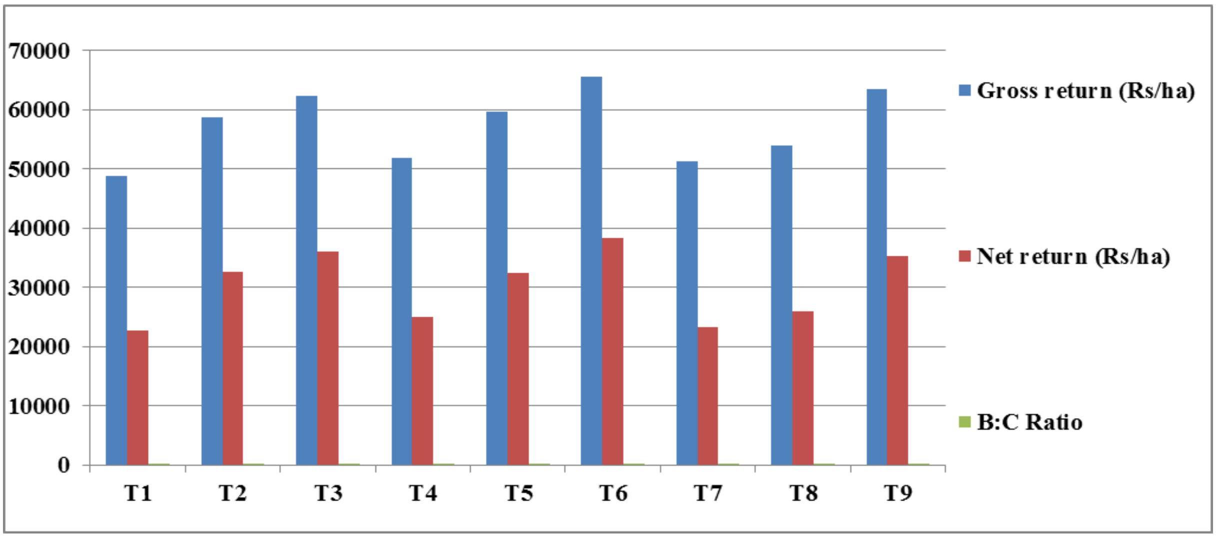

Fig 4: Effect of different levels of phosphorus and biofertilizers (PSB and VAM) on gross return, net return and B: C ratio

Conclusion

In conclusion, the data pertaining to the different treatments, it may be indicated that by using (60 kg ha^{-1} P + PSB+VAM), higher grain yield and monetary benefits can be realized over control and was found to be the best for obtaining highest Seed yield, Straw yield and benefit cost ratio. Since the findings are based on the research done in one season it may be repeated for conformation.

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