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Productivity and profitability of summer mungbean (*Vigna radiata* Wilczek L.) influenced by different phosphorus levels, biophos liquid biofertilizer and growth regulator

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Abstract
A field experiment was carried out during 2019 and 2020 at agriculture research station, Ummedganj, Kota under Agriculture University, Kota, to "Effect of phosphorus, liquid biofertilizer and growth regulator on growth, yield and quality of summer mungbean [*Vigna radiata* (L.) Wilczek]". The experiment was conducted in Split Plot Design with four phosphorus levels (P_0, P_{20}, P_{30} and P_{40} kg/ha), biophos liquid fertilizer (No seed inoculation and Seed inoculation with Biophos) in main plot and three salicylic acid levels control, 75 and 100 ppm sprayed in sub plot (at pre flowering and pod development stage) and replicated three time. P_{30} being at par with P_{40} and recorded significantly higher yield, Gross return (₹82292/ha), net return (₹ 61285/ha), B:C ratio (2.91) as compare to control and P_{20}. Seed inoculation with biophos recorded significantly higher higher yield, Gross return (₹ 76355/ha), net return (₹ 55580/ha), B:C ratio (2.66) yields as compare to no inoculation. Spray of 75 ppm SA, being at par with 100 ppm SA and recorded significantly higher yield, Gross return (₹ 74565/ha), net return (₹ 55859/ha), B:C ratio (2.57) as compare to control.

Keywords: Summer mungbean, yield, gross return, net return, B:C ratio

1. Introduction

Pulses are the cheapest source of proteins to the vegetarian's population of India and it contain high amounts of proteins, nutrients (Ca, P, K, Fe and Zn), vitamins, fibres and carbohydrates for balanced nutrition. Mungbean (*Vigna radiata* L. Wilczek) is the 3rd most important pulse crop of India after chickpea and pigeonpea. Mungbean takes less time to mature, can be cultivated during *kharif*, *rabi* and *summer* seasons and fits well in existing cropping pattern of the country. Sometimes, grown as a catch crop between season of *kharif* and *rabi* and produces per day more productivity. Mungbean has nutritive value, digestibility and reasonable amount of vitamins and essential micronutrients (Akhtar *et al.*, 2013) [1]. Among the various factors responsible for maximizing the yield of mungbean, phosphorus is an important plant nutrient for higher productivity of mungbean. It is necessary to use them economically as per the availability in the soil where mungbean shows high response to applied phosphorus and thus make available to the plants. The soils of Rajasthan state are ranges from poor to medium in available phosphorus due to only 30% of applied phosphorus is available for crops and remaining part converted into insoluble phosphorus (Sharma and Khurana, 1997) [18]. Additional soil application of P helps in increasing nodule formation which further increases nitrogen fixation transduction, macromolecular biosynthesis and respiration. The efficiency of phosphatic fertilizer is very low (15-20%) due to its fixation in soil. Biophos liquid bio-fertilizers are those substance that contain 10^{16} cfu/ml of phosphorus solubilising bacteria (*Paenibacillus tylopili*) living microorganisms and they colonize the rhizosphere of the plant increase the supply or availability of phosphorus requirement of crop. It also promotes plant growth when applied as seed inoculation and can be add 20-25 kg P_2O_5/ha to soil. Biophos liquid bio-fertilizer is increasingly available in the market as one of the alternative and cheapest source to chemical fertilizer. Drought/terminal heat stress is one of the most common abiotic stresses for reducing the crop yields especially grown in arid and semi-arid regions. Plant growth regulators can improve the physiological efficiency including photosynthetic ability thereby helping in effective flower formation, fruit and seed development and ultimately enhance productivity of crops (Solamani *et al.*, 2001) [21].

Growth is affected by plant growth regulators including salicylic acid which works to improve the productivity of crop through its effect on the important physiological process in the plant such as growth, photosynthesis, flowering and drought resistance. Exogenously, foliar spray of plant growth regulators stimulates synchronized bloom, reduces flower drop, improves seed setting and ultimately increases the yield.

2. Material and method

The field experiment was conducted at agriculture research station, Ummedganj, Kota under Agriculture University, Kota, Rajasthan during summer 2019 and 2020. Kota is situated in sub-tropical zone of Vindhyan Plateau of Rajasthan with the average annual rainfall of 750-1005 mm. The mean annual maximum and minimum temperatures are 40.2°C and 18.5°C, respectively. The summer months are hot and May is the hottest month having a maximum temperature up to 43.5°C. Winter month experience mild cold with an average temperature from 8.7°C to 16.6°C. The soil of the experimental field was medium black clay loam in texture fairly deep having good drainage facilities. For seed yield of summer mungbean pods from each net plot (including pods from five sample plants) were threshed separately and seeds yields were expressed in kg/ha. After thorough sun drying of harvested material, weight was taken for biological yield/plot and then converted to kg/ha and by subtracting the seed yield from the biological yield and straw yield was obtained. Gross return was the value of product in rupees.

Net return = Gross return - total cost of cultivation

To estimate the benefits under different treatments for each rupee of expenditure incurred, B:C ratio of each treatment was calculated as below:

$$\text{Benefit cost ratio} = \frac{\text{Net return (₹/ha)}}{\text{Cost of cultivation (₹ /ha)}}$$

3. Result and discussion

3.1. Yield of summer mungbean

3.1.1. Phosphorus

Among different phosphorus levels, P_{30} recorded significantly highest yields (1132, 1988 and 3120 kg/ha seed, straw and biological yields, respectively) over control and P_{20}, however, it was statistically at par with P_{40} (Table 1). Phosphorus is an important element in all biological system, participating in most metabolic pathways and as a structural component of nucleic acids, coenzymes, phosphoproteins and phospholipids. Thus, phosphorus application realized spectacular improvement in grain and straw yield of mungbean. The biological yield is a function of seed and straw yield. This might be due to the role of phosphorus on promotion of root growth and there by enhancement in renewable of nitrogen by the crop. Similar findings have also been observed by Awomi *et al.* (2012) [2], Khan *et al.* (2017) [6], Masih *et al.* (2020) [9], Parvez *et al.* (2013) [13], Singh *et al.* (2017 & 2018) [19, 20] and Venkatarao *et al.* (2017) [22].

Table 1: Effect of phosphorus, biophos liquid biofertilizer and growth regulator on yield (kg/ha) of summer mungbean

Treatment	Seed yield			Straw yield			Biological yield		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Phosphorus levels (kg/ha)									
P_0	729	807	768	1263	1434	1349	1993	2241	2117
P_{20}	919	1028	974	1592	1827	1709	2511	2855	2683
P_{30}	1041	1224	1132	1803	2173	1988	2844	3396	3120
P_{40}	1091	1270	1180	1889	2244	2067	2980	3513	3247
SEm±	26.04	30.52	20.07	44.51	53.84	34.95	70.55	84.31	54.99
CD (P=0.05)	78.98	92.58	58.11	134.99	163.30	101.22	213.97	255.72	159.25
CV (%)	11.69	11.97	11.88	11.54	11.90	11.79	11.59	11.92	11.82
Biophos liquid fertilizr									
No inoculation	900	1043	971	1558	1853	1705	2457	2895	2676
Seed inoculation	991	1122	1056	1716	1986	1851	2707	3108	2907
SEm±	18.41	21.58	14.19	31.47	38.07	24.72	49.88	59.62	38.88
CD (P=0.05)	55.85	65.46	41.09	95.45	115.47	71.57	151.30	180.82	112.60
CV (%)	11.69	11.97	11.88	11.54	11.90	11.79	11.59	11.92	11.82
Growth regulator									
No spray (control)	870	1025	947	1506	1796	1651	2376	2821	2598
Salicylic acid 75 ppm	959	1104	1032	1660	1953	1807	2619	3057	2838
Salicylic acid 100 ppm	1007	1117	1062	1744	2009	1876	2751	3126	2939
SEm+	19.19	21.75	14.50	33.19	38.02	25.23	52.38	58.27	39.17
CD (P=0.05)	65.13	73.81	42.00	112.62	129.04	73.08	177.74	197.74	113.45
CV(%)	9.95	9.84	9.91	9.93	9.71	9.83	9.94	9.51	9.72

3.1.2. Biophos liquid biofertilizer

Seed inoculation with biophos recorded significantly higher yields (1056, 1850 and 2907 kg/ha seed, straw and biological yields, respectively) as compare to no seed inoculation during both years and pooled basis (Table 1). The increase of seed yield may be due to increase in P availability through solubilization of phosphate rich compound. The liquid biofertilizer secrete a number of organic acids which may form chelates resulting in effective solubilization of phosphate, favoured higher nitrogen fixation, dry matter accumulation, rapid growth, higher absorption and utilization of P and other plant nutrients and ultimately positive resultant effect on growth and finely yield attributes (Rathour *et al.* 2015). Several soil bacteria and fungi possess the ability to bring insoluble phosphates in soil into soluble forms by secreting organic acids such as formic, acetic, propionic, lactic, glycolic, fumaric and succinic acids. These acids lower the pH and bring about the dissolution of bound forms of phosphates in to soil solution (Venkateswarlu *et al.* 1984) [23]. These results obtained are in close conformity with findings of Kamble *et al.* (2006) [5], Kumari *et al.* (2017) [8], Rani *et al.* (2016) [14], Singh *et al.* (2018) [20] and Venkatarao *et al.* (2017) [22].

3.1.3. Growth regulator

Recorded and analyzed data presented in Table 1 showed that foliar spray of 75 ppm SA being at par with 100 ppm SA recorded significantly higher yields (1031, 1806 and 2838 kg/ha seed, straw and biological yields, respectively) of mungbean as compare to control on pooled basis. The effect of salicylic acid on the physiological processes is variable, promoting some processes and inhibiting others depending on its concentration, plant species, development stages and environment conditions. The creditability on any exogenously sourced plant hormone is evaluated in terms of biological yield. Salicylic acid known to be a natural signal molecule has been shown to play an important role in regulating various physiological processes in plant including yield. It is believed that increase in the crop yield might be due to delayed senescence of plant organs in response to exogenous SA that will automatically help the plant in extending the duration of photosynthetically active sites and also prevent premature loss of flower and fruits. These results corroborate the finding of Bhaskar *et al.* (2018) [3], Farjam *et al.* (2015) [4], Kumar *et al.* (2018) [7] and Pandey and Lal (2018) [11] and Salingpa *et al.* (2018) [16].

3.2. Economics of summer mungbean

3.2.1. Phosphorus

The application of phosphorus @ 30 kg P_2O_5/ha gave maximum gross return (₹ 81867/ha), net return (₹ 60860/ha) and B:C ratio (2.89) as compared to the rest of the treatments (Table 2) This might be due to higher yield attributes and yield. These findings are in accordance with the results reported by Masih *et al.* (2020) [9] and Singh *et al.* (2017 & 2018) [19, 20] about economic viability of phosphorus.

Table 2: Effect of phosphorus, biophos liquid biofertilizer and growth regulator on gross return, net return and B:C ratio of summer mungbean

Treatment	Gross return (₹/ha)			Net return (₹/ha)			B:C ratio		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Phosphorus levels (kg/ha)									
P_0	52324	58747	55536	32443	38865	35654	1.63	1.95	1.79
P_{20}	65937	74842	70390	45306	54210	49758	2.19	2.63	2.41
P_{30}	74673	89061	81867	53667	68054	60860	2.55	3.24	2.89
P_{40}	78256	92386	85321	56874	71004	63939	2.66	3.32	2.99
SEm±	1867	2221	1451	1867	2221	1451	0.09	0.11	0.07
CD (P=0.05)	5664	6736	4202	5664	6736	4202	0.28	0.33	0.21
CV (%)	11.69	11.96	11.88	16.83	16.24	16.57	17.30	16.57	16.96
Biophos liquid fertilizr									
No inoculation	64525	75878	70201	43849	55203	49526	2.11	2.66	2.38
Seed inoculation	71070	81640	76355	50295	60864	55580	2.41	2.91	2.66
SEm±	1320	1570	1026	1320	1570	1026	0.07	0.08	0.05
CD (P=0.05)	4005	4763	2971	4005	4763	2971	0.20	0.23	0.15
CV (%)	11.69	11.96	11.88	16.83	16.24	16.57	17.30	16.57	16.96
Growth regulator									
No spray (control)	62374	74580	68477	41940	54146	48043	2.04	2.64	2.34
Salicylic acid 75 ppm	68781	80349	74565	47973	59540	53756	2.29	2.85	2.57
Salicylic acid 100 ppm	72237	81348	76793	51304	60414	55859	2.44	2.87	2.66
SEm+	1377	1578	1047	1377	1578	1047	0.07	0.08	0.05
CD (P=0.05)	4672	5356	3032	4672	5356	3032	0.23	0.26	0.15
CV (%)	9.95	9.82	9.90	14.33	13.32	13.80	14.38	13.35	13.85

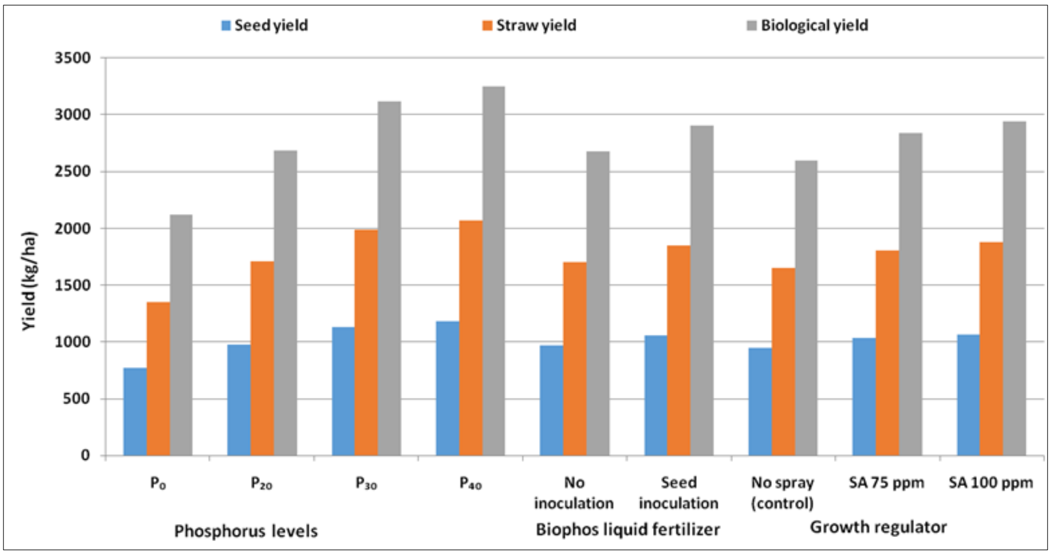

Fig 1: Effect of phosphorus, biophos liquid biofertilizer and growth regulator on yield of summer mungbean

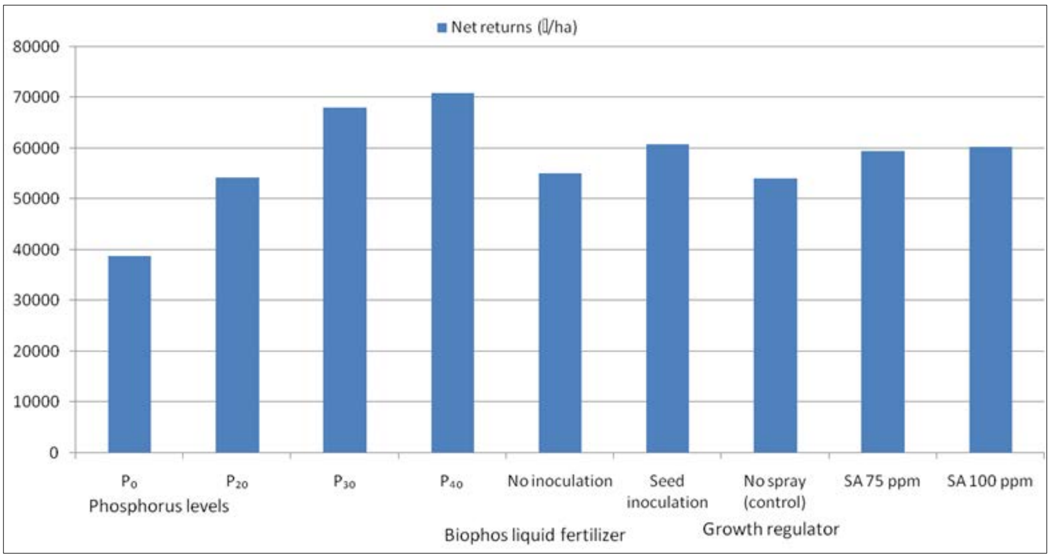

Fig 2: Effect of phosphorus, biophos liquid biofertilizer and growth regulator on Net return of summer mungbean

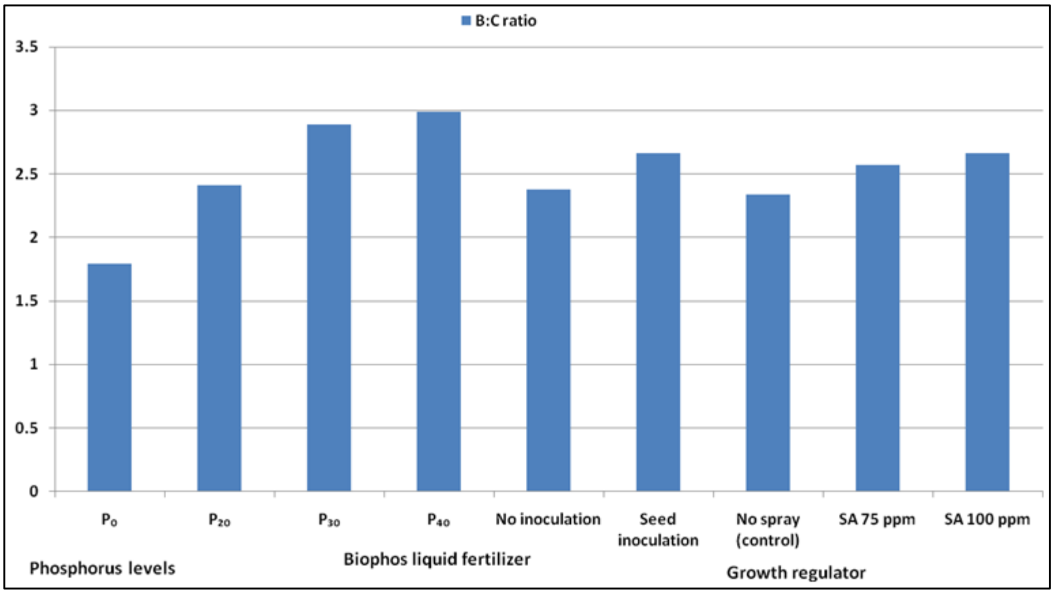

Fig 3: Effect of phosphorus, biophos liquid biofertilizer and growth regulator on B:C ratio of summer mungbean

3.2.2. Biophos liquid biofertilizer

Application of biophos recorded significantly higher gross return (₹ 76355/ha), net return (₹ 55580/ha) and B:C ratio (2.66) as compare to no seed inoculation. This was attributed to greater increase in grain and straw yield as compared to cost of cultivation with biophos. Similar findings were also observed by Pandey *et al.* (2016) [12], Rani *et al.* (2016) [14], Singh *et al.* (2018) [20] and Yadav *et al.* (2017).

3.2.3. Growth regulator

In respect to economics gross return (₹ 74565/ha), net return (₹ 55859/ha) and B:C ratio (2.57) were also got beneficial effect from foliar spray of 75 ppm SA. Thus, the increased yield led to higher net return (Table 2). These results are in close conformity with the findings of Muhal *et al.* (2014) [10] and Sarita *et al.* (2020) [17].

4. Conclusions

Application of 30 kg P_2O_5, seed inoculation with biophos liquid biofertilizer and spray of 75 ppm salicylic acid obtained significantly higher seed yield, gross return, net return and B:C ratio.

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