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Research Paper

Response of summer mungbean (*Vigna radiata*) to phosphorus levels, biophos liquid biofertilizer and growth-regulator

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ABSTRACT

A field experiment was conducted during 2019 and 2020 at Agriculture Research Station, Agriculture University, Ummedganj, Kota, Rajasthan, to study the 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-split plot design with 4 phosphorus levels (P_0, P_{20}, P_{30} and P_{40}), biophos liquid fertilizer (without and with seed inoculation) in main plot and 3 salicylic acid (SA) levels (control, 75 and 100 ppm SA) in subplot at pre-flowering and pod-development stage, and replicated 3 times. The phosphorus level P_{30} being at par with P_{40} recorded significantly higher yield attributes of mungbean, viz. pod length, clusters/plant, pods/plant, seeds/pod, pod weight, test weight, seed (1,132 kg/ha), stover (1,988 kg/ha) and biological (3,120 kg/ha) yields as compared to the control and P_{20}. Seed inoculation with biophos resulted in significantly higher yield attributes, seed (1,056 kg/ha), stover (1,850 kg/ha) and biological (2,907 kg/ha) yields as compared to no-inoculation. Spray of 75 ppm SA, being at par with 100 ppm SA, recorded significantly higher yield attributes, seed (1,031 kg/ha), stover (1,806 kg/ha) and biological (2,838 kg/ha) yields as compared to control.

Key words: Biophos, Phosphorus, Salicylic acid, Summer mungbean, Yield attributes and Yield

Mungbean (*Vigna radiata* L. Wilczek) is the third most important pulse crop of India after chickpea and pigeonpea. It is commonly known as greengram, monggo or mung and belongs to Leguminosae family. Mungbean takes less time to mature, can be cultivated during rainy seasons, (*kharif*), winter season (*rabi*) and summer season and fits well in existing cropping pattern of the country. Sometimes, grown as a catch crop between season of *kharif* and *rabi* and shows more per day productivity. Mungbean has nutritive value, digestibility and reasonable amount of vitamins and essential micronutrients (Akhtar *et al.,* 2013). Among 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 this nutrient economically as per the availability in the soil where mungbean shows high response to applied phosphorus. The soils of Rajasthan state are poor to medium in available phosphorus, since only 30% of applied phosphorus is available for crops and its remaining part converted into insoluble phosphorus (Sharma and Khurana, 1997). 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 substances that contain 10^{16} cfu/ml of phosphorus-solubilizing bacteria (*Paenibacillus tylopili*) 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 add 20–25 kg P_2O_5/ha to soil. Biophos liquid bio-fertilizer is increasingly available in the market as one of the alternatives and low-priced sources 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). Growth is affected by plant-growth regulators including salicylic acid which works to improve the productivity of

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crop through its effect on the important physiological process in the plant such as growth, photosynthesis, flowering and drought resistance. There are research evidences of enhanced (8.9–17.3%) crop yields, such as in rice with foliar spray of growth-regulators (Sarangi and Sharma, 2004). Exogenously, foliar spray of plant-growth regulators stimulate synchronized bloom, reduces flower drop, improves seed setting and ultimately increases the yield. Hence a study was carried out to observe the response of summer mungbean to phosphorus, biophos liquid biofertilizer and growth-regulator in Kota, Rajasthan.

MATERIALS AND METHODS

The field experiment was conducted at agriculture research station, Agriculture University, Ummedganj, Kota, Rajasthan during summer season of 2019 and 2020. Kota is situated in sub-tropical zone of Vindhyan Plateau of Rajasthan, with the average annual rainfall of 750–1,005 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.

The experiment consisted of 4 levels of phosphorus, viz. P_0 (Control), P_{20} (20 kg P_2O_5/ha), P_{30} (30 kg P_2O_5/ha) and P_{40} (40 kg P_2O_5/ha), 2 of biophos iquid fertilizer, viz. without or with seed inoculation; and 3 of salicylic acid, viz control, 75 and 100 ppm. The experiment was laid out in split-plot design, allocating combinations of phosphorus and biophos liquid fertilizer in main plot and salicylic acid in subphots, replicated 3 times. For recording yield attributes of summer mungbean, pod length, clusters/plant, pods/plant, seeds/pod and pod weight were measured or counted or weighed from the 5 observation plants and their mean was taken. From the seed obtained from the net plot area, a sample was collected at random and 1,000-seeds were counted and weighted with the help of an electric balance and expressed in g/1,000-seed. For seed yield of summer mungbean pods from each net plot (including pods from 5 sample plants) were threshed separately and seeds yields were expressed in kg/ha. After a thorough sun drying of harvested material, weight was taken for biological yield/plot and then converted to kg/ha, and stover yield was obtained by subtracting the seed yield from the biological yield. Harvest index was computed by using the formula given as:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg/ha)}}{\text{Biological yield (kg/ha)}} \times 100$$

RESULTS AND DISCUSSION

Yield attributes and yield of summer mungbean

Effect of phosphorus: Yield attributes of summer mungbean, viz. pod length, clusters/plant, pods/plant, seeds/pod, pod weight and test weight, responded favourably owing to increasing levels of phosphorus (Tables 1, 2). Pooled result indicated that, P_{30} being at par with P_{40}, recorded significantly higher yield attributes as compared to the control and P_{20}. It is a well-known fact that, P plays a vital role in improving nutritional status of plant through increased photosynthetic activity and N_2 fixation. The level of phosphorus during this period regulates starch: sucrose ratio in the sources and the reproductive organs (Giaqinta and Quebedeaux, 1980). Among different phosphorus levels, P_{30} recorded significantly highest yields (1,132, 1,988 and 3,120 kg/ha seed, stover and biological yields, respectively) over the control and P_{20}; however, it was statistically at par with P_{40} (Table 3). Phosphorus is an important element in all biological systems, participating in most metabolic pathways and as a structural component of nucleic acids, coenzymes, phosphoproteins and phospholipids. Thus, phosphorus application resulted in spectacular improvement in grain and stover yields of mungbean. The biological yield is a function of seed and stover yields. This might be owing to the role of phosphorus in promotion of root growth and thereby enhancement in renewable of nitrogen by the crop. The improvement in yield is attributed to increase in root nodulation because of phosphorus application (Bhatt *et al.,* 2013). Similar findings have also been observed by Awomi *et al*., (2012), Khan *et al*., (2017) and Masih *et al*., (2020).

Effect of biophos liquid biofertilizer: Seed inoculation with biophos resulted in significantly higher yield attributes of mungbean, viz. pod length, clusters/plant, pods/plant, seeds/pod, pod weight, test weight and higher yields (1,056, 1,850 and 2,907 kg/ha seed, stover and biological yields, respectively) as compared to no-seed inoculation during both years and also on pooled basis (Tables 1 to 3). The increase of seed yield may be owing to increase in P availability through solubilization of phosphate-rich compound. The liquid biofertilizer secretes 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 on yield attributes (Rathour *et al.,* 2015). The seed yield being a function of growth and yield attributes, increased with the increase in these parameters. Biofertilizers (bacteria and fungi) enable P to become available for plant uptake after solubilization. Several soil bacteria and fungi possess the

Table 1. Effect of phosphorus, biophos liquid biofertilizer and growth-regulator on yield attributes of summer mungbean

Treatment	Pod length (cm)			Clusters/plant			Pods/plant		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Phosphorus (kg/ha)									
P_0	5.62	6.08	5.85	2.93	3.11	3.02	13.62	15.70	14.70
P_{20}	6.24	6.59	6.41	3.46	3.86	3.66	15.44	17.28	16.40
P_{30}	6.68	6.96	6.82	3.82	4.33	4.07	16.74	18.41	17.57
P_{40}	6.92	7.11	7.01	3.95	4.52	4.23	17.05	19.01	18.03
SEm±	0.12	0.10	0.08	0.08	0.08	0.06	0.32	0.33	0.24
CD (P=0.05)	0.37	0.31	0.24	0.23	0.26	0.18	0.98	0.99	0.68
CV (%)	8.08	6.38	7.50	9.02	9.06	9.97	8.75	7.86	8.46
Biophos liquid fertilizer									
No inoculation	6.20	6.55	6.37	3.34	3.77	3.74	15.08	16.90	15.99
Seed inoculation	6.53	6.83	6.68	3.74	4.14	4.17	16.34	18.30	17.36
SEm±	0.09	0.07	0.06	0.05	0.06	0.06	0.23	0.23	0.17
CD (P=0.05)	0.26	0.22	0.17	0.16	0.20	0.18	0.69	0.70	0.48
CV (%)	8.08	6.38	7.50	9.02	9.83	9.06	8.75	7.86	8.46
Growth regulator									
No spray (control)	5.96	6.08	6.02	3.26	3.54	3.54	14.81	16.48	15.65
Salicylic acid 75 ppm	6.47	6.86	6.66	3.59	4.10	4.04	15.91	17.79	16.85
Salicylic acid 100 ppm	6.67	7.12	6.89	3.77	4.23	4.29	16.41	18.54	17.54
SEm±	0.12	0.11	0.08	0.06	0.06	0.06	0.29	0.31	0.21
CD (P=0.05)	0.41	0.37	0.23	0.21	0.21	0.21	0.98	1.05	0.61
CV (%)	9.33	7.89	8.61	8.76	7.62	7.64	8.96	8.61	8.77

P_0, Control; P_{20}, 20 kg P_2O_5/ha; P_{30}, 30 kg P_2O_5/ha; and P_{40}, 40 kg P_2O_5/ha

Table 2. Effect of phosphorus, biophos liquid biofertilizer and growth-regulator on yield attributes of summer mungbean

Treatment	Seeds/pod			Pod weight (g)/plant			Test weight (g)		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Phosphorus (kg/ha)									
P_0	5.71	6.58	6.15	4.74	5.07	4.91	27.35	28.91	28.13
P_{20}	6.61	7.40	7.00	5.32	5.77	5.54	29.58	30.79	30.19
P_{30}	7.33	7.98	7.66	5.74	6.39	6.07	31.25	32.45	31.85
P_{40}	7.66	8.23	7.95	5.91	6.61	6.26	32.08	33.13	32.60
SEm±	0.16	0.14	0.11	0.13	0.15	0.10	0.43	0.46	0.32
CD (P=0.05)	0.47	0.42	0.31	0.40	0.46	0.29	1.30	1.39	0.92
CV (%)	9.73	7.85	8.92	10.25	10.91	10.72	6.07	6.20	6.18
Biophos liquid fertilizer									
No inoculation	6.59	7.26	6.92	5.27	5.76	5.51	29.43	30.73	30.08
Seed inoculation	7.07	7.84	7.45	5.58	6.17	5.87	30.70	31.91	31.31
SEm±	0.11	0.10	0.08	0.09	0.11	0.07	0.30	0.32	0.22
CD (P=0.05)	0.34	0.30	0.22	0.28	0.33	0.21	0.92	0.98	0.65
CV (%)	9.73	7.85	8.92	10.25	10.91	10.72	6.07	6.20	6.18
Growth regulator									
No spray (control)	6.26	6.84	6.55	5.02	5.56	5.29	28.92	30.27	29.59
Salicylic acid 75 ppm	7.02	7.80	7.41	5.55	6.03	5.79	30.37	31.53	30.95
Salicylic acid 100 ppm	7.20	8.00	7.60	5.70	6.30	6.00	30.91	32.16	31.54
SEm±	0.10	0.11	0.08	0.11	0.11	0.07	0.37	0.34	0.25
CD (P=0.05)	0.34	0.39	0.22	0.36	0.36	0.22	1.24	1.16	0.73
CV (%)	7.24	7.36	7.32	9.58	8.67	9.10	5.96	5.36	5.66

P_0, Control; P_{20}, 20 kg P_2O_5/ha; P_{30}, 30 kg P_2O_5/ha; and P_{40}, 40 kg P_2O_5/ha

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 *p*H and bring about the dissolution of bound forms of phosphates in to soil solution (Venkateswarlu *et al.,* 1984). Our results are in close con-

Table 3. Effect of phosphorus, biophos liquid biofertilizer and growth-regulator on yield (kg/ha) of summer mungbean

Treatment	Seed yield			Stover yield			Biological yield		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Phosphorus (kg/ha)									
P_0	729	807	768	1,263	1,434	1,349	1,993	2,241	2,117
P_{20}	919	1,028	974	1,592	1,827	1,709	2,511	2,855	2,683
P_{30}	1,041	1,224	1,132	1,803	2,173	1,988	2,844	3,396	3,120
P_{40}	1,091	1,270	1,180	1,889	2,244	2,067	2,980	3,513	3,247
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 fertilizer									
No inoculation	900	1,043	971	1,558	1,853	1,705	2,457	2,895	2,676
Seed inoculation	991	1,122	1,056	1,716	1,986	1,851	2,707	3,108	2,907
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	1,025	947	1,506	1,796	1,651	2,376	2,821	2,598
Salicylic acid 75 ppm	959	1,104	1,032	1,660	1,953	1,807	2,619	3,057	2,838
Salicylic acid 100 ppm	1,007	1,117	1,062	1,744	2,009	1,876	2,751	3,126	2,939
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

P_0, Control; P_{2O}, 20 kg P_2O_5/ha; P_{30}, 30 kg P_2O_5/ha; and P_{40}, 40 kg P_2O_5/ha

formity with findings of Kamble *et al.,* (2006), Rani *et al*., (2016), Kumari *et al*., (2017) and Singh *et al.,* (2018).

Effect of growth regulator: Foliar spray of 75 ppm SA was at par with 100 ppm SA and ensued significantly higher yield attributes, viz. pod length, clusters/plant, pods/plant, seeds/pod, pod weight, test weight and higher yields (1,031, 1,806 and 2,838 kg/ha seed, stover and biological yields, respectively) of mungbean as compared to the control on pooled basis (Tables 1 to 3). 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 findings of Farjam *et al.,* (2015), Bhaskar *et al*., (2018), Kumar *et al.,* (2018) and Pandey and Lal (2018).

Based on results of 2 years experimentation, it may be concluded that application of P_{30}, seed inoculation with biophos and foliar spray of salicylic acid 75 ppm recorded significantly higher yield attributes and yields as compared to the control.

REFERENCES

Akhtar, J., Ahmad, R., Ashraf, M., Tanveer, A., Ahmad, E. and Oraby, O. 2013. Influence of exogenous application of salicylic acid on salt stress mungbean (*Vigna radiata*) growth and nitrogen metabolism. *Pakistan Journal of Botany* **45**: 119–125.

Awomi, T.A., Singh, A.K., Kumar, M. and Bordoloi, L.J. 2012. Effect of phosphorus, molybdenum and cobalt nutrition on yield and quality of mungbean (*Vigna radiata* L.) in acidic soil of Northeast India. *Indian Journal of Hill Farming* **25**(2): 22–26.

Bhaskar, R., Verma, O., Shukla, D.K., Singh, V.K., Guru, S.K. and Reena. 2018. Yield and seed quality of mungbean [(*Vigna radiataradiate* (L.) Wilczek]) in response to foliar spray of nutrients and growth regulators. *International Journal of Agricultural Sciences* **10**(24): 7,639–7,643.

Bhatt, P.K., Patel, P.T., Patel, B.T., Raval, C.H., Vyas, K.G. and Ali, S. 2013. Productivity, quality, nutrient content and soil fertility of summer green gram (*Vigna radiata*) as influenced by different levels of vermicompost and phosphorus with and without PSB. *International Journal of Agricultural Sciences* **9**: 659–662.

Farjam, S., Arbat, H.K., Siosemardeh, A., Yarnia, M. and Rokhzadi, A. 2015. Effect of salicylic and ascorbic acid applications on growth, yield, water use efficiency and some physiological traits of chickpea (*Cicer arietinum* L.) under reduced irrigation. *Legume Research* **38**(1): 66–71.

Giaquinta, R. T. and Quebedeaux, B. 1980. Phosphate induced changes in assimilate partitioning in soybean leaves during pod filling. *Plant Physiology* **65**: 119.

Kamble, B.M., Chougule, S.D., Rathod, S.D. and Rathod, P.K. 2006. Effect of biophos and phosphate levels on growth and yield of groundnut and available nutrient status of the soil. *Asian Journal of Biological Sciences* **1**(2): 83–84.

Khan, M.M.S., Vinit, P.S. and Adesh, K. 2017. Studies on effect of phosphorus levels on growth and yield of *kharif* mung bean [(*Vigna radiata* (L.) Wilczek)]. *International Journal of Pure and Applied Bioscience* **5**(4): 800–808.

Kumar, R., Yadav, R.K., Sharma, N., Yadav, A. and Nehal, N. 2018. Influence of plant growth regulators on biochemical changes of mung bean [(*Vigna radiata* (L.) Wilczek)]. *Journal of Pharmacognosy and Phytochemistry* **1**: 386–389.

Kumari, M.S., Rao, P.C., Padmaja, G., Ramulu, J.D. and Ramakrishana. 2017. Effect of bio and nano phosphorus on yield, yield attributes and oil content of groundnut (*Arachis hypogaea* L.). *Environmental Conservation Journal* **18**(3): 21–26.

Masih, A., Dawson, J. and Singh, R. E. 2020. Effect of levels of phosphorus and zinc on growth and yield of green gram (*Vigna radiata* L.). *International Journal of Current Microbiology and Applied Sciences* **9**(10): 3,106–3,112.

Pandey, A.K. and Lal, E.P. 2018. Effect of salicylic acid on morphological, biochemical and antioxidentantioxidant parameters of mung bean (*Vigna radiata* L.) under salt stress. *Plant Archives* **18**(1): 109–116.

Rani, M., Prakash, V. and Khan, K. 2016. Response of mung bean [*Vigna radiata* (L.) Wilczek] to phosphorus, sulphur and PSB during summer season. *Agricultural Science Digest* **36**(2): 146–148.

Rathour, D., Sadhu, A.C. and Suryawanshi, P. K. 2015. Integrated phosphorus management in summer green gram (*Vigna radiatea* L.). *Advance. Researchs. Journal of Crop Improvement.* **5**: 57–59.

Sarangi, S. K. and Sharma, H. C. 2004. Influence of mode of iron application and growth-regulators on development, yield attributes and yield of upland rice (*Oryza sativa*). *Indian Journal of Agricultural Sciences* **74**(12): 637–642.

Sharma, M.P. and Khurana, A.S. 1997. Biofertilizers, Farmers and Parliament. *Indian Journal of Agricultural Sciences* **38**: 17–18.

Singh, R., Singh, P., Singh, V. and Yadav, R.A. 2018. Effect of phosphorus and PSB on growth parameters, yield, quality and economics of summer green gram (*Vigna radiata* L.). *International Journal of Chemical Research* **6**(4): 2,798–2,803.

Solamani, A., Sivakumar, C., Anbumani, S., Suresh, T. and Arumugam, K. 2001. Role of plant growth regulators on rice production: A review. *Agricultural Review* **23**: 33–40.

Venkatarao, C.V., Naga, S.R., Yadav, B.L., Koli, D.K. and Rao, I.J. 2017. Effect of phosphorus and biofertilizers on growth and yield of mung bean [*Vigna radiata* (L.) Wilczek]. *International Journal of Current Microbiology and Applied Sciences* **6**(7): 3,992–3,997.

Venkateswarlu, B., Rao, A.V., Raina, P. and Ahmad, N. 1984. Evaluation of phosphorus solubilisationsolubilization by microganismsmicroorganisms isolated from arid soils. *Journal of Indian Society of Soil Science* **32**: 273–277.