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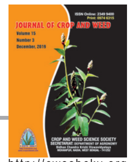

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Yield intensification of spring mungbean (*Vigna radiata* L.) through exogenous foliar nutrition

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ABSTRACT

An experiment was conducted on the role of foliar fertilization on spring mung bean var. Meha (IPM 99-125) during spring seasons of 2019-20 and 2020-21 at "AB" Block Farm, BCKV, Nadia under lower gangetic plains of West Bengal, India. Among the different foliar applications, seed yield (1269.04 kg ha^{-1}) and protein (24.79%) were obtained with salicylic acid at 100ppm which is followed by Zinc at 0.2% obtaining the value of 1218.62 kg ha^{-1} and 24.53% respectively. From the results derived from the two years pooled value, it is concluded that the combination of the prescribed fertilizer dose along with either di-ammonium phosphate at 2% or salicylic acid at 100ppm application enhanced the growth, yield and quality attributes of spring mung bean and also improved the soil nutrient status after harvest in the new alluvial soils of West Bengal, India.

Keywords: Foliar nutrition, spring mung bean, growth, yield, seed protein, soil nutrient status

Pulses are the food crops that can play an important role to mitigate national food security contributing a reliable source of protein (20-25%) which helps in tackling obesity, diabetes malnutrition etc. and contributes in sustaining the economic status of India. It can fix the atmospheric nitrogen through their root nodules approximately 72 to 350 kg N per ha per year improving soil fertility and it also suits best in mixed or intercropping systems and supplies quality fodder to enhance sustainability. Furthermore, pulse contains 1-3% fat, 51% carbohydrates, 3.6-4.8% fibers,4% mineral, good source of Riboflavin, Thiamine and Vitamin C(Ascorbic acid) and is regarded as poor man's meat recording almost triple protein as compared to rice. India is the chief producer of mung bean with 4.5 million hectares with a total production of 2.7 million tonnes with a productivity of 548 kg ha^{-1} which contributes around 10% to the total pulse production, producing approximately 2.65 million tonnes during 2020-21 (Department of Agriculture, Cooperation & Farmers Welfare, GOI). Foliar feeding is a method of applying essential elements in form of liquid, that directly penetrates through leaf cuticle or stomata, is credited remarkably with rapid absorption and improving root development, stimulating nodulation and energy transformation through various metabolic activities by eliminating leaching losses thereby reduces the cost of cultivation and economizing the production (Sabbe and Hodges, 2009). Nitrogen is an important macronutrient that helps in formation of plant hormones which increases the vegetative growth, total carbohydrates, delaying leaf senescence thereby improves in maintaining the source-to-sink relation in pulses (Das and Jana, 2016). Phosphorus is another important primary nutrient that enhances root growth, nodule and seed development, also provides vital metabolic functions like photosynthesis, carbon partitioning, energy storage and transfer that improve colonization of rhizobium and nitrogen fixation (Mitran *et al*., 2018). Zinc (Zn) is an important micronutrient that is closely involved in the nitrogen metabolism, helps in growth and development, also an important constituent of essential enzymes and proteins in the plant body (Mondal *et al*., 2020). Salicylic acid is a growth promoter that regulates essential physiological and biochemical processes including germination of seeds, thermogenesis improves uptake of nutrients and transport, membrane permeability, nitrate metabolism, ethylene biosynthesis, stomatal movements, photosynthesis and enzymatic activities under saline stress conditions mediating in plant protective role of pathogens (Sarkar *et al.*, 2021). Therefore, the ongoing experiment was carried out to judge the role of exogenous foliar application of macro and micro nutrients and growth regulator on crop growth, yield, quality attributes and also soil nutrient status of spring mung bean var. Meha (IPM 99-125) after harvest under new alluvial zone (type - Inceptisol) of West Bengal.

MATERIALS AND METHODS

The field observation was executed during the spring seasons of 2019-20 and 2020-21 at "AB" Block Farm (22°5' N latitude, 89°0' E longitude and 9.75 m above mean sea level) of Bidhan Chandra Krishi

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Viswaidyalaya, Nadia, West Bengal in the New Alluvial Zone (type-Inceptisol) under warm and humid climate. Mung bean was grown during the spring season (January-March) for two successive years.

The average rainfall was 1445 mm, 75 % of which was received during June to September. The temperature tends to increase from the February end reaching towards April-May. The relative humidity prevails maximum from June to October. During the experimental period, average rainfall varies within the range of 8.2 to 11.1mm. The soil was sandy loam in nature having a bulk density of 1.31 gcc^{-1} with optimum moisture availability and neutral in reaction (pH 6.81) having soil organic carbon 0.38%, available N 320.52 kg ha^{-1}, P_2O_5 35.6 kg ha^{-1} and K_2O 106.2 kg ha^{-1}. The average maximum temperature varied from 26.1 to 36.2^{0}C and the mean minimum temperature varied from 11.2 to 24.9^{0}C with average maximum and minimum relative humidity ranging from 89.5 to 91.9 and 52.1 to 45.6 % respectively. The daily average sunshine hour varied from 6.6 to 7.4 hours per day.

The present investigation was conducted under randomized complete block design (RCBD) with three replications comprising of seven different foliar nutrition treatments viz. T_1: No foliar Spray; T_2: Water spray; T_3: Urea@ 2% (20 g l^{-1} of water); T_4: DAP @ 2% (20 g l^{-1} of water); T_5: Zinc @ 0.2% (2 g l^{-1} of water), T_6: Salicylic Acid @100 ppm; T_7: NPK (19:19:19) @ 1% (10 g l^{-1} of water). The experimental site was divided into 21 plots with a dimension of 5 m x 2 m for each plot along with bund of 30 cm width created around each plot. The research fields were broadcasted with the recommended dose of N: P_2O_5:K_2O at 20:40:40 kg ha^{-1} in the form of urea, SSP and MOP. The total amount of nitrogen, phosphate and potash were used as basal application.

The seeds of spring mung bean variety Meha (IPM 99-125) were sown in 25 cm apart rows manually at a distance of 10 cm apart in rows. Small furrows were opened with a hand tyne and seeds were incorporated into the furrows and were covered with soil. In mung bean, weeding was operated manually at 25 and 45 DAS. One light pre-sowing irrigation was given to get a better and uniform plant population. To obtain the plant height of a plot 5 plants were selected and then the heights of the plants were measured with the help of a scale from the base to tip of the plant after stretching the uppermost leaf of the plant upward. The cultivar Meha (IPM 99-125) of mung bean crop was used as semi-dwarf, high yielding cultivar. The seed colour is shining pale green with a duration of variety Meha was 60 days in the spring season. The average yield potential of the cultivar is about 994 kg ha^{-1}. Observations were recorded on growth parameters viz. plant height, leaf area index, number of branches per plant, dry matter accumulation, rate of crop growth as well as yield and quality attributes viz. number of nodule per plant, pod length, number of seeds per pod, seed yield (kg ha^{-1}), stover yield (kg ha^{-1}), test weight (gm), seed protein (%) and soil nutrients available status (N, P and K). The protein content of the seed samples was calculated by the micro kjeldhal procedure by multiplying the per cent nitrogen by the factor 6.25.

All the data were analyzed using analysis of variance (ANOVA) following a randomized block design (Gomez and Gomez, 1984). Differences were considered significant at 5% level of probability and also pooled analysis of two years' data was done.

RESULTS AND DISCUSSION

Crop growth characters

Crop growth parameter i.e. plant height increased as the crop progressed towards maturity. Among the seven different foliar applications, DAP at 2 % reported the maximum value of plant height (59.27 cm) during harvesting time, followed by Urea at 2%.The minimum value of 45.75 cm was derived from no foliar spray (Table 1). The leaf area index (LAI) of spring mung bean was found significant by foliar nutrition levels (Table 1). At 60 DAS, the highest LAI (3.47) was observed with foliar spray of DAP at 2 %, and the lowest value of LAI (2.29) was calculated at no foliar spray. Number of branches per plant at 60 DAS recorded highest (6.84) has been found at DAP at 2 % and was followed by Urea at 2 %. The lowest value of 5.42 was obtained from no foliar spray (Table 1). The best value of dry matter production of 224.16 g m^{-2} was obtained from DAP at 2%, it was followed by urea at 2 % obtaining the value of 222.65 g m^{-2} which is 18.29 % higher over control obtaining value 189.50 g m^{-2}. The rate of crop growth reached at top level during 45-60 DAS of spring mung bean cultivar that was significantly influenced by the different types of foliar nutrition (Table 1) recording the best CGR value 45-60 DAS with DAP at 2% followed by urea at 2% reporting results of 8.13 gm^{-2} day^{-1} and 7.71 gm^{-2} day^{-1}, respectively. On contrary, plots applied without any foliar application (T_1) exhibited less value of CGR. The results found similar with the finding of Ganapathy *et al*. (2008) which reported that growth attributes of pulses record the best value with foliar spray of DAP at 2 % as compared to urea at 2 % due to presence of nitrogen and phosphorus enhances in growth and development of the crop.

Table 1: Effect of foliar nutrition on growth parameters of spring mung bean (Pooled data of 2 years)

Treatments	Plant height (cm) at harvest	Leaf area index at 60 DAS	Number of branches per plant at 60 DAS	Dry matter accumulation ($g\ m^{-2}$) at 60 DAS	Crop growth rate 45-60 DAS
T_1	43.89	2.29	5.42	189.50	6.25
T_2	46.90	2.64	5.81	197.65	6.72
T_3	55.18	3.19	5.96	222.65	7.71
T_4	59.27	3.47	6.84	224.16	8.13
T_5	48.91	2.77	5.96	205.19	6.97
T_6	50.31	2.98	6.11	212.56	7.47
T_7	53.89	3.07	6.48	217.09	7.15
SEm(±)	**0.45**	**0.9**	**0.02**	**0.87**	**0.06**
LSD (0.05)	**1.41**	**0.29**	**0.07**	**3.23**	**0.21**

T_1: No foliar Spray; T_2: Water spray; T_3: Urea@ 2% (20g per litre of water); T_4: DAP @ 2% (20 g per litre of water); T_5: Zinc@0.2% (2 g per litre of water), T_6: Salicylic Acid @100 ppm; T_7: NPK (19:19:19) @ 1% (10 g per litre of water)

Table 2: Effect of foliar nutrition on yield and quality attributes of spring mung bean (Pooled data of 2 years)

Treatments	Number of nodule $plant^{-1}$	Pod length (cm)	Number of seeds pod^{-1}	Seed yield ($kg\ ha^{-1}$)	Stover yield ($kg\ ha^{-1}$)	Test weight (g)	Seed protein (%)
T_1	18.80	6.27	8.34	992.07	1925.73	39.93	22.97
T_2	19.13	6.30	8.89	1027.40	1999.26	40.21	23.36
T_3	22.99	6.96	9.53	1091.70	2504.60	40.66	23.74
T_4	23.75	7.34	9.72	1171.27	2660.57	41.22	24.45
T_5	24.54	8.40	10.89	1218.62	2783.43	41.66	24.53
T_6	24.83	8.91	11.28	1269.04	2976.19	42.50	24.79
T_7	24.37	7.88	10.62	1192.33	2326.40	41.62	24.36
SEm(±)	**0.30**	**0.03**	**0.10**	**11.2**	**31.2**	**0.07**	**0.15**
LSD (0.05)	**0.88**	**0.09**	**0.30**	**34.1**	**93.8**	**NS**	**0.44**

T_1: No foliar Spray; T_2: Water spray; T_3: Urea@ 2% (20g per litre of water); T_4: DAP @ 2% (20 g per litre of water); T_5: Zinc@0.2% (2 g per litre of water), T_6: Salicylic Acid @100 ppm; T_7: NPK (19:19:19) @ 1% (10 g per litre of water

Table 3: Effect of foliar nutrition on soil nutrient status after experimentation

Treatments	Available N in soil ($kg\ ha^{-1}$)	Available P in soil ($kg\ ha^{-1}$)	Available K in soil ($kg\ ha^{-1}$)
T_1	221.97	30.88	161.17
T_2	229.98	31.63	169.58
T_3	235.33	32.04	180.34
T_4	236.62	34.11	181.68
T_5	239.33	34.74	183.29
T_6	241.63	36.16	201.07
T_7	232.96	33.54	180.03
SEm(±)	**1.32**	**0.41**	**3.21**
LSD (0.05)	**4.12**	**1.29**	**10.01**

T_1: Nofoliar Spray; T_2: Water spray; T_3: Urea@ 2% (20g per litre of water); T_4: DAP @ 2% (20 g per litre of water); T_5: Zinc@0.2% (2 g per litre of water), T_6: Salicylic Acid @100 ppm; T_7: NPK (19:19:19) @ 1% (10 g per litre of water)

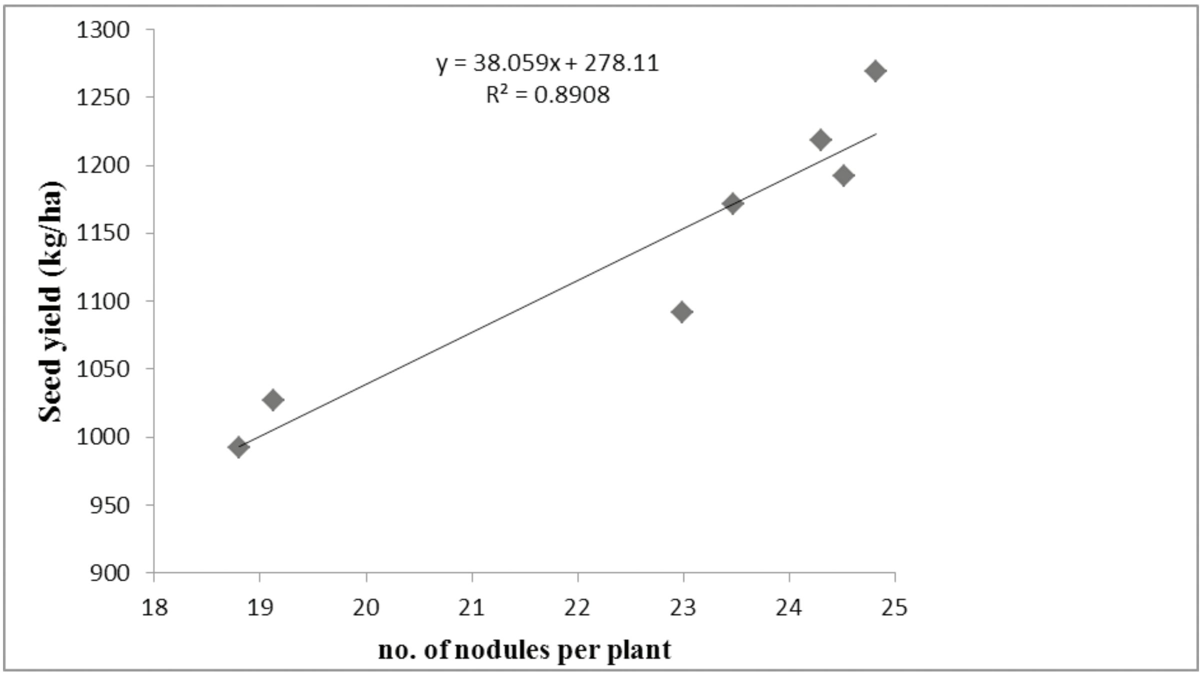

Fig. 1: Correlation between seed yield (kg ha^{-1}) and number of nodules per plant

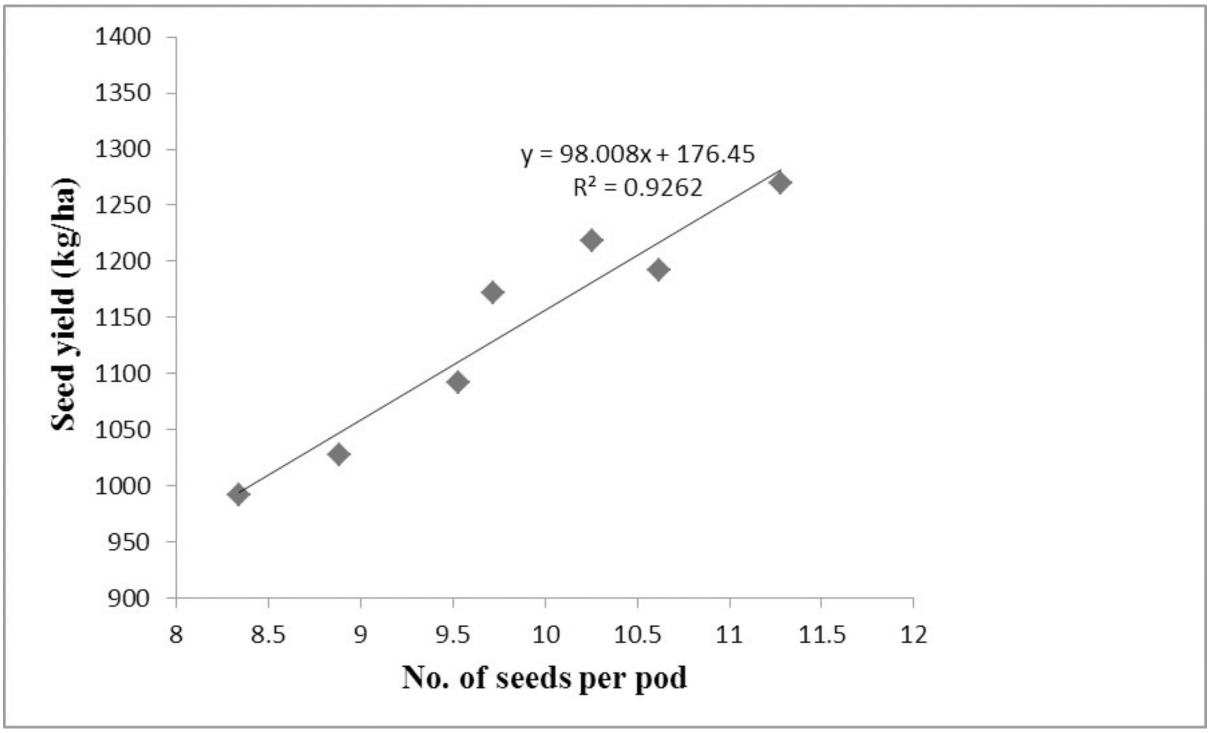

Fig. 2: Correlation between seed yield (kg ha^{-1}) and number of seeds per pod

Yield attributes and yield

The application of foliar nutrition enhanced the yield and quality attributes of mung bean during spring season, compared to the control situation (Table 2). The number of nodules per plant recorded (24.83) best with the application of salicylic acid at 100ppm followed by Zinc at 0.2% recording 24.54 number of nodules per plant. The lowest value of number of nodules per plant (18.80) was recorded from no foliar spray (control). The nodule per plant and seed yield shows a positive correlation between them (R^2 = 0.89) (Fig.1). Under different treatment applications, the highest pod length (8.91) was obtained with salicylic acid @100ppm followed by Zinc@ 0.2%. The lowest value of pod length was recorded from no foliar treatment (6.27). These findings were found in agreement with Shashikumar *et al*., (2013) and Priyanka *et al*., (2005) who revealed that different foliar treatments of exogenous and macronutrients have a positive effect on pod length. The highest value of number of seeds per pod (11.28) was recorded with the application of salicylic acid @100ppm whereas, the lowest value (8.34) was obtained from the control plot (no foliar spray). The number of seeds per plant and seed yield shows a positive correlation between them (R^2 = 0.926) (Fig.2). The application of salicylic acid showed the best value of seed yield (1269.04 kg ha^{-1}) and stover yield (2976.19 kg ha^{-1}) followed by zinc at 0.2%. The lowest value of seed yield (992.07 kg ha^{-1}) and stover yield (1925.73 kg ha^{-1}) was recorded from the control treatment. The salicylic acid @100ppm resulted in improving in seed yield due to its role as growth regulator that boosts crop production and improvement towards abiotic and biotic stress tolerance. Similar findings have also been reported by Marimuthu and Surendran (2015) and Sritharan *et al*. (2005) who reported that the production of higher seed yield due to effective utilization of nutrients might have provided better translocation of photosynthates from source to sink that may induce higher pod formation through foliar application and remained physiologically more active that builds up sufficient food reserves for enhancing flowers and seeds development. The highest test weight (42.50) was obtained with salicylic acid @100ppm followed by Zinc at 0.2% obtaining value of 41.66. The lowest value of test weight (39.93) was reported at no foliar application. The highest seed protein value (24.79%) obtained from salicylic acid was 7.92 % higher over control which is followed by Zinc at 0.2% (2 g per litre of water). Salicylic acid plays a crucial role in enhancing metabolic activities contributing through alternative pathways accompanied by a change in the level of nucleic and amino acids which induces the protein synthesis in plants.

Nutrient status

After harvesting spring mung bean, available soil nutrients varied significantly with different foliar nutrition management practices (Table 3). However, significantly higher available nitrogen (241.63 kg ha^{-1}) was recorded with foliar application of salicylic acid @ 100ppm followed by complex NPK (19:19:19) at 2% (239.33 kg ha^{-1}). The highest soil available phosphorus (36.16 kg ha^{-1}) was recorded in applied plots and the highest available potassium (201.07 kg ha^{-1}) was recorded with salicylic acid @ 100ppm fertilized plots.

CONCLUSION

Conclusively, the application of foliar nutrition was recorded to be superior for enhancing the growth and yield of spring mung bean variety Meha (IPM 99-125). Among the foliar nutrition treatments, application of salicylic acid@100ppm in conjunction with RDF (N, P_2O_5 and K_2O at 20, 40 and 40 kg ha^{-1}) were found to be more beneficial in terms of growth and seed yield which can also improve soil nutrient status in Gangetic alluvial soil of West Bengal.

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