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Growth and productivity of mungbean verities under foliar application of iron in semi-arid eastern plain zone of Rajasthan

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Abstract
Pulses, also known as grain legumes are next to cereals in terms of agricultural importance and have been considered best option for diversification and intensification of agriculture across the globe. Therefore, present investigation was planned to evaluate the response of Mungbean varieties to foliar application of iron. The experiment consisted of 16 treatment combinations of four varieties ie. IPM 02-3, SML-668, RMG-492 and RMG-62 and five iron application practices i.e. Control, 0.5% $FeSO_4$ spray at branching, 0.5%$FeSO_4$ spray at flowering and 0.5% $FeSO_4$ spray at branching +flowering and replicated three times. Results revealed that RMG 492 recorded significantly higher plant height, dry matter accumulation, number of branches and leaf area index over RMG 62, IPM 02-3 and SML 668 at 50 DAS and at harvest. Among the iron spray, foliar application of 0.5% $FeSO_4$ at branching+ flowering stage significantly increased the plant height, dry matter accumulation, number of branches and leaf area index plant height of mungbean over control at 50 DAS and at harvest stages. Likewise, RMG 492 produced significantly higher grain yield (1518 kg/ha) over SML 668 (1221 kg/ha), IPM 02-3 (1311 kg/ha) and RMG 62 (1406 kg/ha) with a quantum increase of 297, 207 and 112 kg/ha, respectively. The corresponding increase in terms of percentage was 24.3, 15.7 and 7.9 per cent, respectively. Foliar spray of 0.5% $FeSO_4$ at all the stages significantly increased the grain yield of mungbean. Application of 0.5% $FeSO_4$ at branching + flowering recorded an increase of 28.5 per cent, over control. The variety RMG 492 recorded the maximum straw yield of 3076 kg/ha which was significantly higher over RMG 62 (2864 kg/ha), IPM 02-3 (2695 kg/ha) and SML 668 (2515 kg/ha) representing quantum increase of 561, 381 and 212 kg/ha, respectively. Application of 0.5% $FeSO_4$ spray significantly increased the straw yield of mungbean. The highest value of straw yield was recorded with of 0.5% $FeSO_4$ spray at branching and branching + flowering stage which was 15.6 and 20.8 per cent higher over control. Based on the results of this experiment, it may be inferred that Mungbean variety RMG 492 was found most suitable for obtaining higher productivity. Similarly, foliar application of 0.5% $FeSO_4$ at branching + flowering stage was observed as the most effective for enhancing growth and yields of Mungbean.

Keywords: foliar nutrition, mungbean, iron sulphate, crop productivity and verities

Introduction
Pulses, also known as grain legumes are next to cereals in terms of agricultural importance and have been considered best option for diversification and intensification of agriculture across the globe (Singh *et al.*, 2006). The per capita availability of pulses is decreasing fast from 64 g in 1950-51 to 38 g/capita/day in 2014-15 as against the minimum requirement of 80 g/capita/day, which is causing protein malnutrition among the growing population (Yadav *et al*. 2017a; Yadav *et al*., 2017b). Mungbean is a one of the important leguminous crop is grown in arid and semi- arid regions of the country. It is tolerant to drought and can be successfully grown on well drained loamy to sandy loam soils in areas of erratic rainfall (Johnanurang *et al.*, 2009). Mungbean is mainly a rainy season crop and raised without irrigation but with the development of early maturing varieties, it has also proved to be an ideal crop for spring and summer season under irrigated condition (Mathur *et al.*, 2007a). Being a short duration crop, it suits well to various multiple and intercropping systems. After picking of pods, mungbean plants may be used as green fodder or green manure (Singh and Singh, 2010).
A number of high yielding varieties have been developed at different research station of the state. These varieties also differ in their yielding potential under different climate and edaphic conditions (Verma *et al.*, 2011).

Different varieties of mungbean have varying nutrient demand and climate adaptability. Therefore, selection of appropriate adoptable variety requires immediate and large efforts in the direction of improved varieties for a particular tract and its distribution (Buriro *et al.,* 2015).

Micronutrients have played vital in the growth, yield and quality of legumes crops. (Sonawane *et al*., 2010). Hallock (1978) observed that foliar application of micronutrient is better than soil application for increasing yield. In recent years, soil and foliar tests indicated a wide spread deficiency of iron particularly in light texture soils, low in organic carbon and alkaline in reaction (Sharma *et al.,* 2007). The soils of arid and semi-arid tract of Rajasthan are vary in texture from sandy to loamy sand and alkaline in nature, low in organic matter content and general fertility status is low (Yadav *et al*., 2017c). Iron being an essential micronutrient takes active part in the metabolic activities of the plant. It acts as activator of dehydrogenase, proteolase and peptidases enzymes, directly or indirectly involved in the synthesis of carbohydrates and proteins (Sadeghi and Noorhosseini, 2014). Iron is a structural component of porphyrin molecules, cytochromes, hemes, hematin, ferrichromes and leghemoglobin involved in oxidation reduction in respiration or in root nodules (Dash and Rautarary, 2017). It is an important part of the enzymes, nitrogenase which is essential for nitrogen fixation through nitrating bacteria. Iron in chloroplast reflects the presence of cytochromes for performing various photosynthetic reduction processes (Nasar and Shah, 2017). The ferredoxins are Fe-S protein and are the first stable redox compound of the photosynthetic electron transport chain (Havlin *et al.,* 1997). Keeping in view the above facts and paucity of research on above aspects the present investigation was planned to evaluate the response of Mungbean varieties to foliar application of iron.

Material and Methods

The experiment was conducted at Agronomy Farm of S.K.N. College of Agriculture, Jobner (26^0 05' N latitude and 75^0 28' E longitude and at an altitude of 427 metres above mean sea level). The region falls in Agro-climatic zone III-a (Semi-Arid Eastern Plain) of Rajasthan. The climate of this region is a typically semi-arid, characterized by extremes of temperature during both summers and winters. The average annual rainfall of this tract varies from 300 mm to 400 mm and is mostly received during the month of July to September. During summer, temperature may go as high as 48^0C while in winter, it may fall as low as -1.5 ^{0}C. the relative humidity fluctuates between 43 to 87 per cent. There is hardly any rain during winter and summers. The experimental soil was loamy sand in texture with high infiltration rate (22.4 cm/hr) and saturated hydraulic conductivity 10.20 cm/h. The soil was low in organic carbon (0.24%), low available nitrogen (125.7 kg N ha^{-1}), medium in available phosphorus (16.12 kg P_2O_5/ha) and in available potassium (151.24 kg K_2O/ha). The soil was non saline with a pH value of 8.2.

The present experiment was carried out in Randomized Block Design (RBD) consisting of 16 treatment combinations of four varieties ie. IPM 02-3, SML-668, RMG-492 and RMG-62 and five iron application practices i.e. Control, 0.5% $FeSO_4$ spray at branching, 0.5%$FeSO_4$ spray at flowering and 0.5% $FeSO_4$ spray at branching +flowering and replicated three times. The treatments were randomly allotted to different plots, using random number table of Fisher and Yates (1963). Seeds of different varieties were sown on the 5^{th} July, 2017 in the rows spaced at 30 cm apart with help of hand operated 'desi' plough with 'pora' attachment using a seed rate of 15 kg /ha. Thinning, hoeing and weeding were done after 20 days of sowing to maintain recommended spacing, proper aeration and weed free field. Five plants were selected randomly from each plot and tagged permanently. The height of each plant was measured from base of the plant to the tip of main shoot at 25, 50 DAS and at harvest. Dry matter production was recorded at 25, 50 DAS and at harvest stage. For this, plants from one metre row length were uprooted randomly from sample rows of each plot. After removal of root portion, the samples were first air dried for some days and finally dried in an electric oven at 70^0C till constant weight. The numbers of branches of the five tagged plants of mungbean from each plot were counted at harvest. The mean number of branches per plant in each experimental unit at aforesaid growth stages were worked out and recorded. Leaf Area Index is calculated by the formula given by Watson (1958). The crop was harvested on 27^{th} September, 2017 after leaving two border rows on each side of plot along the length on both sides, a net area of 2.4m × 3.0m was harvested separately from each plot to assess the grain and straw yields from net plot area. In each plot, bundles were tied and tagged properly and transported on threshing floor for proper sun drying. After complete drying, the produce of each plot was weighed on physical balance and the threshing was done manually by beating with wooden sticks and winnowed traditionally. The clean grain obtained from individual plot was weighed separately and weight recorded as grain yield (kg/plot). The straw yield (kg/plot) was obtained by subtracting the grain yield from biological yield recorded earlier. Harvest index was computed by using the formula given by Singh and Stoskopf (1981) which is expressed as:

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

All data recorded for different parameters were analysed with the help of analysis of variance (ANOVA) technique (Gomez and Gomez, 1984). The least significant difference test was used to decipher the main and interaction effects of treatments at 5% level of significance ($P < 0.05$).

Result and Discussion

Effect of cultivars and foliar spray of iron on plant height and dry matter accumulation: A critical examination of data in Table 1 revealed that RMG 492 recorded significantly higher plant height over RMG 62, IPM 02-3 and SML 668 at 50 DAS and at harvest. The increase in plant height due to RMG 492 was to the magnitude of 18.9, 10.9 and 7.6 per cent at 50 DAS and 17.0, 11.6 and 8.0 at harvest per cent, over SML 668, IPM 02-3 and RMG 492, respectively. There was no significant difference was observed for plant height at 25 DAS among varieties. Further, foliar application of 0.5% $FeSO_4$ at branching+ flowering stage significantly increased the plant height of mungbean over control at 50 DAS and at harvest stages. Application of 0.5% $FeSO_4$ at branching and branching+ flowering stage registered a significant increase of 10.0 and 14.5 per cent at 50 DAS, 11.3 and 16.2 per cent at harvest stages, respectively, over control. There is no significant difference in plant height at 25 DAS.

Table 1: Effect of mungbean varieties and iron application on plant height and dry matter accumulation at different stage of crop

Treatments	Plant height (cm)			Dry matter accumulation (g/m row length)		
	25 DAS	50 DAS	harvest	25 DAS	50 DAS	harvest
Varieties						
IPM 02-3	17.4	41.9	62.6	15.5	59.3	103.1
SML 668	17.2	39.1	59.7	15.1	57.1	99.7
RMG 492	18.5	46.5	69.9	16.0	66.9	111.6
RMG 62	18.4	43.2	64.7	15.6	62.4	103.8
SEm±	0.5	1.0	1.5	0.4	1.4	2.4
CD (P = 0.05)	NS	2.8	4.2	NS	4.1	7.1
Iron application						
Control	17.2	39.8	59.1	15.1	56.9	97.2
0.5% $FeSO_4$ at branching	18.2	43.8	65.8	15.8	63.7	105.6
0.5% $FeSO_4$ at flowering	17.6	41.6	63.3	15.2	58.1	101.0
0.5% $FeSO_4$ branching + flowering	18.4	45.6	68.7	16.0	67.0	114.4
SEm±	0.5	1.0	1.5	0.4	1.4	2.4
CD (P = 0.05)	NS	2.8	4.2	NS	4.1	7.1

A perusal of data indicated that RMG 492 produced significantly higher dry matter over RMG 62, IPM 02-3 and SML 668 at 50 DAS and at harvest (Table 1). Variety RMG 492 indicated an increase of 17.1, 12.8 and 7.2 per cent at 50 DAS and 11.3, 8.3 and 7.5 per cent at harvest, respectively, over variety SML 668, IPM 02-3 and RMG 62 in dry matter accumulation. There is no significant difference was observed for dry matter accumulation at 25 DAS. Among iron sprays, foliar spray of 0.5% $FeSO_4$ on mungbean significantly influenced the dry matter accumulation per metre row length at all the stages. Foliar application of 0.5% $FeSO_4$ at branching + flowering recorded maximum and significantly higher dry matter accumulation over control. At 50 DAS, foliar application at branching and branching+ flowering recorded an increase of 11.9 and 17.7 respectively, over control. While at harvest, application of 0.5% $FeSO_4$ sprays at branching and branching + flowering stage registered an increase of 8.6 and 17.6 per cent, respectively, over control in dry matter accumulation. Dry matter accumulation at 25 DAS did not differed significantly. The significant variations in plant height among the varieties may be due to their genetic variability for this trait. The similar results have also been reported by Ghosh *et al.* (2006), Goswami *et al.* (2010). The higher growth in term of height and dry matter accumulation with the application of iron might be attributed to the favorable influence of iron on metabolism and biological activity and stimulatory effect on photosynthetic pigments and enzymatic activity which in turn increase vegetative growth of plants (Thalooth *et al.*, 2006). The increase in ferrous supply may also result in enhanced synthesis of carbohydrates. The results of present investigation are in conformity with those of Mondal *et al*. (2011); Meena and Meena, (2013); Solanki *et al.* (2017).

Effect of cultivars and foliar spray of iron on branching and leaf area duration

The number of branches/plant of mungbean varieties significantly varied among each other was recorded at 50 DAS and at harvest stages of plant growth (Table 2). Variety RMG 492 recorded the highest number of branches and was found significantly superior to SML 668, IPM 02-3 and remained at par with RMG 62 at both the stages. Variety RMG 492 produced increased number of branches to the extent of 18.7 and 13.2 per cent at 50 DAS and 20.3and 10.4 per cent higher at harvest as compared to SML 668 and IPM 02-3, respectively. Foliar application of 0.5% $FeSO_4$ on mungbean produced significant effect on total number of branches at 50 DAS and at harvest. Foliar application of 0.5% $FeSO_4$ at branching + flowering stage observed significantly higher total number of branches over control and showed an increase of 17.0 per cent at 50 DAS and 19.5 per cent at harvest over control.

Table 2: Effect of mungbean varieties and iron application on branches per plant and leaf area index.

Treatments	Branches/plant		LAI
	50 DAS	At harvest	
Varieties			
IPM 02-3	7.54	8.68	3.67
SML 668	7.19	7.97	3.51
RMG 492	8.54	9.59	4.03
RMG 62	8.11	9.01	3.85
SEm±	0.21	0.25	0.08
CD (P = 0.05)	0.59	0.71	0.22
Iron application			
Control	7.22	8.00	3.52
0.5% $FeSO_4$ at branching	7.89	8.96	3.82
0.5% $FeSO_4$ at flowering	7.82	8.73	3.72
0.5% $FeSO_4$ at branching + flowering	8.45	9.56	4.01
SEm±	0.21	0.25	0.08
CD (P = 0.05)	0.59	0.71	0.22

Data presented in the Table 2 revealed that maximum leaf area index was obtained with RMG 492 which was significantly higher over IPM 02-3 and SML 668 and remained at par with RMG 62. It indicated an increase of 14.8 and 9.8 per cent over variety SML 668 and IPM 02-3, respectively. A perusal of data (Table 2) further revealed that foliar spray of 0.5% $FeSO_4$ at different stages on mungbean significantly increased the leaf area index over control. The data reveals that foliar application of 0.5% $FeSO_4$ at branching and branching + flowering registered an increase of 8.5 and 13.9 per cent over control, respectively.

Branching is an important character of crop which is directly related with the number of pod formation per plant and ultimately the productivity of crop. The differences among the varieties with respect to branches formation may be owing to inheritance of genetic divergence of the varieties. The present findings have been supported by many workers i.e. Parameswarappa *et al*. (2003); Rao *et al.* (2006); Gosami *et al.* (2009). Further, the differential behaviour among the varieties could be explained by the variation in their genetic makeup and their differential behavior under different climatic conditions. Mathur *et al*. (2007b), Vyas *et al*. (2007), Bohra (2007) and Yadav *et al.* (2011) at different locations also obtained similar variation in mungbean varieties in terms of plant height, number of branching, dry matter accumulation and nodules. The higher number of branches and leaf area index with application of iron may be attributed to the higher number of leaves producing higher food material for growth of the plant. In fact higher leaf area was responsible for preparing more photosynthates which increased cell division and resulted in rapid growth of the plants (Kumawat *et al*., 2006; Ravi *et al*., 2008).

Effect of cultivars and foliar spray of iron on plant on crop productivity

A critical examination of data (Table 3) clearly indicated that all varieties differed in grain yield wherein variety RMG 492 produced significantly higher grain yield (1518 kg/ha) over SML 668 (1221 kg/ha), IPM 02-3 (1311 kg/ha) and RMG 62 (1406 kg/ha) with a quantum increase of 297, 207 and 112 kg/ha, respectively. The corresponding increase in terms of percentage was 24.3, 15.7 and 7.9 per cent, respectively. A further reference to data in Table 3 revealed that foliar spray of 0.5% $FeSO_4$ at all the stages significantly increased the grain yield of mungbean. Application of 0.5% $FeSO_4$ at branching + flowering recorded an increase of 28.5 per cent, over control. Foliar application of 0.5 % $FeSO_4$ at branching and flowering stage independently also increased the grain yield of mungbean. The variety RMG 492 recorded the maximum straw yield of 3076 kg/ha which was significantly higher over RMG 62 (2864 kg/ha), IPM 02-3 (2695 kg/ha) and SML 668 (2515 kg/ha) representing quantum increase of 561, 381 and 212 kg/ha, respectively. The corresponding increase in terms of percentage was to the tune of 22.3, 14.1 and 7.4 per cent, respectively. A perusal of data in Table 3 revealed that 0.5% $FeSO_4$ spray significantly increased the straw yield of mungbean. The highest value of straw yield was recorded with of 0.5% $FeSO_4$ spray at branching and branching + flowering stage which was 15.6 and 20.8 per cent higher over control. Harvest index of different varieties did not differed significantly.

Table 3: Effect of mungbean varieties and iron application on grain, straw yield and harvest index

Treatments	Yield (Kg/ha)		Harvest index (%)
	Grain	Straw	
Varieties			
IPM 02-3	1311	2695	32.69
SML 668	1221	2515	32.65
RMG 492	1518	3076	33.01
RMG 62	1406	2864	32.89
SEm$\pm$	34	71	0.83
CD (P = 0.05)	100	204	NS
Iron application			
Control	1177	2498	32.01
0.5% $FeSO_4$ at branching	1418	2888	32.92
0.5% $FeSO_4$ at flowering	1348	2746	32.91
0.5% $FeSO_4$ at branching + flowering	1513	3018	33.38
SEm$\pm$	34	71	0.83
CD (P = 0.05)	100	204	NS

However, foliar spray of 0.5% $FeSO_4$ at branching, flowering and branching + flowering stages could not improve the harvest index of mungbean. However, a numerical increase in harvest index was recorded under foliar application of iron Higher grain yield of RMG 492 was mainly due to higher number of pods per plant, length of pods and test weight contributes mainly to grain yield. In rest of the varieties reason behind low grain yield observed may be inefficient partitioning of assimilates between the vegetative growth and seed formation. Since, yield formation is a complex process and governed by interaction between source and sink. Thus, wide variations in yield attributing parameters persisted among the different varieties obtained from the different parental origin. Attainments of particularly higher or lower yield attributing character among the different varieties are the genetically controlled phenomenon (Mahalashmi *et al.* 2000; Sadeghipur, 2008). Such variations in yield attributes among the mungbean varieties have also been observed by several research workers (Goswami *et al.* 2010 and Verma *et al.,* 2011). The increase in grain and straw yield may be attributed to the fact that favourable nutritional environment in rhizosphere and absorption of iron by plant leaves led to increased photosynthetic efficiency and production of assimilates as stated above, might have also favoured efficient partitioning of photosynthates in different vegetative and reproductive structures particularly the seed which is ultimate sink (Guruprasad *et al.*, 2009; Mondal *et al.*, 2011). The higher translocation of photosynthates in reproductive structures resulted in increased number of effective branching, test weight and ultimately the grain and straw yield of mungbean (Saini and Singh, 2017). Generally, crops require a favourable nutrient balance at reproductive stage for favourable development of pod and seed, whereas the soil applied nutrient does not meet the demand of crop for optimum nutrition. Therefore, foliar application of nutrient is a good way for supplying optimum nutrition for crop to complete its reproductive phases for obtaining higher productivity from crop plants. The results of present investigation are in conformity with those of Singh *et al.* (2013) and Solanki *et al.* (2017).

Conclusions

Based on the results of this experiment, it may be inferred that Mungbean variety RMG 492 was found most suitable for obtaining higher productivity. Similarly, foliar application of 0.5 % $FeSO_4$ at branching + flowering stage was observed as the most effective for enhancing growth and yields of Mungbean. However, these results are only indicative and require further experimentation to arrive at more consistent and final conclusion.

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