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RESEARCH ARTICLE

Effect of Different Nitrogen and Phosphorus Fertilizer Levels in Combination with Nitrogen and Phosphorus Solubilizing Inoculants on the Growth and Yield of Mung bean

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ABSTRACT

Nitrogen and phosphorus fertilizers have great importance for mung bean. The use of nitrogen and phosphorus fertilizers not only increases the yield and yield attributes but also improves seed quality. Therefore, this experiment was conducted to determine the influence of nitrogen and phosphorus fertilizers along with rhizobium and phosphorus solubilizing bacteria. Four fertilizer levels were i.e., F_0 (control), F_1 (20:50 kg NP ha^{-1}), F_2 (10:25 kg NP ha^{-1}) and F_3 (30:75 kg NP ha^{-1}) were tested along with seed treatments with inoculating bacteria i.e., no seed treatment, rhizobium treatment, phosphorus solubilizing bacteria and co-inoculation of the rhizobium and phosphorus solubilizing bacteria. The results revealed that fertilizer application along with inoculation significantly enhanced growth and yield of mung bean. However, in case of fertilizers the application of 20:50 kg NP kg ha^{-1} substantially improved the growth of mung bean, moreover, 20:50 kg NP kg ha^{-1} also registered an increase by 6.99%, 17% and 6.47% in 1000 seed weight, seed and biological yield respectively, over control. Similarly, the co-inoculation of the rhizobium and phosphorus solubilizing bacteria significantly increased the growth and registered an increase by 6.8%, 19.14% and 6.29% in 1000 seed weight, seed and biological yield over control. In conclusion, application of 20:50 kg NP kg ha^{-1} and co-inoculation of the rhizobium and phosphorus solubilizing bacteria can be opted to get maximum growth and yield of mung bean under semiarid conditions.

INTRODUCTION

Mung bean (*Vigna radiata* L.) relates to leguminaseae family and is generally called as green grain. It is highly nutritive crop as it contains 24.8% protein, 0.6% fat, 0.9% fiber and 3.7% ash (Monem et al., 2012), and has high digestibility (Hozayn et al., 2007). Moreover, it is short duration and has great tolerance against the drought stress (Smith, 2006; Naeem et al., 1999). In Pakistan, mung bean production is 93 thousand tons and is being cultivated on an area of 140.8 thousand hectares (Anonymous, 2013). Thus, the maximum resource utilization is necessary to overcome the increasing food demand. Mung bean has the ability to make symbiotic relationship with the special types of bacteria, improving the biological N-fixation in root nodules that supplements the plant nitrogen need (Mahmood and Athar, 2008; Mandal et al., 2009). Fertilizer management is a key factor that affects the development, growth and nutrient uptake of any crop.

Nitrogen is the essential component of protein and also plays pivotal role in chlorophyll formation (Iqbal and Chuhan, 2003). Use of nitrogenous fertilizer becomes limited due to high cost, farmers poor economic conditions and un-availability of fertilizer material at proper time. Water use efficiency and yield of crops is greatly affected by low soil nitrogen availability (Rifat et al., 2010). Excessive application of nitrogen fertilizer contaminates the ground water that causes bad impact on environment and disturbs the soil structure. Biological fixation leads to increase in uptake of nitrogen and decrease in cost of production (Jen-Hshuan, 2006). Leguminous crops are included in cropping system to enrich soil with nitrogen by fixing it from the atmosphere hence improves soil fertility (Yakubu et al., 2010). Through biological system legumes fix about 80% of total nitrogen (Chandrasekhar et al., 2005). On the other hand production of mung bean is enhanced by the combined effect of nitrogen and phosphorus (Aslam et al., 2010). There are different types of nitrifying bacteria but rhizobium species is very important for fixing nitrogen in the atmosphere and nodules formation in the roots of legumes (Lindemann and Glover, 2008). So, the inoculation in legumes especially in mung bean is necessary to accelerate growth and yield under both normal and stressful environments (Ali et al., 2000).

Phosphorus is also essential element for the plant growth and metabolism. Crop production is greatly influenced by phosphorus fertilizer and its deficiency affects other nutrients efficiency (Akinrinde and Adigun, 2005). Phosphorus is essential part of nucleic acid and phospholipids that promote the seed formation, blooming and regulates the metabolism and protein synthesis (Iqbal and Chuhan, 2003). Application of phosphorus enhances the nodule growth, development and dry matter production in legumes (Schulze et al., 2006). In soil increase in phosphorus level trigger nitrogen absorption, pod formation and energy process (Anetor and Aknirinde, 2006). In fruits and seeds, phosphorus is present in high amount that caused early crop maturity and helped in seed formation or disease prevention (Raboy, 2003). Ever demanding increased productivity of mung bean is therefore, hypothesized to be improved in response to inoculation in combination with nitrogen and phosphorus fertilizer. Optimization of a suitable dose of NP fertilizers in combination with appropriate inoculation treatment was done through growth, phonological and yield response of mung bean crop. Such inoculation optimization can help to reduce cost of production by reducing the use of synthetic NP fertilizers.

MATERIALS AND METHODS

Experimental site and soil analysis

The experiment was conducted at Research Area, Directorate of Farm, University of Agriculture, Faisalabad, Pakistan during June, 2013. The experimental site falls under semi-arid region, furthermore, prevailing climatic conditions during the crop growth season are presented in Table 1. To determine physico-chemical properties of experimental soil, composite soil samples were obtained from the top soil (0-20 cm) before sowing. Collected samples were analyzed by using the procedure advised by Homer and Pratt (1961). The soil was clay loam with pH 7.6, EC 2.5 dSm^{-1}, furthermore, it also contain organic matter 1.4%, total nitrogen 0.08%, available phosphorus 18 ppm, exchangeable potassium 230 ppm, respectively.

Treatments

Four fertilizer levels i.e., F_0 (control), F_1 (20:50 kg NP ha^{-1}), F_2 (10:25 kg NP ha^{-1}) and F_3 (30:75 kg NP ha^{-1}) were used along with the four bacterial inoculants i.e., no seed treatment, rhizobium treatment, Phosphorus solubilizing bacteria and co-inoculation of the rhizobium and phosphorus solubilizing bacteria.

Crop husbandry

Mung bean seed and inoculant rhizobium and PSB were obtained from Ayub Agriculture Research Institute, Faisalabad. The 10% sugar solution was prepared and added with inoculants material according to the treatments and mixed thoroughly. After that this solution was mixed with mung bean seed and then seeds were dried under shade for one hour. Seeds were sown in a well prepared seedbed with the help of hand drill to maintain 30 cm row to row and 10 cm plant to plant distance. Seed rate was 24 kg ha^{-1}. All the fertilizers were applied at the time of sowing according to the treatments. All other recommended practices were kept uniform in order to get successful crop production.

Variable measurements

First leaf area, leaf area duration and total dry matter were measured after thirty days of sowing, then after fifteen days interval. Crop leaf area was determined by leaf area meter (CI-202, CID Bio-Science). Leaf area duration was calculated by standard procedures as advised by Hunt (1978). Similarly, for total dry matter, plants from one square meter were harvested and sun

Table 1: Prevailing climatic conditions of the experimental site during crop growing seasons for the year 2013

Months	Monthly Mean Max. Temp (°C)	Monthly Mean Min. Temp (°C)	Monthly Avg. Temp (°C)	Rainfall (mm)	R.H (%)
June-13	39.5	27.9	33.7	67.5	43.3
July-13	37.4	28.6	33.0	58.5	4.7
August-13	35.3	27.2	31.3	114.8	65.6
September-13	36.2	25.4	31.0	53.7	3.3

dried and weighed for the determination of dry matter. At physiological maturity ten plants from each plot, were selected randomly, to determine the plant height, number of nodules, pod bearing branches, number of pods, pod length, 1000 seed weight. Similarly, seed yield, biological yield and harvest index were recorded during the course of study by standard procedures.

Experimental design and statistical analysis

The experiment was laid out in Randomized Complete Block Design (RCBD) in factorial arrangement with three replications. Recorded data were analyzed statistically using MSTAT-C program and the means were compared by least significant difference test at 5% probability level (Steel et al., 1997). Graphs for experimental data were generated by using sigma plot

RESULTS

Data revealed that fertilizer and inoculation significantly ($P \leq 0.05$) affected the growth attributes of mung bean (Fig. 1). In case of fertilizer application maximum improvement in leaf area index, leaf area duration and dry matter was seen with the use of 20:50 kg NP kg ha^{-1}, while a substantial reduction was recorded with no fertilizer application (Fig.1 d, e, f). As for the inoculants maximum leaf area index, leaf area duration and dry matter were recorded with the combined application of rhizobium and PSB (Fig.1 a, b, c), whereas the minimum values of these growth attributes were recorded under control conditions.

Similarly, fertilizers and inoculants appreciably improved the yield related attributes of mung bean (Table 2). Maximum plant height (78.1 cm) was recorded in 20:50 kg NP ha^{-1}, similarly, in case of inoculation rhizobium+PSB produced maximum plant height (78.08 cm), while minimum height was observed under no fertilizer and no inoculation (Table 2). The results revealed that fertilizers and inoculants substantially increased the number of nodules, pod bearing branches and number of pods. As for the fertilizers the application of 20:50 kg NP ha^{-1}, registered an increase of 70.62%, 28.54% and 25.35% in number of nodules, pod bearing branches and number of pods respectively over the control. Moreover, it can be seen from Table 3, no fertilizer application markedly reduced nodules, pods and pod bearing branches. Similarly, in case of inoculants, the use of rhizobium+PSB registered an increase by 48.1%, 18.3% and 25.16% in number of nodules, pod bearing branches and number of pods, respectively over no seed inoculation.

In the same way fertilizers and inoculations significantly affected the seeds per pod, pod length and 1000 seed weight (Table 2). The results revealed that maximum seeds (10.1), pod length (9.8 cm) and 1000 seed weight (45.6 g) were recorded with the application of 20:50 kg NP ha^{-1}, moreover, minimum number of seeds, pod length and 1000 grain weight were obtained with no fertilizer use (Table 3). On the other hand, maximum number of seeds (9.9), pod length (9.7 cm) and 1000 seed weight (45.7 g) were recorded with the combined application of rhizobium and PSB, while the minimum value of these attributes was recorded with no inoculation (Table 2). The results revealed that fertilizers and inoculants application considerably increased the seed yield, biological yield and harvest index (Table 2). Among fertilizer treatments maximum seed yield (1389.7 kg ha^{-1}), biological yield (6560 kg ha^{-1}) and harvest index (0.211) were recorded with the use of 20:50 kg NP ha^{-1}, however, it produced similar, seed yields, biological yields and harvest index as produced by the application 30:75 kg NP ha^{-1}. Similarly, co-inoculation of rhizobium+PSB produced highest seed yield (1402.2 kg ha^{-1}), biological yield (6575 kg ha^{-1}) and harvest index (0.213) which were statistically similar to rhizobium while significantly, lowest seed yield, biological yield and harvest index were recorded when no seed treatment was given to seed.

Table 2: Mean comparison of growth, yield and yield components of mung bean as affected by different NP fertilizer rates and inoculants

Treatments	Plant height	No. of nodules	Pod bearing branches	No. of Pods	Seeds per Pod	Pod length	1000 Seed wt. (g)	Seed yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index
F_0 (control)	68.0c	8.75c	6.48c	11.83c	8.6c	8.8c	42.62c	1187c	6161c	0.195 b
F_1 (10:25 kg NP ha^{-1})	73.8b	11.67b	7.1b	13.17b	9.1bc	9.2bc	44.08b	1285b	6353b	0.202 ab
F_2 (20:50 kg NP ha^{-1})	78.1a	14.93a	8.33a	14.83a	10.1a	9.8a	45.6a	1389.7a	6560a	0.211 a
F_3 (30:75 kg NP ha^{-1})	76.9ab	14.4a	8.05a	13.92b	9.5b	9.3ab	45.39a	1341ab	6528ab	0.205 a
LSD ($P \leq 0.05$)	4.19	7.07	0.495	0.96	0.55	0.51	0.914	66.68	187.91	0.11
Inoculants										
B_0 (No Inoculation)	69.00c	9.98d	6.83c	11.92c	8.7c	8.9c	42.79c	1176.9 c	6186c	0.193 b
B_1 (Rhizobium Inoculation)	76.33ab	13.1b	7.65ab	14a	9.4ab	9.4ab	44.9ab	1335.2 b	6457ab	0.206 ab
B_2 (PSB Inoculation)	73.33b	11.9c	7.4b	12.92b	9.2bc	9.2bc	44.26b	1290.3 b	6385 b	0.202 a
B_3 (Rhizobium+PSB)	78.08a	14.78a	8.08a	14.92a	9.9a	9.7 a	45.7a	1402.2 a	6575 a	0.213 a
LSD ($P \leq 0.05$)	4.19	7.07	0.49	0.96	0.55	0.51	0.91	66.68	187.91	0.11

Means sharing the same letter for a single parameter do not differ significantly at $P \leq 0.05$.

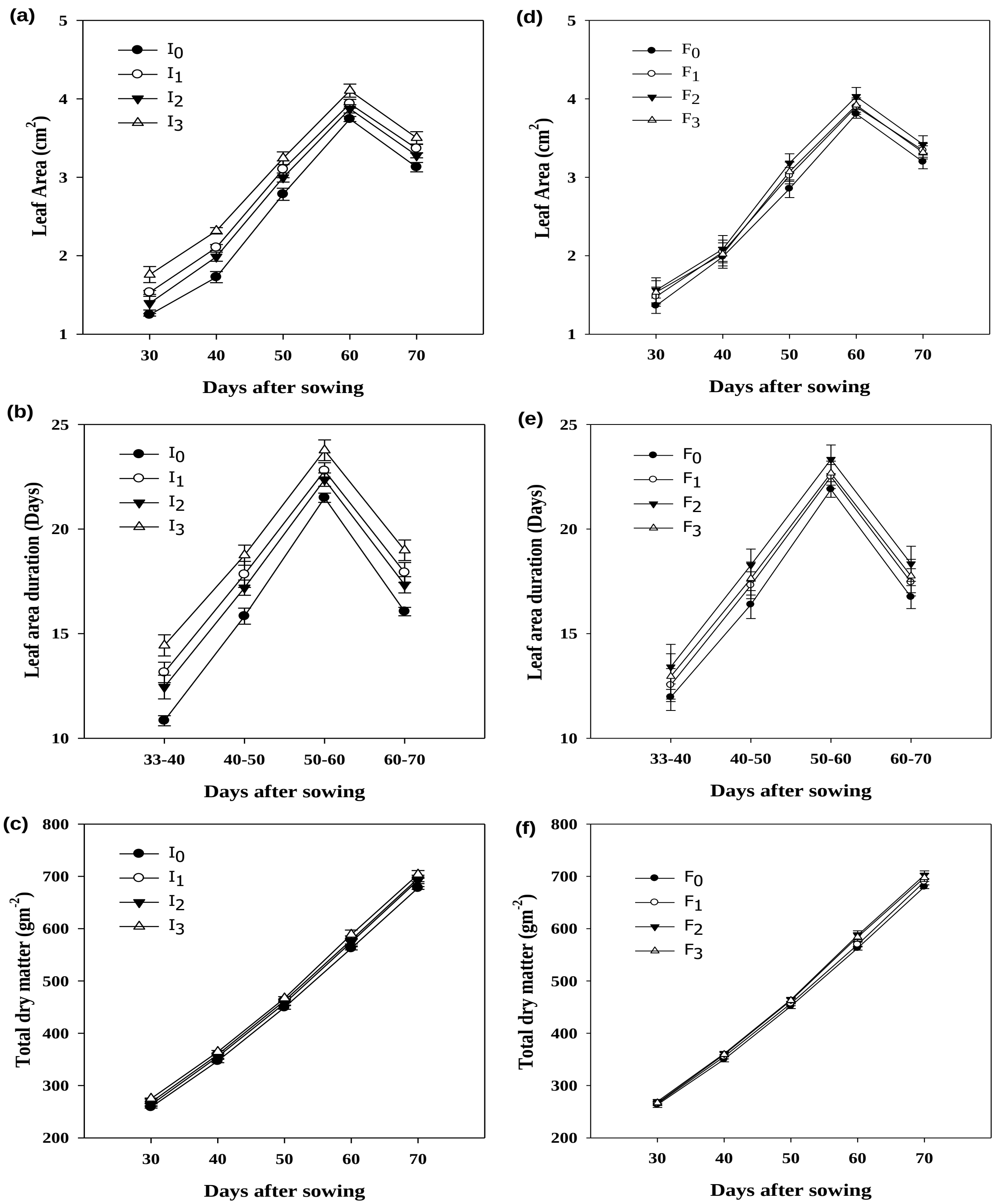

Fig. 1: Effect of different NP fertilizer levels and inoculating bacteria on (a, d) leaf area (cm^2) (b, e) leaf area duration (days) and (c, f) total dry matter (g m^{-2}) of mung bean.

DISCUSSION

The application of fertilizers and inoculants significantly improved the growth attributes of mung bean (Fig. 1). The increase in leaf area, leaf area duration and dry matter production by fertilization and inoculants might be due to efficient portioning and uptake of nutrients from plant roots to areal parts, which in turns increased the leaf size and ultimately leaf area index and leaf area duration. These findings are in line with previous results of Sadeghi and Bohrani, 2001 as they also reported substantial improvement in leaf area index, leaf duration and dry matter, with the application of nitrogen, phosphorus and inoculants. The results also revealed that fertilizers and inoculants remarkably increased the plant height. This increase in plant height can be due to vigorous vegetative growth as by the provision of nitrogen from fertilizer and inoculants. These findings are in consistence with previous results of Hussain et al., (2011) as they, reported substantial increase in plant height with nitrogen application.

Similarly, application of fertilizers and inoculants also increased the number of nodules, pod bearing branches, pods, seeds per pod, pod length and 1000 seed weight (Table 2). The increase in number of nodules might be due to the increased in the number of bacteria by fertilizer application and seed treatments with inoculants. Similarly, Arif et al. (2010) also found that combined application of fertilizers and inoculants appreciably improved the nodule count. The results of our study are in line with the findings of Schulze et al. (2006), they found that phosphorus application enhances the nodule growth, development and functioning of legume plant and dry matter production. Pod bearing branches, number of pods and seeds per pod are direct yield contributing factors and both the fertilizer and inoculations of bacterial strain increased these parameters by the provision of proper nutrition to mung bean plants. Similar results were reported by Khan et al. (1999). These results are also in consistence with previous studies of Ghanem and Abbas (2009) as they reported appreciable increase in number of pod bearing branches, number of pods, number of nodules, 1000 seed weight and seed yield in mung bean by the combined application of fertilizer with inoculation. The comparative increase in 1000 seed weight (Table 2) can be due to improvement in metabolic process involved in the production of healthier seed by the application of fertilizers and inoculants. Similarly, Yadegari et al. (2008) also reported remarkable increase in 1000 seed weight with the application of fertilizers and rhizobacteria strains. In mung bean final yield depends on the number of pods and branches per plant, and 1000 seed weight. In our study the increase in yield can be positively correlated with the increase in pod bearing branches, number of pods, seed per pod and 1000 seed weight by the application of fertilizers and rhizobium+PSB (Table 2). Biological yield was also appreciably influenced by the application of nitrogen and phosphorus along with the application of inoculants (Table 2). The increase in biological yield can be due to positive effect of fertilizers and inoculants on the root proliferation, thereby improved the nutrient uptake, which ultimately, enhance the vegetative growth. Similar, findings were reported by Malik et al. (2003) who observed considerable increase in biological yield with the application of nitrogen (25 kg N ha^{-1}) and phosphorus (75 kg N ha^{-1}). Similarly, the comparative increase in harvest index by fertilizers and inoculants can be due to combined increase in grain and biological yield. These results are in consistence with previous studies (Khan et al., 2008).

In conclusion, nitrogen and phosphorus application combined with rhizobium and phosphorus solubilizing bacteria improved the growth and yield of mung bean. Fertilizer at the rate of 20:50 kg NP ha^{-1} and inoculation of rhizobium and phosphorus solubilizing bacteria proved better sources of fertilization. So it is suggested that future studies must include a wide range of combination of both fertilizer and inoculants to improve the yield of mung bean.

Authors' contributions

MUC, IK, MBC, conceived the idea and deigned the project. MUF conducted the experiment. MUH, IA, WA and MU helped in the preparation of manuscript and literature search. MK helped in statistical analysis. All authors read and approved the final manuscript.

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