Integrated application of phosphorus along with different biofertilizers on various growth parameters of maize (Zea mays L.) under intercropping system

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ABSTRACT

The present study was conducted during kharif seasons of 2012 and 2013 at the Krishi Vigyan Kendra (KVK) of Shere-e-Kashmir University of Agricultural Sciences and Technology, Budgam, Jammu and Kashmir. The climate of the experimental site was temperate with mild summers and cold winters, showing wide variations in mean maximum and minimum temperatures. Common bean variety "Shalimar Rajmash-1" was used for the present study. The experiment was laid out in a complete randomized design (CRD) with each treatment replicated three times. Different levels of DAP (20 and 40 kg) along with different biofertilizer combinations like Rhizobium (Rhizobium leguminosarum), Azotobacter (Azotobacter vinelandi), VAM (Glomus mosseae) have been used during the research. The results of the experiment revealed that he various growth parameters of all the inoculated maize plants was higher as compared to control plants. Rhizobium + VAM @ 20 kg P/ha in the present research showed significant impact on nitrogen content in leaves and stem of common bean as compared to all treatments. Significant increase in various growth parameters of maize plants recorded when plants were inoculated with Rhizobium + VAM @ 20 kg P/ha. Overall the significant on growth of maize plant was due to positive interactions among different microorganisms leading to healthy and vigorously growing plants.

Key words:maize, phosphorus, biofertilizers, fresh weight and dry weight

I. INTRODUCTION

Most growers all over the world own very small land holding, especially in developing countries of Asia and Africa. So there is pressing need to increase production as well as enhance the ability of growers to grow multiple crops in these small areas. Intercropping is followed in many parts of the world to produce more food and feed per unit area(Caruthers *etal*.,2000).Intercropping, as a method of sustainable agriculture, involves simultaneous growing of two or more crops during the same season on the same area, whichas an efficient resource use method ensures better utility of common limiting resources than the individual species grow separately(Ghosh *et al*., 2007).Intercropping of cereals with legumes is popular in humid tropical environmentsand rainfed areas of the world. It is widely employed not only in tropical areas but alsoin temperate areas, resulting in high grain yield (Li *etal.*,2001) and can be environmentally benign by reducing accumulation ofNo_3-N in soil profile and by reducing nitrogen input (Exner *et al.*,1999).

Though India enjoys an exportable surplus of maize at present, there is an urgent need to gear up its production and productivity to meet the projected demand of 40-45 million tons by 2025. Maize is called the 'Queen of cereals' because of its higher productive potential compared to any other cereal crop. Being an exhaustive crop, it has very high nutrient requirement and its productivity is closely linked with nutrient management. Maize is currently the third most traded cereal, after wheat and rice, with a total production of 822 million tons in over 160 million hectares. Because of its low prices and world wide distribution, it has become the most important raw material for animal feed and for several industrial processes**.** The biofertilizers are important to ensure a healthy future for the generationsto come. The improvement in soil fertility and yield and yield attributing characters incorporation by biofertilizers has been reported by many workers (Kachroo and Razdan, 2006, Son *et al.* 2006).

II.MATERIALS AND METHODS

Treatments Details and Crop Culture: The detailed treatments are presented in Table 2. Common bean variety "Shalimar Rajmash-1" and maize variety "C-15" were used for the present study. The maize seeds were sown at row to row distance of 75 cm and plant to plant distance of 20 cm. The common bean seeds were sown in between the maize rows. Sowing was done in the last week of April, 2012 and 2013 and seeds were hand dibbled at a depth of about 2 cm in soil.

Biofertilizers and chemical fertilizers application: The seeds were surface sterilized by sodium hypochlorite (0.1%) for 2 minutes, thoroughly rinsed with distilled water and soaked in distilled water for 6 hours before sowing in plots. Peat based *Rhizobium leguminosarum* inoculum, vesicular arbuscular mycorrhizae (*Glomus mosseae*) and *Azotobacter vinelandi* was procured from the Division of Microbiology, IARI (New Delhi) India. For *Rhizobium* and *Azotobacter* inoculation, the seeds were moistened in sugar solution (48%) before the application of inoculums to get a thin uniform coating of inoculum on the seeds, immediately before sowing the seeds in field. The seed were then shade dried after inoculation.The mycorrhizal inoculum was applied after seed sowing at the rate of 25 Kg/ha by planting holes method.

III.TREATMENTS

(T_1) Maize + common bean (control).

(T2) Maize+ common bean treated with *Rhizobium* .

(T_3) Maize + common bean both treated with *Azotobacter*.

(T_4) Maize + common bean both treated with Arbuscular mycorrhizae.

(T_5) Maize + common bean both supplied with 20 kg Phosphorus/ha.

(T_6) Maize + common bean both supplied with40 kg Phosphorus/ha.

(T_7) Maize + common bean treated with *Rhizobium* + Arbuscular mycorrhizae.

(T_8) Maize + common bean treated with *Azotobacter* + Arbuscular mycorrhizae.

(T_9) Maize + common bean treated with *Rhizobium* + Arbuscular mycorrhizae + 20 kg Phosphorus/ha.

(T_{10}) Maize + common bean treated with *Azotobacter* + Arbuscular mycorrhizae + 20 kg Phosphorus/ha.

(T_{11}) Maize + common treated with *Rhizobium* + Arbuscular mycorrhizae + 40 kg Phosphorus/ha.

(T_{12}) Maize + common bean treated with *Azotobacter* + Arbuscular mycorrhizae + 40 kg Phosphorus/ha.

(T_{13}) Maize + common bean treated with *Rhizobium* + *Azotobacter* + Arbuscular mycorrhizae.

Plant growth parameters

Five maize plants were randomly selected at final growth stage for leaf, stem fresh weights. and data recorded. The samples were subject to oven-drying at 65°C, till the material attained a constant weight and then recorded their dry weight.The shoot lenghth of stem were measured with a measuring tape.

IV.RESULTS

GROWTH PARAMETERS

All the dual inoculation treatments at different levels of phosphorus recorded higher fresh weight in comparisonto single inoculation or control. Maximum fresh weight was recorded in treatment T_9 (35.24 g) followed by$T_{10}$and T_{13} [Table-4]. Minimum fresh weight (29.51 g) was recorded in controlplants (T_1) followed byT_3 (31.02 g). Similar results were observed for dry weights of leaves. Maximum dry weight of leaves (7.04 g) was recorded in T_9 followed by $T_{10}$and T_{13}. Where lowest dry weight of leaves (5.90 g) was recorded in control plants(T_1) followed by T_3(6.20 g).

The maximum fresh weight of stem (146.13g) was observed inT_9 followed by$T_{13}$and T_{10}(145.19 and 145.13 g). Minimum fresh weight of stem (130.68 g)was recorded in control plants(T_1) [Table-4] followed by T_3(133.45 g).Similarly maximum dry weight of stem (46.75 g) was recorded in treatment combination of T_9followed by $T_{13}$and T_{10}(46.45 and 46.43g g). Minimum dry weight of stem (41.81 g) was observed in control plants(T_1) followed byT_4 (44.08 g).

Table 4 revealed that the application of biofertilizers and phosphorus soley or in combination significantly increased shoot length and other traits in maize.Maximum shoot length (212.15 cm) was recorded in T_9 receiving dual inoculation of *Rhizobium* + VAM+ 20 kg phosphorus followed by T_{10} and T_{13} (194.54 and 193.33 cm, respectively). Minimum shoot length (167.64 cm) was observed in control plants followed by T_6 (174.64 cm).

Table 4:- Impact of phosphorus and biofertilizers on fresh and dry weight of leaves and stem of maize under intercropping of common bean + maize.

Treatments	Fresh weight of leaves (g)	Dry weight of leaves (g)	Fresh weight of stem (g)	Dry weight of stem (g)	Shoot length (cm)
T_1 (Control)	29.51±0.45	5.90±0.09	130.68±0.03	41.81±0.02	167.64±1.46
T_2 (*Rhizobium*)	32.36±0.01	6.46±0.00	138.26±0.02	44.23±0.03	181.00±1.15
T_3 (*Azotobacter*)	31.02±0.01	6.20±0.00	133.45±0.00	42.70±0.00	175.27±1.03
T_4 (VAM)	32.24±0.01	6.44±0.00	137.78±0.04	44.08±0.01	185.96±1.44
T_5 (20 kg P)	32.36±0.01	6.46±0.00	138.29±0.02	44.25±0.06	191.88±2.40
T_6 (40 kg P)	32.02±0.01	6.40±0.00	136.34±0.03	43.62±0.03	174.64±0.99
T_7 (Rhz.+ VAM)	33.14±0.01	6.50±0.11	140.13±0.00	44.83±0.08	186.92±1.84
T_8 (Az.+VAM)	32.34±0.00	6.46±0.03	139.23±0.02	44.55±0.00	191.85±1.00
T_9 (Rhz.+ VAM+20kg P)	35.24±0.00	7.04±0.03	146.13±0.00	46.75±0.01	212.15±1.29
T_{10} (Az.+ VAM+20 kg P)	33.82±0.01	6.76±0.00	145.13±0.00	46.43±0.08	194.54±1.14
T_{11} (Rhz.+VAM+40 kg P)	32.46±0.01	6.48±0.04	142.22±0.04	45.50±0.02	187.29±0.68
T_{12} (Az.+VAM+40 kg P)	32.57±0.01	6.51±0.03	143.78±0.33	46.00±0.10	192.14±1.28
T_{13} (Rhz.+Az.+VAM)	33.74±0.01	6.74±0.03	145.19±0.00	46.45±0.00	193.33±1.28
C.D.@ 5%	0.359	0.122	0.298	0.083	1.426

Rhz. = *Rhizobium*, Az. = *Azotobacter*, VAM = *Vesicular arbuscular mycorrhizae*, P = Phosphorus, C.D. = Critical Difference

Fig. General view of experiment at early stage of crops growth

V.DISCUSSION

Application of elemental phosphorus at different rates along with single, dual or multiple usesof biofertilizers had significant effect on common bean growth parameters. Maximum fresh and dry weight of leaves were recorded in treatment combination of *Rhizobium* + VAM + 20 Kg P/ha. Similarly, fresh and dry weight of stem was maximum in *Rhizobium*+ VAM + 20 Kg P/ha which was significantly higher than those of single inoculation of either biofertilizer or phosphorus. The results are in agreement with the findings of Salamone *et al.* (2005) who reported that dual inoculation of *Rhizobium* + VAM in presence of nitrogen and phosphorus increased dry weight of shoot as compared to single inoculation. Phosphorus is the key component of energy generation in plants. It is conceivable that increase in cell division due to phosphorus application results from increase in the amount of adenosine triphosphate(ATP) at growth centers which affect the growth characteristics (Chiera *et al*., 2004). The studies have revealed that beans subjected to phosphorus stress show 50 percent reduction in ATP in leaves and 60% reduction in total leaf area (Mikulska *et al*., 1998).

Artusson *et al*, (2005) reported that arbuscular mycorrhizal (AM) fungi and *rhizobacteria* could interact synergistically to stimulate plant growth through a range of mechanisms that include improved nutrient acquisition (Nitrogen and phosphorus bioavailability) and inhibition of fungal plant pathogens. Studies of Ezz *et al*. (2011) on banana (*Musa* spp.) showed that the using of phosphorus fertilization and microorganisms as a bio-fertilizer increased all studied vegetative growth characters including plant height. Abu and Aly (2011) showed the positive effect of phosphate solubilizing microorganisms on the most plant growth parameters of tomato. The effect of phosphate solubilizing bacteria on growth may be due to the activity of phosphate solubilization caused by the strain and increased further mineral availability uptake.

VI.CONCLUSION

Integrated application of phosphorus in combination with *Rhizobium* and VAM significantly increased various growth parameters of maize plant under intercropping system. Also application of different biofertilizers along with different levels of phosphorus plays a significant rule in becoming the inorganic phosphorus easily available to the plants. Therefore, integrated application of phosphorus with *Rhizobium* and VAM can be highly recommended in common bean and maize intercropping for enhancing other parameters of both crops

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