Response of microbes and bioregulators on yield performance of chickpea (*Cicer arietinum* L.) under rainfed condition

Amal Kumar Bera, Kalipada Pramanik*, Sutapa Dey, Soma Mukherjee, Binoy Kumar Saren and Spurti Mondal

ABSTRACT

A field experiment was conducted to study the response of microbes and bioregulators on yield growth and productivity of chickpea (*Cicer arietinum* L.) under rainfed condition during 2010-11 and 2011-2012 on sandy loam soils with factorial randomized block design consisting of four levels of biofertilizers inoculation *viz.*, no inoculation, phosphate solubilizing bacteria (PSB), vesicular arbuscular mycorrhizae (VAM) and PSB+VAM with two bio-regulators *viz.*, homo-brassinolide @ 1 ppm and gibberelic acid @ 1000 ppm at pre-flowering and pod-filling stage. Result showed that the yield attributes like number of grains plant^{-1}and test weight were highest in treatment receiving homo-brassinolide and dual inoculation of PSB+VAM. Grain yield was highest (2139 and 2211 kg ha^{-1}) in treatment receiving PSB+VAM application over no inoculation (957 and 1072 kg ha^{-1}). The grain yield was highest (1705 and 1797 kg ha^{-1}) in treatment receiving homo-brassnolide and lowest grain yield (1481 and 1569 kg ha^{-1}) at gibberelic acid during 2010-11 and 2011-12, respectively.

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INTRODUCTION

Chickpea is the third most important food legume grown in the world after beans and peas. Also, it is an important crop for both human consumption and animal feed due to 17 - 31% protein in seeds and biological activity of its protein ranges between 52 - 78% (Ciftci, 2004). Chickpea seeds contain essential amino acids like isoleucine, leucine, lysine, phenylalanine and valine (Karim and Fattah, 2006). Chickpea is one of the suitable plants grown broadly in most of the arid regions and dry farming areas in developing countries. The productivity and production of chickpea is limited worldwide because of abiotic and biotic stresses. To overcome these constraints, the use of microbes and bioregulators may play an important role. Microbial communities like VAM and PSB may increase nutrients availability particularly phosphorus, which is key element of pulse production. VAM not only enhances phosphorus uptake in phosphorus deficient soils but also increase the resistance against diseases. This method is the alternative to fungicides to protect plants since there is greater awareness about the harmful effect of fungicides on the natural ecosystem (Vimala and Suriachandraselvan, 2009; Mondal and Mondal, 2012). Biofertilize *Pseudomanas striata*, in the soil (Saxena, 1993) that stimulate plant growth and contribute to the improvement of ecosystem. They also play an active role in biological control of plant pathogens, (Tilak *et al*., 2005). It is well known that AM fungi can improve the nutrient status of their host plants (Smith and Read 2008). Several mineral nutrients, especially P, are allocated through the symbiosis to the plant in exchange for carbon (Pearson and Jakobsen 1993). Mycorrhizal fungi produce antibiotics that inhibit disease organisms and further suppress diseases by improving host nutrition, which increases plant vigor. Healthy plants are better able to resist or tolerate pathogens such as *Fusarium*, *Rhizoctonia*, *Phythium* and *Phytophthora* (all root-rots) and *Verticillum.* Seeds treated with gibberillic acid usually germinate and grow faster, have more developed root system, increase their tolerance to abiotic stress conditions, bloom and mature earlier and give better yields (Abd El-Fattah, 1997; Kaur *et al.*, 2000; Leite *et al.*, 2003; Toker *et al.*, 2004). On the other hand exogenous application of homobrassinolide has an ameliorative effects on plant productivity, physiological and biochemical parameters as well as increase resistance to plants against various abiotic (drought, salinity) /biotic stresses (nematode, fungal and viral infection). Keeping this view, the present study was carried out to study the effect of microbes and bioregulators on the yield performance of chickpea under rainfed condition.

MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 2010-2011 and 2011-2012 at Agricultural research farm, (Institute of Agriculture), Visva-Bharati, Sriniketan, Birbhum. The soil was slightly acidic (p^H 6.1), low in available nitrogen (139 kg ha^{-1}), phosphorus (13.50 kg ha^{-1}) and medium in potassium (164.5 kg ha^{-1}).The experiment was laid out in factorial randomized block design with four levels of biofertilizers inoculation (no inoculation, Phosphate solubilizing bacteria (PSB), Vesicular arbuscular mycorrhizae (VAM) and Phosphate solubilizing bacteria (PSB) + Vesicular arbuscular mycorrhizae (VAM)) and two levels of phytohormone (homobrassinolide and gibberelic acid). In all eight treatments replicated three times. The chickpea, 'Mahamaya-2 (B-115)' was sown on November 11 and November 8 during 2010-2011 and 2011-2012 respectively. The seed was inoculated with PSB by slurry method whereas the soil was inoculated with VAM inoculum (Mfg. by Symbiotic Sciences, New Delhi). The VAM inoculum was placed at the seeding depth of the soil @ 2g $seed^{-1}$ and then pre-inoculated seeds were sown according to the treatment. The yield parameters and yield were recorded at harvesting stage (120 days) of plant.

Statistical Analysis

The data were statistically analyzed applying the techniques of analysis of variance and the significance of different sources of variations were tested by error mean square of Fisher Snedecor's 'F' test at probability level 0.05 (Cochran and Cox, 1977).

RESULTS AND DISCUSSION

Plant height

The plant height (Table 1) was found to be significantly increased with the inoculation of biofertilizers. The highest plant height was recorded in crop receiving PSB + VAM as compared to other biofertilizers treatments. The increase in growth might be due to the enhanced photosynthetic efficiency of PSB + VAM inoculated plant. This showed a strong synergistic effect between PSB + VAM. Inoculation of PSB and VAM which are known to produce growth hormones like cytokinins and gibberellins which responsible for cell division stem elongation (Sattar and Gaur, 1987) are likely to favour increased plant height. The results are conformity with those of Mukherjee and Rai (2000) and Jain *et al*. (1999). Spraying of homo-brassinolide at was significant of plant height as compared to spraying of gibberillic acid in both years. The highest plant height was recorded in crop receiving homo-brassinolide whereas dwarf plant was recorded from gibberillic acid treatment. Increased plant height might be due to positive effect of homo-brassinolide on meristamatic tissues of plant as well as in increasing number and size of cell (Prakash *et al.*, 2008).

Table 1. Plant height, number of branches plant^{-1}, number of nodules plant^{-1} as influenced by microbes and bioregulators

Treatments	**Plant height (cm)**		**Number of branches plant^{-1}**		**Number of nodules plant^{-1}** 45 DAS		**Number of nodules plant^{-1}** 60 DAS	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Biofertilizers								
No inoculation	44.62	46.89	5.6	6.9	12.7	16.5	22.5	27.3
PSB	50.84	55.22	9.5	10.9	19.7	23.5	30.7	37.3
VAM	52.03	56.35	9.8	11.8	23.7	28.0	38.8	44.2
PSB+VAM	63.40	68.51	13.8	14.9	33.3	39.3	49.0	60.2
SEm±	1.11	1.44	0.3	0.4	0.4	0.6	0.6	0.9
C.D.(p=0.05)	3.38	4.38	0.9	1.1	1.1	1.8	1.9	2.7
Phyto-hormones								
Gibberellic acid	48.93	53.42	8.9	9.5	21.0	24.9	32.4	38.2
Homo-brassinolid	56.51	60.06	10.5	12.7	23.7	28.8	38.1	46.3
SEm±	0.79	1.02	0.2	0.3	0.3	0.4	0.5	0.6
C.D.(p=0.05)	2.39	3.10	0.6	0.8	0.8	1.2	1.4	1.9
CV(%)	5.18	6.2	7.3	8.2	4.1	5.3	4.4	5.2

Number of branches plant^{-1}

The number of branches plant^{-1} of lentil was significantly influenced by biofertilizers in both the experimental years (Table 1). The maximum number of branches plant^{-1} (13.8 and 14.9) was recorded with treatment receiving dual inoculation of PSB + VAM over other biofertilizers treatments in 2010-11 and 2011-12, respectively. The minimum number of branches plant^{-1} (5.6 and 6.9) was obtained from no inoculation treatment in 2010-11 and 2011-12, respectively. The increase in number of branches plant^{-1} might be due to the strong synergistic effect between PSB + VAM. Similar results were reported by Mukherjee and Rai (2000) and Pramanik and Bera (2012). Spraying of homo-brassinolide was also showed a significant influence on number of branches plant^{-1} in both the years of experiment (Table 1). The maximum number of branches plant^{-1} (10.5 and 12.7) was obtained with spraying of homo-brassinolide in 2010-11 and 2011-12, respectively whereas the minimum number of branches plant^{-1} (8.9 and 9.5) was recorded with one time spraying of gibberillic acid in 2010-11 and 2011-12, respectively. Similar result was reported by Ramraj *et al.* (1997) and Pramanik and Bera (2012).

Number of nodules plant^{-1}

The number of nodules plant^{-1} at 45 and 60 DAS are presented in table 1. The number of nodules plant^{-1} was higher in the second year than the first year. The maximum number of nodules plant^{-1} was recorded in crop receiving both inoculations of PSB+VAM significantly increased as compared to other treatments in both years. The results are conformity with those of Mitchell and Gregory (1972) and Smith and Daft (1977). Spraying of homo-brassinolide was recorded higher number of nodules plant^{-1} as compared spraying of gibberillic acid. Similar result was reported by Ramraj *et al.*, (1997).

Test weight

Test weight (Table 2) was significantly influenced by biofertilizers inoculation. Inoculation of PSB + VAM recorded significantly higher test weight as compared to no inoculation, PSB and VAM inoculation. This increase in yield parameters by PSB + VAM inoculation might be due to nodule number and dry weight that could be ascribed to a better translocation of photosynthate towards the yield attributes and yield. Shinde (1990) and Yadav and Shrivastava (1997) were recorded similar findings. The spraying of homo-brassinolide recorded maximum test weight over the spraying of gibberillic acid.

Number of grains plant^{-1}

The biofertilizers inoculation exerted significant effect on number of grains plant^{-1}. The crop at no inoculation of biofertilizers registered the lowest number of grains plant^{-1} which was significantly lower than other biofertilizers (Table 2). The highest number of grains plant^{-1} was obtained in crop receiving dual inoculation of PSB+VAM. Homo-brassinolide also showed significant effect on number of grains plant^{-1}. The spraying of homo-brassinolide registered the highest number of grains plant^{-1} over the spraying of gibberillic acid.

Grain yield

The biofertilizers inoculation exerted significant effect on pooled grain yield of chickpea (Table 2). The highest grain yield of 2139 and 2211 kg ha^{-1} was obtained with the dual inoculation of PSB+AM. The second best biofertilizers treatment in relation to grain yield was VAM inoculation. Grain yield produced at this treatment was 1719 and 1774 kg ha^{-1}. The lowest (957.0 and 1072 kg ha^{-1}) grain yield was obtained from crop receiving no inoculation treatment during both the year of experiments. The higher grain yield due to biofertilizers inoculation might be due to increase in nodulated root, growth attributes like number of branches plant^{-1} and yield components like number of grains plant^{-1} and test weight.). The PSB is known to produce vitamins (Baya *et al*., 1981) and IAA and GA like growth substance (Satter and Gaur, 1987). These growth factor in combination due to increase in availability of phosphorus in soil might have played a significant role in increase the grain yield of lentil. On the other hand, VAM helped in supply of essential nutrient and water to plants resulting in better growth that led to increase in grain yield. The dual inoculation recorded higher grain yield apparently arising from a synergistic effect between PSB and VAM. The increase in grain yield by PSB and VAM has been reported by several workers (Yadav and Shrivastava, 1997 and Jain *et al*., 1999). The spraying of homo-brassinolide recorded significantly higher grain yield as compared to spraying of gibberillic acid. The results revealed that spraying of homo-brassinolide increased plant height, branches plant^{-1}, and yield component. These beneficial effects resulted in higher grain yield in the homo-brassinolide treated plant. Similar result was reported by Ramraj *et al*. (1997); Nakashita *et al.* (2003), Bajguz and Hayat (2009) and Pramanik and Bera (2012).

Table 2. Test weight, number of grains plant^{-1}, grain yield, stalk yield and harvest index as influenced by microbes and bioregulators

Treatments	**Test weight (g)**		**Number of grains plant^{-1}**		**Grain yield (kg ha^{-1})**		**Stalk yield (kg ha^{-1})**		**Harvest index (%)**	
	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12	2010-11	2011-12
Biofertilizers										
No inoculation	215.6	216.9	31.5	36.9	957	1072	2466	2570	27.72	29.66
PSB	221.3	222.4	44.3	48.3	1556	1676	3410	3453	31.36	32.65
VAM	222.2	223.0	47.5	50.8	1719	1774	3541	3511	32.67	33.57
PSB+VAM	228.0	228.2	63.2	67.2	2139	2211	4138	4074	34.03	35.13
SEm±	1.9	2.0	1.4	1.4	41	40	104	94	0.48	0.88
C.D.(p=0.05)	5.8	6.1	4.2	4.3	123	121	315	284	1.46	2.68
Phyto-hormones										
Gibberellic acid	219.0	219.9	40.3	45.1	1481	1569	3275	3315	30.51	31.78
Homo-brassinolid	224.5	225.4	53.0	56.5	1705	1797	3502	3488	32.38	33.73
SEm±	1.3	1.4	1.0	1.0	29	28	74	66	0.34	0.63
C.D.(p=0.05)	4.1	4.3	3.0	3.1	87	85	223	NS	1.03	1.90
CV(%)	2.1	2.2	7.3	6.9	6.2	5.8	7.5	6.7	3.7	6.6

Stalk yield

Stalk yield also affected by biofertilizers inoculation and presented in Table 2. Maximum straw yield 4138 and 4074 kg ha^{-1} was obtained in the treatment which received PSB+VAM inoculation respectively, during the both years. The minimum stalk yield of 2466 and 2570 kg ha^{-1} was at no inoculation treatment. The higher stalk yield due to biofertilizers inoculation might be due to increase in plant height, dry matter accumulation and number of branches plant. The increase in biological yield by PSB and VAM has been reported by several workers (Yadav and Shrivastava, 1997; Jain *et al*., 1999 and Pramanik and Bera, 2012a). The application of homo-brassinolide recorded significantly higher straw yield as compared to spraying of gibberillic acid. The increase in straw yield might be due to increase in growth and yield attributes. These beneficial effects resulted in higher straw yield in the homo-brassinolide treated plant. Similar result was reported by Nakashita *et al.,* (2003) and Pramanik and Bera (2012).

Harvest index

The harvest index is a useful index in evaluating treatment effects on partition photoassimilates to grain within a given environment (Fageria, 2009). The biofertilizers inoculation influenced the harvest index significantly (Table 2). The crop at the no inoculation recorded the lowest value of harvest index (27.72 and 29.66 %) while dual inoculation of PSB+VAM which recorded the highest value of harvest index (34.03 and 35.13 %) respectively, during the both years. Homo-brassinolide played an important role on influencing the harvest index. The highest value of harvest index (32.38 and 33.73 %) was obtained from the spraying of homo-brassinolide and the lowest value of harvest index (30.51 and 31.78 %) was recorded spraying of gibberillic acid.

Based on the above results and discussion, conclusion can be drawn that inoculation of PSB + VAM as well as spraying of homo-brassinolide had a significant influence on the plant height, branches plant $^{-1}$, number of nodules plant $^{-1}$, number of grains plant $^{-1}$, test weight, harvest index and ultimately grain yield.

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Amal Kumar Bera, Kalipada Pramanik*, Sutapa Dey, Soma Mukherjee, Binoy Kumar Saren and Spurti Mondal

Department of ASEPAN, Institute of Agriculture, Visva-Bharati, Sriniketan (West Bengal) – 731 236, India

*Corresponding author

Email: kalipada.pramanik@visva-bharati.ac.in