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Physiological Effects of Seed Treatment with Bioinoculants on Growth and Yield of Chickpea (*Cicer arietinum* L.)

A Suresh, Y Ashoka Rani, K Jayalalitha and M Lal Ahmed

Department of Crop Physiology, Agricultural College, Bapatla 522 101, Andhra Pradesh

A field experiment was conducted during *rabi* 2014-15 growing season to assess the effect of seed treatment with bioinoculants on the growth and yield performance of chickpea variety JG 11 at Agricultural college farm, Bapatla. Eleven treatments were laid down in a completely randomized block design with three replications. Treatments include seed treatment with VAM, PSB, *M. ciceri* and *T. viridae* @ 100, 6, 6 and 10 g kg^{-1} seed respectively and in combination *i.e.*, VAM + PSB, VAM + *M. ciceri*, VAM + *T. viridae*, PSB + *M. ciceri*, PSB + *T. viridae* and *M. ciceri* + *T. viridae.* The results of the present study revealed that seed treatment with PSB @ 6 g + *M. ciceri* @ 6 g kg^{-1} seed found superior in increasing the root length, plant height, number of branches and number of effective branches by 6.1 cm, 10.2 cm, 2.7 $plant^{-1}$ and 2.5 $plant^{-1}$ respectively. There was also a marked increase in leaf number (38.1%), leaf area (1.3 folds) and total dry matter (58.11%). Ultimately the pod number, pod weight, seed yield, shelling % and harvest index were increased by 47.76, 55.04, 34.12, 11.98 and 30.77 % respectively over control. Results of this study indicate that combined application of PSB + *M. ciceri* have synergistic effect and showed significantly positive influence, favored better root growth and assimilation with higher nodulation which in consequence resulted into better growth and development of sink size and ultimately higher seed yield. Moreover seed treatment with bioinoculants produced higher biological and grain yield compared to uninoculated plants indicating the importance of effective inoculants in relation to growth and yield of chickpea.

Key words*: Mesorhizobium ciceri, Trichoderma viridae,* PSB, (Phosphorus soluble Bacteria) VAM

Chickpea (*Cicer arietinum* L.) is one of the important annual grain legume crops and third most widely grown legume in the world tolerating a wide range of climatic conditions. It is a major *rabi* pulse crop and is largely grown in soils with poor fertility status and moisture stress. In India, it is grown in an area of about 8.29 million hectares with an annual production of 7.70 million tonnes and productivity of 928 kg ha^{-1}. In Andhra Pradesh it is grown in an area of about 561 thousand hectares with an annual production of 520 thousand tonnes and productivity of 920 kg ha^{-1} (India Stat.com, 2011-12).

Pulse production in most agricultural systems is dependent on symbiotic nitrogen fixation, efficiency of which depends on rhizobium strain and host cultivar interaction and is influenced by several environmental and soil edaphic factors. rhizobium inoculation is well known agronomic practice to ensure adequate nitrogen of legumes instead of N-fertilizers (Gupta, 2004). There is a good possibility to increase crop production through inoculation of effective nitrogen fixing bacteria to the seed or to the soil. Soil may be lacking in effective rhizobium strains or their population may be too low to form sufficient nodules. Hence it is necessary to inoculate the seed with the most efficient strain of rhizobium species to get more nitrogen fixation an increase thereby pulse production (Gothwal *et al.*, 2007). Hence, the present study highlights the efficiency of biofertilizers on Chickpea crop.

MATERIAL AND METHODS

A field experiment was carried out at Agricultural College Farm, Bapatla, Guntur district in Andhra Pradesh during *rabi* 2014-15. The soil of experimental field was sandy clay loam in texture, with pH 7.3, EC 0.20 dS m^{-1}, low in available nitrogen (155.0 kg ha^{-1}), high in phosphorus (53.0 kg ha^{-1}) and high in available potassium (350.0 kg ha^{-1}). The mean maximum and minimum temperatures during crop growth period ranged from 30.2°C and 18.2°C respectively. The experiment was laid out in a complete randomized block design with eleven treatments and replicated thrice. The treatments are as follows $T_{1:}$ Seed treatment with VAM @ 100 g kg^{-1} seed, $T_{2:}$ Seed treatment with PSB @ 6 g kg^{-1} seed, $T_{3:}$ Seed treatment with *M. ciceri* @ 6 g kg^{-1} seed, $T_{4:}$ Seed treatment with *T. viridae* @ 10 g kg^{-1} seed, $T_{5:}$ Seed treatment with VAM @ 100 g + PSB @ 6 g kg^{-1} seed, $T_{6:}$ Seed treatment with VAM @ 100 g + *M. ciceri* @ 6 g kg^{-1} seed, $T_{7:}$ Seed treatment with VAM @ 100 g + *T. viridae* @ 10 g kg^{-1} seed, $T_{8:}$ Seed treatment with PSB@ 6 g + *M. ciceri* @ 6 g kg^{-1} seed, $T_{9:}$ Seed treatment with PSB @ 6 g + *T. viridae* @ 10 g kg^{-1} seed, $T_{10:}$ Seed treatment with *M. ciceri* @ 6 g + *T. viridae* @ 10 g kg^{-1} seed and $T_{11:}$ Control (No seed inoculation).

Variety JG-11 was used for this experimentation. The seeds were treated with bioinoculants individually and in combinations as per treatments mentioned. The seeds were sown on 12 November, 2014 by dibbling 2 to 3 seeds per hill with a spacing of 30 cm between rows and 10 cm between plants within the row. Intercultural operations, irrigation and plant protection measures were done based on requirement. Harvesting was done from each plot separately when the crop attained maturity, Pods were separated by hand and sundried for few days, later which were threshed and the seeds were collected. Yield per net plot was recorded which was computed as yield per hectare

The data on the growth characters such as plant height, root length, number of branches and number of leaves were counted for the five plants selected and tagged for non-destructive measurement and the average was expressed. Inorder to record yield attributes, five tagged plants in each plot were harvested at physiological maturity. The yield was computed from net plot. The data were analyzed statistically following analysis of variance (ANOVA) technique suggested by Panse and Sukhathme (1978) for randomized block design.

RESULTS AND DISCUSSION

Growth Parameters

The data pertaining to the effect of seed treatment with bioinoculants on growth characters in Chickpea were presented in Table 1.

Seed treatment with bioinoculants significantly increased the root length in Chickpea. Maximum root length was observed with PSB + *M. ciceri* (21.1 cm) inoculation. Increase in root length was 6.1, 5.2, 5.1, 4.3, 2.2 and 2.1 cm with PSB + *M. ciceri,* PSB + *T. viridae,* VAM + *M. ciceri, M. ciceri* + *T. viridae,* VAM + PSB and *M. ciceri* respectively and was minimum in control which was at par with all single inoculations except *M. ciceri*. Maximum plant height in chickpea observed with PSB + *M. ciceri* (44.7 cm) with an increase of 7.9 to 10.2 cm with dual inoculations and 4.4 to 6.9 cm with single inoculations compared to control. PSB + *M. ciceri* and *M. ciceri* inoculation produced higher number of branches among dual (10.4 plant^{-1}) and single inoculations (10.0 plant^{-1}) respectively. Increased branches i.e. 1.1 to 2.7 and 0.2 to 2.3 plant^{-1} were more with dual inoculations and with single inoculations respectively when compared to control. PSB + *M. ciceri* dual inoculation produced the greater number of effective branches (8.2 plant^{-1}) in Chickpea with an increase of 1.2 to 2.5 plant^{-1} with dual inoculations and 0.4 to 1.9 plant^{-1} with single inoculations over control. (38.1, 34.0, 30.7, 26.8, 25.0 and 24.5 percent) an increase in leaf number was observed to be with PSB + *M. ciceri,* VAM + *M. ciceri, M. ciceri* + *T. viridae*, PSB + *T. viridae*, VAM + *T. viridae* and VAM + PSB inoculations which resulted in increase of leaf area by 1.2 to 1.3 folds over control. The increased growth in Chickpea might be due to promotion of cell division, elongation and differentiation in the presence of favourable nutritional environment and growth promoting phytohormones like IAA and GA induced by the bioinoculants. The results pertaining to growth characters in the present study were in tune with many scientists who reported 35 % increase in Chickpea root length over control Karnwal and Kumar (2012) reported to increase plant height in Chickpea by 8.5 cm over control Shayam *et al.* (2013). Namvar *et al.* (2011) and Togay *et al.* (2008) reported that *Rhizobium* inoculation increased the number of primary and secondary branches in Chickpea.

Total dry matter

The data on the impact of seed treatment with bioinoculants was presented in Table 1.

Results indicate that among different treatments, PSB + *M. ciceri* showed significant

Table 1. Effect of seed treatment with bioinoculants on growth characters in chickpea.

Treatments	Root length (cm)	Plant height (cm)	No. of branches plant^{-1}	No of effective branches plant^{-1}	No of leaves plant^{-1}	Leaf area (cm^2)	Total dry matter (g plant^{-1})
T1 : Vesicular Arbuscular Mycorrhizae (VAM)	15.8	38.9	7.9	6.1	120.3	141.2	21.37
T2 : Phosphorus Solubulising Bacteria (PSB)	15.9	40.0	8.7	6.7	120.0	139.2	21.79
T3 : *Mesorhizobium ciceri*	17.1	41.4	10.0	7.6	125.9	146.8	21.38
T4 : *Trichoderma viridae*	16.9	40.7	9.2	6.6	120.1	136.7	20.84
T5 : VAM + PSB	17.2	42.4	8.8	6.9	127.2	149.3	24.37
T6 : VAM+ *M. ciceri*	20.1	43.2	10.1	7.9	136.9	149.5	26.75
T7 : VAM + *T. viridae*	17.0	42.4	9.4	7.3	127.8	149.3	24.92
T8 : PSB + *M. ciceri*	21.1	44.7	10.4	8.2	141.2	160.0	29.25
T9 : PSB + *T. viridae*	20.2	42.9	8.9	7.2	129.6	151.2	24.49
T10 : *M. ciceri* + *T. viridae*	19.3	43.0	9.9	7.8	133.6	154.3	26.33
T11 : Control	15.0	34.5	7.7	5.7	102.2	126.9	18.50
SEM ±	0.7	2.0	0.5	0.3	5.2	6.7	1.21
CD (P=0.05)	2.1	5.9	1.6	0.9	15.2	19.8	3.57
CV (%)	7.0	8.4	10.2	7.1	7.2	141.2	8.88

Table 2. Effect of seed treatment with bioinoculants on yield and yield attributes in chickpea.

Treatments	No of pods plant^{-1}	Pod weight (g plant^{-1})	Shelling percentage (%)	Seed yield (kg ha^{-1})	Harvest index
T1 : Vesicular Arbuscular Mycorrhizae (VAM)	33.6	19.54	80.1	2024.6	39.4
T2 : Phosphorus Solubulising Bacteria (PSB)	34.8	20.92	81.6	2129.1	40.0
T3 : *Mesorhizobium ciceri*	35.0	19.19	84.6	2122.1	41.4
T4 : *Trichoderma viridae*	32.4	18.07	80.2	2094.7	40.9
T5 : VAM + PSB	36.7	21.06	84.5	2249.6	42.7
T6 : VAM+ *M. ciceri*	44.3	23.39	85.3	2483.3	44.4
T7 : VAM + *T. viridae*	39.6	21.59	83.5	2356.4	43.6
T8 : PSB + *M. ciceri*	46.1	24.90	86.0	2521.3	45.9
T9 : PSB + *T. viridae*	40.6	21.14	83.7	2298.8	42.9
T10 : *M. ciceri* + *T. viridae*	42.4	22.97	85.0	2471.5	43.7
T11 : Control	31.2	16.06	76.8	1879.9	35.1
SEM ±	1.9	1.04	3.9	103.4	1.9
CD (P=0.05)	5.7	3.06	11.6	304.9	5.7
CV (%)	8.8	8.64	8.2	8.0	7.9

improvement in plant dry matter by 1.58 folds over no inoculation. The other dual inoculations favoured plant dry matter registering 1.32 to 1.45 folds increase over control. This effect seems to be on account of their impact on nutritional environment and involvement in various physiological processes in the plant system, which is considered to be pre-requisites for better growth of the crop. Similar positive effects of rhizosphere bacteria on plant dry matter have also been reported by Amalraj *et al* (2012), Das *et al* (2012), Messele and Pant (2012) and Abraham and Abraham (2011).

Yield and yield attributes

The data pertaining to the effect of seed treatment with bioinoculants on yield attributes in chickpea were presented in Table 2.

The increase in pod number was 47.8, 41.9, 35.9, 30.1 and 26.9 with PSB + *M. ciceri*, VAM + *M. ciceri, M. ciceri* + *T. viridae,* PSB + *T. viridae* and VAM + *T. viridae* respectively. Regarding pod weight single inoculations except *T. viridae* and dual inoculations resulted in 1.2 to 1.3 folds and 1.3 to 1.6 folds increase in pod weight plant^{-1} respectively over control. Statistically there was significant difference in shelling percentage between treatments and control but the differences among the treatments were on par. The increase in shelling percentage was 3.3 to 7.8 % with single inoculations and 6.7 to 9.2 % with dual inoculations. The highest seed yield (2521.3 kg ha^{-1}) was obtained with PSB + *M. ciceri* followed by VAM + *M. ciceri* (2483.3 kg ha^{-1}), *M. ciceri* + *T. viridae* (2371.5 kg ha^{-1}), VAM + *T. viridae* (2356.4 kg ha^{-1}) and PSB + *T. viridae* (2298.8 kg ha^{-1}). These dual inoculations resulted in 22.3 to 34.1 % increase in seed yield and 42.7 to 45.9 % in harvest index, the returns per rupee invested is 2.99 in PSB + *M. ciceri*, 2.94 in VAM + *M. ciceri* and 2.91 in *M. ciceri* + *T. viridae* compared to 1.98 in control. The increased yield in the present study might be due to the fact that increased root nodulation through better root development and more nutrient availability caused vigorous plant growth and dry matter production, which resulted in better flowering, fruiting and pod formation ultimately yield. The results of the present study were in conformity with findings of Gangwar and Dubey, 2012; Messele and Pant, 2012 and Tagore *et al.*, 2013 who reported that mixed inoculation of Rhizobium + PSB significantly increased the number of pods plant^{-1}. Increase in seed yield with Rhizobium + PSB was reported by Rokhzadi and Toashiah (2011), Gupta and Sahu (2012), Selvakumar *et al.* (2012), Shayam *et al.* (2013), Raj *et al.* (2014) and Poonia and Pithia (2014).

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