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# Response of biofertilizers and homo-brassinolide on growth, relative water content and yield of lentil (*Lens culinaris* Medik)

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**ABSTRACT**

*Biofertilizers like phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhizae (VAM) are known to increase nutrients availability particularly phosphorus, which is a key element of pulse production and in other hand homo-brassinolide, a steroidal compound of plant origin increased crop yield. A field experiment was conducted during the rabi season of 2009-2010 and 2010-2011 at Sriniketan, Birbhum to find out the response of biofertilizers and homo-brassinolide on growth, relative water content and yield of lentil. The experiment was laid out in factorial randomized block design with four levels of biofertilizers inoculation viz., no inoculation, PSB, VAM and PSB + VAM) and two spraying of brassinolide viz., at pre-flowering stage and at pre-flowering + pod development stage (Homo-brassionlide). The results showed that inoculation of biofertilizers significantly improved plant height, dry matter accumulation plant$^{-1}$, relative water content, yield parameters like number of pods plant$^{-1}$, grain weight plant$^{-1}$, 1000 grain weight, grain yield, biological yield and harvest index. Dual inoculation of PSB+VAM harvested 31.83, 8.19 and 5.90% in first year and 31.11, 7.43 and 5.85% in second year higher grain yield over no inoculation, PSB and VAM respectively. Spraying of homo-brassinolide at pre-flowering + pod development stages harvested 51.69% in first year and 42.28% in second year higher grain yield than spraying of homo-brassinolide at pre-flowering stage. The highest branches and pod plant$^{-1}$, grain weight plant$^{-1}$ as well as grain yield ha$^{-1}$ were recorded in crop receiving PSB+VAM inoculation at twice spraying of homo-brassinolide at pre-flowering and pod development stage.*

***Keywords*:** Grain yield, homo-brassinolide, lentil, PSB and VAM

Pulses form an integral part of the vegetarian diet and the cheapest source of protein for the resource poor farmers of the Indian sub continent as well as largest producer, consumer, importer and processor of pulses in the world. In India, pulse crop yields are abysmally low, averaging approximately 691 kg ha$^{-1}$ (Anon., 2012). Globally, the average yield is in the range of 819kg ha$^{-1}$, but top-producing countries such as Canada and the US have yields of about 1900kg ha$^{-1}$ (http://www.growmorepulses.com). Productivity of lentil in India is about 591 kg ha$^{-1}$. Phosphorous (P) is an essential key macronutrient for pulse production. Biofertilizers are gaining importance as they are ecofriendly, non-hazardous and non-toxic (Sharma *et al*., 2007). The uses of phosphate solubilizing bacteria (PSB) as inoculants in soil increase the phosphorous uptake by the plants and also improve the crop yield. The ability of phosphate solubilizing bacteria to convert insoluble form of phosphorous in soil as well as applied phosphate fertilizers into soluble one is an important feature in sustainable farming for increasing crops yield particularly of pulse crops. On the other hand, the beneficial effects of VAM upon plant growth seemed to be enhanced in nutrient-deficient tropical soils particularly of phosphorus. VAM also improve plant water status and changes in water relations resulting in more drought resistance. The use of rhizobium, phosphate solubilizing bacteria (PSB) and vesicular arbuscular mycorrhizae (VAM) have opened new vistas of phosphorus nutrition. Brassinosteroids (BRs) are naturally occurring plant growth regulators (Clouse and Sasse, 1998). Their growth regulatory activity is due to their influence on the metabolic process associated with photosynthesis, nucleic acid and protein biosynthesis (Arteca, 1997 and Sasse, 1999). The BRs especially brassinolide and homo-brassinolide have been evaluated for their role in increasing crop yield, stress tolerance and disease resistance (Ramraj *et al*., 1997). The present study was undertaken to investigate response of biofertilizers and homo-brassinolide on growth, relative water content and yield of lentil (*Lens culinaris* Medik).

## MATERIALS AND METHODS

A field experiment was conducted during the *rabi* season of 2009-2010 and 2010-2011 at Sriniketan, Birbhum. The place is situated at 23$^0$39′ N latitude, 87$^0$42′ E longitude and an elevation of 58.9 m above mean sea level. The soil was slightly acidic (5.7), low in available nitrogen (133 kg ha$^{-1}$), phosphorus (13.60 kg ha$^{-1}$) and medium in potassium (157.9 kg ha$^{-1}$). The experiment was laid out in factorial randomized block design with four levels of biofertilizers inoculation *viz.*, no inoculation, phosphate solubilizing bacteria (PSB), vesicular arbuscular mycorrhizae (VAM) and phosphate solubilizing bacteria (PSB) + vesicular arbuscular mycorrhizae (VAM)) and two spraying of brassinolide *viz.*, at pre-flowering stage and at pre-flowering + pod development stage (Homo-

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brassionlide). In all twelve treatments replicated three times. The lentil, 'subrata' was sown on 19th November and 15th November during 2009-2010 and 2010-2011 respectively. The seed was inoculated with PSB by slurry method whereas the VAM inoculum's was placed at the seeding depth of the soil @ 2g seed$^{-1}$ soil at the time of sowing. After that pre-inoculated seeds were sown according to the treatment. The yield parameters and yield recorded at harvesting stage (120 days) of plant. Relative leaf water content (RLWC) was estimated at 30 days interval using the formula given by Turner (1986). The RLWC was calculated by using formula-

$$RLWC = [(FW - DW)/(TW - DW)] \times 100$$

Where, FW is leaf fresh weight,
DW is leaf dry weight,
TW is leaf turgid weight.

Data collected were subjected to statistical analysis of variance according to Gomez and Gomez (1984) using MSTAT computer program.

## RESULTS AND DISCUSSION

The plant height of lentil was significantly influenced by biofertilizers in both the experimental years (Table 1). The tallest plant height (50.05 and 53.31 cm) was recorded with dual inoculation of PSB and VAM over other biofertilizers treatments in 2009-10 and 2010-11, respectively. The smallest plant height (42.05 and 44.82 cm) was obtained from no inoculation treatment in 2009-10 and 2010-11, respectively. The increase in plant height might be due to the enhanced photosynthetic efficiency of PSB + VAM inoculated plant. This showed a strong synergistic effect between PSB + VAM. Inoculations of PSB which are known to produce growth hormones (Sattar and Gaur, 1987) are likely to favour increased plant height. The results are conformity with those of Mukherjee and Rai (2000) and Pramanik and Bera (2012). Spraying of brassinolide had a significant influence on plant height in both the years of experiment (Table 1). The tallest plant (47.02 and 50.33 cm) was achieved with twice spraying of homo-brassinolide at pre-flowering + pod development stage in 2009-10 and 2010-11, respectively. On the other hand, the smallest plant (44.79 and 47.12 cm) was attained with one spraying of homo-brassinolide at pre-flowering stage in 2009-10 and 2010-11, respectively. Similar result was reported by Ramraj *et al.* (1997) and Pramanik and Bera (2012). Increased plant height might be due to positive effect of brassinolide on meristamatic tissues of plant as well as in increasing number and size of cell (Prakash *et al.*, 2008).

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$^{-1}$ (12.13, 13.68 and 12.91) was recorded with treatment receiving dual inoculation of PSB and VAM over other biofertilizers treatments in 2009-10, 2010-11 and pooled of two years, respectively. The minimum number of branches plant$^{-1}$ (6.14, 6.64 and 6.39) was obtained from no inoculation treatment in 2009-10, 2010-11 and pooled of two years, 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 brassinolide was also showed a significant influence on number of branches plant$^{-1}$ in both the years of experiment (Table 1).

**Table 1: Plant height, number of branches of lentil as influenced by biofertilizers and homo-brassinolide**

| Treatments | Plant height at harvest (cm) | | Branches plant$^{-1}$ at harvest | |
|---|---|---|---|---|
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| **Biofertilizers** | | | | |
| No inoculation | 42.05 | 44.82 | 6.14 | 6.64 |
| PSB | 45.32 | 48.24 | 8.27 | 8.98 |
| VAM | 46.22 | 48.52 | 8.68 | 9.31 |
| PSB+VAM | 50.05 | 53.31 | 12.13 | 13.68 |
| **SEm(±)** | **0.68** | **0.58** | **0.41** | **0.25** |
| **LSD(0.05)** | **2.06** | **1.76** | **1.24** | **0.76** |
| **Homo-brassinolide** | | | | |
| Pre flowering | 44.79 | 47.12 | 7.82 | 8.48 |
| Pre flowering+ pod dev. | 47.02 | 50.33 | 9.80 | 10.82 |
| **SEm(±)** | **0.48** | **0.41** | **0.29** | **0.18** |
| **LSD(0.05)** | **1.46** | **1.24** | **0.88** | **0.55** |

The maximum number of branches plant$^{-1}$ (9.80, 10.82 and 10.31) was obtained with two time spraying of brassinolide at pre-flowering + pod development stage in 2009-10, 2010-11and pooled of

two years, respectively whereas the minimum number of branches plant$^{-1}$ (7.82, 8.48 and 8.15) was recorded with one time spraying of brassinolide at pre-flowering stage in 2009-10, 2010-11 and pooled of two years, respectively. Similar result was reported by Ramraj *et al.* (1997) and Pramanik and Bera (2012).

Data on dry matter accumulation (g plant$^{-1}$) are presented in table- 2. Dry matter accumulation at 30, 60 and 90 DAS showed that it was increased with advancement in the age of the crop. Application of biofertilizers significantly increases in dry matter accumulation at all crop growth stages. The combined inoculation of PSB+VAM was recorded significantly maximum dry matter accumulation as compared to no inoculation, PSB and VAM inoculation. The lowest dry matter accumulation was obtained the treatment receiving no inoculation. Increased dry matter accumulation by PSB+VAM might be due to better development of root systems resulting in tapping larger volume of bound soil water and nutrients especially phosphorus. This result is in conformity with the findings of Mukherjee and Rai (2000) and Pramanik (2003). Two times spraying of brassinolide at pre flowering + pod development stages recorded significantly maximum dry matter accumulation (2.58g) over than pre flowering at 90 DAS of the crop growth stage. Similar results were reported by Ramraj *et al*. (1997) and Pramanik and Bera (2012). Increased dry matter accumulation might be due to higher plant height and more branches as well as more positive effect of homo-brassinolide on meristamatic tissues of plant and in increasing number and size of cell (Prakash *et al*., 2008).

**Table 2: Dry matter accumulation of lentil as influenced by biofertilizers and homo-brassinolide**

| Treatments | Dry matter accumulation (g plant$^{-1}$) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | | | 60 DAS | | | 90 DAS | | |
| | 2009-10 | 2010-11 | Pooled | 2009-10 | 2010-11 | Pooled | 2009-10 | 2010-11 | Pooled |
| **Biofertilizers** | | | | | | | | | |
| No inoculation | 0.21 | 0.22 | 0.21 | 0.62 | 0.63 | 0.63 | 1.85 | 1.86 | 1.85 |
| PSB | 0.24 | 0.25 | 0.24 | 0.72 | 0.73 | 0.73 | 2.50 | 2.52 | 2.51 |
| VAM | 0.24 | 0.25 | 0.25 | 0.74 | 0.75 | 0.74 | 2.52 | 2.54 | 2.53 |
| PSB+VAM | 0.27 | 0.28 | 0.27 | 0.80 | 0.84 | 0.82 | 2.72 | 2.76 | 2.74 |
| **SEm(±)** | **0.001** | **0.001** | **0.001** | **0.01** | **0.01** | **0.001** | **0.04** | **0.04** | **0.03** |
| **LSD(0.05)** | **0.01** | **0.01** | **0.01** | **0.02** | **0.02** | **0.01** | **0.11** | **0.11** | **0.07** |
| **Homo-brassinolide** | | | | | | | | | |
| Pre flowering | 0.24 | 0.25 | 0.24 | 0.72 | 0.74 | 0.73 | 2.23 | 2.25 | 2.24 |
| Pre flowering+ pod dev. | 0.24 | 0.25 | 0.24 | 0.72 | 0.74 | 0.73 | 2.56 | 2.59 | 2.58 |
| **SEm (±)** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.001** | **0.03** | **0.02** | **0.02** |
| **LSD (0.05)** | **NS** | **NS** | **NS** | **NS** | **NS** | **NS** | **0.08** | **0.07** | **0.05** |

Data on relative leaf water content are presented in table-3. Application of biofertilizers influenced relative leaf water content value of crop growth period. At 30, 60 and 90 DAS the value of relative leaf water content with PSB was at par with VAM. Dual inoculation of PSB+VAM recorded significantly higher relative leaf water content as compared to other treatments. Dual inoculation of PSB + VAM maintained favorable relative leaf water content throughout the growth period higher relative leaf water content in dry land situation in chickpea (Pramanik, 2003). Pramanik (2003) also reported higher relative leaf water content in the inoculated chick pea plants and opined that it may be due to higher percentage of root colonization in inoculated plants even under water stress conditions. Spraying of homo-brassinolide significantly influenced relative leaf water content at 90 DAS. Spraying of homo-brassinolide at pre-flowering + pod development stage was recorded significantly higher relative leaf water content as compared to one spray of pre-flowering stage. This might be due to better vigorous of root system with consequent supply of nutrient and water from soil. Similar result was reported by Ramraj *et al*. (1997), Vardhini and Rao, (1998) and Nakashita *et al.* (2003).

**Table 3: Relative leaf water content of lentil as influenced by biofertilizers and homo-brassinolide**

| Treatments | Relative leaf water content (%) | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS | | 60 DAS | | 90 DAS | |
| | 2009-10 | 2010-11 | 2009-10 | 2010-11 | 2009-10 | 2010-11 |
| **Biofertilizers** | | | | | | |
| No inoculation | 65.29 | 66.21 | 68.16 | 69.60 | 67.77 | 68.13 |
| PSB | 72.58 | 73.30 | 73.51 | 74.69 | 74.34 | 74.98 |
| VAM | 73.32 | 74.16 | 74.46 | 75.12 | 76.17 | 76.75 |
| PSB+VAM | 78.87 | 80.82 | 80.38 | 82.07 | 82.42 | 83.55 |
| **SEm(±)** | **0.71** | **0.49** | **0.97** | **0.72** | **0.62** | **0.75** |
| **LSD(0.05)** | **2.15** | **1.49** | **2.94** | **2.18** | **1.88** | **2.27** |
| **Homo-brassinolide** | | | | | | |
| Pre flowering | 72.45 | 73.43 | 74.00 | 75.38 | 73.21 | 73.87 |
| Pre flowering+ pod dev. | 72.58 | 73.81 | 74.25 | 75.36 | 77.15 | 77.84 |
| **SEm (±)** | **0.50** | **0.35** | **0.68** | **0.51** | **0.44** | **0.53** |
| **LSD (0.05)** | **NS** | **NS** | **NS** | **NS** | **1.33** | **1.61** |

Numbers of pods plant$^{-1}$ (Table 4) were significantly influenced by biofertilizers inoculation. The maximum (89.01) numbers of pods plant$^{-1}$ was recorded with dual inoculation of PSB + VAM. The PSB (75.56) and VAM (78.10) were recorded significantly higher numbers of pods plant$^{-1}$ over no inoculation treatment (66.60). This increase in numbers of pods plant$^{-1}$ might be due to more number of branches plant$^{-1}$ and more dry matter accumulation in PSB + VAM inoculated plant. Similar results were reported Siag (1995) and Pramanik and Singh (2003). Spraying of homo-brassinolide significantly influenced on numbers of pods plant$^{-1}$. The highest (82.23) numbers of pods plant$^{-1}$ was recorded in crop receiving twice spraying of homo-brassinolide at pre-flowering and pod development stage. The lowest (72.40) numbers of pods plant$^{-1}$ was obtained from one spraying of homo-brassinolide at pre-flowering stage. The similar results are in conformity with Pramanik and Bera (2012).

The grain weight plant$^{-1}$ recorded at maturity from each plot were statistically analyzed and presented in the table 4. The grain weight plant$^{-1}$ varied markedly due to biofertilizers application. The maximum grain weight plant$^{-1}$ (3.483g) was obtained in crop receiving PSB+VAM inoculation and was significantly higher than what obtained at no inoculation. The crop receiving the no inoculation treatment recorded the minimum grain weight plant$^{-1}$ (2.538 g). Spraying of homo-brassinolide showed significant effect on grain weight plant$^{-1}$. The maximum (3.040 g) grain weight plant$^{-1}$ was found in crop at twice spraying of homo-brassinolide at pre-flowering + pod development stage and it was significantly higher than what obtained at one spraying of brassinolide at pre-flowering stage.

The biofertilizers inoculation exerted significant effect on test weight of lentil grain. The crop at no inoculation of biofertilizers registered the lowest test weight (19.92 g) which was significantly lower than other biofertilizers (Table 4). The highest test weight of 22.95 g was obtained in crop receiving dual inoculation of PSB+VAM. Homo-brassinolide also showed significant effect on test weight.

**Table 4: Yield attributes of lentil as influenced by biofertilizers and homo-brassinolide**

| Treatments | No. of pods plant$^{-1}$ | | | Grain weight plant$^{-1}$ (g) | | | 1000 grain weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2009-10 | 2010-11 | Pooled | 2009-10 | 2010-11 | Pooled | 2009-10 | 2010-11 | Pooled |
| **Biofertilizers** | | | | | | | | | |
| No inoculation | 64.22 | 68.98 | 66.60 | 2.452 | 2.625 | 2.538 | 19.84 | 20.01 | 19.92 |
| PSB | 73.49 | 77.64 | 75.56 | 2.750 | 2.851 | 2.801 | 21.30 | 21.41 | 21.35 |
| VAM | 76.69 | 79.50 | 78.10 | 2.820 | 2.970 | 2.895 | 21.39 | 21.65 | 21.52 |
| PSB+VAM | 87.68 | 90.34 | 89.01 | 3.435 | 3.532 | 3.483 | 22.82 | 23.09 | 22.95 |
| **SEm (±)** | **1.65** | **1.92** | **1.23** | **0.034** | **0.033** | **0.023** | **0.24** | **0.19** | **0.15** |
| **LSD(0.05)** | **5.03** | **5.84** | **3.55** | **0.103** | **0.100** | **0.066** | **0.73** | **0.58** | **0.43** |
| **Homo-brassinolide** | | | | | | | | | |
| Pre flowering | 70.61 | 74.13 | 72.40 | 2.745 | 2.892 | 2.819 | 20.77 | 21.02 | 20.90 |
| Pre flowering+ pod dev. | 80.37 | 84.09 | 82.23 | 2.983 | 3.097 | 3.040 | 21.91 | 22.04 | 21.98 |
| **SEm (±)** | **1.17** | **1.36** | **0.87** | **0.02** | **0.02** | **0.02** | **0.17** | **0.13** | **0.11** |
| **LSD (0.05)** | **7.11** | **4.14** | **2.51** | **0.07** | **0.07** | **0.05** | **0.52** | **0.41** | **0.31** |

The crop at one spraying of homo-brassinolide at pre-flowering stage registered the lowest test weight of grain (20.90 g) which was markedly lower than two spraying of homo-brassinolide at pre-flowering and pod development stage.

The biofertilizers inoculation exerted significant effect on pooled grain yield of lentil (Table 5). It varied from 4.85 to 7.29 q $ha^{-1}$. The highest grain yield of 7.29 q $ha^{-1}$ 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 6.64q $ha^{-1}$ but it was at par with PSB treated plant. The lowest (4.85 q $ha^{-1}$) grain yield was obtained from crop receiving no inoculation treatment during both the year of experiments. Among the biofertilizers, combined inoculation of PSB+VAM harvested 31.83, 8.19 and 5.90% in first year and 31.11, 7.43 and 5.85% in second year higher grain yield over no inoculation, PSB and VAM, respectively. The higher grain yield due to biofertilizers inoculation might be due to increase in growth attributes (dry matter accumulation and number of branches $plant^{-1}$) and yield component (number of pods $plant^{-1}$, grain weight $plant^{-1}$ and 1000 grain 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 application of homo-brassinolide at pre-flowering + pod development stage recorded significantly higher grain yield as compared to one spray at pre-flowering stage. Spraying of homo-brassinolide at pre-flowering + pod development stages harvested 51.69% in first year and 42.28% in second year higher grain yield than spraying of homo-brassinolide at pre-flowering stage. The results revealed that spraying of homo-brassinolide at pre-flowering + pod development stage increased dry matter accumulation, branches $plant^{-1}$, relative water content, and yield component (number of pods $plant^{-1}$, grain weight $plant^{-1}$ and 1000 grain weight). 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 5: Yield and harvest index of lentil as influenced by biofertilizers and homo-brassinolide**

| Treatments | Grain yield (kg $ha^{-1}$) | | | Biological yield (kg $ha^{-1}$) | | | Harvest index (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2009-10 | 2010-11 | Pooled | 2009-10 | 2010-11 | Pooled | 2009-10 | 2010-11 | Pooled |
| **Biofertilizers** | | | | | | | | | |
| No inoculation | 531 | 540 | 536 | 1758 | 1778 | 1768 | 30.20 | 30.37 | 30.28 |
| PSB | 647 | 659 | 653 | 2079 | 2101 | 2089 | 31.15 | 31.34 | 31.25 |
| VAM | 661 | 669 | 665 | 2107 | 2124 | 2115 | 31.37 | 31.49 | 31.43 |
| PSB+VAM | 700 | 708 | 704 | 2190 | 22.06 | 2198 | 31.96 | 32.07 | 32.02 |
| **SEm (±)** | **3.19** | **2.90** | **2.09** | **6.69** | **6.95** | **4.68** | **0.11** | **0.85** | **0.06** |
| **LSD(0.05)** | **9.68** | **8.80** | **6.03** | **20.29** | **21.08** | **13.51** | **0.33** | **2.58** | **0.17** |
| Homo-brassinolide | | | | | | | | | |
| Pre flowering | 619 | 630 | 624 | 2000 | 20.21 | 2010 | 30.90 | 31.14 | 31.02 |
| Pre flowering+ pod dev. | 651 | 657 | 654 | 2067 | 20.84 | 2075 | 31.45 | 31.50 | 31.47 |
| **SEm (±)** | **2.25** | **2.05** | **1.48** | **4.73** | **4.91** | **3.31** | **0.80** | **0.06** | **0.05** |
| **LSD(0.05)** | **6.82** | **6.22** | **4.27** | **14.35** | **14.89** | **9.55** | **2.42** | **0.18** | **0.14** |

Biological yield also affected by biofertilizers inoculation and presented table- 5. Maximum pooled biological yield of 22.73 q $ha^{-1}$was obtained in the treatment which received PSB+VAM inoculation. The minimum pooled biological yield of 17.18 q $ha^{-1}$ was at no inoculation treatment. Among the biofertilizers, combined inoculation of PSB+VAM harvested 31.83, 8.19 and 5.90% in first year and 31.11, 7.43 and 5.85% in second year higher biological yield over no inoculation, PSB and VAM, respectively. The higher biological yield due to biofertilizers inoculation is 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, 2012). The application of homo-brassinolide at pre-flowering + pod development stage recorded significantly higher biological yield as compared to one spray at pre-flowering stage. The increase in biological yield might be due to increase in growth and yield attributes. These beneficial effects resulted in higher biological yield in the homo-

brassinolide treated plant. Similar result was reported by Nakashita *et al.* (2003) and Pramanik and Bera (2012).

The harvest index is a useful index in evaluating treatment effects on partition photo-assimilates to grain within a given environment (Fageria, 2009). The biofertilizers inoculation influenced the harvest index significantly (Table 5). The crop at the no inoculation recorded the lowest value of harvest index (28.15 %) while dual inoculation of PSB+VAM which recorded the highest value of harvest index (32.04%). Homo-brassinolide played an important role on influencing the harvest index. The highest value of harvest index (31.35 %) was obtained from the crop at twice spraying of homo-brassinolide at pre-flowering + pod development stage and the lowest value of harvest index (30.07 %) was recorded at one spray at pre-flowering stage.

The interaction effect of biofertilizers and homo-brassinolide on numbers of branches, pods and grain weight plant$^{-1}$ as well as grain yield and harvest index were found significant (Table 6). The highest numbers of branches, pods and grain weight plant$^{-1}$ as well as grain yield and harvest index were recorded in crop receiving PSB+VAM inoculation at twice + spraying of homo-brassinolide at pre-flowering and pod development stage (Table 6).

**Table 6: Interaction effect of biofertilizers and homo-brassinolide on different growth parameters of lentil**

| Interaction | Branches plant$^{-1}$ | Number of pods plant$^{-1}$ | Grain wt. plant$^{-1}$ (g) | 1000 grain wt. (g) | Grain yield (kg ha$^{-1}$) | Biological yield (kg ha$^{-1}$) | Harvest index (%) |
|---|---|---|---|---|---|---|---|
| No inoculation +HBR at Pre- flowering | 5.90 | 70.47 | 2.473 | 20.52 | 525 | 1744 | 30.13 |
| No inoculation +HBR at Pre flowering + Pod dev. | 6.88 | 73.73 | 2.603 | 20.74 | 545 | 1791 | 30.44 |
| PSB + HBR at Pre-flowering | 7.76 | 73.64 | 2.716 | 21.21 | 638 | 2055 | 31.07 |
| PSB + HBR at Pre-flowering+ Pod dev. | 9.49 | 77.49 | 2.885 | 21.49 | 667 | 2124 | 31.48 |
| VAM + HBR at Pre-flowering | 7.97 | 76.36 | 2.790 | 21.29 | 650 | 2081 | 31.24 |
| VAM+ HBR at Pre-flowering+ Pod dev. | 10.03 | 79.84 | 3.000 | 21.58 | 680 | 2150 | 31.63 |
| PSB+VAM+ HBR at Pre- flowering | 10.97 | 79.97 | 3.295 | 21.81 | 683 | 2159 | 31.63 |
| PSB+VAM+HBR at Pre- flowering+ Pod dev. | 14.84 | 87.04 | 3.672 | 22.14 | 724 | 2236 | 32.41 |
| **SEm (±)** | **0.33** | **0.83** | **0.03** | **0.05** | **2.96** | **6.62** | **0.10** |
| **LSD(0.05)** | **0.96** | **2.38** | **0.10** | **NS** | **8.54** | **NS** | **0.28** |

*PF= Pre-flowering, PD= Pod development*

The lowest numbers of branches, pods and grain weight plant$^{-1}$ as well as grain yield and harvest index were obtained from the crop receiving no inoculation treatment along with one spraying of homo-brassinolide at pre-flowering stage. The highest grain yield (724kg ha$^{-1}$) was recorded in crop receiving PSB+VAM inoculation at twice spraying of homo-brassinolide at pre-flowering and pod development stage. The lowest grain yield (525kg ha$^{-1}$) was obtained from the crop receiving no inoculation treatment along with one spraying of homo-brassinolide at pre-flowering stage. The interaction effect of biofertilizers and homo-brassinolide on 1000 grain weight and biological yield were found not significant. However, the highest 1000 grain weight and biological yield were recorded in crop receiving PSB+VAM inoculation at twice spraying of homo-brassinolide at pre-flowering and pod development stage during both the years. The lowest 1000 grain weight and biological yield were obtained from the crop receiving no inoculation treatment along with one spraying of homo-brassinolide at pre-flowering stage during both the years.

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