Response of fertility levels and biofertilizers on growth and yield attributesquality of Chickpea, [*Cicer arietinum*(L.)] crop

ABSTRACT

The experiment was layout in split plot design comprised 4 treatments *viz*., F_1 (control), F_2 (RDF 100%), F_3 (75% RDF), F_4 (50% RDF) in main plot and 3 treatments *viz*., B_1 (Rhizobium + PSB), B_2 (Rhizobium + PGPR), B_3 (Rhizobium + PSB + PGPR) in sub plots with three replications. Growth parameters *viz*., plant height, dry matter accumulation, were influenced significantly by fertility levels and biofertilizers. Higher values of growth parameters in chickpea were observed with the application of 100% RDF (F_2). Biofertilizers treatments resulted higher values of growth parameters in chickpea with the application of Rhizobium + PSB + PGPR (B_3) followed by 75% RDF (F_3) treatment. root dry weight/plant influenced significantly due to different Fertility levels and biofertilizers at all the stages of crop growth except root dry weight/plant at 30DAS. Higher values of root parameters in chickpea were observed with the application of 100% RDF (F_2). Biofertilizers treatments resulted higher values of root parameters in chickpea with the application of Rhizobium + PSB + PGPR (B_3) followed by 75% RDF (F_3) treatment. number of pods/plant, number of seeds per pod influenced significantly due to different Fertility levels and biofertilizers at all the stages of crop growth except no. of branches /plant at 30DAS and 100 seed weight. Higher values of number of pods/plant, number of seeds per pod in chickpea were observed with the application of 100% RDF (F_2). Biofertilizers treatments resulted higher values of number of pods/plant, number of seeds per pod in chickpea with the application of Rhizobium + PSB + PGPR (B_3) followed by 75% RDF (F_3) treatment.

Keywords: RDF- recommended dose fertilizer, PSB- Phosphate solubilising bacteria, PGPR- Plant growth promoting rhizobacteria

1.INTRODUCTION

The Pulses crops in India are grown under a wide range of agro -climatic condition and own a strategic position in intensive as well as subsistence agriculture. They are an excellent source of dietry protein for millions of people, nutritious feed for livestock and a mini nitrogen plant having profound ameliorative effect on soil. (Ali and Kumar, 2006). They are integral part of Indian dietary system due to richness in protein and other important nutrients such as Calcium, Iron, Vitamins viz., carotene, thiamine, riboflavin and niacin. As per the nomenclature, PULSE - (P–people, U-umbrella, L-livestock, S- soil, E-energy).Globally, India is recognized as, a major player in pulses contributing 25% global production, (4-6mt.) and consumer (26-27mt). Import duty on chickpea has been fixed at 60%. The year 2021-2022 had, witnessed record production in pulses (25.23 mt). Chickpea *(Cicer arietinum* L.) is an important pulse crop growing all over the country during *Rabi* season. It is the King of pulses consists of more than 1/3 of area and 40% total pulse production. India is the largest producer as well as consumerof chickpea in the world. It is grown in area of 6.3million ha. With production of 5.1 mt. The average yield of chickpea is 806kg/ha. In India, Madhya Pradesh is the largest pulse producing state, which accounts for 23% of total pulse production. It covers 32.97% area of chickpea in country. Chickpea is a self pollinated crop and cross-pollination is rare event, only 0-1% (Singh 1987, Smithson *et al*., 1985). It is an important source of energy, protein, soluble and insoluble fibre. Mature chickpea grains contain 60-65% Carbohydrates,6% Fat and 12-25% Protein higher than any other pulse crop. Through symbiotic Nitrogen fixation, the crop meetupto 80% of soil nitrogen needs, so farmers have to apply less N fertilizers, then they do for any other non-legume crops. It is an important source of energy, protein, soluble and insoluble fibre. Mature chickpea grains contain 60-65% Carbohydrates,6% Fat and 12-25% Protein higher than any other pulse crop. Through symbiotic Nitrogen fixation, the crop meetupto 80% of soil nitrogen needs, so farmers have to apply less N fertilizers, then they do for any other non-legume crops. Two main types of chickpea are recognized i.e., Desi type with small seeds of various crops, purplish flowers and grains contain 17-22% protein and 60-64% carbohydrate (Aslam*etal*2000) and contribute 80% of the global chickpea production. Kabuli type with bold and cream coloured seed is grown in around 10% area. It is a rainfed cool weather crop or as a dry climate crop in semi-arid regions. To meet the rising demand, a quantum jump in chickpea production is required. But majority of farmers usually grow pulses in marginal land with indiscriminate use of chemical fertilizers without biofertilizers, intensive tillage and other faulty management practices have threatened the sustainability that resulted reduction in the soil fertility due to reduction of organic matter and multi nutrient deficiency is one of the major limitations for pulse crop production particularly in low-input agricultural system around the world (Kumar, 2003). Biofertilizers, a type of organic fertilizers, are emerging as an ecologically safe means of fertilization. It is defined as a substance which contains living micro-organisms which, when applied to seed, plant surfaces or soil, colonizes the rhizosphere or the interior of the plant and promotes growth by increasing the supply or availability of primary nutrients to the host plant (Vessey, 2003).

2. MATERIAL AND METHODS

The experiment was conducted during winter seasons 2021-22 at the Reaserch farm school of Agriculture, Eklavya University ,damooh. Adequate research facilities viz., irrigation, seed, fertilizers, equipment and labour etc. were available in rearch farm to conducted the work smoothly. Considering the nature of factors under study and the convenience of agricultural operation, the experiment was consists of 12 treatment combinations and laid out in split plot design assigning four treatments in main plot *viz.* F1- Control, F2- RDF 100%, F3- RDF 75%, F4- RDF 50% and three treatments in sub plot *viz*. B1- Rhizobium+PSB, B2- Rhizobium+ PGPR, B3- Rhizobium+PSB+PGPR with three replications. Each treatment was randomly allocated within them.

2.1 Plant height (cm)

Plant height was measured from the five randomly selected tagged plants from the ground level upto the tip of growing point at 30DAS, 60DAS and at Harvest and the mean value was expressed in(cm)

2.2 Dry matter accumulation per plant (g)

Five randomly selected tagged plants from sample row and cut from ground level at 30DAS, 60DAS and 90DAS. The plant samples (leaf + stem) were air dried followed by oven drying at 70^{0} C for about 24 hours or more until a constant weight was obtained and then weighed and averaged for one plant.

2.3 Root dry weight per plant (g)

Five randomly selected tagged plants from each plot at 30DAS, 60 DAS and Harvest stage from sample row and uprooted very carefully by moistening the root zone and washed with water. Cut root part of the plant and the root samples were air dried followed by oven drying at 70^{0} C for about 24 hours or more until a constant weight was obtained and then weighed and averaged for one plant.

2.4 Number of pods per plant

The total number of matured and filled pods from five randomly selected tagged plants in each plot was counted, averaged and expressed as number of pods per plant**.**

2.5 Number of seeds per pod

The number of seeds per pod from the pods of tagged plants was counted, averaged and expressed as number of seeds per pod.

2.6 Test weight (g/ 100-seed weight)

A random seed sample was collected from the bulk produce of each net plot, 100-seeds were counted from the sample and then weight was recorded at test weight of each treatment expressed in gram (g).

2.7 Grain yield (q ha^{-1})

Grain yield was recorded after threshing, winnowing, cleaning and drying. The produce of each net plot was threshed separately and weighed plot wise to work out seed yield. Then obtained values were converted into q ha^{-1}

2.8 Straw yield (q ha^{-1})

It was calculated by subtracting the grain yield from the biological yield recorded per net plot and later on converted in q ha^{-1}.

2.9 Biological yield (kg ha^{-1})

All above the ground plant parts of the net plot were dried and weighted in kg per plot to represent the biological yield.

2.10 Harvest Index (%)

It is the economic yield expressed as percentage of biological yield and calculated as follows. It is expressed in percentage.

$$\text{Harvest index (\%)} = \frac{\text{Grain yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

2.12 Quality studies

Protein content in grain (%)

Protein content in grain was obtained by multiplying the nitrogen content in grain with factor 6.25 (AOAC, Washington 1995). The protein yield (kg ha^{-1}) was obtained by the following formula:

Protein yield (kg ha^{-1}) = Protein content (%) x Yield (kg ha^{-1}) / 100

3. RESULTS AND DISCUSSION

3.1 Growth and development studies on crop

Generally the plant develops at a slow rate in the beginning, because the major parts of the plant nutrients are utilized for the extension of root system and for the formation of new leaves with the limited availability of photosynthate. As a result, the development of growth attributes like plant height, dry matter accumulation per plant, branches per plant, nodules per plant, nodule dry weight per plant, root dry weight per plantand receive a setback in early stage of crop growth.Additional advantage of synergistic association and extra nutrients met from chickpea crop might be resulted in overall development of the crop in terms of plant height and dry-matter accumulation $plant^{-1}$.

Enhanced yield attributes under nutrient management practices, which contributed favourably to photosynthetic efficiency might be on account of higher nutrient status of soil because of supplied heavy nutrients to chickpea crop. These findings are on the line with those reported by as well as **(Singh and Prasad *et al*.,2008) .**Significant increase in the grain yield of chickpea was due to increase in yield components like number of pods per plant, number of seeds per pod, number of seeds per plant, pod weight per plant, grain weight per plant and 100-grain weight as observed in present investigation. The results are in line with the findings of **Rabieyan**and **Kashani, Z. F. 2012).**

3.2 Plant height

Fertility levels and biofertilisers did not-differ significant effect on plant population during initial and at harvest stage.Fertility levels found significant effect on plant height at all the stages of crop growth except 30DAS. However, maximum plant height at 60DAS was found with the application of 100% RDF which was statistically at par with 75% RDF and significantly higher than 50% RDF and control treatment. Maximum plant height at harvest stage was found with the application of 100% RDF which was statistically at par with 75% RDF and 50% RDF but significantly higher than control treatment. In general, the plant height increased with the advancement in age of the crop and reached its maximum at maturity. The plant height was influenced with the application of different nutrients levels. With every successive increase in fertility levels there was increase in plant height with successive growth stage and maximum plant height was recorded at harvest stage. The increase in plant height might be due to adequate availability of NPK attributed to better nutritional environment for plant growth at active vegetative stages as a result of enhancement in cell multiplications, cell elongation and cell expression in the plant body which ultimately increased the height of plant. The results of present investigation are also in agreement with the findings of (**Fatima *et al.*,2008)**.

Biofertilisers treatment observed significant effect on plant height at all the stages of crop growth except 30DAS. However, maximum plant height at 60DAS was found with the application of B_3 treatment which was significantly higher than B_2 and B_1 treatment. But at harvest stage maximum plant height was found with the application of B_3 treatment which was statistically at par with B1 treatment and significantly higher than B_2 treatment. This may be due to better uptake of nutrients by plants facilitated by various processes carried out by microbial inoculants **(Singh *et al.,* 2012)**. Application of biofertilisers plant height increased significant due to beneficial enzyme and increased micro floral diversity in soil. This finding is closely related to **(Gupta and Gangwar 2012)**.

3.3 Dry matter accumulation

Plant dry matter accumulation was influenced significantly due to different Fertility levels at all the stages of crop growth except 30 DAS. However, at 60DAS and at 90DAS found maximum plant dry matter accumulation with the application of 100% RDF which was significantly higher than 50% RDF and control treatment. Dry matter accumulation per plant is an ultimate result of all the metabolic processes occurring inside the plant. The recommended nutrient application made higher nutrients available to plants resulted in to more dry matter accumulation **(Jat and Ahalawat 2004)**. The results also revealed higher available nutrients at prime vegetative growth of the crop at higher fertility levels as dry matter accumulation varied sharply from 30DAS to 60DAS and maintaining higher leaf area index which might have resulted higher photosynthetic activity at higher fertility levels.

Biofertilisers treatment found significant effect on plant dry matter accumulation at all the stages of crop growth except 30 DAS. However, maximum plant dry matter accumulation at 60DAS and at 90DAS was found with the application of B_3 treatment which was significantly higher than other treatments. This might be due to the fact that nitrogen fixing and phosphorus solubilizing microorganism secrete certain organic acids and biochemical compounds which are growth promoting in nature and enhance plant growth and development. Hence, the biofertilisers have influenced the soil nutrient availability through better microbial activity and releasing the nutrients from the soil and helped in absorption of ample nutrients and its utilization by the plants.

3.4 Root parameters

All the root parameters i.e. root dry weight/plant, number of nodules per plant and nodule dry weight/plant influenced significantly due to different Fertility levels at all the stages of crop growth except root dry weight/plant at 30 DAS. However, at 60DAS and at harvest stage found maximum root dry weight with the application of 100% RDF which was significantly higher than other treatments respectively. While, at 30DAS and 60DAS was found maximum number of nodules per plant with the application of 100% RDF which was significantly higher than rest of the treatments. But at harvest DAS was found maximum number of nodules per plant with the application of 100% RDF which was statistically at par with 50% RDF and significantly higher than control treatment. However, maximum nodule dry weight at 30DAS and 90DAS was found with the application of 100% RDF which was significantly higher than remaining treatments. But at 60 DAS was found maximum nodule dry weight with the application of 100% RDF which was statistically at par with 75 % and 50% RDF and significantly higher than control treatment. Favourable effect on plant growth with different nutrient levels over control treatment may be attributed to better nutrient availability and number of metabolic processes taking place in the plant body, which in turn are affected by a variety of inherent and environmental factors to which plant is exposed that results more root dry weight, number of nodules per plant and nodule dry weight/plant **(Gray and Bahar, 2013; Egamberdieva*et al.*, 2015)**.

Biofertilisers found significant effect onall the root parameters i.e. root dry weight/plant, number of nodules per plant and nodule dry weight/plant at all the stages of crop growth except root dry weight/plant at 30DAS. However, maximum root dry weight at 60DAS and at harvest stage was found with the application of B_3 treatment which was statistically similar with B_1 treatment but significantly higher than other treatments. Maximum number of nodules per plant and nodule dry weight/plant at all the stages of crop growth was found with the application of B_3 treatment which was significantly superior over all other treatments. The probable reasons for such results could be the growth promoting substances secreted by the microbial inoculants, which in turn might have led to better root development, better transpiration of water and enhanced uptake of nutrients that results more root dry weight/plant, number of nodules per plant and nodule dry weight/plant. These results were in accordance with works of **(Triphati*et al*.,2015, Singh and Prasd 2008.)**

3.5 Yield attributing characters

Yield attributes which determine yield, is the resultant effect of the vegetative development of the crop. All the attributes of yield *viz*., number of branches per plant, number of pods per plant and number of seeds per pod were significantly affected by different fertility levels except number of branches at 30 DAS and 100-seed weight.

However, at 60DAS, maximum number of branches per plant was found with the application of 100% RDF which was significantly higher than other treatments. At harvest stage maximum number of branches per plant was found with the application of 100% RDF which was statistically at par with 75% RDF but significantly higher than 50% RDF and control treatment. While, number of pods per plant and number of seeds per pod was found maximum with the application of 100% RDF which was significantly higher than other treatments. The increased number of branches per plant was probably due to more activities of meristematic tissue of plants at higher fertility levels as NPK plays a role in cell differentiation, more meristematic division and more translocation of food materials in plants, thereby resulting higher production of branches at different growth stages. Application of 100% RDF, nitrogen increased the number of branches per plant and pods per plant by enhancing cell differentiation and chlorophyll synthesis, phosphorus help in vigorous plant root develop results enhance nutrient uptake and potassium help in photosynthates translocation in plant system **(Fatima *et al.,* 2008)** This increase in number of seeds per pod might be due to application of higher dose of fertilizers might have resulted from optimum fertilization of flowers and increased pollen grain viability and there by increased number of seeds per pod.

Biofertilisers treatment were influenced significantly all the yield attributes *viz*., number of branches per plant, number of pods per plant and numbers of seeds per pod except number of branches at 30DAS and 100-seed weight. However, maximum number of branches per plant at 60DAS and at harvest stage was found with the application of B_3 treatment which was significantly higher than other treatments respectively. Number of pods per plant was found with the application of B_3 treatment which was statistically at par with B_1 treatment but significantly higher than B_2 treatment. But, maximum number of seed per plant was found with the application of B_3 treatment which was significantly higher than other treatments respectively. This may be due to higher uptake of nutrients by plants because of enhanced nitrogen fixing ability of nitrogen fixers by the addition of biofertilisers. The results were in accordance with the studies of **(Singh *et al.,* 2006)** and **(Fatima *et al.,*2007)**. Biofertilisers mineralize and solubilize rapidly and provide optimum nutrients to the plants thereby stimulating plant growth that results more number of branches per plant, number of pods per plant and numbers of seeds per pod .

3.6 Yield

Seed yield, stover yield and biological yield influenced significantly due to different fertility levels except harvest index. However, higher seed yield was found with the application of 100% RDF which was significantly higher than other treatments. While, higher stover yield was found with the application of 100% RDF which was statistically at par with 75% RDF and significantly higher than other treatments. But, maximum biological yield was recorded with the application of 100% RDF which was significantly higher than other treatments respectively. The increase in seed and stover yield under adequate nutrients supply might be ascribed mainly due to the combined effect of higher plant height, more branches per plant, number of pods per plant, more number of seeds/pod and higher 100-seed weight, which was the result of better translocation of photosynthates from source to sink ultimately seed yield is increased **(Pathak *et al.,*2003)** and **(Tolanur*et al.,*2008)** also found similar results. The increase in seed yield under adequate nutrients supply mainly due to more yield attributes ultimately resulted more seed yield. Also reported the similar results by **(Kanter*et al.,* 2003)**. The increase in biological yield per hectare could be attributed to increased seed and stover yields under these treatments and also the pattern of dry matter accumulation at different stages. Similar observations were reported by **(Gupta 2007)** and **(Kushwaha 2007)**. Biofertilizer treatments were influenced significantly seed, stover and biological yield However, higher seed, stover and biological yield was found with the application of B_3 treatment which was significantly higher than other treatments respectively. The increase in seed, stover and biological yield may be due to proper establishment of *Rhizobium* strain which resulted in supply of nitrogen in larger quantity to plants. The application of biofertilizer increased seed, stover and biological yield was due to marked improvement in dry matter accumulation, yield attributes and greater nutrient content and their uptake by chickpea and field pea crop.Through the study we also found that treatments inoculated with PGPR had higher nitrogen, phosphorus and potassium content and higher nodulation which provide additional evidence for higher seed, stover and biological yield in biofertilizer inoculated treatments. This may be due to better availability of nutrient to the plant. The probable reasons for such results could be because of certain growth promoting substances secreted by the microbial inoculants, which is turn might have led to better root development, better transpiration of water, uptake and deposition of nutrients **(Pyare and Dwivedi 2005)**.

4 .Quality parameters

4.1 Protein content in seeds (%)

The effect of different fertility levels was found to be non-significant. However, maximum protein content was observed with the application of control treatment and lowest protein content was found with the application of 100% RDF. The increase in fertility levels that results higher nitrogen content in 100% fertilized plot which ultimately results low protein content in seeds **(Singh *et al.*, 2004).** Protein content and nitrogen content have inverse relationship this results confirmed by **(Jat andAhalawat 2004)** The higher nitrogen content in chickpea grain may be achieved due to availability of nitrogen in adequate amount because of better root nodulation and root growth under I_2 treatment.

Biofertilizer treatments found non-significant effect on protein content in seed However, maximum protein content in seed was recorded with the application of B_3 treatment and lowest protein content was found B_2treatment.Application of biofertilisers increase the protein content in seeds because biofertilizers enhance the nutrient uptake and plant use nutrients rapidly and efficiently that results more protein content in seeds **(Singh and Prasad 2008)**.

5.5.2 Protein yield

Protein yield influenced significantly by different fertility levels. However, maximum protein yield was recorded with the application of 100% RDF which was statistically at par with 75% RDF and 50% RDF but significantly higher than control treatment. It is a function of protein content in seeds multiplied by seed yield per hectare. Increasing the seed yield increased the protein yield. These results are in tune with (**Meena *et al.*, 2005)**.

Protein yield influenced significantly by different biofertilisers treatments. However, maximum protein yield was recorded with the application of B_3 treatment which was significantly higher than other treatments. Protein yield is the function of seed yield per hectare multiplied by protein content. Increasing the seed yield increased the protein yield. These results are in tune with**(Meena *et al.*, 2005)**.

Table. 1.Effect of fertility levels and biofertilizers on plant population, plant height ,dry matter accumulation andRoot dry weight.

Treatments	Plant height (cm)			Dry matter accumulation (g/plant)			Root dry weight (g/plant)		
	30DAS	60 DAS	Harvest	30DAS	60DAS	90 DAS	30 DAS	60DAS	Harvest
Fertility levels									
F1	8.50	47.91	50.92	2.40	14.04	20.22	0.17	0.56	0.63
F2	10.49	58.36	61.99	3.01	17.57	25.31	0.21	0.70	0.78
F3	9.95	55.94	58.92	2.86	16.68	24.02	0.20	0.65	0.73
F4	9.41	52.83	55.93	2.70	15.76	22.71	0.19	0.62	0.69
SEm±	0.19	0.69	1.09	0.07	0.27	0.38	0.01	0.01	0.02
CD (P= 0.05)	0.68	2.39	3.77	0.25	0.96	1.31	NS	0.05	0.06
Biofertilizers									
B1	9.59	53.87	56.99	2.75	16.08	23.16	0.19	0.63	0.71
B2	9.10	50.84	53.96	2.58	15.07	21.71	0.18	0.59	0.66
B3	10.07	56.56	59.86	2.89	16.88	24.32	0.20	0.67	0.75
SEm±	0.18	0.89	0.95	0.07	0.25	0.32	0.008	0.02	0.02
CD (P= 0.05)	0.53	2.69	2.85	0.25	0.75	0.96	NS	0.05	0.06
FXB	NS	NS	NS	NS	NS	NS	NS	NS	NS

Where F1-Control, F2- RDF 100% , F3- RDF 75% , F4- RDF 50% ,B1- Rhizobium + PSB ,B2- Rhizobium + PGPR ,B3 – Rhizobium + PSB + PGPR

Table 2.Effect of fertility levels and biofertilizers on yield attributes and quality of chickpea

Treatments	No. of pods/ plant	No.seeds/ pod	100 seed weight(g)	Seed yield (q/ha)	Stover yield (q/ha)	Biological yield (q/ha)	Harvest index	Protein (%)	Protein yield (q/ha)
Fertility levels									
F1	37.36	1.190	19.04	12.15	20.92	40.69	34.27	21.22	427.63
F2	45.05	1.43	22.06	18.05	25.62	50.37	36.15	23.11	572.31
F3	42.73	1.36	20.40	16.30	25.40	48.91	35.32	22.10	523.34
F4	40.80	1.29	20.20	15.62	24.42	46.65	34.57	21.87	485.17
SEm ±	0.99	0.02	0.90	0.35	0.40	0.57	0.70	0.051	11.71
CD(P=0.05)	3.42	0.08	NS	1.19	1.39	1.96	NS	0.17	40.42
Biofertilizers									
B1	41.43	1.37	20.66	15.75	24.60	47.26	36.12	21.81	500.68
B2	39.53	1.21	18.24	13.14	22.78	44.03	34.73	21.67	462.74
B3	43.50	1.41	22.50	17.68	24.90	48.67	35.37	22.70	542.91
SEm ±	0.48	0.01	1.13	0.28	0.39	0.48	0.57	0.039	8.98
CD (P=0.05)	1.44	0.05	NS	0.86	1.17	1.45	NS	0.117	26.94
FXB	NS	NS	NS	S	NS	NS	NS	NS	NS

Where F1-Control, F2- RDF 100% , F3- RDF 75% , F4- RDF 50% ,B1- Rhizobium + PSB ,B2- Rhizobium + PGPR ,B3 – Rhizobium + PSB + PGPR

CONCLUSION

Based on the finding of the present study, it can be inferred that application of 100% RDF (F_2) with Rhizobium + PSB + PGPR (B_3) resulted maximum growth and yield attributes which results more yield and ultimate more protein yield and net profit of late sown chickpea crop during rabi season in central zone of Uttar Pradesh.

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