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# Response of Row Spacing, Bio-fertilizer and Nitrogen Levels on Yield Attributes and Quality Parameters of Chickpea (*Cicer arietnium* L.) under Central Plain Zone of Uttar Pradesh, India

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**A B S T R A C T**

An experiment was conducted during of rabi 2014-15 and 2015-16 at Soil Conservation and Water Management farm of the C. S. Azad University of Agriculture and Technology, Kanpur to find out the response of row spacing, bio-fertilizer and nitrogen levels on yield attributes i.e. number of pods /plant, number of seeds/pod 1000-seed weight, protein content in (% & kg/ha), nodules/plant and fresh & dry weight (mg) of nodules/plant of chickpea crop. The treatments comprised of 2 row spacing i.e. 40 cm and 60 cm, 3 bio-fertilizer i.e. *Rhizobium leguminosarum* culture (seed coating @ 20 g $kg^{-1}$ seed), Phosphate solubilizing bacteria (PSB) @ 2.5 kg $ha^{-1}$ in soil and *Rhizobium leguminosarum* + Phosphate solubilizing bacteria (PSB) and 3 nitrogen level i.e. N10 kg $ha^{-1}$, N20 kg $ha^{-1}$ and N30 kg $ha^{-1}$ in Split plot design with 3 replications. Results obtained in regarded to yield attributes and protein content showed that the 60 cm row spacing produced significantly higher yield attributes in both the years on pooled basis recorded number of pods/plant (57.57), number of seeds /pod (1.72), 1000- seed weight (147.64 g), nodules/plant (28.08), fresh & dry weight nodules/plant (76.58 and 44.37 mg ) and protein content in per cent (21.06) but maximum recorded protein in kg/ha under 40 cm row spacing (295.86 kg/ha). Among the bio-fertilizer the performance of dual inoculation of *Rhizobium leguminosarum* culture + PSB was the best & have recorded significantly superior number of pods /plant (57.61), number of seeds /pod (1.89), 1000- seed weight (148.75)nodules/plant (29.70), fresh & dry weight nodules/plant (81.34 and 48.12 mg) and protein content in per cent (21.26)& (302.02) kg /ha. However nitrogen level @ 30 kg $ha^{-1}$ recorded significantly higher on number of pods /plant (147.64 g), number of seeds /pod (1.97), 1000- seed weight (149.47g), nodules/plant (30.54), fresh & dry weight nodules/plant (81.34 and 48.12 mg) and protein content in per cent (21.15)& (313.22) kg /ha. Nitrogen levels 30 kg $ha^{-1}$ was found superior in all respect as compared to other treatments combinations.

## Introduction

Chickpea (*Cicer arietinum* L.) was first domesticated in the Middle East. It is widely cultivated in India, Australia, Pakistan, Turkey, Myanmar and Ethiopia. It is an important cool season pulse crop and is also called Bengal gram. In terms of pulse production, India contributes about 25% to the total global pulses production (Pooniya *et al.*, 2015). In India, chickpea is a premier pulse crop grown on an area of 8.25 million ha during 2014-15, contributing 7.33 million tonnes to the national pulse basket with productivity of 889 kg $ha^{-1}$. This accounts for about 70% of the total global area with 67% of global production (Anonymous 2016).

Chickpea is an important source of protein in the diets of the poor, and is particularly important in vegetarian diets and is an important substitute for animal protein. It is mostly consumed in the form of processed whole seed (boiled, roasted, fried, steamed, etc.), *dal* and as *dal* flour. It is used in preparing snacks, sweets and condiments. Fresh green seeds are also consumed as a green vegetable. It is an excellent source of protein (18-22%), carbohydrates (52-70%), fat (4-10%), minerals (calcium, phosphorus, iron etc.) and vitamins. It is an excellent animal feed and its straw has good forage value (Prasad 2012).

Leguminous crops have a unique property of maintaining and restoring soil fertility as well as conserving and improving physical properties of soil by virtue of their deep root system which enables them to efficiently utilize applied as well as residual soil nutrients. Further, these crops are capable of fixing atmospheric nitrogen with the help of *Rhizobium* bacteria residing in the root nodules. Under favourable conditions, the symbiotic $N_2$ fixation can be as high as 176 kg N $ha^{-1}$ and needs up to 85% of N requirements in legumes. Seed inoculation with *Rhizobium* increases the nodulation through better root development and improves nutrient availability which is beneficial in improving the grain yield (Das *et al.*, 2013).

## Materials and Methods

The field trail was conducted at Soil Conservation and Water Management Farm, Department of Soil Conservation and Water Management of Chandra Shekhar Azad University of Agriculture & Technology, Kanpur which is situated in the alluvial tract of Indo - Gangetic plains in central part of Uttar Pradesh between $25^{o}$ 26' to $26^{o}$ 58' North latitude and $79^{o}$ 31' to $80^{o}$34' East longitude at an elevation of 125.9 m above mean sea level. The average annual rainfall is 800 mm, a major portion of which is received during the monsoon season from the last week of June to first week of October. The treatments comprised of 2 row spacing i.e. 40 cm and 60 cm, 3 bio-fertilizer *i.e.* Rhizobium *leguminosarum* culture (seed coating @ 20 g $kg^{-1}$ seed), Phosphate solubilizing bacteria (PSB) @ 2.5 kg $ha^{-1}$ in soil and Rhizobium *leguminosarum* + Phosphate solubilizing bacteria (PSB) and 3 nitrogen level i.e. 10 kg $ha^{-1}$, 20 kg $ha^{-1}$ and 30 kg $ha^{-1}$ in Split plot design with 3 replications.

## Results and Discussion

### Yield attributes

### Number of pods/ plant

The data pertaining to the number of pod /plant of chickpea have been given in Table-1 showed that response of row spacing variation among them, where as60 cm row spacing treatment produced significantly highest number of pods/plant recorded on the pooled basis (57.57) of chickpea. However 40 cm row spacing recorded to be the lowest in respect to number of pods /plant on the pooled basis (52.48). Use of bio-fertilizer in

respect of number of pods /plant of chickpea significantly higher number of pods /plant recorded as dual inoculation rhizobium culture + PSB in pooled basis (57.61). However lowest pod/plant was recorded single inoculation bio-fertilizer rhizobium culture number of pods /plant in pooled basis (52.81) respectively. Similarly among nitrogen levels also showed marked variation in respect of number of pods /plant first of chickpea. Significantly higher number of pods /plant was recorded under N30 kg/ha nitrogen levels recorded in pooled basis (58.61) over other nitrogen levels during both the years. Similar results were reported Goud and Kale (2011), Kumar and Singh (2013), Das *et al.,* (2013), Shahnemati *et al.,* (2014) and Singh *et al.,* (2014), Singh and Agrawal (2013), Kumar *et al.,* (2014), Raj *et al.,* (2014) and Singh *et al.,* (2014).

## Number of seeds/pod

The data pertaining to the number of pod /plant of chickpea have been given in Table -1 showed that response row spacing variation among them, where 60 cm row spacing treatment produced non-significantly but highest number of seed/pod recorded pooled basis (1.72) of chickpea however 40 cm row spacing recorded to be the lowest in respect to seed/pod pooled basis (1.63) during both the years. Use of bio-fertilizer in respect of number of seed/pod of chickpea significantly higher number of seed/pod as dual inoculation rhizobium culture + PSB in pooled (1.89). However lowest seed/pod was recorded single inoculation bio-fertilizer treatment rhizobium culture seed/pod recorded in pooled (1.47) respectively during both the years. Similarly among nitrogen levels also showed marked variation in respect of number of seed/pod of chickpea. Significantly higher number of seed/pod was recorded under N30 kg/ha nitrogen levels treatment recorded in pooled basis (1.97) over other nitrogen levels during both the years. Similar results were reported Goyal *et al.,* (2010), Kumar and Singh (2013), Das *et al.,* (2013), Raj *et al.,* (2014), Singh and Agrawal (2013) and Kumar *et al.,* (2014).

## 1000-Seed weight (g)

The data pertaining to the 1000-seed weight (g) of chickpea have been given in Table -1 showed that effect row spacing variation among them, where treatment produced significantly but highest 1000-seed weight (g) as 60 cm row spacing in recorded on pooled basis (147.64) (g) of chickpea however 40 cm row spacing to be the lowest recorded 1000-seed weight in (g) on pooled basis (144.72) during both the years. Use of bio-fertilizer in respect of 1000-weight/plant (g) of chickpea significantly higher 1000-weight/plant (g) recorded in dual inoculation bio fertilizer rhizobium culture + PSB treatment in pooled basis (148.75). However lowest 1000-seed weight (g) recorded in single inoculation rhizobium culture in pooled basis (143.59) respectively during both the years. Similarly among nitrogen levels also showed marked variation in respect of 1000-weight/plant in (g) of chickpea. Significantly higher 1000-seed weight (g) was recorded under N30 kg/ha nitrogen levels treatment in pooled basis (149.47) over other nitrogen levels treatment during both the years.Goyal*et al.,* (2010) reported that higher plant density of 33 plants/$m^2$ with 30 cm rows was recorded significantly higher on yield attributes i.e. 1000-seed weight of kabuli chickpea (*Cicer arietinum L.*) compared plants/ $m^2$ with 45 cm row spacing and similar findings Kumar and Singh (2013), Raj *et al.,* (2014), Singh and Agrawal (2013) and Kumar *et al.,* (2014).

## Quality parameters

## Protein content in per cent and kg/ha

The data related to protein content of chickpea seed both the years with pooled basis are tabulated in Table 2 Showed that

effect row spacing variation among them, where treatment produced significantly but higher protein content in (per cent with kg/ha) recorded in 60 cm row spacing in pooled basis (21.06 %) but kg/ha protein maximum 295.86 kg/ha recorded in 40 cm row spacing of chickpea. However lowest protein content recorded in 40 cm row spacing on pooled basis (20.89 % and 250.67 kg/ha) of chickpea seed both year. Effect of bio-fertilizer also varied remarkably in respect of protein content in (% with kg/ha) of chickpea seed. Significantly higher protein content recorded in dual inoculation bio-fertilizer rhizobium culture + PSB recorded in pooled basis (21.26 % and 302.02kg/ha).However lowest protein content recorded in single inoculation rhizobium culture treatment recorded in pooled basis (20.62% and 237.61 kg/ha) respectively during both the years. Similarly among nitrogen levels also showed marked variation in respect of protein content in seed of chickpea. Significantly higher protein content was recorded under N30 kg/ha nitrogen levels treatment recorded in pooled basis (21.15 and 313.22 kg/ha) per cent. However lowest protein content recorded in N10 kg/ha treatment on pooled basis (20.89and 231.09 kg/ha) during both the years with of experiment. Similar results were reported Mansur *et al.,* (2009), Duhan (2013), Kumar *et al.,* (2014), Arvadiya *et al.,* (2014) and Kumar *et al.,* (2014).

## Nodules plant$^{-1}$ at 50 DAS

The data pertaining to nodules plant$^{-1}$of chickpea recorded 50 DAS as influenced by row spacing, bio fertilizes and nitrogen levels are presented in Table-3 for both the years. The response of row spacing clearly indicate showed that variation among them, where treatment produced significantly highest in 60 cm row spacing number of nodules plant$^{-1}$ of chickpea recorded in pooled basis (28.08). However lowest number of nodules plant$^{-1}$ recorded in 40 cm row spacing on pooled basis (24.98) during both the years. Use of bio-fertilizer also varied remarkably in respect of number of nodules plant$^{-1}$ of chickpea. Significantly higher was recorded in treatment bio-fertilizer dual inoculation rhizobium culture + PSB in recorded in pooled basis (29.70). However minimum recorded nodules plant$^{-1}$ in single inoculation bio-fertilizer rhizobium culture treatment on pooled basis (23.82) during both the years. Similarly, nitrogen levels also result marked variation in respect of number of nodules plant$^{-1}$ of chickpea. Results showed that significantly higher number of nodules plant$^{-1}$ was recorded in N 30 kg/ha nitrogen levels in pooled basis (30.54). However minimum nodules plant$^{-1}$ was recorded in N10 kg/ha nitrogen levels on pooled basis (22.98). Nitrogen level N30 kg ha$^{-1}$ proved to be significantly superior over all other treatment during both the seasons. Similar results were reported Das *et al.,* (2013), Tagore *et al.,* (2013), Yadav *et al.,* (2014), Shahnemati *et al.,* (2014), Raj *et al.,* (2014) and Singh *et al.,* (2014).

## Fresh and dry weight nodules PLANT$^{-1}$ (mg) at 50 DAS

The data pertaining to fresh and dry weight (mg) nodules plant$^{-1}$ of chickpea recorded 50 DAS as influenced by row spacing, bio fertilizes and nitrogen levels are presented in Tables-3for both the years. The data clearly indicate significant variation in terms of fresh and dry weight (mg) of nodules plant$^{-1}$ of chickpea as affected by different row spacing during both the years with pooled. The data showed that 60 cm row spacing significantly higher in terms of fresh and dry weight (mg) of nodules plant$^{-1}$ in mean investigation (76.58 and 44.37) at stage 50 DAS during both the years with.

**Table.1** Effect of row spacing, bio-fertilizer and nitrogen levels on number of pod$^{-1}$, number of seed$^{-1}$ 1000-seed weight (g) of chickpea during 2014-15 &2015-16

| Treatment | Pod plant$^{-1}$ | | | Seed pod$^{-1}$ | | | 1000-seed weight (g) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Row spacing** | | | | | | | | | |
| **40 cm** | 53.74 | 51.22 | 52.48 | 1.67 | 1.59 | 1.63 | 145.13 | 144.29 | 144.72 |
| **60 cm** | **57.76** | **57.41** | **57.57** | **1.82** | **1.63** | **1.72** | **149.41** | **145.81** | **147.64** |
| **SE(d)** | 0.20 | 0.19 | 0.18 | 0.07 | 0.09 | 0.05 | 0.11 | 0.09 | 0.09 |
| **C.D. (P=0.05)** | 0.44 | 0.43 | 0.40 | NS | NS | NS | 0.24 | 0.20 | 0.19 |
| **Bio – fertilizer** | | | | | | | | | |
| **Rhizobium culture (seed coating @20g/kg seed)** | 54.00 | 51.61 | 52.81 | 1.56 | 1.39 | 1.47 | 143.92 | 143.25 | 143.59 |
| **PSB @2.5 kg/ha in soil** | 55.01 | 54.33 | 54.67 | 1.72 | 1.61 | 1.68 | 147.64 | 144.76 | 146.20 |
| **Rhizobium culture+ PSB** | **58.22** | **57.00** | **57.61** | **1.94** | **1.83** | **1.89** | **150.27** | **147.16** | **148.75** |
| **SE(d)** | 0.24 | 0.24 | 0.22 | 0.08 | 0.12 | 0.07 | 0.13 | 0.11 | 0.10 |
| **C.D. (P=0.05)** | 0.54 | 0.52 | 0.49 | 0.17 | 0.27 | 0.15 | 0.29 | 0.25 | 0.23 |
| **Nitrogen levels- kg ha$^{-1}$** | | | | | | | | | |
| **10** | 51.17 | 50.83 | 51.00 | 1.50 | 1.28 | 1.39 | 144.44 | 142.04 | 146.24 |
| **20** | 56.72 | 54.22 | 55.47 | 1.72 | 1.61 | 1.66 | 146.93 | 144.71 | 145.82 |
| **30** | **59.33** | **57.89** | **58.61** | **2.00** | **1.94** | **1.97** | **150.45** | **148.43** | **149.47** |
| **SE(d)** | 0.24 | 0.17 | 0.15 | 0.15 | 0.13 | 0.09 | 0.06 | 0.01 | 0.05 |
| **C.D. (P=0.05)** | 0.49 | 0.34 | 0.30 | 0.30 | 0.27 | 0.19 | 0.12 | 0.02 | 0.14 |

**Table.2** Effect of row spacing, bio fertilizers and nitrogen levels on plant studies content of protein (%) in seed and protein kg ha$^{-1}$ of chickpea during 2014-15 & 2015-16

| Treatment | Protein (%) | | | Protein kg ha$^{-1}$ | | |
|---|---|---|---|---|---|---|
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Row spacing** | | | | | | |
| **40 cm** | 20.69 | 20.95 | 20.82 | 325.66 | 266.07 | 295.86 |
| **60 cm** | **21.02** | **21.10** | **21.06** | **276.62** | **224.72** | **250.67** |
| **SE(d)** | 0.10 | 0.10 | 0.10 | 0.09 | 0.10 | 0.10 |
| **C.D. (P=0.05)** | NS | NS | NS | NS | NS | NS |
| **Bio – fertilizer** | | | | | | |
| **Rhizobium culture (seed coating @20g/kg seed)** | 20.63 | 20.60 | 20.62 | 261.59 | 213.62 | 237.61 |
| **PSB @2.5 kg/ha in soil** | 20.85 | 21.03 | 20.94 | 307.12 | 251.31 | 279.21 |
| **Rhizobium culture+ PSB** | **21.06** | **21.46** | **21.26** | **331.27** | **272.76** | **302.02** |
| **SE(d)** | 0.12 | 0.12 | 0.12 | 0.11 | 0.12 | 0.11 |
| **C.D. (P=0.05)** | 0.26 | 0.27 | 0.26 | 0.26 | 0.27 | 0.26 |
| **Nitrogen levels- kg ha$^{-1}$** | | | | | | |
| **10** | 20.98 | 20.79 | 20.89 | 255.54 | 206.65 | 231.09 |
| **20** | 20.91 | 20.05 | 20.48 | 308.21 | 237.99 | 273.10 |
| **30** | **21.05** | **21.24** | **21.15** | **345.64** | **280.79** | **313.22** |
| **SE(d)** | 0.05 | 0.04 | 0.04 | 0.04 | 0.04 | 0.04 |
| **C.D. (P=0.05)** | 0.10 | 0.09 | 0.08 | 0.09 | 0.08 | 0.08 |

**Table.3** Effect of row spacing, bio-fertilizer and nitrogen levels on number of nodules/plant, fresh and dry weight (mg) of nodules plant$^{-1}$ at 50 DAS of chickpea during both year 2014-15 &2015-16

| Treatment | Number nodules plant$^{-1}$ 50 DAS | | | Nodules fresh and dry weight (mg) plant$^{-1}$ 50 DAS | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | Fresh wt. (mg) | | | Dry wt. (mg) | | |
| | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled | 2014-15 | 2015-16 | Pooled |
| **Row spacing** | | | | | | | | | |
| **40 cm** | 22.21 | 26.74 | 24.98 | 71.74 | 75.65 | 74.16 | 37.72 | 45.93 | 41.56 |
| **60 cm** | **26.23** | **29.93** | **28.08** | **75.15** | **78.00** | **76.58** | **40.21** | **48.54** | **44.37** |
| **SE(d)** | 0.14 | 0.10 | 0.11 | 0.35 | 0.10 | 0.19 | 0.19 | 0.09 | 0.12 |
| **C.D. (P=0.05)** | 0.30 | 0.22 | 0.24 | 0.79 | 0.22 | 0.42 | 0.41 | 0.22 | 0.27 |
| **Bio – fertilizer** | | | | | | | | | |
| **Rhizobium culture (seed coating @20g/kg seed)** | 21.37 | 26.27 | 23.82 | 65.17 | 71.20 | 68.19 | 34.90 | 41.00 | 37.95 |
| **PSB @2.5 kg/ha in soil** | 23.68 | 28.46 | 26.07 | 74.34 | 78.81 | 76.58 | 38.65 | 46.99 | 42.85 |
| **Rhizobium culture+ PSB** | **27.61** | **31.78** | **29.70** | **80.80** | **81.83** | **81.34** | **43.34** | **52.89** | **48.12** |
| **SE(d)** | 0.18 | 0.12 | 0.13 | 0.43 | 0.12 | 0.23 | 0.23 | 0.12 | 0.15 |
| **C.D. (P=0.05)** | 0.37 | 0.27 | 0.30 | 0.97 | 0.27 | 0.52 | 0.50 | 0.27 | 0.33 |
| **Nitrogen levels- kg ha$^{-1}$** | | | | | | | | | |
| **10** | 20.51 | 25.44 | 22.98 | 66.64 | 70.45 | 68.55 | 33.28 | 41.04 | 37.16 |
| **20** | 23.88 | 28.25 | 26.07 | 70.89 | 76.37 | 73.63 | 38.82 | 46.48 | 42.65 |
| **30** | **28.25** | **32.82** | **30.54** | **82.81** | **85.02** | **83.33** | **44.79** | **53.37** | **49.08** |
| **SE(d)** | 0.14 | 0.04 | 0.08 | 0.43 | 0.04 | 0.22 | 0.21 | 0.04 | 0.11 |
| **C.D. (P=0.05)** | 0.28 | 0.08 | 0.15 | 0.89 | 0.09 | 0.45 | 0.43 | 0.08 | 0.22 |

Responses of bio fertilizer on fresh and dry weight (mg) of nodules plant$^{-1}$ of chickpea at 50 DAS higher significantly, where application of dual inoculation bio-fertilizer rhizobium culture + PSB as results fresh and dry weight (mg) plant$^{-1}$ mean investigation (81.34 and 48.12) during course of investigation. The results indicate that the various nitrogen levels showed significant variation at each growth stage in terms fresh and dry weight (mg) of nodules plant$^{-1}$ of chickpea during both the years. Results fresh and dry weight (mg) plant$^{-1}$mean investigation (83.33 and 49.08) during both the seasons. Similar results were reported Yadav *et al.*, (2014), Shahnemati *et al.*, (2014), Raj *et al.*, (2014) and Singh *et al.*, (2014).

In conclusion, response of row spacing, bio-fertilizer and nitrogen levels on yield attributes of crop *i.e.* number of pods /plant, number of pods /plant and 1000-seed weight protein content in per cent and kg/ha, nodules/plant, and fresh & dry weight recorded were significantly increased with increasing row spacing, bio fertilizer Rhizobium culture + PSB and nitrogen levels N30 kg ha$^{-1}$as compared to other treatments. The highest protein content was observed with the bio-fertilizer application of dual inoculation maximum recorded. Overall consideration of results it can be concluded that in the case of nitrogen levels N30 kg ha$^{-1}$ was found superior in all respect as compared to other combinations of fertility

management. So, it may be recommended that growing of chickpea in *rabi* season was found most suitable and remunerative in central plain zone of Uttar Pradesh with 60 cm row spacing, Rhizobium culture + PSB bio-fertilizer and with applied 30 kg /ha nitrogen levels.

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