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Effect of Spacing and Cobalt Application Methods on Root Nodulation and Yield of kabuli Chickpea (*Cicer kabulium* L.) Cultivars

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Abstract

A field experiment was conducted at the College Farm, N. M. College of Agriculture, Navsari Agricultural University, Navsari to study the effect of spacing and cobalt application on *kabuli* chickpea (*Cicer kabulium* L.) cultivars. The treatments of the study included eighteen treatment combinations consisting of three varieties. Two spacing and three-cobalt application methods were evaluated by using factorial randomized block design (FRBD) with three replications. Significantly highest nodule number plant^{-1} (56.02), nodule fresh (2.61 g) and dry weight (0.25 g), seed yield (1497.07 kg ha^{-1}), stover yield (2243.87 kg ha^{-1}) were achieved with variety PKV2 (V_3) followed by variety Kripa. The variety Kripa (V_2) recorded numerically higher harvest index (40.39). The crop sown at spacing 60×10 cm^2 (S_2) produced maximum number of nodules plant^{-1} (53.64), nodule fresh (2.50 g) and dry weight (0.23 g) but only dry weight of root nodules was found at par with 45×10 cm^2 spacing (S_1) (0.21g). Significantly higher seed and stover yield (1274.51 and 2191.95 kg ha^{-1}) and Harvest index (42.16%) were obtained with spacing 45×10 cm^2 (S_1). In case of cobalt application methods, significantly highest number of root nodules plant^{-1} (54.31), maximum fresh (2.54 g) and dry weight (0.25 g) of nodules, seed and stover yield (1520.51 and 2249.40 kg ha^{-1}) were obtained under application of cobalt as foliar spray at 0.01%.

Keywords: Harvest index, root nodules, seed yield, stover yield

1. Introduction

Pulses, generally known as food legumes, belonging to family Fabaceae are an important group among staple crops next to cereals.They form a major and cheapest source of dietary protein especially for vegetarians who form a major part of our Indian population (Terin et al., 2021). Pulses are rich source of minerals like calcium, phosphorus, iron etc. and certain essential amino acids. Thus, inadequate intake of pulses could lead to serious consequences on human health (Abhay et al., 2013).

Chickpea (*Cicer arietinum* L.) is an annual legume. It is the largest produced food legume of south Asia and third largest produced food legume globally after common bean (*Phaseolus vulgaris* L.) and field pea (*Pisum sativum* L.) and which is grown in more than 50 countries (Agajie et al., 2018). India is the largest chickpea producing country accounting for 64% of the global chickpea production. (Gaur et al., 2010). It is valued for its nutritive seeds with an inexpensive and high-quality source of protein (18-22%), carbohydrate (52-70%), fat (4-10%), crude fibers (1.37%), lysine (195-205 mg^{-1}), carotene (89-94 mg^{-1}), fibre (3%), minerals (calcium, magnesium, phosphorus, iron and zinc) and vitamins (Yadav et al., 2007).

Chickpea is leguminous crop that fix atmospheric nitrogen in the root nodules and this process depend on various factors like molybdenum and iron nutrition, which plays a key role in symbiotic nitrogen fixation by legumes (Narayanan et al., 2016). According to the present state of our knowledge, there are seventeen mineral elements are considered essential for plant growth (Arnon and Stout, 1939). Cobalt has not been proved essential for higher plants growth. It is essential for growth of the *Rhizobium*, the specific bacteria involved in legume nodulation and fixation of atmospheric nitrogen into amino acids and proteins in legumes (Ali, 2013). It is constituent of cyanocobalamin (vitamin B_{12}) which is constituent of leghaemoglobin and is synthesized by the *Rhizobium*. The leghaemoglobin content in the nodules is directly related to nitrogen fixation (Rod et al., 2019).

Chickpea varieties play an important role in the production of pulses. Selection of proper variety for a set of agro-climatic conditions is very important to achieve maximum potential, because of differential growth and development behavior (Singh et al., 2014). It is only due to different genetic characters of varieties (Kiran and Chimmad, 2018). There are two main kinds of chickpea *desi* and *kabuli*. *Desi* has small, darker seeds and a rough seed coat, grown mostly in semi-arid regions while, *kabuli* has lighter colour, larger seeds with smoother seed coat mainly grown in temperate regions of Pakistan.

The agronomic practices *viz*., row-to-row spacing, plant-to-plant spacing and use of different varieties could increase the yield. Among all the factors, row-to-row and plant-to-plant spacing is an important factor contributing to higher yield (Sharma et al., 2018). It is quite necessary to study the growth and yield of different varieties of *kabuli* type chickpea with different spacing. (Bavalgave et al., 2009). The optimum row spacing with proper geometry of planting is dependent on variety, its growth habit and agro climatic condition. It is also one of the important factors that ultimately affect nutrient uptake, growth and yield of plant (Sahay et al., 2015). There is a need for maintenance of genetic purity of chickpea varieties. Identification and characterization of varieties based on simple distinct seed and seedling morphological characters for grow-out test of genetic purity in *kabuli* and *desi* varieties has become most essential. It is also a fact that specified genotypes do not exhibit the same phenotypic characteristics in all environmental conditions.

2. Materials and Methods

A field experiment was conducted during the *rabi* season from 16th November to 16th March of 2017−18 at N. M. College of Agriculture, Navsari Agricultural University, Navsari to assess the root nodule parameters, seed and stover yield and harvest index of *kabuli* Chickpea (*Cicer kabulium* L.) cultivars. The soil of the experimental site was clayey in texture (62.56%), medium in organic carbon (0.40%), low available nitrogen (221.32 kg ha^{-1}), medium available phosphorus (28.89 kg ha^{-1}), high available potassium (441.3 kg ha^{-1}) and cobalt (0.45 mg kg^{-1}). The soil reaction was slightly alkaline (pH 7.89) with normal electrical conductivity (0.51 dSm^{-1}). Eighteen treatment combinations consisting of three varieties (V_1-Virat, V_2-Kripa, V_3-PKV2), two spacings (S_1-45×10 cm^2 and S_2-60×10 cm^2) and three cobalt application methods (C_1-seed priming at 1 ppm, C_2-seed treatment at 1 g kg^{-1} seed and C_3-foliar spray at 0.01% at 30 DAS and pre flowering were evaluated in factorial randomized block design with three replications. Before the experiment, paddy was grown in the field after the harvest of the previous crop. The experimental field was cultivated with tractor-drawn cultivator in cross-wise direction. Stubbles of the previous crop were collected and removed and the field was leveled.

The experimental plot was fertilized with total quantity of nitrogen and phosphorus applied as basal dose. The nutrients were applied in the form of urea (46% N), single super phosphate (16% P_2O_5) as per the recommended dose 20-40-0 kg NPK ha^{-1} by the method of band placement. In experimental plot, cobalt was applied through three different application methods namely, seed priming (1.0 ppm), seed treatment (1 g kg^{-1} seed) and foliar application at 30 DAS and pre-flowering (0.01%). Variety wise seed rate of all three varieties was calibrated and sown as per the given spacing. Plot wise quantity of seeds was weighed and it was treated, primed and were dibbled 5-8 cm deep in the same fertilized furrows on 16th November, 2017 at the spacing 45×10 cm^2 and 60×10 cm^2. Seeds were covered properly with soil and light irrigation was applied in each plot immediately after sowing and subsequently spraying of pre-emergent herbicide. During the study, following growth and yield attribute studies were conducted.

2.1. Number of root nodules plant^{-1}

Five plants were dug out randomly from the border rows, in such a way that no nodules detach from the root and remain into the soil. These uprooted plants were kept as such in bowl full of water for easy washing. Then they were washed with clean water. The observations regarding number of nodules plant^{-1} were recorded in each treatment for all the replications at flowering.

2.2. Fresh and dry weight of nodules plant^{-1} (g)

After counting nodules plant^{-1}, their fresh weight (g) was recorded immediately on an electrical balance in mg. Average value of fresh nodule weight was computed and recorded for each treatment. These nodules were first air dried and later dried in an oven at 70°C till constant weight was obtained and average value of dry nodule weight for each treatment was worked out

2.3. Seed yield (kg ha^{-1})

The produce of each net plot was trashed and cleaned separately and the seed yield was recorded in kilograms per net plot and converted into kilograms per hectare, after subjected to sun drying up to constant weight.

2.4. Stover yield (kg ha^{-1})

The plot wise stover yield was recorded in kilograms per net plot and converted into kg ha^{-1}, after subjected to sun drying up to constant weight.

2.5. Harvest index

The harvest index was computed based on seed yield and total biomass production and presented in term of percent. The harvest index was calculated by following formula:

Harvest index (%)=(Economic yield (kg ha^{-1})/Biological yield (kg ha^{-1})×100

3. Results and Discussion

The results of present study as well as relevant discussion have been summarized under following heads

3.1. Number of root nodules plant^{-1}, nodule fresh and dry weight at flowering

Number of root nodules plant^{-1}, fresh and dry weight of nodules were significantly influenced by different varieties.

Among three varieties, variety PKV-2 (V_3) recorded significantly highest number of root nodules (56.02), nodule fresh weight (2.61 g) and dry weight (0.25 g) which remained at par with variety Kripa (V_2) (Table 1). Significantly, lowest number of root nodules (47.04), nodule fresh (2.17 g) and dry weight (0.20 g) were recorded under variety Virat (V_1). The present findings are in close agreement with those reported by Bavalgave et al. (2009) and Onte et al. (2019b) in chickpea.

Table 1: Root nodule parameters (plant^{-1}) of chickpea cultivars as influenced by spacing and cobalt application methods

Treatment	Nodule count at flowering	Nodule fresh weight (g)	Nodule dry weight (g)
Variety			
V_1-Virat	47.04	2.17	0.20
V_2-Kripa	53.90	2.49	0.23
V_3-PKV2	56.02	2.61	0.25
CD (p=0.05)	3.18	0.15	0.018
Spacing (cm)			
S_1-45×10	51.00	2.36	0.21
S_2-60×10	53.64	2.50	0.23
CD (p=0.05)	2.59	0.12	0.014
Cobalt application method			
C_1-Seed priming at 1 ppm	50.04	2.31	0.22
C_2-Seed treatment at 1 g kg^{-1} seed	52.61	2.43	0.23
C_3-Foliar spray at 0.01%	54.31	2.54	0.25
CD (p=0.05)	3.18	0.15	0.018
Interaction (S×V)			
CD (p=0.05)	NS	NS	NS
Interaction (C×V)			
CD (p=0.05)	NS	NS	NS
Interaction (S×C)			
CD (p=0.05)	NS	NS	NS
Interaction (V×S×C)			
CD (p=0.05)	NS	NS	NS

Similarly, the spacings had a significant effect on the number of root nodules plant^{-1}, fresh and dry weight of nodules. In case of spacing, significantly highest number of nodules plant^{-1} (53.64), nodule fresh (2.50 g) and dry weight (0.23 g) were recorded with spacing 60×10 cm^2 spacing (S_2) and significantly lowest number of root nodules plant^{-1} (51.0), fresh weight (2.36 g) and dry weight (0.21 g) of nodules. Goyal et al. (2010) also observed similar findings in chickpea.

Among three cobalt application methods, foliar spray of cobalt at 0.01% (C_1) had the significant effect on the number of root nodules (54.31), nodule fresh weight (2.54 g) and dry weight (0.25 g) and it remained at par with seed treatment of cobalt at 1.0 g kg^{-1} seed (C_2) (Table 1). The results were in accordance with the findings of Kaur et al. (2011) in groundnut.

3.2. Seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index (%)

The yield attributes and seed yield showed significant response to varieties, spacing and cobalt application methods. Significantly maximum seed yield (1497.07 kg ha^{-1}) (Table 2) and stover yield (2243.87 kg ha^{-1}) were observed with variety PKV-2 and harvest index (40.39) was observed with variety Kripa. These results might be due to the growth and development of PKV-2 was found maximum or due to genetic constituent of this varieties and variety PKV-2 showed higher stover yield might be due to higher plant spread, branches,

Table 2: Seed yield (kg ha^{-1}), stover yield (kg ha^{-1}) and harvest index of chickpea cultivars as influenced by spacing and cobalt application methods

Treatment	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
Variety			
V_1-Virat	1384.26	2053.50	40.18
V_2-Kripa	1421.17	2098.82	40.39
V_3-PKV2	1497.07	2243.87	39.95
CD (p=0.05)	84.50	126.92	-
Spacing (cm)			
S_1-45×10	1593.82	2191.95	42.16
S_2-60×10	1274.51	2072.18	38.14
CD (p=0.05)	68.99	103.62	-
Cobalt application method			
C_1-Seed priming at 1 ppm	1351.23	2045.55	39.76
C_2-Seed treatment at 1 g kg^{-1} seed	1430.77	2101.15	40.47
C_3-Foliar spray at 0.01 %	1520.51	2249.40	40.30
CD (p=0.05)	84.50	126.92	-
Interaction (S×V)			
CD (p=0.05)	119.50	179.49	-
Interaction (C×V)			
CD (p=0.05)	NS	NS	-
Interaction (S×C)			
CD (p=0.05)	119.50	179.49	-
Interaction (V×S×C)			
CD (p=0.05)	NS	NS	-

and dry matter plant^{-1}. The findings are in agreement with Naik et al. (2012) and Onte et al. (2019a) in chickpea.

The crop sown at spacing 45×10 cm^2 (S_1) recorded significantly higher seed yield (1593.82 kg ha^{-1}), stover yield (2191.95 kg ha^{-1}) and harvest index (42.16) of chickpea. Seed and stover yield hectare^{-1} are mainly depending on the plant population hectare^{-1} and the spacing of 45×10 cm^2 has considerably higher plant population hectare^{-1}, which in turn lead to more seed yield hectare^{-1}. These results are in confirmation with those reported by Agajie et al. (2018).

Among three cobalt application methods, the overall better growth performance and higher values of most of the yield attributes under application of cobalt as foliar spray at 0.01% (C_3) ultimately resulted into significantly higher seed yield (1520.51 kg ha^{-1}) and stover yield (2249.40 kg ha^{-1}) of chickpea. Sharma et al. (2018) in chickpea and Sahay et al. (2015) also observed the similar findings in lentil. Better development of various growth parameters such as plant height, number of branches, plant spread and dry matter accumulation under application of cobalt as foliar spray at 0.01% (C_3) ultimately reflected into significantly higher seed and stover yield under this treatment (Table 2). Kaur et al. (2011) reported similar findings in groundnut.

4. Conclusion

Foliar spray of cobalt (0.01%) recorded significantly higher nodule count at flowering, nodule fresh weight (g) and nodule dry weight (g) were observed under variety PKV2 with spacing of 60×10 cm^2. The seed and stover yield (kg ha^{-1}) were significantly higher under PKV2 with foliar spray of cobalt at 0.01% under spacing of 45×10 cm^2. The maximum harvest index was observed under variety Kripa, spacing of 45×10 cm^2 and seed treatment of cobalt at 1 g kg^{-1} seed.

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