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Effect of spacing and cobalt application on nutrient content and uptake in *Kabuli* Chickpea (*Cicer kabulium* L.) cultivars and soil nutrient status after harvest

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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 under South Gujarat condition. The treatments of the study included eighteen treatment combinations consisting of three varieties (V_1- Virat, V_2- Kripa and V_3- PKV2), two spacings (S_1- 45 cm x 10 cm and S_2- 60 cm x 10 cm) 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%). The treatments were evaluated with factorial randomized block design (FRBD) with three replications. For estimation of N, P, K and Co content in grain and stover were determined by Modified Kjeldal's method, Vanadomolybdo phosphoric acid colorimetric method, Flame photometric method and 0.005 M DTPA (AAS) methods respectively. Nutrient content was multiplied by yield to calculate nutrient uptake (kg ha^{-1}). Available N, P, K and Co were determined by alkaline permanganate method, Olsen's method, Flame photometric method and 0.005 M DTPA (AAS) method respectively. Sowing of Kripa variety (V_2) with spacing 60 cm x 10 cm (S_2) and application of cobalt as a foliar spray at 0.01% (C_3) had significant effect on N, P, K and Cobalt content in seed and stover and their uptake except foliar spray at 0.01% (C_3) which remained non-significant. Cultivar PKV2 (V_3) and other two factors had significant effect on available N, P, K and CO in soil after harvest.

Keywords: Modified Kjeldahl's method, 0.005 M DTPA (AAS) method, cobalt, nitrogen uptake

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. Pulses are rich source of minerals like calcium, phosphorus, iron etc. and also certain essential amino acids. Thus, inadequate intake of pulses could lead to serious consequences on human health.

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. India is the largest chickpea producing country accounting for 64% of the global chickpea production. (Gaur *et al*., 2010) [4].

Chickpea is leguminous crop, which 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 (Khan *et al*., 2014) [8]. 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. It is the constituent of cyanocobalamin (Vitamin B_{12}) which is constituent of leghaemoglobin and it is synthesized by the *Rhizobium*. The leghaemoglobin content in the nodules is directly related to nitrogen fixation. 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. It is quite necessary to study the growth and yield of different varieties of *kabuli* type chickpea with different spacing. (Bavalgave *et al*., 2009) [3].

In recent years the developments of early duration varieties of chickpea have enabled its successful cultivation under moisture stress conditions and also increase in grain yield is

possible with the application balanced fertilizers and different spacing. Therefore, the present experiment was chalked out to know the effect of spacing and cobalt application on *kabuli* chickpea cultivars.

2. Material and Methods

A field experiment was conducted during the *rabi* season of the year 2017-18, N. M. College of Agriculture, Navsari Agricultural University, Navsari to study the effect of spacing and Cobalt application on nutrient content and uptake in *kabuli* Chickpea (*Cicer kabulium* L.) cultivars and soil nutrient status after harvest. 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}) and 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 cm x 10 cm and S_2-60 cm x10 cm) and three cobalt application methods (C_1-seed priming at1ppm, C_2-seed treatment at 1g 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 replication. 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 levelled.

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 spacings. 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 cm x 10 cm and 60 cm x 10 cm. 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 chemical studies were conducted.

2.1 Nutrient content (%)

Representative sample from crop was taken separately from each plot, then the samples were oven dried at 60 ºC for 24 hrs, powdered by mechanical grinder and analyzed for estimation of N, P, K and Co content by using following procedures

Table 1: Nutrient analysis methods of plant sample

Particulars	Procedure used	Reference
Nitrogen (%)	Modified Kjeldahl's method	Jackson (1967) [6]
Phosphorus (%)	Vanadomolybdo phosphoric acid colorimetric method	Jackson (1967) [6]
Potash (%)	Flame photometric method	Jackson (1967) [6]
Cobalt (%)	0.005 M DTPA (AAS)	Lindsay and Norvell (1978) [9]

2.2 Nutrient uptake (kg ha^{-1}): The nutrient uptake values of nitrogen (N), phosphorus (P), potassium (K) and Cobalt by *kabuli* chickpea was worked out using the following formula.

$$\text{Uptake of nutrient (kg ha}^{-1}) = \frac{\text{Nutrient content (\%)} \times \text{yield (kg ha}^{-1})}{100}$$

2.3 Nutrient status of soil (kg ha^{-1})

Soil samples were collected from each net plot at 30 cm soil depth. These samples were air-dried, ground and passed through 2 mm sieve, for estimation of available N, P, K and Co in soil after harvest of crop by using the following methods.

Table 2: Nutrient analysis methods of soil sample

Sr. No.	Particulars	Procedure used	Reference
1.	Available Nitrogen	Alkaline potassium permanganate method	Subhiah and Asija (1956) [11]
2.	Available Phosphorus	Olsen's method.	Olsen's method. (Jackson, 1967) [6]
3.	Available Potassium	Flame photometric method	Jackson (1967) [6]
4.	Available Cobalt	0.005 M DTPA (AAS)	Linsday and Norvell (1978) [9]

3. Results and Discussion

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

3.1 Nutrient content (%)

Significantly higher N content in seed and stover (3.37 and 1.46%, respectively), P content in seed and stover (0.59 and 0.30%, respectively), K content in seed and stover (1.38 and 1.68%, respectively) were recorded with variety Kripa (V_2). In case of cobalt, significantly highest cobalt content in seed and stover (1.80 and 1.32 mg kg^{-1}respectively) was recorded with variety Virat (V_1) (Table 3) The results were supported by Ray *et al.*, (2017) [10] and Goyal *et al.*, (2010) [5] in chickpea.

In case of spacing significantly higher N content in seed and stover (3.43 and 1.38%, respectively), P content in seed and stover (0.59, 0.30%, respectively), K content in seed and stover (1.33, 1.64%, respectively) and cobalt content seed and stover and (1.77 and 1.28 mg kg^{-1}, respectively) were recorded with spacing 60 x10 cm (S_2) (Table 3).

Among the three cobalt application method, application of cobalt through foliar spray at 0.01% (C_3) showed significantly highest N content in seed and stover were (3.40 and 1.32%, respectively) (Table 3). Similar findings were also recorded by Kandil (2007) [7] and Atiia *et al.* (2016) [2] in faba bean.

3.2 Nutrient uptake

Significantly highest uptake of nitrogen, phosphorous and

potassium was observed by chickpea seed (48.24, 8.78 and 19.74 kg ha^{-1}, respectively) and total (77.02, 15.51 and 56.04, kg ha^{-1}, respectively) were recorded with variety PKV2 except stover. Whereas cobalt was failed to express its significance on nutrient uptake by seed, stover and total (Table 4).

Higher nitrogen, phosphorous, potassium and cobalt uptake by seed (48.71, 9.02, 19.64 kg ha^{-1} and 2.65 g kg^{-1}, respectively) and total (74.22, 15.29, 53.21 kg ha^{-1} and 5.15 g kg^{-1}, respectively) were recorded with spacing 45 cm x10 cm except stover which recorded higher uptake of N, P, K and Co under spacing 60 cm x 10 cm (28.71, 6.29,34.10 kg ha^{-1} and 2.65 g kg^{-1}, respectively) (Table 4). Results are more or less in accordance with those reported by Abhay and sigh (2013) [1] in chickpea.

Application of cobalt through foliar spray at 0.01% (C_3) showed significantly highest N uptake by seed, stover and total N uptake were (51.26, 29.71 and 80.98 kg ha^{-1}, respectively), and P uptake by seed, stover and total (9.16, 6.98 and 16.15 kg ha^{-1}, respectively) and K uptake by seed, stover and total K uptake were (20.69, 38.83 and 59.52 kg ha^{-1}, respectively) (Table 4).

3.3 Nutrient status of soil after harvest (kg ha^{-1})

Different variety had significant effect on available nutrients *i.e*. residual N, P, K and Co in soil after harvest. Variety PKV2 (V_3) recorded significantly higher amount of available nutrients *i.e*. N, P, K and Co (268.86, 37.95, 441.30 kg ha^{-1} and 0.606 mg kg^{-1}, respectively) and were followed by variety Kripa (V_2) (Table 5). Similar results were obtained by Tagore *et al*., (2013) in chickpea.

Crop sown at 60 x10 cm spacing (S_2) recorded significantly higher amount of available nutrients *i.e*., N, P and K (262.00, 37.69 and 438.16 kg ha^{-1}, respectively) and significantly higher available cobalt (0.595 mg kg^{-1}) was registered with spacing 45 x10 cm(S_1) (Table 5). Results were supported by Abhay and Singh (2013) [1] in chickpea.

Foliar spray of cobalt at 0.01% was registered significantly higher available N, P, K and Co (266.33, 37.54, 440.07 kg ha^{-1} and 0.670 mg kg^{-1}, respectively) and which was followed by seed treatment of cobalt at 1 g kg^{-1} seed (253.53, 36.32, 426.22 kg ha^{-1} and 0.583 mg kg^{-1}, respectively) and lowest with seed priming at 1 ppm (244.53, 34.37, 405.38 kg ha^{-1} and 0.484 mg kg^{-1}, respectively) (Table 5).

Table 3: Nutrient content in seed and stover of chickpea cultivars as influenced by spacing and cobalt application methods

Treatment	Nutrient content in seed (%)			Co (mg kg^{-1})	Nutrient content in stover (%)			Co (mg kg^{-1})
	N	P_2O_5	K_2O		N	P_2O_5	K_2O	
Variety								
V_1 - Virat	3.09	0.55	1.14	1.80	1.07	0.27	1.44	1.32
V_2 -Kripa	3.37	0.59	1.38	1.68	1.46	0.30	1.68	1.20
V_3 - PKV2	3.23	0.58	1.32	1.66	1.28	0.29	1.61	1.12
S.Em±	0.07	0.012	0.03	0.04	0.038	0.007	0.038	0.040
CD at 5%	0.21	0.03	0.08	0.12	0.110	0.020	0.109	0.115
Spacing (cm)								
S_1 – 45x10	3.03	0.56	1.22	1.66	1.15	0.28	1.52	1.14
S_2 – 60x10	3.43	0.59	1.33	1.77	1.38	0.30	1.64	1.28
S.Em±	0.06	0.010	0.02	0.03	0.031	0.006	0.031	0.032
CD at 5%	0.17	0.029	0.07	0.10	0.090	0.017	0.089	0.094
Cobalt application method								
C_1– Seed priming at 1 ppm	3.06	0.56	1.19	1.81	1.18	0.27	1.43	1.32
C_2– Seed treatment at 1g kg^{-1}seed	3.22	0.57	1.28	1.70	1.30	0.29	1.58	1.16
C_3 – Foliar spray at 0.01%	3.40	0.60	1.36	1.64	1.32	0.31	1.72	1.15
S.Em±	0.07	0.012	0.03	0.04	0.038	0.007	0.038	0.040
CD at 5%	0.21	0.03	0.08	0.12	0.110	0.020	0.109	0.115
Interaction (S x V)								
S.Em±	0.10	0.017	0.04	0.06	0.054	0.010	0.053	0.056
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (C x V)								
S.Em±	0.12	0.021	0.05	0.07	0.066	0.013	0.065	0.069
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (S x C)								
S.Em±	0.10	0.017	0.04	0.06	0.054	0.010	0.053	0.056
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (V x S x C)								
S.Em±	0.18	0.030	0.07	0.10	0.094	0.018	0.093	0.098
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
CV %	9.72	9.20	10.34	10.53	12.80	10.87	10.87	13.9

Table 4: Nutrient uptake in seed, stover and total nutrient uptake of chickpea cultivars as influenced by spacing and cobalt application methods

Treatment	Nutrient uptake in seed (kg ha^{-1})			Co (g ha^{-1})	Nutrient uptake in stover (kg ha^{-1})			Co (g ha^{-1})	Total nutrient uptake (kg ha^{-1})			Co (g ha^{-1})
	N	P_2O_5	K_2O		N	P_2O_5	K_2O		N	P_2O_5	K_2O	
Variety												
V_1 – Virat	42.46	7.63	15.78	2.49	22.01	5.66	29.83	2.71	64.48	13.30	45.62	5.21
V_2 – Kripa	47.96	8.49	19.55	2.39	30.60	6.44	35.38	2.52	78.56	14.91	54.93	4.91
V_3 – PKV2	48.24	8.78	19.74	2.47	28.78	6.73	36.30	2.50	77.02	15.51	56.04	4.97
S.Em±	1.43	0.26	0.48	0.076	1.02	0.22	1.06	0.09	2.08	0.39	1.29	0.13

CD at 5%	4.13	0.77	1.40	NS	2.95	0.64	3.07	NS	5.98	1.12	3.72	NS
Spacing (cm)												
S_1 – 45x10	48.71	9.02	19.64	2.65	25.51	6.26	33.57	2.50	74.22	15.29	53.21	5.15
S_2 – 60x10	43.73	7.58	17.07	2.25	28.71	6.29	34.10	2.65	72.48	13.87	51.86	4.91
S.Em±	1.17	0.21	0.39	0.062	0.83	0.18	0.87	0.074	1.69	0.31	1.05	0.11
CD at 5%	3.37	0.63	1.14	0.180	2.40	NS	NS	NS	NS	0.91	NS	NS
Cobalt application method												
C_1– Seed priming at 1ppm	41.38	7.58	16.13	2.43	24.31	5.66	29.37	2.71	65.69	13.24	45.51	5.14
C_2– Seed treatment at 1g kg^{-1}seed	46.02	8.16	18.25	2.42	27.36	6.19	33.30	2.44	73.39	14.35	51.56	4.87
C_3 – Foliar spray at 0.01%	51.26	9.16	20.69	2.49	29.71	6.98	38.83	2.58	80.98	16.15	59.52	5.08
S.Em±	1.43	0.26	0.48	0.076	1.02	0.22	1.06	0.09	2.08	0.39	1.29	0.13
CD at 5%	4.13	0.77	1.40	NS	2.95	0.64	3.07	NS	5.98	1.12	3.72	NS
Interaction (S x V)												
S.Em±	2.03	0.38	0.68	0.108	1.42	0.31	1.51	0.12	2.94	0.55	1.83	0.19
CD at 5%	5.85	NS	1.98	NS	NS	NS	NS	NS	8.46	NS	5.26	0.55
Interaction (C x V)												
S.Em±	2.49	0.46	0.84	0.133	1.77	0.38	1.85	0.15	3.6	0.67	2.24	0.23
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Interaction (S x C)												
S.Em±	2.03	0.38	0.68	0.108	1.45	0.31	1.51	0.12	2.9	0.55	1.83	0.19
CD at 5%	NS	NS	NS	0.31	NS	NS	NS	NS	NS		NS	0.55
Interaction (V x S x C)												
S.Em±	3.52	0.65	1.19	0.188	2.51	0.54	2.61	0.22	5.09	0.95	3.17	0.33
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV %	13.21	13.74	11.205	13.28	16.05	15.07	13.40	14.98	12.04	11.38	10.52	11.55

Table 5: Available nutrient in soil as influenced by spacing and cobalt application methods in chickpea cultivars

Treatment	Available nutrient (kg ha^{-1})			Co (mg kg^{1})
	N	P_2O_5	K_2O	
Variety				
V_1 -Virat	238.85	34.23	405.43	0.558
V_2 -Kripa	256.67	36.05	424.94	0.573
V_3 - PKV2	268.86	37.95	441.30	0.606
S.Em±	5.97	0.86	9.52	0.013
CD at 5%	17.16	2.48	27.38	0.037
Spacing (cm)				
S_1 – 45x10	247.59	34.46	409.62	0.595
S_2 – 60x10	262.00	37.69	438.16	0.563
S.Em±	4.87	0.70	7.77	0.010
CD at 5%	14.01	2.028	22.35	0.030
Cobalt application method				
C_1–Seed priming at 1ppm	244.53	34.37	405.38	0.484
C_2–Seed treatment at1g kg^{-1}seed	253.53	36.32	426.22	0.583
C_3–Foliar spray at 0.01%	266.33	37.54	440.07	0.670
S.Em±	5.97	0.86	9.52	0.013
CD at 5%	17.16	2.48	27.38	0.037
Interaction (S x V)				
S.Em±	8.44	1.22	13.47	0.018
CD at 5%	NS	NS	NS	NS
Interaction (C x V)				
S.Em±	10.34	1.49	16.50	0.022
CD at 5%	NS	NS	NS	NS
Interaction (S x C)				
S.Em±	8.44	1.22	13.47	0.018
CD at 5%	NS	NS	NS	NS
Interaction (V x S x C)				
S.Em±	14.62	2.11	23.33	0.032
CD at 5%	NS	NS	NS	NS
CV%	9.94	10.16	9.53	9.594
Initial valve	221.32	28.89	441.3	0.450

4. Conclusion

Remarkable increase in nitrogen, phosphorus and potassium content in seed and stover were observed under Kripa variety of *Kabuli* chickpea under 60 cm x 10 cm spacing with foliar application of cobalt at 0.01%. Significantly higher nutrient uptake was obtained under variety PKV2 with spacing of 45cm x 10 cm and foliar application of cobalt at 0.01%. Significantly higher cobalt content (1.80 mg kg^{-1}) and uptake (2.49 g ha^{-1}) were obtained under Virat variety of *Kabuli* chickpea. Significantly higher N, P_2O_5, K_2O and Co were

observed under PKV2 variety with foliar application of cobalt under spacing of 60 cm x 10 cm.

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