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INFLUENCE OF SPACING AND NUTRITION ON POD CHARACTERS IN PROMISING VARIETIES OF CLUSTER BEAN UNDER MAHANANDI CONDITIONS

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Abstract

The effect of planting geometry and nutrition on growth and flowering of seed guar cultivars *viz*., HG 365 and HG 563 was analysed under Mahanandi conditions. The pod characteristics like number of clusters per plant, number of pods per plant, pod width(cm), dry pod yieldper plant(g) were recorded significantly the highest values in the variety HG 365 planted at the spacing of 30 cm × 20 cm and applied with the fertilizer dose of 45N: 60P: 60K: 30S kg per ha.

Key words : Guar, flowering, pod initiation.

Introduction

Cluster bean is botanically called as *Cyamopsis tetragonoloba* (L.) Taub. It belongs to the family Leguminaceae. The crop is popularly known as guar referring to its seed. The crop is renowned as drought hardy, being deep rooted and having a low water requirement. Guar tolerates high temperature and dry conditions, thus gaining popularity in arid and semi arid climates (Undersander *et al*., 2006). However, the best spacing for seed cluster bean has not been standardized yet and therefore, it is proposed to include the factor of planting geometry levels during the designing of treatments in the present study. Further, in order to realize maximum seed yield, proper dose of nutrients is to be standardized.

Material and Methods

The experiment was conducted in factorial randomized design with three factors *viz*., varieties (2), planting geometry levels (3) and nutritional levels (3) replicated thrice. The plot was laid out at Horticultural Research Station, Mahanandi, Kurnool district of Andhra Pradesh during both *kharif* and *rabi* seasons of the years 2014-15 and 2015-16. The data obtained from both the years was pooled and presented in the tables.

Results and Discussion

Number of clusters per plant

Significant differences were observed in the number of clusters per plant (table 1) due to variety, planting geometry, nutritional combinations and their interactions. Among the varieties HG 365 recorded the highest number of clusters per plant both in *kharif* (21.58) and *rabi* seasons (19.21) at 90 DAS. Planting geometry of 30 cm × 20 cm (S_2) recorded significantly the highest number of clusters per plant (*kharif* 23.12; *rabi* 20.58) followed by 40 cm × 10 cm (S_3) (*kharif* 19.60; *rabi* 17.45). Application of 45N: 60P: 60K: 30S kg per ha (F_3) recorded the highest number of clusters per plant (*kharif* 21.70; *rabi* 19.31) which was on par with 30N: 40P: 40K: 20S kg per ha (F_2) (*kharif* 20.49; *rabi* 18.23).

Number of pods per plant

Significant differences were observed in the number of pods per plant (table 2) due to variety, planting geometry, nutritional combinations and their interactions. The var. HG 365 recorded the highest number of pods per plant both in *kharif* (115.40) and *rabi* seasons (109.63) at 90 DAS. Planting geometry of 30 cm × 20 cm (S_2) recorded significantly the highest number of pods per plant (*kharif*: 119.25; *rabi*: 113.28) followed by 40 cm × 10 cm (S_3) (*kharif*: 98.58; *rabi*: 93.65). Application of 45N: 60P: 60K: 30S kg per ha (F_3) recorded the highest

Table 1 : Number of clusters per plant as influenced by variety, planting geometry and nutritional combination during *kharif* & *rabi* (pooled data of 2014-15 & 2015-16).

Planting Geometry (B)	Nutritional Combination (C)	Variety (A)					
		Kharif			*Rabi*		
		HG 365	HG 563	*Mean*	HG 365	HG 563	*Mean*
S_1 (30 cm × 10 cm) (33.3 plants per m^2)	F_1 (15N:20P:20K:10S)	15.85	13.47	***14.66***	14.10	11.99	***13.05***
	F_2 (30N:40P:40K:20S)	19.48	16.56	***18.02***	17.34	14.74	***16.04***
	F_3 (45N:60P:60K:30S)	20.34	17.29	***18.81***	18.10	15.38	***16.74***
	Mean	***18.55***	***15.77***	***17.16***	***16.51***	***14.04***	***15.27***
S_2 (30 cm × 20 cm) (16.7 plants per m^2)	F_1 (15N:20P:20K:10S)	21.91	18.63	***20.27***	19.50	16.58	***18.04***
	F_2 (30N:40P:40K:20S)	25.32	21.52	***23.42***	22.53	19.15	***20.84***
	F_3 (45N:60P:60K:30S)	27.75	23.59	***25.67***	24.70	20.99	***22.85***
	Mean	***24.99***	***21.24***	***23.12***	***22.24***	***18.91***	***20.58***
S_3 (40 cm × 10 cm) (25 plants per m^2)	F_1 (15N:20P:20K:10S)	19.66	16.71	***18.18***	17.49	14.87	***16.18***
	F_2 (30N:40P:40K:20S)	21.64	18.40	***20.02***	19.26	16.37	***17.82***
	F_3 (45N:60P:60K:30S)	22.28	18.93	***20.61***	19.83	16.85	***18.34***
	Mean	***21.19***	***18.01***	***19.60***	***18.86***	***16.03***	***17.45***
For Comparing varieties (A) and Nutritional combinations (C)							
F_1 (15N:20P:20K:10S)		19.14	16.27	***17.70***	17.03	14.48	***15.76***
F_2 (30N:40P:40K:20S)		22.15	18.82	***20.49***	19.71	16.75	***18.23***
F_3 (45N:60P:60K:30S)		23.45	19.94	***21.70***	20.87	17.74	***19.31***
Mean		***21.58***	***18.34***	***19.96***	***19.21***	***16.33***	***17.77***

Factor	*S Em±* (Kharif)	*CD* (Kharif)	*S Em±* (Rabi)	*CD* (Rabi)
Variety (A)	***0.46***	***1.33***	***0.41***	***1.18***
Ptg. Geom. (B)	***0.60***	***1.73***	***0.53***	***1.54***
Nutril. Combn.(C)	***0.51***	***1.48***	***0.46***	***1.32***
A × B	-	***NS***	***0.89***	***2.59***
B × C	***1.06***	***3.06***	***0.94***	***2.72***
A × C	***0.92***	***2.67***	***0.82***	***2.37***
A × B × C	***1.49***	***4.32***	-	***NS***

CD: CD at 5% level of significance

number of pods per plant (*kharif* 116.44; *rabi* 110.62), which was on par with 30N: 40P: 40K: 20S kg per ha (F_2) (*kharif* 103.63; *rabi* 98.45). With regard to the interactions, the combinations of planting geometry and nutritional level along with variety and nutritional level were tested significant both during *kharif* and *rabi* seasons, whereas, the three way interaction between variety + planting geometry + nutritional level was significant during *rabi* only. Among two way interactions, the highest number of pods per plant was recorded by the combination of planting geometry of 30 cm × 20 cm plus application of 45N: 60P: 60K: 30S kg per ha (*kharif* 141.41; *rabi* 134.34) and that of HG 365 + 45N: 60P: 60K: 30S kg per ha (*kharif* 116.44; *rabi* 110.62). In both the cases, the parity was noticed with the moderate nutritional dose of 30N: 40P: 40K: 20S kg per ha.

The numbers of clusters per plant, pods per cluster and pods per plant exhibited significant variations due to variety, planting geometry and nutritional combinations as well as their interactions. The highest number of clusters with more pods was produced from the variety HG 365 as compared to HG 563 which may be attributed to its genotypic potential. It is also due to contribution from an extended duration of time taken from flowering to pod drying on the plants. Plants spaced widely (at 30 cm × 20 cm) were having a greater amount of space, light and little competition from neighbouring plants and as a result they were late to initiate flowering and took a lot of time for completion of flowering phase and also vested with greater amount of time to translocate their photosynthates into reproductive parts or clusters which might be the reason for good growth of individual clusters and bearing more number of pods in them. Among the

Table 2 : Number of pods per plant as influenced by variety, planting geometry and nutritional combination during *kharif* & *rabi* (pooled data of 2014-15 & 2015-16).

Planting Geometry (B)	Nutritional Combination (C)	Variety (A)					
		Kharif			*Rabi*		
		HG 365	HG 563	*Mean*	HG 365	HG 563	*Mean*
S_1 (30 cm × 10 cm) (33.3 plants per m^2)	F_1 (15N:20P:20K:10S)	69.98	50.56	***60.27***	66.48	48.03	***57.26***
	F_2 (30N:40P:40K:S20)	98.47	71.14	***84.80***	93.54	67.58	***80.56***
	F_3 (45N:60P:60K:30S)	111.38	80.47	***95.93***	105.81	76.45	***91.13***
	Mean	***93.28***	***67.39***	***80.33***	***88.61***	***64.02***	***76.32***
S_2 (30 cm × 20 cm) (16.7 plants per m^2)	F_1 (15N:20P:20K:10S)	107.58	77.72	***92.65***	102.20	73.84	***88.02***
	F_2 (30N:40P:40K:S20)	143.60	103.75	***123.68***	136.42	98.56	***117.49***
	F_3 (45N:60P:60K:30S)	164.19	118.63	***141.41***	155.98	112.70	***134.34***
	Mean	***138.46***	***100.03***	***119.25***	***131.53***	***95.03***	***113.28***
S_3 (40 cm × 10 cm) (25 plants per m^2)	F_1 (15N:20P:20K:10S)	94.47	68.25	***81.36***	89.74	64.84	***77.29***
	F_2 (30N:40P:40K:S20)	118.90	85.90	***102.40***	112.95	81.61	***97.28***
	F_3 (45N:60P:60K:30S)	130.02	93.94	***111.98***	123.52	89.25	***106.38***
	Mean	***114.46***	***82.70***	***98.58***	***108.74***	***78.56***	***93.65***
For Comparing varieties (A) and Nutritional combinations (C)							
F_1 (15N:20P:20K:10S)		90.68	65.51	***78.09***	86.14	62.24	***74.19***
F_2 (30N:40P:40K:S20)		120.32	86.93	***103.63***	114.31	82.59	***98.45***
F_3 (45N:60P:60K:30S)		135.20	97.68	***116.44***	128.44	92.80	***110.62***
Mean		***115.40***	***83.38***	***99.39***	***109.63***	***79.21***	***94.42***

Factor	*S Em±*	*CD*	*S Em±*	*CD*
Variety (A)	***4.53***	***13.12***	***4.30***	***12.46***
Ptg. Geom. (B)	***3.89***	***11.28***	***3.70***	***10.72***
Nutril. Combn.(C)	***4.88***	***14.14***	***4.64***	***13.43***
A × B	-	***NS***	-	***NS***
B × C	***8.34***	***24.15***	***7.92***	***22.94***
A × C	***8.94***	***25.89***	***8.49***	***24.60***
A × B × C	-	***NS***	***12.01***	***34.78***

CD: CD at 5% level of significance.

nutritional combinations, the highest dose of NPK and S at 45N: 60P: 60K: 30S showed the best result with greatest number of clusters bearing number of pods in huge numbers as compared to the lowest dose *i.e.* 15N: 20P: 20K: 10S but was on par with next highest level *i.e.* 30N: 40P: 40K: 20S. The reasons mentioned above may also hold good in the case of nutrient dose since, the greatest nutrient dose influenced the plants to extend their flowering period and enlarged the duration of reproductive phase significantly over the smallest nutrient dose, however, remained at parity with the moderate nutrient dose of 30N: 40P: 40K: 20S. This is evident from the data on days taken for various phases of flowering. Non-significant increase in cluster number and pod number with additional nutrient dose might be due to the corresponding non- significant increase in majority of vegetative parameters and the duration of reproductive phase etc.

The number of clusters per pod and number of pods per cluster significantly varied among the interactions. At a particular population density, the differences between highest (45N: 60P: 60K: 30S) and medium (30N: 40P: 40K: 20S) doses were found to be non-significant. On the contrary, it is interesting to note that the highest nutrient dose of thickest population at 30 cm × 10 cm exhibited parity with the medium nutrient dose in the next lower population density at the spacing of 40 cm × 10 cm. The same was also true in case of the other two planting geometry levels. Therefore, it is inferred that by increasing population along with additional nutrient dose per plant, numbers of clusters and pods could be maintained on par with those produced from a lower population level. This might be due to the reason that the additional nutrient quantities might be useful for increasing the per plant values when the number of plants per unit area happened to be more.

Similar observations were made by Selvaraj and Prasanna (2012), who studied yield attributes *viz*., number of clusters per plant, number of pods per cluster, number of pods per plant, pod length, number of seeds per pod and thousand seed weight were at highest with increased nitrogen level, while they were at their lowest with other lower levels. Higher dry matter production and the efficient translocation of accumulated assimilates to the reproductive parts under comfortable nitrogen nutrition was ascribed to be responsible for the beneficial effect on elevating the stature of all the yield attributes in cluster bean.

Pod width (cm)

The data on pod width (table 3) revealed that there were significant differences due to variety, planting geometry, nutritional combinations and some of their interactions. Among the varieties HG 365 recorded the highest pod width both in *kharif* (1.21 cm) and *rabi* seasons (1.08 cm). Planting geometry of 30 cm × 20 cm (S_2) recorded significantly highest pod width (*kharif* 1.16 cm; *rabi* 1.04 cm) which was on par with 40 cm × 10 cm (S_3) (*kharif* 1.14 cm; *rabi* 1.01 cm). Application of 45N: 60P: 60K: 30S kg per ha (F_3) recorded the highest pod width (*kharif* 1.22 cm; *rabi* 1.08 cm) followed by 30N: 40P: 40K: 20S kg per ha (F_2) (*kharif* 1.14 cm; *rabi* 1.02 cm).

Dry pod yield per plant (g)

Significant differences were observed in the weight of dry pods per plant (table 4) due to variety, planting geometry, nutritional combinations and their interactions. Among the varieties HG 365 recorded the highest weight of dry pods per plant both in *kharif* (27.45 g) and *rabi* seasons (24.43 g) at final harvest. Planting geometry of 30 cm × 20 cm (S_2) recorded significantly the highest weight of dry pods per plant (*kharif*: 26.40 g; *rabi*: 23.49 g) followed by 40 cm × 10 cm (S_3) (*kharif* 25.83 g; *rabi* 22.99 g). Application of 45N: 60P: 60K: 30S kg per ha (F_3) recorded the highest weight of dry pods per plant (*kharif 31*.52 g; *rabi 28*.05 g) followed by 30N: 40P: 40K: 20S kg per ha (F_2) (*kharif 26.56* g; *rabi* 23.64 g). The pod yield is the most important parameter contributing to the seed yield because the only difference lies in pericarps encircling the seeds. The effect of variety, planting geometry and nutritional combination was found significant on the pod yield per plant and per plot. As it is observed in case of growth and flowering parameters, the pod yield was found to be highest in case of HG 365 compared to HG 563 establishing the superiority of the genotype. Owing to great variations in population densities, the weight of pods per individual plant was found to be maximum at the lowest population density at the spacing of 30 cm × 20 cm as compared to other planting geometry levels. This merit is also revealed from the stand point of corresponding superiority of lowest population density in having the highest duration of pod maturity and bold sized pods and seeds ultimately leading to the highest individual weight of pods per plant at the widest spacing. Each plant is vested with a great amount of space, light and nutrients at wider spacing compared to closer orientation. The difference between 30 cm × 20 cm and 40 cm × 10 cm was not found significant in terms of pod yield per plant, however, there was significant difference between these two levels of planting geometry or population density with respect to per plot yield of pods. This may be due to the fact that even though an individual plant yielded more at wider spacing, due to less number of plants per unit area, the net yield per unit area might had worked out to be lower compared to the case where there were more number of plants per unit area yielding lesser weight of pods per plant. The marginal increase on per plant yield by reducing population did not compensate the marginal increase with elevated population levels per unit area.

Nutrition with the highest fertiliser dose made significant difference at all the population levels as compared to the lowest fertiliser dose. However, the difference between the doses at 45N: 60P: 60K: 30S and 30N: 40P: 40K: 20S was not found significant at any population level. The additional dose of nutrients beyond the medium level resulted in a non-significant increase in the weight of dry pods per plant as well as per plot. The highest population density supplied with highest nutritional dose showed the weight of pods per plant on par with moderate population density supplied with medium level of nutrients. With every increase in population density, supply of additional dose of nutrients was found to be beneficial up to the level of 30N: 40P: 40K: 20S. A higher population level at 30 cm × 10 cm was found to exhibit parity with lower population level at 40 cm × 20 cm when supplied with the highest nutritional dose of 45N: 60P: 60K: 30S while the later was receiving moderate nutritional level of 30N: 40P: 40K: 20S. This was also found to be true between the population levels maintained at 40 cm × 20 cm and 30 cm × 20 cm. It is leading to a point that a marginal increase in nutritional level was found beneficial with increased population but not so at the same level of population.

The trend in individual plant yield of pods in respect of planting geometry overturned when it comes to per

Table 3 : Pod width (cm) as influenced by variety, planting geometry and nutritional combination during *kharif* & *rabi* (pooled data of 2014-15 & 2015-16).

Planting Geometry (B)	Nutritional Combination (C)	Variety (A)					
		Kharif			*Rabi*		
		HG 365	HG 563	*Mean*	HG 365	HG 563	*Mean*
S_1 (30 cm × 10 cm) (33.3 plants per m²)	F_1 (15N:20P:20K:10S)	1.01	0.86	***0.94***	0.90	0.76	***0.83***
	F_2 (30N:40P:40K:20S)	1.16	0.98	***1.07***	1.03	0.88	***0.95***
	F_3 (45N:60P:60K:30S)	1.25	1.07	***1.16***	1.12	0.95	***1.03***
	Mean	***1.14***	***0.97***	***1.06***	***1.02***	***0.86***	***0.94***
S_2 (30 cm × 20 cm) (16.7 plants per m²)	F_1 (15N:20P:20K:10S)	1.12	0.96	***1.04***	1.00	0.85	***0.93***
	F_2 (30N:40P:40K:20S)	1.30	1.10	***1.20***	1.16	0.98	***1.07***
	F_3 (45N:60P:60K:30S)	1.35	1.15	***1.25***	1.21	1.02	***1.11***
	Mean	***1.26***	***1.07***	***1.16***	***1.12***	***0.95***	***1.04***
S_3 (40 cm × 10 cm) (25 plants per m²)	F_1 (15N:20P:20K:10S)	1.10	0.94	***1.02***	0.98	0.83	***0.91***
	F_2 (30N:40P:40K:20S)	1.26	1.07	***1.16***	1.12	0.95	***1.04***
	F_3 (45N:60P:60K:30S)	1.34	1.14	***1.24***	1.19	1.01	***1.10***
	Mean	***1.23***	***1.05***	***1.14***	***1.10***	***0.93***	***1.01***
For Comparing varieties (A) and Nutritional combinations (C)							
F_1 (15N:20P:20K:10S)		1.08	0.92	***1.00***	0.96	0.82	***0.89***
F_2 (30N:40P:40K:20S)		1.24	1.05	***1.14***	1.10	0.94	***1.02***
F_3 (45N:60P:60K:30S)		1.31	1.12	***1.22***	1.17	0.99	***1.08***
Mean		***1.21***	***1.03***	***1.12***	***1.08***	***0.92***	***1.00***

Factor	*S Em±* (Kharif)	*CD* (Kharif)	*S Em±* (Rabi)	*CD* (Rabi)
Variety (A)	***0.03***	***0.07***	***0.02***	***0.07***
Ptg. Geom. (B)	***0.01***	***0.03***	***0.01***	***0.03***
Nutril. Combn.(C)	***0.02***	***0.06***	***0.02***	***0.06***
A × B	-	***NS***	-	***NS***
B × C	***0.03***	***0.09***	***0.03***	***0.08***
A × C	***0.05***	***0.13***	***0.04***	***0.12***
A × B × C	-	***NS***	-	***NS***

CD: CD at 5% level of significance.

plot yield of pods. As mentioned earlier, this is only due to more number of plants though yielded relatively lesser pods per plant, could contribute to a higher gross figures per unit area or per plot. However, an examination of interactions between planting geometry and nutritional level at per plot level revealed that enhanced nutrient dose boosted the yield significantly from the lowest level 15N: 20P: 20K: 10S to medium level 30N: 40P: 40K: 20S; further increase being non-significant at a particular planting geometry level. On the contrary, the increase in the nutritional level was found significant when a lower population density was compared to a higher population density *i.e.* in other words, plants at higher population level spaced at 30 cm × 10 cm supplied with the highest nutritional dose of 45N: 60P: 60K: 30S were found to be on par with lower population level at 40 cm × 20 cm supplied with a moderate nutrient level of 30N:40P:40K:20S kg per ha. However, widely spaced plants with the highest nutritional dose were significantly superior to closely spaced plants supplied with the same dose. The same fact can also be extorted from the observations on pod yield between the population densities available at the planting geometry levels of 40 cm × 20 cm and 30 cm × 20 cm.

Significant variations in the number of pods per plant with row spacing were also observed by Abid *et al.* (1988). At very high plant density there was lesser number of pods per plant which was attributed to hard competition for nutrient elements, soil moisture and light among the plants, which could have retarded the growth and development of pods.

The lesser number of pods plant^{-1} at 60 cm row

Table 4 : Dry pod yield per plant (g) as influenced by variety, planting geometry and nutritional combination during *kharif* & *rabi* (pooled data of 2014-15 & 2015-16).

Planting Geometry (B)	Nutritional Combination (C)	Variety (A)					
		Kharif			*Rabi*		
		HG 365	HG 563	*Mean*	HG 365	HG 563	*Mean*
S_1 (30 cm × 10 cm) (33.3 plants per m^2)	F_1 (15N:20P:20K:10S)	18.34	15.59	***16.97***	16.32	13.88	***15.10***
	F_2 (30N:40P:40K:S20)	26.85	22.82	***24.83***	23.89	20.31	***22.10***
	F_3 (45N:60P:60K:30S)	32.49	27.62	***30.06***	28.92	24.58	***26.75***
	Mean	***25.89***	***22.01***	***23.95***	***23.05***	***19.59***	***21.32***
S_2 (30 cm × 20 cm) (16.7 plants per m^2)	F_1 (15N:20P:20K:10S)	20.39	17.33	***18.86***	18.15	15.43	***16.79***
	F_2 (30N:40P:40K:S20)	30.12	25.60	***27.86***	26.81	22.79	***24.80***
	F_3 (45N:60P:60K:30S)	35.10	29.84	***32.47***	31.24	26.56	***28.90***
	Mean	***28.54***	***24.26***	***26.40***	***25.40***	***21.59***	***23.49***
S_3 (40 cm × 10 cm) (25 plants per m^2)	F_1 (15N:20P:20K:10S)	19.96	16.97	***18.46***	17.76	15.10	***16.43***
	F_2 (30N:40P:40K:S20)	29.17	24.80	***26.98***	25.96	22.07	***24.02***
	F_3 (45N:60P:60K:30S)	34.63	29.44	***32.03***	30.82	26.20	***28.51***
	Mean	***27.92***	***23.73***	***25.83***	***24.85***	***21.12***	***22.99***
For Comparing varieties (A) and Nutritional combinations (C)							
F_1 (15N:20P:20K:10S)		19.56	16.63	***18.10***	17.41	14.80	***16.11***
F_2 (30N:40P:40K:S20)		28.71	24.41	***26.56***	25.55	21.72	***23.64***
F_3 (45N:60P:60K:30S)		34.08	28.97	***31.52***	30.33	25.78	***28.05***
Mean		***27.45***	***23.33***	***25.39***	***24.43***	***20.77***	***22.60***

Factor	*S Em±*	*CD*	*S Em±*	*CD*
Variety (A)	***0.58***	***1.69***	***0.49***	***1.52***
Ptg. Geom. (B)	***0.33***	***0.93***	***0.31***	***0.88***
Nutril. Combn.(C)	***1.36***	***4.09***	***1.27***	***3.83***
A × B	-	*NS*	-	*NS*
B × C	***1.45***	***4.15***	***1.38***	***4.07***
A × C	***1.95***	***5.78***	-	*NS*
A × B × C	-	*NS*	-	*NS*

CD: CD at 5% level of significance.

spacing compared to still wider spacings was attributed due to high plant density per unit area (Reddy and Reddy, 2011). Akhtar *et al.* (2012) noticed maximum number of pods per plant (107) at wider row spacing compared to closer orientation. Gireesh and Malabasari (2014) observed an increase in seed yield was due to corresponding increase in pod yield and its components with higher nutrient doses and quoted that it might be due to the enhanced photosynthetic activity, accumulation and translocation of assimilates from source to sink resulting in heavier and bolder seeds. These results are in agreement with those of Amaregouda (2000) in pea and Malik *et al.* (2003) in green gram. Pod and seed yield parameters such as pod yield per plant, seed yield per plant, seed yield per plot, seed yield per ha showed significant variations due to different picking stages across various planting densities and row spacings. The present findings are in agreement with the findings of Mehta *et al.* (1993) and Khatun *et al.* (2010) in chick pea.

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