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EFFECT OF CROP GEOMETRIES ON YIELD COMPONENT, QUALITY AND ECONOMICS OF CLUSTER BEAN (*CYAMOPSIS TETRAGONOLOBA* L.) VARIETIES IN SUMMER SEASON

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SUMMARY

A field experiment was conducted at Dryland Research Area, CCS Haryana Agricultural University, Hisar (Haryana), India during summer 2016. Cluster bean varieties RGC 1055, HG 2-20, RGC 1066 and NBPGR 120 were grown in three crop geometries (22.5 cm × 10 cm, 30.0 cm × 10 cm and 45.0 cm × 10 cm) with factorial randomized block design (RBD) in three replicates to find out the suitable variety and crop geometry for summer season. The inter-row spacing's were 22.5, 30.0 and 45.0 cm but the intra-row spacing was kept 10 cm. Among different varieties, highest seed and straw yield (573.2 and 1920.1 q/ha, respectively) were recorded in the single stem variety RGC 1066 which were on a par with branched variety HG 2-20. Maximum harvest index (0.23) was noticed in HG 2-20 and the same value was also with RGC 1066. Maximum B : C ratio (1.27) was fetched in the single stemmed variety RGC 1066 followed by branched variety HG 2-20. Significantly highest gum content (32.38%) was estimated in HG 2-20. Among different crop geometries, highest seed and biological yield (473.9, 2318.9 kg/ha, respectively) were recorded at 45.0 cm × 10 cm which was on a par with 30.0 cm × 10 cm but significantly superior over 22.5 cm × 10 cm. Highest gum content (32.38%) was estimated with 45.0 cm × 10 cm, which was on a par with 30.0 cm × 10 cm. Maximum B : C ratio (1.09) was fetched with the crop geometry 45.0×10 cm. Significant interaction was observed between variety and crop geometry for seed, straw, biological yield, crude protein and gum content.

Key Words : Cluster bean, crop geometry, seed yield, crude protein, gum and carbohydrate content

Cluster bean (*Cyamopsis tetragonoloba* L.) belonging to family Fabaceae is an important rainy season crop which is popularly known as Guar. Its roots are deep and well developed, mainly cultivated as rainfed crop in arid and semi arid regions during rainy season and is suitable for light to medium textured soils, with no water logging. Cluster bean crop thrives well in rainfall range of 250-450 mm with 3-4 spells, temperature range of 25-40°C, relative humidity values of 50-65%, and longer warmer days with 8-9 hours sun shine, particularly at maturity (Kumar, 2014).

Cluster bean is a multipurpose arid legume grown for seed, vegetable, green fodder and green manuring. It is an important commercial crop also, as its seeds are the source of high quality galactomannan gum and its guar meal is rich in protein (40-45%) which is used as animal feed (Panchta *et. al.*, 2016). Its gum is used as an emollient, softening or thickening agent, flocculent and stabilizer. This gum can also be used in hydraulic fracturing and a wide range of other industries such as production of cosmetics, paper, textiles, detergents and food products (Gresta *et al.*, 2014). India is the major producer of the guar gum in the world, enabling its exports to more than 65 countries. India is also the major exporter of guar gum to the world; it exports other forms of Guar products to a large number of countries. The country has exported 4,23,285.66 MT of guar gum to the world for the worth of Rs. 3,131.74 crores during the year 2016-17 (Anonymous, 2018). Top five export destinations during 2016-17 were United States of America, Norway, China P RP, Russia and Germany.

Cluster bean is generally cultivated as rainy season (*kharif*) crop in Haryana but it can be grown during summer season if one pre sowing and one life

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saving irrigation are available. To convert this idea into an economic advantage for the farming community, varieties with earliness, better adaptability, resistance to drought, photo and thermo insensitivity with efficient root system and nodulation will be the pre requisite. The selection of the varieties depends on its earliness, as the crop has to mature and to be harvested before the onset of monsoon. (Panchta *et. al*., 2017). In addition, the branching pattern of cluster bean varieties varies with plant geometry and in turn optimum plant population achieved through optimum crop geometry has influence on seed yield of cluster bean. The objective of the experiment was to find out suitable variety and crop geometry for summer season.

MATERIALS AND METHODS

The field experiment was conducted during summer 2016 at Dry Land Research Farm, CCS Haryana Agricultural University, Hisar, (Haryana, India) (29° 10' N of 75° 46' E, at an average elevation of 215.2 m above mean sea level). The site experiences semi-arid and sub-tropical climate with hot dry summer and severe cold winter. Average annual rainfall was about 450 mm, 75 % of which is received in three months (July to September) during the south-west monsoon. Fig. 1 represents the weekly weather parameters *i.e.* temperature (^{o}C), relative humidity (%) and rainfall (mm) during the study. The soil of the experimental field was loamy sand in texture, slightly alkaline in reaction (pH 7.4), low in available nitrogen (133.6 kg/ha), medium in available phosphorus (10.0 kg/ha) and low in potassium (205.0 kg/ha). Among the varieties under study, there were two branched (RGC 1055 and HG 2-20) and two single stem varieties (RGC 1066 and NBPGR 120). The experiment consisted of 12 treatment combinations comprising of four guar varieties (RGC 1055, HG 2-20, RGC 1066 and NBPGR 120) and three crop geometries (22.5 cm × 10 cm, 30.0 cm × 10 cm and 45.0 cm × 10 cm). These treatments were tested in factorial randomized block design with three replications. As per treatment, full dose of phosphorus and nitrogen was applied at the time of sowing. Diammonium phosphate (DAP) and urea fertilizers were used as a source of P_2O_5 and N nutrients, respectively. The varieties were sown manually on 27 February 2016. All the other standard agronomic practices were followed uniformly in all the treatments as per the package of practices for *kharif* crops of CCS Haryana Agricultural University, Hisar, India (Anonymous, 2013). Harvest index was calculated by dividing economic yield (seed yield in kg) by biological yield (kg). Crude protein, gum and carbohydrate content were estimated in dried and grinded samples (2 mm sieve size) of seed. The crude protein content was estimated by micro-Kjeldal method (AOAC, 1995). Gum content was estimated by the method of Das *et al*., 1977, modified by Joshi, 2004 and carbohydrates were estimated by method of Dubois et al., 1956. Economics was worked out based on the prevailing market prices of inputs and outputs in the local market. Benefit : Cost ratio (B : C ratio) was worked out by dividing gross returns (?) by cost of cultivation (?). Data were analyzed by using OPSTAT software available at CCS Haryana Agricultural University website (Sheoran *et. al*., 1998). The results are presented at five per cent level of significance (P=0.05) for making comparison between treatments.

RESULTS AND DISCUSSION

Varieties

Data presented in Table 1 reveal that among varieties, highest seed, straw and biological yield (573.2, 1920.1 and 2493.3 q/ha, respectively) were recorded in the single stem variety RGC 1066 which were on a par with branched variety HG 2-20. Test weight (100 seed weight in g) was not affected significantly among different varieties. Significantly highest plant height (100.6 cm) was recorded in the variety NBPGR 120. Significantly highest number of pods/plant and branches/plant (105.4 and 5.6, respectively) were recorded in the variety HG 2-20. Maximum number of days to 50 per cent flowering and days to maturity (45 and 124 respectively) were taken by NBPGR 120 which was significantly superior to all the other varieties. Maximum harvest index was recorded in HG 2-20 and RGC 1066 (0.23, same value in both the varieties) which was on a par with RGC 1055. Data presented in Table 2 reveal that highest crude protein content in seed (32.03%) was estimated in RGC 1066 which was on a par with NBPGR 120 and HG 2-20 but significantly superior to RGC 1055. Seed galactomannan (gum) content ranged from 29.53 to 32.38 % among varieties, however, significantly highest gum content (32.38%) was estimated in HG 2-20. Carbohydrate content ranged from 30.53 to 31.62 % among varieties. However, it was not affected significantly among varieties.

TABLE 1
Effect of crop geometries on yield attributes and yield of cluster bean varieties

Treatments	Plant height at harvest (cm)	No. of pods/ plant	No. of branches plant	Days to 50% flowering	Days to maturity	Seed yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	100-Seed weight (g)	Harvest index
(V) Variety										
RGC 1055	77.5	91.6	4.8	37.3	112.4	389.0	1513.5	1902.5	3.73	0.21
HG 2-20	73.2	105.4	5.6	37.2	110.9	560.3	1893.4	2453.7	3.67	0.23
RGC 1066	87.4	90.4	1.2	36.9	109.4	573.2	1920.1	2493.3	3.91	0.23
NBPGR 120	100.6	56.6	1.0	45.0	124.0	196.6	1483.6	1680.2	3.15	0.12
SEm±	1.5	3.7	0.2	0.3	0.5	20.2	107.7	103.6	0.19	0.01
CD (P=0.05)	4.5	11.0	0.6	0.9	1.6	59.5	317.8	305.9	NS	0.04
(C) Crop geometry										
22.5 cm × 10 cm	81.3	80.5	2.9	38.2	112.0	390.4	1596.1	1986.6	3.67	0.19
30 cm × 10 cm	83.4	87.7	3.1	39.3	114.7	425.0	1666.7	2091.7	3.64	0.20
45 cm × 10 cm	89.3	89.8	3.5	39.8	115.9	473.9	1845.0	2318.9	3.54	0.20
SEm±	1.3	3.23	0.2	0.3	0.5	17.5	93.2	89.8	0.16	0.01
CD (P=0.05)	3.9	NS	0.5	0.7	1.4	51.6	NS	264.9	NS	NS
V × C										
SEm±	2.6	6.5	0.4	0.5	0.9	34.9	186.5	179.5	0.33	0.02
CD (P=0.05)	NS	NS	NS	1.5	NS	103.1	550.4	529.9	NS	NS
CV (%)	5.3	13.0	19.3	2.2	1.4	14.1	18.9	6.8	15.6	20.4

Crop Geometries

Data presented in Table 1 reveal that among different crop geometries, highest seed and biological yield (473.9 and 2318.9 kg/ha, respectively) were recorded at 45 cm × 10 cm which was on a par with 30 cm × 10 cm but significantly superior over 22.5 cm × 10 cm. However, straw yield and test weight (100 seed weight in g) were not affected significantly by different crop geometries. Akhtar *et al*. (2012) also reported that different row spacings *viz*. 30 cm, 45 cm and 60 cm did not affected the test weight of guar significantly. Significantly highest plant height (89.3 cm) was recorded with 45 cm × 10 cm. Maximum number of branches per plant, days to 50% flowering and days to maturity were also observed with 45 cm × 10 cm which were on a par with 30 cm × 10 cm. Harvest index was not affected significantly at different crop geometries. Although, the results are not in agreement but conceptually follow the pattern. When plant density was increased, harvest index decreased. It seems that at higher populations, inter and intra-plant competition between vegetative and reproductive organs for assimilates intensifies and since reproductive buds are formed later than vegetative buds, the adverse effects of intensified competition affect reproductive buds at the first place. On the other hand, the increased plant density also increased respiration and decreased photosynthesis which led to the decrease in the transfer of assimilates to seeds and consequently, harvest index loss (Moosavi *et. al*, 2014). Data presented in Table 2 reveal that highest crude protein content (32.29%) was estimated with 45 cm × 10 cm which was significantly superior to rest of the crop geometries. The estimated gum content ranged from 28.23 to 32.55%, however highest seed galactomannan gum content (32.55%) was estimated in 45 cm × 10 cm which was on a par with 30 cm × 10

TABLE 2
Quality of cluster bean varieties as influenced by different crop geometries

Treatments	Crude protein (%)	Gum content (%)	Carbohydrate (%)
(V) Variety			
RGC 1055	29.91	29.53	31.32
HG 2-20	31.00	32.38	31.62
RGC 1066	32.03	30.42	31.07
NBPGR 120	31.42	30.41	30.53
SEm±	0.43	0.53	0.60
CD (P=0.05)	1.26	1.55	NS
(C) Crop geometry			
22.5 cm × 10 cm	30.59	28.23	31.65
30 cm × 10 cm	30.38	31.28	30.74
45 cm × 10 cm	32.29	32.55	31.01
SEm±	0.37	0.46	0.52
CD (P=0.05)	1.09	1.35	NS
V × C			
SEm±	0.74	0.91	0.04
CD (P=0.05)	2.18	2.69	NS
CV (%)	4.11	5.14	5.81

TABLE 3
Economics of cluster bean varieties as influenced by different crop geometries

Treatments	Cost of cultivation	Gross returns (Rs./ha)	Net returns (Rs./ha)	B : C ratio
(V) Variety				
RGC 1055	19263	17032	-2231	0.88
HG 2-20	19263	23959	4696	1.25
RGC 1066	19263	24474	5211	1.27
NBPGR 120	19263	10045	-9218	0.52
(C) Crop geometry				
22.5 cm × 10 cm	19513	17248	-2265	0.89
30 cm × 10 cm	19263	18634	-629	0.97
45 cm × 10 cm	19013	20750	1737	1.09

TABLE 4
Interaction effect of crop geometry and variety on days to 50 per cent flowering

Crop geometry	Variety				Mean of crop geometries
	RGC 1055	HG 2-20	RGC 1066	NBPGR 120	
22.5 cm × 10 cm	37.0	36.3	35.7	43.7	38.2
30 cm × 10 cm	37.3	37.0	38.3	44.7	39.3
45 cm × 10 cm	37.7	38.3	36.7	46.7	39.8
Mean of varieties	37.3	37.2	36.9	45.0	

CD at 5% is 1.5

TABLE 5
Interaction effect of crop geometry and variety on seed yield (kg/ha)

Crop geometry	Variety				Mean of crop geometries
	RGC 1055	HG 2-20	RGC 1066	NBPGR 120	
22.5 cm × 10 cm	447.2	424.1	539.4	151.2	390.4
30 cm × 10 cm	363.4	549.1	542.6	244.9	425.0
45 cm × 10 cm	356.5	707.9	637.5	193.8	473.9
Mean of varieties	389.0	560.3	573.2	196.6	

CD at 5% is 103.1

TABLE 6
Interaction effect of crop geometry and variety on straw yield (kg/ha)

Crop geometry	Variety				Mean of crop geometries
	RGC 1055	HG 2-20	RGC 1066	NBPGR 120	
22.5 cm × 10 cm	1741.7	1520.4	1630.1	1492.4	1596.1
30 cm × 10 cm	1465.3	1673.2	2019.9	1508.6	1666.7
45 cm × 10 cm	1333.3	2486.6	2110.4	1449.8	1845.0
Mean of varieties	1513.5	1893.4	1920.1	1483.6	

CD at 5% is 550.4

cm. carbohydrate content was not affected significantly by different crop geometries.

Interaction between variety and crop geometry

Data presented in Table 4 reveal the significant interaction between variety and crop geometry for days to 50% flowering. Different branched and single stemmed varieties exhibited variation in their days to 50% flowering pattern. Data presented in Table 5 reveal that seed yield of RGC 1066 (single stemmed) increased with increasing inter row spacing but the increase was not significant from 22.5 to 30 and 30 to 45. But, the seed yield of branched variety HG 2-20 increased significantly from 22.5 to 30 and 30 to 45. The significant interaction between crop geometry and variety (HG 2-20) indicate that branched variety need wider row to row spacing. However, the trend was not followed in another branched variety (RGC 1055) because of its compact plant type and significantly less branching as compared to HG 2-20.The interactive effect of variety and crop geometry for straw yield and biological yield is shown in Table 6 and 7, respectively. The interactive effect of variety and crop geometry for crude protein content is shown in Table 8. Data presented in Table 9 reveal that gum content increased significantly with increase in inter-row spacing from 22.5 cm to 30.0 cm in case of RGC 1055 and HG 2-20. The increase in gum content was further significant in RGC 1055 with increase in inter-row spacing from 30.0 cm to 45.0 cm. In other two single stemmed varieties, gum content was not affected significantly with increasing row to row spacing.

TABLE 7

Interaction effect of crop geometry and variety on biological yield (kg/ha)

Crop geometry	Variety				Mean of crop geometries
	RGC 1055	HG 2-20	RGC 1066	NBPGR 120	
22.5 cm × 10 cm	2188.9	1944.4	2169.5	1643.5	1986.6
30 cm × 10 cm	1828.7	2222.2	2562.5	1753.5	2091.7
45 cm × 10 cm	1689.8	3194.4	2747.9	1643.5	2318.9
Mean of varieties	1902.5	2453.7	2493.3	1680.2	

CD at 5% is 529.9

TABLE 8

Interaction effect of crop geometry and variety on crude protein content (%)

Crop geometry	Variety				Mean of crop geometries
	RGC 1055	HG 2-20	RGC 1066	NBPGR 120	
22.5 cm × 10 cm	28.16	31.50	32.50	30.22	30.59
30 cm × 10 cm	28.00	29.72	32.81	31.00	30.38
45 cm × 10 cm	33.56	31.78	30.79	33.03	32.29
Mean of varieties	29.91	31.00	32.03	31.42	

CD at 5% is 2.18

TABLE 9

Crop geometry	Variety				Mean of crop geometries
	RGC 1055	HG 2-20	RGC 1066	NBPGR 120	
22.5 cm × 10 cm	26.85	28.05	28.95	29.05	28.23
30 cm × 10 cm	29.07	33.77	31.12	31.15	31.28
45 cm × 10 cm	32.67	35.33	31.18	31.02	32.55
Mean of varieties	29.53	32.38	30.42	30.41	

CD at 5% is 2.69

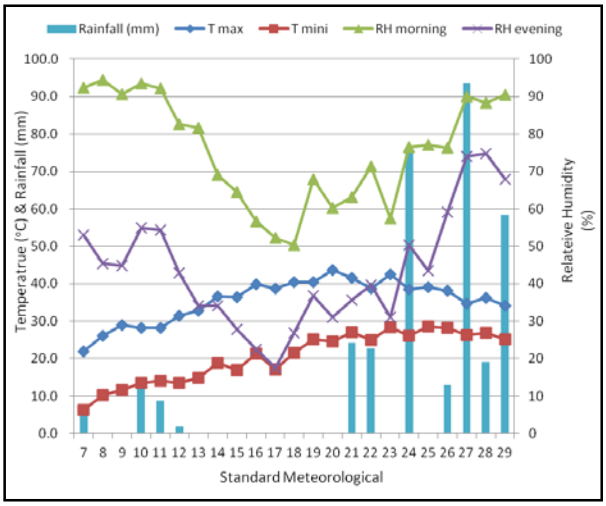

Fig. 1. Weekly weather parameters during the crop season.

ECONOMICS

Perusal of the data from Table 3 reveal that among varieties, maximum gross returns and net returns were fetched in RGC 1066 (Rs. 24474 and 5211/ha) followed by HG 2-20 (Rs. 23959 and 4696/ha). Similarly, maximum B : C ratio (1.27) was fetched in RGC 1066 followed by HG 2-20. Among crop geometries, maximum gross returns and net returns (Rs. 20750 and 1737/ha) were fetched with 45 cm x 10 cm. Maximum B : C ratio (1.09) was also fetched with 45 cm x 10 cm.

CONCLUSION

Among different varieties, highest seed yield (573.2 q/ha) was recorded in the single stem variety RGC 1066, which was on a par with branched variety HG 2-20. Maximum B : C ratio (1.27) was also fetched in RGC 1066 followed by HG 2-20. Among different crop geometries, highest seed yield (473.9 kg/ha) was recorded at 45 cm × 10 cm which was on a par with 30 cm × 10 cm. The varieties RGC 1066 and HG 2-20 performed better in summer season. For HG 2-20 (branched variety), 45 cm × 10 cm and for RGC 1066 (single stemmed) 30 cm × 10 cm crop geometry is suitable for summer season to realize the potential seed yield. The cultivar NBPGR 120 could not realize the potential yield because of its long duration that coincided with rains in the maturity phase and lead to low seed yield in the studied climate.

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