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Effect of date of sowing and row spacing on growth, yield and quality of summer vegetable cowpea (*Vigna unguiculata* L.)

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Abstract
A field experiment, "Effect of date of sowing and row spacing on growth, yield and quality of summer vegetable cowpea (*Vigna unguiculata* L.)" was carried out during the summer season of 2020 at College Farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Gujarat. The cowpea variety local was used for this experiment. The experiment was laid out in split plot design with three replications. Experiment was comprised of two factors *viz*., date of sowing as main plot with four date 10th February (d_1), 20th February (d_2), 1st March (d_3) and 10th March (d_4) and in sub plot with three row spacing 30 cm × 30 cm (s_1), 45 cm × 30 cm (s_2) and 60 cm × 30 cm (s_3). The result revealed that 20th February (d_2) recorded maximum plant height (58.91 cm) at 60 DAS, plant spread (E-W & N-S) (38.61 cm & 51.03 cm, respectively) at 60 DAS, number of branches per plant (6.17) at 60 DAS, number of cluster per plant (34.08), number of pickings (8.04), yield per plant (120.52 g), yield per plot (3.94 kg) and yield per hectare (80.82 q). Minimum days taken for initiation of flowering (54.97) and for first picking after sowing (64.91) were recorded with treatment d_4 (10th March). Whereas, maximum days (113.29) taken for last picking after sowing was recorded with treatment d_1 (10th February). Among the row spacings, 45 cm × 30 cm (s_2) recorded maximum plant height (53.91 cm) at 60 DAS, yield per plot (4.03 kg) and yield per hectare (83.00 q). While, maximum plant spread (E-W & N-S) (35.10 cm & 46.62 cm, respectively), number of branches per plant (5.42) at 60 DAS, number of cluster per plant (34.62) and yield per plant (116.47 g) were noted with treatment of 60 cm × 30 cm spacing (s_3).Quality parameters *viz*., pod length (cm), crude protein content (%), fibre content (%) and chlorophyll content a, b and total (mg/100 g) were found non-significant with different treatments. With respect to economics in date of sowing maximum gross income (₹ 161640), net income (₹ 103103) and benefit cost ratio (2.76) recorded with 20th February as well as in row spacing maximum gross income (₹ 166000), net income (₹ 108263) and benefit cost ratio (2.87) recorded with 45 cm × 30 cm.

Keywords: vegetable cowpea, date of sowing, row spacing, chlorophyll, crude protein, fibre

Introduction
Cowpea (*Vigna unguiculata* L.) is an important leguminous crop believed to be originated in Central Africa. Cowpea belongs to family *Fabaceae*, subfamily *Papilionaceae* and group Phaselea. It is self-pollinated annual herb with an extensive growth habit. It is also known as lobia, black-eye pea and southern pea. In Gujarati it is commonly known as "*chowli*". Tender pods and immature seeds of cowpea are used as vegetable.

It is cultivated in Tropics and Sub-Tropic region of Asia, Africa, America, parts of Southern Europe and Australia. India and Ethiopia are the primary source of origin of cowpea and China as a secondary source of origin. It is grown almost in all the states, but the major cultivating states are Gujarat, West Bengal, Tamil Nadu, Andhra Pradesh, Kerala and Odisha. Cultivation of cowpea in summer season is increasing in Gujarat. The main districts of Gujarat growing this crop are Sabarkantha, Banaskantha, Mehsana, Patan, Ahmedabad, Kheda and Anand.

The proper sowing time exerts a marked effect on the growth and eventually the yield of a crop. Planting the crop at the right time ensures better plant growth and also prevents weed growth. There are evidences that optimum time of sowing as one of the several cultural manipulations has greatly helped in boosting up the yield, particulary in Indian subcontinent where the optimum time of sowing varies to great extent due to widely varying agro-climatic conditions. The optimum time of sowing is decided by several factors, the most important of which is the temperature during the growing season.

A plant population is one such factor that has a direct influence on the yield level of any particular genotype. Spacing plays an important role in maintain adequate plant population.

Establishment of appropriate row spacing for maintaining the optimum plant population per unit area is the most prerequisite to obtain maximum yield for any field crops. Moreover, row spacing provides ease for interculturing, weeding, application of fertilizer and insecticides in the field.

Materials and Methods

A field experiment was conducted at College farm, College of Horticulture, Sardarkrushinagar Dantiwada Agricultural University, Jagudan, Gujarat to study the effect of date of sowing and row spacing on growth, yield and quality of summer vegetable cowpea (*Vigna unguiculata* L.) during summer, 2020. The experiment was laid out in split plot design with three replications. experiment was comprised of two factors *viz*., date of sowing as main plot with four date 10th February (d_1), 20th February (d_2), 1st March (d_3) and 10th March (d_4) and in sub plot with three row spacing 30 cm × 30 cm (s_1), 45 cm × 30 cm (s_2) and 60 cm × 30 cm (s_3).The soil of experimental field was loamy sand in texture, slightly alkaline in nature with low in organic carbon and medium in available nitrogen and available phosphorus and potassium. As per recommended dose, whole quantity of well decomposed FYM (10 t ha^{-1}) applied to each plot after layout preparation and mixed thoroughly with soil and dose of N:P:K: (20:40:00 kg/ha) two days prior to sowing half dose of N and full dose of P_2O_5 were applied as basal application and was properly mixed with the soil. Remaining half dose of nitrogen was applied at 45 DAS. Seed was treated with *Rhizobium* culture before sowing. Weeding and plant protection measure were followed as and when needed. Ten tagged plant from each net plot were selected for recording observations of growth, yield and quality parameters.

Crude protein in the green pod was calculated by multiplying total nitrogen with the factor 6.25 by using method described by AOAC (1995) [2]. The fibre content from green pods was determined by using method given by Chopra and Kanwar (1999) [4]. Chlorophyll a, b and total chlorophyll content was measured as per method described by Sadasivam and Manickam (1997) [15]. The data were statistically analyzed using the method suggested by Panse and Sukhatme (1985) [11].

Results and Discussion

Growth and flowering Parameters

The data on growth and flowering parameters *viz*., plant height (cm) at 30 DAS and 60 DAS, plant spread (E-W & N-S) at 60 DAS (cm), number of branches per plant at 60 DAS, days taken for initiation of flowering, days taken for first picking after sowing, days taken for last picking after sowing depicted in Table 1.

Plant height (cm) at 30 DAS and 60 DAS

A perusal of the data reveals that the plant height at 30 DAS were not affected due to different treatments under the study. The plant height as influenced by different treatments were found significant at 60 DAS. Maximum plant height (58.91 cm) was recorded with treatment d_2 (20th February) which was statistically at par with treatment d_3. While minimum plant height (43.86 cm) was recorded with treatment d_4. Significant variation in plant height among different date of sowing due to longer growth period and their adaptability under favourable conditions available during the growing period of the plant which was ultimately leading to taller plants. Similar results were also reported by Nikam *et al*. (2018) [10] in cluster bean. In spacings, maximum plant height (53.91 cm) was recorded with treatment s_2 (45 cm × 30 cm) which was statistically at par with treatment s_3. Whereas, minimum plant height (49.15 cm) was observed under treatment s_1. It due to more inter and intra row competition among plants for requirement of sunlight for the process of photosynthesis hence plant became taller to compete for sunlight in cowpea. Similar results of significant differences in these characters were also reported by Sathe and Patil (2012) [16] in pigeon pea and Deka *et al.* (2015) [5] in cluster bean.

Plant spread (E-W & N-S) at 60 DAS (cm)

In date of sowing, higher plant spread (E-W & N-S) (38.61 cm & 51.03 cm) was observed with treatment d_2 (20th February) which was statistically at par with treatment d_3 due to best growth condition during this period. Lower plant spread (E-W & N-S) (26.23 cm & 35.55 cm) was obtained with treatment d_4. In row spacings, higher plant spread (E-W & N-S) (35.10 cm & 46.62 cm) was observed with treatment s_3 (60 cm × 30 cm). While lower plant spread (E-W & N-S) (30.43cm & 41.06 cm) was observed with treatment s_1.Significant variation in plant spread due to wider spacing which leads to good growth and development as there was less competition for the uptake of nutrients, water and sunlight, which leads to more lateral growth which increases plant spread. The findings are in conformity with the results of Thirupal *et al.* (2014) [20] and Tejaswini *et al.* (2018) [19] in broccoli and Amruta *et al*. (2015) [1] in black gram.

Number of branches per plant at 60 DAS

A perusal of the data influenced by different treatments was found significant. In date of sowing, maximum number of branches (6.17) was recorded under treatment d_2 (20th February) which was statistically at par with treatment d_3. Whereas, minimum number of branches (4.12) was recorded under treatment d_4. This finding is in close accordance with the results of Nikam *et al.* (2018) [10] and Mathukia *et al.* (2019) [7] in cluster bean.

In row spacing. Maximum number of branches per plant (5.42) was recorded with treatment s_3 (60 cm × 30 cm), however it was statistically at par with treatment s_2. Lower number of branches per plant (4.95) was recorded when sown under narrow spacing s_1 (30 cm × 30 cm). wider row spacing resulted into less competition for resources and space, subsequently improved the availability of soil moisture, nutrients, light and space for better growth and development, wider spacing ultimately resulted into better root proliferation and growth resulting into increased root nodulation and microbial activity which ultimately increased number of branches. The results collaborate with findings of Neha *et al.* (2016) [9] and Patel *et al*. (2018) [13] in cowpea, Sathe and Patil (2012) [16] in pigeon pea, Chaudhary *et al.* (2015) [3] and Sonani *et al.* (2016) [18] in summer green gram and Amruta *et al*. (2015) [1] in black gram.

Days taken for initiation of flowering

Data revealed that the effect of date of sowing on days taken for initiation of flowering was found significant. Minimum days (54.97) taken was observed with treatment d_4 (10th March) which was statistically at par with treatment d_3 and d_2, while maximum days taken was observed with treatment d_1

(10th February).Number of days taken for initiation of flowering was reduced with delay in sowing. Early flowering due to effect of available photoperiod to late sowing at reproductive stage. These findings are in close accordance with the results of Dhedhi *et al.* (2016) [6], Nikam *et al.* (2018) [10] in cluster bean and the effect of row spacing on days taken for initiation of flowering was found non-significant.

Days taken for first picking after sowing

A perusal of the data reveals that effect of date of sowing on days taken for first picking after sowing was found significant. Minimum days (64.91 DAS) taken was found with treatment d_4 (10th March) which was statistically at par with treatment d_3. While, maximum days taken (71.82 DAS) was observed with treatment d_1 (10th February).Delayed picking in early sowing due to the longer duration for vegetative growth, while early picking with delayed sowing plants were forcely switched over the vegetative phase to reproductive phase due to rise in temperature in the March onward. These results are in conformity with the findings of Miah *et al.* (2009) in mungbean. The effect of row spacing on days taken for first picking after sowing was found non-significant.

Days taken for last picking after sowing

Data showed that the effect of date of sowing on days taken for last picking after sowing was found significant. Maximum days taken (113.29 DAS) was found in treatment d_1 (10th February) which was statistically at par with treatment d_2. While, minimum days taken for last picking (96.19 DAS) was observed in treatment d_4. The effect of row spacing on days taken for last picking after sowing was found non-significant.

Yield parameters

The data on yield parameters such as number of pods per cluster, number of cluster per plant, number of pickings, yield per plant (g), yield per plot (kg) and yield per hectare (q) depicted in Table 2.

Number of pods per cluster

The data presented in Table 2 indicated that number of pods per cluster significantly not affected by date of sowing and row spacing.

Number of cluster per plant

Date of sowing, Maximum number of cluster per plant (34.08) was reported with treatment d_2 (20th February) which was statistically at par with treatment d_3. It might be due to congenial climatic conditions and favourable temperature for reproductive growth. Although, the lowest number of cluster per plant (27.31) was noted in treatment d_4. These results are collaborating with findings of Dhedhi *et al.* (2016) [6] and Nikam *et al.* (2018) [10] in cluster bean.

Data showed that effect of row spacing on number of cluster per plant was found significant. Maximum number of cluster per plant (34.62) was reported in treatment s_3 (60 cm × 30 cm). The lowest number of cluster per plant (27.10) was noted in treatment s_1, it due to wider spacing had less inter-plant competition because of more space availability to individual plants for reproductive growth. These findings are in close accordance with the results of Shilpa *et al.* (2016) [17], Vasava and Patel (2020) [21] in cluster bean.

Number of pickings

Data revealed that effect of date of sowing on number of pickings was found significant and row spacing was found non- significant. Maximum number of pickings (8.04) was reported in treatment d_2 (20th February) which was statistically at par with treatment d_3. However, minimum number of pickings (6.00) was noted in treatment d_4.Whereas maximum number of pickings (7.43) with row spacing of 45 cm × 30 cm (s_2).

Yield per plant (g)

The data presented in Table 2 revealed that the effect of date of sowing and row spacing on yield per plant (g) was found significant. In date of sowing maximum yield per plant (120.52 g) was reported in treatment d_2 (20th February) which was statistically at par with treatment d_3. The lowest yield per plant (72.60 g) was noted in treatment d_4.

In row spacing, maximum yield per plant (116.47 g) was reported in treatment s_3 (60 cm × 30 cm) whereas, the lowest yield per plant (72.22 g) was reported with treatment s_1. It due to availability of more unit area per plant which provides less competition for light, moisture, nutrients *etc*. Favourable conditions like nutrient, moisture and light availability to each plant under wider spacing as compared to the plant stand at medium and narrow spacing and more vegetative and accumulation of photosynthesis. The result of present investigation is also corroborated with the finding of Patel *et al.* (2019) [12] in moth bean.

Yield per plot (kg) and yield per hectare (q)

The data presented in Table 2 revealed that the effect of date of sowing on yield per plot (kg) and yield per hectare (q) was found significant. The maximum yield per plot (3.94 kg) and yield per hectare (80.82 q) was reported with treatment d_2 (20th February) which was statistically at par with treatment d_3 (1st March). The lowest yield per plot (3.10 kg) and yield per hectare (63.71 q) were noted with treatment d_4 (10th March).Cowpea sown on either 20th February or 1st March recorded higher values for almost all the growth and yield characters than early and late sowing. Moreover, favourable climatic condition during this period play vital role in development of yield attributes. This finding is in close accordance with the result obtained by Vishal *et al.* (2014) [22] in cluster bean.

Data revealed that the effect of row spacing on yield per plot (kg) and yield per hectare (q) were found significant and maximum yield per plot (4.03 kg) and yield per hectare (83.00 q) were reported with medium spacing s_2 (45 cm × 30 cm). However, the lowest yield per plot (3.78 kg) and yield per hectare (70.01 q) were noted in treatment s_1 (30 cm × 30 cm).Average plant population and higher superiority in growth parameters attributed increased overall yield per plot and yield per hectare. Similar result was worked out by Rajendra (2004) [14] in cowpea.

Table 1: Effect of date of sowing and row spacing on growth parameters of summer vegetable cowpea (*Vigna Unguiculata* L.)

Treatment	Plant height (cm)		Plant spread at 60 DAS (cm)		Number of branches per plant at 60 DAS	Days taken for initiation of flowering	Days taken for first picking after sowing	Days taken for last picking after sowing
	30 DAS	60 DAS	E-W	N-S				
Date of sowing (d)								
d_1: 10th February	21.96	49.77	30.14	42.60	4.78	61.19	71.82	113.29
d_2: 20th February	24.62	58.91	38.61	51.03	6.17	58.72	69.29	106.65
d_3: 1st March	23.16	54.26	35.68	46.69	5.62	56.83	67.40	101.78
d_4: 10th March	20.58	43.86	26.23	35.55	4.12	54.97	64.91	96.19
S.Em. ±	0.79	1.35	0.86	1.49	0.16	1.22	1.20	2.86
C. D. at 5%	NS	4.68	2.99	5.14	0.56	4.22	4.17	9.89
C. V. %	10.56	7.85	7.93	10.14	9.43	6.32	5.29	8.21
Row spacing (s)								
s_1: 30 cm × 30 cm	22.07	49.15	30.43	41.06	4.95	58.91	69.09	102.54
s_2: 45 cm × 30 cm	23.03	53.91	32.46	44.23	5.15	56.95	67.76	106.32
s_3: 60 cm × 30 cm	22.63	52.05	35.10	46.62	5.42	57.93	68.21	104.57
S.Em. ±	0.61	0.99	0.69	0.94	0.11	1.01	1.02	2.26
C. D. at 5%	NS	2.99	2.06	2.83	0.34	NS	NS	NS
C. V. %	9.38	6.60	7.30	7.44	7.67	6.06	5.18	7.50
Interaction								
S.Em. ±	1.22	1.97	1.18	1.89	0.23	2.03	2.04	4.52
C. D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
C. V. %	9.38	6.60	7.30	7.44	7.67	6.06	5.18	7.50

Table 2: Effect of date of sowing and row spacing on yield parameters of summer vegetable cowpea (*Vigna Unguiculata* L.)

Treatment	Number of pods per cluster	Number of cluster per plant	Number of pickings	Yield per plant (g)	Yield per plot (kg)	Yield per hectare (q)
Date of sowing (d)						
d_1: 10th February	2.33	30.16	7.07	84.26	3.45	70.81
d_2: 20th February	2.69	34.08	8.04	120.52	3.94	80.82
d_3: 1st March	2.50	32.21	7.82	110.34	3.73	76.63
d_4: 10th March	2.10	27.31	6.00	72.60	3.10	63.71
S.Em. ±	0.12	0.89	0.25	3.68	0.12	2.42
C. D. at 5%	NS	3.06	0.87	12.74	0.43	8.39
C. V. %	14.48	8.58	10.46	11.39	10.38	9.97
Row spacing (s)						
s_1: 30 cm × 30 cm	2.33	27.10	7.00	72.22	3.78	70.01
s_2: 45 cm × 30 cm	2.41	31.10	7.43	102.10	4.03	83.00
s_3: 60 cm × 30 cm	2.48	34.62	7.27	116.47	2.85	65.96
S.Em. ±	0.05	0.64	0.20	2.63	0.08	1.66
C. D. at 5%	NS	1.91	NS	7.88	0.24	4.98
C. V. %	7.24	7.14	9.75	9.39	7.96	7.88
Interaction						
S.Em. ±	0.10	1.28	0.41	5.26	0.16	3.32
C. D. at 5%	NS	NS	NS	NS	NS	NS
C. V. %	7.24	7.14	9.75	9.39	7.96	7.88

Quality Parameters

Effect of date of sowing and row spacing with respect to quality parameters *viz*., pod length (cm), crude protein content (%), fibre content (%) and chlorophyll content a, b and total (mg/100 g) were found non-significant (Table 3).

Economics

With respect to economics in date of sowing maximum gross income (₹ 161640), net income (₹ 103103) and benefit cost ratio (2.76) recorded with 20th February as well as in row spacing maximum gross income (₹ 166000), net income (₹ 108263) and benefit cost ratio (2.87) recorded with 45 cm × 30 cm (Table 4).

Conclusion

On the basis of results obtained from present investigation, it can be concluded that summer vegetable cowpea (*Vigna unguiculata* L.) should be sown during last week of February to first week of March (20th February to 1st March) with spacing of 45 cm × 30 cm to fetch higher yield and net realization.

Table 3: Effect of date of sowing and row spacing on quality parameters of summer vegetable cowpea (*Vigna Unguiculata* L.)

Treatment	Length of pod (cm)	Crude protein content (%)	Fiber content (%)	Chlorophyll content (mg/100g)		
				Chlorophyll a	Chlorophyll b	Total Chlorophyll
Date of sowing (d)						
d_1: 10th February	13.03	21.13	12.43	84	69	158
d_2: 20th February	13.99	22.30	13.05	87	72	163
d_3: 1st March	13.41	21.70	12.70	86	70	151
d_4: 10th March	12.57	20.45	12.11	80	65	157
S.Em. ±	0.30	0.41	0.22	0.02	0.01	0.03
C. D. at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C. V. %	6.69	5.69	5.36	5.70	5.67	4.90
Row spacing (s)						
s_1: 30 cm × 30 cm	13.10	20.99	12.46	83	67	158
s_2: 45 cm × 30 cm	13.38	21.73	12.68	86	70	162
s_3: 60 cm × 30 cm	13.28	21.51	12.58	84	69	159
S.Em. ±	0.20	0.35	0.19	0.01	0.01	0.02
C. D. at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C. V. %	5.20	5.61	5.10	4.56	5.26	4.10
Interaction						
S.Em. ±	0.40	0.69	0.37	0.02	0.02	0.04
C. D. at 5%	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
C. V. %	5.20	6.07	5.10	4.56	5.26	4.10

Table 4: Economics of different treatments (₹ /ha)

Treatment	Yield per hectare (kg)	Gross returns (₹/ha)	Total cost (₹/ha)	Net returns (₹/ha)	Benefit Cost Ratio
Date of sowing (d)					
d_1: 10th February	7081	141620	58457	83163	2.42
d_2: 20th February	8082	161640	58537	103103	2.76
d_3: 1st March	7663	153260	60537	92723	2.53
d_4: 10th March	6371	127420	56377	71043	2.26
Row spacing (s)					
s_1: 30 cm × 30 cm	7001	140020	61237	78783	2.28
s_2: 45 cm × 30 cm	8300	166000	57737	108263	2.87
s_3: 60 cm × 30 cm	6596	131920	56037	75883	2.35

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