

ASSESSMENT OF OPTIMAL SOWING TIME BASED ON HEAT INDICES AND ROW SPACING FOR SUMMER GUAR (*CYAMOPSIS TETRAGONOLOBA* [L.] TAUB.)

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ABSTRACT

A field experiment was conducted during summer seasons of 2013–2015 on clayey soil of Junagadh (Gujarat) to ascertain proper time of sowing (4th week of January, 2nd week of February, and 4th week of February) and spacing (30 cm×15 cm, 45 cm×15 cm, and 60 cm×15 cm) in relation to growth and yield of guar (*Cyamopsis tetragonoloba* [L.] Taub.). The results revealed that sowing in the 2nd week of February enhanced growth and yield attributes, namely plant height, pods per plant, and test weight, and ultimately gave higher seed yield (1387 kg/ha) and stalk yield (2846 kg/ha) with higher growing degree days, heliothermal units, photothermal units, and heat use efficiency as well as higher net returns (₹ 42,051/ha) and B: C ratio (2.29) over early (4th week of January) and late (4th week of February) sowing. The results further indicated that 45 cm×15 cm spacing promoted growth and yield attributes, namely plant height, branches per plant, pods per plant, and test weight compared to 30 cm×15 cm and 60 cm×15 cm, which reflected in higher seed yield (1272 kg/ha) and stalk yield (2680 kg/ha) along with higher net returns (₹ 37,154/ha) and B: C ratio (2.03) over 30 cm×15 cm and 60 cm×15 cm spacing. Therefore, sowing in the 2nd week of February (when soil temperature >22.3°C at 5 cm and >23.9°C at 10 cm depth) and spacing of 45 cm×15 cm could be appropriate for maximizing yield and monetary returns from summer guar under south Saurashtra agro-climatic conditions of Gujarat.

Keywords: Summer guar, *Cyamopsis tetragonoloba*, Sowing time, Spacing, Broadcast, Heat indices.

INTRODUCTION

Guar (*Cyamopsis tetragonoloba* [L.] Taub.) is a multipurpose crop. Its green pods are used as vegetable, grains as pulse, and green plants as fodder and for soil manuring purpose. Since it is a leguminous crop, it also has soil enriching and erosion resisting properties. At present, it is grown more for mucilaginous gum production. Guar, a versatile crop with industrial uses and export potential, has transformed economic status of large number of farmers. Low input cost and high returns encourage farmers to cultivate drought tolerant legume guar seed.

Guar is photosensitive crop. It grows in specific climatic condition, which ensures a soil temperature around 25°C for proper germination, long photoperiod with humid air during its growth period, and finally short photoperiod with cool dry air at flowering and pod formation. Accordingly, it is definitely a *kharif* season crop, it also prefers warm climate and grows well in the subtropics during summer.

In arid region, it is grown as a *kharif* crop. However, in semi-arid regions of Saurashtra, occasional heavy rains and temporary waterlogged condition hinder its cultivation in *kharif* season. Moreover, due to low requirement of water, fertilizer and plant protection measure in summer season, a large number of farmers in Saurashtra region are turn toward growing guar as summer crop.

Among crop production factors, sowing time, and spacing contribute much to a proper crop stand establishment in the field. Patel *et al.* (2004) suggested sowing of summer guar from the 3rd week of February to the 1st week of March at 45 cm row spacing for higher yield and net returns. Under paucity of research on sowing time and spacing requirement for gum guar, in general, and for summer gum guar, in particular, the present experiment was carried out to ascertain proper sowing time and spacing for summer gum guar.

MATERIALS AND METHODS

A field experiment was carried out at the Department of Agronomy, College of Agriculture, Junagadh Agricultural University, Junagadh,

Gujarat, during summer seasons of 2013–2015. The soil of the experimental plot was clayey in texture and slightly alkaline in reaction (pH 7.9 and EC 0.36 dS/m) as well as low in available nitrogen (262 kg/ha), available phosphorus (26 kg/ha), and high in available potash (325 kg/ha). During the crop period, the range of maximum temperature was 30.3–41.0, 28.1–41.1, and 29.4–42.3°C, average relative humidity was 26–63, 38–69, and 35–60%, and evaporation was 4.5–11.7, 5.1–11.0, and 4.8–11.9 mm/day, respectively, during 2013, 2014, and 2015. The experiment comprising three sowing time (4th week of January, 2nd week of February, and 4th week of February) and three spacing (30 cm×15 cm, 45 cm×15 cm, and 60 cm×15 cm) was laid out in split plot design with four replications. The gross plot size was 6.0 m×3.6 m, while net plot size for 30 cm×15 cm and 60 cm×15 cm spacing was 5.1 m×2.4 m, and for 45 cm×15 cm spacing, net plot size was 5.1 m×2.7 m. The guar variety “Gujarat Guar 2” was sown as per sowing time and spacing treatments using seed rate of 15–30 kg/ha and harvested in May–June during all the 3 years. The crop was fertilized with 20–40 kg N-P₂O₅/ha as basal dose in the form of diammonium phosphate and ammonium sulfate. For weed management, pendimethalin 0.9 kg/ha was applied as pre-emergence supplemented with intercultivation and hand weeding at 30 days after sowing. Irrigations each of 5 cm depth were given at 0.9 IW: CPE ratio. The average daily pan evaporation during the crop period was 8.6, 8.5, and 8.0 mm in 2013, 2014, and 2015, respectively. Various heat indices were worked out as follows:

$$\text{Growing degree days (GDD)} = \sum T_{\text{mean}} - T_b$$

Where, T_{mean} = daily mean temperature, T_b = base temperature for summer guar taken as 14.6°C (Angus *et al.*, 1981)

$$\text{Heliothermal unit (HTU)} = \text{GDD} \times n$$

Where, n = daily actual bright sunshine hours.

$$\text{Photothermal unit (PTU)} = \text{GDD} \times N$$

Table 1: Effect of sowing time and spacing on growth, yield of attributes, and yield of guar and economics

Treatment	Plant height (cm)	Branches per plant	Pods per plant	1000 seed weight (g)	Seed yield (kg/ha)				Stalk yield (kg/ha)				Net returns (₹/ha)	B: C
					2013	2014	2015	Pooled	2013	2014	2015	Pooled		
Sowing time														
January 4 th week	81.3	4.68	56.6	30.2	767	948	862	859	1762	1916	1906	1861	19125	1.04
February 2 nd week	87.7	5.43	66.3	33.6	1632	1318	1211	1387	3166	2616	2756	2846	42051	2.29
February 4 th week	78.6	4.91	58.5	32.9	1394	1081	964	1146	2859	2204	2312	2458	31648	1.73
S.E.m.±	1.3	0.23	0.9	1.2	45	49	36	25	101	96	67	52	-	-
CD (p=0.05)	4.5	NS	3.2	4.0	155	169	123	74	350	332	232	153	-	-
Spacing														
30 cm×15 cm	78.2	4.53	53.7	29.8	1320	1140	1059	1173	2759	2217	2381	2452	32341	1.72
45 cm×15 cm	87.9	5.56	68.3	34.5	1460	1227	1128	1272	2949	2529	2561	2680	37154	2.03
60 cm×15 cm	81.6	4.93	59.4	32.4	1015	979	850	948	2079	1991	2031	2034	23330	1.30
S.E.m.±	1.2	0.19	0.8	1.0	40	33	31	20	88	72	68	44	-	-
CD (p=0.05)	3.7	0.56	2.5	3.1	120	100	91	57	260	215	203	125	-	-

Table 2: Mean weekly soil temperature at different sowing times

Soil depth	Year	Soil temperature (°C)		
		January 4 th week	February 2 nd week	February 4 th week
5 cm	2013	20.0	23.3	22.6
	2014	22.2	21.3	24.4
	2015	19.7	22.2	21.0
	Mean	20.6	22.3	22.7
10 cm	2013	21.7	24.9	25.3
	2014	22.2	21.4	24.5
	2015	21.6	25.3	23.0
	Mean	21.8	23.9	24.3

*Indicates significant at 5% level of significance, **indicates significant at 1% level of significance

Table 3: Correlation coefficient (r) of soil temperature at sowing with germination and yield

Character	Soil temperature (°C) at	
	5 cm	10 cm
Germination (%)	0.5827**	0.4817**
Seed yield (kg/ha)	0.6009**	0.6296**
Stalk yield (kg/ha)	0.5245**	0.7105**

**Indicates significant at 1% (0.3862) level of significance

Where, N= monthly maximum possible bright sunshine hours or day length.

Heat use efficiency (HUE) = Seed yield/GDD

RESULTS AND DISCUSSION

Growth and yield attributes

The data presented in Table 1 indicated that different sowing times significantly influenced growth and yield attributes of guar. Sowing of guar crop in the 2nd week of February significantly enhanced plant height (87.7 cm), number of pods per plant (66.3), and test weight (33.6 g); however, it remained at par with sowing in the 4th week of February in respect of test weight. Whereas, significantly the lowest plant height was observed under late sowing (4th week of February). The early sowing (4th week of January) resulted in significantly the lowest number of pods per plant and test weight. Enhanced germination due to optimum soil temperature and later on favorable climatic condition might have favored growth and development under the 2nd week of February sowing as compared to early and late sowing. Deshmukh *et al.* (2014a) also reported similar results.

The data furnished in Table 1 revealed that significantly, the highest plant height, number of branches per plant, number of pods per plant,

and test weight were recorded with 45 cm×15 cm spacing; however, it remained at par with 60 cm×15 cm spacing in case of test weight. While, 30 cm×15 cm spacing resulted in significantly the lowest values of these growth and yield attributes. The absence of interplant competition for moisture, nutrients, and solar radiation in optimum spacing (45 cm×15 cm) might have been responsible for improved growth and development of individual plant. These results are in conformity with findings of Sharma *et al.* (2014).

Seed and stalk yields

The data furnished in Table 1 showed that different sowing times significantly influenced seed yield of guar during individual years and in pooled results. Sowing of guar crop in the 2nd week of February resulted in significantly the highest seed yield of 1632, 1318, 1211, and 1387 kg/ha in 2013, 2014, 2015, and pooled results, respectively, whereas significantly, the lowest seed yield of 767, 948, 862, and 859 kg/ha was observed under early sowing (4th week of January) in 2013, 2014, 2015, and pooled results, respectively. Significantly, the highest stalk yield of 3166, 2616, 2756, and 2846 kg/ha was registered with sowing on the 2nd week of February in 2013, 2014, 2015, and pooled results, respectively, which remained at par with sowing in the 4th week of February in 2013. The early sowing (4th week of January) resulted in significantly the lowest stalk yield of 1762, 1916, 1906, and 1861 kg/ha in 2013, 2014, 2015, and pooled results, respectively. Averaged over 3 years, sowing in the 2nd week of February increased seed yield by 61.5 and 21.0% and stalk yield by 52.9 and 15.8% over the 4th week of January and 4th week of February sowing, respectively. Improved growth and development of crop with the 2nd week of February sowing ultimately resulted in increased yield over early as well as late sowing. The results corroborate the findings of Patel *et al.* (2004) and Deshmukh *et al.* (2014b).

Table 1 shows that significantly, the highest seed yield (1460, 1227, 1128, and 1272 kg/ha) was recorded with 45 cm×15 cm spacing in all the individual years and pooled results; however, it remained statistically comparable to 30 cm×15 cm spacing in 2014 and 2015, whereas 60 cm×15 cm spacing resulted in significantly the lowest seed yield (1015, 979, 850, and 948 kg/ha) in all the years and pooled results. The data furnished in Table 1 indicated that significantly, the highest stalk yield of 2949, 2529, 2561, and 2680 kg/ha was recorded with 45 cm×15 cm spacing in 2013, 2014, 2015, and pooled results, respectively, which remained statistically at par with 30 cm×15 cm in 2013 and 2015. While, sowing at 60 cm x 15 cm spacing resulted in significantly the lowest stalk yield (2079, 1991, 2031 and 2034 kg/ha) in all the years and pooled results. On an average of 3 years, 45 cm×15 cm spacing increased seed yield by 34.2 and 8.4% and stalk yield by 31.8 and 9.3% over 60 cm×15 cm and 30 cm×15 cm spacings, respectively. Optimum plant population under 45 cm×15 cm spacing might have been responsible for higher yield compared to narrow and wider

Table 4: Thermal requirement of guar under different sowing times

Year	Treatment	GDD (°C day)	HTU (°C day h)	PTU (°C day h)	HUE (kg/ha°C day)
2013	January 4 th week	1337	13164	16337	0.573
	February 2 nd week	1331	13275	16483	1.228
	February 4 th week	1231	12354	15342	1.133
2014	January 4 th week	1691	16289	21068	0.560
	February 2 nd week	1704	16478	21451	0.774
	February 4 th week	1578	15482	20055	0.685
2015	January 4 th week	1339	12468	16517	0.643
	February 2 nd week	1335	12588	16571	0.908
	February 4 th week	1209	11484	15138	0.797
Mean	January 4 th week	1456	13980	17975	0.592
	February 2 nd week	1457	14114	18168	0.970
	February 4 th week	1339	13107	16845	0.872

GDD: Growing degree days, HTU: Heliothermal unit, PTU: Photothermal unit, HUE: Heat use efficiency

spacing. Bhadoria and Chauhan (1994) and Siddaraju *et al.* (2010) also reported analogous results.

Interactions, namely sowing time x spacing, year x sowing time, year x spacing, and year x sowing time x spacing, were found to be non-significant in respect of growth, yield attributes, and yield throughout the results.

Correlation between soil temperature and crop yield

To establish a relationship of soil temperature at sowing under different dates of sowing (Table 2) with germination, seed yield, and stalk yield, the coefficient of correlation (r) was worked out (Table 3). The data indicated that germination percent, seed yield, and stalk yield showed positive and highly significant correlation with soil temperature at 5 and 10 cm depth. The data ultimately suggest that soil temperature of at least 22.3°C (at 5 cm depth) and 23.9°C (at 10 cm depth) seems to be necessary for satisfactory germination and subsequent growth and development of guar crop during summer season.

Heat indices

Various heat indices, namely GDD, HTU, PTU, and HUE, were worked out according to different sowing times (Table 4). The results indicated that the crop accumulated more GDD (1457°C day), HTU (14,114°C day h), and PTU (18,168°C day h) at the 2nd week of February sowing. The HUE in terms of economic yield was the highest (0.970 kg/ha°C day) in the 2nd week of February sowing followed by late sowing (4th week of February). It was the lowest (0.592 kg/ha°C day) in the early date of sowing. Thus, accumulated heat indices utilized by the crop were not constant. This is due to the fact that days required to maturity decreased with the advancement of growing season. This may be attributed to the increase of temperature during the later dates of sowing.

Economics

Sowing in the 2nd week of February gave maximum net returns of `42,051/ha with B: C ratio of 2.29, followed by sowing on the 4th week

of February, which recorded net returns of ` 31,648/ha and B: C ratio of 1.73.

Sowing the crop at 45 cm×15 cm spacing accrued maximum net returns of ` 37,154/ha and B: C ratio of 2.03, followed by 30 cm×15 cm spacing by recording net returns of ` 32,341/ha and B: C ratio of 1.72. Patel *et al.* (2004) reported higher seed yield and B: C with sowing of guar in the 3rd week of February at 45 cm row spacing.

It was concluded that higher yield and net returns from summer guar could be achieved by sowing in the 2nd week of February at 45 cm×15 cm spacing under south Saurashtra agro-climatic conditions of Gujarat.

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