

Evaluation of Guar as a Proposed New Crop for Rainfed Semiarid Regions of Western Sudan

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Abstract

A set of guar varieties was tested for three seasons (1998-99, 1999-02 and 2000-01) at El Fasher Research Station under rain-fed conditions. This study was intended to evaluate the adaptability of this crop to the agro-ecological environment of the semiarid Darfur region. The average seed yields of all guar varieties in the three seasons were 1036, 1088 and 490 kg/ha respectively, while the overall average across the three seasons was 871 kg/ha. Although variations in yield were not statistically significant, some varieties were superior (e.g. HFG-182) and produced best yield (951 kg/ha) across seasons. On the other hand, the effects of three inter-row spacing (40, 60 and 90 cm), three intra-row spacing (20, 30 and 40 cm) and three plant population levels (1, 2 and 3 plants per hole) on yield and some agronomic traits of guar were studied in separate experiment in the same location during season 1999-00, 2000-01 and 2001-02. Significant differences in seed and hay yields among the three seasons were observed. This was mainly attributed to the variations in rainfall during the growing seasons. Seed and hay yields increased with decreasing inter-row and intra-row spacing. However, days to maturity and plant height showed opposite trend. The maximum seed and hay yields were obtained at 40 cm inter-row spacing, 20 cm intra-row spacing and 3 plants per hole. Significant effects of intra-row spacing, inter-row spacing and plants per hole on seed and hay yields suggest the use of closer inter-row and intra-row spacing with 2-3 plants per hole to obtain higher yields under semiarid regions. In general, guar yields in both experiments were higher than that of the other crops under the same prevailing environmental conditions. Therefore, this crop is suggested to be one of the new food/feed crops in the region.

Introduction

Guar, or cluster bean, (*Cyamopsis tetragonoloba* L. Taub.) is a coarse, upright, bushy, drought-tolerant summer annual legume (belongs to the family Leguminaceae). It is a native plant of India and Pakistan where it is grown principally for its green fodder and for the pods that are used for food and feed. It is grown in tropical Asia, Africa and America. The major world suppliers are India, Pakistan and the United States, with smaller acreages in Australia and Africa (Undersander *et al.*, 2006). Guar is a new crop in Sudan, and is grown commercially in limited scale near Singa, Blue Nile, for seed processing into flour (Osman, 2005). This crop grows well in a variety of soils and thrives in alluvial and sandy loams with well-drained subsoil.

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Unlike the seeds of other legumes, guar seeds contains sufficient amount of galactomannan gum, which form a viscous gel in cold water. Guar gum has 5-8 times the thickening power of starch. It is used in textile, paper manufacture, stamps, cosmetics, pharmaceuticals, food products, e.g. bakery products, ice cream, stabilizer for cheeses and meat binder. Also it is used recently in oil wells, mining industries, explosives, and other industrial applications (Undersander *et al.*, 2006). On the other hand, guar is considered as an excellent soil improvement crop, like other legumes, with respect to available nitrogen, which improve yield of succeeding crops.

In sandy soils of semiarid regions, drought stress and lack of nutrients (mainly nitrogen and phosphorus) are considered as the main production constraints. Therefore, guar is expected to fit very well in this region as an important drought tolerant cash crop and soil-building crop, with respect to available nitrogen through nitrogen fixation, to maintain soil quality and sustainable productivity. It was found that inclusion of guar in the rotation had a beneficial effect on enzyme activities, nitrifying bacteria, organic matter, available nitrite and phosphorus over fallow-pear millet, resulting in a significant increase in pearl millet production (Rao *et al.*, 1995)

Guar production is greatly affected by climatic factors (rainfall and temperature), soil factors and cultural practices (e.g. sowing date, seed rate, plant spacing, sowing methods, weeding and harvesting methods). Although guar is grown under wide range of annual precipitation, the amount and distribution of rainfall is the limiting factor for guar production under semiarid regions. Guar was introduced and tested in the Sudan under rainfed and irrigation conditions. Its yield potential is highly affected by cultural practices, mainly plant spacing and population. The highest seed yield of rain-grown guar was found at the closest spacing of 10 x 60 cm in Samsam (Taha, 1993). Spacing of 75 x 15 cm and 2 plants per hole gave the highest yield under rain-fed at Abu Naama (Loggale, 2001). At El Obeid, the highest yield was obtained at 60 x 20 cm spacing under rainfed condition (Osman, 2001). The objectives of this study were to evaluate the performance of guar varieties and to investigate the appropriate inter- and intra-row spacing and number of plants per hole that lead to the highest seed yields under semiarid rainfed conditions of Darfur region.

Materials and Methods

Two experiments were conducted for three seasons at El Fasher Research Station Farm, El Fasher (13° 63 N, 25° 33 E, 710 m asl) in sandy soil under rainfed conditions. Mean annual rainfall of the region is about 250 mm.

Experiment 1

This experiment was conducted for three seasons (1998-99, 1999-00 and 2000-01) to evaluate the performance of guar varieties under semiarid conditions of Darfur region. Ten guar varieties were tested in this experiment. Sowing was done on 23 July, 22 July and 16 July for the three years respectively. Each genotype was planted in 6 rows of 6-meter length and spacing of 60 cm between rows and 15 cm between plant holes. The plants were thinned to one plant per hole after two weeks from sowing. Treatments were arranged in a randomized complete block design with 4 replications. Data were recorded from the central four rows of each plot.

Experiment 2

This experiment was conducted for three seasons (1999-00, 2000-01 and 2001-02) to study the effects inter- and intra-row spacing and number of plants per hole on yields and some agronomic traits of guar under semiarid rainfed conditions of Darfur region. The experiment consisted of 27 treatments in factorial combinations of three factors namely: inter-row spacing (40, 60 and 90 cm), intra-row spacing (20, 30 and 40 cm) and plant population levels (1, 2 and 3 plants per hole). In each year, variety Brooks was planted in flat plots of 5 x 3.6 meter size. Sowing dates were on 22 July, 16 July and 21 July for the year 1999, 2000 and 2001 respectively. These treatments were arranged in a randomized complete block design with 3 replications.

Results

Monthly and annual rainfalls, during the growing periods, are presented in Table 1. In general, most of rainfalls were received in July and August. The total annual rainfalls were 332.5, 291.6, 146.2 and 130.4 mm for the years 1998, 1999, 2000 and 2001 respectively.

Experiment 1

Seed yield

Combined analysis of data revealed significant differences among seasons for seed yield, but the interaction of genotype x year was not significant. The overall mean of seed was lowest in the third season than the first and second season (Table 2). This was probably attributed to low rainfall during the third season compared to the other seasons. Although there were variations in seed yields, differences among the guar varieties were not statistically significant due to high coefficient of variability in each of three seasons (Table 2). Seed yield was very low in the third season compared to the previous two seasons due to low rainfall during this growing season (Table 1 and 4). The highest overall mean seed yield of the three seasons was produced by HFG-182 (951 kg/ha). The mean differences among the three seasons were statistically significant (Table 4).

Hay yield

Differences among the guar varieties in hay yield were not statistically significant in spite of large variations due to high coefficient of variability in each of the three seasons (Table 2). However, genotype HFG-182 produced the highest mean hay yield (1674 kg/ha), while RGC-192 produced the lowest mean yield (1149 kg/ha) of the three seasons (Table 2). The mean differences among the three seasons were statistically significant (Table 4).

Days to maturity

Genotype differences for days to maturity were not significant in each of the three seasons (Table 3). However, seasons had significant effect on it, which ranged between 73-89 days (Table 4).

Plant height

Plant height variations were not statistically significant in each of the three growing seasons (Table 3). However, seasonal effects were statistically significant (Table 4).

Experiment 2

Combined analysis

Combined analysis of data revealed significant differences among seasons for seed yield, straw yield, days to maturity and plant height. In addition, the interactions of year x inter-row spacing x intra-row spacing x plant numbers were not significant for all parameters. The overall means of seed and hay yield were highest in the first season followed by the second then the third season (Table 5). This was probably attributed to high rainfall during the first season compared to the other seasons (Table 1).

Seed yield

Data on seed yield from separation and combined analysis of the three seasons exhibited the same trend (Table 5). Significant effects were obtained via the main effects of Inter-row spacing on seed yield in the first and third season, but it was not significant in the second season. The 40 cm inter-row spacing gave the best yields in the first (1799 kg/ha), second (489 kg/ha) and the third season (135 kg/ha). Intra-row spacing had highly significant effect on seed yield only in the first, but had no significant effect in the second and third season. However, the best yields were obtained at 20 cm intra-row spacing in the first (1755 kg/ha), second (482 kg/ha) and third season (106 kg/ha) which was not significantly difference from yields at 30 cm. The main effects of plant numbers per hole on seed yield were highly significant in the first and third season, without significant effect in the second season. The highest seed yields were produced at three plants per hole in the first season, one plant per hole in the second season and two plants per hole in the third season. However, the highest mean yield of the three seasons was obtained from three plants per hole, which was not significantly different from that of the two plants per hole. These results indicated that there was a trend to increase seed yield with closer inter-row and intra-row spacing and 2-3 plants per hole.

Hay yield

Inter-row spacing and intra-row spacing had significant effects on hay yields in the first season, but had no significant effects in the second and third season (Table 5). In general, hay yield increased with narrowing inter-row and intra-row spacing. The effect of number of plants per hole on hay yield was significant in the first and third season, but was not significant in the second season. However, hay yield increased with increasing number of plants per hole.

Days to maturity

The main effect of inter-row spacing on days to maturity was not significant in the first, but it was significant in the second and third season (Table 6). In addition, intra-row spacing had highly significant effect on days to maturity in the first and third season, but had no significant effect in the second season. On the other hand, number of plants per hole showed significant effect only in the third season. In general, days to

maturity delayed with increasing inter-row and intra-row spacing and decreasing plant numbers per hole.

Plant height

Significant effects of inter-row and intra-row spacing on plant height were obtained in the first season only (Table 6). However, there was a trend to increase plant height with widening inter-row and intra-row spacing. In addition, number of plants per hole had no effect on plant height.

Discussion

The guar cultivars tested under rainfed semiarid region of Darfur showed high adaptability to the region compared to the other crops. The overall means of the seed yields across the three seasons was 871 kg/ha, but they varied from year to another due to fluctuation in rainfall. In the first two seasons the yields were high (1036-1088 kg/ha) compared to the third season (490 kg/ha) due to drought stress. Variety HFG-182 produced the highest mean yield across the three seasons (951 kg/ha). These guar varieties were tested earlier under rainfed conditions at El Obeid Research Station and found that variety DPS produced the highest yield (219 kg/ha) while the mean of all genotypes was 134 kg/ha (Abuelgasim, 1985). In addition, the mean yield of 2000-01 growing season (490 kg/ha) was higher than that produced at Abu Naama (372 kg/ha) in the same season (Loggale, 2001). Under the prevailing rainfed conditions, millet produced very low mean yields (224, 118 and 219 kg/ha for the three seasons respectively), while guar produced good seed yields (1036, 1088 and 490 kg/ha for the same seasons). On the other hand, Growing guar in Darfur semiarid region at different inter-row and intra-row spacing and plant numbers per hole, significantly effect seed and hay yields. The maximum seed and hay yields were obtained at 40 cm inter-row spacing, 20 cm intra-row spacing with 2-3 plants per hole throughout the three growing seasons. These results indicated that the closest spacing gave the highest yields than the widest spacing even under lower rainfall conditions. The highest seed yield of rain-grown guar was found at the closest spacing of 10 x 60 cm at Samsam (Taha, 1993). Closer spacing of 75 x 15 cm and 2 plants per hole gave the highest yield under rainfed at Abu Naama (Loggale, 2001). Seed yield at 80 x 20 cm spacing was found to be higher than the wider spacing or broadcasting under flood irrigation at Gash Delta (Osman, 2005). At El Obeid,, the highest yield was obtained at closer spacing of 60 x 20 cm under rainfed condition (Osman, 2001). In general, guar yields were higher than that of the other crops under the prevailing environmental conditions for both experiments and guar growth did not show severe symptoms of drought stress during extremely dry seasons, compared to the other crops, although its growth and yields were lower than that of the normal conditions. Therefore, guar is a promising crop for this dry environment. However, its acceptability, utilization and marketing are to be determined.

Recommendations

Based on the results of the two experiments the following recommendations are proposed:-

1. Guar is proposed as a new food/feed crop in semiarid region of western Sudan under rainfed conditions to increase diversification and improve soil fertility.
2. The inter-row spacing of 40 cm and intra-row of 20-30 cm and 2-3 plants per hole are suggested for guar production in flat sandy soil under rainfed semiarid regions.

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Table 1. Rainfall data at El Fasher Research Station during 1998-2001 growing seasons.

Month	Total rainfall (mm) per month				
	1998	1999	2000	2001	Mean
July	124	112.5	65.5	76.2	94.6
August	108.6	131.2	62	31.6	83.4
September	95.9	41.9	18.7	22.6	44.8
October	4	6	0	0	2.5
Total	332.5	291.6	146.2	130.4	

Table 2. Mean seed yield (kg/ha) and hay yield (kg/ha) of guar evaluated under semiarid region of western Sudan for the growing seasons 1998-99, 1999-2000 and 2000-2001

Genotype	Seed yield (kg/ha)				Hay yield (kg/ha)			
	1998-99	1999-00	2000-01	Mean	1998-99	1999-00	2000-01	Mean
IC-9065	880	1252	519	875	1672	1552	626	1283
HFG-408	1064	1178	559	934	1888	1484	585	1319
HFG-75	1002	984	471	819	1880	1377	543	1267
HFG-182	1082	1287	484	951	2199	2301	521	1673
HFG-53	1111	948	449	836	1979	1227	555	1254
RGC-192	1081	944	465	830	1766	1151	530	1149
DPS	1033	1090	525	883	2058	1502	602	1387
Brooks	1114	900	473	829	1993	1299	540	1248
Kinman	1018	1248	472	913	1777	1692	606	1358
Esser	978	1057	482	845	1921	1355	564	1280
Mean	1036	1088	490	871	1913	1494	558	1322
S.E ±	123.5	135.9	52.3	64	224.7	228.1	88.7	111
CV %	24	25	21		23	31	32	

Table 3. Mean number of days to maturity and plant height of guar evaluated under semiarid region of western Sudan for the growing seasons 1998-99, 1999-2000 and 2000-2001

Genotype	Days to maturity (days)				Plant height (cm)			
	1998-99	1999-00	2000-01	Mean n	1998-99	1999-00	2000-01	Mean n
IC-9065	88	87	72	82	58	51	41	50
HFG-408	84	91	74	83	64	49	44	52
HFG-75	89	85	73	82	68	54	40	54
HFG-182	85	90	75	83	70	56	43	56
HFG-53	85	92	72	83	76	60	45	60
RGC-192	84	89	76	82	66	47	36	50
DPS	86	88	76	83	68	57	41	55
Brooks	87	89	74	83	70	49	39	52
Kinman	84	91	74	83	67	59	42	56
Esser	89	92	70	83	69	55	41	55
Mean	86	89	73	83	68	53	41	54
S.E ±	1.5	2.7	2.2	1.3	3.1	3.5	2.8	1.8
CV %	4	6	6		9	13	14	

Table 4. Seasonal effects on seed yield, straw yield, number of days to maturity and plant height of guar varieties evaluated under semiarid region of Darfur across three seasons.

Season	Seed yield (kg/ha)	Hay yield (kg/ha)	Days to maturity (days)	Plant height (cm)
1998-99	1036	1913	86	68
1999-00	1088	1494	89	53
2000-01	490	558	73	41
Mean	871	1322	83	54
S.E ±	94	129	1.2	1.1
CV %	25	29	5	12

Table 5. The effects of Inter-row and intra-row spacing and number of plants per hole on seed and hay yield of guar grown under semiarid region of western Sudan, seasons 1999-00, 2000-01 and 2001-02.

Factor	Seed yield (kg/ha)				Hay yield (kg/ha)			
	1999-00	2000-01	2001-02	Mean	1999-00	2000-01	2001-02	Mean
Inter-row								
40	1799	489	135	807	2421	822	207	1150
60	1410	467	104	660	2052	832	176	1020
90	1263	440	67	590	1924	829	120	958
Intra-row								
20	1755	482	106	781	2382	849	177	1136
30	1554	449	103	702	2204	809	171	1061
40	1161	465	97	574	1811	825	154	930
Plants/hole								
1	1150	481	87	573	1685	815	147	882
2	1622	452	113	729	2405	792	164	1120
3	1698	463	106	756	2308	875	192	1125
Mean	1490	465	102	687	2132	827	168	1043
S.E ±	91	28.5	4.9	33.1	139	44.1	12.5	50.8
CV %	32	32	29	44	33	28	39	44

Table 6. The effects of inter and intra-row spacing and number of plants per hole on days to maturity and plant height of guar grown under semiarid region of western Sudan, seasons 1999-00, 2000-01 and 2001-02

Factor	Days to maturity				Plant height (cm)			
	1999-00	2000-01	2001-02	Mean	1999-00	2000-01	2001-02	Mean
Inter-row								
40	85	74	80	80	65	37	28	43
60	85	79	81	82	65	40	31	45
90	88	80	82	83	70	43	33	48
Intra-row								
20	83	75	80	79	65	38	29	44
30	87	79	81	82	69	39	32	47
40	88	79	82	83	66	42	31	46
Plants/hole								
1	87	81	82	83	62	43	32	46
2	86	76	80	81	69	38	29	46
3	85	76	80	80	68	38	31	46
Mean	86	78	81	81	66	40	31	46
S.E ±	1.1	1.7	0.4	0.7	2.1	1	0.7	0.8
CV %	7	11	3	8	16	13	12	16