Effect of intra-row spacing on grain yield of sorghum in the Gash Delta

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Abstract

In the Gash Delta the traditional farmer method of very wide plant spacing is unappropriate under average or good flood irrigation level. Different intra-row spacings of 30, 50 and 70 cms along 80 cm row spacing were compared with the farmer's practice (80-100x80 cm). The local tall and late cultivar (Aklamoi) and the improved cultivar Gadam El Hamam were used in the experiment in a randomized complete blocks design with four replications. Across two seasons the highest mean grain yield was recorded at the spacing 50x80 cm. The short and earlier variety Gadam El Hamam tended to give its highest yield at 30x80 cm, while the tall and late Aklamoi gave the best yield at 50x80 cm. Plant height and head length were not affected by plant spacing. It was recommended that the short, early maturing sorghum Gadam El Hamam to be planted at the spacing of 30-50x80 cm, while Aklamoi to be planted at 50x80 cm using ridger plough under good flood irrigation levels in the Gash Delta.

Introduction

Gash Delta farmers go for very wide plant spacing for all crops irrespective of the flood irrigation level. Usually the basins (misga) are flooded for 15–25 days. The wetting depth reaches 180–300 cm in the loamy soils of the Gash Delta which is characterized with a high water holding capacity. The traditional previous studies in the Gash Delta suggested 80 cm between rows (furrows) for all crops, with varying intra-row spacing. To reduce the cost of fallow opening for the farmers, the tractors owners used wider spacing between furrows. Hence the sorghum is sown with a foot–pressed Selluka at a spacing of 80–100 cm along furrows opened with a 2–plate disc plough 150–200 cm apart. The in–row spacing is controlled by the foot step of the farmer using the Selluka, while the furrow spacing is determined by the tractor driver. It was observed that farmers growing rain-fed sorghum in the terrace system west of the Gash Delta use closer spacing of 80x100 and 100x100 cm.

For the purpose of our experiment and for easy and valid comparisons between treatments, the spacing between furrows for all treatments, including the farmer practice was fixed at 80 cm.

Experiments were conducted in the Gash Delta to determine the optimum intra-row plant spacing for highest grain yield under the flood irrigation system.

Materials and methods

Experimental work

The experiment was conducted in the seasons 1990-91 and 1991-92 in the Gash Delta with silty clay loam soil and different levels of irrigation. Intra-row spacings were tested using two distinctly different cultivars: Aklamo, a tall late maturing cultivar and Gadam El Hamam, a short medium maturing cultivar. Intra-row spacing tested were 30, 50, 70 cm, and farmers' method. Furrow spacing was 80 cm. The experiments were carried out in a randomized complete block design with four replications. A different experimental site was used each year. In 1990-91, Tendelai

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pilot basins was filled with 700 ml of water equivalent to 20-25 flood days and in 1991-92, Tendelai pilot basins was filled with 500 ml of water equivalent to 15-20 days.

Demonstration plots

To verify the results obtained in 1990-91 and 1991-92, the traditional cultivar Aklamoi was planted with various planting methods and different spacing in 1992-93 and 1993/94 seasons.

Both experiments were executed in the second flood irrigation, and cultivars were sown on 26 September 1990 and 8 September 1991. Treated seeds were sown at 6-8/hole. Seedling emergence was recorded on the 4th day of sowing with a percent emergence of 84-100%. Plants were thinned to 3 plants/hole two weeks after sowing. Dry heads of Aklamoi were harvested at age of 111-130 days, and Gadam El Hamam at age of 111 days.

Results

Grain yield in 1990-91

Differences between cultivars or due to intra-row spacing or interaction were statistically not significant. However, Gadam ElHamam out yielded Aklamoi by a small margin of 153 kg/ha. Gadam ElHamam recorded its highest yields at the closer in–row spacing of 30 and 50 cm, while Aklamoi produced its best yield at the intra-row spacing of 50 and 70 cm. The mean maximum yield was achieved at 50 cm in–row spacing which was 21% higher than the farmers yield (Table 1).

Grain yield in 1991-92

The effects of the intra-row spacing and its interaction with cultivars were statistically significant (P = 0.05). Although Gadam ElHamam out yielded Aklamoi by 556 kg/ha, the difference was not statistically significant (Table 1). Gadam El Hamam gave its best grain yield at the closer intra-row spacing of 30 cm, which was not significantly different from the yield of the intra-row spacing of 50 cm. The highest yield of Aklamoi was produced at 50 cm. The higher mean yield of 4443 kg/ha was recorded at the in–row spacing of 50 cm, which was 39% higher than the farmer's yield.

The combined analysis of the two seasons revealed a statistically high significant effect of the intra-row spacings on grain yield (P = 0.01), and a significant interaction effect of cultivars x in -row spacing. The maximum mean yield for both cultivars was recorded at 50 cm, which was 30% higher than the farmer's yield. The differential response of the two cultivars was shown where Gadam recorded its maximum yield at 30-50 cm, while the maximum of Aklamoi was at 50 cm intra-row spacing.

Head length

The head length was recorded in one season where there was no significant effect caused by intra-row spacing. But the difference in head length between the two cultivars was statistically highly significant (P = 0.01). Gadam Elhamam recorded a mean head length of 16 cm, while Aklamoi short heads were 10 cm (Table 2).

Plant height

There was no significant difference in plant height caused by in–row spacing. However, the data of 1990-91 season showed that Aklamoi plants were nearly twice as tall as Gadam Elhamam plants (Table 3).

Results of the demonstration plots

The results in Tables 4 and 5 gave consistently higher grain yield at the plant spacing of 80x50 cm, which supports the findings of the previous two seasons.

Economic analysis

The economic analysis showed a net benefit of 90422 SD/ha for the recommended spacing compared to 36659 SD/ha for the farmer's practice (Table 6).

Discussion

The experiments were conducted in the silty clay loam soil, the predominant soil type in the Gash delta. Although the flooding periods in the Gash delta vary widely, depending on location and the flushes of the Gash River, the experimental locations represent the flooding level for the main crops (15- 25 days, wetting depth ≥ 180 cm).

Averaged across cultivars and seasons, the mean maximum grain yield was attained at 50x80 cm spacing. Nevertheless, the two cultivars responded differently to plant spacing under the same growing conditions. The tall, late-maturing local sorghum Aklamoi gave its highest grain yield at the spacing 50x80 cm; while the short medium-maturing cultivar Gadam Elhamam recorded its best grain yield at 30-50x80 cm, the yield level at high plant density depends on the flood level. Hermans (1995) reported that the wetting depth in the Gash delta was more reliable than the number of flooding days. The wetting depth in the experimental locations was 180 cm at the inlet of the basin and 300 cm at the tail of the basin (Gamar 1994). It was found by Hermans (1995) that the moisture content increased with depth. He estimated that each depth of 100 cm was equivalent to 200 mm of water. Hence, the moisture reserve in the experimental plots was 480 mm. Sorghum water requirements was estimated as 450 mm (Doorknobs et al, 1979). Hence, the flood irrigation level at the experimental basins was adequate. This together with the good fertility of the alluvial silty clay loam soils of the Gash delta made it possible for both cultivars to attain high yields at comparatively closer spacings (30x80 and 50x80 cm) compared to the farmer's practice. The favorable effects of close plant spacing on grain yield of sorghum was similarly reported by some workers. Ali (1981) reported the highest grain yields of 3 irrigated sorghum cultivars from the closest intra-row spacing of 5 cm in Kenana. Farah (1987–90), in the Gezira, reported the highest grain yield of irrigated sorghum at 15x60 cm. Although the first experiment (1990-91) was planted relatively later than the second experiment (1991-92), the yields in the first season were relatively better than those of the second season, which could be due to the varying flooding periods this suggests that more research work is needed on the optimum sowing dates for the various periods of flooding.

Recommandations

Based on the reported consistent response of sorghum to close plant spacing in the Gash delta, and due to the economic high returns it is recommended to:

1. Plant the short, medium-maturing cultivar Gadam Elhamam at a close intra-row spacing of (30-50)x80 cm.
2. Plant the tall, late-maturing Aklamoi at the close intra-row spacing of 50x80 cm.

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Table 1. Effect of plant spacing on grain yield of sorghum in the Gash Delta.

Treatment		Grain yield 1990-91 kgs/ha	% increase over FM	Grain yield 1991-92 kg/ha	% increase over FM*	Combined 1990-91-1991-92 kgs/ha	% increase over FM
Variety	**Intra-row sp. cm.**						
G. Elhamam.	30x80	4498	+18.5	4737	+32.5	4617	+32.0
	50x80	4582	+33.8	3992	+11.7	4287	+22.5
	70x80	3332	-2.7	3193	-10.6	3263	-6.8
	FM	3425		3574		3499	
Aklamoi	30x80	3795	+6.5	2516	-11.1	3155	-1.2
	50x80	3887	+9.1	4893	+73.0	4390	+37.3
	70x80	3980	+11.7	3036	+7.3	3508	+9.8
	FM	3563		2829		3196	
	S.E (±)	394		432.		292	
	C.V (%)	17.6		20.8		19.2	
Means							
	Varieties						
	Gadam	3958.9		3874.2		3917	
	Aklamoi	3806.3		3318.5		3562	
	S.E (±)	197		216		146.	
	Intra-rows						
	30x80	4146.3	+18.7	3626.7	+13.3	3887	+16.1
	50x80	4234.3	+21.2	4442.6	+38.8	4339	+29.6
	70x80	3655.9	+4.6	3114.6	-2.7	3385	+1.1
	FM	3494.0		3201.5		3348	
	S.E (±)	278.7		305.8		206.9	

* Farmer's method

Table 2. Effect of intra- row spacing on head length of two sorghum cultivars the Gash Delta (1991-92).

Cultivars	Intra-row spacing (cm)	Head length (cm)
Gadam Hamam	30x80	16.9
	50x80	15.2
	70x80	15.7
	F M*	17.8
Aklamoi	30x80	10.1
	50x80	10.3
	70x80	10.2
	FM	10.1
	S.E (±)	0.98
Means:		
	Cultivars:	
	G. Elhamam	16.4
	Aklamoi	10.2
	S.E. (±)	0.49
	Intra-row spacing:	
	30	13.5
	50	12.7
	70	13.0
	F M	14.0
	S.E (±)	0.69
	C.V (%)	12.8

* Farmer's method

Table 3. Effect of intra-row spacing on plant height of two of sorghum cultivars in the Gash Delta (1990-91).

Cultivars	Intra-row spacing (cm)	Plant height (cm)
Gadam Hamam	30x80	124.7
	50x80	124.5
	70x80	119.8
	FM	122.9
Aklamoi	30x80	231.9
	50x80	232.7
	70x80	255.1
	FM	235.3
	S.E (±)	10.7
Means:		
	Cultivars	
	Gadam	123.0
	Aklamoi	238.8
	S.E (±)	5.4
	Intra- row spacing:	
	30	178.3
	50	178.6
	70	187.5
	FM	179.1
	S.E (±)	7.6
	C.V. (%)	10.3

Table 4. Effect of plant spacing on grain yield of the sorghum cultivar Aklamoi (Demonstration plots, 1992-93).

Treatment spacing (cm)	Grain yield (kg/ha)	% Change	Head wt. (kg/ha)	Head length (cm)

80x30	Selluka	903.4	106.6	1606.3	12.4
80x50	Selluka	1996.6	356.6	3044.5	13.3
80x80	Selluka	1603.9	266.6	2467.6	12.8
80x10	Planter	725.7	65.9	1491.3	12.4
80x20	Planter	672.6	53.8	1451.1	11.4
150x30	Selluka	444.3	1.6	827.8	12.2
150x50	Selluka	564.5	29.1	904.9	13.9
150x80	Farmer's method	437.2		847.5	13.5

Table 5. Effect of plant spacing on grain yield of sorghum cultivar Alklamoi in the Gash Delta (1993-94).

Spacing (cm)	Grain yield (kg/ha)	% Change	Head length (cm)	% lodging
80x50	3659.5	+40.2	13.1	10
80x10	3271.1	+25.4	11.0	28
80x20	3235.7	+24.0	11.3	15
120x30	3228.6	+23.7	12.3	22
120x50	2961.9	+13.5	14.0	10
Farmer's method Selluka (150x80)	2609.5		14.8	-

Table 6. Estimated production costs and benefits (SD/ha) for Alklamoi sorghum in the Gash delta

Operation	Cost/Benefit (SD/ha)	
	Farmer's Method Spacing	Recommended Spacing
Cost:		
Land preparation	3570	6743
Planting	2380	4760
Resowing	1190	2380
Weed control	9620	9520
Seed dressing	2380	2380
Harvesting	14280	28560
Straw	8330	16660
Seeds	1428	1428
Water rate	7140	7140
Sacks	1900	4300
Guards	6000	6000
Transport to local market	3800	7600
Subtotal cost	57010	90871
Interest (10% of subtotal)	5701	9087
Total cost	62711	99958
Benefits:		
Average yield (ton/ha) seed	1.9*	4.3
Average price (SD/ton)	30000	30000
Benefits from seed (SD/ha)	57000	129000
Benefits from straw (SD/ha)	47600	71400
Gross benefits (SD/ha)	104600	200400
Deductions:		
Zakat (5% of returns)	5230	10020
Actual gross benefits (SD/ha)	99370	190380
Net benefits (SD/ha)	36659	90422
Net benefit/cost (%)	58.4%.	90.4%

* The average grain yield used is the long term commercial average of the scheme.