Research Article

Effects of plant density on yield and quality of watermelon (*Citrullus lanatus* thunb) under Gezira conditions, Sudan

Abstract

An experiment was conducted at the Gezira Research Farm in the winter season of 2009/10 and *kharif* (autumn) season of 2010 to study the effects of plant density on watermelon performance. Treatments consisted of three intra-row spacing of 50, 70 and 90 cm and three number of plants per hole; 1, 2 and 3. Treatments were arranged in randomize complete block design with three replicates. Results indicated significant differences among treatments in number of branches/plant in both seasons. However no significant differences were observed in vine length in both seasons and number of leaves/plant in the winter season, but in *kharif* (autumn) season significant differences was observed in number of leaves/plant. Results of yield components indicated no significant differences among treatments in number of fruits per hectare. There were highly significant differences in marketable fruits yield in both seasons. Also there were significant and highly significant differences in total soluble solids in the winter and *kharif* (autumn) seasons, respectively. The results indicated that 70 cm intra-row spacing with one plant/hill gave the optimum plant density for watermelon, since it resulted in optimum growth and the highest marketable yield and best quality.

Keywords: gezira, kharif, plant density, watermelon, performance, intra-row spacing

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Introduction

Watermelon (*Citrullus lanatus* (Thunb.) Mansfed is one of the widely cultivated crops in the world.[1] In the Sudan it produced as an irrigated crop along the river banks of central and northern parts of the country. Plant spacing is an important agronomic attribute, since it is believed to have effects on light interception which affects the photosynthetic process. In watermelon, increasing planting density decreases the number of fruits per plant, but individual fruit size is mostly unaffected.[2] Also, it affects the photosphere and rhizosphere exploitation by the plants especially when spacing is inadequate and the plants suffer from clustering together.[3]

Watermelon yield and quality in Gezira are low. Marketable yield is usually around 9 tons/ha and unmarketable fruits exceed 3 tons/ha. Many factors contribute to this situation such as fertilizer application and plant density.

No studies on plant population of watermelon were conducted in the Sudan. Farmers usually sow numerous seeds per hole at various intra-row spacing ranging between 50 and 150 cm and inter-row spacing of 250, 300, or 350cm. The crop is thinned to 1-2 plants/hole one month after sowing. This accounts for 20-27 thousand plants per hectare. The objective of this study was to evaluate the response of watermelon to intra-row spacing and number of plants/hole.

Materials and methods

The experiment was carried out in the Vegetable Research Farm of the Gezira Research Station at Wad Medani Sudan (14° 6'N 33° 38'E, 400m asl) Soil of the Farm belongs to the heavy cracking clay plains of central Sudan, During the winter season of 2009/10 and the autumn of 2010 to study the effects of intra-row spacing and number of plants per hill on yield and quality of irrigated watermelons under Gezira conditions. Treatments consisted of three intra-row spacing 50, 70 and 90 cm and three number of plants/hole 1, 2 and 3 (Table 1)

Sowing dates on 19th October 2019/10 and 24th July 2010, treatments were arranged in randomize complete block design with 3 replicates. The land was first cleaned and then disc ploughed, harrowed, leveled and then divided into raised beds 3m wide. Experimental units were formed to include two beds 8m long (48m²). Urea (46% N) was applied at the rate of 86kg/ha in two equal doses at 4 and 7weeks after sowing, other cultural practices were done as recommended by ARC. The data consisted of growth, yield and quality (measured as TSS) parameters of watermelon. The data collected from the experiment was subjected to analysis of variance procedure using the GenStat computer package.[4]

Table 1 Factorial combinations of 3 intra-row spacing and 3 numbers of plants/hole and their projected plant populations/ha

Treatment number	Intra-row spacing	No. of plants/hole	Plant population/ha (X1000)
1	50cm	1	11.7
2	50cm	2	23.3
3	50cm	3	35
4	70cm	1	8.3
5	70cm	2	16.7
6	70cm	3	25
7	90cm	1	6.7
8	90cm	2	13.3
9	90cm	3	20

Results

Results show in Table 3, Figure 1 & Figure 2indicated no significant effects of intra-row spacing and number of plants/hole or their interaction on vine length, number of branches/plant and number of

leaves/plant in both seasons. No significant effects were detected for the intra-row spacing, number of plants/ha and their interaction on the number of marketable fruits/ha in the both seasons; except the main effect of the number of plants/hole in the *kharif* season which illustrated very highly significant effect (Table 3). The highest number of marketable fruits/ha in the *kharif* season was obtained with a single plant per hole. The effects of intra-row spacing, number of plants/hole and their interaction, in the winter and *kharif* season, on marketable watermelon yield are show in Table 4. Very highly and highly significant differences were observed for the main effects and interactions of the two factors in both seasons; except for the main effect of the intra-row spacing in the *kharif* season. The highest marketable yield was obtained from intra-row spacing of 70cm and one plant/hole in both seasons. The lowest yield in the winter season was scored by the intra-row spacing of 50cm intra-row spacing with three plants/hole and 70cm intra-row spacing with two plants/hole in the *kharif* season. No significant effects were detected for the main effects of intra-row spacing or the interaction between the intra-row spacing and the number of plants/hole for watermelon fruits quality as measured by percentage total soluble solids (TSS). Significant differences were detected only for the main effects of the number of plants/hole in the two seasons. The highest TSS was obtained when one plant is kept/hole in both seasons (Figure 3).

Table 2 Effect of intra-row spacing and number of plants/hole (P) on plant length of watermelon

| Intra-row spacing | Plant length (cm) | | | | | | | |
| | Winter season 2009/10 | | | | Kharif season 2010 | | | |
	P1[Ω]	P2	P3	mean	P1	P2	P3	mean
50 cm	145	167	152	152	148	170	147	155
70 cm	148	120	142	142	151	123	162	145
90 cm	159	115	133	133	142	118	126	129
mean	151	134	143	143	155	145	129	143
CV (%)	18.4				17.1			
	Statistics:				Statistics:			
			Prob.	SE(±)			Prob.	SE(±)
	Intra-row (S)		0.323	-	Intra-row (S)		0.102	-
	Plants/hole (P)		0.414	-	Plants/hole (P)		0.672	-
	S × P		0.161	-	S × P		0.234	-

[Ω]P1, one plant/hole; P2, two plants/hole; P3, three plants/hole.

Table 3 Effect of intra-row spacing and number of plants/hole (P) on number of marketable fruits/ha of watermelon

| Intra-row spacing | Number of fruits/ha (X 1000) | | | | | | | |
| | Winter season 2009/10 | | | | Kharif season 2010 | | | |
	P1[Ω]	P2	P3	mean	P1	P2	P3	mean
50cm	4.31	4.58	6.25	5.05	5.55	5.42	5.83	5.6
70cm	5.28	4.72	5.42	5.14	5.83	5	5.42	5.42
90cm	6.25	5.14	5	5.46	5.83	4.86	5.69	5.46
mean	5.28	4.81	5.56	5.22	5.74	5.09	5.65	5.49
CV (%)	14.5				12.8			
	Statistics:				Statistics:			
			Prob.	SE(±)			Prob.	SE(±)
	Intra-row (S)		0.489	-	Intra-row (S)		0.7	-
	Plants/hole (P)		0.144	-	Plants/hole (P)		0.02	0.15
	S × P		0.35	-	S × P		0.466	-

[Ω]P1, one plant/hole; P2, two plants/hole; P3, three plants/hole.

Table 4 Effect of intra-row spacing and No. of plants/hole (P) [Ω] on marketable yield of watermelon at Gezira Research Station

| Intra-row spacing | Marketable yield (ton/ha) | | | | | | | |
| | Winter season 2009/10 | | | | Kharif season 2010 | | | |
	P1[Ω]	P2	P3	mean	P1	P2	P3	mean
50cm	11.2	11	9.5	10.5	11.2	11	10.7	11
70cm	12	9.7	10.5	10.7	12.1	10.3	10.7	11
90cm	11.7	10.2	10.7	10.9	11.2	10.3	10.7	10.8
mean	11.6	10.3	10.2	10.7	11.5	10.5	10.7	10.9
CV (%)	5				3			
	Statistics:				Statistics:			
			Prob.	SE(±)			Prob.	SE(±)
	Intra-row (S)		<0.001	0.019	Intra-row (S)		0.231	-
	Plants/hole (P)		<0.001	0.019	Plants/hole (P)		<0.001	0.11
	S X P		<0.001	0.032	S X P		0.004	0.19

[Ω]P1, one plant/hole; P2, two plants/hole, P3, three plants/hole.
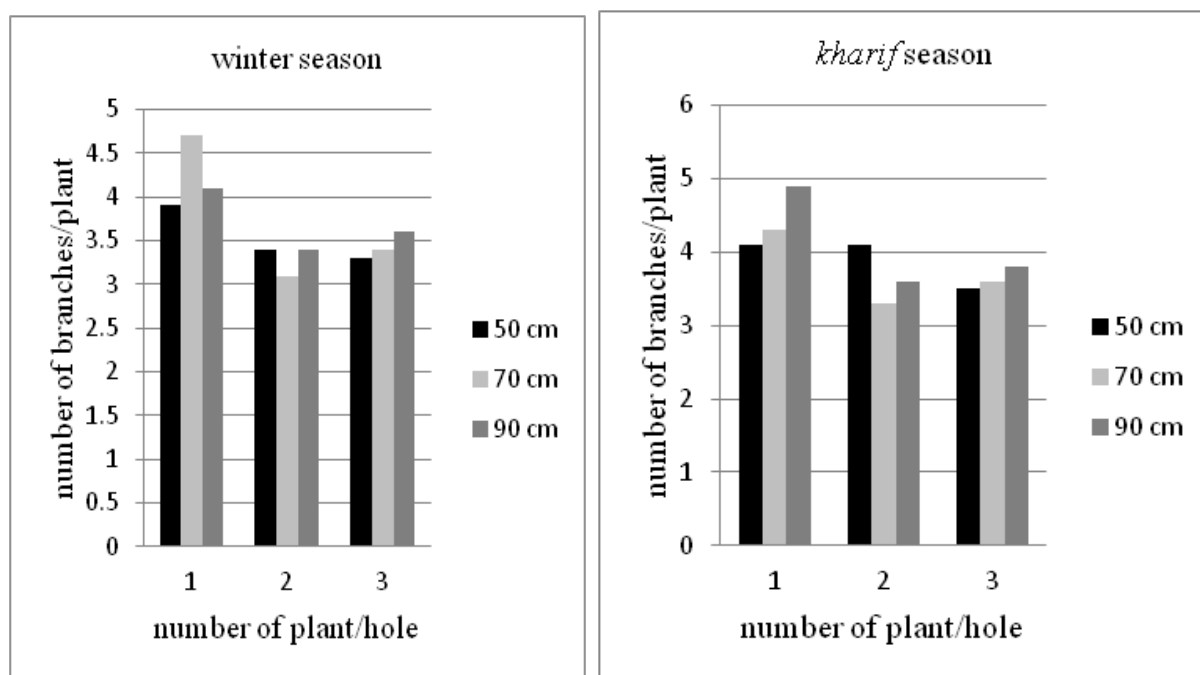

Figure 1 Effect of number of plant/hole on number of branches/plant of watermelon.

Discussion

Results of plant growth obtained from winter and *kharif* seasons were in agreement with those reported by Dean,[5] who found no influence of intra-row spacing on growth parameters of muskmelon. In both seasons, the number of marketable fruits/ha produced by one plant/hole increased with an increase in plant spacing. This result was in agreement with those reported by Maynard & Scott[6] who stated that in the wider spaced plants, the area allotted for development of the single plant is larger and hence provide a possibility for more lush growth and development of fruit bearing branches. For high densities, plants compete with each other for nutrients, water and light and, therefore, develop less fruiting branches. In both seasons, the intra-row spacing of 70cm with one plant/hole (8.3 thousand plants/ha) gave the highest marketable yield and TSS followed by the 90cm and one plant/hole (6.7 thousand plants/ha) and then the 50cm and one plant/hole (11.7 thousand plants/ha). Similar observations were reported by[2] who stated that watermelon yield per unit area tends to increase with plant density up to a certain level and then decrease due to interplant competition.
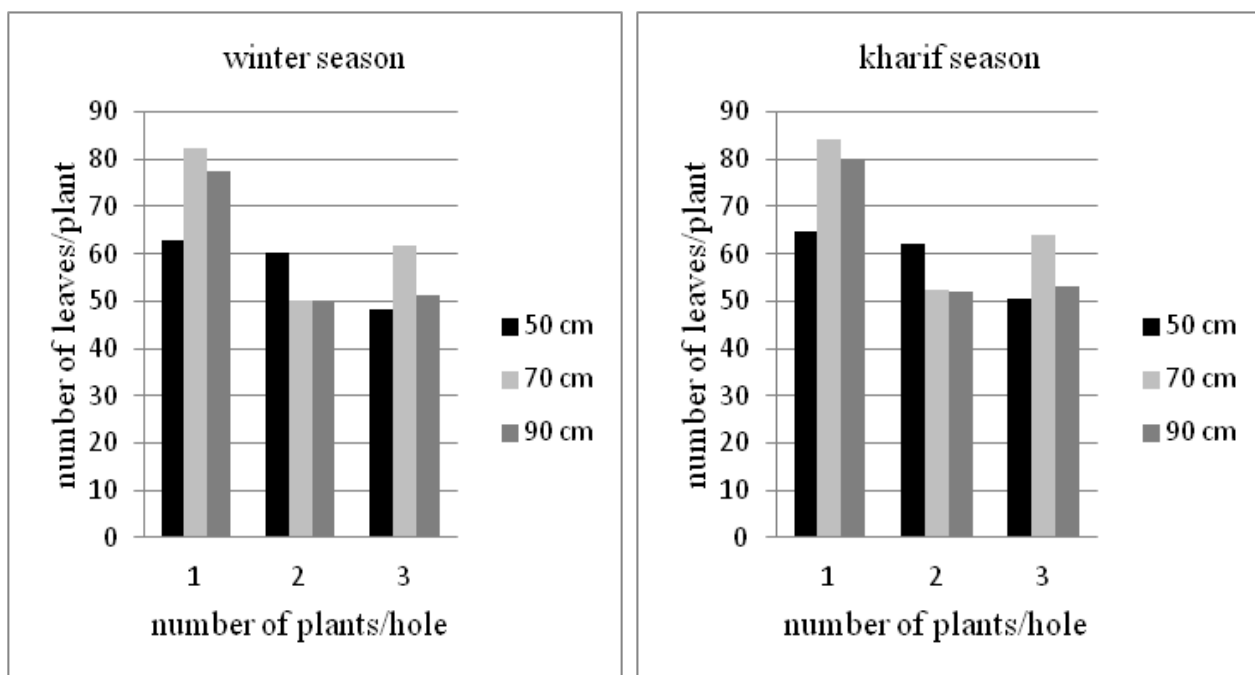
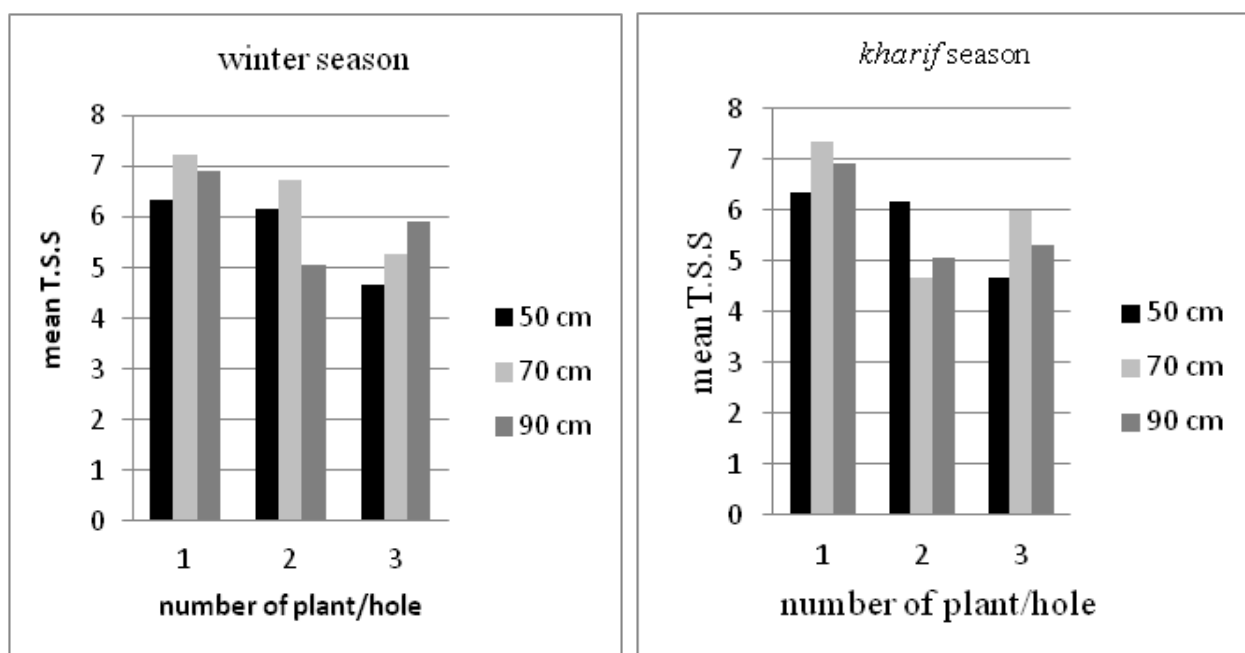**Figure 2** Effect of number of plants/hole on number of leaves/plant of watermelon.

Figure 3 Effect of number of plants/hole on TSS of watermelon.

Conclusion

Highly significant effects of intra-row spacing and number of plant/hole were detected on weight of marketable fruits and the highest weight was obtained from 70cm intra-row spacing with one plant/hole in both seasons.

Watermelon quality was highly affected by number of plants/hole and the sweetest fruits (high TSS %) were obtained from keeping one plant/hole in both seasons. According to the results of this study 70cm intra-row spacing with one plant/hole can be suggested as the optimum planting method to produce quality watermelon with high yield in the Gezira area, Sudan.

Acknowledgements

Conflict of interest

Author declares that there is no conflict of interest.

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