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Effect of Weeding Frequencies on Growth and Yield of Two Roselle (*Hibiscus sabdariffa* L) Varieties under Rain Fed

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Abstract: Fields experiments were conducted at North Kordofan state, Sudan, on naturally infested fields within the same area, using three similar fields during 2008/2009 rainy season, to determine optimal weeding frequency for weeding management in two widely used cultivated varieties of *Hibiscus sabdariffa* L, (Elrahad and Elfashir). The weeding (hand hoeing) treatments consisted of four levels (no weeding, weeding once (at 2weeks), weeding twice (at 2 and 3 weeks) and weeding three times (at 2, 4 and 6 weeks after sowing). Weeding three times at 2, 4 and 6 weeks after sowing was optimal for plant height, leaf area index, number of branches, number of calyces per plant, calyx diameter and. calyces yield per unit area. Elfahsir variety was a superior in all frequencies of weeding. The land used was dominated by *Cenchrus biflours* L.

Key words: *Hibiscus sabdariffa*, weeding, leaf area index, yield

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L) family Malvaceae, known commonly as "Karkade". It is known under different names in different countries viz roselle, razelle, sorrel, red sorrel, Jamaica sorrel, Indian sorrel, Guinea sorrel, sour -sour, and Queens land jelly plant (mahadevan *et al.,* 2009; morton, 1987). Roselle is an important cash crop and source of income for small farmers of western Sudan, especially, North Kordofan State. The Crop is grown mainly in traditional farming system, exclusively under rainfed conditions.

Morduck (Mordock, G.P., 1959). Suggested West Africa as center of origin, from there it was carried to India and other parts of Asia and by slave trade to Central America and U.S.A. Cobley (1975). reported that Hibiscus originated in West Africa and have been grown in many tropical countries and India.

The species sabdariffa according to Crane (1949) was probably brought to the western hemisphere by slave from Africa and its use in Jamica was as early as 1707.

Hacket and Carolene (1982) reported that roselle is a short day plant with a critical photoperiodic of 12-12.5 hours and grown successively at temperature of 25 to 35 ˚ C. The plants grow well in the most soils especially well-drained soils. It tolerates poor soils, and it's often grown as a supplementary rather than primary crop (Martinez, A., M.H., Bernal and A., Casers, 2000). The total area annually cultivated in Sudan is estimated about 18,000 ha (Mclean, K., 1973). The total area planted in Kordofan State is variable is highly affected by the prevailing prices and the presence of market. North Kordofan State alone planted about 16, 000 ha during 1997-98 with total production of 123 tons (Abulgasim, E.H., 1998). Roselle has many industrial and domestic uses. Locally, in the Sudan it is used as a beverage, where the dried calyx is soaked in water to prepare a colorful cold drink. Traditionally the product has been used for medicinal purposes for relief of sour throat and for healing wounds as an anti-septic (Aziz, E.E., N. Gad and N.M., Badran, 2007).

Mahadevan *et al* (2009) reported that, in many parts of the world leaves is consumed as green vegetable and the stem is used as a source of pulp for paper industry. Seeds used as a poultry feed and as an aphrodisiac coffee substitute (Anonymous, 1959, Khidir, M.O., 1997). In crops as general, Parker and Freyer, (1975) reported that, weed competition reduced crop yields by about 5 % in commercial agriculture, 10% in semi commercial agriculture and 20 % in subsistence agriculture.

The main problems limiting production and expansion roselle pointed out by Elawad, (2001) are: Scarcity and reliability of rainfall, Limited research and agricultural extension services, Poor cultural practices, inadequate weed control and Harvest problems. Hand hoeing is still by far the most widely practiced cultural

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weed control technique in field crop production throughout the tropics because of the prohibitive costs of herbicides and fear of toxic residue coupled with the lack of knowledge about their use. The objectives of this study were: to investigate the effect weeding frequencies on growth, yield and yield's components of *Hibiscus sabdariffa* L.

MATERIALS AND METHODS

A field experiment was conducted during season 2008/2009 under rainfed conditions in three fields naturally weeds infested in North Kordofan State, Sudan. The fields were: Abu Haraz, Kordofan University farm and Khor taqqat. The experiment was laid out in a randomized complete block design (RCBD) with four replications. The plot size was 5×4 meters consisted of 7 rows with 5 m along. The weeding treatments consisted of four levels (no weeding, weeding once (at 2weeks), weeding twice (at 2 and 3 weeks) and weeding three times (at 2, 4 and 6 weeks after sowing) designated as W_0, W_1, W_2 and W_3 respectively. Two widely used cultivated varieties of roselle (Elrahad, and Elfashir) were used in the experiment, designated as V_1 and V_2, respectively. Sowing dates on 11th, 16th and 20th of July for Abu Haraz, Kordofan University farm and Khor taqqat respectively. Seeds were sown on rows at spacing of 70 cm apart and 40 cm within row, five seeds were placed in each hole. The plants were thinned to two plants per hole, two weeks later. The weed species found at each site were recorded at 15 DAS and then continued as interval of 14 days. Weeds counts made by placing the quadrate (0.5m x 0.5m) at random locations in plots repeated four times in order to obtain a reasonably good estimate of small weeds. The relative weed densities were calculated.

Growth Attributes:

A sample of five plants was taken at random from inner rows in each experimental unit at 45 days after sowing, then continued at interval of 14 days to measure the following growth attributes.

-Plant height: measured from the ground level to the tip of the plant.

-Number of branches per plant: determined by counting reproductive branches.

-Leaf area index (L.A.I).

Leaf area index (L.A.I), a dimensionless quantity, is the leaf area (upper side only) per unit area of soil below.

It is expressed as m^2 leaf area per m^2 ground area. Leaf area was determined using the punch method[34] by taking 10 leaf discs, using a puncher of 10 mm diameter. The discs were weighed dry (at 85ºC for 24 hours). The leaf area was calculated from the following relationship:

$$\text{Leaf area} = \frac{\text{Total area of leaf discs}}{\text{Dry weight of leaf discs}} \text{ X Total dry weight of leaves}$$

And leaf area index (L.A.I) was determined as following:

$$\text{Leaf area index} = \frac{\text{Leaf area per plant}}{\text{Plant ground area}}$$

Yield Attributes:

A destructive sample of five plants was taken at random from the five inner rows of experimental plot at maturity to measure the following yield attributes.

-Number of capsules per plant

-Capsule diameter (cm): by using a Vernier

- Calyces yield per plant (g): The calyces of five plants were peeled off from the capsules by using simple hand tools. The calyces were dried under shade to constant weight, and then average calices yield per plant (g.) was determined.

- Final calyces yield (kg / ha). Calculated by using the following formula:

$$\text{Calyces yield (Kg /ha)} = \frac{\text{calyces yield (kg) of plot}}{\text{Harvested plot area } (m^2)} \text{ x } 10000$$

- Harvest index was determined by using the following formula:-

$$\text{Harvest index} = \frac{\text{Economical Yield (calyces per plant)}}{\text{Biological yield (shoot dry weight)}} \text{ X } 100$$

Data were analyzed statistically using analysis of variance according to Gomez and Gomez (1984) procedure for a randomized complete block design. The differences of means were identified by Duncan's Multiple Range Test (DMRT) at $P \geq 0.05$.

RESULTS AND DISCUSSION

Weeds and Stand:

The majority of weeds in the experimental sites were the broad leaves (dicotyledons), while grasses (monocotyledons) found in a lesser density (Table 1)**.** The dominant weed flora infesting Roselle (Karkade) during growing season were *Cenchrus biflorus* L (Alhuskaneet), *Zornia glochidiata* L (Sheilini) and *Trienemara pentanture* L (Alraba). They had relative weeds density of 26%, 22% and 12% respectively.

Growth Attributes:

Increased weeding frequencies increased plant height (Table 2). The significant differences in plant height among treatments may be attributed to the competition of weeds for soil moisture, nutrients, light and carbon dioxide. Weeding facilitates plants to have more resources for growth, these results agreed with Joshi[17], who showed that, increasing weeding times increased plant height, due to efficient weed control. Rolfs[29] reported that, when the plant height of roselle reach 1.5 to 2 ft weeds will be shaded out and no longer problems. Weeds decreased the plant height. Similar findings were obtained by Spines*, et al.* (1959) in cotton, who found that weeds decreased the height of plants.

Generally Elfashir cultivar (V_2) had significantly greater plant height than (V_1). Significant Differences in plant height among cultivars were reported by many workers: Cheweya (1992) and sulaiman (2005). The significant differences among weeding treatments in leaf area index (LAI) were observed in this study. Increased weeding frequencies increased leaf area index (Table 3). This was due to better control of weeds. The reduced competition and increased availability of resources like nutrients, soil moisture and light paved way for higher leaf area per plant (leaf area index). These results are conformity with the findings of Kumara *et al* [20]. There were no significant differences between cultivars in leaf area index at all locations.

In the present study, weeding exhibited significant differences in mean number of branches per plant (Table 4). This result may be attributed to vigorous plant with less competition for light, nutrients, and free space in weed free environment. Similar results were reported by Malik *et al.* (1983) in cotton, Adejonow (1988) in okra and Gaffer (1984) in cotton. They noted that improvement in yield contributing factors was due to hand hoeing.

Yield Attributes:

In the present study, increased levels of weeding increased the number of calyces per plant (Table 5). These results agree with Small , Adjun (2003) and Baylan et al. (1983). They showed that weeding three times resulted in high crop vigor score in number of calyces per plant. Moreover Ibeawuchi *et al.* [16] reported that component of yield; pod number per plant can severely reduced by weed competition. The conservation water by plants due to weeding frequency could explain this result and this facilitating the growth essentials for regulating growth. The non significant differences among cultivars in number of calyces per plant might be to genotypic factors. Sulaiman (2005) reported that a significant variation among roselle cultivars in number of calyces per plant. Significant differences in the calyx diameter were observed among weeding treatments (Table 6). W_0 weeding produced significantly lower mean calyx diameter compared with other weeding (W_1, W_2, and W_3). This result indicated that at least one weeding improved calyx diameter. Vanvalkenburg *et al.* (2002) stated that, weeding increased calyx size in roselle crop.

Significant differences among cultivars in calyx diameter were obtained; by Mahmoud *et al*. (1996) and Sulaiman(2005). They reported that land races of roselle in Sudan have considerable variation in size of calyx. Increased weeding frequencies increased the calyces yield per unit area (Table 7). This is because the number of calyces per plant and calyces diameter improved with levels of weeding, which led to increased yield (g /plant) and finally increased yield per unit area. Khater and Ahmed[18] found that the competition of weeds for light, water and minerals reflected on metabolic process of the plant and finally caused reduction in yield.

Chowdhury *et al.* (1995) reported that, weed free regime gave the highest yield than no weeding regime. Elfashir (V_2) had greater yield per unit area than Elrahad (V_1). This is because V_2 cultivar had the highest calyx's number and calyx diameter. Similar findings reported were by Sulaiman[32]. Non significant differences were reported among the treatment in harvest index (Table 8). This is because the weeding frequencies and variety had similar effect in the economical and biological yield. These results are different from that obtained by Alam *et al*. (1995) in cotton.

Table 1: Weeds species, classification and their relative density of non weeded roselle during the growing season in the experimental sites (mean of three fields).

Scientific name	Classification	Common name	Weeds density
Zornia glochidiata.	Dicot	Sheilini	22%
Cenchrous biflours.	Monocot	Alhuskaneet	26%
Trienemra pentanture.	Dicot	Alraba	12%
Sesamum alatum.	Dicot	Simsim Elgumal	3%
Ocimum basilicum.	Dicot	Elryhan	0.7%
Allium spp.	Bulb	Bureaj	1.3%
Echinocola colonum.	Monocot	Aldiffera	3%
Rullia patula.	Dicot	Tagtaga	9%
Corchorus olitorius.	Dicot	Almlukhia	3%
Tribulus trerrestris.	Dicot	Aldraisa	0.3%
Ipomea kordofana.	Dicot	Eltabar	1.6%
Solanum dobium.	Dicot	Aljubain	5%
Abutilon figarinum.	Dicot	Alniada	7.2%
Ipomea sinensis.	Dicot	Elhantoot	0.1%

Table 2: Effect of weeding frequencies and cultivar on plant height (cm) of roselle.

Treatments	Abu Haraz			Kordofan University farm			Khor taqqat		
	45 DAS	60 DAS	75 DAS	45 DAS	60 DAS	75 DAS	45 DAS	60 DAS	75DAS
W_0	11.65 ^{c}	14.05 ^{c}	17.30 ^{c}	12.81 ^{a}	17.75 ^{c}	23.48 ^{c}	17.90 ^{a}	21.08 ^{a}	25.51^{a}
W1	19.55 ^{b}	26.33 ^{b}	37.35 ^{b}	18.46 ^{a}	27.73 ^{b}	44.45 ^{b}	22.30 ^{a}	31.30 ^{b}	52.95^{b}
W2	21.21 ^{a}	29.80 ^{a}	42.01 ^{a}	18.72 ^{a}	31.23 ^{a}	48.20 ^{a}	21.01 ^{a}	33.53 ^{b}	53.67 ^{b}
W3	34.10 a	32.00 a	44.10 a	21.06 a	32.85 a	51.50 a	24.08 a	37.26 b	54.70 b
SE±W	6.15	0.69	2.09	0.78	1.65	1.72	0.96	1.81	3.56
V1	19.10 ^{b}	25.84 ^{a}	37.04 ^{a}	18.08 ^{a}	29.68 ^{a}	45.65 ^{a}	21.63 ^{a}	32.60 ^{a}	51.25 ^{a}
V2	24.16 ^{a}	25.84 ^{a}	33.34 ^{a}	17.45 ^{a}	25.10 ^{a}	38.17 ^{b}	21.01 ^{a}	28.98 ^{a}	42.17 ^{b}
SE±V	4.35	0.49	1.48	0.55	1.17	1.22	0.68	1.28	2.52
SE±W×V	8.71	0.98	2.96	1.11	1.65	2.43	1.36	2.56	5.03
CV%	5.43	7.69	16.48	12.48	17.07	11.61	12.77	16.88	20.83

Table 3: Effect of weeding frequencies and cultivar on leaf area index (LAI) of roselle.

Treatments	Abu Haraz			Kordofan University farm			Khor taqqat		
	45 DAS	60 DAS	75 DAS	45 DAS	60 DAS	75 DAS	45 DAS	60 DAS	75 DAS
W0	0.49^{b}	0.58^{b}	0.66^{b}	0.58^{b}	0.59^{b}	0.59^{b}	0.48^{b}	0.53^{b}	0.64^{b}
W1	1.53^{a}	1.73^{b}	1.96^{a}	1.84^{a}	2.08^{a}	2.08^{a}	1.04^{a}	1.18^{a}	1.28^{a}
W2	1.45^{a}	1.64^{a}	2.24^{a}	2.17^{a}	2.36^{a}	2.36^{a}	1.12^{a}	1.29^{a}	1.43^{a}
W3	1.62^{a}	1.86^{a}	2.21^{a}	2.23^{a}	2.36^{a}	2.36^{a}	1.02^{a}	1.17^{a}	1.27^{a}
SE±W	0.09	0.12	0.19	0.10	0.13	0.13	0.07	0.07	0.09
V1	1.24 ^{a}	1.43 ^{a}	1.78 ^{a}	1.63 ^{a}	1.69 ^{b}	1.69 ^{b}	0.95 ^{a}	1.08 ^{a}	1.24 ^{a}
V2	1.31^{a}	1.47^{a}	1.76^{a}	1.79^{a}	2.00^{a}	2.00^{a}	0.88^{a}	1.00^{a}	1.07^{a}
SE±V	0.07	0.08	0.14	0.07	0.09	0.09	0.05	0.05	0.68
SE±W×V	0.13	0.17	0.27	0.14	0.18	0.18	0.10	0.09	0.13
CV%	14.62	23.24	13.12	16.70	25.30	25.30	21.82	19.06	22.07

Similar letters are not significantly different at the 0.05 level of probability according to Duncan multiple ra

Table 4: Effect of weeding frequencies and cultivar on number of branches per plant of roselle.

Treatments	Abu Haraz			Kordofan University farm			Khor taqqat		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
W0	0.45	0.35	0.40^{c}	0.50	0.70	0.60 c	0.50	0.50	0.50^{b}
W1	4.35	4.55	4.45^{b}	8.00	5.30	6.65^{b}	2.85	2.90	2.88^{a}
W2	6.03	5.40	5.71^{a}	8.25	6.45	7.35^{a}	3.00	3.80	3.40^{a}
W3	6.45	7.85	7.15^{a}	8.40	7.40	7.90 ^{a}	3.50	4.35	3.92^{a}
Mean	4.32^{a}	4.54^{a}		6.29^{a}	4.96^{a}		2.46^{a}	2.89^{a}	
SE± W	0.45			0.48			0.29		
SE± V	0.31			0.34			0.20		
SE±W×V	0.63			0.69			0.41		
CV %	28.42			24.36			29.41		

Similar letters are not significantly different at the 0.05 level of probability according to Duncan multiple range test.

Table 5: Effect of weeding frequencies and cultivar on number of calyces per plant

Treatments	Abu Haraz			Kordofan University farm			Khor taqqat		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
W0	3.00 ^{e}	3.50 ^{e}	3.25 ^{c}	3.00 ^{e}	2.75 ^{e}	2.88 ^{c}	2.25	2.00	2.13^{a}
W1	13.50 ^{d}	15.75 ^{c}	14.64 ^{b}	15.25 ^{b}	11.25 ^{c}	13.25 ^{b}	9.75	8.25	9.00^{a}
W2	15.25 ^{c}	21.50 ^{b}	18.38 ^{a}	13.75 ^{c}	15.75 ^{b}	14.75 ^{b}	11.00	10.50	10.75^{a}
W3	16.00c	27.50a	21.75a	14.25b	32.25a	18.75a	10.50	12.75	11.63^{a}
Mean	11.94b	17.06a		11.50b	15.50a		8.38	8.38	
SE± W	1.40			1.73			0.63		
SE± V	0.99			1.22			0.44		
SE±W×V	1.98			2.45			0.88		
CV %	27.26			39.36			21.09		

Similar letters are not significantly different at the 0.05 level of probability according to Duncan multiple range test.

Table 6: Effect of weeding frequencies and cultivar on calyx diameter (cm) of roselle.

Treatments	Abu Haraz			Kordofan University farm			Khor taqqat		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean\
W0	2.12	2.59	2.36^{b}	2.21	2.51	2.36^{b}	2.47	2.56	2.51^{a}
W1	2.69	2.75	2.72^{a}	2.61	2.72	2.66^{a}	2.63	2.67	2.65^{a}
W2	2.63	2.76	2.69^{a}	2.68	2.79	2.73^{a}	2.56	2.67	2.61^{a}
W3	2.67	2.78	2.72^{a}	2.73	2.83	2.78^{a}	2.60	2.63	2.61^{a}
Mean	2.53^{b}	2.72^{a}		2.56^{b}	2.71^{a}		2.57^{a}	2.63^{a}	
SE± W	0.042			0.06			0.04		
SE± V	0.03			0.04			0.03		
SE±W×V	0.06			0.08			0.06		
CV %	4.48			5.95			4.74		

Similar letters are not significantly different at the 0.05 level of probability according to Duncan multiple range test.

Table 7: Effect of weeding frequencies and cultivar on calyces yield (kg / ha) of roselle.

Treatments	Abu Haraz			Kordofan University farm			Khor taqqat		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
W0	58.56^{e}	124.42^{e}	91.49^{c}	61.13^{e}	71.31^{e}	66.22^{c}	58.80	60.67	59.78^{c}
W1	354.87^{c}	662.24^{b}	508.55^{b}	358.31^{c}	276.24^{c}	317.28^{b}	173.5	200.71	187.33^{b}
W2	371.7^{c}	779.84^{b}	575.81^{b}	449.33^{b}	804.11^{a}	662.72^{a}	198.08	208.30	198.90^{b}
W3	435.04^{c}	1190.80^{a}	812.92^{a}	422.50^{b}	925.24^{a}	673.87^{a}	195.37	294.37	244.70^{a}
Mean	305.06^{b}	689.32^{a}		322.83^{b}	519.23^{a}		156.55	191.03	
SE± W	44.11			36.84			17.89		
SE± V	31.1			26.05			12.56		
SE±W×V	62.39			25.10			25.30		
CV %	25.35			24.41			27.63		

Similar letters are not significantly different at the 0.05 level of probability according to Duncan multiple range test.

Table 8: Effect of weeding frequencies and cultivar on harvest index (H. I %) of roselle.

Treatments	Abu Haraz			Kordofan University farm			Khor taqqat		
	V1	V2	Mean	V1	V2	Mean	V1	V2	Mean
W0	13.74	26.76	20.25^{a}	13.58	17.66	15.62^{a}	13.23	15.95	14.59^{a}
W1	21.00	29.41	25.21^{a}	17.13	21.00	19.16^{a}	18.45	17.77	18.01^{a}
W2	21.77	26.77	24.27^{a}	19.55	18.62	19.06^{a}	19.50	21.00	20.25^{a}
W3	16.35	27.89	22.12^{a}	19.80	21.66	20.73^{a}	18.66	19.07	18.85^{a}
Mean	18.12^{b}	27.17^{a}		17.65^{a}	19.73^{a}		17.45^{a}	18.45^{a}	
SE± W	1.38			1.48			1.41		
SE± V	0.98			1.05			0.99		
SE±W×V	1.95			1.05			1.99		
CV %	17.00			22.57			22.26		

Similar letters are not significantly different at the 0.05 level of probability according to Duncan multiple range test

Conclusion:

Hand hoeing three times at 2, 4 and 6 weeks after sowing is effective to control weeds and recommended to improved calyxes' yield of *Hibiscus sabbadariffa* in north Kordofan of Sudan.

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