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Effect of Competition and Seed Rates on Forage Production of *Crotalaria saltiana* at Central Darfur State, Sudan

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Abstract: *The study was conducted at experimental field of Agricultural Research Corporation (Nertiti Station), Western Jebel Marra Locality (WJML) Central Darfur State, Sudan. The aim objective was to determine the effect of weeds reduction and seed rates on growth and other yield attributes of Crotalaria saltiana plant. A split plot design was used with four replications. The main plot included weed reduction (Weeded) and no weeding (un-weeded). Weeding was done via hand mowing. Three seed rates were also applied as sub-plot: 10, 20 and 30kg/ha. Data were analyzed by MSTAT-C. The results indicated that weeded ×20 kg/ha seed rates treatment was significantly different from un-weeded ×30 kg/ha seed rates treatment; also highly significant differences were shown between the same treatment and un-weeded ×10 kg/ha seed rate treatment on Crotalaria saltiana biomass production in the second season, where their average yield reach 2470.7, 1368.0 and1193.0 kg DM/ha respectively. These results confirmed the importance of weed control in forage production either in rain fed or even in extensive irrigation schemes. The treatment was stated earlier is recommended for Crotalaria saltiana forage production in (WJML).*

Key words: *Biomass, Weeds Mowing, Tillers, Leaves.*

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I. Introduction

In Sudan more than 80% of the population lives in rural areas and is engaged in one way or another in agricultural production (Hamdoun, 1997). Agriculture is importance in the national economy is manifested in providing food, feed, foreign exchange, fuel and employment. With the ever rising demand for food to feed a rapidly growing population, crop yield and animal production must be increased through adoption of good husbandry techniques, including weed control (Braun, 1991). Some control of erect annual dicotyledonous weeds may be achieved by mowing when their apical parts are above the cutting height. Most prostrate or rosette species, e.g. *Capsella bursa-pastoris* (shepherd's- purse), *Galiumaparine* (Cleaves), *Stelaria media* (Common chick weed) and *Acanthospermum hespidum* (Horabhawsa), may actually be encouraged by mowing (Stephens, 1982), also the same author indicated that there was little scope for preventing weed ingress by increasing seed rates much above 15- 25 kg/ha. In *Sorghum bicolar* seeding rate did not affect any of the seed yield and yield components measured (Yunhua Han *et al.*, 2013). Sowing and weeding significantly affected number of leaves per plant of *Blepharis linarifolia* after 30 days from sowing. Neither sowing method nor did weeding had significant effect on plant height (Abla and Adar 2015). Higher yields at narrower row spacing could be explained by improved light interception and decreased intra-row competition between plants (Steiner, 1986 and De Bruin and Pederson, 2008). New ryegrass seed is often drilled at 18-30 kg/ha, although previous research indicated that pastures drilled at 10-12 kg/ha can be just as productive (Frame and Boyd 1986; and Praat *et al.* 1996). Lower seeding rates ranging from 116,000 to 291,000 seeds ha^{-1}did not significantly impact yields (Snider*et al*, 2012). Higher seed rates can increase biomass production in some cases, where (Stickler and Laude, 1960; Steiner, 1986; Habyarimana *et al.*, 2004; and Wortmann *et al.*, 2010) stated that the effect of seeding rate on yield in sorghum have been inconsistent, where higher seeding rates have been shown to increase dry matter productivity in some instances, and to have no effect on yield in others. Weeds are herbaceous plants growing in places where they are not wanted and interfering with the growth of the desired crop; they sometimes reduced its harvesting quality if allowed to remain (Ashton, 1991). Moreover, weeds invade sites where competing vegetation has been destroyed. Also weeds represent an economically important challenge for crop production.

The main objective of this study was to investigate the effect of weeds reduction by hand removal or by mowing and Determine optimum seed rate on growth and yield attributes of *Crotalaria saltiana* plant in Western Jebel Marra Locality (WJML), Nertiti area, Central Darfur State- Sudan.

II. Materials and Methods

The study area

The study was carried out at the experimental field of Agricultural Research Corporation (Nertiti station) –over two seasons (July-October 2016 andJuly-October2017) in (WJML) Central Darfur State, Sudan. The area is located in the western part of Jebel Marra massive and extends between latitudes 12°57´ and 13° 00´ N and longitudes 24° 02´and24°04´ E. The altitude at Nertiti is 600 m above sea level (m.a.s.l.) (DRCO 2011). Due to the influence of elevation, Jebel Marra climatic conditions resemble those of the Mediterranean region. Rainfall in the western slopes ranges between 420 mm/annum at Golol, Murtagello and Nertiti (1000 m.a.s.l.), and 1200 mm / annum at the upper slopes (2500 – 3000 m.a.s.l.).The minimum temperature ranges between 6°Cand 10°C (FAO 1980).

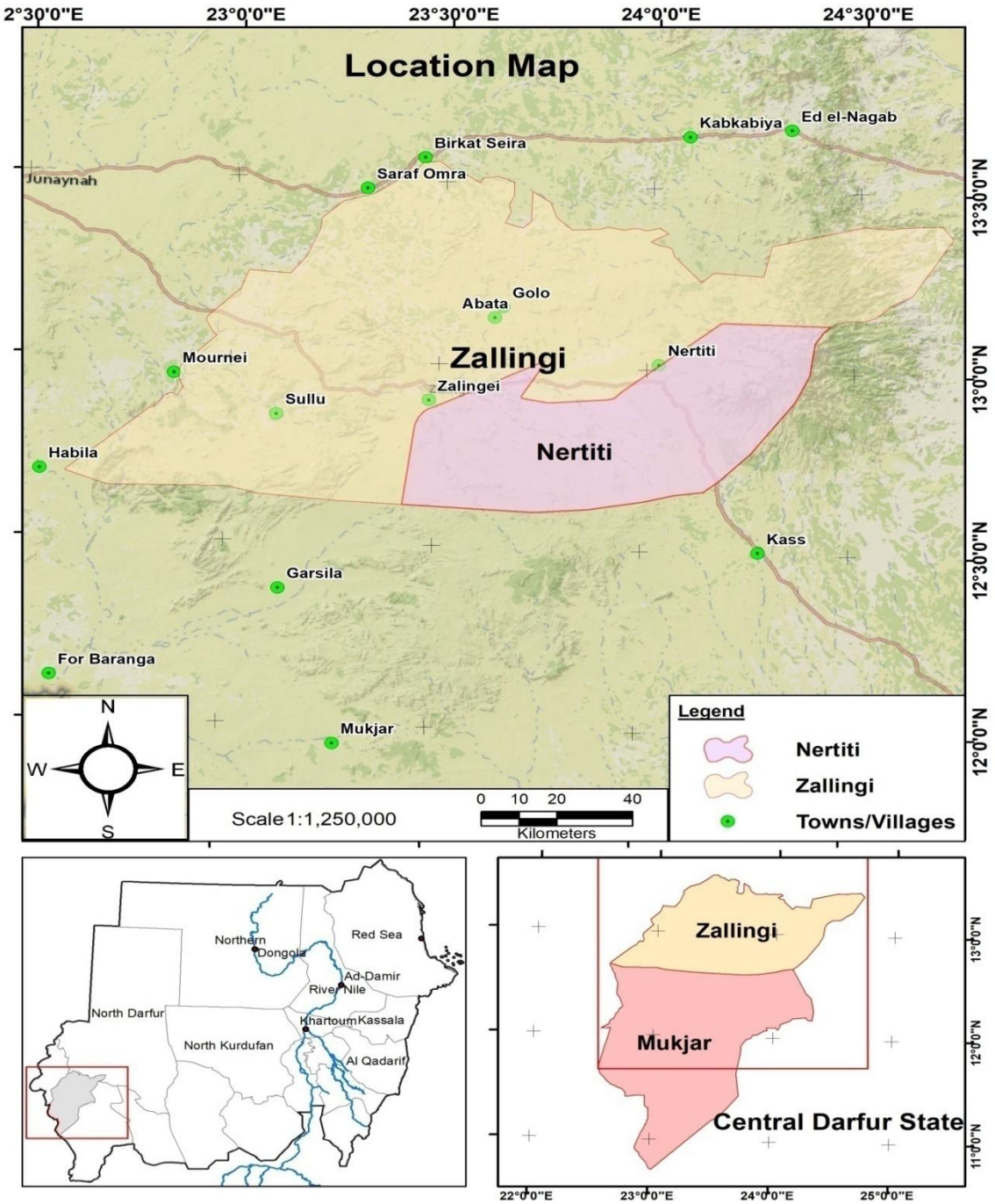

Figure1. Central Darfur State Map in Republic of Sudan- Nertiti is the head quarter of WJML

Table1. Temperature (°C) and Rainfall (mm) during 2013- 2017 in WJML

Year	Max tem (°C)	Min tem (°C)	Mean tem (°C)	Highest monthly tem (°C)	Lowest monthly tem (°C)	Rainfall (mm)
2013	36.6	9.3	23	40	4	1035.5
2014	35.8	9.8	22.8	39.9	4.5	829.4
2015	35.6	15.6	25.6	39.4	8.5	691.8
2016	37.4	15.2	26.3	39.4	9.4	846.5
2017	35.5	11.3	23.4	38.5	8.2	780.4

Source: Jebel Marra Rural Development Project Meteorological Section (2018)

Table2. Rainfall (mm) distribution during 2013- 2017 in WJML

Year	Months							
	April	May	June	July	August	September	October	Total
2013	-	11.7	81.5	287	534	121.3	-	1035.5
2014	0.9	22.6	30.3	153.7	441.4	179.8	0.7	829.4
2015	-	1.2	16.6	118.7	387.1	103.4	64.8	691.8
2016	-	8.7	96.8	229.1	419.9	85.3	6.7	846.5
2017	2.7	15.4	100.6	118.7	440.1	102.9	-	780.4

Source: Jebel Marra Rural Development Project Meteorological Section (2018)

Land preparation

The land was disc ploughed and then followed by harrowing and levelling. The area of the experiment was divided into 24 plots 2 × 2 meter each.

Competition and Reseeding Experiment

The experimental layout was a split plot arrangement with four replications. Weeds control was the main plot, while seed rates represented the sub-plot. Weeds control was practised via hand weeding and carried out through the experiment whenever necessary to evaluate the effect of competition reduction on growth attributes, where mowing method was used for that process. Un-weeded plots were left un-touched. Seeds were broadcasted under rain fed irrigation, three seed rates were used 10, 20 and 30kg/ha. Method of sowing was broadcasting seeds on flat and then covering by rake at a depth of about one (cm).The parameters investigated were plant height(m), number of tillers /plant, number of leaves /plant and biomass production (kg DM/ha).

Competition and Seed rates experiment layout for one replication

Species	Main plot UW	Sub-plot UW×Sr1	Sub-plot W×Sr3	Sub-plot W×Sr2
	Main plot W	Sub-plot W×Sr1	Sub-plot UW×Sr2	Sub-plot UW×Sr3

UW= un-weeded, W= mow weeded, Sr1= seed rate1 (10 kg/ha), Sr2= seed rate2 (20 kg/ha) and Sr3= seed rate3 (30 kg/ha).

Data analysis

Data were analysed using MSTAT-C statistical program, version 9.0 (Nissan, 1983). MSTAT-C and mean comparisons were made using the F-protected least significant difference for separation at 5% level of significance (Steel and Torrie, 1997).

III. Results and Discussion

The results indicated no significant differences among treatments neither on *Crotalaria saltiana* height nor tillers number per plant during the study. But significant differences were found between weeded and un-weeded treatments on number of leaves per plant and biomass production in some instances (Table 3).

Table3. Effect of competition on growth and yield attributes of *Crotalaria saltiana*

Treatment	Parameters							
	Plant height (m)		Tillers/plant		Leaves/plant		Biomass(kg DM/ha)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
W	103.96 Ns	1.05 Ns	11.02 Ns	8.09 Ns	198.7	74.45 Ns	2207 Ns	2212.1
UW	97.91 Ns	1.05 Ns	10.43 Ns	7.18 Ns	156.8*	55.67 Ns	1567 Ns	1449.8*
Mean	100.94	1.05	10.73	7.64	177.75	65.06	1887	1830.95
SL	Ns	Ns	Ns	Ns	*	Ns	Ns	*

S.L= significant level, Ns= not significant at P> 0.05, * = significant differences at P ≤0.05

As shown in table 3 above; weeding and un-weeded did not affect plant height and number of tillers per plant. These results in line with those obtained by (Abla and Adar 2015) who stated that neither sowing method nor did weeding had significant effect on plant height. In the first season weeded treatment a statistically significant effect on number of leaves per plant. This result is confirmed by findings from same authorities, who stated that sowing and weeding significantly affected number of leaves per plant of *Blepharis linarifolia* after 30 days from sowing. Significant differences were also found between weeded and un-weeded treatments on biomass production in the second season. Weeded treatment was superior by: 2212.1 and 1449.8 kg DM/ha respectively. These results agree with (Steiner, 1986 and De Bruin and Pederson, 2008) who stated that higher yields at narrower row spacing could be explained by improved light interception and decreased intra-row competition between plants.

Different seed rates treatments did not have an effect on growth and yield attributes of *Crotalaria saltiana* plant in this study (Table 4).

Table4. Effect of seed rates on growth and yield attributes of *Crotalaria saltiana*

Treatment	Parameters							
	Plant height (m)		Tillers/plant		Leaves/plant		Biomass(kg DM/ha)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Sr1	93.1 ^{Ns}	0.95 ^{Ns}	11.31 ^{Ns}	7.80 ^{Ns}	181.3 ^{Ns}	68.59 ^{Ns}	1376 ^{Ns}	1523.0 ^{Ns}
Sr2	102.7 ^{Ns}	1.11 ^{Ns}	10.23 ^{Ns}	7.21 ^{Ns}	177.6 ^{Ns}	53.60 ^{Ns}	1985 ^{Ns}	2129.5 ^{Ns}
Sr3	107.0 ^{Ns}	1.10 ^{Ns}	10.64 ^{Ns}	7.89 ^{Ns}	174.3 ^{Ns}	72.99 ^{Ns}	2300 ^{Ns}	1840.2 ^{Ns}
Mean	100.94	1.05	10.73	7.63	177.75	65.06	1887	1830.9
SL	Ns	Ns	Ns	Ns	Ns	Ns	Ns	Ns

S.L= significant level, Ns= not significant at P> 0.05, * = significant differences at P ≤0.05

This study emphasized that there was no effect of different seed rates treatments on *Crotalaria saltiana* plant height, number of tillers per plant, number of leaves per plant and biomass production during the two seasons. These results are in line with those achieved by (Yunhua Han *et al*, 2013), working with (*Sorghum bicolar*) who reported that seeding rate did not affect any of the seed yield and yield components measured. In contrast (Frame and Boyd 1986; and Praat *et al.* 1996) stated that new ryegrass seed is often drilled at 18-30 kg/ha, although previous research indicated that pastures drilled at 10-12 kg/ha can be just as productive.

The different treatments which composed weeded, un-weeded and seed rates showed that there was no interaction with regard to *Crotalaria saltiana* plant height and number of tillers per plant. But the treatment weeded with 30 kg/ha seed rates had a significant effect on number of leaves per plant compared with un-weeded involving 20kg/ha seed rates treatment in the second season. Also the weeded ×20 kg/ha seed rates had statistically significant effect on biomass yield in the second year compared with the un-weeded ×10 kg/ha and un-weeded ×30 kg/ha seed rates (Table 5).

Table5. Effect of competition and seed rates on growth and yield attributes of *Crotalaria saltiana*

Treatment	Plant height (m)		Tillers/plant		Leaves /plant		Biomass (kg DM/ha)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
W ×Sr1	0.89 ^{Ns}	0.91 ^{Ns}	11.48 ^{Ns}	7.60 ^{Ns}	199.27 ^{Ns}	75.85 ^{Ns}	1706 ^{Ns}	1853.0 ^{Ns}
W ×Sr2	1.10 ^{Ns}	1.11 ^{Ns}	10.50 ^{Ns}	7.93 ^{Ns}	194.00 ^{Ns}	64.83 ^{Ns}	2343 ^{Ns}	2470.7 ^{Ns}
W ×Sr3	1.13 ^{Ns}	1.14 ^{Ns}	11.08 ^{Ns}	8.75 ^{Ns}	202.92 ^{Ns}	82.66 ^{Ns}	2572 ^{Ns}	2312.5 ^{Ns}
UW ×Sr1	0.97 ^{Ns}	0.99 ^{Ns}	11.15 ^{Ns}	8.00 ^{Ns}	163.35 ^{Ns}	61.33 ^{Ns}	1046 ^{Ns}	1193.0**
UW ×Sr2	0.96 ^{Ns}	1.10 ^{Ns}	9.95 ^{Ns}	6.50 ^{Ns}	161.25 ^{Ns}	42.37*	1627 ^{Ns}	1788.3 ^{Ns}
UW ×Sr3	1.01 ^{Ns}	1.06 ^{Ns}	10.20 ^{Ns}	7.03 ^{Ns}	145.73 ^{Ns}	63.32 ^{Ns}	2027 ^{Ns}	1368.0*
Mean	1.01	1.05	10.73	7.63	177.75	65.06	1886.8	1830.9
CV	1.32	17.10	20.7	21.11	25.1	36.53	25.6	37.71
SL	Ns	Ns	Ns	Ns	Ns	*	Ns	**
SE±	0.10	0.09	1.8	0.81	0.39	11.88	0.73	34.52

Ns= not significant at P> 0.05, * = significant at P ≤0.05, **= high significant at P <0.01

The study revealed that interaction between different treatments did not have an influence in Crotalaria saltiana plant height and number of tillers per plant. These results indicated that hand weeding and seed rates had inconsistent results; where they sometimes encourage plants to release more tillers while in others they led to reduction in tillers. These results are similar to those found by (Stephens, 1982) who reported that there was little scope for preventing weed ingress by increasing seed rates much above 15- 25 kg/ha. No difference was observed between treatments in number of leaves per plant in the first season, while weeded ×30 kg/ha seed rates treatment significantly affected number of leaves per plant in the second season when compared with un-weeded ×20 kg/ha seed rate treatment. This finding agreed with (Snideret al, 2012) who reported that lower seeding rates ranging from 116,000 to 291,000 seeds ha−1did not significantly impact yields. Weeded ×20 kg/ha seed rates treatment was significantly different from un-weeded ×30 kg/ha seed rates treatment; also highly

significant differences were shown between the same treatment and un-weeded ×10 kg/ha seed rate treatment on Crotalaria saltiana biomass production in the second season, where their average yield reach 2470.7, 1368.0 and1193.0 kg DM/ha respectively. These results confirmed the importance of weed control in forage production either in rain fed or even in extensive irrigation schemes. The result is in line with that achieved by(Ashton, 1991) who stated that weeds are herbaceous plants growing in places where they are not wanted and interfering with the growth of the desired crop; they sometimes reduced its harvesting quality if allowed to remain. Moreover, weeds invade sites where competing vegetation has been destroyed. Also weeds represent an economically important challenge for crop production. It is believed by many authorities that higher seed rates can increase biomass production in some cases, where (Stickler and Laude, 1960; Steiner, 1986; Habyarimana et al., 2004; and Wortmann et al., 2010) stated that the effect of seeding rate on yield in sorghum have been inconsistent, where higher seeding rates have been shown to increase dry matter productivity in some instances, and to have no effect on yield in others.

IV. Conclusion

Successful hand weeding and optimum seeds rate (20 kg/ha) efforts can aid rangeland ecosystem recovery by rapidly establishing a *Crotalaria saltiana* plant community and thereby reducing the likelihood of infestation by invasive plants. Although the success of hand weeding and reseeding remediation are critical, few efforts have been made to leverage existing herbicides technologies to develop methodologies to assess reseeding success following a weed control. Most range plants seed rates are not known and there is scarcity of studies in this specific parameter. Also the weeds are still negatively impacting forage crops production in developing countries due to the lack of knowhow on use of herbicides. Weeds control is often done by hand mowing, which take too long a time, and at the same time it is tedious and adversely affects the growth of forages. Due to high labour cost and time required, chemical methods are suggested for dicotyledonous weeds control instead of hand removal. However caution must be exercised regarding the impact of chemicals on soil and livestock and that needs investigation before taking a decision to adopt chemical weeding.

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