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EFFECT OF SOWING METHODS, SEEDING RATES AND CUTTING MANAGEMENT ON SEED YIELD OF ALFALFA (*Medicago sativa* L.)

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ABSTRACT
A field experiment was conducted at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum during the period November 2003 to July 2005, to study the effect of sowing methods, seeding rates and cutting management on alfalfa (*Medicago sativa* L.) seed yield. The treatments comprised two sowing methods which were sowing on flat (F), sowing on ridges (R), three seeding rates which were 7.1 (S_1), 14.3(S_2) and 21.4 (S_3) kg/ha and four cutting management which were no cutting (C_0), one cut (C_1), two cuts (C_2)and three cuts (C_3). The plot size was (3 × 3) with 0.7 m space between ridges. Four replications were established each one consisted of 24 plots. Parameters measured were plant density, seed yield component, and final seed production. Results showed that sowing on ridges had a significant effect on plant density, number of racemes per plant and number of flowers per plant, whereas sowing on flat had no significant effect on any parameter. Seed rate of 21.4 Kg / ha (S_3) had a significant effect on plant density, number of seeds per pod in the two seasons and on the thousand seed weight in the second season, while seed rate of 14.3 kg/ha (S_2) had a significant effect on number of pods per plant in the second season only. Seed rate of 7.1 kg/ha (S_1) had a significant effect on number of seeds per pod and thousand seed weight in the first season, and total seed weight in the two seasons. Result also showed that cutting plants three times (C_3) had a significant effect on plant density in the first season, while cutting once (C_1) had a high significant effect on number of flowers per plant in the second season and on number of pods per plant in the first season. No cutting (C_0) had a significant effect on number of seeds per pod in the second season and on total seed yield.

INTRODUCTION

Among the irrigated forages of high importance in Sudan is alfalfa (*Medicago sativa* L.). The crop is grown mainly in northern Sudan where climatic conditions are favorable. The Sinnar-Kosti line is considered to be the southern limit of it's cropping in the Sudan because of the high humidity as it causes alfalfa diseases (Abusuwar and Darrag, 2002). To produce alfalfa seeds, usually, the crop is left for fodder production in the first three years after planting, then in the fourth year it is left for seed production. By the fourth year, only adapted plants will be left in the field as a result of competition, and those left to produce seeds are of high adaptability (survival for the fittest) (Abusuwar and Darrag, 2002). Alfalfa is considered as across pollinated crop. Climate, soil, crop management and injurious insects can directly affect seed production, but they were secondary causes and operate only after the flower have been tripped and cross-pollinated. However, the chief requirements for good seed production are relative normal growth of adapted variety, the presence of an abundant pollinating insects, absence of harmful insects and bright sunny weather during bloom and harvest (Abusuwar and Darrag,2002). Plant population did not correlate significantly with seed rate. This finding seems to be unexpected since the number of plants is a reflection of the number of seed sown, but it could be attributed to the relatively high death rate associated with denser populations (Nayel 1984). Alfalfa is a perennial fodder of high quality and high yield. It is grown either under rain fed or irrigated conditions (Fadul, 2001). Seasonal fluctuations in yield occurred with high yield being obtained during October to April and lower yield from May through September. Local seed production is also practiced in the north of Sudan. Zambrana (1973) found no significant difference in total seed yield per plant between harvesting after forage harvest and harvesting directly for seed. The areas of dry climates in arid areas, like those in Sudan, are best areas to alfalfa seed production. Harvesting is one of the most critical operations in alfalfa seed production, since all of seeds do not mature at the same time (Garrison, 1960). Highest seed yield of Lucerne was obtained from the plots left for seed production after schedule time of cutting on 11th April (El Amin, 1976) Farid and Hassan (1990) compared seed yield of alfalfa plant at end of October using different cutting treatments. Cutting treatments were (a) no cutting before seed crop, (b) one cut at the end of March before seed crop and (c) two cuts before seed crop at the end of May. Their results showed that, the highest seed yield was obtained from treatment with no cutting before the seed crop (Farid and Hassan, 1990). The objectives of this study were to evaluate the effects of sowing methods, seeding rates and cutting management on alfalfa forage and seed production.

MATERIALS AND METHODS

Treatments: The experiment consisted of two sowing methods, three seeding rates and four cutting management practices. The local variety Hegazi (*Medicago sativa* L.) was used and seeds were provided by the Sudan Arab Company for seeds, Khartoum, Sudan. The experimental design used was (R.C.B.D) in a factorial manner. Two sowing methods (namely flat and ridge) and with three

seeding rates, S1, S2 and S3 (7.14, 14.29, and 21.43 kg/ha, respectively). The entire plots were cut 1st before imposing the cutting management. The cutting managed practices are denoted by C_1 after 90 days, C_2 after 120 days, C_3 after 150 days after sowing, and the control. Accordingly, each replication consisted of 24 different treatments. The whole experiment was sown manually, broadcasting the seeds over the flattened plots and drilling the seeds on the upper east side of the ridges in rows opened with a piece of wood. Irrigation was applied immediately after sowing. Second irrigation was done after 7 days from the first irrigation to facilitate seedling emergence. Subsequent irrigations were at 7 to 15 day intervals depending on weather condition. Aphids, which appeared during the cool months were controlled by using the insecticide Melathion. In the middle of each experimental plot, an area of 0.70 m^2 was determined by markers and used for counting plant density. One foliage crop cut was taken after 45 days.

Parameters: A marked area of 0.7 m^2, using a quadrate in each treatments was used. In ridges it was taken from the center of the second middle ridge in half of the plots and on flat it was taken from the center of the plot. Numbers of plants were counted after 30 and 45 days from sowing and at the end of the experiment. After the establishment cut (at 45 day), the treatment of cutting was established when the crop reached 30 to 50% flowering. The management cuts were at 90, 120 and 150 days, and denoted as C_1, C_2 and C_3, respectively. After the last cut, the crop was left to produce seeds. Ten plants were tagged at random in each plot. The number of racemes per plant was counted at intervals starting from the appearance of the first floral bud, and the average number of racemes per plant was recorded. Three counts were made. Three counts of flowers number per plant were taken, and the average number was recorded for 10 tagged plants. At harvest, the 10 tagged plants were harvested by hand. Then the pods were counted and the average number of pods per plant was recorded. Ten pods from the ten tagged plant were picked, threshed and number of seeds for each pod was counted. The average number of seed/pod was recorded. When the color of pods turned dark brown, harvesting started. Manual harvesting of seeds for three times was done by picking the mature pods at an interval, dried, threshed and cleaned by using micro-sieves. The clean seeds were weighed and total seed yield for each plot was transformed into kg/ha. Thousand seeds were counted from the seed yield of each plot randomly and weighed.

Statistical analysis: Analysis of variance was done, using the SAS system (SAS, 2000). Least significant differences at the 5% probability level were used to differentiate treatment means.

TABLE1. The effect of treatments on plant density throughout the two seasons

Treatments	Sampling Dates					
	Season 2003 - 2004			Season 2004 – 2005		
	30 days	45 days	At harvest	30 days	45 days	At harvest
F	27.8^{b}	70.5^{b}	97.5^{b}	29.7^{b}	63.2^{b}	79.6^{b}
R	53.1^{a}	110.8^{a}	169.8^{a}	62.2^{a}	127.3^{a}	173.0^{a}
LSD	6.1^{**}	11.1^{**}	16.3^{**}	3.2^{**}	7.2^{**}	5.8^{**}
S_1	23.5^{c}	83.2^{c}	156.9^{a}	26.7^{c}	69.3^{c}	105.6^{c}
S_2	39.5^{b}	90.2^{b}	130.6^{b}	41.5^{b}	101.1^{b}	128.0^{b}
S_3	58.2^{a}	98.5^{a}	113.4 b	69.7^{a}	115.3^{a}	145.4^{a}
LSD	7.5^{**}	13.6^{*}	20.0^{*}	3.9^{**}	8.8^{**}	7.1^{**}
C_0	44.0^{b}	96.4^{a}	137.4^{a}	43.5^{b}	91.7^{b}	20.7^{b}
C_1	29.0^{c}	86.8^{a}	126.2^{a}	43.4^{b}	88.4^{b}	124.9^{ab}
C_2	34.5^{c}	84.7^{a}	124.5^{a}	45.4^{b}	104.6^{a}	130.3^{a}
C_3	54.1^{a}	94.7^{a}	146.4^{a}	51.5^{a}	96.2^{ab}	129.3_{a}
LSD	8.6^{**}	15.7^{ns}	23.1^{ns}	4.6^{**}	10.2^{**}	8.1^{**}
C.V	37.1	30.1	30.0	17.2	18.5	11.2

Means followed by same letter(s) in each column for each factor are not significantly different .

* = ≤ 0.05 ** = ≤0.01 ns = ≥0.05 F = Sowing on flat R = Sowing on ridges S_1 = (7.14 kg/ha) S_2 = (14.28 kg/ha) S_3 = (21.42 kg/ha) C_0 = No cutting (control) C_1 = Cutting on time C_2 = Cutting two times C_3 = Cutting three times.

RESULTS AND DISCUSSION

Sowing on ridges had a high significant effect on plant density compared to sowing on flat (Table 1). This result is in agreement with the finding of Mustafa (1996) who reported that sowing alfalfa on ridges increased plant density before harvest. Sowing on ridges had a high significant effect on the number of racemes per plant in the second season. It increased the number of racemes/plant by 8% compared to sowing on flat (Table 2). This result is in line with the findings of Khair (1999) who reported that row planting are generally superior to solid planting because they fit well with irrigation and they make it easy to control weeds and volunteer alfalfa seedlings. Sowing on ridges in the second season had a high significant effect on the number of flowers/plant compared to sowing on flat (Table 3). Sowing methods had no significant effect on number of pods/plants in the two seasons (Tables2-3). This result is in agreement with finding of Khair (1999) who reported that there were no significant difference in yield components between ridges and flat sowing methods conducted at the Gezira and Hodeida Research Stations. Sowing methods had no significant effect on number of seeds/ pod in the two seasons (Tables2-3). This result is in agreement with the

finding of Fadul (2001) who reported that sowing methods had no significant effect on number of racemes per plant, number of pods per raceme, number of seed per pod and 1000-seed weight. Sowing methods had no significant effect on either thousand seeds weight or total seed yield in the two seasons (Tables 2-3). This result is in agreement with Khair (1999) who reported that there were no significant differences between ridges and flat sowings in yield in an experiment conducted at Gezira and Hudiba Research Stations.

TABLE 2. The effect of treatments on seed yield and seed yield components for the second season 2004-2005

Treatments	Racemes	Flowers	Pods	Seed/Pod	THSW	TSW
F	15.3^{b}	79.1^{b}	61.1	5.3	4.2	22.4
R	16.6^{a}	87.1^{a}	62.7	5.2	4.1	22.7
LSD	0.9^{**}	5.9^{**}	4.5^{ns}	0.2^{ns}	0.2^{ns}	$1.\ 2^{ns}$
S_1	15.9	79.9	62.5b	5.3^{a}	4.5^{a}	25.9^{a}
S_2	15.8	84.4	70.2^{a}	4.9^{b}	4.2^{b}	21.1^{b}
S_3	16.1	84.8	52.9^{c}	5.4^{c}	3.8^{c}	20.6^{b}
LSD	1.2^{ns}	7.3^{ns}	6.7^{**}	0.2^{**}	0.2^{**}	1.5^{*}
C_0	15.7	81.6^{a}	61.8^{a}	5.4^{a}	4.3	25.1^{a}
C_1	15.9	89.6^{a}	66.9^{a}	5.2^{a}	4.1	22.5^{b}
C_2	16.2	85.9^{a}	62.0^{a}	5.1^{a}	4.1	21.2^{b}
C_3	15.9	75.1^{b}	56.8^{b}	5.16^{b}	4.1	21.4^{b}
LSD	1.4^{ns}	8.4^{*}	7.7^{*}	0.3^{*}	0.2^{ns}	1.8^{*}
C.V	14.7	17.6	21.7	8.8	8.7	12.9

Means followed by same letter(s) in each column for each factor are not significantly different .
* = ≤ 0.05 ** = ≤0.01 ns = ≥0.05 F = Sowing on flat R = Sowing on ridges. S1 = (7.14 kg/ha) S2 = (14.28 kg/ha) S3 = (21.42 kg/ha) C0 = No cutting (control) C1 = Cutting on time. C2 = Cutting two times C3 = Cutting three times THSW = 1000 seed weight TSW = Total seed weight

TABLE 3. The effect of treatments on seed yield and yield components for the first season 2003-2004

Treatments	Racemes	Flowers	Pods	Seed/Pod	THSW	TSW
F	13.2	70.4	38.1	4.9	2.8	18.6
R	14.2	72.3	37.4	4.8	2.7	17.9
LSD	1.336^{ns}	10.133^{ns}	5.617^{ns}	0.189^{ns}	0.182^{ns}	1.605^{ns}
S_1	13.7	71.8	41.0	5.1	3.1^{a}	23.2^{a}
S_2	13.9	74.4	35.6	4.7	2.7^{b}	15.3^{b}
S_3	13.3	67.9	36.5	4.7	2.5^{c}	16.2^{b}
LSD	1.636^{ns}	12.41^{ns}	6.879^{ns}	0.231^{ns}	0.223^{**}	1.965^{*}
C_0	13.2	74.1	44.7^{a}	4.9^{a}	2.9^{a}	22.1^{a}
C_1	13.9	77.9	45.2^{a}	4.7^{b}	2.7^{ab}	19.2^{b}
C_2	13.9	71.9	28.3^{bc}	4.7^{b}	2.8^{a}	16.8^{c}
C_3	13.5	61.55	32.7^{b}	4.9^{a}	2.7^{ab}	14.8^{c}
LSD	1.889^{ns}	17.33^{ns}	7.943^{*}	0.267^{*}	0.298^{*}	2.269^{*}
C.V	24.1	34.9	36.6	9.6	16.2	21.6

Means followed by same letter(s) in each column for each factor are not significantly different .
* = ≤ 0.05 ** = ≤0.01 ns = ≥0.05 F = Sowing on flat R = Sowing on ridges.
S1 = (7.14 kg/ha) S2 = (14.28 kg/ha) S3 = (21.42 kg/ha) C0 = No cutting (control) C1 = Cutting on time
C2 = Cutting two times C3=Cutting three times THSW=1000 seed weight. TSW = Total seed weight.

The highest seed rate S_3 (21.4 kg/h) resulted in a significantly higher plant density compared to the other seed rates S_2 (14.3 Kg /h) and S_1 (7.1 Kg/h) with the exception of the final count in 1st season (Table 1). This result is in agreement with finding of Carmer and Jacobs (1963), who reported that an increase in number of plant per unit area was associated with increased seed rate. Seed rate had no significant effect on the number of racemes/plant or number of flowers/plant in the two seasons (Table 2). This finding seems to be unexpected since numbers of flowers are affected by competition as it leads to flower shedding, and could also be attributed to relatively high death rate associated with denser populations. Seed rate of 14.28 kg/ha (S_2) had a high significant on number of seeds/pod in the second season compared to the other seed rate (Table 2). The lowest seed rate used of 7.14 kg/h (S_1) had a high significant effect on number of seeds/pod in the first season compared to the higher seed rate (S_2 and S_3) as shown in Table 2. In the second season, the highest seed rate of 21.28 kg/ha had a high significant effect on number of seeds/pod compared to other seed rates (Table 2). This result may be attributed to the increase in plant density. This result is in agreement with Carmer and Jacobs (1963) who reported that an increase in number of plants per unit area was coupled with increasing seed rates. The lowest seed rate of 7.14 kg/ha (S_1) had a high significant effect on thousand seeds weight compared to other seeding rates of S_2 and S_3 in the first season (Table 3). In the second season, however, the highest seed rate used (S_3) had a high significant effect on thousand seed weight compared to other seeding rates of S_2 and S_1 (Table 2). This result was expected since (S_1) in

the first season and (S_3) in the second season showed a good result with respect to number of seeds per pod; and that may be attributed to the good cultivation and growth. The lowest seed rate (S_1) had a high significant effect on total seed yield in both seasons compared to other seeding rates of S_2 and S_3 (Tables 2-3). This result was expected since (S_1) had a high significant effect in the number of seeds per pod. However, increasing the seed rate may increase number of flowers, which in turn , cause ovule abortion to the flowers due to high competition. This result is in agreement with Abusuwar (2004) who reported that increasing plant density per unit area resulted in increasing ovule abortion to the pollinated flowers.

Cutting three times (C_3) had a high significant effect on plant density at 30 days compared to other cutting management (Table 1). In the second season, C_2 had a high significant effect on plant density compared to the other cutting management (Table 1). This might be due to the fact that increasing the number of cutting permits the growth of more branches from the crown buds at the base of the stem. This result is in agreement with Granfield (1964) who reported that alfalfa generally recommended be cutting and then leaving to re-growth. Cutting management did not significantly affect the number of racemes/plant (Table 2). This result is in agreement with Nayel (1984) who reported that number of racemes per unit area; numbers of seeds per pod and seed weight were not affected by seed rate or cutting management. Cutting once (C_1), had a high significant effect on number of flowers/plant in the second season compared to other cutting management treatments (Table 2). This may be attributed to the enhanced shoot growth after cutting and consequently increased the number of flowers per plant by supplementation of high amount of assimilates. This result was supported by Messengal (1974). Moreover, cutting once gave more time for flowering and seed production. Cutting once (C_1) had a significant effect on number of pods/plants in the first season compared to the other cutting management (Table 3). Cutting once (C_1) was superior over the other cutting management. This may be attributed to the increased number of tiller that might increased number of pods. This result is in agreement with Nayel and Khider (1995). The control (C_0) had a significant effect on number of seeds/pod in the first season compared to other cutting management (Table 3). This may be attributed to high death rate of plants due to continuous cutting. This result is in agreement with Palmer and William (1976) who reported that death rate of Lucerne plants was high with denser populations. Cutting management had no significant effect on thousand seeds weight in the two seasons (Tables 2-3). This may be attributed to high death rate of plants which is in line with results reported by Palmer and William (1976) who reported that death rate of Lucerne plant was high with denser population. No cutting (C_0) had a high significant effect on total seed yield in both seasons compared to other cutting management (Tables2-3). This may be attributed to the high death rate of plants after cutting or high ovule abortion rate to pollinated flowers due to the increase in plant density which resulted from continuous cutting(Palmer and William (1976) and Abusuwar (2004)).

SUMMARY AND CONCLUSION

Results of this study can be summarized in the followings:

*sowing on ridges had a significant effect on plant density, number of racemes per plant and number of flowers per plant compared to sowing on flat

*seed rate of 21.4kg/ha (S_3) had a significant effect on plant density, number of seeds per pod in the two seasons and 1000-seed weight in the second season

*seed rate of 7.1 kg/ha(S_1) had a significant effect on number of seeds per pod and 1000-seed weight in the first season and total seed weight in the two seasons

*leaving the crop without harvesting forage (C_0) significantly increased the number of seeds per pod and total seed yield

It can be concluded from the results of this study that growing alfalfa for seed production, in the study area and similar areas, that planting on ridges with a seeding rate of 7.1 kg/ha without having any cuts for forage is recommended.

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