Zagazig J.Agric. Res., Vol. 29 No.(6) 2002 1781-1804

SORGHUM - PEARL MILLET MIXTURE UNDER SANDY SOIL CONDITIONS

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Received 5 / 10 / 2002 *Accepted 26 / 11 / 2002*

ABSTRACT: Two field experiments were carried out in the Experimental Farm Faculty of Agriculture, Zagazig University at Khattara, Sharkia Governorate, Egypt, during 2000 and 2001 summer seasons, to study yield potential of sorghum (S), pearl millet (M) and their intercropping systems (75%S + 25%M, 50%S + 50%M and 25%S + 75%M) when grown under three row spacings (20, 30 and 40 cm apart) in sandy soils.

The obtained results indicated that the medium row spacing of 30 cm recorded the shortest sorghum plant height at the 2nd cut. While, at the 3rd cut pearl millet plants were taller in wide (40 cm) than in narrow rows (20 cm). Gain in number of tiller/m^2 for the associated millet was secured under different row spacing, however, the gain at the narrow spaced rows was higher than at wider ones. Also, gain in number of tillers/m^2 for the associated sorghum was secured only at narrow spaced rows. Consequently, the narrow rows outyielded the wider one in the seasonal fresh forage yield of pearl millet. Moreover, it was surpassed the other two spacings in the seasonal fresh forage yield of sorghum, as well as, the seasonal total fresh forage yield of the two components. Also, advantage in total dry forage yield for the associated both components tended to increase due to narrowing row spacing. Narrowing row spacing to 20 cm enhanced leafness ratio for sorghum over the two seasons.

It was found that intercropping systems had no significant effect on plant height of either of sorghum or millet. Although the reduction in the proportional area of either of the two components followed with similar reduction in its number of tillers/m^2 at most cases, the reduction in component population for sorghum from 50 to 25% and for millet from 75 to 50% followed without decreases in this triat at different cuts. Thus, decreasing the area sown by sorghum up to 25% and by millet up to 50% both components achieved gain in number of tillers/m^2. Hence, at different cuts and all over the two seasons, the intercropping systems produced intercrop fresh and dry forage yields comparable to those of the higher yielding sole crop i.e. pearl millet. Where, the advantage in intercrop dry forage yield of millet was increased with the reduction in its component population from 75 to 50 to 25%. Also, any replacing of sorghum by millet generally increased dry forage CP%. Even so, increasing pearl millet component population in association up to 50% at the first cut and to 75% at 2nd and 3rd cut maximized CP% in the forage.

Results of the present work conclude that, high forage yield of a good quality could be produced in sandy soils, when sorghum was intercropped with or replaced by pearl millet in rows spaced at 20 cm apart.

INTRODUCTION

It is observed that there are great diversities between sorghum varieties and pearl millet in growth habit (Abdel-Gawad, 1987 ; Geweifel, 1997 and Meawad, 1997), and in their efficiency to intercep light through different cuts (Aly and Sarhan, 1992), as well as in their efficiency to exploit layers of different soil types (Bogdan, 1977). Accordingly, results of previous studies concluded that varieties of forage sorghum can perform well than pearl millet under heavy texture soil conditions (Shafshak *et al*, 1994 and Gheit and Shahawy, 2000). While, the reverse is the case under light texture soil conditions (Mahmoud *et al*., 1993 ; Mousa *et al*., 1995 and Geweifel, 1997). However, extension of pearl millet cultivation through the wide newly cultivated sandy soil areas in Egypt is limited by the low local production of this crop seeds, due to the heterogeneous maturity of its inflorescence, which in turn expose its seeds to severe attack by birds for long period and get harvest process is very hard and expensive.

Although, intercropping cereals with cereals may sound counterintuitive, Osiro (1974) recorded 9% yield advantages when two hybrids of sorghum were intercropped. Also, Willey and Rao (1981) found complementary relationships among some genotypes of intercropped sorghum and pearl millet for under and above ground resources. Even so, yield advantages reached up to 30% were recorded by Anonymous (1977), Stoop (1987) and Aly and Sarhan (1992).

Willey (1979) pointed out that even when the space allocated to intercropped component crops is directly related to component populations, the intimacy of the spatial arrangement can still vary in intercropping. Francis (1986) concluded that if interactions between intercropped component crops are expected to provide benefits to total production, the narrower the strips, and thus the greater the extent of plant interactions, the better. Hence, it is of necessary to definite suitable row spacing for crops in associations.

In sole of pearl millet, Mousa *et al*., (1991) recorded a decrease in fresh and dry forage, as well as, protein yields due to widening row spacing from 20 to 40 cm. In contrary Mousa *et al*., (1994) showed that widening row spacing from 20 to 30 then to 40 cm followed with significant increases in fresh and dry forage yields of pearl millet.

Moreover, in sole cropping of sorghum, Hassanein *et al*., (1983) recorded an increase in fresh and dry forage yields due to widening row spacing from 20 to 40 or 60 cm. However, Aly (1992) found an increase in fresh and dry forage yields of sorghum due to narrowing row spacing from 50 to 25 cm.

The present work was, therefore, conducted to obtain detail information about the effect of replacing sorghum by millet under different row spacing on growth and forage yields of the intercropped both component crops in sandy soils.

MATERIALS AND METHODS

Two field experiments were performed in the Experimental Farm Faculty of Agriculture, Zagazig University at El-Khattara, Sharkia Governorate, Egypt, during 2000 and 2001 summer seasons. The study included two factors, three row spacings (20, 30 and 40cm) and five intercropping replacements of sorghum – sudangrass hybrid (local hybrid Giza 102) and pearl millet (Local population).

The tried intercropping replacements were as follows:

1- Sole seeding of sorghum – sudangrass hybrid at seeding rate of 16 kg/fad (100 % S).
2- Three rows of sorghum – sudangrass hybrid alternated with one row of pearl millet (75 % S + 25 % M).
3- Two rows of sorghum – sudangrass hybrid alternated with two rows of pearl millet (50 % S + 50 % M).
4- One row of sorghum – sudangrass hybrid alternated with three rows of pearl millet (25% S + 75 % M).
5- Sole seeding of pearl millet at seeding rate of 16 kg/fad (100 % M).

A split plot design with three replicates was used. Row spacings were assigned to the main plots, while, the intercropping replacements were distributed in the sub-plots. The sub – plot area was 14.4 m^2 (4.8 m width and 3 m length). The preceding crop was wheat in the 1st season, while, in the 2nd season, sowing was after winter fallow preceded by sesame in summer. The soils of the experimental field were sandy in texture having pH of 7.8 ; 0.36 % organic matter and containing 8, 2.8 and 94 ppm available N, P and K, respectively (average of the two seasons for the upper foot of soil surface). Calcium superphosphate (15.5 % P_2O_5) at rate of 200 kg / fad and potassium sulphate (50 % K_2O) at rate of 100 kg /fad were added before sowing. Sowing was on June 1st and May 15th in the 1st and the 2nd seasons, respectively. In both seasons, three cuts were taken at 50,90 and 120 ; 50 , 85 and 120 days from sowing in the 1st and the 2nd seasons, in respective order. Nitrogen fertilizer as ammonium sulphate (20.6 %) at rate of 40 kg N/fad/cut was added two weeks after sowing and one week after cutting. Surface irrigation using underground water was followed. The other normal culture practices were applied at proper time.

At each cut, 10 competitive plants in the fourth inner rows of the outer intercropping both units were used to estimate plant height (cm) then they were cut and used to determine leafness ratio of the component crops (leaves / plant dry weight ratio). Meantime, plants in 2.4 m^2 of the middle one or two intercropping units were cut and used to count number of tillers)/m^2, as well as, to determine fresh and dry forage yield (ton/fad) of the associated both crops. Gain or loss in number of tillers/m^2 and advantage or disadvantage in dry forage yield were then calculated by subtracting the expected value of the prometer from the actual one.

In the 2nd season, nitrogen content (%) in the dry forage for the whole plants of either of the associated both crops, was estimated at each cut, according to A.O.A.C. (1970) technic, with the modified Kjeldahal method. Protein content (%) was then calculated using a conversion factor of 6.25.

Data were subjected to standard variance analysis of split-plot design (Snedecor and Cochran, 1967). A combined analysis was performed between data of both seasons. Duncan's multiple range test was also used to compare means as described by Duncan (1955).

RESULTS AND DISCUSSION

1- Plant height:

Data presented in Table 1 demonstrate that the tried row spacings had no significant effect on plant height of sorghum at two cut of the three cuts taken every season. This was also the same in the combined of both seasons. Where, results of the 1st season confirmed by those of the combined analysis clear that the medium spacing get sorghum plants shorter than the other two spacing at the 2nd cut. Also, at the 3rd cut in the 2nd season, the medium spacing gave the shortest sorghum plants while, the narrow spacing gave the tallest ones.

As evident from data of different cuts in the 2nd season and the combined analysis for the early two cuts, it is observed the tried spacing had no significant effect on pearl millet plant height. Though, results of different cuts in the 1st season confirmed by those of the combined analysis for the lattest cut exhibit significant effect for row spacing on pearl millet plant height. In contrary with the response of sorghum plant height, widening row spacing from 20 to 30 cm significantly increased pearl millet plant height at the 1st and 2nd cuts. This was also the same in the 3rd cut but with widening row spacing from 20 to 40 cm apart. In other words, these results show a diversity between sorghum and pearl millet in response of their plant heights to intra-specific competition. However, Mousa *et al.*, (1994) recorded a decrease in pearl millet plant height due to widening row spacing up to 40 cm apart.

Results of both seasons and their combined analysis clear that the tested intercropping patterns had no significant effect on plant height of the two associated components. But, except for pearl millet at the 2nd cut in the 2nd season, where, plant height of this component crop was increased with decreasing component population to 50% and 25%. In the latter instance, it seem that the inter – specific competition on certain limited environmental resources was lower than intra – specific one. Hence advantages in pearl millet plant height can be achieved.

As obvious from data of grand mean for different cuts in both seasons and their combined analysis, it is of worthy to show that plant height of the two associated crops tended to decrease with the advancing in cutting. Also, pearl millet was taller than sorghum at different cuts. This was more pronounced in the 2nd cut.

2- Number of tillers/m^2:

As shown in Table 2, results generally clear that row spacing had no significant effect on number of tillers/m^2 for both crops. But, with one exception for pearl millet at the 1st cut in the 1st season, where, sowing pearl millet in narrow spacing (20 cm) produced much number of tillers/m^2 as compared with wider spacings (30 and 40 cm). Though data in Table 2-a, indicate that pearl millet can secure gain in this number under different spacings. Yet, the narrow spacing overcome the wider one in the magnitude of this gain. Meantime, sorghum plants also achieved gain in that number only when it was grown at narrow spaced rows. This mean that tillers of both component intermingly freely when they were grown in narrow rows. In other words, these findings stress that both component crops can cooperate mutually in this concern when grown at narrow spaced rows. In respect with the effect of row spacing on number of pearl millet tillers/m^2, similar results were recorded by Aly and Geweifel (1996).

The obtained results clearly show that the tested intercropping systems had a significant effects on number of tillers/m^2 for both component at different cuts. This was true in both seasons and their combined analysis. Data of the combined analysis exhibit significant decrease in number of sorghum tillers/m^2 at the 1st cut with decreasing its sown proportion to less than 75%. Moreover, at the 2nd and 3rd cuts, pure stand recorded the highest number of sorghum tillers/m^2 followed by the intercropping system in which sorghum occupied 75% of its area then the rest two intercropping systems at par as well.

Meantime, results of the combined analysis for different cuts also indicated that pearl millet could produce the highest number of tillers/m^2 in sole seeding. While, the lowest number of pearl millet tillers/m^2 was recorded when the component population was reduced to 25%. Herein, it is worthy to note that number of pearl millet tillers/m^2 was not affected significantly by the increase in its area sown in association, with sorghum from 50 to 75%. This was in concurrence with the non significance of increasing the proportional area for component sorghum from 25 to 50% on its number of tillers/m^2.

Accordingly, as shown from data in Table 2-a, it is evident that when 25% of pearl millet field area was replaced by sorghum, the latter component recorded gain whereas the former recorded loss in number of tiller/m^2 i.e. sorghum was the dominant component and pearl millet was the dominated one. But, the opposite was the case in the rest two intercropping systems. Meanwhile, the numerical values of gains for the latter two intercropping systems in number of pearl millet tiller/m^2 were higher than the numerical values of losses in number of associated sorghum tillers/m^2. Hence, a complementary relationship between the associated both crops may be established in this concern. Yet, since, the magnitude of benefits from such relationship based not only on the gain in number of tillers but also, on mean of tiller height and diameter. Thus, the precise judgement on the magnitude of benefits from such relations must be depend on the advantages in dry forage yield.

As evident from data of the grand mean, it is interest to show that number of tillers for the two components was decreased with the advancing from the 1st to the 2nd cut. This was also the same only for pearl millet with the advancing from the 2nd to the 3rd cut. Meantime, pearl millet overcome sorghum in number of tillers/m^2 at different cuts. This was more clear at the 1st and 2nd cuts.

3- Fresh forage yield.

As presented in Table 3, data generally indicate that row spacings had no significant effect on fresh forage yield of the two associated crops. But, with few exceptions. The narrow rows outyielded the wider both ones in fresh forage yield of pearl millet at the 3rd cut in the 2nd season. Also, results of the 1st cut in the 2nd season confirmed by those of the combined analysis of both seasons for this cut demonstrate the superiority of the medium spaced rows (30 cm) over the wide, narrow ones in fresh forage yield of sorghum. However, data of the combined seasonal yield over both seasons showed that the seasonal fresh forage yield of pearl millet was decreased due to widening row spacing from 30 to 40 apart. Moreover, seasonal fresh forage yield of sorghum, as well as, total seasonal fresh forage yield of the two components were decreased consistently with each widening in row spacing. This reflected a higher intra than inter row competition with widening row spacing for sorghum and pearl millet more than 20 and 30 cm apart in respective order. Here, it is of noticeable that the superiority of narrow rows in fresh forage yield is in concurrence with the gain in number of tillers recorded there for the associated both crops simultaneously (Table 2-a). These results support those recorded by

Mousa (1991) ; Mousa *et al.*, (1994), Aly (1992) and Aly & Gewifel (1996).

The obtained results showed a significant differences among the exercised intercropping systems in fresh forage yield. This was true for the associated both components allover different cuts through both seasons and their combined analysis. Yet, data of the combined analysis exhibit no significant decrease in intercrop fresh forage yield of sorghum component with replacing 25% of the area sown by pearl millet. This was the case at different cuts. But, such replacing was followed with a significant decrease in seasonal yield of this component. Also, results of the combined analysis indicated that even with replacing 25 or 50% of the area sown by sorghum, pearl millet could components be produce as much fresh forage yield as its pure stand in the first two cuts. This was also the same in the 3rd cut as well as the seasonal yield but only with replacing 25% of the area sown by sorghum. Accordingly, all the exercised intercropping systems produced fresh forage yield comparable to that of the higher yielding sole crop i.e. pearl millet. This was the same in total fresh forage yield for different cuts as well as for the season. The superiority of different intercropping systems over pure stand yield of sorghum implies that the intra-specific competition within sole sorghum was severe than inter – specific competition in association. Findings of the present work sustained those outlined by Anouymous (1977) and Willey & Rao (1981).

4- Dry forage yield:

As shown in Table 4, results generally indicate that the studied row spacings had no significant effect on dry forage yield of sorghum or pearl millet, but, with one exception for each component in the 2nd season, where the medium spacing outyielded the narrow one in dry forage yield of sorghum at the 1st cut. While, the narrow rows surpassed the wider ones in dry forage yield of pearl millet at the 3rd cut. Meantime, results of the combined analysis for the two seasons stressed that the seasonal dry forage yield for either of both components, as well as, the total dry forage yield of the two components at each cut and allover the season were not affected by the exercised row spacing. The latter findings reflect the higher moisture content of forages in narrow spaced rows, which recorded the highest total seasonal fresh forage yields (see Table, 3). Though, it seems that the well distribution of plants in sandy soils is that which can help in providing them by moisture. Withal, results in Table 4-a demonstrate that under different row spacing, sorghum had a negative sign of disadvantages. While, the reverse was the case for pearl millet i.e. sorghum was the dominated component and pearl millet was the dominant one. Consequently compensation relationships was established between the associated both components in that yield. Fortunately, the numerical values of advantages in dry forage yield of millet were higher than the corresponding disadvantages in dry forage yield of sorghum. Hence, advantages in total dry forage yield per cut averaged by 0.379, 0.192 and 0.023 ton/fad could be secured when both component crops were grown in association at 20, 30 and 40 cm row spacing , in respective order. Most of advantages recorded here ascribed to the gain in number of tillers/m^2 (Table 2-a). The present results are in agreement with those recorded by Mousa (1991) and Aly (1992). But, they are in contrary with those recorded by Hassanein *et al.*, (1983) and Mousa *et al.*, (1994).

Like as in fresh forage yield , the exercised intercropping systems exerted significant effects on dry forage yield of the associated both crops at different cuts in both seasons and their combined. Data of the combined analysis generally showed no significant decrease in intercrop dry forage yield of either of sorghum or pearl millet at any cut due to replacing 25% of the area sown by the another associated component. This was also the same for seasonal intercrop dry forage yield of pearl millet. Whereas, the seasonal intercrop dry forage yield of sorghum was decreased even with replacing 25% of the area sown by millet. However, all the exercised replacements produced as much intercrop dry forage yield as the higher yielding sole crop i.e. pearl millet. Such capability of different replacements to matching with pearl millet in dry forage yield could be explained through the compensation relationships between the associated both crops. Data in Table 4-a clear that sorghum was the dominated component and pearl millet was the dominant one in different replacements. Since, they had negative and positive signs, respectively. Also, it is evident that the advantages in intercrop dry forage yield of millet was increased with decreasing its component population from 75 to 25%. This finding ensure the determent effect of intra than inter-specific competition. In different replacements, the numerical values of advantages in intercrop dry forage yield of pearl millet was higher than that of disadvantages in intercrop dry forage yield of sorghum. Accordingly, the mean value of advantages in component population dry forage yield per cut due to replacing 25,50 and 75% of the area sown by pearl millet were 0.273, 0.167 and 0.093, respectively. Such advantage are in concurrence with the gains in number of tillers/m^2 (Table, 2-a). This finding also imply that number of tillers/m^2 can be used as an early indicator about advantages in yield at such instances. Similar advantages in yield of intercropped sorghum and pearl millet were also recorded by Stoop (1987) and Aly & Sarhan (1992).

5- Leafness ratio:

As shown in Table 5, results generally indicate that the tried row spacings had no significant effect on leafness ratio for the associated both component crops, with one exception for either of both i.e. for pearl millet at the 1st cut in the 2nd season, as well as, for the seasonal yield of sorghum. Where, plants in the narrow spaced rows attain higher leafness ratio than in the wider two spacings. Here, it seems that distribution of sorghum and pearl millet plants also may help in maximizing their intake by livestock. In general, these results are in agreement with those recorded on pearl millet by Aly and Geweifel (1996).

Over both seasons and their combined analysis, results of different cuts indicate that, neither leafness ratio for sorghum nor leafness ratio for pearl millet was affected by intercropping systems. Nevertheless, results of the combined analysis for both seasons showed the superiority of intercropping system having 50% sorghum +50% millet over that having 75% sorghum +25% pearl millet as well as over pure sorghum in leafness ratios for the total yields of the season and the 1st cut, in respective order. Meantime, the aforementioned intercropping system overcome the latter one in leafness ratio for the seasonal yield of sorghum. As obvious from data of the grand mean, it is of noticeable that leafness ratio for pearl millet was decreased with the proceeding in cuts. While, the opposite was true for leafness ratio of sorghum. Accordingly, intercropping sorghum and pearl millet can help in improving leafness ratio for their combined forage yield. Hence, it can raise forage intake by livestock over different cuts.

6- Crude protein content % (CP%):

It is evident from data of CP% in the 2nd season, presented in Table 6, that CP% of sorghum, pearl millet and their combined yield were not affected by the studied row spacings. This was true at different cuts. Meantime, this was in concurrence with the non-significant effect of row spacings on leafness ratio at most cases (Table, 5).

Moreover, the obtained results indicated that the exercised intercropping systems had no significant effect on CP% of sorghum at different cuts. However, the intercropping system having 50% sorghum +50% pearl millet overcome pure stand in CP% of pearl millet at the 1st cut. Also, at the 2nd cut, decreasing the component population of millet from 100 to 75% significantly raised its CP% but, the further decreases in the area sown by this component crop followed with a consistent reductions in its CP%. Moreover, decreasing pearl millet proportion area to 25% lowered its CP% at the 3rd cut. Meantime, data of

CP% for the total yield indicated that pure sorghum had the lowest CP% value at different cuts. In other words, replacing sorghum by millet generally increased CP% for their combined yield. Furthermore, increasing the area occupied by millet in association up to 50% and 75% could be maximized CP% for the total combined dry forage yield at the 1st and the latter two cuts, respectively.

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Table (1): Plant height of sorghum and pearl millet as influenced by row spacings and intercropping systems in the two seasons and their combined analysis.

Main effects and interaction		First season						Second season					
		1[st] cut		2[nd] cut		3[rd] cut		1[st] cut		2[nd] cut		3[rd] cut	
		Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Row spacings (S)													
20 cm		116.6	118.2b	103.0a	107.9b	90.4	108.6b	145.7	145.8	107.9	133.6	100.2a	99.0
30 cm		121.0	128.3a	95.2b	117.6a	94.8	113.0ab	147.4	147.2	99.9	125.3	91.5c	95.9
40 cm		115.0	119.4ab	109.1a	121.1a	97.9	115.5a	145.4	150.9	108.2	122.3	96.7b	100.1
F. test		N.S	*	*	*	N.S	*	N.S	N.S	N.S	N.S	**	N.S
Intercropping systems (I)													
Sorghum%	Millet%												
100	-	119.7	-	101.0	-	96.0	-	152.4	-	108.4	-	99.6	-
75	25	120.9	121.4	103.5	112.4	94.5	113.4	149.3	148.4	104.7	135.4a	96.5	100.5
50	50	113.3	119.1	100.5	116.2	92.5	111.0	147.9	143.8	105.2	133.1a	96.5	95.6
25	75	116.3	125.1	104.8	120.1	94.2	111.2	135.1	151.1	103.0	121.8b	91.8	99.7
-	100	-	122.1	-	113.5	-	114.1	-	149.8	-	118.0b	-	97.6
F. test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S
Interaction													
SXI		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (1): Cont.

Main effects and interaction		Combined analysis					
		1st cut		2nd cut		3rd cut	
		Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Row spacings (S)							
20 cm		131.1	132.5	105.5a	120.8	95.3	103.8b
30 cm		134.2	137.7	97.6b	120.4	93.1	104.5ab
40 cm		130.2	135.1	108.7a	121.7	97.3	107.8a
F. test		N.S	N.S	*	N.S	N.S	*
Intercropping systems (I)							
Sorghum%	Millet%						
100	-	136.0	-	104.7	-	97.8	-
75	25	135.1	134.9	104.1	123.9	95.5	106.9
50	50	130.6	131.4	102.8	124.7	94.5	103.3
25	75	125.7	138.1	103.9	120.9	93.0	105.4
-	100	-	136.0	-	115.8	-	105.8
F. test		N.S	N.S	N.S	N.S	N.S	N.S
Interaction							
SXI		N.S	N.S	N.S	N.S	N.S	N.S

Table (2): Number of tillers/m^2 of sorghum and pearl millet as influenced by row spacings and intercropping systems in the two seasons and their combined analysis.

Main effects and interaction	First season						Second season					
	1st cut		2nd cut		3rd cut		1st cut		2nd cut		3rd cut	
	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Row spacings (S)												
20 cm	49.0	149.8a	27.5	87.0	39.4	56.3	46.6	96.5	41.6	113.6	38.0	81.2
30 cm	49.9	85.0b	31.5	78.3	26.6	67.3	56.7	121.9	34.4	116.3	40.9	71.2
40 cm	33.8	85.6b	28.7	70.6	28.8	47.3	46.1	94.7	32.2	82.5	35.5	56.9
F. test	N.S	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Intercropping systems (I)												
Sorghum% Millet%												
100 -	69.7a	-	57.0a	-	47.5a	-	76.2a	-	67.2a	-	61.3a	-
75 25	51.0ab	68.4c	31.9b	47.0c	30.8b	39.7b	66.9ab	49.1c	38.0b	55.5c	46.1b	38.7c
50 50	33.1bc	103.3bc	16.3c	77.4b	24.6b	48.5b	40.1bc	89.0b	25.7bc	94.4bc	29.1c	63.7bc
25 75	23.2c	115.2ab	11.8c	82.4b	23.6b	56.6b	15.9c	118.8b	13.4c	105.9b	15.9c	76.6ab
- 100	-	140.2a	-	107.7a	-	83.0a	-	160.6a	-	160.6a	-	100.0a
F. test	*	**	**	**	**	**	**	**	**	**	**	**
Interaction												
SXI	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (2): Cont.

Main effects and interaction		Combined analysis					
		1st cut		2nd cut		3rd cut	
		Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Row spacings (S)							
20 cm		47.8	123.1	34.6	100.3	38.7	68.7
30 cm		53.3	103.5	33.0	97.3	33.8	69.2
40 cm		39.9	90.1	30.4	76.5	32.1	52.1
F. test		N.S	N.S	N.S	N.S	N.S	N.S
Intercropping systems (I)							
Sorghum%	Millet%						
100	-	72.9a	-	62.1a	-	54.4a	-
75	25	58.9a	58.8c	34.9b	51.3c	38.5b	39.2c
50	50	36.6b	96.1b	21.0c	85.9b	26.8c	56.1bc
25	75	19.6b	117.0b	12.6c	94.1b	19.7c	66.6b
-	100	-	150.4a	-	134.2a	-	91.5a
F. test		**	**	**	**	**	**
Interaction							
SXI		N.S	N.S	N.S	N.S	N.S	N.S

Table (3): Fresh forage yield (ton/fad.) for sorghum and pearl millet as influenced by row spacings and intercropping systems in the two seasons and their combined analysis.

Main effects and interaction		First season						Second season					
		1st cut		2nd cut		3rd cut		1st cut		2nd cut		3rd cut	
		Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Row spacings (S)													
20 cm		5.783	13.160	3.610	10.220	2.503	5.833	6.018b	12.017	3.529	11.070	4.360	8.109a
30 cm		5.276	12.800	3.170	9.533	2.025	7.306	7.953a	13.870	2.269	8.399	3.175	6.700b
40 cm		3.444	10.786	3.285	8.994	2.586	5.826	5.960c	13.330	2.445	7.043	3.159	6.422b
F. test		N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	*
Intercropping systems (I)													
Sorghum%	millet%												
100	-	7.985a	-	5.895a	-	4.091a	-	11.210a	-	5.112a	-	6.338a	-
75	25	5.728ab	6.961b	4.438a	5.222b	2.714b	3.595c	9.013a	6.413c	3.098b	5.946c	4.122b	4.676c
50	50	4.037bc	12.760ab	1.931b	9.610a	1.488c	5.420bc	4.217b	10.392c	1.77bc	7.551bc	2.497bc	5.902bc
25	75	1.586c	`14.780a	1.162b	11.380a	1.191c	6.724b	2.134b	14.770b	1.004c	9.973ab	1.303c	8.491ab
-	100	-	14.050a	-	12.110a	-	9.548b	-	20.720a	-	11.870a	-	9.240a
F. test		**	**	**	**	**	**	**	**	**	**	**	**
Interaction													
SXI		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (3): cont.

Main effects and interaction	Combined analysis											
	1st cut			2nd cut			3rd cut			Seasonal yield		
	Sorghum	Millet	total	Sorghum	Millet	total	Sorghum	Millet	total	Sorghum	Millet	total
Row spacings (S)												
20 cm	5.900ab	12.59	14.79	3.570	10.640	11.370	3.432	6.971	8.322	12.90a	30.20a	34.48a
30 cm	6.614a	13.34	15.96	2.721	8.966	9.350	2.600	7.003	7.682	11.94b	29.30a	32.99b
40 cm	4.702b	11.89	13.27	2.865	8.018	8.707	2.872	6.124	7.197	10.44c	26.03b	29.18c
F. test	*	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	*	**
Intercropping systems (I)												
Sorghum% Millet%												
100 -	9.581a	-	9.597b	5.504a	-	5.504b	5.215a	-	5.215b	20.32a	-	20.32b
75 25	7.371ab	6.687b	14.06ab	3.768a	5.584b	9.352ab	3.418ab	4.135c	7.553ab	14.56b	16.41c	30.96a
50 50	4.127bc	11.57ab	15.70ab	1.853b	8.582ab	10.44a	1.993bc	5.661bc	7.654ab	7.973c	25.82b	33.79a
25 75	1.860c	14.77a	16.63ab	1.083b	10.68a	11.76a	1.247c	7.607ab	8.854a	4.190c	33.06ab	37.25a
- 100	-	17.39a	17.39a	-	11.99a	11.99a	-	9.394a	9.394a	-	38.77a	38.77a
F. test	**	**	**	**	**	**	**	**	**	**	**	**
Interaction												
SXI	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (4): Dry forage yield (ton/fad.) for sorghum and pearl millet as influenced by row spacings and intercropping systems in the two seasons and their combined analysis.

Main effects and interaction	First season						Second season					
	1st cut		2nd cut		3rd cut		1st cut		2nd cut		3rd cut	
	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Row spacings (S)												
20 cm	0.944	2.047	0.918	2.228	0.405	1.005	0.900b	1.613	0.545	1.598	0.613	1.209a
30 cm	0.868	1.867	0.733	2.004	0.342	1.132	1.360a	1.926	0.369	1.176	0.471	0.980ab
40 cm	0.606	1.654	0.812	1.955	0.420	0.963	1.034ab	1.842	0.406	1.058	0.458	0.861b
F. test	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S	**
Intercropping systems (I)												
Sorghum% Millet%												
100 -	1.401a	-	1.474a	-	0.684a	-	1.903a	-	0.861	-	0.903a	-
75 25	0.898ab	1.121b	1.033a	1.200b	0.422ab	0.597c	1.469ab	0.846c	0.448	0.791b	0.653ab	0.698b
50 50	0.606b	1.828ab	0.491bc	2.223a	0.253ab	0.825bc	0.658bc	1.312bc	0.285	1.129b	0.333bc	0.909ab
25 75	0.319b	2.334a	0.284c	2.327a	0.198b	1.134b	0.362c	1.963b	0.167	1.269ab	0.167c	1.192ab
- 100	-	2.142a	-	2.500a	-	1.577a	-	3.053a	-	2.131a	-	1.268a
F. test	**	**	**	**	**	*	**	**	N.S	**	**	**
Interaction												
SXI	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (4): cont.

Main effects and interaction		Combined analysis											
		1st cut			2nd cut			3rd cut			Seasonal yield		
		Sorghum	Millet	total	Sorghum	Millet	total	Sorghum	Millet	total	Sorghum	Millet	total
Row spacings (S)													
20 cm		0.922	1.830	2.202	0.732	1.913	2.117	0.509	1.107	1.293	2.163	4.850	5.610
30 cm		1.114	1.896	2.408	0.551	1.590	1.713	0.407	1.056	1.170	2.072	4.542	5.291
40 cm		0.820	1.748	2.054	0.609	1.507	1.693	0.439	0.912	1.081	1.868	4.167	4.828
F. test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Intercropping systems (I)													
Sorghum%	Millet%												
100	-	1.652a	-	1.652b	1.168a	-	1.168b	0.794a	-	0.794b	3.614a	-	3.614b
75	25	1.183ab	0.984c	2.167ab	0.741ab	0.996b	1.736ab	0.537ab	0.648c	1.185ab	2.461b	2.627c	5.088ab
50	50	0.632bc	1.570bc	2.202ab	0.388bc	1.676ab	2.064ab	0.293bc	0.867bc	1.160ab	1.313c	4.113b	5.426a
25	75	0.341c	2.149ab	2.489ab	0.226c	1.798ab	2.023ab	0.182c	1.163ab	1.345a	0.749c	5.109ab	5.858a
-	100	-	2.597a	2.597a	-	2.210a	2.210a	-	1.422a	1.422a	-	6.230a	6.230a
F. test		**	**	**	**	**	**	**	**	**	**	**	**
Interaction													
SXI		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (5): Leafness ratio for sorghum and pearl millet as influenced by row spacings and intercropping systems in the two seasons and their combined analysis.

Main effects and interaction		First season						Second season					
		1st cut		2nd cut		3rd cut		1st cut		2nd cut		3rd cut	
		Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet	Sorghum	Millet
Row spacings (S)													
20 cm		0.562	0.635	0.450	0.408	0.561	0.482	0.467	0.623a	0.597	0.643	0.584	0.487
30 cm		0.554	0.610	0.426	0.394	0.597	0.437	0.413	0.552b	0.628	0.618	0.615	0.537
40 cm		0.541	0.618	0.433	0.398	0.523	0.443	0.364	0.565b	0.565	0.649	0.601	0.546
F. test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	N.S	N.S	N.S
Intercropping systems (I)													
Sorghum%	Millet%												
100	-	0.540	-	0.449	-	0.568	-	0.426	-	0.602	-	0.590	-
75	25	0.509	0.617	0.421	0.397	0.548	0.413	0.387	0.588	0.623	0.580	0.583	0.500
50	50	0.583	0.660	0.444	0.411	0.566	0.436	0.439	0.603	0.612	0.648	0.629	0.523
25	75	0.577	0.600	0.431	0.390	0.560	0.487	0.408	0.588	0.550	0.663	0.596	0.518
-	100	-	0.607	-	0.402	-	0.480	-	0.542	-	0.653	-	0.553
F. test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Interaction													
SXI		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (5): cont.

Main effects and interaction		Combined analysis											
		1st cut			2nd cut			3rd cut			Seasonal yield		
		Sorghum	Millet	total	Sorghum	Millet	total	Sorghum	Millet	total	Sorghum	Millet	total
Row spacings (S)													
20 cm		0.515	0.629	0.572	0.523	0.525	0.528	0.573	0.485	0.526	0.532a	0.547	0.539
30 cm		0.484	0.581	0.538	0.527	0.506	0.513	0.606	0.487	0.526	0.503ab	0.520	0.510
40 cm		0.452	0.592	0.538	0.499	0.524	0.521	0.562	0.494	0.522	0.473b	0.536	0.514
F. test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	**	N.S	N.S
Intercropping systems (I)													
Sorghum%	Millet%												
100	-	0.483	-	0.483b	0.526	-	0.526	0.579	-	0.579	0.505a	-	0.506ab
75	25	0.448	0.602	0.518ab	0.522	0.489	0.502	0.566	0.457	0.503	0.478b	0.518	0.496b
50	50	0.511	0.632	0.595a	0.528	0.530	0.528	0.598	0.480	0.512	0.525a	0.552	0.543a
25	75	0.491	0.594	0.576ab	0.490	0.527	0.520	0.578	0.502	0.510	0.502ab	0.539	0.532ab
-	100	-	0.574	0.574ab	-	0.528	0.528	-	0.517	0.517	-	0.528	0.528ab
F. test		N.S	N.S	**	N.S	N.S	N.S	N.S	N.S	N.S	*	N.S	*
Interaction													
SXI		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (6): Crude protein percentage for sorghum and pearl millet as influenced by row spacings and intercropping systems in the second season.

Main effects and interaction		Second season								
		1st cut			2nd cut			3rd cut		
		Sorghum	Millet	total	Sorghum	Millet	total	Sorghum	Millet	total
Row spacings (S)										
20 cm		11.19	12.92	12.74	10.23	12.46	11.67	10.16	11.86	11.23
30 cm		11.14	12.71	12.04	10.10	12.04	11.62	10.05	11.82	11.14
40 cm		11.06	12.59	12.01	10.16	12.20	11.51	10.05	11.70	11.08
F. test		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S
Intercropping systems (I)										
Sorghum%	Millet%									
100	-	11.24	-	11.24c	10.17	-	10.17d	10.11	-	10.11d
75	25	10.96	12.70ab	12.13b	10.15	11.74c	11.43c	10.02	11.21b	10.84c
50	50	11.16	12.95a	12.82a	10.17	12.38b	11.91bc	10.12	12.01a	11.06bc
25	75	11.16	11.88ab	12.72ab	10.15	12.76a	12.46a	10.10	12.00a	11.79a
-	100	-	12.44b	12.44ab	-	12.03bc	12.03ab	-	11.93a	11.93a
F. test		N.S	*	*	N.S	*	*	N.S	*	*
Interaction										
SXI		N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S	N.S

Table (2-a): Effect of row spacings and intercropping systems on gain or loss in number of tillers/m^2 for the associated sorghum and pearl millet (average of different cuts over the two seasons).

Main effects and interaction		Sorghum	Pearl millet
Row spacings (S)			
20 cm		7.2	20.5a
30 cm		- 6.9	10.7ab
40 cm		- 7.3	2.9b
F. test		N.S	*
Intercropping systems (I)			
Sorghum%	Millet%		
100	-	-	-
75	25	- 4.4	19.2a
50	50	- 3.9	16.8a
25	75	1.3	- 2.0b
-	100	-	-
F. test		N.S	*
Interaction			
SXI		N.S	N.S

Table (4-a): The mean values of advantages or disadvantages calculated for intercrop dry forage yield (ton/fad) of sorghum and millet as well as their total percent as affected by row spacings and intercropping systems (mean of different cuts over the two seasons).

Main effects and interaction		Sorghum	Pearl millet	Total
Row spacings (S)				
20 cm		- 0.044	0.423	0.379
30 cm		- 0.131	0.263	0.132
40 cm		0.126	0.149	0.023
F. test		N.S	N.S	N.S
Intercropping systems (I)				
Sorghum%	Millet%			
100	-	-	-	-
75	25	- 0.083	0.356a	0.273
50	50	- 0.165	0.333ab	0.167
25	75	- 0.052	0.145b	0.093
-	100	-	-	-
F. test		N.S	*	N.S
Interaction				
SXI		N.S	N.S	N.S

مخلوط السورجم والدخن تحت ظروف الأراضى الرملية

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أقيمت تجربتان حقليتان بمزرعة كلية الزراعة فى منطقة الخطارة بمحافظة الشرقية بمصر خلال موسمى صيف ٢٠٠٠ ، ٢٠٠١ للوقوف على الجدارة المحصولية للسورجم والدخن ونظم تحميلهما (٧٥% سورجم + ٢٥ دخن ، ٥٠% سورجم + ٥٠% دخن ، ٢٥% سورجم + ٧٥% دخن) عند زراعتهما بالأراضى الرملية على سطور المسافة بينها ٢٠ ، ٣٠ و ٤٠ سم .

أشارت النتائج المتحصل عليها إلى أن مسافة التسطير المتوسطة (٣٠ سم) سجلت أقل ارتفاع لنبات السورجم بالحشة الثانية بينما فى الحشة الثالثة زاد ارتفاع نبات الدخن بالمسافات الواسعة عن الضيقة . هذا وقد تحققت زيادة فى عدد الأفرع / م٢ للدخن المحمل عن المتوقع تحت كل مسافات التسطير ولكن تلك الزيادة بالمسافات الضيقة كانت أكبر منها بالمسافات الواسعة. أيضا تحققت زيادة فى عدد الأفرع / م٢ للسورجم المحمل عن المتوقع بمسافات التسطير الضيقة فقط . بالتبعية تفوقت المسافات الضيقة على المسافات الواسعة فى محصول الدخن من العلف الغض بالموسم . علاوة على ذلك تفوقت المسافات الضيقة على المسافتين الأخريتين فى محصول السورجم من العلف الغض بالموسم وأيضا فى إجمالى محصول العلف الغض للنوعين النباتيين خلال الموسم . كما اتجهت الميزة فى إجمالى محصول العلف الجاف بالموسم لمكونى التحميل إلى الزيادة بتضييق مسافة التسطير . بالإضافة إلى ذلك أدى تضييق مسافة التسطير حتى ٢٠ سم إلى زيادة نسبة الأوراق للنبات من السورجم خلال الموسم .

أوضحت النتائج أن نظم التحميل لم تؤثر على ارتفاع النبات لأى من السورجم أو الدخن. رغم أن النقص فى نسبة مساحة أى من مكونى التحميل قد تبعها نقص فى عدد أفرعه/م٢ فى معظم الأحوال، فإن النقص فى نسبة المساحة للسورجم من ٥٠ إلى ٢٥% وللدخن من ٧٥ إلى ٥٠% لم يتبعها نقص فى ذلك العدد بالحشات المختلفة . لذلك أدى نقص نسبة المساحة للسورجم حتى ٢٥% وللدخن حتى ٥٠% إلى جعل مكونى التحميل يحققان زيادة فى عدد الأفرع/م٢ عن الزراعة المنفردة. ومن ثم أنتجت كل نظم التحميل المدروسة – فى كل حشة وخلال الموسم – محصول علف غض وجاف يعادل – تقريبا – ذلك الناتج فى المكون الأعلى إنتاجية فى الزراعة المنفردة أى الدخن . حيث زادت الميزة فى إنتاجية الدخن من العلف الجاف مع خفض نسبة مساحته فى التحميل من ٧٥ إلى ٢٥% . أيضا فإن أى إحلال للسورجم بالدخن قد تبعه زيادة فى نسبة البروتين الخام بالعلف الجاف بوجه عام . وبزيادة نسبة مساحة الدخن فى التحميل إلى ٥٠ أو ٧٥% أمكن تعظيم محتوى العلف الجاف من البروتين الخام بالحشة الأولى والحشتين الأخريتين .

تستخلص نتائج الدراسة الحالية أنه يمكن الحصول على محصول مرتفع من علف ذات جودة عالية بالأراضى الرملية عند تحميل السورجم مع أو إحلاله بالدخن مع الزراعة فى سطور المسافة بينها ٢٠ سم.