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EFFECT OF INTERCROPPING PATTERNS ON FORAGE YIELD AND LAND USE EFFICIENCY OF SOME SUMMER FODDER CROPS

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ABSTRACT: Two field experiments were carried out during two successive summer seasons of 2014 and 2015 at Kafr Al-Hamam Agricultural Research Station, Agric. Research Center (ARC) to study the effect of intercropping of six summer fodder crops *i.e.* pure stand of sudan grass (100%), pearl millet (100%), teosinte (100%), cowpea (100%), guar (100%) and lima bean (100%), respectively, planting each of sudan grass (50%) + cowpea (50%), sudan grass (50%)+ guar (50%), sudan grass (50%) + lima bean (50%), pearl millet (50%)+ cowpea (50%), pearl millet (50%) + guar (50%), pearl millet (50%) + lima bean (50%), teosinte (50%)+ cowpea (50%), teosinte (50%) + guar(50%) and teosinte (50%) + lima bean (50%) in row alternatives on the same ridge, respectively on forage and protein yields and land use efficiency. The important results could be summarized as follows: Pure stand of pearl millet gave higher total fresh and dry forage yields than either sudan grass or teosinte, whereas cowpea pure stand gave higher total fresh and dry forage yields compared with sole planting of either guar or lima bean. Results also confirmed the superiority of pearl millet + cowpea intercropping in total fresh and dry forage yields (32.51 and 6.50 ton/fad.), respectively over pure legumes and all other intercropping patterns. The intercropping of pearl millet + cowpea gave the highest total crude protein yield (766.56 kg/fad.) than all other intercropping patterns. The contribution percentage of grasses in dry yield for the three cuts of any intercropping system were high, whereas that of legumes were low than the expected. Cowpea was the highest competitive associate crop in the three cuts compared to either guar or lima bean. Planting of grasses intercropped with legumes caused increase in total land equivalent ratio (LER) for the total three cuts of both crops which was greater than one in all intercropping patterns under study as dry matter basis. Also, land equivalent coefficient (LEC) exhibited similar trend. The values of competition ratio (CR) for the total three cuts of grasses were greater than intercropped legumes indicating the dominance of grasses and the legumes as the dominated component under different intercropping patterns.

Key word: Intercropping, LER, LEC, CR, cowpea, teosinte, sudan grass, pearl millet, lima bean, guar.

INTRODUCTION

Fodders as group of crops differ from food and commercial crops as they are primarily grown for the fresh green vegetative biomass Eskandari *et al*. (2009). Grasses forage such as sudan grass, pearl millet and teosinte are high important in feeding ruminant animals for their high dry matter production and low cost. However, grasses forage is poor in protein content which show their low quality and nutritive value. Regarding to high feed costs of protein supplementations, legume forage such as cowpea, guar and lima bean can be used in livestock nutrition for their high protein content. Since legumes have low dry matter yield, acceptable forage yield and quality can obtained from intercropping of grasses and legumes compared with their sole crops (Asangla and Gohain, 2016). Moreover, Ali (1992) showed that the contribution percentage of maize in dry yield of any intercropping pattern was high, whereas that of cowpea was low than the expected. Hassan (2003) revealed that guar plant

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height significantly decrease due to planting in association with fodder maize. Thus, guar plants in pure stand were the tallest as compared with those in mixed cropping. Nor El-Din *et al.* (1992) showed that the highest fresh and dry forage yields were obtained with planting the mixture of 10 kg millet + 10 kg guar/fad., whereas the lowest yield was obtained with planting guar alone. Sharief and Said (1999) indicated that land equivalent ratio (LER) more useful agronomical parameter for measurement of utilization of land by intercropped crops. The solid planting of sorghum surpassed all intercropping system in sorghum forage yield/ fad. With regard to cowpea, the solid planting exceeded all intercropping system in cowpea forage yield/fad., and land equivalent ratio (LER) of both crops was greater than one in all intercropping systems. Sarhan and Atia (2000) revealed that teosinte + cowpea mixture was superior to monocropping with an increase in forage and protein yields. Zeidan *et al*. (2003) stated that fodder maize sole planting gave higher fresh and dry forage yields than either cowpea or guar. Whereas, planting cowpea in pure stand gave higher protein yield/fad., when compared with fodder maize and guar. Maurice *et al*. (2010) reported that cowpea/ maize intercropping reduced the yield of cowpea due the maize canopy that interfere with light penetration. Eskandari (2012) reported that intercropping of cereals and legumes is important for the development of sustainable food production system, particularly in cropping system with limited external inputs. This may be due to some of the potential benefits for intercropping system such as high productivity and profitability, improvement of soil fertility through the addition of N by fixation, efficient use of resources, reducing damage caused by pests, diseases and weeds, control of legume root parasite infection and improvement of forage quality through the complementary effects of two crops grown simultaneously on the same area of land. Also he stated that the higher total protein yield produced by intercropping was attributed to higher forage production by intercrops and also protein content. Legumes supply nitrogen to grass-legume mixtures, so it produced more forage yield than grasses grown alone. Grasses grown in intercropping with legumes also contain a higher percentage of protein. Reza (2012) indicated that the crude protein and dry matter yields of sorghum increased with legumes compared with sorghum monoculture, and the intercropping of forage sorghum and lima bean gave higher land use efficiency than sole cropping of sorghum.

The objective of this study was to investigate the most appropriate summer grasses and legumes and intercropping patterns for producing the highest forage yield and quality as well as land use efficiency.

MATERIALS AND METHODS

The present investigation was carried out at Agriculture Research Center, Kafr Al-Hamam Agriculture Research Station, Zagazig City, Sharkia Governorate, Egypt, during 2014 and 2015 summer seasons. The soil of the experimental field was clay in texture having 8.55 pH and containing 25, 23 and 488 ppm available N, P_2O_5 and K_2O, respectively (mean of the two seasons for the upper 30 cm of the soil surface). The study included 15 treatments which were six summer fodder crops and the combinations among them. The summer crops were sudan grass (*Sorghum sudanense* ((P.) Staph) var. Giza 2, pearl millet (*Pennisetum americanum* (L.) K. Schum) var. Shandawil, teosinte (*Euchlaena Mexicana*) local variety, cowpea (*Vigna sinensis* L.) local variety, guar (*Cyamopsis tetragonoloba* L.) local variety and lima bean (*Phaseolus vulgaris* L.) local variety. The treatments used were as follows:

1. Pure stand of sudan grass with a seeding rate of 15 kg/fad., using planting distance of 20 cm on both sides of the ridge (100%).
2. Pure stand of pearl millet with a seeding rate of 15 kg/fad., using planting distance of 20 cm on both sides of the ridge (100%).
3. Pure stand of teosinte with a seeding rate of 20 kg/fad., using planting distance of 20 cm on both sides of the ridge (100%).
4. Pure stand of cowpea with a seeding rate of 20 kg/fad., using planting distance of 20 cm on both sides of the ridge (100%).

5. Pure stand of guar with a seeding rate of 15 kg/fad., using planting distance of 20 cm on both sides of the ridge (100%).
6. Pure stand of lima bean with a seeding rate of 60 kg/fad., using planting distance of 20 cm on both sides of the ridge (100%).
7. Planting sudan grass on one side of the ridge using seeding rate of 7.5 kg/fad., (50%) alternating with cowpea on the other side using seeding rate of 10 kg/fad., (50%).
8. Planting sudan grass on one side of the ridge using seeding rate of 7.5 kg/fad., (50%) alternating with guar on the other side using seeding rate of 7.5 kg/fad., (50%).
9. Planting sudan grass on one side of the ridge using seeding rate of 7.5 kg/fad., (50%) alternating with lima bean on the other side using seeding rate of 30 kg/fad. (50%).
10. Planting pearl millet on one side of the ridge using seeding rate of 7.5 kg/fad., (50%) alternating with cowpea on the other side using seeding rate of 10 kg/fad., (50%).
11. Planting pearl millet on one side of the ridge using seeding rate of 7.5 kg/fad., (50%) alternating with guar on the other side using seeding rate of 7.5 kg/fad., (50%).
12. Planting pearl millet on one side of the ridge using seeding rate of 7.5 kg/fad., (50%) alternating with lima bean on the other side using seeding rate of 30 kg/fad.(50%).
13. Planting teosinte on one side of the ridge using seeding rate of 10 kg/fad., (50%) alternating with cowpea on the other side using seeding rate of 10 kg/fad., (50%).
14. Planting teosinte on one side of the ridge using seeding rate of 10 kg/fad., (50%) alternating with guar on the other side using seeding rate of 7.5 kg/fad., (50%).
15. Planting teosinte on one side of the ridge using seeding rate of 10 kg/fad., (50%) alternating with lima bean on the other side using seeding rate of 30 kg/fad., (50%).

Using planting distance of 20 cm on both sides of the ridge in all intercropping patterns.

A randomize complete block design with three replicates was used. The plot area was 10.5 m^2 (3.5 × 3m) *i.e.* 5 ridges each of 0.7 m width and 3 m long. The preceding crop for both seasons was wheat (*Triticum aestivum* L.). Sowing dates took place on June 2^{nd} and 8^{th} in the 1^{st} and 2^{nd} seasons, respectively. Calcium superphosphate (15.5% P_2O_5) was added before sowing at rate of 100 kg/fad., and 75 kg N/fad., (as urea 46.5%) applied at three equal doses, *i.e.* at the first irrigation, after the 1^{st} and the 2^{nd} cut, respectively. The three cuts were taken in both seasons, the first cut was after 56 days of planting and the following cuts were done 40 day intervals in both seasons.

At cutting time, plants of an area 0f 4.2 m^2 were cut from the two inner ridges to determine the following parameters:

Growth characters

Plant height (cm) for each sole crop as well as for both components in each of intercropped, *i.e.*, number of tillers/plant. This character was calculated for sudan grass, pearl millet and teosinte. Whereas number of branches/plant was calculated for cowpea, guar and lima bean.

Fresh and dry forage yield (ton/fad.)

Fresh forage yield for each sole crop as well as for both components in case of intercropping. Samples of 250 g fresh forage, were oven dried at 70^oC up to constant weight to estimate dry forage yield (ton/fad.)

Crude protein yield (kg/fad.)

Nitrogen content (%) was estimated according to AOAC (1995) with the modified Kjidahal method, for the whole plants of both components and multiplying by the factor of 6.25, then the crude protein yield was calculated.

Botanical composition

i.e. the contribution percentage of both components in the average of the combined intercrop dry forage yield of both seasons.

Land use efficiency

In order to assess the land use efficiency Total land equivalent ratio (LER), land equivalent coefficient (LEC) and competition ratio (CR) were determined for each yield recorded per faddan *i.e.* dry forage yield. This was achieved for cropping systems.

Total land equivalent ratio (Total LER)

Was suggested by Monzon *et al*. (2014) it was determined as the sum of yield relative *i.e.* intercrop yields relative to their solid yield. The total LER an accurate assessment of the biological efficiency of the intercropping situation, using the following equation to evaluate and compare the productivity of relay intercropping and mono cropping:

Total LER = (Yab/Yaa) + (Yba/Ybb).

Where:

Yaa and Ybb are yields as sole crops of a (grasses) and b (legumes) and Yab and Yba are yields as intercrops of a and b, respectively. Values of total LER greater than 1.0 are considered advantages. While, values of total LER less than 1.0 are considered disadvantages.

Land equivalent coefficient (LEC)

A measure of interaction concerned with the strength of relationship was calculated thus,

$$LEC = La \times Lb.$$

Where:

La= partial LER of main crop and Lb= partial LER of intercrop (Aditiloye *et al*., 1983). For a two- crop mixture the minimum expected productivity coefficient (PC) is 25% that is a yield advantage is obtained if LEC exceeds 0.25.

Competition ratio (CR)

Represents simply the ratio of individual LERs of the two component crops and takes into account the proportion of the crops in which they are initially sown. The CR is calculated according to the following formula:

$$CR=\{ (Ia/Ma)(Ib/Mb)^{-1} \}(Sb/Sa)$$

Where:

Ia= yield of crop a in intercropping, Ib = yield of crop b in intercropping, Ma = yield of crop a in sole cropping, Mb = yield of crop b in sole cropping, Sa= relative space occupied by crop a and Sb= relative space occupied by crop b (Willey and Rao, 1980).

Statistical Analysis

The obtained data were statistically analyzed according to Steel *et al.* (1997). Therefore, the assumption of normality and the homogeneity of variance of the experimental error was checked according to Bartlet,s method, which showed an appropriate homogeneous of errors variance. Least significant differences were used for the comparison between means. Therefore, the combined analysis over both seasons was done using MSTAT (1988).

RESULTS AND DISCUSSION

Growth Characters

Results presented in Table 1 showed that the differences in plant height due to intercropping pattern in both grass and legume components for all cuts as combined data, where the grass component is usually taller with a faster growing compared with legum component. These results are in harmony with those obtained by Amanullah *et al*. (2016). It may be due to cereal, a C_4 plants characterized by high efficiency of light utilization and rapid growth rate might have suppressed the early and subsequent growth of legume, a C_3 plant with low high use efficiency. In both cases sudan grass plants either solid or planted combined with legumes gave the tallest plants when compared with other sole cropping *i.e.*, pearl millet and teosinte as well as their intercropping patterns. Also, cowpea plants either solid or planted in combined with grasses gave the tallest plants when compared with other sole cropping *i.e.*, guar and lima bean as well as their intercropping patterns. Likely, most grasses plant height were not significantly affected with intercropping patterns, but legumes plant height significantly decreased due to intercropped with grasses. Thus, legumes planting pure stand were taller as compared with that in intercropped. This may be due to that legume plants in monoculture did not suffered from competition especially for light from grasses plants compared to those in different intercropped. These results are in harmony with those reported by Mohamed (1989) and Lithourgidis et *al.* (2011) who found that shading in intercropping would reduce the energy available to the shorter component crop. Finally, most legumes plant height were taller when planted intercropping with sudan grass plants compared with other grasses. These were true in the three individual cuts for combined data.

Table 1. Effect of intercropping on plant height and number of tillers or branches/plant of summer forage crops (combined data)

Solid and intercropping	Plant height(cm)						Number of tillers or branches/plant					
	1st cut		2nd cut		3rd cut		1st cut		2nd cut		3rd cut	
	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes
Sudan grass solid	150.00	_	137.73	_	128.90	_	6.80	_	6.20	_	5.53	_
Pearl millet solid	119.17	_	115.67	_	111.53	_	11.13	_	9.13	_	9.00	_
Teosinte solid	88.47	_	103.10	_	112.47	_	3.87	_	6.67	_	4.80	_
Cowpea solid	_	61.60	_	55.50	_	65.90	_	11.80	_	9.27	_	7.13
Guar solid	_	52.53	_	44.87	_	58.33	_	10.07	_	8.40	_	6.67
Lima bean solid	_	47.00	_	43.13	_	49.40	_	7.80	_	7.13	_	5.67
Sudan grass+cowpea	153.50	52.50	147.10	50.23	138.10	64.67	8.13	6.87	6.87	5.53	6.13	3.67
Sudan grass+guar	150.73	45.83	140.13	39.07	134.80	57.73	7.93	6.07	6.67	4.07	5.80	3.33
Sudan grass+lima bean	152.63	41.80	146.93	38.73	139.77	49.37	7.87	5.80	6.93	4.53	5.93	2.67
Pearl mille+cowpea	129.97	50.63	127.93	49.57	122.30	61.90	11.80	6.53	10.07	5.00	9.73	3.33
Pearl millet+guar	125.60	44.57	124.17	39.83	119.70	55.70	11.27	6.13	9.73	4.00	9.33	3.00
Pearl millet+lima bean	126.40	42.80	123.43	40.13	118.20	48.07	11.67	5.80	9.80	3.67	9.67	2.33
Teosinte+cowpea	100.07	51.50	105.67	48.87	110.33	60.73	4.87	6.93	7.20	5.93	5.20	4.33
Teosinte+guar	94.23	44.83	104.00	40.57	104.13	54.57	4.67	6.47	6.73	5.07	5.00	4.00
Teosinte+lima bean	98.23	44.87	107.33	39.80	107.90	43.00	4.80	6.00	7.13	5.20	5.07	3.00
LSD 0.05	7.94	3.96	10.24	3.52	7.77	4.60	1.04	0.69	0.49	0.79	0.56	0.78

Number of tillers or branches for grasses and legumes as affected by intercropping are shown in Table 1. The statistical analysis revealed significant differences between solid crops and their intercropped. Generally, pearl millet plants as grasses, either solid planting or their intercropped planting gave the highest number of tillers/plant whereas, cowpea plants as legumes, either solid planting or their intercropped planting gave the highest number of branches/plant. This was true in the 1st, 2nd and the 3rd cuts for the combined data. Growing grasses with cowpea, guar and lima bean produced highest number of tillers/plant of grasses as compared with solid planting. On contrary, the sole legume plants produced significantly the higher number of branches/ plant when compared with those in association with grasses. Herein, the adverse effect of growing taller plant like grasses on the shorter one like legumes was observed. In this concern Hassan (2003) found that intercropping guar or cowpea with maize reduced the percentage of light interception in guar or cowpea canopy compared to solid planting. Also, Eskandari (2012) obtained that shading the intercropping would reduce light intensity available to the shorter crop components.

Forage Yield (ton/fad.)

The results presented in Table 2 indicate significant differences in fresh and dry forage yields among all treatments for each cut and the total forage yield as combined data. Grasses gave higher fresh and dry forage yields compared with legume forage yields for the three cuts individualy and the total fresh and dry forage yields in combined data. Similar finding were reported by Poodineh *et al.* (2014). Generally, pearl millet sole planting gave higher

Table 2. Effect of intercropping on fresh and dry forage yields (ton/fad.) of summer forage crops (combined data)

Solid and intercropping	Fresh forage yield (ton/fad.)				Dry forage yield (ton/fad.)			
	1st cut	2nd cut	3rd cut	Total	1st cut	2nd cut	3rd cut	Total
Sudan grass solid	17.125	13.525	7.717	38.367	3.344	3.086	1.881	8.311
Pearl millet solid	18.888	15.398	9.289	43.575	3.485	3.264	2.099	8.848
Teosinte solid	6.813	11.742	9.687	28.242	1.115	2.284	2.070	5.469
Cowpea solid	12.340	7.125	3.897	23.362	1.879	1.064	0.656	3.599
Guar solid	9.757	5.115	2.830	17.702	1.462	0.802	0.514	2.778
Lima bean solid	8.819	5.368	2.361	16.548	1.527	0.922	0.424	2.873
Sudan grass+cowpea	13.786	10.313	4.882	28.981	2.801	2.258	1.147	6.206
Sudan grass+guar	12.068	8.662	4.565	25.295	2.512	1.845	1.108	5.465
Sudan grass+lima bean	12.276	8.549	4.241	25.066	2.574	1.871	1.039	5.484
Pearl mille+cowpea	15.527	11.269	5.716	32.512	3.009	2.199	1.292	6.500
Pearl millet+guar	12.899	9.523	5.231	27.653	2.587	1.997	1.162	5.746
Pearl millet+lima bean	14.242	9.260	4.992	28.494	2.712	1.969	1.123	5.804
Teosinte+cowpea	9.572	9.416	5.830	24.818	1.766	1.693	1.158	4.617
Teosinte+guar	7.215	7.951	5.472	20.638	1.410	1.484	1.103	3.997
Teosinte+lima bean	7.434	8.332	5.366	21.132	1.505	1.607	1.067	4.179
LSD 0.05	0.730	0.694	0.522	1.129	0.129	0.124	0.089	0.186

fresh and dry forage yields than either sudan grass or teosinte as a solid planting. This was true in all individual cuts and the total fresh and dry forage yields on basis of combined data. The total fresh forage yield amounted 43.57, 38.36 and 28.24 ton/ faddan for pearl millet, sudan grass and teosinte, respectively. The same trend could be seen from the results of dry forage yield, these results were confirmed those found by Geweifel (1997). Also, sole pearl millet gave the highest fresh and dry forage yields when compared with intercropping patterns, in the three cuts and the total fresh and dry forage yields (combined data). The increases forage yield in every cut or total yield/fad., of solid planting may be due to increase in number of plants per unit area. However the increases of intercropping forage yield per unit area mostly derives from the cereals component under all intercropping treatments. The grass component, with relatively higher growth rate, higher advantage, is favored in the competition with the association legume. The pearl millet + cowpea intercropping significantly increase intercrop fresh as well as dry forage yields compared with all another intercropping. On the contrary, the lowest values of fresh and dry forage yields were produced by planting teosinte+ guar and teosinte+ lima bean intercropping patterns. This was true in the three cuts and the total fresh and dry forage yields in combined data.

Crude Protein Yield (kg/fad.)

Results related to crude protein yield (kg/ fad.) as influenced by intercropping patterns in combined data are presented in Table 3. The statistical analysis of variance showed significant differences among the 15 treatments. This was true in the three individual cuts and the total crude protein yield. In the first cut, planting cowpea

Table 3. Effect of intercropping on crude protein yield (kg/fad.) of summer forage crops (combined data)

Solid and intercropping	1st cut	2nd cut	3rd cut	Total
Sudan grass solid	322.380	278.100	152.621	753.101
Pearl millet solid	362.263	327.930	197.248	887.441
Teosinte solid	111.379	248.797	207.450	567.626
Cowpea solid	377.521	179.966	99.720	657.207
Guar solid	258.517	116.364	69.991	444.872
Lima bean solid	286.007	139.707	60.319	486.033
Sudan grass + cowpea	355.502	247.320	101.979	704.800
Sudan grass + guar	289.211	182.247	93.161	564.619
Sudan grass + lima bean	302.313	189.994	87.705	580.012
Pearl mille + cowpea	388.250	251.202	127.115	766.567
Pearl millet + guar	309.681	210.483	107.178	627.342
Pearl millet + lima bean	345.095	213.167	105.637	663.898
Teosinte + cowpea	264.388	218.101	129.706	612.194
Teosinte + guar	203.962	173.775	116.888	494.625
Teosinte + lima bean	223.777	196.262	115.595	535.635
LSD 0.05	17.708	13.993	8.269	22.725

in solid gave the highest protein yield kg/ fad., (377.52) when compared with other sole cropping (322.38, 362.26, 111.37, 258.51 and 286.01 for sudan grass, pearl millet, teosinte, guar and lima bean) as well as most of intercropping patterns (355.50, 289.21, 302.31, 309.68, 345.10, 264.38, 203.96 and 223.77 kg/ fad., for (sudan grass + cowpea, sudan grass + guar, sudan grass + lima bean, pearl millet+ guar, pearl millet+ lima bean, teosinte + cowpea, teosinte + guar and teosinte + lima bean in respective order). The superiority of cowpea sole planting than other sole cropping and intercropping patterns might be due to the increase in protein percentage. Likewise, the results of the first cut indicated that the protein yield of fodder pearl millet + cowpea intercropping pattern (388.25 kg/fad.) surpassed that of the other forge intercropping. The superiority of this intercropping pattern over the other intercropping pattern may be due to the increase in dry matter production. Similar results were obtained by many researchers who found that high protein yield was produced from the intercrop of pearl millet or teosinte with legumes compared to sole cropping of grass (Sarhan and Atia, 2000; Eskandari *et al*., 2009; Lithourgidis *et al*., 2011; Legwaila *et al*., 2012). While the results of the second and the third cuts were significantly affected by intercropping patterns. The sole cropping of sudan grass, pearl millet and teosinte gave the highest total crude protein yield compared to other sole cropping *i.e.*, cowpea, guar and lima bean as well as intercropping patterns. Since the increase in crude protein content did not compensate the decrease in dry matter production by legume component. The finding obtained by Abuneran (2013) stated that dry matter production is an important factor in determining crude protein yield per unit area. In general, the highest total crude protein yield obtained from planting pearl millet + cowpea intercrop pattern reached 766.56 while the lowest ones planting teosinte +

guar intercrop pattern reached 494.62 kg/fad., compared with other intercropping patterns on basis of the total crude protein yield.

Botanical Composition

Table 4 which illustrated graphically in Figs. 1a, 1b and 1c indicate that, the contribution of different legumes in the intercropping patterns was almost one fourth in the 1st cut, then it came down in the 3rd cut with clear reduction in the 2nd cut for intercropping patterns of sudan grass and pearl millet. Generally, the results obtained suggest that shading in intercropping would reduce the energy available to the shorter component crop. Similar trend was obtained by Reza (2012). As in the case of intercropping various legumes with teosinte find that it's somewhat different. In the 1st cut found that legumes involved in forage crop by more than half and attributed the large participation of legumes in the 1st cut of weakness and slow the growth of teosinte accompanying plants in intercropping patterns, which reducing of interspecific competition between teosinte plants and legumes component, so we note that legume component in the 1st cut was more productive over teosinte component, while in the 2nd cut, the share of legumes in crop dry matter decreased less than 30% less in teosinte intercropping patterns. Finally both guar and lima bean did not give regrowth, it is worth to note here that both guar and lima bean did not share much in the 3rd and the dry forage yield of the 3rd cut was almost teosinte in these three intercropping patterns, as for cowpea was the highest in the percentage of their contribution exceeding 10% in the 3rd cut. Generally cowpea was satisfactory in intercropping patterns with other summer grasses forage crops, such as teosinte, sudan grass and pearl millet, respectively.

Land Equivalent Ratio (LER)

Results in Table 5 show the effect of intercropping of some summer crops on LER and fractions obtained from dry forage yield basis of grasses and legumes in combined data. It can be noted that, all intercropped plants had higher $L_{grasses}$ values and lower $L_{legumes}$ values than the expected. This was true when these values were calculated whether on dry forage yield basis. In the 1st cut, all intercropping plants significantly produced LER more than unity indicating a yield advantage. The highest LER amounted to 1.21for intercropping pattern of teosinte + cowpea on based of dry forage yield. This value of LER indicated that almost 21% more land would be required to plant the sole crops to produce the same quantity of the yield of the intercropping pattern. While in the 2nd cut the only one tested intercropping pattern, teosinte + cowpea significantly produced land equivalent ratio (LER) more than unity indicating yield advantage. This value of LER indicated that 2% more land would be required to plant the sole to produce the same quantity of the yield of the intercropping pattern, but other intercropping patterns produced land equivalent ratio less than unity. On the other hand, in the last cut, the LER in all intercropping patterns studied was less than unity, indicating disadvantage in forage yield production. Finally, according to the results of the total LER for the three individual cuts of grasses and legumes, the intercropping patterns were exceed than unity, the greater LER of the intercrops was mainly due to a greater recourse use and resource complementarily, when the species were grown alone. These results are in general agreement with those reported by several investigators included Dwivedi *et al*. (2015), Sharief and Said (1999), Ali (1992) and Shri *et al*. (2014), they reported yield occurs, when the component crops do not compete for the same ecological niches and the intraspecific competition. Normally, complementary use of resources occurs when the component species of an intercrop use qualitatively different resources or they use the same resources at different places or at different times.

Land Equivalent Coefficient (LEC)

Results in Table 6 show the effect of intercropped plants on LEC and fractions obtained from dry forage yield basis of grasses and legumes in combined data. It can be noted that, all intercropped grass plants had higher $L_{grasses}$ values and legume plants had lower $L_{legumes}$ values than the expected. This was a true when these values were calculated whether on dry forage yield basis. The highest LEC amounted to 0.36 and 0.25 for intercropping pattern of teosinte + cowpea on dry forage base

Table 4. Effect of intercropping on the contribution percentage of grasses and legumes on dry forage yield basis (combined data)

Intercropping	1st cut		2nd cut		3rd cut	
	Grasses	Legumes	Grasses	Legumes	Grasses	Legumes
Sudan grass+cowpea	68.062	31.938	78.190	21.810	91.472	8.528
Sudan grass+guar	74.133	25.867	83.828	16.172	95.125	4.875
Sudan grass+lima bean	73.423	26.577	84.582	15.418	96.247	3.753
Pearl mille+cowpea	70.728	29.272	80.198	19.802	92.957	7.043
Pearl millet+guar	73.560	26.440	84.033	15.967	94.867	5.133
Pearl millet+lima bean	73.837	26.163	85.177	14.823	96.088	3.912
Teosinte+cowpea	40.585	59.415	68.218	31.782	88.967	11.033
Teosinte+guar	47.258	52.742	75.545	24.455	91.422	8.578
Teosinte+lima bean	46.310	53.690	75.107	24.893	93.852	6.148

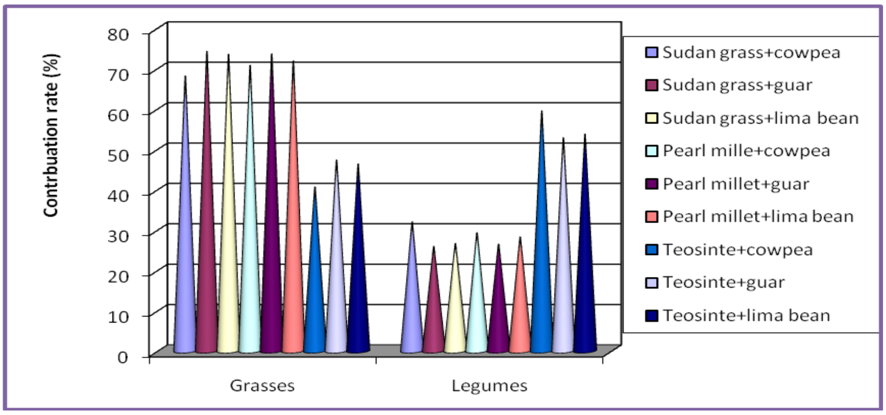

Fig. 1a. Effect of intercropping on the contribution percentage of grasses and legumes in dry forage yield of associations in the 1st cut (combined data)

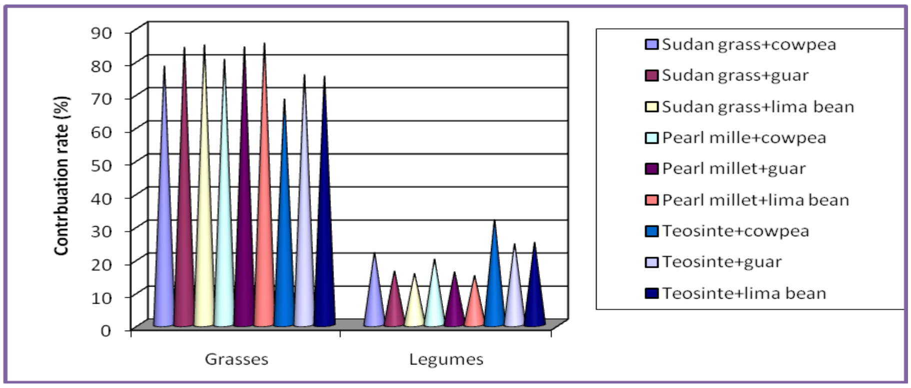

Fig. 1b. Effect of intercropping on the contribution percentage of grasses and legumes in dry forage yield of associations in the 2nd cut (combined data)

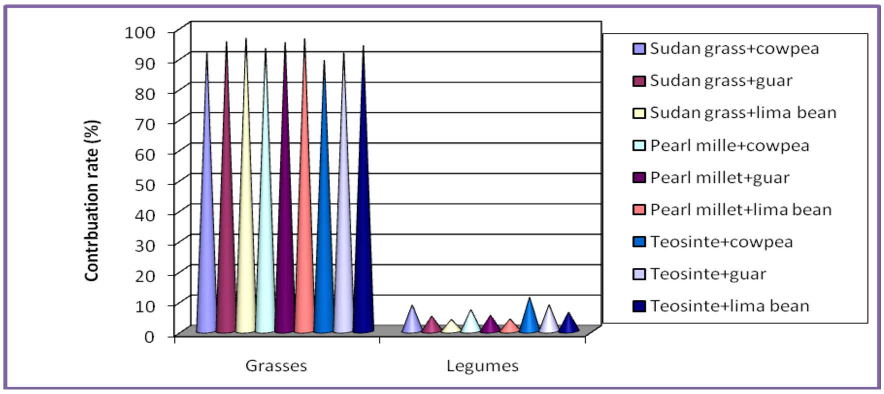

Fig. 1c. Effect of intercropping on the contribution percentage of grasses and legumes in dry forage yield of associations in the 3rd cut (combined data)

Table 5. Effect of intercropping on relative yield of grasses (L_g) and legumes (L_l) as well as land equivalent ratio (LER) values, calculated on dry forage yield basis (combined data)

Intercropping	1st cut			2nd cut			3rd cut			Total		
	L_g	L_l	LER	L_g	L_l	LER	L_g	L_l	LER	L_g	L_l	LER
Sudan grass+cowpea	0.572	0.477	1.049	0.550	0.435	0.985	0.555	0.152	0.707	1.677	1.063	2.740
Sudan grass+guar	0.560	0.450	1.010	0.503	0.373	0.876	0.558	0.112	0.670	1.622	0.935	2.557
Sudangrass+lima bean	0.568	0.448	1.016	0.515	0.358	0.873	0.528	0.092	0.620	1.612	0.898	2.510
Pearl mille+cowpea	0.612	0.468	1.080	0.542	0.413	0.955	0.570	0.140	0.710	1.723	1.022	2.745
Pearl millet + guar	0.545	0.470	1.015	0.517	0.398	0.915	0.523	0.118	0.641	1.585	0.987	2.572
Pearl millet + lima bean	0.575	0.463	1.038	0.515	0.323	0.838	0.515	0.098	0.613	1.605	0.885	2.490
Teosinte+cowpea	0.650	0.558	1.208	0.510	0.508	1.018	0.498	0.193	0.691	1.658	1.260	2.918
Teosinte + guar	0.608	0.515	1.123	0.495	0.443	0.938	0.483	0.192	0.675	1.587	1.150	2.737
Teosinte + lima bean	0.637	0.535	1.172	0.533	0.442	0.975	0.482	0.153	0.635	1.652	1.130	2.782
LSD 0.05	NS	0.051	0.068	0.032	0.085	0.085	0.043	0.027	0.035	0.071	0.110	0.100

Table 6. Effect of intercropping on relative yield of grasses (L_g) and legumes (L_l) as well as land equivalent coefficient (LEC) values, calculated on dry forage yield basis (combined data)

Intercropping	1st cut			2nd cut			3rd cut			Total		
	L_g	L_l	LEC	L_g	L_l	LEC	L_g	L_l	LEC	L_g	L_l	LEC
Sudan grass+cowpea	0.572	0.477	0.272	0.550	0.435	0.239	0.555	0.152	0.084	1.677	1.063	0.597
Sudan grass+guar	0.560	0.450	0.252	0.503	0.373	0.187	0.558	0.112	0.062	1.622	0.935	0.502
Sudan grass+lima bean	0.568	0.448	0.257	0.515	0.358	0.184	0.528	0.092	0.048	1.612	0.898	0.490
Pearl mille+cowpea	0.612	0.468	0.286	0.542	0.413	0.223	0.570	0.140	0.080	1.723	1.022	0.590
Pearl millet+guar	0.545	0.470	0.256	0.517	0.398	0.205	0.523	0.118	0.062	1.585	0.987	0.524
Pearl millet+lima bean	0.575	0.463	0.266	0.515	0.323	0.166	0.515	0.098	0.050	1.605	0.885	0.484
Teosinte+cowpea	0.650	0.558	0.362	0.510	0.508	0.259	0.498	0.193	0.096	1.658	1.260	0.718
Teosinte+guar	0.608	0.515	0.313	0.495	0.443	0.219	0.483	0.192	0.093	1.587	1.150	0.632
Teosinte+lima bean	0.637	0.535	0.339	0.533	0.442	0.235	0.482	0.153	0.074	1.652	1.130	0.649
LSD 0.05	NS	0.051	0.035	0.032	0.085	0.043	0.043	0.027	0.012	0.071	0.110	0.056

yield in the 1st and the 2nd cuts, respectively. While, the values LEC were less (0.25), indicating disadvantage in forage yield production, as shown in the 3rd cut. Generally, the total LEC for the three individual cuts of grasses and legumes, the values LEC for all studied treatments were above 0.25. This means that all treatments had LEC values above 0.25 suggesting yield advantages and showed efficient utilization of land resource by growing both crops together and *vice versa*.

Competition Ratio (CR)

Results presented in Table 7 show a significant effect of intercropping plants on CR values of both grasses (CR_g) and legumes (CR_l) calculated on dry forage yield basis in combined data. In all other intercropping the values of CR for grasses (sudan grass, pearl millet and teosinte) were greater than those for legume intercropped indicating the dominance of grasses under these intercropping patterns. This clearly shows that in all intercropping, intercropped cowpea had higher competitive ratios in intercropping patterns whether it with sudan grass, pearl millet or teosinte compared with either guar and lima bean, indicating that intercropped cowpea is more competitive than legumes in these intercropping patterns, while the corresponding values of CR for intercropped lima bean were the least. On the other hand, the values of CR for sudan grass and pearl millet were greater than for teosinte in all intercropping patterns. This results hold fairly true in the three cuts and the total for three cuts in combined data. In this concern Ali (1992) found that maize was the dominant productive component, the tendency for balanced competition accompanied with lower yielding. In generally, the grass is described as the dominant component and the legume as the dominated component. Thus, the general observation is that yields of legume component are significantly depressed by grasses components in intercropping. Similar findings were observed by Al-Bakri *et al.* (2003), Singh and Tarawali (2007) and Abuneran (2013).

Conclusion

From the previous results of different intercropping under this study, planting pearl millet on one side of the ridge using seeding rate of 7.5 kg/fad., (50%) alternating with cowpea on the other side using seeding rate of 10 kg/fad., (50%) could be recommended for economic forage production, good quality fodder and increased land use efficiency under the same conditions of this study.

Table 7. Effect of intercropping on competition ratio values of the grasses (CRg) and legumes (CR_l) calculated on dry forage yield basis (combined data)

Intercropping	1st cut		2nd cut		3rd cut		Total	
	CR_g	CR_l	CR_g	CR_l	CR_g	CR_l	CR_g	CR_l
Sudan grass+cowpea	1.205	0.837	1.272	0.798	3.760	0.270	6.237	1.905
Sudan grass+guar	1.262	0.812	1.373	0.752	5.495	0.195	8.130	1.758
Sudan grass+lima bean	1.275	0.792	1.458	0.700	6.362	0.175	9.095	1.667
Pearl mille+cowpea	1.307	0.768	1.337	0.770	4.213	0.245	6.857	1.783
Pearl millet+guar	1.170	0.865	1.325	0.773	4.798	0.225	7.293	1.863
Pearl millet+lima bean	1.247	0.807	1.637	0.625	5.642	0.192	8.525	1.623
Teosinte+cowpea	1.187	0.875	1.017	1.002	2.655	0.385	4.858	2.262
Teosinte+guar	1.198	0.863	1.140	0.897	2.785	0.382	5.123	2.142
Teosinte+lima bean	1.215	0.868	1.257	0.837	3.242	0.318	5.713	2.023
LSD 0.05	0.079	0.069	0.199	0.183	0.896	0.068	0.972	0.217

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تأثير نظم التحميل على محصول العلف و كفاءة استخدام الأرض في بعض محاصيل العلف الصيفية

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أقيمت تجربتان حقليتان بمزرعة محطة بحوث كفر الحمام - محافظة الشرقية، خلال الموسميين الصيفيين ٢٠١٤ و٢٠١٥، وذلك بهدف دراسته تأثير ستة محاصيل علف صيفية وتسع توافقات تحميل فيما بينها ٥٠% لكل منها وهي (حشيشة السودان منفرد (١٠٠%)، دخن منفرد (١٠٠%)، ريانة منفرد (١٠٠%)، لوبيا علف منفرد (١٠٠%)، جوار منفرد (١٠٠%)، فاصوليا ليما منفرد (١٠٠%)، حشيشة السودان (٥٠%) + لوبيا علف (٥٠%)، حشيشة السودان (٥٠%) + جوار (٥٠%)، حشيشة السودان (٥٠%) + فاصوليا ليما (٥٠%)، دخن (٥٠%) + لوبيا علف (٥٠%)، دخن (٥٠%) + جوار (٥٠%)، دخن (٥٠%) + فاصوليا ليما (٥٠%)، ريانة (٥٠%) + لوبيا علف (٥٠%)، ريانة (٥٠%) + جوار (٥٠%) وريانة (٥٠%) + فاصوليا ليما (٥٠%) على محصول العلف الأخضر والجاف ومحصول البروتين بالإضافة إلى كفاءة استخدام الأرض، ويمكن تلخيص اهم النتائج فيما يلى: في الزراعة المنفردة للمحاصيل النجيلية الثلاثة، فقد أعطى الدخن أعلى محصول كلي للعلف الأخضر والجاف مقارنة بالزراعة المنفردة لكل من حشيشة السودان والريانة، في حين أعطت لوبيا العلف أعلى محصول كلي للعلف الأخضر والجاف مقارنة بالزراعة المنفردة لكل من الجوار وفاصوليا ليما، فى حين تفوق نظام التحميل دخن (٥٠%) + لوبيا علف (٥٠%) في محصول العلف الأخضر والجاف الكلي (٣٢.٥١ و٦.٥٠ طن/ فدان) على التوالي مقارنة بالبقوليات المنفردة ونظم التحميل الأخرى، أمكن الحصول على أعلى محصول كلى للبروتين من نظام التحميل دخن (٥٠%) + لوبيا علف (٥٠%) حيث قدر بنحو ٧٦٦.٥٦ كجم/فدان، كانت مساهمة المحاصيل النجيلية في محصول العلف الجاف أعلى من مساهمة البقوليات، وبدون شك لوبيا العلف المكون البقولي الأعلى مساهمة فى إنتاج العلف مقارنة بكل من الجوار أو فاصوليا ليما، أدى تحميل محاصيل العلف النجيلية مع محاصيل العلف البقولية بنسبة ٥٠% لكل منها إلى زيادة نسبة المكافئ الارضي الكلي لمجموع الثلاث حشات (LER) لكل من المكونين النجيلي والبقولى، فكان اكبر من الوحدة في كل نظم التحميل المستخدمة في الدراسة على أساس محصول العلف الجاف.كما كان معامل المكافئ الأرضي (LEC) له نفس اتجاه (LER)، حققت النجيليات أعلى قيم للتنافس (CR) عن البقوليات المحملة معها وذلك لمجموع الثلاث حشات، ويشير هذا إلى أن النجيليات هي المكون السائد والبقوليات المسود عليها تحت نظم التحميل المختلفة، من النتائج السابقة للتحميل تحت الدراسة: يمكن التوصية بزراعة الدخن (٥٠%) بمعدل تقاوي ٧.٥ كيلوجرام/فدان + لوبيا العلف (٥٠%) بمعدل تقاوي ١٠ كيلوجرام/فدان، كل على ريشة من ريشتي الخط، لتحقيق أعلى إنتاجية وأفضل جودة للعلف الاقتصادي الناتج مع زيادة كفاءة استخدام الأراضي تحت نفس الظروف المشابهة لهذه الدراسة.

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