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EFFECT OF INTERCROPPING PATTERNS OF SUDANGRASS AND FORAGE COWPEA WITH DIFFERENT DENSITIES ON FORAGE YIELD, COMPETITIVE RELATIONSHIPS, AND PROFITABILITY

El-Nahrawy, Shereen M.[(1)]; Koriem, M. H.M.[(2)] and Hatab, S. H.[(1)]

[(1)] Forage Crop Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt.

[(2)] Crop Intensification Research Department, Field Crops Research Institute, Agricultural Research Center, Giza, Egypt

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ABSTRACT: A field experiment was carried out during the summer seasons of 2023 and 2024 at Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, Egypt, to study the effect of different seeding rates of forage cowpea (10, 20, 30, 40, 50, and 60% of the recommended seeding rate "30 kg/fed") intercropped with 100% sudangrass seed at a rate of 20 kg/fed on the yield of both crops and the competitive relationships. The treatments were arranged in a randomized complete block design with three replications. The intercropping pattern of 100% sudangrass + 60% cowpea gave the highest production values per feddan (fresh and dry yield/fed) and exhibited the highest crude protein percentage (CP%). Additionally, the same intercropping pattern yielded the highest land equivalent ratio (LER) and net return; thus, it could be the best option for the highest productive and economic values for farmers in the North Delta region of Egypt.

Keywords: Intercropping, sudangrass, cowpea, land equivalent ratio (LER), and economic return.

INTRODUCTION

Arid regions constitute the predominant portion of Egypt's 1 million km² land area. There are camels, sheep, goats, and cattle among Egypt's rather abundant animal resources. But year-round fodder crops, such as berseem clover, are the primary and most traditional method of raising livestock in Egypt. The remaining portion is provided by summer fodder crops, such as cowpea, alfalfa, sorghum, grasses, and straw, which are planted. Egypt currently faces significant challenges in supplying summer fodder to meet livestock demand because cotton, corn, and rice are the principal summer crops that compete fiercely with one another, and less space is being devoted to forage crops, resulting in a shortage of green fodder.

To increase the output of fodder crops from sudangrass and cowpea per fed, the Ministry of Agriculture and Land Reclamation in Egypt has implemented a strategy, as stated by the Agriculture Research Center in 2018. To satisfy animal demands and close the gap between forage production and consumption, forage output must be increased. Increasing unit area productivity is one strategy to boost forage output. The best agricultural techniques, such as intercropping patterns, should be used to improve forage productivity.

Abd Rabboh *et al.* (2020) studied the forage yield and quality of sudangrass and cowpea under different intercropping patterns. The results revealed that the best intercropping pattern, 100% sudangrass + 75% cowpea, had the highest forage productivity and quality, land equivalent ratio (LER), and net return. Jabereldar *et al.* (2023) showed that intercropping cowpea with sorghum and Roselle gave a higher yield than single cropping. Intercropping with cowpea, a legume, is a beneficial method for maximizing land productivity per unit area and increasing the yield of associated non-legumes (Salem *et al.* 2019). Thomas *et al.* (2024) found that sorghum-sudangrass has the potential to improve stocker cattle performance compared with mixed Bermuda grass, and intercropping cowpea with sorghum-sudangrass may further improve forage

* Corresponding author: shereenelnahrawy@gmail.com

nutrient composition in late summer and early fall when sorghum-sudangrass crude protein decreases and neutral detergent fiber increases. Therefore, the main objective of this experiment was to study the effects of different cowpea plant densities intercropped with sudangrass on the yield of both crops and on competitive relationships in the North Delta region of Egypt.

MATERIALS AND METHODS

A field experiment was conducted at the Sakha Agricultural Research Station, Kafr El-Sheikh Governorate, during the summer seasons of 2023 and 2024. Six intercropping patterns combining cowpea and sudangrass at different seeding rates were evaluated as follows:

P1 = 100% sudangrass seed + 10% cowpea seed (3 kg/fed) planted in a single row in the middle of the ridge.

P2 = 100% sudangrass seed + 20% cowpea seed (6 kg/fed) planted in a single row in the middle of the ridge.

P3 = 100% sudangrass + 30% cowpea seed (9 kg/fed) planted in a single row in the middle of the ridge.

P4 = 100% sudangrass + 40% cowpea seed (12 kg/fed) planted in a single row in the middle of the ridge.

P5 = 100% sudangrass + 50% cowpea (15 kg/fed) planted in a single row in the middle of the ridge.

P6 = 100% sudangrass + 60% cowpea (18 kg/fed) planted in a single row in the middle of the ridge.

Whereas, sudangrass was planted on both sides of the bed (120 cm) at a distance of 20 cm at a seeding rate of 20 kg/fed (100% of seeding rate).

In addition, monocropped sudangrass and cowpea were sown according to the recommended agronomic practices. Randomized complete block design (RCBD) with three replications was used in this experiment. The net area of the experimental plots was 18 m^2 (0.00428 fed) with 3 beds per plot, 3.60 m width × 5 m length. The previous crop was wheat in both seasons. Sudangrass and cowpea were sown on May 15 and 20 in the 2023 and 2024 seasons, respectively. A sufficient amount of a bio-fertilizer containing N_2-fixing bacteria (*Bradyrhizobium sp*.) was applied to cowpea seeds directly before sowing, and the success of nodulation was assessed after 30 days from sowing by counting more than ten active nodules per root. Sudangrass was fertilized by 50kg of urea per fed (46.5% N) before the first irrigation, and the same rate was applied after each cutting. All plots received phosphate fertilizer in the form of calcium superphosphate (15.5% P_2O_5) at a rate of 150 kg/fed, which was applied during land preparation in one dose. Potassium sulfate was added at a rate of 50 kg/fed. Throughout the growth period, seven irrigations were conducted at 15-day intervals, commencing at planting and concluding with the final mowing, while adhering to all other prescribed cultural practices. Both crops were harvested at 15 cm above the ground at each cutting.

The first mowing was carried out 48 days after planting, the second mowing 40 days after the first mowing, and the third mowing 35 days after the second mowing. The chemical composition of the protein content of the forage was analyzed in the central laboratory of the Sakha Agricultural Research Station. During the two growing seasons, soil samples were randomly collected from 0-30 cm of the soil surface during soil preparation. Particle size distribution and chemical analyses were conducted using the method described by Page *et al*. (1982), and the results are shown in Table 1.

Table 1. Particle size distributions and chemical soil properties at the experimental sites during the 2023 and 2024 growing seasons.

Properties		2023 Season	2024 Season
A- Particle size distribution:			
Sand %		9.72	9.73
Silt %		30.24	29.99
Clay %		60.04	60.28
Texture		Clay	Clay
B- Chemical analysis:			
pH		7.75	7.82
EC dS/m^2		1.92	1.45
Organic matter %		2.29	2.59
Total N %		0.14	0.13
Total carbonate %		6.20	6.21
CEC meq/100 g soil		41.38	41.60
SP %		78.40	78.52
SAR		4.58	4.67
Available (mg/kg)	N	26.20	27.10
	P	8.70	8.55
	K	250.60	260.40
	Zn	6.15	6.00
	Mn	14.10	13.75
Soluble cations (meq/L)	Ca^{++}	5.7	5.62
	Mg^{++}	2.04	2.15
	Na^{+}	8.23	8.57
	K^{+}	0.59	0.61
Soluble anions (meq/L)	CO_3^{--}	0.00	0.00
	HCO_3^{-}	2.84	2.81
	CL^{-}	7.54	7.51
	SO_4^{--}	6.18	6.63

Cation Exchange Capacity (CEC), Saturation Percentage (SP%), Sodium Adsorption Ratio (SAP)

Data of sudangrass and cowpea:

1- Fodder yield and its attributes:

1.1. Plant height (cm).
1.2. Stem diameter (mm).
1.3. Number of stems /m^2.
1.4. Fresh leaf/stem ratio
1.5. Fresh forage yield (ton/fed).
1.6. Dry forage yield (ton/fed).
1.7. Crude protein (CP%).

2 - Competitive relationships;

2.1. Land equivalent ratio (LER): was determined according to the formula described by Willey and Rao (1980):

$$\text{LER} = \frac{Yab}{Yaa} + \frac{Yba}{Ybb}$$

Where: Yaa and Ybb were pure stands of crop a (sudangrass) and b (cowpea), respectively.

Yab is the mixture yield of (a) crop, and Yba is the mixture yield of (b) crop.

2.2- Economic evaluations:

Net Return = total revenues - production cost.

The total income for each crop was calculated in Egyptian pounds (LE) per feddan, using local market prices of 725 LE per ton for sudangrass and 1,250 LE per ton for cowpea, averaged across the two growing years.

Statistical analysis

SAS version 9.2 (2009) was used to perform the Analysis of Variance (ANOVA) using statistical procedures. Means comparisons were carried out using the Least Significant Difference (LSD) test at the 5% significance level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSIONS

1- Forage yield and its components

1.1. Plant height (cm)

Data in Table 2 showed significant differences between the different intercropping systems in the height of the sudangrass plant in the second and third plots only, as well as in the cowpea with the first and second cuts only, respectively, where the pattern 100% Sudan + 60% cowpea (P6) gave the tallest sudangrass plants, which reached 181.81 and 160.14 cm in the second and third cuts, respectively. compared to all other treatments. Similarly, the 100% Sudan + 60% cowpea (P6) pattern produced the tallest cowpea plants in the first and third cuts, which reached 70.69 and 80.59 cm, respectively. While the shortest sudangrass plants were recorded with the 100% Sudan + 10% cowpea (P1), the values were 169.7 cm in the second cuts and 152.97 cm in the third cuts. Shortest cowpea plants were recorded in the same intercropping system, P1, reaching 66.05 cm for the first plot, in addition to 72.60 cm for the second cut. This is due to intense competition between Sudangrass and cowpea at high density for sunlight during photosynthesis. These results are consistent with previous studies conducted by Surve *et al.* (2011) and Abd Rabboh *et al.* (2020).

1.2. Stem diameter (mm)

According to the results shown in Table 2, there is no significant difference in the intercropping system between cowpea and sudangrass grown during the first, second, and third plowing. This is due to fierce competition between the two crops for sunlight, nutrients, and water, consistent with the results of Awad and Ahmad (2012) across the two seasons, as did Abd Rabboh *et al.* (2020).

Table 2. Effect of intercropping systems on plant height (cm) and stem diameter (mm) of sudangrass and cowpea in the combined data across the two seasons

Treatments (Sudan grass + cowpea)	Plant height (cm)						Stem diameter (mm)					
	1st cut		2nd cut		3rd cut		1st cut		2nd cut		3rd cut	
	Sudan grass	Cowpea	Sudan grass	Cowpea	Sudan grass	Cowpea	Sudan grass	Cowpea	Sudan grass	Cowpea	Sudan grass	Cowpea
P1(100+10%)	156.55	66.05	169.70	72.60	152.97	61.65	1.13	0.62	1.19	0.95	1.01	0.51
P2(100+20%)	158.40	67.14	171.74	74.41	154.14	62.38	1.17	0.66	1.23	0.97	1.07	0.54
P3(100+30%)	164.30	67.94	176.26	76.15	157.36	64.69	1.25	0.66	1.29	1.02	1.11	0.58
P4(100+40%)	165.67	68.10	178.32	77.54	156.64	66.11	1.28	0.71	1.31	1.07	1.13	0.60
P5(100+50%)	166.64	69.25	179.79	79.78	157.73	66.21	1.33	0.73	1.34	1.09	1.13	0.61
P6(100+60%)	170.54	70.69	181.81	80.59	160.14	67.46	1.35	0.75	1.39	1.11	1.18	0.63
S. grass pure	171.49	-	186.00	-	161.00	-	1.39	-	1.42	-	1.33	-
Cowpea pure	-	70.49	-	81.50	-	70.71	-	0.78	-	1.18	-	0.69
LSD at 5%	NS	1.21	0.88	1.80	5.08	NS	NS	NS	NS	NS	NS	NS

1.3. Number of stems/m^2

The average number of sudangrass and cowpea stems per square meter was significantly affected by intercropping techniques (Table 3). According to the data, increasing plant density significantly increased the number of stem plants for both crops from P1 to P6, resulting in an increase in stems per square meter across the three cuts during both growing seasons. The P6 intercropping pattern (100% sudangrass + 60% cowpea) recorded the highest number of stems per m² for both crops, showing a significant increase compared to lower cowpea densities. The highest number of sudangrass stems/m^2 was recorded with 100% sudangrass + 60% cowpea (P6), achieving 139.85, 145.77, and 135.06 stems/m^2, respectively. The highest number of cowpea plants/m^2 was recorded with 100% sudangrass + 60% cowpea (P6). The obtained values for the number of cowpea stems/m^2 were 79.30,88.65, and 58.89, respectively. On the other hand, the lowest number of stems per m^2 was for sudangrass (131.23, 132.60, and 124.26). The lowest number of stems per m^2 was for cowpea (68.78, 80.98, and 52.76) with the intercropping system (100% sudangrass + 10% cowpea). Respectively, this illustrates how intercropping patterns clearly affected sudangrass and cowpea plants. According to Azraf *et al.* (2007), in intercropping systems, forage sorghum alone produced the most stem plants in 2004 and 2005. With an area of 58.0 and 70.2 square meters, respectively. Abd Rabbo et al. (2020) and Mohamed *et al*. (2020) found that planting 30 × 30 cm of sorghum next to cowpea resulted in the highest number of stem plants per unit area.

Table 3. Effect of intercropping systems on the number of stem plants/m^2 of sudangrass and cowpea in the combined data across the two seasons

Treatments (sudangrass+ cowpea)	Number of stems /m^2					
	1st cut		2nd cut		3rd cut	
	sudangrass	cowpea	sudangrass	cowpea	sudangrass	cowpea
P1 (100%+10%)	131.23	68.79	132.59	80.98	124.26	52.76
P2 (100%+20%)	133.73	70.79	134.76	81.98	126.66	54.33
P3 (100%+30%)	134.83	73.79	138.05	83.98	130.20	55.43
P4 (100%+40%)	135.95	75.23	140.66	84.65	132.09	56.93
P5 (100%+50%)	137.56	76.89	144.46	87.32	134.23	57.70
P6 (100%+60%)	139.85	79.30	145.76	88.65	135.06	58.89
sudangrass pure	142.30	-	145.85	-	137.69	-
cowpea pure	-	80.88	-	90.23	-	60.16
LSD at 5%	4.05	2.67	6.66	0.91	3.25	2.06

1.4. Fresh leaf/stem ratio

The data in Table 4 indicated that the percentage of fresh leaves/stems was significantly affected by intercropping patterns. sudangrass recorded the highest percentage of leaves/stems under the intercropping pattern of 100% Sudan + 60% cowpea (P6) with three cuts. The highest fresh leaf/stem ratio was recorded for sudangrass at 40.69, 43.02, and 38.03 for the three harvest methods, respectively. Similarly, the cowpea exhibited the highest fresh leaf/stem ratio values when the 100% sudangrass + 60% cowpea (P6) cropping pattern was implemented. While the 100% sudangrass + 10% cowpea (P1) planting pattern recorded the lowest values for the ratio of fresh green leaves to stem for both sudangrass and cowpea with three tillers, the values reached 62.11, 64.29, and 60.48. An increase in the values of fresh green leaves/stems was observed when the density of mixed plants (sudangrass and cowpea. Conversely, these results are related to competition between intercropping components and to shading caused by taller sudangrass under intercropping patterns. This shading can reduce the respiration and photosynthesis rates of lower-growing plants. These results are consistent with the findings of Abd Rabboh *et al.* (2020) and Mohamed *et al.* (2020).

Table 4. Effect of intercropping systems on fresh leaf/stem of sudangrass and cowpea in the combined data across the two seasons

Treatments (sudangrass + cowpea)	Fresh leaf/stem (%)					
	1st cut		2nd cut		3rd cut	
	sudangrass	cowpea	sudangrass	cowpea	sudangrass	cowpea
P1(100%+10%)	37.99	58.31	38.86	61.54	36.03	56.84
P2(100%+20%)	39.18	58.99	40.03	61.96	36.79	58.09
P3(100%+30%)	39.54	59.61	41.13	62.53	37.58	58.86
P4(100%+40%)	39.96	60.26	42.01	62.94	37.79	59.30
P5(100%+50%)	40.39	60.95	42.39	63.54	37.86	60.28
P6(100%+60%)	40.69	62.11	43.02	64.29	38.03	60.48
sudangrass pure	41.36	-	43.74	-	38.15	-
cowpea pure	-	62.94	-	64.86	-	61.39
LSD at 5%	0.93	1.83	1.01	0.95	0.98	1.01

1.5. Fresh forage yield (ton/fed)

Regarding the main effects of the sudangrass and cowpea mixture cropping pattern, the results of fresh forage yield (tons/fed) are shown in Table 5. Plants grown in a mixture at plant density (P6) gave the highest values for sudangrass and cowpea growth, but they performed better when grown as a pure group than when grown as a mixture. The growth of the sudangrass mixture was also reduced.

Table 5. Effect of intercropping systems on fresh forage yield (ton/fed) of sudangrass and cowpea in the combined data across the two seasons

Treatments (sudangrass + cowpea)	Fresh forage yield (ton/fed)									
	1st cut		Mixed of forge	2nd cut		Mixed of forge	3rd cut		Mixed forage	Total mixed (t/f)
	cowpea	sudan-grass		cowpea	sudan-grass		cowpea	sudan-grass		
P1(100+10%)	15.51	3.00	18.52	16.01	2.97	18.99	10.18	2.02	12.21	49.72
P2(100+20%)	15.65	3.37	19.03	15.95	3.79	19.75	11.15	2.17	13.32	52.10
P3(100+30%)	15.88	3.42	19.30	16.45	4.07	20.52	11.54	2.28	13.83	53.65
P4(100+40%)	15.99	3.60	19.59	17.01	4.24	21.25	11.94	2.33	14.28	55.11
P5(100+50%)	16.83	3.72	20.55	18.02	4.50	22.53	12.48	2.46	14.95	58.03
P6(100+60%)	17.07	4.00	21.07	18.90	4.76	23.66	13.21	2.71	15.92	59.32
sudangrass pure	17.15	3.00	18.52	18.98	-	-	13.34	-	-	-
cowpea pure	-	14.22	-	-	15.02	-	-	12.89	-	-
LSD at 5%	0.53	0.18	0.59	0.50	0.31	0.46	0.249	0.24	0.27	0.45

The fresh forage yield (tons/fed) is clearly evident across the three plots, indicating its inability to compete with a high cowpea seed rate in the mixture. Therefore, the cowpea mixture is best formed when grown with 100% sudangrass + 60% cowpea (P6), recording the highest fresh forage yield (tons/fed). The lowest values of fresh forage production (tons/fed) were obtained with sudangrass or cowpea with an intercropping system of 100% sudangrass + 10% cowpea (P1)

across the three cuts in both seasons of the study. Egbe *et al.* (2010) reported competition among different cropping patterns for water, light, air, and nutrients, as well as the inhibitory effect of sudangrass (C4) on cowpea (C4). However, higher intercropping densities yielded lower yields than the control treatments, which may be attributed to the direct and indirect effects of cross-shading in intercropping systems on morphological evolution. As for forage productivity, similar results were observed by Azraf *et al.* (2007), Awad and Ahmed *et al.* (2006), Gunjan and Naveen (2016), Ugur *et al.* (2017), and Abd Rabboh *et al.* (2020).

1.6. Dry forage yield (ton/fed)

Dry fodder production (ton/fed) was significantly affected by intercropping treatments for Sudan grass in the second mowing only, while cowpea yield was significantly affected by intercropping treatments with all three mowing except the third mowing only, as shown in Table 6. The intercropping pattern (100% sudangrass + 60% cowpea) produced the highest total dry forage yield (8.47tons/fed). The lowest value (7.30 tons/fed) was recorded for the mixture planted with the pattern (100% sudangrass + 10% cowpea). The appropriate number of stem plants per square meter may explain the increased fresh green leaf-to-stem ratio (Table 4), thereby enhancing dry forage yield in tons per fed at the highest density. These results are in harmony with those reported by Babu *et al.* (1994), Barik and Tiwari (1996), Singh *et al.* (2005), Azraf *et al.* (2007), Awad and Ahmad (2012), Rathor (2015), Gunjan and Naveen (2016), Uğur *et al.* (2017), and Abd Rabbo *et al.* (2020).

Table 6. Effect of intercropping systems on dry forage yield (ton/fed) of sudangrass and cowpea in the combined data across the two seasons

Treatments (sudangrass + cowpea)	Dry forage yield (ton/fed)									
	1st cut		Mixed of forge	2nd cut		Mixed of forge	3rd cut		Mixed of forge	Total mixed (t/f)
	sudan -grass	cowpea		sudan-grass	cowpea		sudan-grass	cowpea		
P1(100+10%)	2.19	0.38	2.57	2.28	0.43	2.72	1.68	0.32	2.01	7.30
P2(100+20%)	2.25	0.40	2.65	2.32	0.47	2.79	1.76	0.35	2.12	7.56
P3(100+30%)	2.28	0.41	2.69	2.36	0.50	2.87	1.81	0.37	2.19	7.75
P4(100+40%)	2.37	0.42	2.79	2.39	0.67	4.54	1.89	0.38	2.28	9.61
P5(100+50%)	2.37	0.42	2.79	2.47	0.55	3.03	1.99	0.40	2.39	8.21
P6(100+60%)	2.39	0.44	2.83	2.54	0.58	3.12	2.10	0.41	2.52	8.47
sudangrass pure	2.37	-	-	2.72	-	-	2.09	-	-	-
cowpea pure	-	2.25	-	-	2.45	-	-	2.06	-	-
LSD at 5%	NS	0.01	NS	0.11	0.05	NS	NS	NS	NS	0.35

1.7. Crude protein %

The data in Table 7 indicate that the percentage of crude protein (CP%) for sudangrass and cowpea was significant only in the second harvest. The data showed that the percentage of crude protein was significant for both crops.

Anticipate that the cowpea in the first cut will remain largely unaffected by three cuts. It was noted that the percentage of crude protein (CP%) recorded the highest values for sudangrass and cowpea in the intercropping system of 100% sudangrass + 60% cowpea (p6). The data showed that the minimum values were observed in the intercropping system with 100% sudangrass and the +10 % cowpea (P1) pattern, respectively. These findings align with previous studies by Dahmardeh *et al.* (2009), Salem *et al.* (2019), and Abd Rabbo *et al.* (2020).

Table 7. Effect of intercropping systems on crude protein % of sudangrass and cowpea in the combined data across the two seasons

Treatments (sudangrass + cowpea)	crude protein (CP%)					
	1st cut		2nd cut		3rd cut	
	sudangrass	cowpea	sudangrass	cowpea	cowpea	sudangrass
P1(100%+10%)	10.30	18.65	10.46	18.93	10.03	18.43
P2(100%+20%)	10.34	18.86	10.55	19.17	10.13	18.62
P3(100%+30%)	10.42	19.08	10.63	19.67	10.22	18.75
P4(100%+40%)	10.51	19.36	10.83	20.08	10.26	18.92
P5(100%+50%)	10.63	19.54	10.91	20.17	10.34	19.14
P6(100%+60%)	10.73	19.76	11.17	20.32	10.46	19.25
sudangrass pure	10.75	-	11.19	-	10.47	-
cowpea pure	-	19.77	-	20.33	-	19.31
LSD at 5%	NS	NS	0.24	0.48	NS	NS

2. Competitive relationships

2.1. Land equivalent ratio (LER)

The data in Table 8 show that the intercropping system affects the quantitative measure of LER (land equivalent ratio), which is used to evaluate the effectiveness of intercropping patterns. It has been proven that measuring the effect of planting several agricultural plants simultaneously on the same plot of land is the most acceptable method. Regarding the effect of intercropping patterns in Table 8, the results showed that the average land equivalent ratios varied in the following order. The land equivalent ratio was higher than 1.00 in Table 8 and revealed that the intercropping system of 100% sudangrass + 60% cowpea (P6) followed by 100% sudangrass + 50% cowpea (P5) produced the highest values of the total land equivalent ratio (LER). While intercropping of sudangrass and cowpea in the 100% sudangrass + 10% cowpea (P1) intercropping system gave the lowest values of total land equivalent ratio. These results are consistent with those reported by Abd Rabbo *et al.* (2020).

Table 8. Effect of intercropping system on land equivalent ratio (LER) of sudangrass and cowpea in the combined data across the two seasons

Treatments	Land equivalent ratio (LER)									Mean
	1st cut			2nd cut			3rd cut			
	Ls	L c	LER	Ls	L c	LER	Ls	L c	LER	
P1(100%+10%)	0.84	0.25	1.08	0.91	0.35	1.26	0.77	0.38	1.15	1.17
P2(100%+20%)	0.84	0.27	1.10	0.92	0.39	1.31	0.84	0.43	1.26	1.22
P3(100%+30%)	0.86	0.28	1.14	0.93	0.44	1.37	0.87	0.44	1.30	1.27
P4(100%+40%)	0.90	0.29	1.19	0.94	0.45	1.38	0.90	0.46	1.35	1.30
P5(100%+50%)	0.95	0.30	1.25	0.98	0.48	1.46	0.94	0.48	1.41	1.37
P6(100%+60%)	1.00	0.33	1.33	1.00	0.50	1.50	0.99	0.51	1.50	1.44

3. Economic evaluations

Regarding the economic evaluation of the intercropping systems of cowpeas grown with sudangrass, the available data in Table 9 showed that the highest values of the total income of the actual sudanese grass crop (Egyptian pounds) and the actual return of cowpeas (Egyptian pounds)

were 36,710 Egyptian pounds, while the lowest values of the net return (Egyptian pounds) were 30,242. It is also noted from the previous results that the best values of gross income and net return for cowpeas grown with sudangrass were obtained from the intercropping system of 100% sudangrass + 60% cowpea (P6). These results are partially consistent with those found by Sharma *et al.* (2008), Sharma *et al.* (2009), and Surve *et al.* (2011).

Table 9. Effect of intercropping system on economic return/fad (L.E) of sudangrass and cowpea in the combined data across the two seasons

Treatments	Economic return/fad (L.E)				
	sudangrass	cowpea	Total income (L.E)	Total cost (L.E)	Net return (L.E)
P1(100%+10%)	30799	10043	40842	10600	30242
P2(100%+20%)	31602	11094	42695	11200	31495
P3(100%+30%)	32408	11827	44234	11700	32534
P4(100%+40%)	33365	12130	45494	12300	33194
P5(100%+50%)	35104	12839	47942	12800	35142
P6(100%+60%)	36436	13775	50210	12100	36710
sudangrass pure	35865	-	-	9754	26611
cowpea pure	-	52662		20043	32619

Conclusion

The intercropping system of 100% sudangrass + 60% cowpea (P6) from its pure stand could be recommended as the most effective treatment for achieving the highest production and economic values for farmers in the North Delta region of Egypt. This system has the highest yield, highest quality, best land equivalent ratio (LER), and net return.

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تأثير نظم تحميل حشيشة السودان ولوبيا العلف بكثافات مختلفة على محصول العلف والعلاقات التنافسية والربحية

شيرين محمد النحراوي[١]، محمد حامد محمد كريم[٢]، صفوت حسين حطب[١]

[١] قسم بحوث العلف، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، الجيزة، مصر.

[٢] قسم بحوث التكثيف المحصولي، معهد بحوث المحاصيل الحقلية، مركز البحوث الزراعية، الجيزة، مصر.

الملخص العربي

أجريت تجربة حقلية في موسمي ٢٠٢٣ و٢٠٢٤ بمحطة البحوث الزراعية، سخا - كفر الشيخ لدراسة تأثير معدلات التقاوي المختلفة للوبيا العلف المحملة على حشيشة السودان على كل من محصول العلف والعلاقات التنافسية باستخدام نظم تحميل مختلفة (١٠٠٪ حشيشة السودان + ١٠٪ لوبيا العلف، ١٠٠٪ حشيشة السودان + ٢٠٪ لوبيا العلف، ١٠٠٪ حشيشة السودان + ٣٠٪ لوبيا العلف، ١٠٠٪ حشيشة السودان + ٤٠٪ لوبيا العلف، ١٠٠٪ حشيشة السودان + ٥٠٪ لوبيا العلف، و١٠٠ % حشيشة السودان + ٦٠٪ لوبيا العلف) مقارنة بالزراعة المنفردة لكلا المحصولين. تم تنفيذ التجربة في تصميم قطاعات كاملة العشوائية في ثلاث مكررات. أظهرت النتائج المتحصل عليها أن نمط تحميل حشيشة السودان ١٠٠٪ + لوبيا العلف ٦٠٪ أعطت أعلى قيم إنتاجية للفدان (محصول أخضر وجاف)، وسجلت أعلى نسبة بروتين خام (CP%)، كما أعطت أعلى قيم لنسبة المكافئ الارضي (LER) والعائد الصافي. لذا يمكن التوصية باستخدام نمط التحميل ١٠٠٪ حشيشة السودان + ٦٠٪ لوبيا علف، والذي حقق أعلى محصول وأعلى بروتين وأفضل نسبة مكافئ أرضي (LER) والعائد الصافي والأفضل لأعلى القيم الإنتاجية والاقتصادية للمزارعين في منطقة شمال الدلتا في مصر.

الكلمات الدالة: التحميل، حشيشة السودان، لوبيا العلف، معدل كفاءة استغلال الأرض والعائد الاقتصادي.