Effect of Fodder Shrub Population and Utilization Methods on The Productivity of Interplanted Saltbush (*Atriplex nummularia* L.) and Barley under Rainfed Conditions, Northwest Coast of Egypt

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INTRODUCTION

The Northwest coastal (NWC) zone of Egypt extends about 500 km from west of Alexandria to the Egyptian - Libyan border. Like most semi- arid regions, this area possesses a fragile natural resource base. The average annual rainfall during the last ten years is 140 mm. The total arable land is about 16% of the forementioned total area. Approximately, 7% is planted, whereas, 9% is left fallow. In the meantime, about 48% of that area is rangelands, while, 35% is barren lands, which facilitate water catchments and generates run-offs. Barley is grown on the northern plateau. In the area extends 300 Km long with 40-70 km inland from Fouka to El-Saloum, barley area is about 83000 ha in wet years. In dry years, the area shrinks to only 40-50%. Yields are, generally, low and variable, averaging 250-300 kg grains/fed, besides, 300-360 kg straw (Document 870 of Matrouh Resources Management Project "MRMP", 2002). The formerly nomadic Bedouin agro-pastoralist inhabitants of the region commenced sedenterlization, approximately fifty years ago. Sheep and goat populations have increased substantially over time (about 627,000 small ruminants mainly sheep, and goats) and opportunistic barley planting has encroached on formerly productive rangeland. The region faces many of the challenges found in similar dryland areas of the Middle East, concerning, how to reverse environmental degradation and manage the natural resource base, whilst providing sustainable livelihoods for inhabitants. Heavy grazing pressure on natural forage resources has increased and led to a deterioration in nature vegetation. Since largely, livestock still the main source of Bedouin's income, establishment and conservation of rainfed forage crops, especially barley, is an important way to overcome feeding gap (Moselhy, 2001). Watts and El-Mourid (1988) cited that the main feeding resources in the semi-arid regions were cereal residues, including straw and field stubbles. Among cereal crops, barley (*Hordium vulgare*, L.) proved to be withstanding the adverse conditions. However, continuous conventional planting of barley led to native plant resources deterioration and soil surface exposed to wind erosion. Jones and Singh (1995) reported that wide expansion of planted rainfed areas without windbreaks might be strongly affected by wind erosion. In addition, heavy grazing by small ruminants on field stubble and fallen spikes, after harvest of barley, has provided these animals with unbalanced nutritive diet and increased erosion problem during the dry summer season.

It was noticeable that new adapted plant materials were introduced to that area through MRMP project activities. The main reasons were to fill the grazing animals feed gap, as a protein source

supply, improve forage quality and protect soil surface against the detrimental effects of wind erosion and other environmental stress. One example is old man saltbush (*Atriplex nummularia L.*). *Atriplex* species are growing under 100-400 mm rainfall and produce one to three tons dry matter/ ha /year (Sankary 1986). Such cropping systems, provided by barley and fodder shrubs, would help to sustain a balanced diet for grazing animals and minimize the harmful effects of soil erosion (Cook, 1972; Welch, 1989; Papanastasis, 1996 and Moselhy, 2001). Some studies, conducted on introduced fodder shrubs, assessed production and water use efficiency under rainfed conditions. Moselhy (2001) showed that dry matter yield of interplanted saltbush with barley increased with increasing shrub population under rainfed conditions. The favorable effects of interplanting diverse crops, in sustaining yield potential, were reported by Le Houerou *et al.*, 1991, Correal *et al*, 1990; Otal *et al*, 1991 and Moselhy 1999 and 2001. Moreover, Le Houerou (1992 and 1994) reported that saltbush shrubs had a relatively high water use efficiency under rainfed conditions.

The objective of the present study was to determine the optimum utilization method of interplanting saltbush fodder shrubs in different populations with barley under the environmental conditions of the NWC of Egypt.

MATERIALS AND METHODS

The present, on-farm trials, were carried out under rainfed conditions in agro-ecological zone 2 (5-15 km inland), west of El-Negilla, 77 Km west of Marsa Matrouh, NWC of Egypt, during five rainfall years (2002/2003 – 2006/2007). This experiment aimed to find out the optimum land use for rainfed barley areas through interplanting of saltbush shrubs in different populations as strip-alley cropping.

The studied treatments were three saltbush populations; i.e., 252, 336 and 504 shrubs/ha. These populations resulted from transplanting seedlings in rows, 10 m apart, with 4, 3 and 2 m within row. Two utilization methods of these shrubs were practiced during five years; i.e., cut and carry and browsing.

The seedlings of saltbush (*Atriplex nummularia* L.) were nursed by Matrouh Resources Management Project (MRMP) during 2001 season, then, transplanted with the onset of effective rain on Dec, 15thof the same season. Long furrows, perpendicular to the land slope, were made by using a ditcher. Saltbush seedlings, of 30 cm height, were transplanted at the required distances as previously described. In each of the experimental years, barley seeds, at a rate of 72 Kg/ha, was sown within the strips among saltbush shrubs rows. The sowing date of barley differed from year to another, according to the onset of effective rainfall.

The average recorded rainfall of the last ten years, in the NWC, was 140 mm/year (documents of MRMP). However, the amount and distributions of rainfall during the on-farm trials period were as shown in Table (1). The amount of rainfall in each year was less than the general average over all the years of study. Only, in the first season, rainfall distribution was balanced.

The soil of the on-farm trials was sandy-loam in texture, (Nous in Bedouin terminology). It had 0.023-0.026 % available nitrogen, 21-26 ppm phosphorus and high Ca Co_3 content (22-25 %). The EC of soil ranged between 0.25 to 0.27 m mhos/cm.

The experiments were laid out in a strip plot design, with four replicates. Utilization methods were distributed in the strip main plots. The sub-plots were allocated to the fodder shrub populations. The plot size of barley was 200 m^2 (10 m wide x 20 m long).

At harvest, 20 m^2 from each sub-plot was used to determine grain and straw yields of barley, as well as field stubble. In the same time, before applying the two treatments of fodder shrub utilization, five saltbush shrubs from each sub-plot were used to determine forage yield and its components. During the first week of June each year, each strip, in each replicate, was fenced. The first strip was used through cut and carry system. The resulted forage was fed to a group of ten Barqi sheeps. Whereas, the second was directly browsed by other ten Barqi sheeps for one week. Every year, five saltbush shrubs, from each sub-plot, were labeled to determine the edible precentage of leaves and twigs.

The collected data were statistically analyzed, according to Snedecor and Cochran (1967, a). For comparisons among means, Duncan's multiple range tests were used (Duncan, 1955). For combined analysis among years, homogeneity of experimental error (Barlett's test) was tested, according to Snedecor and Cochran (1967, b).Economic

Table 1: Monthly rainfall precipitation (mm) during the five years of the study.

Season	Month						Total
	Oct.	Nov.	Dec.	Jan.	Feb.	March	
2002/ 03	12.0	2.6	18.5	24.0	22.0	26.9	106.0
2003/ 04	0.0	0.7	18.1	47.0	19.5	0.0	85.3
2004/ 05	7.6	35.8	0.0	1.8	0.0	0.0	45.2
2005/ 06	3.0	15.0	30.0	40.0	2.0	0.0	90.0
2006/ 07	0.0	0.0	30.0	35.0	14.0	19.0	98.0

analysis, using partial budget, was made, according to Perrin *et al* (1983). Where, five Bedouin farmers were interviewed every year to estimate the variable cost of products and total sales (barley grains, straw, stubbles and fodder shrubs) in the form of Scandinavian feed units (SFUs), where, one Kg of barley grains equals one SFU, while, one Kg of dry matter equals 0.45 SFU (Le Houerou, 1986).

RESULTS AND DISCUSSION

A. Yield and its attributes of saltbush:

A. 1. Seasonal variations of rainfall:

Results of the combined analysis for different seasons, presented in Table (2), showed that there were significant seasonal differences in all recorded yield and yield attributes of saltbush shrubs. The relatively high and even distribution of rainfall precipitation in the first year had favourable effects on saltbush shrubs, which recorded the highest values of yield and its attributes, except for shrub height, since, plants were still young. On the contrary, with the exposure to severe drought in the third year, in most cases, saltbush shrubs recorded the lowest values of yield and its attributes. Meanwhile, it seems that leaves and twigs became more stiff with the advance in shrub age. Therefore, the percentages of edible leaves and twigs were significantly decreased with advancing to the fifth year. The significant sharp decrease in such percentages, especially that of leaves in the latter year, could be explained through the uneven distribution of rainfall. Where, there were no precipitations in the early two months of that rainfall season. However, the adverse effects on leaves / twigs percentage and the rest yield attributes, as well as forage yields due to advancing the shrubs in age and / or the uneven distribution of rainfall precipitation in the latter winter season, were less severe than those of low precipitation in the third winter season. Under conditions of 150-200 mm/ year, Le Houerou (1986) found that dry matter yield of saltbush ranged between 0.8 and 1.2 Kg/ shrub/ year. However, Tork Nejad and Koocheki (1996) indicated that a mean dry matter yield of 1.5 ton/ ha/ year could be obtained from saltbush plantation.

A. 2. Effect of utilization methods:

As obvious from results in Table (2), it is evident that utilization methods had a significant effect on all recorded yield and its attributes of saltbush shrubs. Where, browsing method overestimated cutting ones. These results, generally, concluded that browsing method had favorable effects on growth and yields of saltbush shrubs. This could be explained through the role of trampling animals in water preservation in such areas, as well as through the simulative effects of their dung and urinary excret.

A. 3. Effect of shrub population:

The obtained data clearly indicated that the tried saltbush population had a significant effect on shrub height and perimeter, as well as fresh, dry forage and SFUs yields/ha allover different years of study. While, shrub populations did not affect the remaining yield attributes of saltbush shrubs, presented in Table (2). These results concluded that, though height and perimeter of shrubs were consistently increased due to increasing the studied shrub populations from 252 to 336 and, then, to 504 shrubs/ ha, the opposite was always the case in fresh, dry and SFUs yields/ ha; i.e., the higher population studied was the highest forage production.

A. 4. Interactions:

A. 4. 1. Seasonal variation x utilization method:

Data, presented in Table (3), showed the significant interaction effects between the rainfall years and utilization methods on each of shrub height, shrub perimeter, leaves fresh weight, total fresh weight, total dry weight, leaves/ twigs percentage, edible leaves (%), edible twigs (%) and forage yield of saltbush. The low amount of rainfall precipitation shortened saltbush shrub height in the second and third years, compared to the later three years. Also, cutting method shortened shrub height, compared to browsing in the two years of high and low rainfall precipitation (i.e., the first and the third, respectively). Yet, there were no significant differences between the two utilization methods in shrub height in the remaining three years. With the relatively high and even distribution of rainfall precipitation, the widest saltbush shrub perimeter was recorded in the first year, followed by the second one, while, the narrowest shrub perimeter was recorded in the third year due to the limited rainfall precipitation. In the first year of a relatively high and even distribution of rainfall precipitation, cut shrubs attained a wider perimeter than browsed ones. The reverse was the case in the drier conditions prevailing in the remaining four years.

As in shrub perimeter, the highest leaves and total fresh weights/ shrub were obtained in the first year. While, the lowest values of these traits were recorded in the third year. In addition, differences between the two utilization methods in leaves and total fresh weights/ shrub were significant overall years. Where, browsing method overestimated cutting in these traits. It seems that the highest value of total dry weight/ shrub, also, was recorded in the first year, followed by the fifth year, but without significance in fourth and fifth ones. While, the lowest value of this weight was recorded in the third year. Meanwhile, differences between the two utilization methods were, only, significant in the first, third and fifth years, where browsing method overestimated cutting one in this weight.

In similarity with shrub perimeter, leaves and total fresh weights/ shrub, saltbush shrubs had the highest leaves/ twigs percentage in the first year, followed by the second year. While, the lowest value of this percentage was recorded in the driest conditions of the third year. Differences between the two utilization methods, in this percentage, did not reach to the level of significance, except in the

Table 2: Effect of utilization methods and shrub population on yield and its attributes mean values of saltbush shrubs.

Main effects and interactions	Shrub height (cm)	Shrub perimeter (cm)	Leaves fresh wt. (kg/sh)	Twigs fresh wt. (kg/sh)	Total fresh wt. (kg/sh)	Total dry wt. (kg/sh)
Years (Y):						
2002/2003	64.19 b	69.22 a	1.529 a	1.699 a	3.228 a	0.794 a
2003/2004	63.27 b	62.92 b	1.229 b	1.457 b	2.687 b	0.664 c
2004/2005	53.94 c	46.14 d	0.628 d	1.020 c	1.648 c	0.496 d
2005/2006	68.48 a	59.84 c	1.220 bc	1.452 b	2.672 b	0.695 b
2006/2007	69.01 a	60.98 c	1.201 c	1.478 b	2.679 b	0.697 b
F. test	**	**	**	**	**	**
Utilization methods (U):						
Cutting	61.08 b	58.50 b	1.122 b	1.383 b	2.505 b	0.649 b
Browsing	66.48 a	61.14 a	1.201 a	1.459 a	2.600 a	0.689 a
F. test	**	**	**	**	**	**
Shrub population (P):						
252 shrubs/ha	71.45 a	66.09 a	1.166	1.424	2.591	0.672
336 shrubs/ha	63.20 b	59.78 b	1.161	1.42	2.582	0.668
504 shrubs/ha	56.69 c	53.59 c	1.157	1.419	2.576	0.667
F. test	**	**	N.S	N.S	N.S	N.S
Interactions:						
Y x U	**	**	**	N.S	*	*
Y x P	**	**	N.S	N.S	N.S	N.S
U x P	N.S	N.S	N.S	N.S	N.S	N.S
Y x U x P	N.S	N.S	N.S	N.S	N.S	N.S

Main effects and interactions	Leaves/ twigs (%)	Edible leaves (%)	Edible twigs (%)	Fresh forage Yield (t/ha)	Dry forage Yield (t/ha)	SFUs of shrubs / ha
Years (Y):						
2002/2003	47.36 a	88.57 a	22.14 a	0.759 a	0.194 a	87.23 a
2003/2004	46.06 b	83.89 b	18.98 b	0.617 b	0.160 b	72.13 b
2004/2005	38.11 e	72.03 c	15.47 c	0.414 e	0.107 e	48.35 d
2005/2006	45.67 c	70.14 d	14.71 d	0.607 c	0.158 c	71.00 bc
2006/2007	44.83 d	44.69 e	10.66 e	0.595 d	0.155 d	69.69 c
F. test	**	**	**	**	**	**
Utilization methods (U):						
Cutting	44.02 b	70.58 b	15.56 b	0.570 b	0.148 b	66.41 b
Browsing	4.79 a	73.16 a	17.23 a	0.627 a	0.162 a	72.95 a
F. test	**	**	**	**	**	**
Shrub population (P):						
252 shrubs/ha	44.47	72.08	16.46	0.414 c	0.108 c	48.46 c
336 shrubs/ha	44.4	71.79	16.38	0.553 b	0.143 b	64.47 b
504 shrubs/ha	44.34	71.73	16.34	0.829 a	0.214 a	96.11 a
F. test	N.S	N.S	N.S	**	**	**
Interactions:						
Y x U	**	**	**	*	N.S	N.S
Y x P	N.S	**	**	**	**	**
U x P	N.S	N.S	N.S	**	**	**
Y x U x P	N.S	N.S	N.S	N.S	N.S	N.S

* and ** : Significant at 0.05 and 0,01 levels of probability, respectively.
Mean values followed by the similar letter are not significantly different at $P < 0.05$ by Duncan's multiple range test.

Table 3: Some characters mean values of yield and its attributes of saltbush shrubs, as affected by the interaction between utilization methods and rainfall years.

Characters	Utilization methods	Rainfall years				
		2002/03	2003/04	2004/05	2005/06	2006/07
		B	B	C	A	A
Shrub height (cm)	Cutting	61.73 b	63.21 a	44.00 b	67.74 a	68.69 a
		AB	B	B	AB	A
Shrub perimeter (cm)	Browsing	66.66 a	63.33 a	63.88 a	67.74 a	69.33 a
		A	B	D	BC	C
	Cutting	69.69 a	61.33 b	42.26 b	59.21 b	60.02 b
		A	B	D	C	BC
Leaves fresh wt (kg./sh)	Browsing	68.74 b	64.50 a	50.02 a	60.48 a	61.94 a
		A	B	D	C	C
	Cutting	1.470 b	1.207 b	0.618 b	1.170 b	1.146 b
		A	BC	D	B	CB
Total fresh wt. (kg/sh)	Browsing	1.588 a	1.252 a	0.639 a	1.270 a	1.256 a
		A	B	D	C	C
	Cutting	3.140 b	2.623 b	1.621 b	2.571 b	2.571b
		A	C	D	B	B
Leaves/ twigs (%)	Browsing	3.317 a	2.750 a	1.675 a	2.773 a	2.787 a
		A	B	D	C	BC
	Cutting	46.82 a	45.06 b	38.10 a	44.51 b	44.47 a
		A	A	D	B	C
Total dry wt. (kg/sh)	Browsing	47.09 a	47.05 a	38.11 a	45.82 a	45.08 a
		A	C	D	B	B
	Cutting	0.771 b	0.656 a	0.484 b	0.668 a	0.669 b
		A	C	D	B	B
Edible leaves (%)	Browsing	0.817 a	0.673 a	0.508 a	0.721 a	0.724 a
		A	B	C	D	E
	Cutting	85.90 b	81.86 b	70.82 b	69.74 b	44.56 a
		A	B	C	D	E
Edible twigs (%)	Browsing	91.24 a	85.92 a	73.23 a	70.54 a	44.83 a
		A	B	C	D	E
	Cutting	20.42 b	18.09 b	14.88 b	14.31 b	10.08 b
		A	B	C	D	E
Fresh forage yield (t/ha)	Browsing	23.86 a	19.88 a	16.07 a	15.11 a	11.23 a
		A	B	D	BC	C
	Cutting	0.731 b	0.590 b	0.393 b	0.576 b	0.558 b
		A	B	D	BC	C
	Browsing	0.788 a	0.644 a	0.434 a	0.638 a	0.632 a

Small and capital letters compare among rows and columns, respectively.
Mean values followed by the similar letter are not significantly different at $P < 0.05$ by Duncan's multiple range test

second and fourth years, where browsing overcame cutting in this concern. The obtained results showed a consistent decrease in percentage of edible leaves and twigs with the advance in saltbush shrubs age. It means that these organs became stiffer in aged shrubs. In the early four years, browsing increased the percentage of edible leaves, compared to the edible twigs percentage allover different rainfall years of study.

In concurrence with the shrub perimeter, leaves and total fresh weights/ shrub, results, also, indicated that the highest fresh forage yield/ ha could be secured in the first year, followed by the second. While, the lowest fresh forage yield/ ha was recorded with the exposure to the driest conditions in the third year. In different years, browsing had a favorable effect on fresh forage yield/ ha, compared to cutting method.

A. 4. 2. Seasonal variation x shrub populations:

As presented in Table (4), the interaction between rainfall years and shrub populations had a significant effect on saltbush shrub height, shrub perimeter, edible leaves and twigs percentages, as well as fresh forage, dry forage and SFUs yields/ ha. Height of saltbush shrub was the tallest in the fifth year, followed by the fourth and first years under all tried shrub populations.. While, the shortest shrubs were recorded in the most dry conditions of the third year. Saltbush shrub height was decreased with each increase in shrub population tried here during the five rainfall years. It was observed that saltbush shrubs had the widest perimeter in the first year, followed by the second and fifth years, without significance. While, the narrowest shrub perimeter was recorded in the most dry years; i.e., the third one. In all years of study, shrub perimeter was decreased with each increase in shrub population from 252 to 336, then, to 504 shrubs/ ha.

Table 4: Mean values of shrub height and perimeter, edible leaves and twigs percentages, forage fresh and dry yields/ha, as well as SFUs yield/ ha of saltbush shrubs, as affected by the interaction between shrub population and rainfall years.

Characters	Shrub population	Rainfall years				
		2002/03	2003/04	2004/05	2005/06	2006/07
		B	C	D	BC	A
Shrub height (cm)	252 shrubs/ha	75.17 a AB	72.20 a C	60.50 a D	74.37 a B	75.23 a A
Shrub perimeter (cm)	336 shrubs/ha	67.50 b A	63.08 b C	53.32 b D	67.47 b B	67.92 b A
	504 shrubs/ha	64.02 c A	54.53 c B	48.00 c D	62.62 c C	64.08 c BC
	252 shrubs/ha	78.25 a A	71.58 a B	50.02 a E	64.68 a D	65.92 a C
Edible leaves (%)	336 shrubs/ha	69.90 b A	63.83 b D	45.77 b E	59.22 b C	60.17 b B
	504 shrubs/ha	59.50 c A	53.33 c B	42.63 c C	55.63 c D	56.87 b E
	252 shrubs/ha	87.70 c A	84.20 a B	72.67 a C	70.83 a D	45.00 a E
Edible twigs (%)	336 shrubs/ha	88.58 b A	83.58 a B	71.87 b C	70.07 a D	44.58 a E
	504 shrubs/ha	89.43 a A	83.62 a B	71.55 b C	69.53 a D	44.50 a E
	252 shrubs/ha	21.67 c A	19.03 a B	15.82 a C	15.03 a D	10.75 a E
Fresh forage yield (t/ha)	336 shrubs/ha	22.13 b A	18.92 a B	15.42 a C	14.67 b D	10.77 a E
	504 shrubs/ha	22.62 a A	19.00 a B	15.18 b D	14.43 b BC	10.45 a C
	252 shrubs/ha	0.523c A	0.436 c B	0.278 c C	0.424 c B	0.409 c B
Dry forage yield (t/h)	336 shrubs/ha	0.701 b A	0.558 b B	0.407 b C	0.549 b B	0.548 b B
	504 shrubs/ha	1.055 a A	0.857 a B	0.557 a D	0.847 a BC	0.829 a C
	252 shrubs/ha	0.136 c A	0.113 c B	0.072 c C	0.110 c B	0.107 c B
SFUs yield/ ha	336 shrubs/ha	0.180 b A	0.145 b B	0.106 b C	0.143 b B	0.143 b B
	504 shrubs/ha	0.265 a A	0.223 a B	0.145 a D	0.220 a BC	0.215 a C
	252 shrubs/ha	61.3 c A	51.0 c B	32.5 c C	49.6 c B	48.0 c B
	336 shrubs/ha	81.1 b A	65.2 b B	47.5 b C	64.3 b B	64.2 b B
	504 shrubs/ha	119.2 a	100.2 a	65.2 a	99.1 a	96.9 a

Small and capital letters compare among rows and columns, respectively.
Mean values followed by the similar letter are not significantly different at $P < 0.05$ by Duncan's multiple range test.

The obtained data showed a consistent significant decrease in percentage of edible leaves and twigs with the advance in shrub age. In the first year, percentages of these traits were decreased significantly with each increase in shrub population. Increasing saltbush shrub population, more than 252 shrubs/ ha, also, decreased the percentage of edible leaves in the third year, as well as that of edible twigs in the fourth year. This, also, was the same for edible twigs percent in the third year with increasing shrub population more than 363 shrubs/ ha. It is clear the highest values of each fresh and dry forage yield, as well as SFUs yield / ha, could be secured in the first year, followed by those of the second and fourth years. While, the lowest values of these yields were obtained in the third year. These results assured the great dependence of yield on the amount and distribution of rainfall. Even so, the delay in rainfall onset, in the later year, had a detrimental effect on yield. However, in controversy with the effect of shrub population on the abovementioned yield attributes, increasing saltbush population, followed with a consistent significant increase in fresh, dry and SFUs yields/ ha of saltbush shrubs. Moselhy (2001) found that increasing plant density of interplanted saltbush with barley up to 170 shrubs/ fed increased fresh, dry matter and SFUs yields/ fed.

A.4.3. Utilization methods x shrub population:

The interaction between utilization methods and shrub populations had a significant effect on fresh, dry and SFUs yields/ ha of saltbush, as presented in

Table (5). The obtained results indicated the superiority of browsing over cutting method under different shrub populations. This was the same for fresh, dry and SFUs yields/ha. Moreover, under both utilization methods all of these three yields responded to increasing saltbush populations up to the higher level tried; i.e., 504 shrubs/ ha. Van Heerden *et al.* (1996) reported that increasing shrub population of saltbush caused a decrease in the yield per individual shrub, but, increased forage yield// ha.

B. Barley yield:

B.1. Seasonal variations of rainfall:

As evident from results presented in Table (6), there were great differences among years in grain, straw, field stubble and SFUs yields, as well as harvest index of barley associated with saltbush. It is seems that the highest grain and straw yields/ ha of barly were secured in the first, followed by the second, then, the fourth years. While, the lowest values of both, yields were recorded in the third year. In addition to the unfavorable effect of continuous association of barley with saltbush population, as was obvious from the comparison between the second and the fourth seasons, these results, also, reflectel the adverse effects of drought in the third season, as well as the uneven distribution of rainfall precipitation. Where, it was seen that the delay in the onset of rainfall, as occurred in the fifth winter season, had a severe adverse effect on grain and straw yields of barley than its shortage under casing late, as occurred in the second, third and fourth winter seasons.

In turn, field stubble was the highest in the first year, followed by the fifth, then, the fourth ones. While, the lowest value of field stubble was obtamed in the driest year; i.e. the third one. The superiority of fifth year over the second, third and forth years in field stubble might be due to extending the precipitation, in the winter season, until March. Ultimately, the highest SFUs yield of barley could be securel in the first year, followed by the second and fourth ones. While, the lowest value of this yield was obtained in the third year of the driest conditions.

B.2. Utilization methods of saltbush:

Data in Table (6) indicated the superiority of browsing over cutting utilization methods of saltbush shrubs in grain, straw, field stubble and SFUs yields of associated barley. Meanwhile, harvest index of barley was not significantly affected by utilization methods of saltbush. The superiority of browsing, over cutting method in yields of associated barley, might be due to the role of trampling animals in minimizing water evaporation from soil surface which relatively become compact and/ or due to providing plants with certain nutrient elements through animal dung and urinary excretes.

B.3. Saltbush shrub population:

The obtained results confirmed the significant effect of saltbush shrub populations on grain and straw yields, as well as field stubbles and total SFUs of barley, except for harvest index, which was not affected (Table 6). As obvious from these results, it was clear that grain, straw, field stubble and SFUs yields of barley significantly decreased with each increase in saltbush shrub population. Here, it was noticed that the higher shrub population was the highest in forage production of saltbush, but, the lowest yield of barley. These results reflected the adverse effect of competition between the two associated crops on certain limited environmental factors, especially water. In this respect, according to fluctuation of amount and distribution of rainfall precipitation, the fodder shrubs did not reach the effective height to be made, as windbreaks, to protect the planted barley strips among rows of saltbush shrubs from harmful effects of warm winds during the maturity stage of barley. However, Jones and Singh (1995) and Chriyaa and Boulanouar (1996) reported that wide expanse of planted rainfed areas, without windbreaks, were strongly affected by wind erosion.

Table 5: Mean values of fresh and dry forage yields and SFUs yield /ha of saltbush shrubs as affected by the interaction between utilization methods and shrub populations.

Character	Utilization methods	Shrub populations		
		252 shrubs/ha	336 shrubs/ha	504 shrubs/ha
Fresh forage yield (t/ ha)	Cutting	C 0.394 b	B 0.517 b	A 0.798 b
	Browsing	C 0.434 a	B 0.588 a	A 0.860 a
Dry forage yield (t/ ha)	Cutting	C 0.103 b	B 0.135 b	A 0.206 b
	Browsing	C 0.113 a	B 0.152 a	A 0.222 a
SFUs yield/ ha	Cutting	C 46.20 b	B 60.60 b	A 92.50 b
	Browsing	C 50.80 a	B 68.30 a	A 99.80 a

Small and capital letters compare among rows and columns, respectively.
Mean values followed by the similar letter are not significantly different at $P < 0.05$ by Duncan's multiple range test.

Table 6: Effect of utilization methods and shrub populations of saltbush shrubs on yield of the associated barley.

Main effects and interactions	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index	Field stubble (t/fad)	SFUs of barley (Kg/ha)
Years (Y):					
2002/2003	0.737 a	1.409 a	0.34 d	0.148 a	1438.3 a
2003/2004	0.528 b	0.855 b	0.38 c	0.119 d	967.5 b
2004/2005	0.309 e	0.460 e	0.40 a	0.103 e	562.1 d
2005/2006	0.525 c	0.843 c	0.38 c	0.125 c	960.5 b
2006/2007	0.494 d	0.745 d	0.39 b	0.127 b	886.6 c
F. test	**	**	**	**	**
Utilization methods (U):					
Cutting	0.514 b	0.853 b	0.38	0.122 b	952.9 b
Browsing	0.523 a	0.872 a	0.38	0.128 a	973.1 a
F. test	**	**	N.S	**	**
Shrub population (P):					
252 shrubs/ha	0.534 a	0.895 a	0.38	0.133 a	996.9 a
336 shrubs/ha	0.517 b	0.865 b	0.38	0.124 b	962.9 b
504 shrubs/ha	0.504 c	0.827 c	0.38	0.117 c	929.2 c
F. test	**	**	N.S	**	**
Interactions:					
Y x U	**	**	N.S	N.S	**
Y x P	**	**	**	**	**
U x P	N.S	N.S	N.S	N.S	N.S
Y x U x P	N.S	N.S	N.S	N.S	N.S

** : Significant at 0,01 level of probability.
Mean values followed by the similar letter are not significantly different at $P < 0.05$ by Duncan's multiple range test.

B.4. Interaction effects:

B.4.1. Seasonal variation x utilization methods:

Utilization methods indicated significant differences with rainfall years for grain, straw and SFUs yields of barley, as shown in Table (7). The obtained results indicated that barley could secure the highest values of grain, straw and SFUs yields in the first year, followed by the second and forth ones at par. While, the lowest values of these yields were recorded in the third year. These results reflected the positive effect of rainfall precipitation on yields of barley, except in the fifth year, where, the rainfall onset delayed up to Dec. (Table 1). Browsing method of saltbush shrubs out-yielded the cutting one for grain, straw and SFUs of associated barley in most cases.

B.4.2. Seasonal variation x shrub population:

The interaction between seasonal variation and saltbush shrub population had a significant effect on grain, straw and SFUs yields of barley, as shown in Table (8). Data recoded, herein, ascertained what is previously mentioned as a response of grain, straw and SFUs yields of barley to the winter seasonal variation in the amount and distribution of rainfall. Moreover, the highest field stubble yield of barley was produced in the first year of high rainfall, only, with the increase in shrub population up to 336 shrubs/ ha. Nevertheless, the lowest value of this yield was recorded in the third year of low rainfall under all tried shrub populations. However, a comparable field stubble yields of barley were produced in the second, fourth and fifth years when shrub population, only, increased from 252 to 336 shrubs/ha. Meanwhile, the increases in forage yields of saltbush shrubs, due to increasing their population, were on the expense of the forementioned yields of barley. This could be ascribed to the interspecific competition between the two associated crops on the limited environmental factors, especially water.

C. Partial budget analysis:

As shown in Table (9), the highest values of gross return (GR), net return (NR) and average rate of return (ARR) for total forage products (SFUs/ ha) of associated saltbush and barley were obtained when applying browsing method of saltbush shrub utilization, compared to cutting one. These values varied overall the five rainfall years, according to the amount and distribution of rainfall precipitation and their effect on saltbush regrowth and barley production. The highest values of GR, NR and ARR were recorded in the fifth year, followed by the fourth and, then, the first ones. While, the lowest values, were recorded in the third year, followed by the second one. The superiority of browsing method to the cutting one might be due to low total variable

Table 7: Barley grain and straw yields and SFUs/ha as affected by the interaction between utilization methods of saltbush shrub and rainfall years.

Characters	Utilization methods	Rainfall years				
		2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
		A	B	D	B	C
Grain yield (t/ha)	Cutting	0.736 b	0.527 a	0.300 b	0.524 a	0.483 b
		A	B	D	B	C
	Browsing	0.739 a	0.529 a	0.317 a	0.526 a	0.504 a
		A	B	D	B	C
Straw yield (t/ha)	Cutting	1.403 b	0.852 a	0.449 b	0.840b	0.722 b
		A	B	D	B	C
	Browsing	1.416 a	0.858 a	0.471 a	0.846 a	0.768 a
		A	B	D	B	C
SFUs of barley	Cutting	1433.0 b	962.4 b	546.9 b	957.7	864.3 b
		A	B	D	B	C
	Browsing	1443.7 a	972.6 a	577.2 a	963.3	908.9 a

Small and capital letters compare among rows and columns, respectively.
Mean values followed by the similar letter are not significantly different at $P < 0.05$ by Duncan's multiple range test.

Table 8: Grain and straw yields of barley, harvest index, field stubble and SFUs/ ha as affected by the interaction between shrub population and rainfall years.

Characters	Shrub population	Rainfall years				
		2002/2003	2003/2004	2004/2005	2005/2006	2006/2007
		A	B	D	B	C
Grain yield (t/ha)	252 shrubs/ha	0.770 a	0.544 a	0.314 a	0.539 a	0.505 a
		A	B	D	B	C
	336 shrubs/ha	0.737 b	0.527 b	0.308 b	0.524 b	0.492 b
		A	B	D	B	C
	504 shrubs/ha	0.705 c	0.514 c	0.305 b	0.512 c	0.485 b
		A	B	D	B	C
Straw yield (t/ha)	252 shrubs/ha	1.524 a	0.876 a	0.467 a	0.847 a	0.764 a
		A	B	D	B	C
	336 shrubs/ha	1.424 b	0.853 b	0.457 ab	0.846 a	0.743 ab
		A	B	D	B	C
	504 shrubs/ha	1.281 c	0.835 b	0.455 b	0.837 b	0.729 b
		A	B	C	B	B
Field stubble (t/ha)	252 shrubs/ha	0.179 a	0.122 a	0.105 a	0.126 a	0.131 a
		A	B	C	B	B
	336 shrubs/ha	0.148 b	0.120 a	0.103 a	0.124 a	0.127 ab
		B	B	C	A	A
	504 shrubs/ha	0.118 c	0.117 b	0.101 b	0.124 a	0.125 b
		A	B	D	B	C
SFUs/ha of barley	252 shrubs/ha	1535.8 a	993.0 a	571.3 a	976.8 a	907.7 a
		A	B	D	B	C
	336 shrubs/ha	1443.8 b	967.7 b	559.5 ab	960.3 b	883.2 b
		A	B	D	B	C
	504 shrubs/ha	1335.3 c	941.8 c	555.3 b	944.3 c	869.0 c

Small and capital letters compare among rows and columns, respectively
Mean values followed by the similar letter are not significantly different at $P < 0.05$ by Duncan's multiple range test.

costs for browsing method, where, it did not need labor, compared to cutting method. In addition, the highest values of ARR, resulted from each shrub population, were recorded in the fifth year, particularly when saltbush shrubs were browsed (Table 9). In general, the obtained data indicted that low shrub population/ ha reduced the total variable costs, which led to increase the NR and ARR. These results agreed with those obtained by Nesheiwat (1996).

SUMMARY

Data of the present work indicated that, in drier regions, yields of associated saltbush and barley were a function of the amount and distribution of rainfall precipitation. The higher amount and/ or the well distribution gave the highest yields of both associated crops. Accordingly, these results ascertained the importance of entering some of contingent forage crops, such as saltbush.

Table 9: Partial budget analysis of total forage products (SFUs/ ha) as affected by shrub populations and utilization methods of saltbush during the five years of study.

Shrub populations	Utilization methods							
	Cutting				Browsing			
	GR (LE/ha)	TVC (LE/h)	NR (LE/ha)	ARR	GR (LE/ha)	TC (LE/ha)	NR (LE/ha)	ARR
				2002/003				
252 shrub/ha	1191.5	352.8	838.7	2.38	1204.2	332.8	871.4	2.62
336 shrub/ha	1138.7	385.1	753.6	1.96	1148.7	360.8	787.9	2.18
504 shrub/ha	1083.8	447.5	636.3	1.42	1097.9	417.5	680.4	1.63
				2003/2004				
252 shrub/ha	882.1	360.6	521.5	1.45	892.7	336.8	555.9	1.65
336 shrub/ha	869.1	395.4	473.7	1.20	886.8	365.4	521.4	1.43
504 shrub/ha	878.8	459.5	419.3	0.91	892.6	423.5	469.1	1.11
				2004/2005				
252 shrub/ha	672.1	330.2	341.9	1.04	716.6	307.8	408.8	1.33
336 shrub/ha	679.5	365.6	313.9	0.86	716.5	336.4	380.1	1.13
504 shrub/ha	693.6	430.4	263.2	0.61	733.6	395.2	338.4	0.86
				2005/2006				
252 shrub/ha	1276.4	402.2	874.2	2.17	1289.6	372.2	917.4	2.46
336 shrub/ha	1274.8	438.2	836.6	1.91	1286.9	399.8	887.1	2.22
504 shrub/ha	1293.0	502.7	790.3	1.57	1325.6	465.6	847.0	1.81
				2006/2007				
252 shrub/ha	1434.5	449.6	984.9	2.19	1528.0	421.4	1106.6	2.63
336 shrub/ha	1424.8	485.6	939.2	1.93	1512.0	449.9	1062.1	2.36
504 shrub/ha	1464.0	551.9	912.1	1.65	1530.3	507.8	1022.5	2.01

GR: Gross return; TVC: Total variable costs; NR: Net return; ARR: Average rate of return.

In comparison between browsing and cutting, as utilization methods for forage of saltbush shrubs, browsing encouraged regrowth of saltbush shrubs and had a favorable effect on yields of the two associated component crops. While, increasing saltbush population suppressed growth of its individual shrubs, and forage yields/ ha of saltbush were increased. This was in coincidence with a decrease in yields of associated barley, where, the intraspecific competition within saltbush shrubs, as well as the interspecific competition between associated saltbush and barley on the limited environmental factors, especially water, became severe with increasing population of saltbush shrubs. This type of alley-cropping system could be adopted to improve the crop/ range/ livestock farming system and to sustainable development of rainfed areas, which characterized by harsh environmental conditions.

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الملخص العربى

تأثير كثافة الشجيرات العلفية وطرق الاستخدام على إنتاجية نظام الزراعة المتداخلة للقطف والشعير تحت ظروف الزراعة المطرية بالساحل الشمالى الغربى لمصر

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أجريت هذه الدراسة تحت ظرو ف الزراعة المطرية بمنطقة النجيلة بالشريحة الثانية (٥– ١٥ كم جنوب ساحل البحر)، ٧٠ كم غرب مدينة مرسى مطروح بالساحل الشمالى الغربى لمصر خلال خمس سنوات متتالية (٢٠٠٢/٢٠٠٣– ٢٠٠٣/٢٠٠٤– ٢٠٠٤/٢٠٠٥– ٢٠٠٥/٢٠٠٦– ٢٠٠٦/٢٠٠٧). وذلك بهدف الحصول على أفضل كثافة للشجيرات العلفية وأفضل طرق الاستخدام وتأثير ذلك على إنتاجية القطف والشعير المنزرعين بنظام الزراعة المتداخلة. وقد أظهرت النتائج ما يلى:

- كان هناك تأثير معنوى لمعدلات وتوزيع الأمطار خلال الخمس سنوات على محصول العلف ومكوناته لشجيرات القطف وكذلك محصول الشعير من الحبوب والتبن ومخلفات الحقل بعد الحصاد ومجموع الوحدات العلفية الناتجة من كلا المحصولين.
- أظهرت النتائج أن طريقة الرعى المباشر لشجيرات القطف قد تفوقت معنويا على طريقة القطع فى الوزن الغض للاوراق لكل شجيرة والوزن الكلى الغض والجاف بالهكتار ومحصول الوحدات العلفية بالهكتار. وكان نفس التأثير المعنوى جلياً على محصول الشعير من الحبوب والتبن ومخلفات الحقل بعد الحصاد والوحدات العلفية الكلية بالهكتار للشرائح المنزرعة بالشعير.
- أظهرت النتائج أيضاً أن زيادة عدد شجيرات القطف بالهكتار أدت إلى زيادة محصول العلف ومكوناته للقطف، بينما كان التأثير معاكس على محصول الشعير.
- كانت أعلى قيمة من متوسط معدل العائد عندما استخدمت طريقة الرعى المباشر لشجيرات القطف المنزرعة بكثافة ٢٥٢ شجيرة بالهكتار. وزادت هذه القيمة بزيادة عمر الشجيرات طبقا لمعدلات وتوزيع الأمطار.
- يستنتج من هذه الدراسة أنه يمكن التوصية بالتوسع فى نظام الزراعة المتداخلة لشجيرات القطف فى حقول الشعير لتحسين النظام المزرعى السائد بالشريحة المطرية الثانية وهو: "**محاصيل حقل/ مراعى/ إنتاج حيوانى**" ، وذلك من أجل التنمية المستدامة لإراضى الشعير التى تعتمد على الأمطار بمنطقة الساحل الشمالى الغربى لمصر. وهذا النظام ربما يساعد فى الحد من التأثيرات البيئية المعاكسة المواكبة للتغيرات المناخية.