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Development of Fodder Resources in Sinai: The Role of Forage Crops in Agriculture Development, North Sinai-Governorate, Egypt

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Abstract: The rainfall rate has decreased at latter years which led to deficient of fodder resources and animal wealth has decreased by 50%. Therefore, providing higher quantity and quality feed with lower cost and high palatability under North Sinai-conditions to improve the animal wealth in the agricultural sector of North Sinai are essential. Five hundred twenty three fields were cultivated in North Sinai-Governorate. The total area of each field is one and quarter Fadden divided to five plots. Two plots seeded by perennial forage crops; Alfalfa (*Medicago sativa* L.) and Rhodes Grass (*Chloris gayana*) and three plots seeded by summer crops; Cowpea (*Vigna unguiculata*), Sudan Grass (*Sorghum bicolor* subsp. *drummondii*) and Pearl millet (*Pennisetum glaucum* L.), followed by Egyptian clover (*Trifolium alexandrinum* L.), Barley (*Hordeum vulgare* L.), Oat (*Avena sativa*) and fodder beet (*Beta vulgaris*) in winter season. Regarding the Water Use Efficiency Based on Dry yield (WUED) for cultivated forage crops, the districts which more affected by saline water (El-Hasana and Nekhel-districts) achieved the lowest value of WUED among the other districts by values of 0.70 and 0.65 kg m⁻³, respectively. Whilst, the WUED in Rummana district was 5.90 kg m⁻³. The distribution of forage production costs and their net profit/fad. revealed that, the ton cost for Egyptian clover was higher in Nekhel-district compared with Rummana-district. The obtained results will be encouraging the North Sinai-farmers to spread cultivating of forage crops for meeting the acute shortage in fodder resources, taking into consideration, the competitiveness and preferences for used forage crops.

Key words: Fodder, forage crops, drought, salinity, quality, economical analysis

INTRODUCTION

The North Sinai-Governorate is located in the North Eastern sector of Egypt between a longitude of 30.5°N 33.6°E. The total population is 395.000 and the density of population about 14 km² (37/sq mi). In addition, the total area for North Sinai-Governorate about 27574 km² (10.646 sq mi) and divided to 6-districts; Rafha, El-Sheik Zawayed, Al-Arish, Bir Al-Abd, El-Hasana and Nekhel, which involved 82-villages and 458-Sub villages (Hamlets). Mittler and Blumwald (2010) mentioned that, the ever increasing of human population, concomitant with loss of agricultural land due to urbanization processes and diminishing water availability associated with climate change pose serious challenges to world agriculture. In addition, water stress due to drought and/or salinity is probably the most significant abiotic factor limiting plant and, also, crop growth and development in North Sinai-Governorate. So, salinity and drought are the most important environmental factors caused inhibiting photosynthesis and decreasing growth

and productivity of plants. Therefore, they are the major causes of crop loss worldwide, reducing average yields for most major crop plants by more than 50% (Wang *et al.*, 2001; Ashraf, 2004; Qadir *et al.*, 2008; Naz *et al.*, 2010). Accordingly, increasing water productivity is an important strategy to increase food production (Rosegrant *et al.*, 2002) under conditions of limited water supply. Therefore, the water use efficiency is an, especially, important consideration, where, irrigation water resources are limited or diminishing and where rainfall is a limiting factor. Regardless of the situation, it's crucial that growers get the most out of every liter of available water, whether that water comes through underground water, rainfall, or both of them. Where, the forage crops play a key role in ruminant livestock production and environmental protection, the rainfall rate has decreased at latter years which led to deficient of fodder resources and animal wealth has decreased by 50%. Among these forage crops, it is worth to mention that, Egyptian clover is one of the most important economic cultivated winter forage legumes in Egypt and

countries of Mediterranean region. It is used as a green fodder, hay and silage. Furthermore, Graves *et al.* (1987) mentioned that, Egyptian clover is tolerates moderate salinity. Estimation of the production costs in North Sinai-farms is a difficult task due to structural farm problems and the reasons bearing from cost calculation methodology. So, from district to other even from farm to farm, production costs and profitability of the forage crops can significantly vary depending on changes in crop yields and input use levels (Kara *et al.*, 2008). Where, quantity of forage production problem is one the most important farmer problems in North Sinai-region of Egypt but, providing higher quantity and quality feed with lower cost and high palatability under North Sinai-conditions to improve the animal wealth in the agricultural sector of North Sinai are essential. This can be accessed by estimated the cost and the profit of many forage crops that can be cultivated under North Sinai-conditions and choose the more profitable forage crops. Today's world, the most prominent aim of human beings is to maximize the profit by increasing production (Avei *et al.*, 2005). They added that, higher inputs used in production in order to get maximum profit cause some economic losses, since, they pollute environment. Preventing environmental pollution and minimizing economic losses are gaining importance in sustainability concept. Sustainability would only be possible with the conservation of soil and plant. Rotation application for the plants grown in the field from which obtain from basic food will, not only, increase the yield but also, make remarkable contribution to sustainability. Therefore, the main objective of this study was:

- To investigate the role of forage crops in agriculture development in desert lands and explore the possibility of providing higher quantity and quality feed with high palatability under sandy soils and saline water in North Sinai-region
- To estimate the water use efficiency for used forage crops
- To determine the nutritive value for produced fodder
- To distribute the forage production costs and their net profit/feddan for determining the competitiveness and preferences for studied crops

MATERIALS AND METHODS

- The research project carrying out in North Sinai-Governorate, Egypt during two successive years; (summer season; 2010, winter season; 2010-11, summer season; 2011 and winter season; 2011-12) to

investigate the role of forage crops in agriculture development in desert lands, North Sinai-Governorate, Egypt

- Five hundred twenty three fields were cultivated in North Sinai-Governorate as shown in Table 1. The total area of each field is one and quarter Feddan (Feddan = 4200 m² = 0.42 ha) divided to five plots. Two plots seeded by perennial forage crops; Alfalfa (*Medicago sativa* L.) and Rhodes Grass (*Chloris gayana*) and three plots seeded by summer crops; Cowpea (*Vigna unguiculata*), Sudan Grass (*Sorghum bicolor* subsp. *drummondii*) and Pearl Millet (*Pennisetum glaucum* L.), flowed by Egyptian clover (*Trifolium alexandrinum* L.), Barley (*Hordeum vulgare* L.), Oat (*Avena sativa*) and Fodder Beet (*Beta vulgaris*) in winter season and distributed as shown in Table 2. The plot area was 1/4 fed
- The drip irrigation is the popular irrigation system in North Sinai-region; 1.00 m between lines and 0.30 m between drippers
- The underground water is the main source of irrigation water and their TDS-total dissolved salts (ppm) are ranged from: 1408-2304 ppm in Rafha district to: 8960-10240 ppm in Nekhel district Table 3
- The broadcast seeding is a method of seeding that scattering seed by hand practices was used through the welt area of 30-50 cm on both sides of the irrigation lines

Table 1: Number of villages, suggested fields, actual fields and fields for estimated data in North Sinai-Districts, Egypt

North Sinai-districts	No. of villages	No. of suggested fields	No. of actual fields	Increase or Decrease (%)	No. of fields for estimated data
Rafah	11	44	30	-32	05
El-Sheik Zawayed	14	56	39	-30	05
Al-Arish	04	40	59	+47	05
Bir Al-Abed					
Bir Al-Abed	7	30	65	+117	05
Rummana	16	70	232	+231	20
El-Hasana	20	80	15	-81	05
Nekhel	10	80	33	-59	05
Non-governmental organization	----	----	50	+100	05
Total	82	400	523	+30.75	55

%: For increase or decrease = (Actual Number-Suggested No.)/Suggested No.

Table 2: Distribution of forage crops through the successive two years in North Sinai-districts, Egypt

Summer: 2010	Winter: 2010-2011	Summer: 2011	Winter: 2011-2012
Perennial cops (Only, for saving fodder resource over the year, especially, between summer and winter seasons)			
Alfalfa	Alfalfa	Alfalfa	Alfalfa
Rhodes grass	Rhodes grass	Rhodes grass	Rhodes grass
Annual cops			
Cowpea	Fodder Beet	Sudan Grass	Egyptian cover
Pearl millet	Barley-Oats	Cowpea	Fodder bet
Sudan grass	Egyptian clover	Pearl millet	Barley-Oats

- Due to, the large number of cultivated fields (523-fields), the displayed collecting data has been estimated from a limited number of such fields which continue the two successive years as shown in Table 1. In addition, the number of mows was differed from district to other and detected in Table 4

Experimental design: A three factors experiment was executed in a Randomized Complete Block Design (RCBD) arranged in split-split-plots and four replications. The factors were distributed as follows: two years as main plots, seven locations as sub-plots and nine forage crops as sub-sub plots.

Fresh forage yield: The fresh forage yield was estimated by mowed of fixed plot area ($1.00 \times 10.00 \text{ m} = 10.00 \text{ m}^2$) and four replications through the two successive years and weighted (kg plot^{-1}).

Conformably with plot yield and plot area (10.00 m^2), the total fresh yield fad^{-1} was calculated for the growing season as a follow:

$$\text{Fresh forage yield } \frac{\text{ton}}{\text{fad}} = \text{Fresh forage yield (kg plot}^{-1}) \times \frac{4000 \text{ m}^2}{10.00 \text{ m}^2}$$

Dry matter percent: Occasional subsamples were taken and weighted; air dried, oven dried at 105°C for 48 h and re-weighted to determine dry matter percent.

Dry forage yield: Dry forage yield (kg plot^{-1}) was calculated on the basis of the dry matter percent as a follow:

$$\frac{\text{Dry forage yield (kg)}}{\text{plot}} = \frac{\text{Fresh forage yield (kg)}}{\text{plot}} \times \text{Dry matter percent}$$

Conformably with plot yield and plot area (10.00 m^2), the total dry yield fad^{-1} was calculated for the growing season as a follow:

$$\text{Dry forage yield } \frac{\text{ton}}{\text{fad}} = \text{Dry forage yield (kg plot}^{-1}) \times \frac{4000 \text{ m}^2}{10.00 \text{ m}^2}$$

Water use efficiency: The water use efficiency based on dry weight was calculated according to Ehdaie and Waines (1993) formula as a ratio of forage dry yield (kg m^{-3}) to Total Water Consumed (TWC) by the forage crop plants as a follow:

$$\text{WUE (kg m}^{-3}) = \frac{Y}{\text{TWC}}$$

Forage quality

Chemical analysis: The samples were taken and oven dried at 70°C for 72 h. The sample was conducted following AOAC (1980) methods.

Crude protein: Kjeldahl method was used, the catalyst being metallic mercury 0.10 g and 4.00 mL H_2SO_4 conc. After clearing, digestion continued for 3 hours and the total Nitrogen (N) was determined and multiplied by the factor 6.25 to calculate CP as following formula:

$$\text{CP} = \text{N} \times 6.25$$

Crude fiber: Samples of 1.00 g with assistance of H_2SO_4 and NaOH (1.25%, w/w) were used in CF determination, keeping the column constant with boiling water through automatically fiber apparatus (Takeotor Company). The final residues were washed by acetone, weighed and ashen at 550°C for 3 h. Determination was according to the method described by AOAC (1990).

Total digestible nutrients: The Total Digestible Nutrients (TDN) based on dry mater basis was estimated according to Heeney (1978). Because of the legume forages have higher protein content, the legume

Table 3: Range of electrical conductivity and TDS-Total dissolved salts for used underground water in North Sinai-Districts, Egypt

North Sinai-districts	Ec_w	ppm*
Rafah	2.20-3.60	1408-2304
El-Sheik Zawayed	3.30-4.20	2112-2688
Al-Arish	3.80-4.50	2432-2880
Bir Al-Abed		
Bir Al-Abed	4.80-6.20	3072-4960
Rummana	6.60-8.40	5280-6720
El-Hasana	10.80-12.60	8640-10080
Nekhel	11.20-12.80	8960-10240

*ppm: $\text{Ec}_w \times 640$; EC: 0.1-5.0 dS m^{-1} , *ppm: $\text{Ec}_w \times 800$; EC: $>5.0 \text{ dS m}^{-1}$

Table 4: Number of mows/season over two years for cultivated forage crops in North Sinai-Districts, Egypt

Locations	Alfalfa*	Rhodes grass*	Cowpea	Pearl millet	Sudan grass	Egyptian clover	Barley	Oats
Rafah	4.0	4.0	3.2	4.1	3.3	4.2	2.0	3.2
El-Sheik Zawayed	4.3	4.2	3.0	4.0	3.0	4.0	2.0	3.0
Al-Arish	5.3	5.1	4.0	5.0	5.0	5.0	2.0	4.1
Bir Al-Abed	5.5	5.3	4.0	5.0	5.0	6.1	2.0	4.0
Rummana	6.3	6.0	4.0	5.6	5.0	6.5	2.0	4.3
El-Hasana	3.0	2.0	1.0	2.0	2.0	3.0	1.0	2.0
Nekhel	3.0	3.0	1.0	2.0	2.0	3.0	1.0	2.0

*: The No. of mows for Alfalfa and Rhodes grass was calculated as average mean for two season, Summer and winter seasons for each year

forages must be handled separately from non-legume forages. This formula seems to be fairly accurate:

Legumes forages: $TDN = 74.43 + 0.35 \text{ CP} - 0.78 \text{ CF}$

Non-legumes forages: $TDN = 50.41 + 1.04 \text{ CP} - 0.07 \text{ CF}$

Digestible crude protein: The Digestible Crude Protein (DCP) based on dry matter was, also, estimated according to Heeney (1978) used following formula:

$$DCP = CP \times 0.929 - 3.48$$

Statistical analysis: Data for two seasons were analyzed by standard Analysis of Variance (ANOVA) of the split-split-plot design. Means were compared by the L.S.D. values at 1% and 5% levels (Snedecor and Cochran, 1968) using MSTAT-C (1986).

Economical analysis: Distribution of forage production costs and their net profit/fadden were estimated according to El-Shorbagey (1992).

RESULTS AND DISCUSSION

Forage yield and its quality: The forage yields and their quality for nine forage crops over two year derived from

North Sinai-Districts are summarized in Table 5. Dry matter percent (DM %) and digestible crude protein (DCP) traits exhibited non significant differences. Whilst, highly significant ($p \leq 0.01$) differences were detected among years (Y), districts (D) and investigated forage Crops (C) for the quantitative forage yields and their quality under study. Likewise, highly significant ($p \leq 0.01$) differences effects of Y×C and D×C interactions were noted for forage fresh and dry yields and WUED-water use efficiency based on dry matter (Table 5). In addition, Y×D interaction was, also, highly significant ($p \leq 0.01$) difference effects for FDY, WUED, Crude Protein (CP), Total Digestible Nutrients (TDN) and Digestible Crude Protein (DCP) characters. On the contrary, this interaction was insignificant for FFY, DM % and CF traits. Abreast, the Y×D×C interaction was non-significant effects for all forage quality traits under investigation i.e.: CP, CF, TDN and DCP, as well as, FDY and DM% as evidenced in Table 5.

The significant mean square values obtained for Years (Y), Districts (D) and forage Crops (C) are shown in Table 5. The result indicated that, the conditions among the two years, in the seven locations using the nine forage crops were not similar effects in many ramifications and that is why the forage crops did not perform similarly in all districts. The obtained result revealed that, there was enough variation amongst used forage crops as well as

Table 5: Forage yield and its quality and distribution of forage production costs and their net profit/fadden over two years in North Sinai-Districts, Egypt

Crops			Forage yield and DM (%)				Forage quality (%)				Distribution of forage production costs and their Net Profit/Fadden (L.E)				
			FFY	FDY	DM	WUED	CP	CF	TDN	DCP	T.C	N.P.F	P.T.P	P.L.P	
Districts															
Rafah	Perennial crops	Alfalfa	9.8	2.9	29.5	1.4	24.8	23.0	65.3	19.6	756.5	2500.00	843.5	1.20	
		Rhodes grass	5.9	1.6	25.9	0.8	14.4	36.9	62.8	10.0	1291.7	-660.00	-491.7	-0.30	
		Mean	7.9	2.3	27.7	1.1	19.7	29.9	64.1	14.8	1024.1	920.00	175.9	0.40	
	Summer crops	Cowpea	11.5	2.2	18.5	1.4	21.9	23.8	63.6	16.8	851.3	400.00	148.8	0.20	
		Pearl millet	24.0	5.9	24.2	3.8	14.4	29.5	63.3	9.9	318.3	2625.00	431.8	1.50	
		Sudan grass	11.2	3.0	26.2	1.9	13.5	29.1	62.4	9.0	641.3	412.50	108.7	0.20	
	Winter crops	Mean	15.6	3.7	22.9	2.4	16.6	27.5	63.1	11.9	603.6	1145.80	229.8	0.60	
		Berseem	16.7	3.8	22.8	1.5	19.3	23.1	63.3	14.5	509.5	2710.00	690.6	1.50	
		Barley	1.6	0.5	31.4	0.2	8.0	25.5	56.9	3.9	3406.3	-1260.00	-2656.3	-0.80	
		Oats	4.0	1.0	24.7	0.4	7.7	28.2	56.4	3.6	1875.0	-1050.00	-1125.0	-0.60	
		Fodder beet	29.9	4.7	15.5	1.9	8.6	11.9	58.5	4.5	428.7	1810.00	371.4	1.00	
		Mean	13.0	2.5	23.6	1.0	10.9	22.2	58.8	6.6	1554.9	552.60	-679.9	0.30	
	El-Sheik Zawayed	Perennial crops	Alfalfa	13.1	3.6	26.8	1.8	26.2	24.1	64.8	20.8	619.2	3580.00	980.8	1.70
			Rhodes Grass	7.9	1.9	23.5	0.9	15.2	38.7	63.5	10.7	1046.4	-380.00	-246.4	-0.20
			Mean	10.5	2.8	25.1	1.4	20.7	31.4	64.2	15.7	832.8	1600.00	367.3	0.80
Summer crops		Cowpea	16.5	2.8	16.8	1.8	23.0	25.0	63.0	17.9	655.1	1050.00	344.9	0.60	
		Pearl millet	34.2	7.6	22.0	5.0	15.1	31.0	64.0	10.6	247.9	3900.00	502.2	2.20	
		Sudan grass	16.1	3.9	23.8	2.5	14.2	30.5	63.0	9.7	481.9	1125.00	268.2	0.60	
Winter crops		Mean	22.1	4.8	20.9	3.1	17.4	28.8	63.4	12.7	461.6	2025.00	371.8	1.10	
		Berseem	20.8	4.3	20.7	1.8	20.4	24.2	62.7	15.4	450.0	3310.00	750.1	1.80	
		Barley	1.9	0.6	28.5	0.3	8.4	26.8	57.2	4.3	3211.6	-1222.50	-2461.6	-0.80	
		Oats	4.9	1.1	22.5	0.4	8.1	29.6	56.7	4.0	1692.3	-975.00	-942.3	-0.50	
		Fodder beet	37.5	5.3	14.1	2.1	9.0	12.5	58.9	4.9	376.6	2330.00	423.4	1.20	
		Mean	16.3	2.8	21.4	1.1	11.5	23.3	58.9	7.1	1432.6	860.70	-557.6	0.40	
Al-Arish		Perennial crops	Alfalfa	16.3	4.0	24.4	2.0	27.5	25.1	64.6	22.1	546.90	4300.00	1053.20	2.10
			Rhodes grass	9.7	2.1	21.4	1.0	16.0	40.3	64.3	11.4	938.90	-220.00	-138.80	-0.10
			Mean	13.0	3.1	22.9	1.5	21.8	32.7	64.4	16.8	742.90	2040.00	457.20	1.00
	Summer crops	Cowpea	20.7	3.2	15.3	2.1	24.2	26.0	62.7	19.0	574.40	1450.00	425.70	0.80	
		Pearl millet	42.7	8.6	20.0	5.7	15.9	32.2	64.7	11.3	218.90	4650.00	531.10	2.60	
		Sudan grass	20.1	4.4	21.6	2.9	14.9	31.8	63.7	10.4	427.00	1500.00	323.10	0.80	

Table 5: Continue

Districts	Crops		Forage yield and DM (%)				Forage quality (%)				Distribution of forage production costs and their Net Profit/Fadden (L.E)			
			FFY	FDY	DM	WUED	CP	CF	TDN	DCP	T.C	N.P.F	P.T.P	P.I.P
Bir Al-Abd	Winter crops	Mean	27.8	5.4	19.0	3.5	18.4	30.0	63.7	13.6	406.80	2533.40	426.60	1.40
		Berseem	26.1	5.0	18.8	1.9	21.4	25.2	62.3	16.4	391.40	4090.00	808.70	2.20
		Barley	2.4	0.7	25.9	0.3	8.8	27.8	57.6	4.7	2656.90	-1147.50	-1906.90	-0.70
		Oats	6.3	1.3	20.4	0.5	8.5	30.8	57.1	4.4	1462.50	-825.00	-712.50	-0.50
	Perennial crops	Fodder Beet	46.8	6.1	12.8	2.4	9.5	13.0	59.4	5.3	329.80	2930.00	470.30	1.50
		Mean	20.4	3.3	19.5	1.3	12.1	24.2	59.1	7.7	1211.70	1261.90	-335.20	0.70
		Alfalfa	21.2	4.8	22.2	2.3	28.4	25.8	64.3	22.9	468.00	5420.00	1132.00	2.60
		Rhodes Grass	13.2	2.6	19.4	1.3	16.5	41.5	64.7	11.9	781.50	140.00	18.60	0.10
	Summer crops	Mean	17.2	3.7	20.8	1.8	22.4	33.7	64.5	17.3	624.80	2780.00	575.30	1.30
		Cowpea	26.8	3.8	14.0	2.5	25.0	26.7	62.3	19.7	481.90	2050.00	518.20	1.20
		Pearl millet	60.3	11.1	18.2	7.2	16.4	33.2	65.1	11.8	170.00	6487.50	580.10	3.60
		Sudan grass	28.7	5.7	19.7	3.7	15.4	32.7	64.1	10.8	330.50	2475.00	419.60	1.40
Rummana	Winter crops	Mean	38.6	6.9	17.2	4.5	18.9	30.9	63.9	14.1	327.50	3670.90	506.00	2.10
		Berseem	37.1	6.4	17.1	2.5	22.1	25.9	62.0	17.0	301.60	5830.00	898.50	3.20
		Barley	3.4	0.8	23.6	0.3	9.1	28.6	57.9	4.9	2180.00	-1035.00	-1430.00	-0.60
		Oats	8.9	1.7	18.6	0.7	8.7	31.7	57.3	4.6	1142.30	-562.50	-392.30	-0.30
	Perennial crops	Fodder beet	66.9	7.9	11.6	3.1	9.8	13.4	59.7	5.6	254.60	4370.00	545.40	2.30
		Mean	29.1	14.6	17.7	1.7	12.4	25.0	59.2	8.1	969.60	2150.70	-94.60	1.10
		Alfalfa	30.5	7.4	23.8	3.6	30.5	26.1	64.8	24.9	299.10	9660.00	1301.00	4.60
		Rhodes Grass	20.9	4.4	20.9	2.2	17.8	41.9	66.0	13.0	450.70	1620.00	349.30	0.90
	Summer crops	Mean	25.7	5.9	22.4	2.9	24.1	34.0	65.4	18.9	374.90	5640.00	825.20	2.70
		Cowpea	38.7	5.9	15.0	3.8	26.8	27.0	62.8	21.4	313.50	4100.00	686.60	2.30
		Pearl millet	88.9	17.6	19.5	11.5	17.7	33.5	66.4	12.9	107.20	11362.50	642.80	6.30
		Sudan grass	49.1	10.5	21.1	6.8	16.5	33.1	65.3	11.9	179.90	6037.50	570.10	3.40
El-Hasana	Winter crops	Mean	58.9	11.3	18.5	7.4	20.3	31.2	64.8	15.4	200.20	7166.70	633.20	4.00
		Berseem	61.9	11.5	18.4	4.6	23.8	26.2	62.3	18.6	168.20	11950.00	1031.80	6.50
		Barley	5.7	1.4	25.3	0.6	9.8	28.9	58.6	5.6	1224.10	-585.00	-474.10	-0.40
		Oats	14.8	3.0	20.0	1.2	9.4	32.0	58.0	5.2	625.00	450.00	125.00	0.30
	Perennial crops	Fodder beet	111.4	14.1	12.5	5.6	10.5	13.6	60.4	6.3	141.50	9370.00	658.60	4.90
		Mean	48.4	7.5	19.0	3.0	13.4	25.2	59.8	8.9	539.70	5296.30	335.40	2.80
		Alfalfa	4.8	1.5	29.8	0.8	32.5	26.6	65.1	26.7	1537.90	220.00	62.10	0.10
		Rhodes Grass	2.9	0.8	26.1	0.4	18.9	42.7	67.0	14.1	2638.90	-1300.00	-1838.90	-0.70
	Summer crops	Mean	3.9	1.1	28.0	0.6	25.7	34.7	66.1	20.4	2088.40	-540.00	-888.40	-0.30
		Cowpea	3.4	0.7	18.7	0.4	28.6	27.5	63.0	23.1	2843.80	-1100.00	-1843.80	-0.60
		Pearl millet	12.0	3.0	24.4	1.9	18.8	34.2	67.5	14.0	641.30	412.50	108.70	0.20
		Sudan grass	5.7	1.5	26.4	1.0	17.6	33.7	66.4	12.9	1250.00	-675.00	-500.00	-0.40
Nekhel	Winter crops	Mean	7.0	1.7	23.2	1.1	21.6	31.8	65.6	16.6	1578.40	-454.20	-745.00	-0.30
		Berseem	8.3	1.9	23.0	0.8	25.2	26.7	62.5	20.0	1018.90	430.00	181.20	0.20
		Barley	0.7	0.3	31.7	0.1	10.4	29.5	59.1	6.2	6812.50	-1447.50	-6062.50	-0.90
		Oats	2.1	0.5	25.0	0.2	10.0	32.7	58.5	5.8	3750.00	-1425.00	-3000.00	-0.80
	Perennial crops	Fodder Beet	15.0	2.4	15.6	0.9	11.2	13.8	61.1	6.9	832.00	10.00	-32.00	0.00
		Mean	6.5	1.3	23.8	0.5	14.2	25.7	60.3	9.7	3103.40	-608.20	-2228.30	-0.40
		Alfalfa	4.1	1.4	33.1	0.7	34.2	26.9	65.5	28.2	1610.80	60.00	-10.80	0.03
		Rhodes grass	2.4	0.8	29.0	0.4	19.9	43.2	68.1	15.0	2955.60	-1340.00	-2155.60	-0.71
	Summer crops	Mean	3.3	1.1	31.0	0.5	27.0	35.0	66.8	21.6	2283.20	-640.00	-1083.20	-0.34
		Cowpea	2.7	0.6	20.8	0.4	30.1	27.8	63.3	24.4	3437.50	-1200.00	-2437.50	-0.69
		Pearl millet	10.6	2.9	27.1	1.9	19.8	34.6	68.6	14.9	648.50	375.00	101.60	0.21
		Sudan grass	4.9	1.5	29.3	1.0	18.5	34.1	67.3	13.7	1250.00	-675.00	-500.00	-0.38
Coefficient of variation (C.V.) (%)	Winter crops	Mean	6.0	1.7	25.8	1.1	22.8	32.1	66.4	17.7	1778.70	-500.00	-945.40	-0.29
		Berseem	6.6	1.8	25.5	0.7	26.6	27.0	62.7	21.2	1101.20	250.00	98.80	0.14
		Barley	0.6	0.3	35.2	0.1	10.9	29.8	59.7	6.7	6812.50	-1447.50	-6062.50	-0.89
		Oats	1.6	0.4	27.7	0.2	10.5	33.0	59.0	6.3	4800.00	-1500.00	-4050.00	-0.84
	Perennial crops	Fodder beet	12.0	2.1	17.4	0.9	11.8	14.0	61.7	7.5	943.80	-230.00	-143.80	-0.12
		Mean	5.2	1.1	26.5	0.4	14.9	26.0	60.8	10.4	3414.40	-731.90	-2539.40	-0.43
		Alfalfa	38.70	56.50	63.30	54.70	3.50	1.40	0.50	85.40				
		Districts (D)	46.30	48.30	3.60	48.60	2.30	1.90	0.50	111.6				
	Summer crops	Crops (C)	19.80	18.50	1.72	21.80	12.00	3.10	2.70	109.5				
		Standard deviation	22.91	5.62	2.20	7.49	7.78	3.64	17.04					
		Years (Y)	--	--	N.S	--	--	--	--	--				
		Districts (D)	--	--	--	--	--	--	--	N.S				
Significant	Crops (C)	YD	N.S	--	N.S	--	--	N.S.	--	--				
		YC	--	--	--	--	N.S	N.S	N.S	--				
		DC	--	--	--	--	N.S	--	--	N.S				
		YDC	--	N.S	N.S	--	N.S	N.S	N.S	N.S				

FFY: Fresh forage yield (Ton/Fad.), FDY: Dry forage yield (Ton/Fad.), DM (%): Dry matter (%), WUED: Water use efficiency based on dry yield, CP and CF: Crude protein and crude fiber, TDN: Total digestible nutrients, DCP: Digestible crude protein, T.C: Ton cost, N.P.F: Net Profit/Fadden, P.T.P: Profit from Ton production, P.I.P: Profit from Investor Pound, L.E: Egyptian Pound, N.S: Non-significant, Significant at 0.05 and 0.01, respectively

environments under study. In addition, the significant effects of Y×D interaction mean squares that were observed (Table 5), in five characters (FDY, WUED, CP, TDN and DCP) under study, also, suggests that, the environmental conditions in the seven locations influenced the values of the abovementioned traits. This result was emphasized the importance of evaluating of these forage crops in different locations over the years to ascertain their stability for use it as reliable selected forage crops for improvement the fodder recourses under North Sinai-conditions.

According to coefficient of variation (C.V); it expresses the variation as a percentage of the mean. The C.V, also, provides a general "feeling" about the performance of a method. C.Vs of 5.00% or less, generally, give us a feeling of good method performance, whereas, C.Vs of 10.00% and higher sound bad (Westgard, 1998; NCCLS, 1999). However, should look carefully at the mean value before judging a C.V. So, at very low concentrations, the C.V, may be, high and at high concentrations the C.V, may be, low. For some measures, the Standard Deviation (SD) increases as the average increases. In this case, the C.V is the best way to summarize the variation. In other cases the standard deviation does not change with the average. In this case, the standard deviation is the best way to summarize the variation. Because of, the data is more spread out (has more variability) and resulted higher standard deviation. It's often difficult to interpret a standard deviation, since; it's based on the sample of data. Anyhow, the larger coefficient of variation (Table 5) are due to the data is varies more.

The contrast reality in salinity levels of used irrigation water from district to another accompanied with lowest rate of total rainfall leading to the forage production was more affected, not only, by forage crops but also, by environmental condition and their interactions. Therefore, the comparative performances of nine forage crops across seven locations for twelve characters studied (Table 5) provide a clear indication of the superiority of some of the forage crops over others. These twelve characters involving distribution of forage production costs and their net profit/fed. and other parameters were used; there was considerable variability present in the forage crops investigated. These results would be useful in choosing forage crops to use and improve their productivity for animal feeding under North Sinai-condition. Where, the fresh and dry forage yields of Egyptian clover was ranked the second winter forage crops after fodder beet among other forage crops (Table 5) in various locations or districts as a mean of total yield over two seasons. On account of, the mean values for fresh and dry yields of berseem was highest in Rummana-district (61.90 and 11.50 ton fed⁻¹, respectively)

and lowest in Nekhel-district (6.60 and 1.80 ton fed⁻¹, respectively). This means that, the response of forage crops varied from location to another due to, mainly, the level of salinity in irrigation water (Table 3), in addition, the level of soil fertility. The close similarity of the previous finding, fodder beet was recorded 111.40 and 14.10 ton fed⁻¹, respectively; in Rummana-district and 12.00 and 2.10 ton fed⁻¹, respectively; in Nekhel-district. Furthermore and in the same trend, the Egyptian clover was produced 4.60 kg of DM m⁻³ in Rummana-district, whilst, the water use efficiency based on dry matter in Nekhel-district was 0.70 kg m⁻³ (Table 5). Conformity, previous mentioned data was abided by Ibrahim (2005), who avowed that, fodder beet has a high dry matter yield and recognized for its high nutritional value as it is a good source of energy for animals. Wanas *et al.* (2007) showed that, the lowest value of WUE for fodder beet was 13.04 kg m⁻³, while, the highest values was 25.93 kg m⁻³. In addition, the highest fresh weights were 74.12 ton fed⁻¹.

From previous results, can be conclude that Water Use Efficiency Based on Dry Matter (WUED) are suitable criteria for screening drought and salinity tolerant forage crops under North Sinai-conditions. This conclusion seems logical based on its positive and highly significant correlation with forage yields and TDN-total digestible nutrients (Table 6) and its ability to select forage crops according to drought and salinity stresses resistance. This is very clear in case of Egyptian clover and fodder beet. Where, in all locations were given the highest values of forage yields and TDN and their related with WUED as shown in Table 5. Generally, a reduction was evident of forage yields and water use efficiency with increased salinity levels in used irrigation water in North Sinai-districts as shown in Table 3 and 5. Zeng and Shannon (2000) was attributed this reduction to sensitivity of crops to increased level of salinity has been regarded as a chronic factor in displaying poor growth and economic yield. This has mainly been attributed to the salinity induced deficiency of essential nutrients and enhanced toxicity of the elements present in excess in the salinity affected soil.

Referring to Table 5, also, in the term of forage quality for berseem, the Crude Protein (CP) was ranged from 19.30% in Rafah-district to 26.60% in Nekhel-district. Equivalently, the crude fiber (CF) was ranged from 23.10% in Rafah-district to 27.00% in Nekhel-district. From aforementioned traits (CP and CF), the Total Digestible Nutrients (TDN) and Digestible Crude Protein (DCP) were estimated and described in Table 5. Rafah-district was recorded highest value of TDN for Egyptian clover (63.30%) and lowest value of DCP (14.50%). In contrast, Bir-Al-Abd-district was recorded lowest value of TDN (62.00%) and Nekhel-district was recorded highest value of DCP (21.20%). The same conclusion was outlined by

Table 6: Phenotypic correlation coefficient and standard error (in brackets) for eight forage yield and its quality over two years in North Sinai-Governorate, Egypt

	FFY	FDY	DM%	WUED	CP	CF	TDN	DCP
FFY	---	0.948** (±0.002)	-0.517** (±0.009)	0.856** (±0.002)	-0.022 (±0.015)	-0.022 (±0.015)	0.117 (±0.007)	-0.001 (±0.033)
FDY		---	-0.371** (±0.061)	0.956** (±0.008)	0.066 (±0.088)	0.066 (±0.088)	0.235* (±0.042)	0.063 (±0.200)
DM%			---	-0.293** (±0.017)	0.099 (±0.059)	0.099 (±0.059)	0.145 (±0.029)	0.102 (±0.135)
WUED				---	0.09 (±0.151)	0.09 (±0.151)	0.312** (±0.070)	0.064 (±0.345)
CP					---	---	0.623** (±0.017)	0.510** (±0.087)
CF						---	0.238* (±0.020)	0.012 (±0.098)
TDN							---	0.291** (±0.200)
DCP								---

*and **: Significant at 0.05 and 0.01, respectively, FFY: Fresh forage yield, FDY: Dry forage yield, DM (%): Dry matter (%), WUED: Water use efficiency based on dry yield, CP: Crude protein, CF: Crude fiber, TDN: Total digestible nutrients and DCP: Digestible crude protein

Nadaf *et al.* (1998), who reported that, the calculated energy content of fodder beet (tubers and leaves) was about 61.00% TDN and CP content of the leaves ranged between 11.40 and 15.80%, while, the tubers contained between 4.50 and 9.80%. In addition, El-Bably (2002) found that, three irrigation events between cuttings significantly increased total cuttings of fresh and dry yields (FY and DY, respectively) to 104.14 and 19.48 t ha⁻¹, respectively. On the other hand, it decreased Water Use Efficiency (WUE). In addition water consumptive use values were 59.62, 48.98 and 37.98 cm, over both seasons, for three, two and one irrigation time (sec) between cuttings, respectively. Under shortage of irrigation water, single irrigation between cuttings could be useful, because, it produced 91.97 and 16.75 t ha⁻¹ FY and DY, respectively; consumed 37.98 cm (170 d)⁻¹ and gave higher WUE of 440.9 kg of dry matter (DM) ha⁻¹ cm⁻¹ water consumed compared with irrigation three times, which produced 104.14 and 19.48 t ha⁻¹ FY and DY, respectively; consumed 59.62 cm (170 d)⁻¹ and gave lower WUE of 326.5 kg of DM ha⁻¹ cm⁻¹ water consumed, over both seasons.

Table 6, shows the once again, forage crops breeders have uncovered the fact that some characters or aspects of them affect other characters. Each of these characters has its own optimal mean value which is commensurate with the adaptive fitness of the genotype under stress condition. So, the interrelationships between characters are expressed in statistical term, as phenotypic correlation coefficients, which show how one variable changes as the other changes. Therefore, positive correlations show that as breeders change the mean of one character towards the higher side, the other also goes up with it, while, in the negative as the mean value of one character goes up, the value for the other character goes down. Consequently, the Water Use Efficiency (WUED) had highest positive correlation with fresh and dry forage yields as shown in

Table 6. Contrarily, WUED had negative and highly significant correlation with dry matter percent (DM %). The existing negative correlation between the dry matter (%), forage yields and WUED (Table 6) makes it difficult to perform selection in the direction of a simultaneous increase DM%, forage yields and WUED. Commendable, Total Digestible Nutrients (TDN) were positively and strongly correlated with WUED and crude protein (CP). Likewise, phenotypic correlations were positive and significant between digestible crude protein (DCP) and CP and TDN. Whilst, negative and significant correlated was detected between CP and FFY. The same conclusion was outlined by Bakheit (1986), who reported that, negative correlation was found between mean protein percentage with seasonal fresh and dry forage yield. From the results, can be concluding that, the direct and most important contributor to forage yields, under North Sinai-condition are WUED.

Economic evaluation: Production may bear in mind as more logical. However, when making decisions for production a number of factors, such as price expectations, labor and input availability, soil structure and crop rotation affect the decision process. The feasibility study reported in Table 5 proved that cultivating of selected forage crops under North Sinai-conditions is advisable economically in some districts such as Rummana. This conclusion because, this district are characterized by the lowest ton costs and maximum values of net profit/fed., profit from ton production and profit from investor pound, taking into account, the environmental impact and social returns. Where, the ton costs of forage production (Table 5) revealed that, the ton cost for Egyptian clover ranged from 1101.20 L.E. in Nekhel-district to 168.20 L.E. in Rummana-district. Based on the above mentioned, the net profit/fad. ranged from 250.00 L.E. in Nekhel-district to 11950.00 L.E. in Rummana-

district. Based on previous estimates, the profit from ton production and investor pound were 98.80 and 0.14 L.E., respectively, in Nekhel-district and 1031.80 and 6.50 L.E., respectively, in Rummana-district. Furthermore, when accepted these factors as stable for all crops, the subject to be considered is the amount of revenue in return of Egyptian clover. Considering a sustainable production it is a reality that, among winter forage crops, Egyptian clover and fodder beet are the two production branches supporting animal production under North Sinai-condition. Similarly, taking into consideration of extremely increasing fodder recourses prices during summer season, it is clear enough that pearl millet production are the most important and profitable production forage crop. Because it was recorded the lowest ton cost among summer forage crops and ranged from: 107.20 L.E in Rummana-district to: 648.50 L.E in Nekhel-district (Table 5), in addition, positive net profit/fed. (11362.50 and 375.00 L.E, respectively), positive profit from ton production (642.80 and 101.60 L.E, respectively) and positive profit from investor pound (6.30 and 0.21 L.E, respectively). In this study, the incentives of these forage crops and their importance for livestock production, as well as, their positive impact on the environment were not taken into account in calculations. In addition, the positive impacts form cultivating of legume forages such as Egyptian clover. So, it means that profitability of forage crops production is higher than presented.

CONCLUSION

Considerable variation exists among forage crops, indicating the potential for selecting of superior and better adapted forage crops for both their production and their quality.

From the aforementioned discussion, it is suggested to cultivate forage crops under sandy soils, saline water and drip irrigation system to obtain the highest water use efficiency of forage crops should be carefully evaluated to the studied area.

The direct and most important contributor to forage yields, under North Sinai-condition are WUED.

It is worth to mention that, among winter forage crops, Egyptian clover or berseem was recorded the positive and highest value for net profit/fed. (N.P.F), profit from ton production (P.T.P) and profit from investor pound (P.I.P) in all locations. Therefore, Egyptian clover is stable better than other forage crops in all North Sinai-districts.

Increased forage production from Egyptian clover and fodder beet could enhance ruminant livestock production substantially without requiring additional inputs from resource-poor livestock farmers.

RECOMMENDATIONS

To implement technology transfer activities for cultivating of Egyptian clover and other forage crops on regional level within rotation to help alleviate drought, saline water and agriculture problems using the prevailing drip irrigation system in North Sinai-region.

To implement researches to studying the impact of cultivating of berseem compared with other forage crops on natural resources, biodiversity and sustainability of agricultural production in North Sinai-region.

To study the applicability of cultivating of berseem and other forages for different locations to improve the animal wealth in North Sinai-districts based on obtained data.

To establish breeding program for drought and salinity tolerance under natural selection for essential crops in North Sinai-Governorate, especially, Egyptian clover.

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