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COMPETITION AND ECONOMIC INDICES AS AFFECTED BY NITROGEN FERTILIZATION RATE AND INTERCROPPING SYSTEM OF ROSELLE AND GUAR

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ABSTRACT: *This investigation was conducted to evaluate different intercropping systems between roselle and guar; viz., 1:2, 1:3 and 2:4 as well as sole planting of each crop, different nitrogen fertilization rates (i.e., 0, 18, 36 or 72 kg nitrogen/fad.) and their combinations. Evaluation of the above mentioned treatments was performed on basis of several competition and economic indices; viz., land equivalent ratio (LER), area time equivalent ratio (ATER), aggressivity (A), land utilization efficiency (LUE) and monetary advantage index (MAI). Competition indices revealed that, all applied intercropping systems were more efficient than sole cropping while nitrogen rate had no significant effect on these indices in most cases. Aggressivity estimation indicated that roselle was dominant while guar was dominated. The highest values of the above mentioned competition and economic indices were belonged to intercropping system of 1:3 roselle and guar fertilized with 72 kg nitrogen/fad. This treatment seemed to be promising for high economic return.*

Key words: *Roselle, Guar, intercropping system, nitrogen fertilization, LER, ATER, LUE, MAI*

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.), an annual shrub, is commonly used to make jellies, jams and beverages. Roselle has also many medicinal properties since it is used as digestive, choleretic, antibilious, laxative, diuretic, hypotensive, antiscorbutic. The seeds contain sterols, including 3.2% ergosterol (Khare, 2007). Seeds contain about 21.1 % lipids (Al-Wandawi *et al.*, 1984).

Guar (*Cyamopsis tetragonoloba* Taub.) is a tropical legume; that is drought resistant and grows during the hot summer months (Jones and Johnson, 1983), its drought resistance and N_2-fixing ability affect profitable production (Gerik *et al.*, 1983). The commercial importance of guar is due to the gum (guaran or galactomanan) that is extracted from the seed and used in food processing, paper manufacturing, pharmaceuticals, and as an emulsifier in drilling muds for the petroleum industry (Whistler and Hymowitz, 1979). Guar is used as Laxative, antibilious. Gum is hypoglycaemic, hypolipidaemic, appetite depressor, reduces glycosuria during gum supplementation. Taking Guar gum orally with meals was found to lower post-prandial glucose levels in patients with type 1 diabetes (Khare, 2007).

Multiple cropping has been practiced for centuries by small-scale farmers in Africa to reduce the risk of crop failure, attain higher yields, and to improve soil fertility (Litsinger and Moody, 1976). Intercropping, through more effective use of water, nutrients and solar energy, can significantly enhance crop productivity compared to the growth of sole crops (Midmore, 1993). The increasing concern on agricultural sustainability favors the maintenance of the intercropping systems, due to a positive effect on soil conservation and improvement of soil fertility (Jarenyama *et al.*, 2000). Yield increments resulting from mixed intercropping were attributed mainly to the presence of complimentary effects, better resource use efficiency of the mixed cultures and the buffering effects of the mixtures against diseases and weeds (Willey, 1979 and Anil *et al.*, 1998).

In intercropping systems involving a legume and a nonlegume, part of the nitrogen fixed in the root nodule of the legume may become available to the nonlegume component (Li *et al*., 2009). Therefore productivity normally is potentially enhanced by the inclusion of a legume in the cropping system (Maingi *et al*., 2001).

To date, experimental reports about intercropping between medicinal and aromatic plants are rare (Carrubba *et al*., 2008).

Various indices such as land equivalent ratio (LER), area time equivalent ratio (ATER), aggressivity (A), land utilization efficiency (LUE) and monetary advantage index (MAI), have been developed to describe the competition and possible economic advantage in intercropping (Mead and Willey, 1980; Hiebesch and McCollum, 1987; Ghosh, 2004). Mathematical indices can help researchers to summarize, interpret, and display the results from plant competition trials (Weigelt and Jolliffe, 2003). Indices can express various attributes of competition in plant communities, including competition intensity, competitive effects, and the outcome of competition (Agegnehu *et al*., 2006).

The present study was designed to evaluate the effect of intercropping system and nitrogen fertilization rate on different competition (i.e., LER , ATER, A and LUE) and economic (MAI) indices in roselle-guar intercropping systems for better resources management and higher crop productivity and income.

MATERIALS AND METHODS

The present study was conducted at the Experimental Farm of Faculty of Agriculture, Zagazig University during two seasons of 2009 and 2010 to investigate the effect of intercropping system of roselle (*Hibiscus sabdariffa* L.) and guar (*Cyamopsis tetragonoloba* Taub.) on competitive relationships; i.e., land equivalent ratio (LER), area time equivalent ratio (ATER), aggressivity (A), land utilization efficiency (LUE) and monetary advantage index (MAI) in cropped roselle and guar under Sharkia Governorate conditions.

Seeds of both species were obtained from Ministry of Agriculture, Research Centre of Medicinal and Aromatic Plants, Dokky, Giza. Seeds were sown on 1st May during both seasons then immediately irrigated. After three weeks from planting, germinated plants were thinned to be one plant of roselle per hill and two plants of guar per hill for guar. The physical and chemical properties of the experimental farm soil are shown in Table 1.

The plot area was 2.00 × 7.20 m included twelve rows; each row was 60 cm apart and two meters in length. The seeds were sown on row in hills on one side. The distances between hills were 50 cm for roselle and 30 cm for guar plant.

This experiment included 20 treatments, which were the combinations between five intercropping systems and four nitrogen fertilization rates; i.e., control (without nitrogen fertilization), 87.5 kg/faddan (fad.) ammonium sulphate (20.5% N) which gave about 18 kg nitrogen/fad., 175 kg/fad. ammonium sulphate which gave about 36 kg nitrogen/fad. and 350 kg/fad. ammonium sulphate which gave about 72 kg nitrogen/fad. The later rate was the recommended rate for roselle fertilization according to Selim *et al*. (1993). The intercropping system treatments were as follows:

Table (1). Physical and chemical properties of the experimental farm soil

Physical properties	(%)	Chemical properties	
Sand	26.96	Total nitrogen	0.18%
Silt	16.23	Water soluble phosphorus	0.14%
Clay	56.81	Available potassium	390 ppm
Organic matter	1.45	pH	8.20

1. Solid planting system of roselle, since it was practiced on one side of the row, one plant/hill, at 50 cm distance apart. Such treatment was used as control for roselle characters.
2. Solid planting system of guar; since it was applied on one side of the row, two plants/hill, at 30 cm distance apart. Such treatment was used as control for guar characters.
3. Intercropping system of 1:2; since planting one row of roselle alternated with two rows of guar (1 row of roselle: 2 rows of guar). Such system provides the proportional area of 33.3: 66.7 to each of roselle and guar, respectively.
4. Intercropping system of 1:3; since planting one row of roselle alternated with three rows of guar (1 row of roselle: 3 rows of guar). Such system provides the proportional area of 25:75 to each of roselle and guar, respectively.
5. Intercropping system of 2:4; since planting two rows of roselle alternated with four rows of guar (2 rows of roselle: rows of guar). Such system provides the proportional area of 33.3:66.7 to each of roselle and guar, respectively.

All the plants received normal agricultural practices whenever they needed. All plants were fertilized with phosphorus and potassium fertilizers at the rate of 200 kg/fad. of calcium super phosphate (15.5% P_2O_5) and 50 kg/fad. of potassium sulphate (50% K_2O), respectively. Phosphorus and potassium fertilizers were added during soil preparation as a soil application. While, nitrogen fertilizer was divided into three equal portions and added to the soil at 30, 60 and 90 days after sowing.

Recorded Data

The outer two rows (1^{st} and 12^{th}) of each plot were considered as a belt. Samples were taken from guarded plants in center of each plot.

Pods of guar were harvested after 165 days of seed sowing and the seed yield/fad. (kg) of guar was calculated. After 188 days from sowing of roselle seeds the yield of sepals was harvested and the air dry sepals yield/fad. (kg) was calculated.

Competitive relationships were calculated as follows:

1. Land equivalent ratio (LER):

This gives an indication to the relative land area under sole crops that is required to produce the same yields achieved by intercropping. It was determined for roselle sepals and guar seeds yields recorded per faddan according to Mead and Willey (1980) equation as follows:

$$LER = Lr + Lg$$

Where:

$$Lr\,(\text{relative yield of roselle}) = \frac{\text{Intercrop yield of roselle sepals}}{\text{Sole yield of roselle sepals}}$$

$$Lg\,(\text{relative yield of guar}) = \frac{\text{Intercrop yield of guar seeds}}{\text{Sole yield of guar seeds}}$$

2. Area-Time Equivalent Ratio (ATER):

It was calculated according to Hiebsch and McCollum (1987) equation as follows:

$$ATER = \frac{Yrg / Yrr \times tr + Ygr / Ygg \times tg}{T}$$

Where: Yrg = Intercrop yield of roselle, Yrr = Sole yield of roselle, Ygr = Intercrop yield of guar, Ygg = Sole yield of guar, tr = The duration of roselle in days, tg = The duration of guar in days and T = The total duration of intercropping system in days.

3. Land Utilization Efficiency (LUE):

By using LER and ATER values, the land use efficiency (LUE) was calculated according to Mason *et al.* (1986) as follows:

$$LUE\ \% = \frac{LER + ATER}{2} \times 100$$

4. Aggressivity (A):

Aggressivity value was calculated according to Mc Gilchrist (1965) equation as follows:

1. For combination of 50:50 and 100:100, they were calculated according to the following equations:

$$Ar = \frac{\text{Mixture yield of roselle}}{\text{Sole yield of roselle}} - \frac{\text{Mixture yield of guar}}{\text{Sole yield of guar}}$$

$$Ag = \frac{\text{Mixture yield of guar}}{\text{Sole yield of guar}} - \frac{\text{Mixture yield of roselle}}{\text{Sole yield of roselle}}$$

2. For the other combination ratios, the used equations were:

$$Arg = \frac{Yrg}{Yrr \times Zrg} - \frac{Ygr}{Ygg \times Zgr}$$

$$Agr = \frac{Ygr}{Ygg \times Zgr} - \frac{Yrg}{Yrr \times Zrg}$$

Where:

Yrg = Intercrop yield of roselle
Ygr = Intercrop yield of guar
Yrr = Sole yield of roselle
Ygg = Sole yield of guar
Zrg = Sowing proportion of roselle
Zgr = Sowing proportion of guar

5. The monetary advantage index (MAI) which gives an indication of the economic advantage of the intercropping system was calculated according to Ghosh (2004) as follows: MAI = (monetary value of combined intercrops) (LER – 1) / LER.

Statistical Layout of Experiment

The statistical layout of this experiment was two-factor factorial experiment in completely randomized block design. Since the first factor was intercropping system which contained five treatments, while the second factor was nitrogen fertilization rate included four treatments. Each treatment included three replicates. Each replicate contained twelve rows. The recoded data were statistically analyzed, and the means were compared using Duncan multiple range test according to Little and Hills (1978).

RESULTS

1. Land Equivalent Ratio (LER):

Total land productivity in terms of LER of relative dry sepals yield of roselle per faddan and relative seeds yield of guar per faddan as influenced by intercropping system, nitrogen fertilization and their interactions treatments are recorded in Table 2. It can be observed that the means of all intercropping treatments were greater than one (LER > 1). This confirms the advantage of these types of intercropping to get more production from the same area of land as compared with the same unit of area in which monocropping is applied. Intercropping of roselle and guar at 1:2 and 1:3 were more productive than growing them separately or cropping them in 2:4 system since LER values were 1.18, 1.22, 1.00 and 1.09 during first season and 1.12, 1.17, 1.00 and 1.01 during second season, respectively. There was no significant difference between 1:2 and 1:3 cropping systems. These LER values indicated that 18 to 22% and 12 to 17% more land would require to plant the sole crops to produce the same quantities of intercrop yield of roselle and guar produced by using 1:2 and 1:3 during both seasons, respectively. In most cases there was no significant difference between different nitrogen fertilization rates. This means that increasing nitrogen fertilization rate had no effect on LER value. Generally, there was no significant difference could be detected among interaction treatments between intercropping and nitrogen fertilization rate. All interaction treatments were more productive than sole crop except the treatment of 2:4 system without nitrogen fertilization which produced less than one (0.96 and 0.98 during both seasons, respectively).

2. Area-Time Equivalent Ratio (ATER)

Since land equivalent ratio does not take into account the time for which land is occupied by the component crops of an intercropping system, ATER was also determined. The ATER provides more realistic comparison of the yield advantage of intercropping over that of sole cropping than LER as it considers variation in time taken by the component crops of different intercropping systems.

Yield advantage in terms of ATER followed the trend similar recorded to LER (Table 3). All ATER values for intercropping systems were greater than unity except with 2:4 system during the second season, thus demonstrating yield advantages for the

Table (2). Effect of intercropping system, nitrogen rate (Kg/fad.) and their interactions on land equivalent ratio (LER) during the two seasons of 2009 and 2010

Intercropping system	Nitrogen rate (Kg/fad.)				Mean
	0.0	18	36	72	
			First season		
Roselle + guar (1: 2)	1.16 a	1.17 a	1.20 a	1.19 a	1.18 A
Roselle + guar (1: 3)	1.19 a	1.22 a	1.21 a	1.26 a	1.22 A
Roselle + guar (2: 4)	0.96 b	1.13 a	1.19 a	1.10 ab	1.09 B
Mean	1.10 B	1.17 AB	1.20 A	1.18 AB	
			Second season		
Roselle + guar (1: 2)	1.14 ab	1.14 ab	1.10 bc	1.10 bc	1.12 A
Roselle + guar (1: 3)	1.16 ab	1.13 ab	1.16 ab	1.22 a	1.17 A
Roselle + guar (2: 4)	0.98 c	1.03 bc	1.04 bc	1.00 c	1.01 B
Mean	1.09 A	1.10 A	1.10 A	1.11 A	

* Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability

Table (3). Effect of intercropping system, nitrogen rate (Kg/fad.) and their interactions on area time equivalent ratio (ATER) during the two seasons of 2009 and 2010

Intercropping system	Nitrogen rate (Kg/fad.)				Mean
	0.0	18	36	72	
			First season		
Roselle + guar (1: 2)	1.09 a	1.10 a	1.13 a	1.11 a	1.11 A
Roselle + guar (1: 3)	1.11 a	1.13 a	1.13 a	1.16 a	1.13 A
Roselle + guar (2: 4)	0.89 b	1.06 a	1.13 a	1.03 a	1.03 B
Mean	1.03 B	1.10 AB	1.13 A	1.10 AB	
			Second season		
Roselle + guar (1: 2)	1.07 ab	1.06 abc	1.02 abcd	1.03 abcd	1.04 A
Roselle + guar (1: 3)	1.08 ab	1.04 abcd	1.07 ab	1.13 a	1.08 A
Roselle + guar (2: 4)	0.92 d	0.96 bcd	0.97 bcd	0.93 cd	0.94 B
Mean	1.02 A	1.02 A	1.02 A	1.03 A	

* Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability

intercropped systems compared to monocrop system (Table 3). The highest ATER values were significantly recorded with 1:3 and 1:2 systems without significant difference between both of them during both seasons. On the other side, the lowest ATER value was produced with 2:4 system.Again, in most cases there was no significant difference between different nitrogen fertilization rates which means that nitrogen fertilization rate had no effect on ATER value. Concerning the interaction treatments, all combinations between intercropping system and nitrogen fertilization rate produced higher ATER values (more than one unit) compared with monocrop system except when 2:4 system did not fertilized with nitrogen in the first season or fertilized with any nitrogen rate during second season. In all the treatments, ATER values were smaller than LER values (Table 3), indicating the over estimation of resource utilization in the latter. Thus contrary to LER, ATER is free from problems of over estimation of resource utilization.

3. Land Utilization Efficiency (LUE)

Main effect of intercropping system on LUE demonstrate that there was no significant difference between Roselle + guar (1: 2) and (1: 3) systems, while 2: 4 system produced lower significant value of LUE compared with the above mentioned systems (Table 4). Also, main effect of nitrogen fertilization rate revealed that all nitrogen rates gave LUE values more than 100% without significant differences between different rates during both seasons in most cases.

As shown in Table 4, all interactions between intercropping systems and fertilization rates gave LUE values more than 100% during first season except when the intercropping system of Roselle + guar (2: 4) was applied without nitrogen fertilization. During the second season LUE values did not excess 100% when nitrogen fertilization rates were combined with Roselle + guar (2: 4) intercropping system, while other combination treatments values surpassed 100%.

Table (4). Effect of intercropping system, nitrogen rate (Kg/fad.) and their interactions on land utilization efficiency (LUE %) during the two seasons of 2009 and 2010

Intercropping system	Nitrogen rate (Kg/fad.)				Mean
	0.0	18	36	72	
First season					
Roselle + guar (1: 2)	113 a	113 a	117 a	115 a	115 A
Roselle + guar (1: 3)	116 a	118 a	117 a	122 a	118 A
Roselle + guar (2: 4)	93 b	110 a	116 a	107 ab	106 B
Mean	107 B	113 AB	117 A	114 AB	
Second season					
Roselle + guar (1: 2)	111 ab	110 ab	106 abcd	107 abcd	108 A
Roselle + guar (1: 3)	112 ab	109 abc	112 ab	118 a	113 A
Roselle + guar (2: 4)	95 d	100 bcd	100 bcd	97 cd	98 B
Mean	106 A	106 A	106 A	107 A	

* Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability

4. Aggressivity

Aggressivity measures the interspecies competition in intercropping by relating the yield changes of the two component crops (McGilchrist, 1965). This index compares the yields between intercropping and monoculture, as well as their respective land occupancy (Li *et al*., 2001; Williams and McCarthy, 2001; Zhang and Li, 2003; Wahla *et al*., 2009).

It is known that an aggressivity value of zero indicates that the component crops are equally competitive. For any other situation, two crops will have the same numerical value by positive for the dominant crop and negative for the dominated one. The greater the numerical value, the larger the difference in competitive abilities.

It is evident from data in Tables (5 and 6) that the competitive ability of the component crops in an intercropping system is determined by its aggressivity value. Regardless of the planting patterns, there was a positive sign for roselle and a negative sign for the intercropped guar, indicating that roselle was dominant while guar was dominated. Results showed the highest positive aggressivity for roselle at 1:3 system, while it proved less competitive at 1:2 planting pattern during both seasons.

5. Monetary Advantage Index (MAI)

Analysis of variance of MAI shows that all applied intercropping systems had positive values which mean that these systems had more economic advantage compared with sole cropping (Table 7). The highest averages of MAI (3734.8 - 3123.7 and 2454.7 -2044.2 LE) were obtained in the 3:1 and 1:2 intercropping systems during both seasons, respectively, which implied that these planting patterns were highly economical and advantageous for the mixtures. It is worth to mention that, there was no significant difference between both systems, while 1:3 system had the highest MAI value (3734.8 and 2454.7 LE) during both seasons, respectively.

Table (5). Effect of intercropping system, nitrogen rate (Kg/fad.) and their interactions on aggrisssivity value (A) of roselle (Arg) during the two seasons of 2009 and 2010

Intercropping system	Nitrogen rate (Kg/fad.)				Mean
	0.0	18	36	72	
First season					
Roselle + guar (1: 2)	0.94	0.89	1.09	0.64	0.89
Roselle + guar (1: 3)	0.97	1.32	1.20	0.89	1.09
Roselle + guar (2: 4)	0.48	0.95	1.59	0.84	0.96
Mean	0.80	1.05	1.29	0.79	
Second season					
Roselle + guar (1: 2)	0.86	0.46	0.32	0.53	0.54
Roselle + guar (1: 3)	0.80	0.67	0.59	0.88	0.73
Roselle + guar (2: 4)	0.87	0.56	0.50	0.60	0.63
Mean	0.84	0.56	0.47	0.67	

Table (6). Effect of intercropping system, nitrogen rate (Kg/fad.) and their interactions on aggressivity value (A) of guar (Agr) during the two seasons of 2009 and 2010

Intercropping system	Nitrogen rate (Kg/fad.)				Mean
	0.0	18	36	72	
	First season				
Roselle + guar (1: 2)	- 0.94	- 0.89	- 1.09	- 0.64	- 0.89
Roselle + guar (1: 3)	- 0.97	- 1.32	- 1.20	- 0.89	- 1.09
Roselle + guar (2: 4)	- 0.48	- 0.95	- 1.59	- 0.84	- 0.96
Mean	- 0.80	- 1.05	- 1.29	- 0.79	
	Second season				
Roselle + guar (1: 2)	- 0.86	- 0.46	- 0.32	- 0.53	- 0.54
Roselle + guar (1: 3)	- 0.80	- 0.67	- 0.59	- 0.88	- 0.73
Roselle + guar (2: 4)	- 0.87	- 0.56	- 0.50	- 0.60	- 0.63
Mean	- 0.84	- 0.56	- 0.47	- 0.67	

Table (7). Monetary advantage index (MAI) as affected by intercropping system, nitrogen rate (Kg/fad.) and their interactions

Intercropping system	Nitrogen rate (Kg/fad.)				Mean
	0.0	18	36	72	
	First season				
Roselle + guar (1: 2)	2353.3 b	2700.5 b	3536.2 b	3904.6 b	3123.7 A
Roselle + guar (1: 3)	2821.5 b	3401.5 b	3522.7 b	5193.6 a	3734.8 A
Roselle + guar (2: 4)	1218.2- c	2108.6 b	3209.7 b	2039.8 b	1535.0 B
Mean	1318.9 B	2736.9 AB	3422.9 A	3712.7 A	
	Second season				
Roselle + guar (1: 2)	2063.5 ab	2217.4 ab	1806.7 bc	2089.2 ab	2044.2 A
Roselle + guar (1: 3)	1883.7 b	1724.0 bc	2293.4 ab	3917.7 a	2454.7 A
Roselle + guar (2: 4)	459.8- d	508.5 bcd	664.5 bcd	99.5- cd	153.4 B
Mean	1162.5 A	1483.3 A	1588.2 A	1969.1 A	

* Means having the same letter (s) within the same column are not significantly different according to Duncan's multiple range test at 5% level of probability

Although there was no significant difference in MAI values between different nitrogen rates, there was remarkable gradual increase in MAI values with increasing in nitrogen fertilization rate during both seasons.

Among different interaction treatments between intercropping systems and nitrogen fertilization rates, 1:3 system fertilized with the highest nitrogen rate (72 kg nitrogen/fad.) proved to be the most profitable treatment especially during the first season since it was significantly higher than all other treatments.

DISCUSSION

The above mentioned results clearly signifying the superiority of intercropping over monocropping of either of the two crops; i.e., roselle or guar since all intercropping systems produced LER and ATER values more than unit in most cases. Also, LUE values were more than 100% with all applied intercropping systems except with Roselle + guar (2: 4) system during the second season. Intercropping of roselle and guar at 1:2 and 1:3 systems were more promising than sole crop or 2: 4 system since the total yield of both crops increased by 18 - 22 and 11 – 13 % compared with sole crop during both seasons, respectively. The enhancing effect of intercropping on land use efficiency indices was previously reported by Rajeswara Rao (2002), John and Mini (2005), Marer *et al.* (2007) and Rahman *et al.* (2009). This advantage is probably due to different above- and below-ground growth habits and morphological characteristics of intercrop components causing a greater efficiency in the utilization of plant growth resources, i.e. water, nutrients and radiation energy (Willey, 1979; Ofori and Stern, 1987 and Fukai and Trenbath, 1993).

Analysis of variance demonstrates that nitrogen fertilization rate had no significant effect on LER, ATER and LUE values. However, all nitrogen fertilization rates surpassed the unit. A similar result was reported by Ghaley *et al.* (2005), Dariush *et al.* (2006) and Li *et al.* (2009).

The maximum values of LER, ATER and LUE were recorded when roselle and guar were intercropped in 1:3 system and fertilized with the highest nitrogen rate (72 kg nitrogen/fad.) which considered the best system to be followed.

The above mentioned data showed that the component crops did not exhibit equal competitive intensity based on aggressivity (Tables 5 and 6). The aggressivity index of roselle relative to guar was positive which indicating that roselle was the dominant species and had much greater competitiveness in the intercropping system of roselle with guar. In general, earlier studies demonstrated that nonlegume crop is considered a suppressing crop in annual legume/nonlegume intercrop system (Haynes, 1980 and Wahla *et al.*, 2009), for examples soybean/wheat (Li *et al.*, 2001), peanut/maize (Inal *et al.*, 2007), and faba bean/barley (Strydhorst *et al.*, 2008). This reveals that roselle intercropped with guar utilized the resources more aggressively, and its production was the major factor that determined the overall yields.

Monetary advantage index is indicator of the economic feasibility of intercropping systems and show the most advantageous intercrops (Banik *et al.*, 2000). Our results indicate that MAI followed the trend similar to LER. In this study, the MAI values were the greatest in 1:2 and 1:3 systems, which indicates that these intercropping systems had the highest economic advantage, probably due to better utilization of growth resources. Dhima *et al* (2007) reported that if LER value was higher, then there was an economic benefit expressed with MAI values such as that obtained in the present study. Krantz *et al* (1976) also reported higher monetary returns from systems involving intercropping of legumes and non-legumes compared to sole non-legume cropping which was attributed to better utilization of resources. All MAI values were positive except the treatment of Roselle + guar (2: 4) without nitrogen fertilization during both seasons and 2:4 system fertilized with the highest nitrogen fertilization during the second season. Positive MAI values indicate that these treatments have more economic advantages compared with sole crop which has zero value.

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تأثير معدل التسميد النتروجيني ونظام التحميل للكركدية والجوار على بعض المقاييس التنافسية و الإقتصادية

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الملخص العربي

أجريت هذه الدراسة بهدف تقييم نظم تحميل مختلفة بين الكركدية والجوار (1:2و 1:3 و 2:4) علاوة على الزراعة المنفردة لكل من المحصولين علي حده ، وكذلك معدلات مختلفة من التسميد النتروجيني (صفر، 18 ، 36 أو 72 كجم نتروجين/فدان) والتداخلات بينهما. و قد تم التقييم للمعاملات السابقة على أساس عدة مقاييس تنافسية و إقتصادية هي نسبة المكافئ الأرضي و نسبة المكافئ الأرضي لوحدة الزمن و العدوانية و كفاءة إستخدام الأرض و دليل العائد النقدي. و قد أشارت المقاييس التنافسية إلى أن جميع نظم التحميل المستخدمة كانت أكثر فاعلية من الزراعة المنفردة كما لم يكن لمعدل التسميد النتروجيني تأثيراً معنوياً على تلك المقاييس فى معظم الحالات. كذلك أشار تقدير العدوانية إلى أن نبات الكركدية كان هو المحصول السائد بينما كان الجوار هو المسود. و قد تحققت أعلى القيم للمقاييس التنافسية و الاقتصادية السابق الإشارة إليها عند إستخدام نظام التحميل صف من الكركدية بالتبادل مع ثلاثة صفوف من الجوار مع التسميد النتروجيني بمعدل 72 كجم نتروجين/فدان. و من الواضح أن هذه المعاملة بدت واعدة للحصول على عائد إقتصادي مرتفع.