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EFFECT OF PHOSPHORUS, NITROGEN FERTILIZATION AND IRRIGATION INTERVALS ON GUAR CROP UNDER CALCAREOUS SOIL

Modaihsh, A.S.; A.A. Taha and M.O.Mahjoub
Soil Sci. Dept., College of Food and Agric. Sci., King Saud Univ., Saudi Arabia

ABSTRACT

A field experiment was carried out in a calcareous soil at Dirab Experiments and Researches Station, Fac. of Food and Agric. Sci., King Saud University during 2005-2006 season. This research aims to study the effect of phosphorus, nitrogen fertilizers and irrigation intervals on forage yield and yield components of guar plant. The experiment includes three levels of nitrogen fertilizer (0, 40 and 80 Kg N/ha), four levels of phosphorus fertilizer (0, 40, 80 and 120 Kg P_2O_5/ha) and two irrigation intervals (5 and 10 days).

The results showed that irrigation interval periods had significant effect on green forage yield (GFY), dry forage yield (DFY), protein percentage (CP %) and nitrogen content in guar plant, while the effect was no significant on dry matter percentage (DM%), crude protein yield (CPY), phosphorus and potassium contents in guar plant.

Application of nitrogen fertilizer had significant effect on green forage yield, dry forage yield and crude protein yield. There were no significant effects on dry matter percentage, protein percentage, nitrogen, phosphorus and potassium contents in guar plant. The same trend was obtained when phosphorus treatments were applied.

The best treatment in this study was irrigation intervals every 5 days with applying 80 Kg N/ha and 40 Kg P_2O_5/ha.

Keywords: Guar, forage yield, calcareous soil, irrigation intervals, P and N fertilization.

INTRODUCTION

Guar or Clusterbean (Cyamopsis tetragonoloba, L. Taub) is a leguminous herb, characterized as a warm weather, drought tolerant, deep rooted, summer annual legume adapted to semiarid climates (Ahmed et al., 1958 and Whistler and Hymowitz, 1979). It is generally grown for feed, fodder and provides edible pods which are used as a vegetable.

Guar is considered a promising leguminous forage crop especially in the new soils due to its tolerance of drought, salinity and its wide adaptability in a variety of soils (Ghanem, 1990). It is a new crop to Saudi Arabia, which needs more researches to investigate the best environmental factors for optimum growth and productivity under stress environments.

Guar is grazed in many regions of the world, usually after frost (to reduce bloat problems) and makes good forage. It is a drought tolerant, performing well in areas having 400-900 mm of rainfall. Yields may double with irrigation. Guar grows well in a variety of soils and thrives in alluvial and sandy loam with well drained subsoil (NAS, 1979).

Despite initial success in guar production, problems with declining productivity have arisen in recent years because of the reduction in soil fertility. Therefore, fertilizers are extremely dependent on many factors

including; availability of nutrients and its distribution, leaching or runoff by water irrigation, soil temperature and atmosphere.

Guar, like other legumes, has the ability to supply their own nitrogen needs, if they have been inoculated and the soil contains many fertilizer elements. However, if seeds are uninoculated, it is necessary to supply nitrogen fertilizer as a small amount of a starter for legume plants cultivated in low soil nutrients. Barber (1978) and Wilcox (1987) reported that legume crops need nitrogen to stimulate the growth of leaves and stems and the vegetative parts of the plants. Ali (1990) mentioned that application of 25 and 50 N Kg/ha to guar plants caused a significant increase respecting plant height, number of branches/plant, green forage yield/ha and both straw and seed yield/ha.

Ghanem (1990) mentioned that adding N level at 30 Kg N/fed detected significant increases in both straw and green forage yields. Also, Baboo and Rana (1995) reported that application of 20 Kg N/ha resulted in a significantly higher yield of seeds and stover as well as nitrogen uptake by guar plant.

The positive response of guar plants to phosphorus fertilizer was reported by Gabr (1988) and Ghanem (1990) who stated the dose of 75 Kg P_2O_5/ha and detected a significant increase in green forage yield/ha and seed yield/ha. Tag El-Din and Osman (1994) found that application of phosphorus and nitrogen had highly significant effect on green and dry forage yields of guar. Baboo and Rana (1995) stated that phosphorus fertilizer application significantly increased nitrogen uptake and protein contents of guar plant. Also, Bhadoria et al.(1997) found that phosphorus fertilizer showed a significant influence on protein content of guar plant.

El-Dash (2005) reported that there was a highly significant effect for nitrogen and phosphorus fertilizers on the yield of guar as well as N, P and K contents in guar plant.

The proper irrigation level during the growing season of plants can reduce the threat of leaching losses (Vitoch, 1985). Tag El-Din and Assaeed (1995) showed that little decrease but significant in fresh, dry yield and protein content of alfalfa was associated with increasing irrigation intervals. The same finding was performed by El-Gnawers (1996). Also, Al-Shaikh (2004) stated that irrigation interval periods had highly significant effect on dry matter percentage, protein percentage as well as green forage and protein yields.

The current investigation was designed to elucidate the effect of phosphorus, nitrogen fertilizers and irrigation intervals expanding on forage yield and yield components of guar crop.

MATERIALS AND METHODS

A field experiment was carried in a calcareous soil low in available phosphorus at Dirab Researches and Experiments Station, Fac. of Food and Agric. Sci., King Saud University, Saudi Arabia to study the effect of phosphorus, nitrogen fertilizers and irrigation intervals on the forage yield and yield components of guar crop. The physical and chemical properties of the

experimental soil are shown in Table 1. Soil properties were determined according to the method of Jackson (1967).

Table 1: Some physical and chemical properties of the soil

Soil property	Values
Sand,%	68.79
Silt,%	18.67
Clay,%	12.54
Soil texture	sandy Loam
$CaCO_3$,%	29.80
Organic matter,%	0.17
pH (soil paste)	7.96
EC_e, dSm^{-1}	1.85
Available N, ppm	34.07
Available P, ppm	3.37
Available K, ppm	75.80
Available Fe, ppm	3.20
Available Mn, ppm	1.11
Available Zn, ppm	0.86
Available Cu, ppm	0.59

The experiment includes 24 treatments, which were the combination of three nitrogen fertilizer application treatments (0, 40 and 80 Kg N/ha as urea, 46% N), four phosphorus fertilizer application treatments (0, 40, 80 and 120 Kg P_2O_5 as triple super phosphate, 46% P_2O_5) and two irrigation interval periods treatments (5 and 10 days). Seeds of guar were sown on 17 April 2006 season. The experimental design was split-split-plot design with three replicates where irrigation intervals treatments occupied the main plots, nitrogen fertilizer treatments in the sub-plots and phosphorus fertilizer treatments in the sub-sub plots. The experiment was irrigated with surface irrigation method by well water. The chemical characteristics of the irrigation water used are presented in Table 2.

Table 2: Chemical analysis of the irrigation water

pH	EC	Cations m.e./L				Anions m.e./L				ppm	
	dS/m	Ca^{++}	Mg^{++}	Na^{+}	K^{+}	CO_3--	HCO_3	Cl^{-}	SO_4	NO_3	B
7.8	5.3	20.5	16.3	27.0	0.7	---	6.0	24.3	27.0	46.3	2.9

Phosphorus fertilizer treatments were applied a week before sowing, while the irrigation interval treatments and nitrogen fertilizer treatments were applied after stand establishment (3 weeks after sowing).

When about 75% of guar stands were flowered (after about three months from sowing), the plots of the experiment were harvested with a mower at a height of approximately 7 cm from the soil surface. The green forage yield from each plot was weighed to determine the green forage yield/ha (GFY). Fresh forage samples weighing about 300g were oven dried at 70°C and weighed to determine dry matter percentage (DM%), dry forage yield/ha (DFY) and for chemical analysis. Dry samples were ground and wet

digested. The nutrients content of N, P and K in Guar plant was determined according to the method of Chapman and Pratt (1961). Crude protein percentage (CP %) was estimated by multiplying N% X 6.25. Crude protein yield/ha (CPY) was estimated from DM% and CP%.

The data were analyzed by using Statistical Analysis System-Analysis of Variance (SAS-ANOVA) (Statistical Analysis System Institute, 1989) with least significant difference (LSD) for the mean separation (snedecor and Cochran, 1967). Also, Duncan's new multiple test was applied (Duncan, 1955).

RESULTS AND DISCUSSION

Green Forage Yield (GFY):

Effect of irrigation intervals and application of nitrogen and phosphorus fertilization on green forage yield (GFY) are listed in Table 3. Irrigation intervals had significant effect on green forage yield. GFY were 37.07 and 21.65 ton/ha for the 5 and 10 days irrigation interval treatments, respectively.

Table 3: Effect of treatments on some parameters of guar

Treatments	GFY (ton/ha)	DM (%)	DFY (ton/ha)	% Protein	CPY (ton/ha)
Irrigation intervals (A)					
5 day	37.07 a	19.23 a	7.22 a	22.39 b	1.62 a
10 day	21.65 b	20.21 a	4.36 b	33.98 a	1.48 a
N level (kg/ha) (B)					
0	26.26 c	19.96 a	5.20 b	27.88 a	1.45 b
40	30.28 b	19.27 a	5.81 b	28.13 a	1.63 ab
80	31.53 a	19.94 a	6.37 a	28.53 a	1.82 a
P Level (Kg/ha) (C)					
0	27.37 b	19.80 a	5.36 b	27.17 a	1.46 b
40	30.99 a	19.96 a	6.31 a	27.25 a	1.72 a
80	29.24 a	19.53 a	5.70 ab	27.45 a	1.56 b
120	29.83 a	19.61 a	5.79 ab	28.05 a	1.62 b

Application of nitrogen fertilizer, significantly increased GFY and this increasing from 26.26 to 30.28 and 31.53 ton/ha when nitrogen fertilizer applied from 0 to 40 and 80 Kg N/ha, respectively. Also, application of phosphorus fertilizer increased significantly GFY. Data in Table 3 clear that phosphorus fertilizer treatment of 40 Kg P_2O_5/ha gave a significant increase in GFY compared to 80 and 120 Kg P_2O_5/ha treatments. At the same time, no significant difference could be seen between the treatments of 40, 80 and 120 Kg P_2O_5/ha.

Dry Matter Percentage (DM %):

Data presented in Table 3 indicate that there was a slight increase in the DM% due to increasing irrigation intervals up to irrigation every 10 days but the differences between the two irrigation periods (5 and 10 days) were insignificant. The obtained results are in agreement with those recorded by Bosila (1982).

As shown in Table 3, fertilizers application either nitrogen or phosphorus had no significant effect on DM%.

Dry Forage Yield (DFY):

Data in Table 3 indicate that irrigation intervals treatment had a significant effect on DFY. DFY combined averages were 7.22 and 4.36 ton/ha when irrigated at 5 and 10 days intervals, respectively.

Application of nitrogen fertilizer, significantly increased DFY with increasing nitrogen rates. The significant increase was obtained by applying the rate of 80 Kg N/ha. DFY's were 5.20, 5.81 and 6.37 ton/ha when 0, 40 and 80 Kg N/ha fertilizer were applied.

Phosphorus fertilizer application with 40 Kg P_2O_5/ha increased, significantly DFY. At the same time, no significant differences were detected between 80 and 120 Kg P_2O_5/ha. Furthermore, the highest phosphorus treatment (120 Kg P_2O_5/ha) resulted in a nonsignificant increments respecting all parameters under study as compared with the lowest treatment (40 Kg P_2O_5/ha) and un-fertilized control. These results are clear in the combined data as observed in the Table 3.

Tag El-Din and Osman (1994) found that application of nitrogen and phosphorus fertilizers had significant effect on dry forage yields of guar. Also, the results of this study are in agreement with those obtained by Tag El-Din and Assaeed (1995) who reported that increasing P application increased, significantly fresh and dry yield of alfalfa.

The results recorded herein indicate that in the extremely poor soil of low nitrogen, phosphorus and low organic matter like used in this investigation, 80 Kg N/ha should be used as a starter dose at the first period of the growth to increase the amount of metabolites synthesized by guar plants and in this turn might account much for the superiority of green forage as well as their attributive characters. Singh and Sharma (1982) and Ghanem (1990) recorded similar results.

The better growth and yield observed in phosphorus applied treatments was possibly due to the role of phosphorus which plays in cell division in growing root and shoot tips. Better root growth might have helped to absorb more nutrients from the deeper layer of the soil and ultimately resulted in better growth of the plant. Moreover, phosphorus is also involved in basic plant processes which increase growth and dry matter (Tag El-Din and Osman, 1994 and Nassar, 1999).

Crude Protein Percentage (CP %):

It is clear from the data listed in Table 3 that there was a significant increase in crude protein percentage (CP %). Expanding irrigation intervals from 5 to 10 days increased, significantly protein% from 22.39 to 33.98%. The increase of protein% may be due to compact drought, as increasing of protein%, increased osmotic pressure by which the plant could absorb more water from the soil, beside that the increase in CP% is due to the increasing in N% in guar plant with increasing irrigation intervals from 5 to 10 days.

Nitrogen and phosphorus fertilizers application had no significant effect on CP% (Table, 3). Application of 40 and 80 Kg N/ha increased CP% from 27.88 to 28.13 and 28.53%, respectively. Also, application of 120 Kg

P_2O_5/ha increased, insignificantly, CP% to 28.05%. These results are in good agreement with those reported by Al-Shaikh (2004).

Crude Protein Yield (CPY):

Crude protein yield (CPY) of guar plant represents the total protein of leaves and shoots which animals could be utilized per hectare.

Data in Table 3 show that crude protein yield decreased insignificantly with expanding the irrigation period intervals from 5 to 10 days. CPY's were 1.62 and 1.48 ton/ha when irrigated at 5 and 10 days intervals, respectively. These results are in harmony with those of Al-Shaikh (2004).

Application of nitrogen and phosphorus fertilizer treatments, significantly, increased CPY (with some exceptions). CPY's were 1.45, 1.63 and 1.82 ton/ha when 0, 40 and 80 Kg N/ha were applied, respectively. Application of 40 Kg P_2O_5/ha treatment gave the highest value of CPY compared with the other phosphorus treatments. These findings are in good agreement with those reported by Tag El-Din and Assaeed (1995) who found that increasing phosphorus application increased, significantly, CPY of alfalfa.

The significant effect of irrigation period intervals, nitrogen and phosphorus fertilizers application treatments (Interaction effect) on the productivity parameters (green and dry forage yield and dry matter %), protein percentage and its content in guar plant are presented in Table 4.

The interaction between irrigation intervals, N and P fertilizers rates was significant respecting only green forage yield (ton/ha), while its effect was not significant on DM%, DFY, CP% as well as CPY. The results of the Table 4 indicate that expanding irrigation intervals from 5 to 10 days decreased significantly green forage yield. Also, the data showed that guar plants which fertilized with 80 Kg N/ha and 40 Kg P_2O_5/ha rates gave a positive response regarding DM%, DFY, CP% as well as CPY in compared to control treatment.

From the aforementioned data, it is revealed that, in a low fertility soil (especially low in available P) like used herein, phosphorus fertilization was necessary for maximum response to applied nitrogen. Also, applying of N and P fertilizers encouraged meristematic cells division and enlargement of guar plant organs and this in turn might account for high accumulation of metabolites which improve green forage yield (GFY) and dry forage yield (DFY). The results are in a good line with those found by Dahiya (1996), Anurag Saxena et al. (2003) and El-Dash (2005).

Table 4: Interaction effect on the studied parameters of guar

Treatments			GFY (ton/ha)	DM (%)	DFY (ton/ha)	% Protein	CPY (ton/ha)
Irrigation periods	Kg N/ha	Kg P_2O_5/ha					
5 DAY	0	0	32.57	19.20	6.25	21.19	1.34
		40	35.32	20.39	8.16	23.88	1.94
		80	43.40	19.01	8.24	23.69	1.95
		120	49.15	20.07	9.87	22.32	2.20
	40	0	33.99	19.06	6.48	22.10	1.42
		40	35.74	19.93	7.13	24.37	1.74
		80	34.32	19.21	6.60	22.63	1.50
		120	32.15	18.74	6.01	21.29	1.28
	80	0	36.68	19.07	6.99	21.42	1.49
		40	34.02	18.06	6.16	21.11	1.54
		80	38.15	20.08	7.67	21.38	1.64
		120	39.31	18.00	7.07	23.27	1.64
10 DAY	0	0	14.82	20.58	3.04	37.52	1.14
		40	26.16	20.34	5.26	33.67	1.77
		80	24.57	20.18	4.96	32.42	1.62
		120	26.24	19.78	5.17	33.58	1.71
	40	0	21.99	20.60	4.52	33.52	1.50
		40	24.65	21.25	5.23	32.94	1.71
		80	11.91	19.91	2.37	31.89	0.75
		120	15.32	21.02	3.22	34.27	1.08
	80	0	24.16	20.31	4.89	36.25	1.75
		40	30.05	19.75	5.93	27.55	1.56
		80	23.07	18.78	4.36	32.71	1.44
		120	16.82	20.07	3.38	41.38	1.40
F test			*	Ns	Ns	Ns	Ns
LSD		5%	4.05	--	--	--	--
		1%	--	--	--	--	--

N, P and K contents in guar plant:

Effect of irrigation intervals and application of nitrogen and phosphorus fertilizers on N, P and K contents in guar plant (g/Kg) are presented in Tables 5 and 6.

Table 5: Effect of treatments on N, P and K content in guar (g/Kg)

Treatments	N	P	K
Irrigation intervals (A)			
5 day	35.82 b	1.96 a	30.13 a
10 day	54.32 a	1.84 a	31.92 a
N level (kg/ha) (B)			
0	45.58 a	1.92 a	31.18 a
40	44.61 a	1.85 a	31.43 a
80	45.01 a	1.93 a	30.45 a
P Level (Kg/ha) (C)			
0	45.87 a	1.88 a	31.83 a
40	43.51 a	1.86 a	31.15 a
80	43.92 a	1.94 a	29.46 a
120	46.97 a	1.92 a	31.64 a

As indicated in Table 5, irrigation intervals had a significant effect on nitrogen content in guar plant. N content were 35.82 and 54.32 g/Kg for the 5 and 10 days irrigation intervals treatments, respectively. At the same time, no significant differences could be seen at P and K contents in guar plant as affected by irrigation intervals.

Data in Table 5 indicated that there is insignificant effect in N, P and K contents in guar plant due to applying N or P fertilizers in compared to the control treatment.

Interaction between all the studied treatments as indicated in Table 6, showed a slight increase in N, P and K contents in guar plant.

However, expanding irrigation intervals from 5 to 10 days increased only, significantly, N content in guar plant. This increase in N content may be due to increasing osmotic pressure by which the plant could absorb more water from the soil (Al-Shaikh, 2004). Also, El-Dash (2005) reported that favorable effect of P on increasing N contents in plants may be attributed to the deficiency of available P in the soil. Beside this, guar is a legume crop and the effect of P is known to activate microbial population responsible for nodulation, but efficient nodulation owing to P application might have enhanced N fixation to be utilized by plants and ultimately increased the protein content

Table 6: Interaction effect on N, P and K content in guar (g/Kg)

Treatments			N	P	K
Irrigation Periods	Kg N/ha	Kg P_2O_5/ha			
5 DAY	0	0	33.90	1.90	28.90
		40	38.20	1.77	30.33
		80	37.90	1.97	30.13
		120	35.70	1.93	30.73
	40	0	35.37	2.00	33.40
		40	39.00	2.03	30.13
		80	36.20	2.07	30.37
		120	34.07	2.00	28.67
	80	0	34.27	1.93	29.33
		40	33.77	1.97	27.87
		80	34.20	2.03	28.77
		120	37.23	1.97	32.87
10 DAY	0	0	60.03	1.87	35.07
		40	53.33	1.87	33.17
		80	51.87	2.10	28.47
		120	53.73	1.93	32.67
	40	0	53.63	1.60	31.37
		40	52.70	1.63	34.27
		80	51.03	1.83	30.77
		120	54.87	1.67	32.47
	80	0	58.00	2.00	32.93
		40	44.05	1.91	31.11
		80	52.33	1.63	28.27
		120	66.20	2.03	32.47
F test			Ns	Ns	Ns
LSD		5%	--	--	--
		1%	--	--	--

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تأثير التسميد الفوسفاتي والنيتروجيني وفترات الري على محصول الجوار تحت ظروف الأراضي الجيرية

عبد الله سعد المديهش ، أحمد عبد القادر طه و محمد عثمان محجوب
قسم علوم التربة- كلية علوم الأغذية والزراعة- جامعة الملك سعود- المملكة العربية السعودية

تم إجراء تجربة حقلية على تربة جيرية في محطة الأبحاث والتجارب بديراب التابعة لكلية علوم الأغذية والزراعة بجامعة الملك سعود وذلك خلال موسم النمو ٢٠٠٥-٢٠٠٦ ويهدف هذا البحث لدراسة تأثير كل من التسميد الفوسفاتي والنيتروجيني وفترات الري على محصول العلف والتركيب الكيماوي لمحصول الجوار.

اشتملت التجربة على ثلاث مستويات من التسميد النيتروجيني (صفر، ٤٠ و٨٠ كجم نيتروجين/هكتار)، أربعة مستويات من التسميد الفوسفاتي (صفر، ٤٠، ٨٠ و١٢٠ كجم P_2O_5 /هكتار) هذا بالإضافة إلى فترتي ري (كل ٥ أيام وكل ١٠ أيام).

أوضحت النتائج أن فترات الري كانت ذات تأثير معنوي على كل من محصول العلف الأخضر والجاف للجوار وكذلك النسبة المئوية للبروتين ومحتوى الجوار من عنصر النيتروجين، بينما كان تأثير فترات الري غير معنوياً على كل من النسبة المئوية للمادة الجافة ومحصول البروتين للجوار وكذلك محتوى الجوار من عنصري الفوسفور والبوتاسيوم.

كما أوضحت النتائج أن إضافة التسميد النيتروجيني كان له تأثير معنوي على كل من محصول العلف الأخضر والجاف ومحصول البروتين الخام للجوار، بينما لم تظهر أي فروق معنوية على تأثير التسميد النيتروجيني على كل من النسبة المئوية للمادة الجافة والنسبة المئوية للبروتين،وأيضاً على محتوى الجوار من عنصري الفوسفور والبوتاسيوم.

وجد أيضاً أن تأثير التسميد الفوسفاتي على الصفات المدروسة للجوار كان له نفس تأثير التسميد النيتروجيني.

كانت أفضل معاملة في هذه الدراسة هي: الري كل ٥ أيام مع إضافة معاملة التسميد النيتروجيني ٨٠ كجم نيتروجين/هكتار ومعاملة التسميد الفوسفاتي ٤٠ كجم P_2O_5 /هكتار.