U. of K. J. Agric. Sci. 18(3), 290-309, 2010

Effect of Nitrogen and Intercropping with Lablab Bean (*Lablab purpureus*) on Growth of Fodder Maize (*Zea mays* L.) Under Two Irrigation Frequencies*

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Abstract: A field experiment was conducted during 2000/01 and 2001/02 winter seasons at the farm of the Faculty of Agriculture, University of Khartoum, to study the effects of nitrogen and intercropping with lablab bean (*Lablab purpureus*) on growth of fodder maize under two irrigation frequencies using a randomized complete block design. Irrigation intervals of 10 and 20 days were applied four weeks after planting. Nitrogen at a rate of 0 and 88 kg N/ha was applied two weeks after sowing. Planting methods were pure stand of maize, alternating rows and alternating holes of maize and lablab bean. Nitrogen application significantly increased, LAI in the second season. It reduced days to 50% tasseling and silking significantly. Intercropping significantly increased plant height and shoot dry weight in the second season, but reduced LAI significantly during both seasons. Days to 50% tasseling and silking were not affected by intercropping. Prolonging irrigation interval to twenty days had no significant effect on most vegetative growth parameters; however, it reduced days to 50% silking significantly. Plant population was, also, not affected by irrigation intervals.

Key words: Maize; lablab; irrigation frequency; nitrogen fertilization; intercropping

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*Part of an M.Sc. (Agric.) thesis by the first author, the University of Khartoum. Sudan

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INTRODUCTION

With the expansion of irrigated agriculture, Sudan will face increasing water shortage in the near future. Increasing demand for water may prompt the need for major changes in irrigation management and scheduling in order to increase the efficiency of crop water use (Kirda 2000). On the other hand, to cope with the increase in animal population and the shortage in forage in natural rangeland, expansion in irrigated forages may become necessary (Elshiekh *et al*. 2006). Maize (*Zea mays* L.) is one of the important forage crops that had the greatest impact on the improvement of animal production worldwide. It is widely used as an irrigated fodder in the subtropics (Suttie 2000) including some parts of northern Sudan. One way to improve its irrigation efficiency is through prolonging irrigation intervals. However, maize is known to be a relatively heavy water user (Ransom *et al*. 2004), and lengthening of the irrigation interval may induce water stress injurious to the crop (Whitty and Chambliss, 1992).

There are conflicting reports about the role of nitrogen under water stress conditions. Application of nitrogen mitigates the effects of water stress by improving plant resistance against stress (Salehpour *et al*. 2009) in addition to meeting the substantial requirements for nitrogen by maize (Wadworth 2003). It may, however, reduce plant resistance to stress by enhancing vegetative growth and transpiration rate. It may, also, delay stomatal closure under water stress. Nitrogen application may, however, be beyond the capability of most resource – poor farmers. Intercropping maize with legumes may provide a more feasible solution to such farmers. In addition, the merits of intercropping grasses with legumes were suggested by many researchers (Hussein 1999; Njunie *et al*. 2004).

In the Sudan, grass/legume intercropping studies included forage sorghum (Abu Sabien) and some tropical grasses (Kabashi 1991; Hussein 1999). However, no data are available concerning the intercropping of fodder maize with legumes, although it is practiced traditionally in northern Sudan. There may, thus, be a need to investigate the performance of fodder maize intercropped with legumes.

The objectives of this study were to investigate the effects of nitrogen application and intercropping with lablab bean on the growth of fodder maize under two irrigation frequencies.

MATRIALS AND METHODS

A field experiment was conducted at the demonstration farm of the Faculty of Agriculture (Shambat), University of Khartoum (Latitude 15^o 40$^-$ N, longitude 32^o 32$^-$ E), during two winter seasons (2000/01 and 2001/02). The climate of the locality is tropical semi-arid with low relative humidity. The soil of the experimental site is heavy clay with low permeability and low nitrogen content (0.05%) and pH of 7.9.

The land was ploughed, leveled and ridged at 70 cm spacing. The experimental design was randomized complete block, arranged in split-split plots, with three replicates. The main plot was 15 x 8 m, the sub-plot 15 x 4 m and the sub-sub-plot 5 x 4 m, with four rows of four metres length. One metre was left between the blocks and main plots as guard area for water control. Maize (cultivar Mugtma 45) and lablab bean (local type) were planted and irrigated every 7-10 days, up to four weeks after sowing, for establishment. Two irrigation treatments were applied: every 10 days (W_1) and every 20 days (W_2).

Nitrogen, in the form of urea (46%N), was applied once, two weeks after planting to sub-plots at two rates: No nitrogen (0N) and 88kg/ ha (2N). The planting method treatments were pure stand of maize and two intercropping methods of alternating rows of maize and lablab bean and alternating holes of maize and lablab bean. Maize was planted at the rate of 7 seeds/hole and 10 cm between holes, whereas lablab bean was planted at the rate of 4 seeds/hole and 30 cm between holes. Planting on the top of ridges was done by "Khulal", a local planting stick. Two months after planting, the plants were sprayed with folimat against stem borer. Weeding was done manually when necessary, in both seasons. In addition, a field survey was carried out to test for the presence and effectiveness of root nodules by cutting them across and checking the presence of leghaemoglobin, which gives the nodules their red colour.

Ten plants from the inner rows of each sub-sub-plot were randomly chosen and labeled to determine plant height and leaf area index, whereas five plants were used to determine shoot dry weight. Data were collected every two weeks, beginning at 42 days from sowing. Plant population density was determined once at harvest. The percentage of tassels and silked plants was calculated after twelve weeks from sowing in the first season, because plants failed to reach days to 50% tasseling and silking until twelve weeks of age. Days to 50% tasseling and silking were recorded for the second season.

Data were analyzed as split-split plot design by the analysis of variance (Gomez and Gomez 1984). Means were separated using the least significant difference (LSD) and Duncan's Multiple Range Test procedures. Data presented in percentage were transformed using Arc sine transformation.

RESULTS

Plant height was insignificantly increased under short irrigation interval in the second season (Table 1) Nitrogen application significantly increased plant height in the second season at 6 and 10 weeks only (Table1). Intercropping of fodder maize with lablab bean significantly increased plant height in the second season in the last two sampling occasions (Table1).

Irrigation frequency significantly affected LAI in the last sampling occasion of the first season (Table 2). Nitrogen application significantly increased LAI only during the second season (Table 2). In both seasons, alternating holes of maize and lablab significantly reduced LAI as compared with pure stand of maize and alternating rows of maize and lablab bean, which were not significantly different from each other (Table 2).

Shoot dry weight was not affected by irrigation interval during both seasons (Table 3). Nitrogen increased shoot dry weight in both seasons with a significant effect in the second seasons at the 6th and 10th weeks sampling (Table3). No significant differences between planting methods in shoot dry weight, except at the 8th week sampling, were detected in the first season; however, a significant increment was recorded for alternating holes in the second season (Table 3).

Irrigation frequency and nitrogen application had no significant effect on plant population density, but planting method significantly reduced it in both seasons, (Table 4).

Neither irrigation interval nor nitrogen application and planting methods affected the percentage of tassels or days to 50% tasseling in the first season. However, nitrogen application significantly reduced days to 50% tasseling in the second season (Table 4). Irrigation frequency had no significant effect on the percentage of silked plants in the first season, while in the second season watering every 10 days led to earlier 50% silking than 20 days irrigation interval (Table 4). Nitrogen application had no significant effect on the percentage of silked plants in the first season and significantly reduced days to 50% silking in the second season (Table 4). Planting methods did not affect the percentage of silked plants in the first season or days to 50% silking in the second season (Table 4).

Table 1. Effects of irrigation interval, nitrogen and plantin methods on plant height (cm) at different weeks from planting for the 2000/01 and 2001/02

Treatment	First season (2000/2001) (weeks)						Second season (2001/2002) (weeks)				
	6	8	10	12	15	Mean	6	8	10	12	Mean
Watering											
W_1	33.5	48.3	59.7	63.1	62.6	53.4	82.9	126.4	166.3	169.4	136.3
W_2	35.5	49.7	61.0	65.8	64.5	55.3	74.7	88.9	129.6	132.2	106.4
SE$\pm$	3.3	1.5	1.5	1.6	2.2		2.5	6.6	7.5	6.9	
$LSD_{0.05}$	NS	NS	NS	NS	NS		NS	NS	NS	NS	
Nitrogen											
0N	33.7	48.6	60.0	64.6	63.2	54.4	69.5	93.1	132.4	134.9	107.5
2N	35.3	49.5	60.6	64.4	64.0	54.8	88.1	122.2	163.5	166.7	135.1
SE$\pm$	3.0	3.2	1.73	1.5	1.5		2.1	7.6	6.8	8.9	
$LSD_{0.05}$	NS	NS	NS	NS	NS		8.2*	NS	26.6*	NS	

Table 1. Cont.

Treatment	First season (2000/2001) (weeks)						Second season (2001/2002) (weeks)				
	6	8	10	12	15	Mean	6	8	10	12	Mean
Planting method											
PS	34.4	50.9	63.4	67.4	67.8	56.8	78.1	102.3	134.5	136.0	112.7
AR	34.0	48.1	58.5	62.3	61.2	52.8	77.5	109.9	151.4	153.8	123.2
AH	35.2	48.0	59.1	63.7	61.7	53.5	80.9	110.8	157.9	162.6	128.1
SE±	2.2	1.9	2.2	2.1	2.0		2.6	4.4	5.4	5.3	
$LSD_{0.05}$	NS	NS	NS	NS	NS		NS	NS	16.3*	16.0*	

W_1 = watering every 10 days, W_2 = watering every 20 days;
ON = no nitrogen, 2N = 88 kg N/ ha;
PS = pure stand of maize, AR = alternating rows of maize and lablab bean; AH= alternating holes of maize and lablab bean
NS = not significant; *significant at 5 % level

Table 2. Effects of irrigation interval, nitrogen and planting methods on leaf area index (LAI) at different weeks from planting for two seasons.

Treatment	First season (2000/2001) (weeks)						Second season(2001/2002) (weeks)				
	6	8	10	12	15	Mean	6	8	10	12	Mean
Watering											
W_1	2.7	5.4	7.9	7.1	4.0	5.4	18.5	21.8	21.3	21.5	20.8
W_2	3.0	6.0	10.3	9.8	5.8	7.0	13.5	18.4	17.0	17.8	16.7
SE±	0.5	0.5	0.5	0.6	0.2		1.5	2.3	1.5	1.7	
$LSD_{0.05}$	NS	NS	NS	NS	1.2*		NS	NS	NS	NS	
Nitrogen											
0N	2.8	5.6	9.5	9.2	5.2	6.5	13.9	16.7	16.1	16.8	15.9
2N	2.9	5.8	8.7	7.8	4.6	6.0	18.1	23.6	22.2	22.5	21.6
SE±	0.5	0.7	0.9	0.9	0.6		0.9	0.7	1.2	0.9	
$LSD_{0.05}$	NS	NS	NS	NS	NS		3.5*	2.7*	4.5*	3.6*	

Table 2. Cont.

Treatment	First season (2000/2001) (weeks)						Second season(2001/2002) (weeks)				
	6	8	10	12	15	Mean	6	8	10	12	Mean
Planting method											
PS	3.3	6.9	12.0	10.5	6.2	7.8	18.1	22.1	20.9	20.9	20.5
AR	3.2	5.9	9.3	8.7	5.2	6.5	19.6	24.3	22.3	23.5	22.4
AH	2.0	4.2	6.1	6.2	3.3	4.4	10.3	14.0	14.2	14.6	13.3
SE±	0.2	0.5	0.9	1.1	0.6		1.2	1.3	1.15	1.5	
$LSD_{0.05}$	0.7*	1.5*	2.8*	3.2*	1.8*		3.5*	4.0*	3.5*	4.4*	

Irrigation treatments: W_1 = watering every 10 days; W_2 = watering every 20 days
Nitrogen fertilization: 0N = no nitrogen; 2N = 88 kg N/ ha
Planting methods: PS = pure stand of maize; AR = alternating rows of maize and lablab bean;
AH= alternating holes of maize and lablab bean
NS = not significant; / * significant at 5 % level

Table 3. Effects of irrigation interval, nitrogen and planting methods on shoot dry weight (gm) at different weeks from planting for two seasons

Treatment	First season(2000/2001) (weeks)						Second season(2001/2002) (weeks)				
	6	8	10	12	15	Mean	6	8	10	12	Mean
Watering											
W_1	3.1	4.3	14.1	11.8	16.5	10.0	19.0	32.8	52.1	50.6	38.6
W_2	3.0	5.1	8.4	12.1	19.6	9.6	10.3	19.5	46.0	48.3	31.0
SE$\pm$	0.1	0.7	3.7	1.6	1.4		1.6	2.7	5.0	4.3	
$LSD_{0.05}$	NS	NS	NS	NS	NS		NS	NS	NS	NS	
Nitrogen											
0N	3.3	4.2	10.0	11.9	17.9	9.5	9.1	15.4	34.2	40.7	24.9
N_2	2.8	5.2	12.5	12.1	18.1	10.1	30.6	36.8	63.8	58.2	47.4
SE$\pm$	0.9	1.2	1.7	1.2	1.4		1.9	7.2	3.9	9.1	
$LSD_{0.05}$	NS	NS	NS	NS	NS		7.5*	NS	15.5*	NS	

Table 3. Cont.

Treatment	First season(2000/2001) (weeks)						Second season(2001/2002) (weeks)				
	6	8	10	12	15	Mean	6	8	10	12	Mean
Planting method											
PS	3.1	5.7	8.8	12.1	19.6	9.9	12.4	21.8	41.3	37.8	28.3
AR	2.6	3.9	12.3	12.4	17.2	9.7	11.5	20.9	37.8	46.9	29.3
AH	3.5	4.6	12.7	11.4	17.3	9.9	20.2	35.7	68.0	63.7	46.9
SE±	0.5	0.5	2.4	1.8	1.2		2.2	3.4	6.9	6.1	
$LSD_{0.05}$	NS	1.4*	NS	NS	NS		6.7*	10.0*	20.7*	18.1*	

Watering treatments: W_1 = watering every 10 days; W_2 = watering every 20 days
Nitrogen fertilization: 0N = no nitrogen; 2N = 88 kg N/ ha
Planting methods: PS = pure stand of maize; AR = alternating rows of maize and lablab bean;
AH = alternating holes of maize and lablab bean
NS = not significant; / * significant at 5 % level

Table 4. Effects of irrigation interval, nitrogen and planting methods on plant population and flowering of fodder maize for the two seasons

Treatment	Plant population (No./m^2)	Tasseling (%) (2000/2001)	Silking (% (2000/2001	Plant population (No./m^2)	Days to 50% Tasseling (2001/2002)	Days to 50% silking (2001/2002)
Watering						
W_1	35.2	3.27	0.39	42.8	54.7	63.1
W_2	39.0	3.42	0.55	40.7	58.7	66.3
SE±	4.7	0.47	0.14	2.1	0.7	0.5
$LSD_{0.05}$	NS	NS	NS	NS	NS	2.9*
Nitrogen						
0N	38.4	3.92	0.44	41.6	58.1	66.8
2N	35.8	2.76	0.50	41.9	55.3	62.6
SE±	0.9	0.38	0.05	1.8	0.5	0.6
$LSD_{0.05}$	NS	NS	NS	NS	1.8*	2.5*

Table 4. Cont.

Treatment	plant population (No./m^2)	Tasseling (%) (2000/2001)	Silking (% (2000/2001)	Plant population (No./m^2)	Days to 50% Tasseling (2001/2002)	Days to50% silking (2001/2002)
Planting Method						
PS	61.8	3.51	0.52	73.7	56.8	65.1
AR	31.2	3.58	0.47	31.8	56.3	64.8
AH	18.3	2.93	0.43	19.7	57.1	64.3
SE$\pm$	1.5	0.48	0.05	1.7	0.6	0.7
LSD$^{00.5}$	4.4*	NS	NS	5.0*	NS	NS

Watering treatments: W_1 = watering every 10 days; W_2 = watering every 20 days
Nitrogen fertilization: 0N = no nitrogen; 2N = 88 kg N/ ha
Planting methods: PS = pure stand of maize; AR = alternating rows of maize and lablab bean;
AH= alternating holes of maize and lablab bean
NS = not significant; / * significant at 5 % level

DISCUSSION

The significant reduction in plant height with increasing watering interval observed in the second season supports the results found by EL Hag (1996), working on maize, and Saeed (1988) and Kabashi (1991), working on fodder sorghum. Moisture stress affects the length of internodes by inhibiting the elongation of cells (Ahn 1993). The significant increase in plant height due to nitrogen application supports the findings of Saeed (1988) in some grasses and legumes, Sawi (1993) in maize and Koul (1997) in fodder maize. Ahn (1993) reported that nitrogen increases vegetative growth and length internodes. The non-significant effect of intercropping on maize height in the first season may have been due to ineffective nodules observed in this study (unpublished data) and, hence, small amounts of fixed nitrogen available for maize. Water stress is known to decrease symbiotic nitrogen fixation partly by altering nodule fine-structure (DeJong and Philips 1982). However, in the second season intercropping increased plant height of maize, and the same finding was reported by Kabashi (1991) for fodder sorghum when grown in mixture with clitoria.

The reduction in LAI by the long irrigation interval in the second season, which supports the findings of Saeed (1988),working on sorghum, can be attributed to a reduction in leaf area and shedding of lower leaves caused by water stress so that plants can reduce transpirational water losses (Traore *et al*. 2000). Leaf area may be reduced by water stress through inhibition of leaf initiation or decreasing leaf size or accelerating leaf senescence and consequently leaf shedding (Ibrahim *et al*. 1997). The significant reduction in LAI resulting from intercropping in alternating holes during both seasons is probably due to the reduction in plant population. A similar result was reported by Prasad and Prasad (1989) who found that maize LAI is reduced when intercropped with radish, in India.

The lack of response of shoot dry weight to changing watering intervals is in line with the results found by Saeed (1988) and Kabashi (1991) for fodder sorghum and El Hag (1996) and Hassan (1999) for maize. It has generally been reported that vegetative growth in maize is less sensitive to water stress than reproductive growth (Evans *et al*. 1996).

Nitrogen increases vegetative growth and the photosynthetic capacity of maize (Ahn 1993) and hence increases shoot dry weight. In the present study, shoot dry weight and LAI were increased due to nitrogen application with a significant effect in the second season. This result supports by the findings of Saeed (1988) for fodder sorghum, Sawi (1993) for maize and Hussein (1999) for pioneer 988 dry weights. The significant increment in shoot dry weight caused by intercropping in alternating holes is in accordance with the results found by Hussein (1999) who reported that pioneer 988 in a mixture with lablab bean showed higher dry weight per plant than monocropping. Also, Kabashi (1999) reported an increase in plant dry weight of fodder sorghum mixed with clitoria. Maize may have, thus, benefited from the nitrogen fixed in the accompanying lablab bean crop with a resulting increase in shoot dry weight.

There was no significant difference in the number of plants per unit area under different irrigation intervals. This may be explained by the fact that plant population is determined by seed rate and survival of emerged seedlings, and the seed rate was the same in both seasons and the application of irrigation intervals started after 4 weeks from planting when seedlings were strong enough to persist. The non-significant effect of nitrogen application on plant population supports the results obtained by Sawi (1993) and Koul (1997) working on maize. The significant reduction in plant population resulting from intercropping reflects the different proportions of the plant components of the planting methods. The reduction in maize forage production may, however, be compensated for by that of lablab bean.

The lack of significant effect of irrigation intervals on tasseling supports the findings of Hassan (1999) who reported that days to 50% tasseling were not significantly affected by watering treatments. A significant reduction in days to 50% tasseling during the second season due to the application of nitrogen may confirm the findings of Sawi (1993) who reported that addition of urea results in earlier 50% tasseling than in the control.

The significant delay in days to 50% silking under the long watering interval may reflect the sensitivity of silking to water stress in maize as pointed out by Ahn (1993). The increase in the percentage of silked plants as a result of nitrogen application may indicate the enhancing effect of nitrogen on flowering in maize. The significant effect of nitrogen application in reducing days to 50% silking supports the findings of Sawi (1993) who reported that nitrogen fertilization significantly reduces the time to 50% silking in maize.

Alternating rows of lablab bean and maize resulted in a LAI comparable to that resulting from nitrogen application; however, total shoot dry weight under alternating rows was lower than that produced under nitrogen and was not significantly higher than that produced by pure maize stand. On the other hand, alternating holes of lablab bean and maize produced a total shoot dry weight comparable to the one produced under nitrogen possibly because of the greater proximity of fixed nitrogen to maize plants. Since a high shoot dry weight is an ultimate goal of forage crop production, it may be concluded that alternating holes of maize and lablab bean can substitute for nitrogen application.

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مجلة جامعة الخرطوم للعلوم الزراعيه: المجلد الثامن عشر – العدد الثالث 2010م

تأثير إضافة النيتروجين والتحميل مع اللوبيا عفن على نمو الذرة الشامية العلفية تحت فترتي ري

مني الطيب خوجلي، والطيب الحاج على أحمد وسيدة عمر الحويرص

قسم النبات والتقانه الزراعيه ، كلية الزراعه – جامعة الخرطوم، شمبات - السودان

المستخلص: أجريت تجربة حقلية خلال موسمي شتاء 2001/2000 و2001/ 2002 بمزرعة كلية الزراعة، جامعة الخرطوم لدراسة تأثير النيتروجين والتحميل مع لوبيا عفن على نمو الذرة الشامية العلفية باستخدام فترتين من الري. استخدم التصميم ذي القطاعات العشوائية الكاملة في تنفيذ التجربه. بعد أربعة أسابيع من الزراعة روي المحصول كل 10 20 يوم. أما معاملات النيتروجين فكانت صفر و88 كجم نيتروجين/ الهكتار طبقت بعد أسبوعين من بدء الزراعة. كانت طرق الزراعة كالآتي: الذرة الشامية منفرداً، وفي خطوط متبادلة، وفي حفر متبادلة من الذرة الشامية واللوبيا عفن. أدت إضافة النتروجين إلى زيادة معنوية في طول النبات، ودليل سطح الورقة، والوزن الجاف للمجموع الخضري كما قلل معنوياً. أدى تحميل الذرة الشامية مع اللوبيا إلى زيادة معنوية في طول النبات والوزن الجاف للمجموع الخضري في الموسم الثاني ولكنه أدى إلى نقصان معنوي في دليل سطح الورقة خلال الموسمين. بينما لم تتأثر الفترة لظهور 50% من النورات المذكرة والحرير بتحميل الذرة الشاميه مع اللوبيا. لم تؤدي إطالة فترة الري الي عشرين يوماً الى زيادة معنوية فى معظم مكونات النمو الخضري، بينما أدت الى الى تقليل معنوي فى الفترة لظهور 50% من الحرير . ولم تتأثر الكثافة النباتية معنوياً بفترات الري.

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