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EFFECT OF CHEMICAL FERTILIZERS ON YIELD AND NUTRITIVE VALUE OF INTERCROPPED *SORGHUM BICOLOR* AND *LABLAB PURPUREUS* FORAGES GROWN UNDER SALINE CONDITIONS

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ABSTRACT

Two field experiments were carried out during 2009-10 and 2010-11 seasons at Hada Al-Sham experimental Farm of King Abdulaziz University, Jeddah, Saudi Arabia to evaluate the effect of some chemical fertilizers on productivity and nutritive value of *Sorghum bicolor* Var. Panar intercropped with Lablab bean (*Lablab purpureus* L. Sweet) in an adverse conditions of soil and irrigation water. The chemical fertilizers applied were 50 kg/ha of urea (46%N), 50kg/ha of triple superphosphate (46% P), 50 kg/ha of KNO_3, 50kg/ha of NPK (20:20:40) in additition to the control. Panar and Lablab bean were sown as a pure stand and as a mixture. Treatments were laid out in a split plot design with the fertilizer treatments in the main plots and the intercropping treatments in the subplots. Parameters measured were plant height and nutritive value for the Panar, fresh and dry yields and the Land Equivalent Ratio (LER). The chemical fertilizers had no significant effects ($P \leq 0.05$) on productivity but significantly improved forage quality in terms of CP and nutrients contents.. Intercropping of Panar and Lablab significantly ($P \leq 0.05$) increased forage productivity and improved forage quality. Lablab bean was not a good competitor as it disappeared following the first cut.

Key words: Chemical fertilization, intercropping, Lablab bean, Sorghum forage, salinity.

INTRODUCTION

The Kingdom of Saudi Arabia has an area of about 2.25 million km^2, most of which is located in arid regions. The available ground and surface water resources are limited, coupled with low precipitation and high evaporation rates, making crop production a rather difficult business. In western Saudi Arabia, the over exploitation of ground water in Wadi Fatima has led to the appearance of upcoming salinization and saline water encroachment.

Animal resources in the kingdom are estimated to be over sixteen million heads of camels, sheep, goats and cattle, in addition to a reasonable number of other domestic and game animals. However, the main and most traditional approach to livestock production in Saudi Arabia is grazing desert livestock year-round, but mostly during 3 to 4 months of better rangeland productivity and the rest are supplemented by cultivated fodders (alfalfa, sorghum, grasses and straw). These high quality forages are available in the market but with increasing prices during the period of low quantity and quality rangeland forages as the dry season begins, as well as , during the peak of livestock marketing times (during Ramadan, the two Eids and Al-Hajj). The strategy of forage production in the Kingdom (Ministry of Water and Agriculture, 2009) indicated that rangeland produces 20.7 million tons dry matter, of which only 10.35 million tons are palatable and available for animal feed. The study also indicated that this feed is enough for only 2.3 million animal units which represents 50% of the herd in the Kingdom. Therefore, there is a feed gap of variable magnitude according to the region. Means and ways of increasing forage productivity are needed to bridge this feed gap. Addition of fertilizers and intercropping of cereal and leguminous forages could be one of the means.

Intercropping, which is defined as the growing of two or more crop species simultaneously in the same field during a growing season, is important for the development of sustainable food production systems, particularly in cropping systems with limited external inputs (Adesogan *et al*., 2002). This may be due to some of the potential benefits of intercropping systems such as high productivity and profitability (Yildirin and Guvence, 2005), improvement of soil fertility through nitrogen fixation and excretion from the component legume (Hauggaard-Nelson *et al*., 2001, Hoeieson *et al.,* 2008), efficient use of resources, reducing damage caused by pests, diseases and weeds (Said and Ityula,2003, Banik *et al*., 2006), and improvement of forage quality through the complementary effects of two or more crops grown on the same piece of land (Bingol *et al.,* 2007: Ross *et al*., 2004).

Panar is one of the Sorghum –Sudan grass hybrids grown for forage with high yielding ability that gives up to four cuts during the growing season. Forage grasses benefit from the addition of legumes in the intercropping and the productivity may be equal to nitrogen fertilization. In drought stress experiments Eneji *et al.* (2008) found that Sudan grass, compared with the other three forage plants, was the least affected by deficit irrigation, possibly on account of improved root mass and its natural drought tolerance. Jianwei *et al*. (2004) obtained five cuttings from Sudan grass in which the third harvest produced the greatest response as phosphorus fertilization increased yield by 28%.

In Africa, legumes have been tested as components of grass-legume mixtures, used to reinforce native pastures, established as fodder-banks, planted as intercrops and in leys, and in some cases, sown under trees in plantations.

Lablab bean (*Lablab purpureus* L. Sweet) is the one of the most important leguminous forage crops in the tropic, it is believed to have originated in India , used as cover crop in many countries, produces adequate ground cover and good weed suppression (Ekeleme *et al*.,2003) . *Lablab purpureus* is a useful grain legume, rotational legume in tropical areas. Legumes utilized as green manure may provide on-farm organic nitrogen (Cherr *et al.,* 2006). It is palatable to livestock, also the seeds used for human consumption and the plant as a break crop to control soil erosion and drought tolerant (Ewansiha and Singh, 2006).

The objective of this study was to evaluate the effect of chemical fertilizers on the performance of Panar (a cereal forage) and Lablab bean (a leguminous forage) each grown as pure stand and as a mixture in an adverse environmental conditions of soil, water and climate of western Saudi Arabia.

MATERIALS AND METHODS

Two field experiments were carried out during 2009/10 and 2010/11 seasons at the Experimental Station of the Faculty of Meteorology, Environment and Arid Land Agriculture of King A\Aziz University in Hada Al-Sham. The site is located about 40 km north – east of Mecca (21° $48^{-}3^{=}$ N, 39 $43^{-}25^{=}$ E), at approximately 240 m asl. The site soil has a very poor productivity, with pH ranging from 7.1 to 7.99. The organic matter, calcium carbonate and cation exchange capacity are low (Al-Solaimani, 2003 and Al-Solaimani *et al*. 2003). During the last decade, average monthly temperatures ranged between 23˚ C in January (winter) and 36˚ C in July (summer). Average annual rainfall was low and irregular at the site (100mm/annum). Mean relative humidity ranged between 57% (January) and 20 % or less (June-July) with an average dry season of about 8 months during the year.

The experimental site was ploughed, leveled, then ridged up 70 cm apart. The experimental area was divided into plots of 2×3 meters (main plots). Each plot consisted of three ridges (subplots).

Surface irrigation with plastic pipes running along each ridge and perforated to allow free and uniform flow of water was installed. Irrigation was applied every 3 or 4 days according to weather condition. Borehole water containing 3000 TDS (ppm) was the source of irrigation. Detailed chemical analysis of the irrigation water is presented in table 1.

Treatments consisted of four chemical fertilizers in addition to the control. These were; 50 kg\ha of urea (46% N) denoted as N, 50 kg\ha of triple super phosphate (46% P) denoted as P, 50 kg\ha of NPK (20:20:40) denoted as NPK and 50 kg\ha of KNO_3 denoted as K, in addition to the control (no fertilizer added). These were assigned to the main plots (2×3 meters). In the subplots(ridges) Panar cereal and Lablab bean legume forages were planted one time as a pure stand and another time as a mixture (with a ratio of 1:1) by planting half the seed rate of each crop used in the pure stand in the mixture. Planting was done by digging 3cm holes on both sides of ridges, 30 cm apart. Four seeds per hole of Lablab bean and 6 seeds per hole of Panar were sown in case of pure stand, whereas two seeds of Lablab bean and three seeds of Panar per hole were used in the mixture. Three replications in a split plot design were established. In each of the two seasons, three forage cuts were obtained. The following parameters were measured during each cut; Plant height for the cereal forage in the pure stand and in the mixture, forage fresh and dry yields. In addition, proximate analysis was performed for the cereal forage during the first cut and land equivalent ratio was calculated for the dry matter yield using the formula:

$$\text{LER} = \frac{\text{Yield of intercropped cereal}}{\text{Yield of pure cereal}} + \frac{\text{yield of intercropped legume}}{\text{Yield of pure legume}}$$

RESULTS AND DISCUSSION

Plant height. The effect of fertilizer treatments on the height of the cereal forage (Panar) was not significant during both seasons except for the third cut in the second season(Table 2a) when nitrogen fertilizer resulted in significantly ($P \leq 0.05$) taller plants over phosphorus fertilized plants. In view of the irrigation water quality and the poor soil properties (Table 1), addition of chemical fertilizers may add up to the soil solution concentration; therefore creating more adverse conditions around the rooting zone for plants to utilize nutrients (Abusuwar and Abbaker, 2009).

Mixing the cereal with the leguminous forage resulted in a significantly taller plants throughout the two seasons in all cuts (Table 2b). This might be attributed to the benefits of the cereal from the leguminous forage in providing the required nitrogen via nitrogen fixation by the legume in the mixture.

The interaction between main plot and subplot treatments was not significant in both seasons.

Forage production (Fresh and dry yields). The effect of fertilizers on fresh and dry yields was not significant except for the 3rd cut in the 1st season when P and K fertilized plots significantly ($P \leq 0.05$) out yielded other treatments (Tables 3a and 4a). Significant differences in fresh and dry yields were reported for the intercropping throughout the two seasons (Tables 3b and 4b). Panar grown as a pure stand or in mixture with Lablab bean significantly out yielded other treatments in five out of six harvesting occasions. Lablab bean performed better when grown as a pure stand than when grown as a mixture. Moreover, Lablab bean when grown as a mixture with Panar disappeared in the 2nd and 3rd cuts in both seasons indicating its inability to compete with Panar in the mixture. Addition of chemical fertilizers may add up to the soil solution concentration; therefore creating more adverse conditions around the rooting zone for plants to utilize nutrients (Abusuwar and Abbaker, 2009). Salinity-fertility relationships are of great economic importance and have been the subject of many greenhouse and field studies, but Endris and Mohamed (2007) concluded that the research work resulted in different and even contradictory conclusions. Positive, negative and no effects of fertilization were reported

The interaction between main plot and subplot treatments was not significant in both seasons.

Nutritive Value. The nutritive value of Panar forage, in terms of CP, CF, Ca, Mg, K, P and Na, as affected by the fertilizer and intercropping treatments is presented in table 5. Significant ($P \leq 0.05$) differences for the fertilizer treatments were observed for all elements measured except the CF % (Table 5a). Nitrogen fertilizer significantly improved forage quality in terms of CP% compared to other treatments, whereas NPK treatment significantly increased P, K, Mg, Ca and Na compared to other fertilizer treatments.

Mixing Panar with Lablab bean significantly improved forage quality in terms of CP, P, K, Mg, Ca and Na compared to Panar when grown as a pure stand (Table 5b). No significant differences were reported for the CF% of the Panar forage whether grown in pure stand or in mixture. Obviously the cereal benefitted from the legume in the mixture and that was also reflected in the improvement of its nutritive value in terms of CP, Ca, P, and K. Several researchers reported similar findings when intercropping grasses with legumes (Beschow *et al*.,2000; Mpairwe *et al*.,2002; Ross *et al*., 2004; Bingol *et al*.,2007; Cipollini *et al*., 2007; Howeison *et al*., 2008). The disappearance of the lablab following the 1st cut in both seasons is an indicative to its low competitive ability and probably to its low salt tolerance. Ewansiha and Singh (2006) reported that Lablab bean is drought tolerant but less competitor.

Land Equivalent Ratio (LER). Land equivalent ratio calculated on dry matter yield basis is presented in table 6. Land equivalent ratio was higher in the first season compared to the second season regardless of the treatments used. Moreover, LER was always greater than one in all cuts of the first season, whereas in the second season it was greater than one in the third cut only.

Land equivalent ratio is a quantitative index, used to evaluate the output efficiencies of intercropping pattern. It is the most suitable parameter used to measure the impact of growing different plant species at the time on the same land. If LER value is equal to one, it indicates no difference in yield between the intercrop and the monoculture, that means the intercropping produces yield as in monoculture. If the LER value is greater than one, it indicates a yield advantage for the intercrop (Dariush *et al*., 2006). Table 6 indicated that LER was greater than 1 in four out of six cuts. Land equivalent ratio in all cuts during the first season and the 3rd cut of the 2nd season was greater than 1, whereas during the second season for the 1st and 2nd cut it was less than 1. This drop in LERL during the second season compared to the first season was due to lower productivity of the mixture in that season .Moreover, it is worth mentioning here that rainfall during the first season was higher compared to the second season which might helped leaching of salts below rooting zone in all treatments. This was reflected in the higher yield in the first season. Bilalis *et al*., (2011) reported a negative effect of salinity on LER when intercropped maize with cowpea in a saline area in western Greece. Liu and Zhang (2006) reported that land use efficiency under intercrops was raised by 38% compared to single cropping, Dariush *et al*., (2006) reported that LER was significantly affected by intercropping when planting Sorghum with legumes and the LER ranged between 1.70 to 1.89 which indicated yield advantage of intercropping over sole cropping.

Table 1. Chemical analysis of the irrigation water

pH	Ec ds^{-1}	Na^+ (mgl)	K^+ (mgl)	Ca^{++} (mgl)	Mg^+ (mgl)	Cl^- (mgl)	SO_4^- (mgl)	NO_3^- (mgl)	HCO_3^- (mgl)	$CO_3^=$ (mgl)
7.40	1.58	164	24.6	160	41	246	221.6	123	246	0

Table 2. Panar-Lablab bean - plant height (cm)

a- Main plot treatment

Treatment	1st	season	2010	2nd season	2011	3rd cut
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	
Control	151.33a	123.33a	138.83a	147.83a	154.83a	125.83ab
N	141.83a	118.67a	125.50a	151.17a	140.00a	136.83a
P	163.83a	132.67a	145.67a	160.50a	133.50a	120.83b
K	159.50a	126.33a	161.00a	153.67a	154.00a	124.83ab
NPK	148.33a	123.33a	132.83a	156.33a	148.17a	131.33ab
LSD at 0.05	23.58	16.96	38.75	35.92	28.50	12.42
CV	2.74	13.18	7.68	10.64	5.10	4.13

b- subplot treatment

Treatment	1st season	2010	3rd cut	2nd season	2011	3rd cut
	1st cut	2nd cut		1st cut	2nd cut	
P	150.73b	125.80a	132.53b	132.53b	139.73b	122.60b
P/L	159.20a	124.13a	145.80a	145.80a	152.47a	133.27a
LSD at 0.05	3.45	13.40	8.69	13.33	6.07	4.29
CV	2.74	13.18	7.68	10.64	5.10	4.13

*Figures followed by same letter(s) within each column are not significantly different at 0.05 level of probability using the LSD Test.

Table 3. Panar-Lablab bean-Fresh yield(ton/ha)

a- Main plot treatment

Treatment	1st	season	2010	2nd season	2011	3rd cut
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	
Control	17.86a	17.40a	9.08ab	7.93a	11.47a	10.63a
N	16.32a	19.56a	6.50b	9.03a	11.87a	9.77a
P	18.76a	16.60a	12.72a	9.83a	12.87a	11.47a
K	17.04a	15.64a	13.88a	11.13a	13.70a	11.00a
NPK	17.50a	16.60a	9.57ab	9.47a	12.67a	9.63a
LSD at 0.05	2.26	6.90	5.54	4.60	6.43	5.87
CV	18.25	19.10	14.77	21.58	14.52	14.23

*Figures followed by same letter(s) within each column are not significantly different at 0.05 level of probability using the LSD Test.

b- subplot treatment

Treatment	1st	season	2010	2nd season	2011	3rd cut
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	
P	24.28a	32.26a	19.06a	13.00a	19.83a	17.97a
PM	13.62b	33.12a	21.86a	12.07a	20.17a	18.50a
L	22.24a	3.22b	0.32b	12.00a	10.03b	5.53b
LM	9.82c	0.00c	0.00c	9.07b	0.00c	0.00c
LSD at 0.05	2.38	5.00	4.20	2.87	3.27	3.46
CV	18.25	19.10	14.77	21.58	14.52	14.23

*Figures followed by same letter(s) within each column are not significantly different at 0.05 level of probability using the LSD Test.

Table 4. Panar-Lablab bean-Dry yield(ton/ha)

a- Main plot treatment

Treatment	1st	season	2010	2nd season	2011	3rd cut
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	
Control	8.77a	6.20a	4.87ab	7.37a	3.73a	3.63a
N	8.83a	8.87a	3.13b	3.93a	4.13a	3.10a
P	12.23a	5.97a	6.43a	4.63a	4.17a	4.10a
K	8.23a	5.37a	7.47a	4.77a	4.40a	3.70a
NPK	9.83a	6.03a	5.07ab	3.77a	4.30a	3.23a
LSD at 0.05	6.5	4.00	3.17	2.60	2.00	1.87
CV	18.79	19.61	19.03	20.75	21.47	20.04

*Figures followed by same letter(s) within each column are not significantly different at 0.05 level of probability using the LSD Test.

b- subplot treatment

Treatment	1st	season	2010	2^{nd} season	2011	3rd cut
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	
P	12.20a	11.63a	7.35a	7.00a	7.13a	6.37a
PM	11.63a	12.47a	11.73a	4.87b	6.93a	6.63a
L	9.60ab	1.80b	0.00b	3.87b	2.53b	1.23b
LM	4.87b	0.00c	0.00b	0.19c	0.00c	0.00c
LSD at 0.05	5.20	1.93	2.27	1.70	0.97	1.10
CV	18.79	19.61	19.03	20.75	21.47	20.04

*Figures followed by same letter(s) within each column are not significantly different at 0.05 level of probability using the LSD Test.

Table 5. Panar-Lablab bean- proximate analysis
a-main plot treatments

Treatment	CP%	CF%	P %	Ca%	Na%	K%	Mg%
Control	16.46c	23.46a	0.135c	0.453d	0.848d	1.26d	0.0132d
N	17.41a	24.28a	0.240b	0.518b	0.933b	1.65ab	0.0143b
P	17.08b	24.41a	0.248b	0.488c	0.915c	1.55c	0.0138c
K	17.03b	23.88a	0.240b	0.526ab	0.930b	1.60bc	0.0144b
NPK	17.55a	24.05a	0.260a	0.550a	0.968a	1.68a	0.0147a
LSD 0.05	0.22	1.00	0.009	0.026	0.013	0.082	0.0002
CV	0.96	2.89	3.81	3.37	0.973	5.13	0.67

*Figures followed by same letter(s) within each column are not significantly different at 0.05 level of probability using the LSD Test.

b- subplot treatments

Treatment	CP%	CF%	P%	Ca%	Na%	K%	Mg%
P	16.86b	23.93a	0.220b	0.506a	0.892b	1.47b	0.0138b
PM	17.35a	24.11a	0.228a	0.508a	0.945a	1.63a	0.0143a
LSD 0.05	0.13	0.56	0.007	0.014	0.007	0.065	0.0001
CV	0.96	2.89	3.81	3.37	0.973	5.13	0.67

*Figures followed by same letter(s) within each column are not significantly different at 0.05 level of probability using the LSD Test.

Table 6. Land Equivalent ratio (LER)

Parameter	1st	season	2010	2^{nd} season	2011	3rd cut
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	
LER	1.46	1.07	1.59	0.75	0.97	1.04

Conclusion: It can be concluded from the results of this study that intercropping of Panar and Lablab bean increased forage productivity and improved forage quality under the prevailing soil and irrigation water quality of western Saudi Arabia. Moreover, inclusion of Lablab bean in the mixture should not be recommended unless only one cut is needed. The addition of chemical fertilizers to such soils, although improved forage quality, but had no significant effect on forage productivity.

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