African Journal of Microbiology Research Vol. 6(14), pp. 3485-3491, 16 April, 2012
Available online at http://www.academicjournals.org/AJMR
DOI: 10.5897/AJMR12.007
ISSN 1996-0808 ©2012 Academic Journals

Full Length Research Paper

Effect of chemical fertilizers on yield and nutritive value of intercropped Sudan grass (*Sorghum Sudanense*) and cowpea (*Vigna unguiculata* L. Walp) forages grown in an adverse environment of western Saudi Arabia

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Accepted 27 February, 2012

A field experiment was carried out during 2009/10 and 2010/11 seasons at Hada Al-Sham experimental Farm of King A/Aziz University in Jeddah, Saudi Arabia. The objective was to evaluate the effect of some chemical fertilizers on productivity and nutritive value of *Sorghum Sudanense* Var. Panar intercropped with Cowpea (*Vigna unguiculata* L. Walp) in an adverse condition of soil and irrigation water. The chemical fertilizers applied were 50 kg/ha of urea (46%N), 50 kg/ha of triple superphosphate (46% P), 50 kg/ha of KNO_3, 50 kg/ha of NPK (20:20:40) and a control for check. Sudan grass and Cowpea were sown as sole crops 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 Sudan grass, fresh and dry yields and the land equivalent ratio (LER). The chemical fertilizers had no significant ($P \leq 0.05$) effect on productivity but significantly improved forage quality. Intercropping of Sudan grass and Cowpea significantly ($P \leq 0.05$) increased forage productivity and improved forage quality and land equivalent ratio (LER). Cowpea was not a good competitor as it disappeared following the first cut in the first season.

Key words: Chemical fertilization, intercropping, cowpea, sorghum forage, Sudan grass, salinity, land equivalent ratio (LER).

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. Moreover, 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 (Dabbagh and Abderrahman, 1997).

There is a reasonable number of animal resources in the kingdom that is 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 (Ministry of Water and Agriculture, KSA, 2009). 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 is supplemented by cultivated fodders (alfalfa, sorghum, grasses and straw). The strategy of forage production in the Kingdom (Ministry of Water and Agriculture, KSA, 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 .This 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 of increasing forage productivity are needed to

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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 (Ofori and Stern, 1987), 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, Howieson 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).

Sudan grass is one of the cereal forages 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 (Dwivedi and Kumar, 1999). In drought stress experiment 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 (Thomas and Sumberg, 1995). The seeds are used in human food in many countries and the seed flour contained 30% protein on a dry weight basis (Venkatachalam and Sathe, 2007).

Cowpea (*Vigna unguiculata* L. Walp) is the one of the most important leguminous forage crops in the tropic, used as cover crop in many countries, produces adequate ground cover and good weed suppression (Ekeleme et al., 2003). Cowpea is a useful grain and a rotational legume in tropical areas (Musa et al., 2012; Allen and Obura, 1983). 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 (Shehu et al., 2001) and drought tolerant (Ewansiha and Singh, 2006).

The objective of this study was to evaluate the effect of chemical fertilizers on the performance of Sudan grass (a cereal forage) and Cowpea (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

A field experiment was 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), 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; Al-Solaimani et al., 2003). During the last decade, average monthly temperatures ranged from 23℃ in January (winter) to 36℃ in July (summer). Average ann ual rainfall was 100 mm and irregular. Mean relative humidity ranged from 57% (January) to 20% or less (June to July) with an average dry season of about 8 months during the year.

The experimental site was ploughed, leveled and 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. Irrigation water containing 3000 TDS (total dissolved solids) was used .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 m). In the subplots (ridges) Sudan grass cereal and Cowpea legume forages were planted one time as a pure stand and another time as a mixture (at 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 3 cm holes on both sides of ridges, 30 cm apart. Four seeds per hole of Cowpea and 6 seeds per hole of Sudan grass were sown in case of pure stand, whereas two seeds of Cowpea and three seeds of Sudan grass 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:

LER = Yield of intercropped cereal **/** Yield of pure cereal **+** yield of intercropped legume **/** Yield of pure legume as described by Willey (1979).

RESULTS AND DISCUSSION

Plant height

The effect of fertilizer treatments on the height of the cereal forage (Sudan grass) was not significant in all cuts during both seasons (Table 2). Mixing the cereal with the leguminous forage resulted in a significantly ($P \leq 0.05$) taller plants throughout the two seasons in all cuts. Sudan grass in the mixture was always taller than when grown as a pure stand (Table 2). The interaction between

Table 1. Chemical analysis of the irrigation water.

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

Table 2. Sudan grass-Cowpea - plant height (cm).

Treatment	1st season 2010			2nd season 2011		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Main plot treatments (height in cm)						
Control	206.83[a]	137.17[a]	138.67[a]	161.00[a]	142.66[a]	125.83[a]
N	215.67[a]	141.67	141.33[a]	162.16[a]	145.33[a]	126.83[a]
P	201.17[a]	141.83[a]	148.00[a]	147.83[a]	151.83[a]	116.83[a]
K	213.50[a]	144.33[a]	144.83[a]	153.83[a]	156.00[a]	131.00[a]
NPK	200.50[a]	151.00[a]	142.33[a]	151.50[a]	148.66[a]	127.50[a]
LSD at 0.05	17.85	27.77	41.47	22.59	16.93	10.9
CV	3.64	6.01	5.77	9.27	5.77	6.53
Subplot treatments (height in cm)						
S	200.27[b]	133.27[b]	131.40[b]	148.40[b]	138.53[b]	116.67[b]
S/C	214.80[a]	153.13[a]	154.67[a]	162.13[a]	15.27[a]	134.53[a]
LSD at 0.05	6.15	7.01	6.72	11.71	7.00	6.67
CV	3.64	6.01	5.77	9.27	5.77	6.53

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

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

Fresh yield

The effect of fertilizers on fresh yield 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 (Table 3). Significant differences ($P \leq 0.05$) in fresh yield were reported for the intercropping throughout the two seasons (Table 3). 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. The interaction between main plot and subplot treatments was not significant in both seasons.

Dry yield

Similar to fresh yield, dry yield was not significantly affected by fertilizer treatments in both seasons except for the 2nd cut in the 2nd season when NPK fertilized treatment produced significantly lower yield compared to other treatments (Table 4).

Table 3. Sudan grass-Cowpea-fresh yield (ton/ha).

Treatment	1st season	2010		2nd season	2011	
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Main plot treatments **(ton/ha)**						
Control	206.83[a]	137.17[a]	138.67[a]	161.00[a]	142.66[a]	125.83[a]
N	215.67[a]	141.67	141.33[a]	162.16[a]	145.33[a]	126.83[a]
P	201.17[a]	141.83[a]	148.00[a]	147.83[a]	151.83[a]	116.83[a]
K	213.50[a]	144.33[a]	144.83[a]	153.83[a]	156.00[a]	131.00[a]
NPK	200.50[a]	151.00[a]	142.33[a]	151.50[a]	148.66[a]	127.50[a]
LSD at 0.05	17.85	27.77	41.47	22.59	16.93	10.9
CV	3.64	6.01	5.77	9.27	5.77	6.53
Subplot treatments **(ton/ha)**						
S	200.27[b]	133.27[b]	131.40[b]	148.40[b]	138.53[b]	116.67[b]
S/C	214.80[a]	153.13[a]	154.67[a]	162.13[a]	15.27[a]	134.53[a]
LSD at 0.05	6.15	7.01	6.72	11.71	7.00	6.67
CV	3.64	6.01	5.77	9.27	5.77	6.53

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

The subplot treatments, on the other hand, had a significant (P ≤ 0.05) effect on forage dry yield in all cuts during both seasons (Table 4). Cowpea grown as a mixture consistently produced the lowest dry yield compared to other treatments. Cowpea in the mixture disappeared following the first cut in the first season but persisted in the 2nd season apparently to the high rains in that season that modified the high temperature prevailing in western Saudi Arabia. The interaction between main plot and subplot treatments was not significant in both seasons.

Nutritive value

The nutritive value of Sudan grass 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 differences (P ≤ 0.05) for the fertilizer treatments were observed for all elements measured (Table 5). Chemical fertilizers (N, P, K, and NPK) significantly improved forage quality in terms of CP, CF. P, K, Ca, Mg and Na % compared to the control.

Mixing Sudan grass with Cowpea significantly improved forage quality in terms of CP, P, K, Mg, Ca and Na compared to Sudan grass when grown as a pure stand (Table 5).

It was obvious from the results that addition of chemical fertilizers had no significant effect on plant height or forage productivity (fresh and dry yields except for dry yield in the 2nd cut of the 2nd season). 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, 1994). Salinity-fertility relationships are of great economic importance and have been the subject of many greenhouse and field studies, but Feigin (1985) concluded that the research work resulted in different and even contradictory conclusions. Positive, negative and no effects of fertilization were reported.

Intercropping of Sudan grass and Cowpea, on the other hand, resulted in significantly taller Sudan grass plants in the mixture and higher fresh and dry yields in the Sudan grass pure stand and Sudan grass-Cowpea 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

Table 4. Sudan grass-Cowpea- Dry yield (ton/ha).

Treatment	1st season	2010		2nd season	2011	
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
Main plot treatments (ton/ha)						
Control	10.76[a]	9.73[a]	6.83[a]	4.93[a]	5.33[a]	4.23[a]
N	11.44[a]	8.93[a]	4.77[a]	5.00[a]	5.03[ab]	3.97[a]
P	10.04[a]	8.70[a]	5.83[a]	5.30[a]	4.70[a]	5.53[a]
K	10.06[a]	9.27[a]	5.23[a]	5.17[a]	5.23[ab]	4.13[a]
NPK	10.86[a]	11.83[a]	5.37[a]	5.87[a]	0.00[c]	6.20[a]
LSD at .05	2.48	4.40	2.66	1.63	1.63	3.07
CV	21.49	23.61	19.63	14.01	19.93	20.93
Subplot treatments (ton/ha)						
S	13.98[a]	10.36[a]	8.80a	5.57a	7.13[ab]	5.33[a]
SM	10.58[b]	10.36[a]	9.73a	6.67a	7.93[a]	6.00[a]
L	13.70[a]	2.54[b]	4.17b	5.40b	5.63[b]	4.83[a]
LM	4.02[c]	0.00[c]	0.00c	1.33c	0.80[c]	1.47[b]

*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. Sudan grass-Cowpea - proximate analysis.

Treatment	CP%	CF%	P%	Ca%	Na%	K%	Mg%
Control	17.40[c]	21.08c	0.108c	0.413d	0.831c	1.433b	0.0127[d]
main plot treatments							
N	18.03[ab]	22.08[ab]	0.228[b]	0.521[c]	0.915[b]	1.416[b]	0.0135[c]
P	17.90[b]	22.18[a]	0.246[a]	0.525[bc]	0.900[b]	1.483[b]	0.0141[b]
K	18.00[ab]	21.26[bc]	0.233[ab]	0.543[b]	0.900[b]	1.667[a]	0.0145[b]
NPK	18.25[a]	22.76[a]	0.240[ab]	0.615[a]	0.943[a]	1.583[ab]	0.0150[a]
LSD 0.05	0.29	0.84	0.015	0.021	0.025	1.67	0.0005
CV	1.34	1.35	3.76	2.36	1.07	9.17	3.81
subplot treatments							
S	17.70[b]	21.36[b]	0.205[b]	0.508[b]	0.89[b]	1.380[b]	0.0137[b]
SM	18.10[a]	22.39[a]	0.217[a]	0.539[a]	0.91[a]	1.635[a]	0.0141[a]
LSD 0.05	0.195	0.24	0.006	0.01	0.008	0.113	0.0004
CV	1.34	1.35	3.76	3.36	1.07	9.17	3.81

*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			2nd season 2011		
	1st cut	2nd cut	3rd cut	1st cut	2nd cut	3rd cut
LER	1.05	1.00	1.11	1.45	1.25	1.1.56

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; Howieson et al., 2008). The disappearance of the Cowpea following the 1st cut in the first season is an indicative to its low competitive ability and probably to its low salt tolerance. Higher rains during the second season might have washed some of the salts and assisted in survival of Cowpea. Ewansiha and Singh (2006) reported that Cowpea 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 is 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 ranged from 1.00 to 1.11 in the first season and from 1.25 to 1.56 in the 2nd season. It was obvious from the dry yield data the higher values of the LER were due to the persistence of Cowpea in all cuts of the 2nd season. Land equivalent ratio in all cuts during both seasons was greater or equal to 1.00. Land equivalent ratio dropped during the 1st season compared to the 2nd season due to disappearance of Cowpea following 1st cut in the first season. 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.

Conclusion

It was concluded that intercropping of Sudan grass and Cowpea increased forage productivity and improved forage quality under the prevailing soil and irrigation water quality of western Saudi Arabia. Moreover, inclusion of Cowpea 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.

ACKNOWLEDGEMENT

The funding of this project by the Deanship of Scientific Research, King Abdulaziz University, KSA is highly appreciated.

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