INTERNATIONAL JOURNAL OF SCIENCE AND NATURE

www.scienceandnature.org

EFFECT OF DIFFERENT CHEMICAL FERTILIZERS ON YIELD AND NUTRITIVE VALUE OF ALFALFA GROWN UNDER STRESS ENVIRONMENT OF WESTERN SAUDI ARABIA

Ahmed A. Bakhashwain and Awad O. Abusuwar
Dept. of Arid Land Agric., Faculty of Meteorology, Environment and Arid Land Agriculture,
King A/Aziz University, Jeddah Saudi Arabia

ABSTRACT
A study was conducted in Hada Al-Sham Research Station , King A/Aziz University in Jeddah, Saudi Arabia for two consecutive years (2009-2010) to evaluate the effect of some chemical fertilizers (N, P, K, and NPK) on yield and nutritive value of alfalfa grown under stress environment of irrigation water salinity and poor soil. The treatments consisted of N in the form of urea, P in form of superphosphate , K in form of KNO_3 and NPK, all applied at a rate of 50 kg/ha. Significant differences ($P \leq 0.05$) for the fertilizer treatments compared to the control were reported for dry matter production. Nitrogen in form of urea increased dry yield over the control by 18 % in year 1 and by 26 % in year 2. Significant differences for CP, CF, and P were reported for year2 when NPK produced significantly higher CP and lower CF compared to other treatments. In year 1, though no significant differences were reported, NPK and K treatments improved forage quality compared to other treatments.

KEYWORDS: water salinity, alfalfa yield, nutritive value, chemical fertilizers

INTRODUCTION

Arid lands are characterized with fragile ecosystems, low land productivity, limited and/or scarcity of good quality irrigation water and non-sustainable farming systems. The Kingdom of Saudi Arabia entirely lies within arid and semi-arid dry land, with an annual rainfall ranging from 00 to 100mm/annum. The range and forest resources that provide grazing and browsing resources for livestock are also limited. There is a reasonable number of animal resources in the kingdom that is estimated to be over sixteen million heads (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 hay 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, KSA, 2002) 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 animal units in the Kingdom. Therefore, there is a feed gap of variable magnitude according to the region . For example , the Riyadh area ranked top, followed by Medina and then Najran area with respect to feed shortage.

Leguminous crops constitute a major group of crops in the world. They provide food, feed and fiber for the welfare of humans. Their nutritional value as a source of protein has long been recognized. Only recently, however, leguminous crops have risen to prominence in the KSA (Al-Tahir *et. al*, 1989). The statistics released by the Ministry of Water and Agriculture ,KSA (2009) revealed that forage production sector represents 23% of the total cropping area and the area planted with alfalfa in year 2009 was about 102 million ha that produced 2 million tons of dry matter. Area planted with other forages for the same year was 60,400 ha that produced 1021 tons of dry matter. The Riyadh area contributed 47.7% of the total forage produced in the Kingdom, followed by Kasseem area (11.3 %), and the Jouf area (9.1%). Moreover, the Kingdom imports about 80% of its feed requirements to bridge the forage gap.

As alfalfa represents the most important forage crop in the Kingdom and the bulk of the imports is alfalfa hay, the objective of this study was to evaluate the performance of the crop under different types of chemical fertilizers under the stresses of soil and environment in Mecca District , western Saudi Arabia.

MATERIALS AND METHODS

Site Characteristics

The study was carried out in 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). Details soil chemical characteristics are presented in Table 1. 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.

TABLE 1.Soil chemical analysis of the experimental site

Soil depth	Chemical analysis								
	pH	EC ds^{-1}	O.M. %	N (mg/kg)	P (mg/kg)	K (mg/kg)	Ca (mg/kg)	Mg (mg/kg)	Na (mg/kg)
0-30cm	7.89	1.61	0.50	0.32	0.129	2.5	3.6	6.3	16.8
30-60cm	8.25	0.38	0.41	0.30	0.108	2.2	0.9	1.4	6.60
60-90 cm	8.17	0.39	0.41	0.28	0.400	2.0	1.5	5.9	3.80

Land Preparation

The experimental site was ploughed, leveled, ridged 80 cm apart, then flattened of ridges to form a flatten bed between ridges. Plot size was 3X3.2 m, each plot consisted of 3 ridges.

Treatments

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

50 kg\ha of KNO_3 denoted as K

In addition to the control (no fertilizer added)

A Randomized Complete Block Design (RCBD) with three replications was used.

Alfalfa cultivar *Siriver* (from Australia) was used as a test crop, planted in November 2009 and November 2010 for year one and two, respectively. Seeding rate was 20 kg\ha of inoculated seeds with *Rhizobium melilotti* prior to planting.

Irrigation

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 2.

TABLE 2. 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 3.Effect of treatments on dry matter yield (tons/ha) -1st year

	1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	9th cut	10thcut	Overall mean
control	2.23b	3.86b	1.20b	1.73b	1.31b	0.89b	0.77b	1.00b	0.95b	0.84b	1.48
N	2.50a	4.43a	1.39a	2.02a	1.68a	1.20a	0.83ab	1.10a	1.25a	0.98ab	1.74
P	2.29ab	4.19ab	1.31ab	1.82ab	1.36ab	1.13ab	0.89ab	1.12a	1.25a	0.91ab	1.63
K	2.28ab	4.21ab	1.35a	1.79ab	1.36ab	0.93ab	0.85ab	1.02ab	1.18ab	0.88ab	1.59
NPK	2.42ab	4.32ab	1.28ab	1.93ab	1.58ab	1.12ab	1.02ab	1.13a	1.12ab	1.07a	1.70
LSD 0.05	0.20	0.50	0.15	0.25	0.29	0.25	0.20	0.10	0.25	0.20	
C.V.	26	28	24	17	15	22	20	19	23	13	

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

TABLE 3.Effect of treatments on dry matter yield (tons/ha) -1st year

	1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	8th cut	9th cut	10thcut	Overall mean
control	2.23b	3.86b	1.20b	1.73b	1.31b	0.89b	0.77b	1.00b	0.95b	0.84b	1.48
N	2.50a	4.43a	1.39a	2.02a	1.68a	1.20a	0.83ab	1.10a	1.25a	0.98ab	1.74
P	2.29ab	4.19ab	1.31ab	1.82ab	1.36ab	1.13ab	0.89ab	1.12a	1.25a	0.91ab	1.63
K	2.28ab	4.21ab	1.35a	1.79ab	1.36ab	0.93ab	0.85ab	1.02ab	1.18ab	0.88ab	1.59
NPK	2.42ab	4.32ab	1.28ab	1.93ab	1.58ab	1.12ab	1.02ab	1.13a	1.12ab	1.07a	1.70
LSD 0.05	0.20	0.50	0.15	0.25	0.29	0.25	0.20	0.10	0.25	0.20	
C.V.	26	28	24	17	15	22	20	19	23	13	

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

Parameters measured

The parameters measured during the 2-year study were forage productivity and nutritive value in terms of crude protein, crude fiber and minerals of P, K, Ca, Mg, S and Na. Forage productivity in terms of dry matter was determined several cuts each year when 10 to 50% of the population is flowering. Proximate analysis was performed on ground samples of the dry weight. Crude protein was determined using the Micro-kjeldahl technique and crude fiber by the Acid Detergent Fiber Test (AOAC.1984). The minerals were estimated by the spectrophotometer and the methods described by Chapman and Patt (1961).

Data analysis

Data were analyzed using the SAS 2000 software and means were separated using the LSD method (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Productivity (dry yield)

Significant differences ($P \leq 0.05$) between fertilizer treatments and the control were reported for both years (Tables 3 and 4 for year 1 and year 2, respectively). N applied in the form of urea out yielded other fertilizer treatments in 8 out of 10 cuts in year 1 and in all cuts in year 2. NPK out yielded other fertilizer treatments in 2 out of 10 cuts in year 1 and 3 out of 7 cuts in year 2. P out yielded other forms of fertilizers in 2 out of 10 cuts in year 1and one out of 7 cuts in year 2. Potassium (K) out yielded other fertilizer treatments in one out of 10 cuts in year 1 and the least production in year 2. Mohamed and Abusuwar (1996) reported that addition of N and P improved growth and productivity of the leguminous forages of *Lablab purpureus*(L.), *Phaseolus trilobus* (L.), and *Cymopsis tetragonoloba*(L.). Phosphorus addition increased forage productivity and quality in Clitoria ternata (Ibrahim *et al*, 1996) , in cowpea (Jin *et al*, 1992) and in faba bean (El Sheikh and El Zidany, 1997).

TABLE 4. Effect of treatments on dry matter yield (tons/ha) -2nd year

	1st cut	2nd cut	3rd cut	4th cut	5th cut	6th cut	7th cut	Overall mean
control	1.08b	1.65b	1.01b	1.27b	1.68b	1.52b	1.20b	1.34
N	1.28a	1.86a	1.51a	1.85a	1.92a	1.75a	1.68a	1.69
P	1.24ab	1.71ab	1.39ab	1.69ab	1.97a	1.54ab	1.63ab	1.60
K	1.13ab	1.68ab	1.40ab	1.66ab	1.81ab	1.56ab	1.51ab	1.54
NPK	1.33a	1.73ab	1.58a	1.55ab	1.73ab	1.60ab	1.69a	1.60
LSD	0.20	0.20	0.50	0.50	0.21	0.20	0.47	
C.V.	21	13	17	18	21	17	18	

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

TABLE 5.Effect of treatments on nutritive value of the forage- 1st year

	CP%	CF%	Ca (mg/L)	Mg (mg/L)	P(%)	K(ppm)	S(%)	Na(ppm)
Control	14.95a	44.27a	41.48a	6.83a	0.18a	63.09a	0.50a	15.72a
N	16.61a	40.36a	42.59a	6.90a	0.18a	60.11a	0.31b	15.72a
P	17.58a	40.62a	50.12a	6.76a	0.17a	60.96a	0.32b	16.78a
K	16.37a	38.28a	45.82a	7.36a	0.21a	64.77a	0.34b	16.84a
NPK	16.83a	36.20a	52.75a	7.19a	0.21a	65.19a	0.38ab	16.28a
LSD	6.26	8.38	32.28	1.35	0.06	8.83	0.15	4.15
C.V.	20	11.14	36.83	10.36	16.36	7.46	21.54	13.54

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

TABLE 6. Effect of treatments on nutritive value of the forage- 2nd year

	CP (%)	CF% (mg/l)	Ca (mg/L)	P (%)	K (ppm)	Mg (mg/L)	S(%)	Na (ppm)
Control	18.27c	29.00a	34.7b	0.146d	56a	8.8a	0.70a	16.70a
N	20.69ab	28.33a	44.6ab	0.302b	59a	8.9a	0.51a	16.81a
P	20.38abc	28.33a	52.3a	0.418a	57a	8.8a	0.56a	17.90a
K	19.25bc	27.67ab	47.9ab	0.226c	68a	9.4a	0.51a	18.00a
NPK	21.71a	23.67b	54.8a	0.302b	61a	9.2a	0.53a	17.30a
LSD	2.36	4.26	17.1	0.07	15	1.2	0.25	3.50
C.V.	6.26	8.26	25.13	13.18	8.32	11.3	20.55	14.54

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

For the overall average dry matter production, N treatment increased dry yield over the control by 18 % in year 1 and by 26 % in year 2. It is worth mentioning here that dry matter production was generally low in comparison to production of alfalfa under normal soils and non-saline irrigation water. Water salinity has adverse effect on alfalfa yield (Abusuwar and El Hassan,2009) and on many other crops (De Luca *et al*,2001).

Nutritive value

Nutritive value of the fodder in terms of crude protein, crude fiber , Ca, Mg, P, K, S, and Na are presented in Table 5 for year 1 and Table 6 for year 2.

Significant differences ($P \leq 0.05$) with respect to CP, CF, Ca and P were reported for the second year data. In year 2 , NPK produced significantly higher CP , higher Ca and lower CF compared to other fertilizer treatments (Table 6). In year 1, though no significant differences were reported between fertilizer treatments ,yet NPK and K fertilizer treatments produced higher CP, Ca, Mg, P, K,S ,Na and lower CF compared to other fertilizer treatments (Table 5). NPK as a compound fertilizer containing N,P, and K is expected to improve forage quality (Abusuwar and Mohemed,1999; Abusuwar and Ahmed, 2003; Voss *et al* 1990; Ali *et al* 1998).

CONCLUSION

It can be concluded from the results of this study that NPK and P were effective in increasing productivity and improving quality of alfalfa under the adverse environment of Mecca District in western Saudi Arabia.

REFERENCES

Abusuwar, A.O. and A.S. Mohamed (1999) Effect of phosphorus application and Rhizobium inoculation on forage yield and quality of two alfalfa cultivars. J. of Natural Resources and environmental Sciences (JONARES). 2 (1): 7-12.

Abusuwar, A. O, and S.A. Ahmed (2003) Effects of Rhizobium bacteria and VA-Mycorrhizal fungi on forage yield and quality of two alfalfa cultivars. University of Qatar J. of Agric. Sci. vol. 23:117-133 .

Abusuwar, A. and Bakri, M. Elhassan (2009) Effect of water Quality and weeding on yield and Quality of three alfalfa cultivars. Australian J. of Crop Sciences Vol.3 (6) :315-321

Ali, E.S., Abusuwar, A.O. and A.S. Mohamed (1998) Effect of phosphorus application and Rhizobium inoculation on forage yield and quality of two alfalfa cultivars. Journal of Natural Resources and Environmental Sciences (JONARES). 2 (1): 7-12.

Al-Solaimani, S .G. (2003) Chemical properties of soils and underground water of Hada Al-Sham Research Station , Kingdom of Saudi Arabia . J. Environ. Sci. , Ain Shams University. 6:257-284.

Al-Solaimani, S.G., Al-Toukhy, A. and Al-Zahrani, S (2003) Mineral characteristics , classification and evaluation of soils of Hada Al-Sham Res. Station, Kingdom of Saudi Arabia. J. Environ. Sci., Ain Shams University 6:285- 322.

Al-Tahir, O. A., Al-Karouri, A. M.O., Bin Deuhesh,O. and Abo-Rady, M. (1989) Final report on adaptation and selection of grain legumes under some environmental stresses in Saudi Arabia. Res. Project No. AR-7-193, College of Agric. And Food Sci. and King A/Aziz City for Science and Technology (KACST).

AOAC (1984) Official *Methods of Analysis* . Association of Official Agricultural Chemists.

Chapman, D.H. and Patt, P.F. (1961) *Methods of Analysis for Soil, Plant and Water*. University of California. Division of Agricultural Sciences.

De Luca, M., Garcia, S. Salgado, M and Taliesnik, E. (2001) Physiological causes of decreased productivity under high salinity in *Chloris gayana* cultivar. Aust. J. Agric. Res. 52:903-910

El Sheikh, E.E. and El Zidany, A. A. (1997) Effect of Rhizobium inoculation , organic and chemical fertilizers on yield and physical properties of Faba bean seeds. *Plant Foods for Human Nutrition.* Kluwar Academic Publishers, Netherland 12(7): 1-8

Gomez, K. A. and Gomez, A. A. (1984) *Statistical Procedures for Agric. Research*. 2nd Ed. Pp.75-165.John Wiley and Sons Inc., New York.

Ibrahim, A. E., Osman, E. K, and Khair, M. (1996) Effect of phosphorus on growth and forage yield of Clitoria ternata, Lablab purpureus, and Vigna trilobata. *University of Khartoum Journal of Agric. Sci*. 4(2):18-24.

Jin, W. J., Cho, N.K. and Yang, C.B. (1992) The effect of phosphorus fertilizers levels on the agronomic characters of Cowpea. *J. of the Korean Soc. Of Grassland Sci.* 12:193-200.

Ministry of Water and Agriculture, KSA (2002) *Agricultural Statistic Year Book.* Issue No. 14.Riydah. Saudi Arabia.

Ministry of Water and Agriculture, KSA (2009) *Agricultural Statistic Year Book.* Issue No. 20.Riydah. Saudi Arabia.

Mohamed, G.G and Abusuwar, A. O. (1996) The effect of nitrogen and phosphorus fertilizers on growth and yield of some leguminous forage (1996). *Emirates J. of Agric. Sci.* Vol.8: 73-83.

Voss, M.A., Calargi, A. and Robciro, P.G.(1990) Response of peas to inoculation with Rhizobium and phosphate fertilizer application . *Field Crops Abstract.*34 Abst. No.1186