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INFLUENCE OF SOME MACRO- AND MICRONUTRIENTS FERTILIZATION ON PRODUCTIVITY AND QUALITY OF FORAGE SORGHUM

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ABSTRACT

This work was conducted in Giza Experimental Agricultural Research Station, Agricultural Research Center (ARC), to study the influence of macronutrients fertilization of N (60, 90 and 120 Kg N/fed), P (10, 20 and 30 Kg P_2O_5/fed), K (25, 50 and 75 Kg K_2O/fed) as well as micronutrients treatments of Zn, Fe (0.3 g/l) and their mixture in addition to untreated control on the productivity and quality of forage sorghum sudan hybrid cultivar 102 during 1998 and 1999 growing seasons.

The results showed that application of 90N+20P+50K fertilization as kg/fed. resulted in a significant increase of plant height, leaf area, dry forage yield, protein, fiber and ash yields of the three cuts and increased Zn and Fe uptake. Zn and Fe application mixture as foliar spray led to significant increase of the all studied characters at the three cuts. At the same time, the highest plant height, leaf area, dry forage, protein, fiber and ash yield of the three cuts and Zn and Fe uptake were obtained by 90 N + 20 P + 50 K with Zn and Fe mixture. The dry forage yield showed positive and high by significant correlation with all characters under study.
Keyword: Nitrogen, Phosphorus, Potassium, Micronutrients, Sorghum

INTRODUCTION

In Egypt, increasing forage production during summer time is an important target to cover the acute shortage in animal feed. This could be achieved through cultivating high yielding forage crop varieties and, improve cultural practices such as macronutrient and micronutrient fertilization.

Several investigators in Egypt and other countries studied the effect of NPK and micronutrients fertilization on the yield and quality of forage sorghum. Rammah and Ali (1980), Harfoush (1982) and El-Keredy et al. (1986) concluded that green and dry yield, plant height, crude protein and crude fiber were increased by increment nitrogen level. Haggag et al. (1986) and Geweifel (1997) indicated that plant height, fresh and dry forage yield as well as crude protein percentage of some forage sorghum cultivars were significantly increased with phosphorus application but it decreased crude fiber percentage. Plant height, leaf area, highest fresh and dry forage yield, crude protein and ash percentage were significantly increased with supplying 90 Kg N per fed in 3 equal doses (Khawaga and Geweifel, 1991). Khapre et al. (1994) found that application of trace elements Zn, Fe or Mn increased grain yield by 16.71% (with Mn) and 22.74% (with Fe). The highest increase of yield (26.3 %) was obtained with Zn + Mn. Patel and Patel (1994) indicated that green forage yield was increased by 6.8 and 7.0% by the application of 80 and 100 Kg N/ha, respectively, compared with 60 Kg N/ha and by 8 and 12 % by the application of 2.5 and 5.0 Kg Zn/ha. Maximum forage yield was

obtained by 80 Kg N/ha and 2.5 Kg Zn/ha fertilization. Naphade et al. (1995) reported that the average yield of sorghum and N, P and K uptake in sorghum reached the highest with 150% of the recommended NPK rates (RR) of 100 Kg N + 50 Kg P + 40 Kg K/ha, while application of 100% RR of NPK gave similar yield.

MATERIALS AND METHODS

Two field experiments were carried out at Giza Experimental Agricultural Research Station, A.R.C., during 1998 and 1999 summer seasons to study the influence of NPK and micronutrients fertilization on the productivity and quality of forage sorghum (Sorghum-sudan hybrid 102). Soil texture of the experimental site was clay that contained 1.5% organic matter and total nitrogen of 0.15%. Soil pH was 8.0, available Zn, Fe and Mn were 0.94, 5.1 and 4.2 PPM, respectively.

Each experiment included 12 treatments which were the combination of three macronutrients fertilization (60 N+10 P+25 K, 90 N+20 P+ 50 K and 120 N+ 30 P+ 75 K) and micronutrients application of Zn (0.3 g/l), Fe (0.3 g/l) and their mixture (1:1) in addition to unfertilized treatment that used as control. The treatments were arranged in split plot design with three replicates. NPK fertilization was arranged at random in the main plots, whereas the micronutrients fertilization treatments were assigned at random in sub-plot. Each plot was 12 m^2 and included 12 rows (20 cm a part). The preceding crop was Egyptian clover and sowing dates were 17 th and 15 th May in the first and second seasons, respectively. The seeding rate used was 20 Kg/fed. which is the recommended seeding rate for field application. Nitrogen fertilizer was applied as ammonium sulphate (20.6% N) at a rate of 60, 90 and 120 Kg N/fed in the three equal splits after 21 days from sowing and after the first and second cuts. Phosphorus levels i.e., 10, 20 and 30 Kg P_2O_5/fed as calcium superphosphate (15.5% P_2O_5/fed) and potassium levels i.e., 25, 50 and 75 Kg K_2O/fed as potassium sulphate (48.0% K_2O/fed) were added before sowing. Micronutrients fertilization was applied as foliar spray Fe or Zn or Fe+Zn (1:1) at the rate of 0.3 g/l in 300 liters/fed after 25 days from planting and after cutting the first and the second cut. The other agronomical practices for forage sorghum were applied as recommended in the district. The first sample (whole plant) was collected after fifty days of cultivation, then sample was collected consequently every forty day. Whole plant samples were cut into equal parts, then dried and analysed. Characters recorded at each cut in both seasons were: plant height (cm), leaf area (cm^2) and dry yields (ton/fed). The dry samples of each cut were chemicaly analysed to determine crude protein (CP), crude fiber (CF) and ash contents. The chemical analysis used in this investigation followed the conventional methods recommended by A.O.A.C. (1980). Zinc and iron were determined by atomic absorption spectrophotometeric according to Chapman and Pratt (1961). Results were statistically analyzed by the least significant differences of Snedecor and Cochran (1980). Correlation Coefficients between dry matter yield and protein, fiber, ash yield, Zn and Fe uptake were estimated.

RESULTS AND DISCUSSION

A- Agronomical characters:

1- Plant height:

The effect of macronutrients (NPK), micronutrients and their interaction on the plant height (Table 1) indicated that the application of 90N+20P+50K resulted on a high plant height at the first, second and third cut 139.80, 120.50 and 98.20 cm, respectively. While the treatment of 60N+10P+25K showed an opposite trend at the first, second and third cut 122.00, 103.10 and 82.16 cm, respectively. There was a significant difference between micronutrients treatment on plant height at all cuts.

Table 1: Combined analysis of 1998 and 1999 seasons for agronomic characters of the three cuts of forage sorghum as affected by different rates of NPK, micronutrients foliar and interaction of NPK X micronutrients foliar

Characters / Treatments	Plant height (cm)			Leaf area (cm^2)			Dry forage (ton/fed)		
	Cut			Cut			Cut		
	First	Second	Third	First	Second	Third	First	Second	Third
Macronutrients (NPK) treatments									
60N+10P+25K	122.00	103.10	82.16	173.00	173.00	141.40	1.722	1.643	1.002
90N+20P+50K	139.80	120.50	98.20	198.30	198.30	159.00	2.624	2.180	1.377
120N+30P+75K	129.80	110.80	89.18	186.00	186.00	149.40	1.999	1.747	1.057
L.S.D. 0.05	0.75	0.62	1.43	0.90	0.90	1.50	0.02	0.02	0.02
Micronutrients spraying treatments									
Control	126.70	107.90	86.48	208.60	180.70	145.80	1.873	1.656	0.995
Zn	132.00	112.80	91.37	217.80	188.10	152.00	2.195	1.934	1.195
Fe	129.80	110.70	89.02	214.20	184.20	148.40	2.088	1.822	1.119
Zn + Fe	133.60	114.40	92.52	220.80	190.20	153.30	2.305	2.015	1.272
L.S.D. 0.05	1.69	1.32	1.43	2.70	1.90	2.10	0.03	0.02	0.02
Interaction									
60N+10P+25K									
Control	118.70	99.90	79.30	198.00	168.00	137.00	1.588	1.497	0.883
Zn	123.60	104.50	83.40	206.50	175.00	144.00	1.775	1.704	1.046
Fe	121.70	102.60	81.70	202.50	171.50	140.50	1.719	1.650	0.992
Zn + Fe	124.20	105.30	84.25	208.00	177.50	144.00	1.808	1.721	1.089
90N+20P+50K									
Control	135.10	116.40	93.95	218.20	193.50	155.00	2.207	1.899	1.193
Zn	141.60	122.10	100.70	230.00	201.30	161.00	2.769	2.279	1.443
Fe	138.40	118.90	96.65	226.50	196.60	156.80	2.562	2.103	1.322
Zn + Fe	143.80	124.40	101.60	233.20	202.00	163.00	2.959	2.438	1.550
120N+30P+75K									
Control	126.30	107.40	86.20	209.50	180.20	145.50	1.824	1.572	0.910
Zn	130.80	111.70	90.05	217.00	188.00	151.00	2.040	1.819	1.097
Fe	129.40	110.40	88.70	213.50	184.50	148.00	1.981	1.713	1.045
Zn + Fe	132.60	113.60	91.75	221.20	191.00	153.00	2.149	1.884	1.176
L.S.D. 0.05	2.93	2.29	2.49	4.60	3.30	3.70	0.05	0.04	0.04

It is clear from the data presented in Table 1 that the treatment of Zn + Fe was of higher effect than the other treatments, while the control treatment showed an opposite trend at all cuts as compared with foliar plants in the other three micronutrients treatments. It is clear from the data presented in Table 1 that the effect of applying 90N+20P+50K with Zn + Fe mixture fertilization was higher than the other treatments in plant height at all

cuts. Increasing plant height by the application of macronutrients and micronutrients may be attributed to the increment in internode length that results from the increment of protoplasm to cell wall material proportion and consequently of increment in cell size that manifested in internode elongation. These results are in agreement with those obtained by El-Keredy *et al*. (1986), Harfoush and Ali (1986) and Khawaga and Geweifel (1991).

2- Leaf area

Concerning the effect of the applied rates of macronutrients (NPK), micronutrients foliar and the interaction between them on leaf area (cm^2) on forage sorghum. The data presented in Table 1 indicated that the values of leaf area ranged from 203.8 to 227.0, from 173.0 to 198.3 and from 141.4 to 159.0 cm^2 at first, second and third cut, respectively. It could be noticed that the treatment of 90N+20P+50K gave the highest leaf area at the first, second and third cut, 227.0, 198.3 and 159.0, respectively. While the treatment of 60N+10P+25K showed an opposite trend at the first, second and third cut 203.8, 173.0 and 141.4, respectively. The results in Table 1 showed that the effect of micronutrients exhibited a significant difference regarding the leaf area values. It could be noticed that the treatment of Zn + Fe was higher than the other treatments on the leaf area at all cuts. According to the data presented in Table 1 it appears that using 90N+20P+50K with Zn + Fe mixture fertilization was higher than the other treatments on leaf area at all cuts. Harfoush and Ali (1986) deduced that leaf area of the first cut received 60 Kg N/fed at sowing and/or 60 Kg/fed 3 weeks after sowing were much greater than that without N fertilization. El-Khawaga and Gewifil (1991) found that the application of 90 Kg N/fed in 3 equal doses resulted in plant of superior leaf area.

3- Dry forage yield

Results of dry forage yield of Sorghum-sudan as effected by macronutrients, micronutrients and their interaction are presented in Table 1. Among the macronutrients treatments the statistical analysis indicated the presence of significant differences in the dry forage yield of the three cuts. The treatment of received 90N+20P+50K gave the highest dry forage yield at the first, second and thrid cut (2.624, 2.180 and 1.377 ton/fed, respectively). While the treatment of 60N+10P+25 K gave the lowest dry forage yield at the first, second and third cut (1.722, 1.643 and 1.002 ton/fed, respectively). The marked increase of dry forage yield due to the application of 90N+20P+50K reflect the importance of this application in increasing growth and regrowth of plants. There was a significant difference between micronutrients treatments on dry forage yield at all cuts. It is clear from the data presented in Table 1 that the treatment of Zn + Fe was higher than the other treatments, while the control treatment gave the lowest dry forage yield at all cuts under study. The data presented in this table showed that using 90N+20P+50K with Zn + Fe mixture fertilization had pronounced effect of dry forage yield as compared with the other treatments at the three cuts. This increment of dry forage yield may be due to the increment in plant height and leaf area by the application of micronutrients. These results agreed with those of Choi et al. (1988), Khapre et al. (1994) and Patel and Patel (1994).

Table 2: Combined analysis of 1998 and 1999 seasons for chemical analysis of the three cuts of forage sorghum as affected by different rates of NPK, micronutrients foliar and interaction of NPK X micronutrients foliar

Characters / Treatments	Crude protein yield (kg/fed)			Crude fiber yield (kg/fed)			Ash yield (kg/fed)		
	Cut			Cut			Cut		
	1st	2nd	3rd	1st	2nd	3rd	1st	2nd	3rd
Macronutrients (NPK) treatments									
60N+10P+25K	159.30	141.60	83.60	496.10	481.70	307.60	207.90	204.90	129.10
90N+20P+50K	269.20	211.60	129.10	722.40	616.40	400.40	351.30	303.60	199.30
120N+30P+75K	194.30	159.60	93.10	564.30	507.40	316.50	251.20	228.60	143.00
L.S.D. 0.05	1.70	2.20	1.50	6.00	9.16	3.00	2.60	2.90	1.30
Micronutrients spraying treatments									
Control	179.50	148.50	85.90	533.00	491.20	301.10	232.60	214.00	132.40
Zn	215.90	178.60	106.60	614.50	557.30	355.10	282.60	257.90	165.50
Fe	203.00	166.20	99.00	589.30	530.10	335.90	264.20	238.50	151.90
Zn + Fe	231.90	190.50	116.00	640.20	575.40	374.00	301.10	272.40	178.70
L.S.D. 0.05	3.10	1.50	1.40	9.10	8.63	3.20	3.60	2.60	1.60
Interaction									
60N+10P+25K									
Control	144.10	126.10	71.30	463.30	466.40	275.40	186.60	181.50	110.20
Zn	163.80	146.70	86.80	508.30	502.60	319.00	217.00	215.50	136.80
Fe	158.20	141.10	83.10	497.30	492.80	306.30	205.60	203.30	126.10
Zn + Fe	171.20	152.30	93.00	514.90	505.20	329.90	222.30	219.30	143.40
90N+20P+50K									
Control	221.00	179.40	108.60	616.30	545.90	352.60	285.00	254.90	166.10
Zn	284.20	221.50	135.60	760.40	642.30	418.50	373.60	320.30	211.00
Fe	260.30	202.70	122.90	709.50	598.70	387.30	339.70	290.20	189.20
Zn + Fe	311.20	242.80	149.20	803.40	678.60	443.20	406.90	349.20	231.10
120N+30P+75K									
Control	173.60	140.00	78.00	519.20	461.20	275.40	226.30	205.60	121.10
Zn	199.70	167.50	97.50	575.00	527.10	327.80	257.10	237.90	148.70
Fe	190.60	154.70	91.10	560.50	498.80	314.10	247.30	222.10	140.4
Zn + Fe	213.40	176.40	105.80	602.30	542.40	348.80	274.10	248.80	161.80
L.S.D. 0.05	5.40	2.50	2.30	15.80	14.95	5.50	6.30	4.80	2.70

B- Forage quality

1- Chemical composition

Results of protein, fiber and ash yield in forage sorghum as affected by different rates of macronutrients (NPK), micronutrients foliar and their interaction are presented in Table 2. Among the macronutrients rates the statistical analysis indicated the presence of significant differences in the protein, fiber and ash yield at the three successive cuts. The data presented in Table 2 indicated that the treatment 90N+20P+50K gave the higher contents of protein (269.2, 722.4 and 351.3), fiber (211.6, 616.4 and 303.6) and ash (129.1, 400.4 and 199.3 Kg/fed), at the first, second and third cut, respectively. While the treatment of 60N+10P+25K gave the lowest values of protein (159.3, 496.1 and 207.9), fiber (141.6, 481.7 and 204.9) and ash (83.0, 307.6 and 129.1 Kg/fed) at the first, second and third cut, respectively. Concerning the protein, fiber and ash contents the results in Table 2 indicated that the treatment Zn + Fe gave the highest content of protein, fiber and ash at all cuts as compared with the other micronutrients under study. The

interaction between the different rates of macro and micronutrients fertilization had a significant effect on protein, fiber and ash contents of forage sorghum. The highest values were obtained for protein, fiber and ash at the three cuts by using the treatment 90N+20P+50K with Zn + Fe mixture. The increases in these characters due to the application of trace elements may be attributed to that these elements enable the plant to grow well and improved transferring the photosynthetic substances from leaves to the whole plant.

Table 3: Combined analysis of 1998 and 1999 seasons for Zinc and Iron uptake of the three cuts in forage sorghum as affected by different rates of NPK, micronutrients foliar and interaction of NPK X micronutrients foliar

Characters /	Zinc uptake (mg/plant)			Iron uptake (mg/plant)		
Treatments	First cut	Second cut	Thrid cut	First cut	Second cut	Third cut
Macronutrients (NPK) treatments						
60N+10P+25K	4.84	4.38	2.40	27.81	24.86	13.10
90N+20P+50K	8.10	6.59	4.00	59.30	46.88	30.80
120N+30P+75K	5.99	5.21	3.00	39.25	32.47	17.60
L.S.D. 0.05	0.13	0.12	0.10	0.17	0.11	0.10
Micronutrients spraying treatments						
Control	3.62	3.03	1.60	17.00	13.98	6.70
Zn	7.35	6.23	3.70	36.92	29.93	16.80
Fe	5.13	4.32	2.40	51.77	43.44	24.10
Zn + Fe	9.13	8.00	4.80	62.79	51.60	34.50
L.S.D. 0.05	0.14	0.11	0.10	0.16	0.14	0.10
Interaction						
60N+10P+25K						
Control	2.65	2.35	1.20	9.10	7.85	4.20
Zn	5.65	5.03	2.90	21.85	19.30	9.90
Fe	3.95	3.60	1.90	36.05	32.83	16.80
Zn + Fe	7.10	6.55	3.70	44.25	39.45	21.70
90N+20P+50K						
Control	4.65	3.80	2.10	25.75	22.20	11.80
Zn	9.60	7.60	4.70	55.32	42.15	25.20
Fe	6.65	5.25	3.10	70.80	56.33	33.30
Zn + Fe	11.50	9.70	6.10	85.32	66.85	53.20
120N+30P+75K						
Control	3.55	2.95	1.50	16.15	11.90	4.10
Zn	6.80	6.05	3.40	33.60	28.35	15.50
Fe	4.80	4.10	2.30	48.45	41.15	22.20
Zn + Fe	8.80	7.75	4.70	58.80	48.50	28.80
L.S.D. 0.05	0.024	0.19	0.10	0.27	0.23	0.20

2- Zinc and iron uptake

Regarding the zinc and iron uptake content, the results in Table 3 indicated that the differences between the rates of macronutrients on forage sorghum reached to the level of significance. The results in Table 3 show that the treatment of 90N+20P+50K gave the highest values of Zn (8.10, 6.59 and 4.00) and Fe (59.30, 46.88 and 30.80 mg/plant) at the first, second and third cut, respectively. While, the control treatment gave the lowest values of zinc (4.84, 4.38 and 2.40) and iron (27.81, 24.86 and 13.10 mg/plant) at the first, second and third cut, respectively. The data presented in Table 3 indicated that spraying zinc and iron mixture increased significantly Zn and Fe uptake at all cuts as compared with the other micronutrient treatments. Concerning the

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interaction between macro- and micronutrients, the data presented in Tables 1, 2 and 3 indicated that the treatment of 90N+20P+50K with Zn and Fe mixture was higher than the other treatments in zinc and iron uptake at all cuts.

Interrelationship between different traits

Results of simple correlation coefficients between dry forage yield and protein, fiber and ash yield and also Zn and Fe uptake are presented in Figures 1 and 2. It is interesting to note that dry forage yield/fed showed positive and highly significant correlations with all other characters.

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تـأثير التسـميد بـبعض العنـاصـر الكبـرى و الصـغرى علـى الأنتاجيـة و الجـودة فـى سورجم العلف

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١. معهد بحوث الاراضى والمياه والبيئة - مركز البحوث الزراعية - الجيزة - مصر

٢. معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر

أجريت هذه الدراسة بمزرعة البحوث الزراعية بالجيزة بمركز البحوث الزراعية بغرض تحديد تأثير ثلاث مستويات للتسميد بالعناصر الكبرى (٦٠ ن + ١٠ فو + ٢٥ بو ، ٩٠ ن + ٢٠ فو + ٥٠ بو ، ١٢٠ ن + ٣٠ فو + ٧٥ بو) و أربعة معاملات من العناصر الصغرى (بدون معاملة - رش زنك مخلبى - رش حديد مخلبى - رش مخلوط الزنك المخلبى مع الحديد المخلبى) على الانتاجية و الجودة فى سورجم العلف صنف هجين سورجم سودان ١٠٢ خلال موسمى ١٩٩٨ و ١٩٩٩. و تشير النتائج المتحصل عليها أن التسميد بأستخدام ٩٠ ن + ٢٠ فو+ ٥٠ بو آدى الى حدوث زيادة معنوية فى ارتفاع النبات و مساحة الورقة و المحصول الجاف و محتوى البروتين و الألياف و الرماد و أمتصاص كل من الزنك و الحديد فى الثلاث حشات. كما آدى اضافة خليط من الزنك و الحديد المخلبى كرش الى زيادة معنوية فى جميع الصفات تحت الدراسة فى الثلاثة حشات. و هنا يجب التنويه أن أعلى أرتفاع للنبات و مساحة الورقة و المحصول الجاف و محتوى البروتين و الألياف و الرماد و الممتص من الزنك و الحديد كانت نتيجة أستخدام معدل ٩٠ ن + ٢٠ فو + ٥٠ بو مع أستخدام الرش بالحديد و الزنك معا فى الثلاث حشات. و أظهرت النتائج أن محصول المادة الجافة أعطى أرتباط موجب و عالى المعنوية مع كل الصفات المدروسة.