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Effect of Potassium and Magnesium Fertilization on Yield and Nutrient Content of Rice Crop Grown on Artificial Siltation Soil*

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Abstract: The main purpose of this study was to determine the effect of potassium and magnesium fertilization on the yield and N, P, K, Mg, Fe, Cu, Zn, Mn contents of rice crop grown on soil used for cultivation after siltation from the Kelkit River. The experiment was carried out in a randomised block design with 4 replications, using Riba rice grown in pots containing 5 kg of soil. Potassium, K_2SO_4, at 0, 20, 40, 60 and 80 kg K_2O/ha and magnesium, MgO, at 0, 20, 40, 60 and 80 Mg/ha were applied before sowing.

Increasing amounts of potassium significantly increased the rice straw dry matter and grain yield compared to the control. However, there were no differences in the potassium treatments (20, 40, 60 and 80 kg K_2O/ha). Magnesium had a significant effect on the rice straw yield. The maximum rice straw yield was obtained with 60 kg Mg/ha. Mg treatment had no significant effect on the rice grain yield. K fertilization had a significant effect on the nutrient content in straw and grain. On the other hand, Mg fertilization had a significant effect on the K, Mg, Zn and Mn contents in straw, and P, K and Mg content in grain. The uptake of all nutrients in straw was increased with K and Mg treatment. However, the K treatments increased the nutrient uptake in grain, whereas Mg treatments significantly enhanced the N uptake in rice grain.

Potasyum ve Magnezyumlu Gübrelemenin Siltasyon ile Tarıma Yeni Kazandırılan Topraklarda Yetiştirilen Çeltik Bitkisinin Gelişimi ve Bazı Besin Elementi Kapsamına Etkisi

Özet: Araştırmanın amacı potasyum ve magnezyum gübrelemesinin Kelkit çayından siltasyon ile tarıma yeni kazandırılan topraklarda yetiştirilen çeltik bitkisinin gelişimi ve N, P, K, Mg, Fe, Cu, Zn, Mn kapsamına etkisinin tespit edilmesidir. Deneme, 5 kg toprak içeren saksılarda, tesadüf parselleri deneme desenine göre dört tekerrürlü olarak yürütülmüş, bitki olarak Riba çeltik çeşidi yetiştirilmiştir. 0, 20, 40, 60 ve 80 kg K_2O/ha dozlarında potasyumlu gübre K_2SO_4 formunda, 0, 20, 40, 60 ve 80 kg Mg/ha dozlarında magnezyumlu gübre MgO formunda çimlenmeden önce saksılara uygulanmıştır.

Araştırma sonuçlarına göre potasyumlu gübreleme çeltik sap ve dane verimini önemli ölçüde etkilemiş, ancak 20, 40, 60 ve 80 kg K_2O/ha dozları arasında önemli bir fark ortaya çıkmamıştır. En yüksek sap verimi 60 kg Mg/ha uygulamasında gerçekleşmiş, dane verimi açısından magnezyumun önemli bir etkisi ortaya çıkmamıştır. Potasyumlu gübreleme sap ve dane bitki besin kapsamını önemli düzeyde etkilemiş, buna karşılık magnezyum gübrelemesi çeltik saplarında K, Mg, Zn ve Mn kapsamlarına, çeltik danelerinde ise P, K, Mg kapsamlarına önemli etkide bulunmuştur. Potasyum ve magnezyum gübrelemesi ile birlikte sap ve danelerce sömürülen tüm bitki besin elementlerinin miktarı artmıştır. Çeltik danelerinde ise potasyum uygulaması sömürülen bitki besin maddeleri miktarını artırmış, magnezyum uygulaması önemli bir etkide bulunmamıştır.

Introduction

Rice is an important cereal crop in Turkey. It is cultivated in limited areas and the yields are also too low to satisfy local consumption. Hence, Turkey imports huge amounts of rice each year. During the last two decades, there has been no change in the total hecterage of rice cultivation due to water unavailability, the low prices paid to cultivators, the shortage of inputs, the unsuitability of climatic conditions at the time of sowing and harvesting, and inappropriate fertilizer application. This is particularly true for the rice grown on artificial siltation soils, since these soils are very poor in almost all nutrients. Rice is cultivated on about 35-67000 hectares and production ranges from 100 to 175000 tons, whereas yields range from 2040 to 2930 kg/ha. This is quite low compared to the yields of developed countries (1).

Siltation work is currently being carried out by the Directorate of Village Affairs of the Ministry of Agriculture of Turkey. The work is being carried out under the name of the Tokat-Niksar-Yarbaşı Project. It comprises 700 hectares. Bunds are established 250 meters apart and the silty water of the Kelkit River is

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directed to these protected areas for silt deposit. Artificial siltation areas are generally poor in nutrients. Siltation is carried out according to the decantation method, where the muddy water of a river is applied to land which is protected with soil bunds. Water is lost by leaching and evaporation, leaving the silt on the protected area. This treatment is repeated more than twice and is continued for many years in order to obtain a soil profile with different depths. As mentioned above, soils obtained through siltation for cultivation are generally poor in terms of fertility (2).

In Turkey, rice is usually grown using the broadcast method. The seeds are broadcast in standing water. When the seeds germinate, the water is drained to let the seedlings grow. Then, the fields are reflooded throughout the normal growing season. The pratice is usually employed to help seedling development after broadcast of the seed. Hence, in Turkey, this type of rice cultivation is practised because flooded land often gives more yield per hectare than unflooded land. The beneficial effect of flooding on rice growth has been attributed to the increased availability of mineral nutrients, as reported by many researchers (3).

The highest rice grain yield has been obtained with the application of 97 kg N, 62 kg P_2O_5 and 59 kg K_2O/ha rates on NPK fertilization (4). The application of 15 kg Mg/ha to rice under field conditions increased the rice grain yield by 34 percent (5). Roy and Mathur (1991) (6) applied 0, 20, 40 and 60 kg K_2O/ha to a rice crop. They obtained the highest yield with 20 kg K_2O/ha. Potassium application also increased the K uptake in this study. In another study, the maximum rice yield was obtained with 40 kg K_2O/ha NPK fertilization (7). Ahmet et al. (1991) (8) applied different P, Zn and Mg combinations to a rice crop. They reported a maximum yield with 80 kg P + 50 kg Zn + 60 kg Mg/ha.

The main object of the present study was to find out the optimum rates for potassium and magnesium fertilizers for the study area under greenhouse conditions and to continue the research work under field conditions so that recommendations on fertilizer use could be made.

Material and Methods

A greenhouse experiment was carried out in a randomised block design with two factors and 4 replications. Potassium at 0,20, 40, 60 and 80 kg K_2O/ha and magnesium at 0, 20, 40, 60 and 80 kg Mg/ha in the form of potassium sulphate and magnesium oxide respectively were applied to pots containing 5 kg of soil before the sowing of Riba rice seeds. The rice seeds (10 seeds per pot) were sown on 6th June, 1995. Phosphorus at 100 kg P_2O_5/ha in the form of triple superphosphate was also applied before sowing. In addition, half of nitrogen, 60 kg/ha in the form of ammonium suphate was applied on 17th June 1995 and the same quantity of nitrogen, in the form of urea, was applied on 3rd of August 1995. The rice crop was harvested on October 9th, 1995 (after 16 weeks).

The rice straw dry matter yield and grain yield were recorded together with analyses of some nutrients in the straw and grain (9, 10). The soil analysis was carried out according to routine methods (9, 10). The soil used in the experiment was clay-loam, containing 45.28, 32.56 and 22.16% clay, silt and sand respectively. The field capacity, wilting point, pH, $CaCO_3$, EC (25°C), organic matter content, C.E.C., and available P, K, Mg, Fe, Cu, Zn and Mn were 25.84%, 17.83%, 8.00, 24.19%, 107 µmhos/cm, 0.73%, 48.0 me/100 gr soil, and 8.50, 3.90, 2.90, 1.80, 1.27, 0.55 and 2.29 ppm, respectively. In general, the experimental soil was poor in organic matter and available P, K, Fe contents, whereas it was rich in Cu, Zn and Mn and $CaCO_3$ contents (9, 10).

Results and Discussion

Effect of K and Mg Fertilization on the Dry Matter Yield of Rice Straw and Grain

The effect of K and Mg fertilization on the dry matter yield of rice straw and grain is given in Tables 1 and 2, respectively.

Increasing rates of potassium sulphate significantly increased the rice straw dry matter yield. Dry matter yields of 15.69, 19.35, 21.44, 19.61 and 20.08 grams/pot were obtained with 0, 20, 40, 60 and 80 kg K_2O/ha respectively. Similarly, dry matter yields of 17.82, 17.96, 18.56, 21.43 and 20.43 grams straw/pot were obtained with 0, 20, 40, 60 and 80 kg Mg/ha respectively. 20 kg K_2O/ha and 60 kg Mg/ha were sufficient to increase the straw yield in this experiment (Table 1).

Different rates of potassium sulphate applied to rice crop grown on siltation soil significantly affected grain yield. A maximum grain yield of 10.82 grams/pot was obtained with 40 kg K_2O/ha of potassium sulphate compared to an 8.92 grams/pot yield for the control treatment. There were no istatistical differences between the potassium sulphate rates except with the control.

Table 1. Rice straw dry matter yield as affected by K and Mg fertilization (gr/pot).

K_2O kg/ha	Mg, kg/ha 0	20	40	60	80	Av.
0	13.32	14.71	13.92	16.60	19.86	15.69 b
20	17.28	15.75	18.97	24.61	20.15	19.35 a
40	20.85	19.85	22.14	23.46	20.90	21.44 a
60	19.54	20.32	17.35	20.50	20.36	19.61 a
80	18.09	19.14	20.40	21.96	20.83	20.08 a
Av.	17.82 b	17.96 b	18.56 b	21.43 a	20.43 ab	

LSD (K-rates): 2.672**; LSD (Mg-rates): 2.670*; LSD (K x Mg): N.S.

Table 2. Rice grain yield as affected by K and Mg fertilization (gr/pot).

K_2O kg/ha	Mg, kg/ha 0	20	40	60	80	Av.
0	8.14	8.31	7.46	10.18	10.51	8.92 b
20	10.48	9.11	10.85	11.01	10.99	10.49 a
40	10.89	10.57	11.06	12.20	9.37	10.82 a
60	10.38	10.83	10.07	10.46	9.60	10.27 a
80	10.81	10.67	10.11	10.32	9.94	10.37 a
Av.	10.14	9.90	9.91	10.84	10.08	

LSD (K-rates): 1.637**; LSD (Mg-rates): N.S.; LSD (K x Mg): N.S.

However, magnesium had no significant effect on grain yield (Table 2). These results show that potassium might have replaced the magnesium, as suggested by some researchers (11, 12, 13, 14). Dwivedi and Patel (1990) (15) obtained a maximum rice yield with 80 kg K_2O/ha. In other studies, the maximum rice yield was obtained with 60 kg Mg/ha (8, 16, 17, 18).

Effect of K and Mg Fertilization on the Nutrient Contents in Rice Straw and Grain.

The effect of K and Mg fertilization on the nutrient contents in straw and grain is given in Tables 3 and 4 respectively.

Different rates of potassium sulphate applied to the rice crop decreased the straw N content from 0.29 (control) to 0.27% (80 kg K_2O/ha); increased the P content from 0.033 (control) to 0.05% (40 kg K_2O/ha) and K content from 0.20 (control) to 0.34% (80 kg K_2O/ha) (except 20 kg K_2O/ha); decreased the Mg content from 2559 ppm (control) to 1356 ppm (80 kg K_2O/ha); increased the Fe content from 56 ppm (control) to 121 ppm (60 kg K_2O/ha); increased and then decreased the Cu content; and generally increased the Zn content. These findings are in agreement with the results of other studies (12, 19, 20, 21, 22).

Mg significantly affected only the K, Mg, Zn and Mn contents of the rice grain. The Mg content in straw increased from 1422 ppm (control) to 2255 ppm (at 80 kg Mg/ha) (Table 4). The results are in agreement with the findings (17, 18, 23, 24) of other studies.

The application of potassium sulphate had no effect on the N or Fe content of the rice grain, whereas it significantly affected the P, K, Mg, Cu, Zn and Mn content. Generally, K rates (except 40 kg K_2O/ha) had a positive effect on the grain P content. A maximum K content of 0.40 % was obtained with 20 kg K_2O/ha. Mg content increased from 2008 ppm (control) to 3598 ppm (60 kg K_2O/ha). However, it decreased with 20 kg K_2O/ha (20, 21).

Mg significantly affected the content of P, K and Mg in the grain. The Mg content increased from 2026 ppm

Table 3. Nutrient content in straw as affected by K and Mg fertilization.

K_2O kg/ha	N %	P %	K %	Mg ppm	Fe ppm	Cu ppm	Zn ppm	Mn ppm
0	0.29a	0.033c	0.29ab	2559a	56.34b	9.43c	8.12c	71.44a
20	0.29b	0.050a	0.26b	1502c	57.85b	14.44a	11.79ab	47.08b
40	0.28c	0.050a	0.33a	1964bc	83.08b	12.17b	14.21a	71.71a
60	0.28d	0.044b	0.29ab	2103b	121.20a	8.29c	12.22ab	72.46a
80	0.27e	0.035c	0.34a	1356d	91.22ab	8.11c	10.91bc	53.40ab
LSD	0.002*	0.007**	0.054**	430.15**	33.41*	2.75**	2.89**	21.95**
Mg, kg/ha								
0	0.28	0.035c	0.31ab	1422c	71.72	10.75	10.57b	79.11ab
20	0.28	0.037c	0.28b	1949ab	68.25	10.63	9.98b	50.41c
40	0.28	0.042b	0.27b	1734b	86.92	10.45	13.55a	45.92c
60	0.29	0.045b	0.30b	2123a	89.27	10.51	11.72ab	57.85bc
80	0.29	0.053a	0.35a	2255a	93.54	10.10	11.43ab	82.80a
LSD	N.S.	N.S.	0.072**	560**	N.S.	N.S.	2.17**	32.75**

**; Significant 1 % Level, *; Significant 5 % Level; N.S.; Non-significant.

Table 4. Nutrient content in grain as affected by K and Mg fertilization.

K_2O kg/ha	N %	P %	K %	Mg ppm	Fe ppm	Cu ppm	Zn ppm	Mn ppm
0	0.94	0.19b	0.39a	2008cd	44.27	11.46b	31.93ab	34.66a
20	0.97	0.19b	0.40a	1775d	46.22	11.77b	34.02a	32.85ab
40	1.58	0.17b	0.34b	2376c	34.03	14.72ab	33.86a	34.08a
60	0.94	0.25a	0.35b	3598a	45.11	14.60ab	32.76a	32.89ab
80	0.94	0.26a	0.40a	2832b	27.97	17.45a	29.56b	30.38b
LSD	N.S.	0.007**	0.031**	876**	N.S.	3.38**	2.93*	3.46*
Mg, kg/ha								
0	0.95	0.21b	0.40a	2026c	37.87	12.94	31.92	32.48
20	0.94	0.22ab	0.37ab	2257c	39.04	13.59	33.42	32.53
40	0.95	0.21b	0.37ab	2610b	42.96	15.00	31.73	32.22
60	0.59	0.20b	0.36b	2597b	43.67	15.00	32.62	33.41
80	0.95	0.23a	0.40a	3099a	34.04	13.48	32.44	33.22
LSD	N.S.	0.043**	0.045*	950**	N.S.	N.S.	N.S.	N.S.

**; Significant 1 % Level, *; Significant 5 % Level; N.S.; Non-significant.

(control) to 3099 ppm (80 kg Mg/ha), (Table 4). The results are parallel with other previous findings (17, 18, 24).

Effect of K and Mg Fertilization on the Uptake of Nutrients in Rice Straw and Grain

The effect of K and Mg fertilization applied to the rice crop on the uptake of some nutrients in rice straw and grain yield is given in Tables 5 and 6, respectively.

Increasing rates of potassium sulphate fertilizer significantly increased the uptake of nutrients in straw. Magnesium oxide applied at different rates also increased the uptake of nutrients (except for Cu). This was mainly dependent on the dry matter yield and nutrient content of the straw. N uptake increased from 45.54 (control) to a maximum of 60.93 mg/pot (40 kg K_2O/ha rate), P uptake increased from 5.42 (control) to 10.85 mg/pot (60 kg K_2O/ha) and Mg uptake decreased from 42.49 (control) to 21.17 mg/pot (80 kg K_2O/ha). The decrease in Mg uptake can be attributed to the antagonistic effect of potassium (6, 13, 19, 20, 21).

Mg fertilizer increased the N, P, K, Mg and Fe uptake, whereas it decreased the uptake of Mn in straw (17, 18, 23, 24).

The application of different rates of potassium sulphate fertilizer increased the N, P, K, Mg, Cu, Zn and Mn uptake in the grain. However, Fe uptake has been found to decrease (6, 19, 20). Magnesium significantly affected only N uptake in grain (Table 6). The N uptake increased from 96.70 (control) to a maximum of 105.10 mg/pot at the rate of 80 kg Mg/ha (17, 18, 24).

In conclusion, potassium and magnesium fertilization increased the dry matter yield and micronutrient uptake by rice plants in the artificial siltation soils created by the silty water of the Kelkit River. This treatment can increase rice production, especially in artificial siltation areas poor in nutrients. Increasing rates of potassium significantly increased the rice straw dry matter and grain yield when compared to the control treatment. However, there were no differences between the potassium treatments (20, 40, 60 and 80 kg K_2O/ha). Magnesium significantly affected the rice straw yield. The maximum rice straw yield was obtained with 60 kg Mg/ha. Mg treatment had no significant effect on the rice grain yield. It was also found that the macro and micro nutrient contents and uptakes of straw and grain were significantly affected by K and Mg fertilization. This research is the first in a number of regional studies, and further detailed studies under field conditions in these areas will follow.

Table 5. Nutrient uptake in straw as affected by K and Mg fertilization.

K_2O kg/ha	N	P	K	Mg	Fe	Cu	Zn	Mn
		mg/pot				µg/pot		
0	45.54b	5.42c	48.76c	42.49a	866c	155b	132c	1135ac
20	55.93a	9.85a	49.68c	29.55b	1156bc	275a	227b	885c
40	60.93a	10.85a	71.43a	42.45a	1814ab	261a	295a	1530a
60	54.66a	8.64ab	56.90bc	41.18a	2367a	163b	234b	1388ab
80	54.78a	7.23bc	67.93b	27.17b	1853ab	161b	210b	1064bc
LSD	8.72**	2.17**	12.83**	9.55**	731**	36.67**	59.30**	398**
Mg, kg/ha								
0	49.55b	6.21c	56.11b	25.16c	1287b	197	185bc	1332ab
20	50.00b	6.93c	51.45b	34.94b	1245b	190	182c	914c
40	51.06b	7.99bc	51.12b	32.14b	1637ab	195	255a	903c
60	61.58a	9.98ab	62.59ab	44.33a	1934a	228	245ab	1183bc
80	59.64a	10.89a	73.44a	46.27a	1953a	205	233ac	1672a
LSD	7.75**	2.28**	12.83**	10.03**	548.0*	N.S.	59.30**	398**

**; Significant 1 % Level, *; Significant 5 % Level; N.S.; Non-significant.

Table 6. Nutrient uptake in grain as affected by K and Mg fertilization.

K_2O kg/ha	N	P	K	Mg	Fe	Cu	Zn	Mn
	mg/pot					µg/pot		
0	83.89b	17.38b	35.46b	18.48c	364	101c	281c	306b
20	102.00a	20.20b	42.41a	18.81c	464	124c	355ab	345ab
40	104.40a	18.32b	37.01ab	25.46b	360	157ab	367a	368a
60	96.76a	25.87a	36.05b	36.80a	470	151ab	336ab	338ab
80	92.26a	26.24a	42.47a	29.16ab	291	180a	306bc	318ab
LSD	10.21**	3.76**	11.98**	11.00**	N.S.	36.5**	47.1*	46.4*
Mg, kg/ha								
0	96.70b	21.01	40.83	21.05	365	132	322	330
20	92.87b	22.00	36.46	22.86	385	136	328	322
40	93.98b	20.24	37.17	26.01	393	150	314	328
60	105.10a	21.69	38.47	27.98	470	162	355	360
80	95.66b	23.07	40.47	30.82	335	134	326	335
LSD	7.66**	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.	N.S.

**; Significant 1 % Level, *; Significant 5 % Level; N.S.; Non-significant.

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