OnLine Journal of Biological Sciences 1 (12): 1112-1115, 2001

Potassium Deficiency and Response of Rice to its Application in Hafizabad District

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Abstract: Potassium deficiency symptoms were observed on rice 1999 in a number of fields throughout the Hafizabad district. Soil and plant samples from 98 rice fields showing K deficiency symptoms were collected. These soil and plant sample were analyzed for K contents. All the 98 plant samples had low K contents according to critical limits while soil samples were tested medium in ammonium acetate (CH_3-CO-O-NH_4) extractable K. In the same year K was applied to rice crop @ 62.5 Kg ha^{-1} showing K deficiency symptoms at 11 sites. The paddy and straw yields improved from 4.17 to 36.20 % and 2.94 to 40.0 % over control by the application of K, respectively. Similarly K concentration also increased in both paddy and straw over control, by applying K, from 18.75 to 36.59 % and 6.70 to 14.46 % respectively. Potassium uptake by paddy and straw yields and total K uptake also increased by applying K over control.

Key words: Potash deficiency, rice, K application

Introduction

There is a general consensus that most of the cultivated soils in Pakistan have sufficient supply of available K for optimum plant growth (Bhatti, 1978). The need for K is not as wide spread as that for N and P in Pakistan, most probably due to the dominance of hydrous mice in the clay fraction. Its use as fertilizer was introduced in 1966-67 (Saleem and Bertillson, 1978). In term of usage per hectare cropped area, K consumption in 1985-86 was about 2.04 Kg ha^{-1} (Saleem *et al*., 1989). While exploring the K status in Punjab (Pakistan), the analysis of the thousands of samples during 1973 to 1978 showed that K values of ammonium acetate (CH_3-CO-O-NH_4) extractable ranged from 142 to 160 ppm in the surface 0-15 cm depth (Bhatti, 1978). Accordingly, the soils of Punjab are classified adequate in available K status. Since no work has been done on critical limits of K, therefore, limits adopted by the Rapid Fertility Survey and Soil Testing Institute, Lahore are those of Tamhane and Subbiah (1960). According to these limits, soils containing less than 50 ppm K are categorized as poor, 50-125 ppm satisfactory and greater than 125 ppm as adequate. Soil analysis further revealed that continuous mining of K through crops significantly depleted the soil K with time. This trend showed a decline of 8.6 ppm K ha^{-1} annually (Malik *et al*., 1989). In another effort to characterize the K status of Pakistan soils the Fuji Fertilizers Corporation (Sadiq, 1985) analyzed 4,583 samples for K status. The results showed that nearly 90 % of the samples representing different areas in the four provinces contained more than 100 ppm K_2O, less than 1 % of the samples had less than 30 ppm K_2O and about 11 % with less than 100 ppm K_2O. The above K values, however, have not been correlated with crop response.

On soils where present K levels are considered adequate, the increased use of other fertilizers and production inputs can quickly shift the soil K status from one of the adequacy to that of deficiency. Intensive cropping with irrigation and improved verities and higher application rates of N and P may hasten the removal of K from the reserve supply, thus requiring the use of K fertilizers to sustain economical crop production (Malik *et al*., 1989). However Ahmad (1996) observed that plant growth parameter remained unaffected by K application. Since no K is applied particularly to rice which is a short duration crop and its requirement for K are more than long duration crops like wheat. Therefore it is prone to K deficiency the research work was undertaken to find out the. a) the K status of Hafizabad district. b) K contents of soil and plant showing K deficiency symptoms. c) Rice response to K application in K different fields.

Materials and Methods

Potassium deficiency symptoms were observed on rice crop 1999 in a number of fields all over the Hafizabad district. From these K deficient fields, soil and plant samples were collected from 98 selected sites. The plant samples were collected from 8 plants at each site by taking 4 leaves after leaving upper fresh 3 leaves from each plant. The soil samples were taken upto 0-15 cm depth from 4 places in the same fields where plant samples were collected to make a composite sample. These samples were collected in the months of July, August and September at an interval of 10 days. Moreover K deficiency symptoms were noted in the fields in which the rice was transplanted 25 to 45 days previously. The varieties of rice used by farmers were Super (15 plots), Basmati 385 (54 plots), IRRI – 6 (16 plots), Basmati 386 (5 plots, Niab IRRI – 9 (4 plots), Satthi (2 plots) and Shaheen Basmati (2 plots). These samples were taken to laboratories, first air-dried and then the plant samples were oven dried to constant weight at 65°C. K contents from soil and plant samples were determined.

During the same year K response trials at 11 selected sites were conducted on rice. Each plot was divided into two equal portions. To one portion K was applied as MOP @ 62.5 Kg K ha^{-1} while other was kept as control. Soil analyses of all the sites were done, paddy and straw samples were analyzed for K contents. All the analysis were done according to methods described in hand book No.60 (U. S. Salinity Lab., 1954) except texture by Moodie *et al*. (1959).

Results and Discussion

Potash deficiency survey: The data of surveyed 98 soil and plant samples each, showed that four soil samples were saline sodic (EC > 4 d S m^{-1} and SAR > 13 (m mol l^{-1}) ^{½} and 47 were sodic (EC < 4 d S m^{-1} and SAR > 13 (m mol l^{-1}) ^{½} (Table 1). All the soil samples were medium in available K according to the standards used by Tamhane and Subbiah (1960). Texturally all soil samples were sandy loam to loamy sand with a few sandy clay loams. In case of all the 98 plant samples collected had low K contents according to limits prescribed by Bhargava and Raghupathi (1993).

The reason for low K contents in plants and medium supply of K by soil samples indicate that K deficiency occurred due to continuous mining of K from these soils. More over all soils are loose textured in which leaching of K can occurred during flooding a pre requite of rice. Another important factor for K deficiency in this area is that K was never applied to soil upto conduct of survey. Malik *et al*. (1989) also gave similar

Table 1: Potassium deficiency survey

Name & address	Texture	pH	Ec (dSm^{-1})	SAR ($m\ mol^{-1})^{½}$	K in leaves (%)	Available K ($mg\ Kg^{-1}$ soil)	Variety
Noor Din, Thatta Karim Dad	Sandy loam	8.8	2.2	17	1.02	96	Super
Nazir S/O Mian Khan, Haveli Karim Dad	Sandy loam	8.1	3.6	29	0.80	84	Super
Muhammad Arshad, Haveli Karim Dad	Loamy sand	8.7	3.1	26	0.60	79	IRRI-6
Ch.Abdul Ghafoor, Haveli Karim Dad	Sandy loam	8.2	2.9	22	1.05	90	Super
Hayat Muhammad, Hinduana	Sandy loam	8.3	2.3	19	1.15	105	Bas.385
Mehr Mula Dad, Jhandwala	Sandy loam	8.1	4.1	33	1.00	97	Bas.385
Ahmad Din, Hinduana	Sandy loam	8.3	3.6	29	1.16	100	Bas.385
Muhammad Anwar S/O Malla, Hinduana	Loam	8.1	3.1	33	1.05	86	Bas.385
Muhammad Salahat Boon S/O Shah Muhammad, Sharbagha	Sandy loam	8.8	3.4	28	0.86	75	Bas.385
Muhammad Salahat Boon S/O Shah Muhammad, Sharbagha	Sandy loam	8.1	2.1	19	0.90	77	IRRI-6
Bashir Ahmad, Kot Murad	Loamy sand	8.1	1.9	14	0.98	82	Bas.385
Muhammad Ashiq, Kot Murad	Loamy sand	8.1	1.8	11	1.05	89	Bas.385
Zafar Iqbal, Chah Anna	Sandy loam	8.8	1.2	9	1.0	92	386
Talib Gujjar, Kot Nakhah	Loam	8.0	1.1	13	0.95	87	Bas.385
Muhammad Riaz, Bohopra	Sandy loam	8.9	3.9	21	1.20	103	Niab IRRI-9
Muhammad Iqbal Manika, Nothain	Sandy loam	8.1	2.1	17	0.80	88	386
Malik Muhammad Rasib, Nothain	Loamy sand	8.2	2.3	20	1.0	91	386
Nawaz Arain, Addoke	Loam	8.4	3.4	26	1.26	114	Niab IRRI-9
Majeed Ali Haider, Thatta Manika	Sandy loam	8.9	3.6	25	0.88	79	Bas.385
Sadi Ahmad, Kalika Village	Sandy loam	8.8	3.1	29	0.85	84	Super
Muhammad Ali Number Dar, Nahrianwala	Sandy loam	8.1	3.1	30	0.96	90	Bas.385
Ahmad Ali, Tibbi Goria-Batianwala	Loamy sand	8.1	2.1	16	1.15	94	Super
Ch.Amin Nawaz Tarar, Rasul Pur Tarar	Loamy sand	8.3	1.0	14	0.80	79	Super
Abdul Rasool Jat, Jharianwala	Sandy loam	8.3	1.2	9	0.88	82	IRRI-6
Hafeez Ahmad, Winge	Sandy loam	8.9	3.6	27	0.90	81	Bas.385
Asghar S/O Maula Dad, Channi Hanjran	Sandy clay loam	8.0	2.1	21	0.90	81	IRRI-6
Malik Muhammad Adris, Winge	Loamy sand	8.1	2.1	16	1.05	89	Bas.385
Ghulam Rasool Tarar, Dheerinke	Loam	8.6	2.6	14	1.16	105	IRRI-6
Muhammad Afzal Number Dar, Beriwala	Loamy sand	8.8	2.8	11	0.65	70	Bas.385
Mumtaz S/O Fateh Muhammad, Bukkan	Loamy sand	8.1	4.1	29	0.90	75	IRRI-6
Nazir Ahmad S/O Muhammad Khan, Koot Ishaq	Sandy loam	8.1	1.0	8	1.18	100	IRRI-6
Muhammad Rafiq Chatha, Mehdiabad	Sandy loam	8.7	3.6	19	1.10	101	Bas.385
Muhammad Ahsa, Mehdiabad	Sandy loam	8.1	2.1	14	0.80	77	Bas.385
Allah Dad Khokhar, Pindi Sadrana	Loamy sand	8.0	4.1	30	0.75	75	IRRI-6
Sana-Ullah, Jogi Jamke	Loamy sand	8.1	1.0	9	0.78	77	Satthi
Mian Iqbal Hussain, Tibba Shah Behlol	Loam	8.9	1.6	19	0.96	90	IRRI-6
Mian Ifzal Hussain, Shah Behlol	Sandy loam	8.8	3.6	26	1.14	100	Bas.385
Sher Muhammad, Shah Behlol	Loamy sand	8.6	2.9	19	1.0	91	Satthi
Murtaza S/O Shamir, Shah Behlol	Loamy sand	8.8	3.4	21	0.60	78	IRRI-6
Tufail S/O Mirza, Sahuka	Sandy clay loam	8.3	2.1	15	0.78	70	Bas.385
Gehangir S/O Saring, Bharke Sargana	Loamy sand	8.1	1.6	14	0.80	76	IRRI-6
Karm-Ullah, Kanda Bhattian	Sandy loam	7.9	1.1	7	0.86	90	Bas.385
Malla, Kanda Bhattian	Sandy loam	8.3	1.6	11	0.74	79	IRRI-6
Haji Churagh, Kanda Bhattian	Loamy sand	8.2	2.3	17	1.15	100	Bas.385
Abdul Chishti, Kanda Bhattian	Loamy sand	8.4	3.1	21	1.20	104	Bas.385
Muhammad Ashraf Lohar, Pindi Bhattian	Sandy loam	8.3	2.6	15	0.86	80	Bas.385
Nujam-Ul-Hassan Bhatti (Master Ahmad Contractor), Pindi Bhattian	Sandy loam	8.1	1.3	9	0.60	75	IRRI-6
Mian Intisar Hussain Bhatti, Pindi Bhattian	Sandy loam	8.2	1.1	7	0.78	76	Bas.385
Ghulam Shabbir Lohar, Behlolpur	Sandy loam	8.1	1.4	10	0.80	75	Bas.385
Mirza Muhammad Ashraf, Bahlolpur	Loamy sand	8.4	2.1	17	1.15	103	Bas.385
Khan Muhammad, Praim Kot (Pippli)	Sandy loam	8.2	1.9	13	1.25	106	386
Muhammad Nawaz, Mulo	Sandy loam	8.1	1.0	7	0.60	70	Bas.385
Noor Muhammad, Mulo	Loamy sand	7.9	1.2	11	1.0	104	Bas.385
Muhammad Akram, Kolo Tarrar	Loamy sand	8.0	1.5	14	1.02	97	386
Muhammad Nazir, Kolo Tarrar	Loam	8.1	1.6	20	1.0	95	Niab IRRI-9
Muhammad Sharif, Kolo Tarrar	Loamy sand	8.2	1.1	8	0.86	81	Bas.385
Niaz S/O Chanda, Kot Chian	Sandy loam	8.1	1.0	7	0.80	85	IRRI-6
Sheikh Raisar Iqbal, Dauluwala	Sandy loam	8.0	1.3	9	0.90	84	Bas.385
Bashir Charera, Jhottianwala	Sandy loam	8.2	1.4	10	0.80	77	Bas.385
Mansib Ali, Machehonikka	Loam	8.1	1.6	11	0.80	82	Super
Nawaz S/O Maula Dad, Machehonikka	Sandy loam	8.1	1.0	7	1.15	101	IRRI-6
Tahir Abbas, Barshi (Badar Ali)	Loamy sand	8.2	1.7	10	1.15	103	Bas.385
Zafar Iqbal, Chukarian	Sandy loam	8.4	3.2	21	1.0	95	Bas.385
Khan Muhammad, Thabal	Sandy loam	8.7	4.1	30	1.25	104	Bas.385
Muhammad Yousaf, Bagh Kohna	Sandy loam	8.5	4.3	31	1.05	100	Bas.385
Muhammad Iqbal, Bagh Kohna	Loamy sand	8.6	2.2	16	0.40	65	Bas.385

Nusrullah, Thatta Asalatka	Loamy sand	8.4	2.1	14	0.50	69	Bas.385
Muhammad Arif, Thatta Asalatka	Loam	8.1	1.4	7	1.15	100	Bas.385
Dr.Yaqub, Thatta Asalatka	Sandy loam	8.2	1.2	6	1.02	96	IRRI-6
Allah Ditta S/O Slam, Dhalkan Kala	Sandy loam	8.3	3.1	21	0.75	76	Bas.385
Muhammad Anwar, Tahli Goria	Sandy loam	8.6	3.2	24	0.90	97	Bas.385
Muhammad Nazir Ahmad, Tahli Goria	Sandy loam	8.4	2.6	16	0.85	89	Bas.385
Amir Ahmad, Thatta Mona Slubat	Loamy sand	8.4	3.5	19	0.85	80	Bas.385
Nazir Ahmad, Thatta Mona Slubat	Loamy sand	8.1	2.7	13	1.0	92	IRRI-6
Mian Ehsan, Pindi Bhattian	Sandy loam	8.2	1.9	9	0.60	70	Bas.385
Jehangir Khan, Bagh Nao	Sandy clay loam	8.1	1.0	6	0.80	71	Super
Muhammad Zulfqar, Kot Dilawar Bas.385	Loam	8.1	1.2	8	0.85	79	
Sultan & Ashraf, Kot Dilawar	Loam	8.0	1.1	7	0.60	70	Super
Muhammad Sarwar, Kot Hussain	Sandy loam	8.2	2.3	14	0.78	84	Bas.385
Bahawal, Dilu Khurd	Sandy loam	8.4	3.2	20	1.20	103	Super
Yaqub, Kot Nizam	Sandy loam	8.6	3.6	17	0.54	66	Bas.385
Abdus-Sattar, Kot Nizam	Sandy loam	8.0	1.0	6	1.05	100	Bas.385
Mehmood S/O Ahmed, Kot Baila Bas.385	Sandy loam	8.1	1.1	7	1.0	91	
Muhammad Boota, Lundawala	Sandy loam	8.1	1.0	6	0.96	95	Bas.385
Ghous Muhammad, Lundawala	Loamy sand	8.15	1.3	7	1.0	93	Bas.385
Ghulam Miran, Thatta Karim Dad	Sandy loam	8.2	1.2	7	0.88	80	Bas.385
Zahoor Ahmad, Thatta Karim Dad	Sandy loam	8.0	1.1	6	1.25	104	Super
Falak Sher, Thatta Karim Dad	Sandy loam	8.4	2.1	10	1.15	100	Bas.385
Muhammad Nawaz, Thatta Karim Dad	Sandy loam	8.2	1.7	9	0.95	91	Super
Muhammad Sharif, Makamwala	Sandy loam	8.1	1.3	9	0.87	82	Shaheen
Sultan Ali, Makamwala	Sandy loam	8.1	1.2	7	0.68	74	Bas.385
Khizur Hayat, Makamwala	Loam	8.2	1.6	9	0.96	85	Shaheen
Mehnda Khan, Makamwala	Sandy loam	8.1	1.9	7	1.0	92	Super
Bashir Ahmad, Makamwala	Sandy loam	8.2	1.1	6	1.20	109	Super
Muhammad Jamil, Haveli Karim Dad	Sandy loam	8.1	1.0	5	0.86	77	Bas.385
Mian Ehsan, Pindi Bhattian	Sandy loam	8.1	1.6	8	1.0	94	Bas.385
Muhammad Sultan, Kot Dilawar	Sandy loam	8.0	0.7	4	1.02	94	Super
Muhammad Nazir, Dhalka Khurd	Sandy loam	8.2	1.4	8	0.96	90	Bas.385

SAR = Sodium adsorption ratio EC = Electrical conductivity of saturation extract Bas. = Basmati K = Potassium

Table 2: Response of rice to K application

Name of site	pH	EC (dS m^{-1})	SAR (m mol l^{-1})	Extractable (K mg kg^{-1})	Paddy (t ha^{-1})			Straw (t ha^{-1})		
					Control	K Applied	% increase over control	Control	K Applied	%increase
Ghulam Miran, Haveli Karim Dad	8.2	1.2	7.0	80	4.7	5.1	8.51	13.5	15.0	11.11
Zahoor Ahmad, Haveli Karim Dad	8.0	1.1	6.0	104	4.5	4.8	7.77	12.0	13.5	12.50
Falik Sher, Haveli Karim Dad	8.4	2.1	10.0	100	1.8	2.0	8.11	5.0	5.5	10.00
M. Nawaz, Haveli Karim Dad	8.2	1.7	9.0	91	2.4	2.5	4.17	6.8	7.0	2.94
M.Sharif, Makam Wala	8.1	1.3	9.0	82	3.9	4.3	10.26	11.0	12.9	17.27
Sultan Ali, Makam Wala	8.1	1.2	7.0	74	4.5	4.8	6.67	12.7	13.7	7.45
Khizar Hayat, Makam Wala 40.00	8.2	1.6	9.0	85	1.6	2.2	37.5		4.5	6.3
Mehnda Khan, Makam Wala	8.1	1.9	7.0	92	2.8	3.3	17.85	8.0	9.4	17.50
Bashir Ahmad, Makam Wala	8.2	1.1	6.0	109	2.5	2.8	12.00	7.5	8.1	8.00
M.Jamil, Haveli Karim Dad	8.1	1.0	5.0	77	2.9	3.9	36.20	8.2	9.8	19.51
Mian M.Ehsan, Pindi Bhattian.	8.1	1.6	8.0	94	2.7	3.6	35.19	7.9	8.8	11.39

Table 3: K concentration, K uptake by paddy and straw and total K uptake by rice plants.

K in Paddy (%)			K in straw (%)			K uptake by paddy (Kg ha^{-1})		K uptake by straw (Kg ha^{-1})		Total K uptake	
Control	K Applied	% increase over control	Control	K Applied	% Increase over control	Control	K Applied	Control	K Applied	Control	K Applied
0.50	0.61	22.00	1.60	1.82	13.75	23.5	31.11	216.00	273.00	239.5	304.11
0.52	0.68	30.76	1.70	1.85	8.82	23.4	32.98	204.00	249.75	227.4	282.73
0.47	0.60	27.66	1.65	1.78	7.88	8.70	12.00	82.50	97.90	91.2	109.9
0.49	0.62	26.53	1.64	1.75	6.70	11.76	15.50	111.52	122.50	123.28	138.00
0.44	0.58	31.82	1.59	1.70	6.92	17.16	24.94	174.90	219.30	192.06	244.24
0.41	0.56	36.59	1.56	1.69	8.33	18.45	26.88	198.90	231.53	217.35	258.41
0.48	0.57	18.75	1.59	1.78	11.95	7.68	12.54	71.55	112.14	79.23	124.68
0.50	0.63	26.00	1.67	1.89	13.17	14.00	20.79	133.6	177.66	147.6	198.45
0.54	0.69	27.77	1.66	1.90	14.46	13.50	19.32	124.5	153.9	138.0	173.22
0.41	0.57	31.71	1.59	1.76	10.69	11.89	22.51	130.38	172.48	142.27	194.99
0.48	0.59	22.92	1.62	1.84	13.58	12.96	21.54	127.98	161.92	140.94	183.44

reasons for K fertilization in Punjab soils.

The correlation between extractable K and K in plants was also calculated (Steel and Torrie, 1986) which was highly significant having value of r = 0.73 at 5 % level of probability. The regression equation was computed for these data, which is:

$$Y = 0.079 + 0.0113 X$$

Where Y = K concentration in plant
X = K in soil (Extractable)

This equation is helpful in determining K fertilizer requirement of particular rice field if its extractable K contents are known e.g. soil extractable K = 80 mg Kg^{-1} soil.

The K requirement will be determined as

$Y = 0.079 + 0.0113 x$
$Y = 0.079 + 0.0113 X 80$
$Y = 0.983$

It means plants will have K = 0.983 % if the plant is not suffering from K deficiency and if it will have K contents e.g., = 2.0 %

Difference = 2.0 – 0.983
= 1.017

$Y = 0.079 + 0.0113 X$
$1.017 = 0.079 + 0.0113 X$
$1.017 - 0.079 = 0.0113 X$
$0.932 = 0.0113 X$
$X = 0.932/0.0113 = 83$ mg Kg^{-1} soil.

One hundred and sixty six Kg ha^{-1} has to be applied to obtain the targeted yield in these types of soils (Coarse textured).

Response of rice to application of K.

Paddy and straw yield of rice: Response of rice to K applied was studied at 11 sites. The data indicated that all the fields were free from salinity/sodicity hazard, having extractable K 74 to 109 mg Kg^{-1} soil "medium supply of K" (Table 2). The paddy and straw yield was improved at all the sites by applying 62.5 Kg K ha^{-1}. The increase in paddy yield was from 4.17 to 36.20 % over control. While in case of straw it was 2.94 to 40 % over control. The increase in paddy and straw yield by applying K was also reported by Malik *et al.* (1989) and Mehdi *et al.* (2001). The data further revealed that yield of paddy and straw was not dependent on the original level of K, rather depend on total fertility status of soil.

Potassium concentration and its uptake by paddy and straw of rice: Potassium concentration in paddy and straw of rice increased by applying K at all the 11 sites (Table 3). The K concentration in paddy increased by 8.75 to 36.59 % over control while in straw this increased from 6.70 to 14.46 %. The K percentage increased in paddy was more than straw. Many workers also have reported that an increase in K contents by the application of K (Shakir, 1984; Mehdi *et al.*, 2001). These workers noted that increase in K contents upto 75 mg K Kg^{-1} soil in some instance. Potassium uptake was also calculated by multiplying percentage of K with yield and dividing by 100.The data showed that there was an increase in K uptake by both paddy and straw over control when K was added. Total K uptake by rice plant was also computed by adding K uptake by paddy and straw, which also showed an increase in total K uptake by the application of K over control. The difference between K uptake by control plants and K applied plants did not exceed the K application rate. Similar findings were reported by Mengel (1982) and Mehdi *et al.* (2001). These results of K deficiency survey and response of rice to K application lead to do further investigations on K application rate required in these soils for optimum paddy and straw yield of rice. The computed value of K by regression equation may also be tested.

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