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Evaluation of various concentrations of ammonium acetate in potassium extraction and its critical levels determination in some of paddy soils

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ABSTRACT: An investigation was undertaken to evaluate different concentrations of extractant ammonium acetate (NH_4OAc) for available potassium and critical levels of potassium for wetland rice soils of Guilan province in north of Iran. Some 35 soils from 0-30 cm depth were collected from different location paddy soils. Potassium in the soils was extracted with normal ammonium acetate. Based on soils were grouped in low, medium and high potassium. Finally, 19 soil samples were selected for micro plot experiment. Micro plot experiment with 2 treatment (0 and 250 mg K kg^{-1} of soil) and 3 replicates was performed. In this experiment, concentrations 0.1, 0.25, 0.5 and 1M extractant ammonium acetate were used for extraction potassium. Results showed that in most soils K application increased grain and straw yield and K uptake in rice plant. High correlation were observed between different concentrations of extractant ammonium acetate (NH_4OAc) with K uptake and concentration in rice plant and provided useful indicators for evaluating K. The critical level of soil K was determined graphical method (Cate and Nelson). For rice, the values of critical limit were 120,119,109 and 105 mg kg^{-1} for concentrations 1, 0.5, 0.25 and 0.1 M extractant ammonium acetate respectively.

***Keywords*:** Available potassium, Extractant, Rice, Paddy soil

INTRODUCTION

Potassium is the most important macronutrient cation in plant growth and development. As cropping intensity increases, there will be a greater demand for K to sustain increased productivity. Potassium fertility of paddy soil of Iran is progressively depleting due to the heavy withdrawal of potassium from soil under intensive cultivation, and may become a limiting factor in crop production.

The ability of soils to supply K to plants depends on K in solution, exchangeable K and a substantial amount of non-exchangeable K (My Hoa, 2003). These forms or fractions are supposed to be related to each other. Soils differ in terms of power supply and potassium supply to plants. Therefore, understanding the different soils can provide essential nutrients needed to produce ever more important. Soil testing has been recognized as an effective tool for determining fertilizer need of a crop under all situations, but its importance is by far the greatest in circumstances when the fertilizer is a scarce and costly commodity with respect to the farmer's investment ability. The main objectives of soil test crop response correlation study was to obtain a basis for precise quantitative adjustment of fertilizer doses for varying soil test values in farmer's fields as well as to help cultivators to increase their production and profit considerably through economic and judicious use of fertilizers. Many attempts have been made to find the best method for measuring plant- available K, using different extraction solutions. In many countries, 1 *M* NH_4OAc is considered the best option for routine soil testing purposes (Eckert and Watson, 1996; Hosseinpur and Samavati, 2008). The success or failure of a soil extractor is probably related to different forms of soil K depending on the type and amount of soil minerals. The correlation between K extracted by each extractant and its uptake by plants as an important criteria for choosing an extractant is mentioned (Zarrabi and Jalali, 2008). After choosing an extractor, determination of the critical concentration of nutrients in the soil to predict plant response to chemical fertilizers and optimum fertilizer recommendation and ultimately enhance performance and improve the quality of the product is necessary. Bandara et al (2009) reported that Critical K levels in paddy fields of Asia are between 100 to120 mg kg^{-1} of potassium. In a field experiment in 20 regions of India with fertilizer treatments of 0 and 50 mg K kg^{-1} critical concentration of exchangeable K 160 mg kg^{-1} obtained with the NH_4OAc extractant (Bansal et al., 1985). The critical concentration depends on several factors including the type extractants, for extractant selection in addition to soil characteristics, economic justification should be considered.

MATERIALS AND METHODS

Some 19 soils (0-15 cm depth) were collected from different location of paddy soils of Giulan province in north of Iran. These soil samples were air dried ground, passed through a 2 mm sieve and thoroughly mixed. To see the usefulness of the different concentrations of extractant ammonium acetate (NH_4OAc) and also to determine the critical level of soil potassium for wetland rice (Hashemi CV.), a micro plot culture experiment was conducted with each soil. There were two K treatments viz., 0 and 250 mg K kg^{-1}. Each of the treatments was replicated thrice in a CRB to give a total of 114 micro plots. A basal dressing were added in solution through urea, potassium sulfate, and triple super phosphate respectively and mixed thoroughly with the soil to support the normal plant growth. Three forty five day old seedlings were transplanted in each plot. All plots were kept submerged with water to a depth of 5 cm. Weeds were removed as they appeared.

After physiological maturity plants were cut at ground level followed by washing with distilled water and drying in an oven at 65 C for 24h. The grain and straw yield and K uptake in their were recorded. Available potassium of soil was extracted by different concentrations of NH_4OAc include 0.1, 0.25, 0.5 and 1 M. The potassium in the extract was determined flam photometer. The critical level of extractable K for rice was determined by graphical approach. In this method the critical level of extractable K as determined by different concentrations of NH_4OAc extraction procedures were calculated separately using the procedure developed by Cate and Nelson (1971). According the relative yield was calculated from the following relationship.

$$\% \text{ Relative yield} = \frac{\text{yield without K}}{\text{yield with K}} \times 100$$

RESULTS AND DISCUSSION

The pH of the soils varied from 6.2 to7.6; organic carbon, 1.01 to 3.42%; total N, 0.108 to 0.381%; available P, 4 to 44 ppm, exchangeable K, 54 to 285 ppm (Table 1). The amount of extractable K varied markedly depending on the soils and the extraction methods used (Table 2). This is expected because various extractants differ in their extracting power according to conditions of extraction chosen (Kuhsar Bostani ,2003). The 1*M* NH_4OAc extracted the maximum amount of K and the 0.1*M* NH_4OAc did the minimum. The mean values of K extracted by different concentrations of NH_4OAc ranked in the order of 45-373 mg kg^{-1} and Average extractable potassium in soils was 149 mg kg^{-1} (Table 2). Ustan (1994) in the study on the removal of potassium from the paddy soils of the north of Iran by 52 soil samples reported that the average potassium utilized soil was 146 mg kg^{-1}**.** Tofighi (1999) determined the mean potassium extracted by 1*M* NH_4OAc 133 mg kg^{-1} by comparing four chemical extracts to estimate the potassium available in paddy soils in north of Iran. This value was reported by Shokri Vahed (2002) for a Khazar cultivar in Guilan province of 138 mg kg^{-1}**.** According to the results of analysis of variance (Table 3), there is a significant difference between soils at 1% level and potassium consumption on measured characteristics such as grain and straw yield levels at 5% and 1% respectively, potassium uptake and potassium concentration of straw have a significant effect on 1% level.

Table1. Some of physical and chemical soil properties

Soil properties	Unit	Range	Mean
Clay	%	8 - 44	30.63
Ava.K	mg kg^{-1}	54 - 285	149
Ava.P	mg kg^{-1}	4 - 44	17
Total Nitrogen	%	0.108 - 0.381	0.222
Cation Exchange Capacity	Cmol kg^{-1}	20 - 44	32
Organic Carbon	%	1.01 – 3.42	2.09
Electrical Conductivity	dS m^{-1}	0.7 – 2.4	1.1
pH	-	6.2 – 7.6	7.0

Table 2. Range and mean of K (mg kg^{-1}) extracted by different concentrations of (NH_4OAc) from 19 soils

Location	1*M* NH_4OAc	0.5*M* NH_4OAc	0.25*M* NH_4OAc	0.1*M* NH_4OAc
Koumleh	91	81	72	63
Roudsar	185	128	114	104
Kalachai	104	142	142	123
Amlash	171	142	137	119
Shalmanroud	161	114	114	100
Vajarga	100	86	81	72
Havigh	137	180	176	156
Gilesara	137	128	133	123
Khanegha	109	119	123	104
Moridan	161	128	123	104
Lisar	195	180	176	147
Polroud	114	58	54	45
Shafaroud	95	81	77	63
Khak o ab	161	147	152	128
Sharif	171	229	224	210
janga	264	280	280	254
Dostlat	280	321	305	280
Shaghagi	373	290	290	254
Saravan	190	244	239	224
Mean	168	162	159	141
Range	91-373	58-321	54-305	45-280

Table 3. Analysis of variance for grain and straw yield, K uptake and concentration in straw

S.O.V	df	Mean of square			
		Grain yield (gr pot^{-1})	K Uptake in straw (gr pot^{-1})	K Concentration in straw (%)	Straw yield (gr pot^{-1})
Soil (A)	18	1160.72**	0.59**	0.43**	1708.24**
Potassium(B)	1	858.28*	12.89**	14.37**	2063.38**
A×B	18	507.27**	0.14**	0.11 ns	194.12 ns
Error	74	139.76	0.06	0.08	158.44
C.V		15.9	21.7	20	16.1

ns, * and **, not significant, significant at 5 and 1 % levels, respectively.

As shown in Table 5, potassium consumption significantly increased potassium uptake and potassium concentration in straw of rice in 84% and 68% of soils respectively. Increasing amount of uptake, concentration and also yield components in rice plant as a result of potassium consumption has been reported by various researchers (Mehlich, 1984; Kalala et al., 2016).

Potassium utilization increased the amount of grain yield in 36 and straw yield in 63% of soils, but these differences were statistically significant only in 16% of soils for increasing rice yield and in 21% of soils for straw yield. The average increase in grain and straw yield, potassium uptake and potassium concentration in straw yield of Hashemi cultivar were 8, 11, 85 and 65%, respectively with fertilizer treatment applied to control. In a similar experiment conducted at the International Rice Research Institute, the average increase in the plant aerial yield was 8.5% due to the application of potassium (Dobermann et al., 1996). The correlation coefficients (r) between potassium extracted by various concentrations of NH_4OAc with potassium uptake and potassium concentration in rice straw and as well as straw yield and relative yield are presented in Table 2. The results show an acceptable correlation between these factors and the difference between different concentrations of NH_4OAc is one or two units. These relationships indicate that this extract provides a good indicator of the soil available potassium. NH_4OAc is considered as the standard available potassium index in the United States and Canada (Slaton et al., 2009). There are, of course, good correlations between the other extractors and plant responses (2003, My hoa).Table 3 shows the very close relationship between potassium extracted by different concentrations of NH_4OAc.

Table 4. Correlation coefficients (r) of K extractable by NH_4OAc in different concentrations and plant indexes

Plant indexes / Extractant	K Uptake in straw ($grpot^{-1}$)	K Concentration in straw (%)	Straw yield ($grpot^{-1}$)	Relative yield (%)
1*M* NH_4OAC	0.77**	0.71**	0.54*	0.53*
0.5*M* NH_4OAC	0.76**	0.69**	0.54*	0.52*
0.25*M* NH_4OAC	0.75**	0.70**	0.53*	0.53*
0.1*M* NH_4OAC	0.74**	0.71**	0.55*	0.50*

ns, * and **, not significant, significant at 5 and 1 % levels, respectively.

Table 5. Critical level of soil available K for rice by graphical methods

Different concentrations of NH_4OAc	Critical level ($mgkg^{-1}$)
1*M* NH_4OAC	120
0.5*M* NH_4OAC	119
0.25*M* NH_4OAC	109
0.1*M* NH_4OAC	105

Figures 1 to 4 show a critical level of potassium for 90% relative yield of rice of the Hashemi indigenous variety by the Cate-Nelson drawing method and for different concentrations of NH_4OAc. The critical level of potassium with 1 *M* NH_4OAc extracts (Fig. 1), 0.5 *M* NH_4OAc (Fig. 2), 0.25 *M* NH_4OAc (Fig. 3), 0.1 *M* NH_4OAc (Fig. 4), is 120, 119.109, and 105 mg kg^{-1} respectively. In the case of indigenous rice cultivars (such as the used cultivar), critical level of potassium is lower due to less fertilization. Comparison of the results obtained in this experiment with the reported critical level for high yielding cultivars such as Khazar cultivar confirms this prediction. Tofighi (1998; 1999) reported a critical level of potassium for Khazar cultivar of 135 mg kg^{-1}. In the variable report titled Critical level Using 1 *M* NH_4OAc of 51 to 160 mg kg^{-1} soil (Dobermann et al., 2000). Also, in another study, the amount of potassium extracted in rice paddy soils was determined to be between 19.68 and 782 mg kg^{-1} soil and its critical level was 78 mg kg^{-1} soil, using a 1 *M* NH4OAc extractor (Doberman et al., 2000).

The variability of the results of these reports suggests that critical level can depend on some soil characteristics such as soil texture, clay mineralogy, and also potassium input through natural resources as well as the type of cultivars cultivated. The results of this study also show that the critical level of 1*M* NH_4OAc and 0.5*M* NH_4OAc are almost intimately. The correlation of these concentrations with the amount of potassium uptake and concentration in the plant and its yield, which is one of the important criteria in choosing an extractant, is an acceptable and close relationship has it. As a result, it seems reasonable to consider the three factors of ease of preparation, extraction speed, and economics in soils with similar conditions, In order to extract potassium from soil, the concentration of 0.5 *M* NH_4OAc replaced with 1 *M* NH_4OAc. Kuhsar Bostani et al. (2003) investigated the correlation between two methods of extracting potassium absorbent in Kurdistan soils with concentrations of 0.1 *M* NH_4OAc and 1 *M* NH_4OAc and reported a very significant linear relationship between the two concentrations of this extractor. They considered the use of lower ammonium acetate (0.1 M) concentration in determining the available potassium.

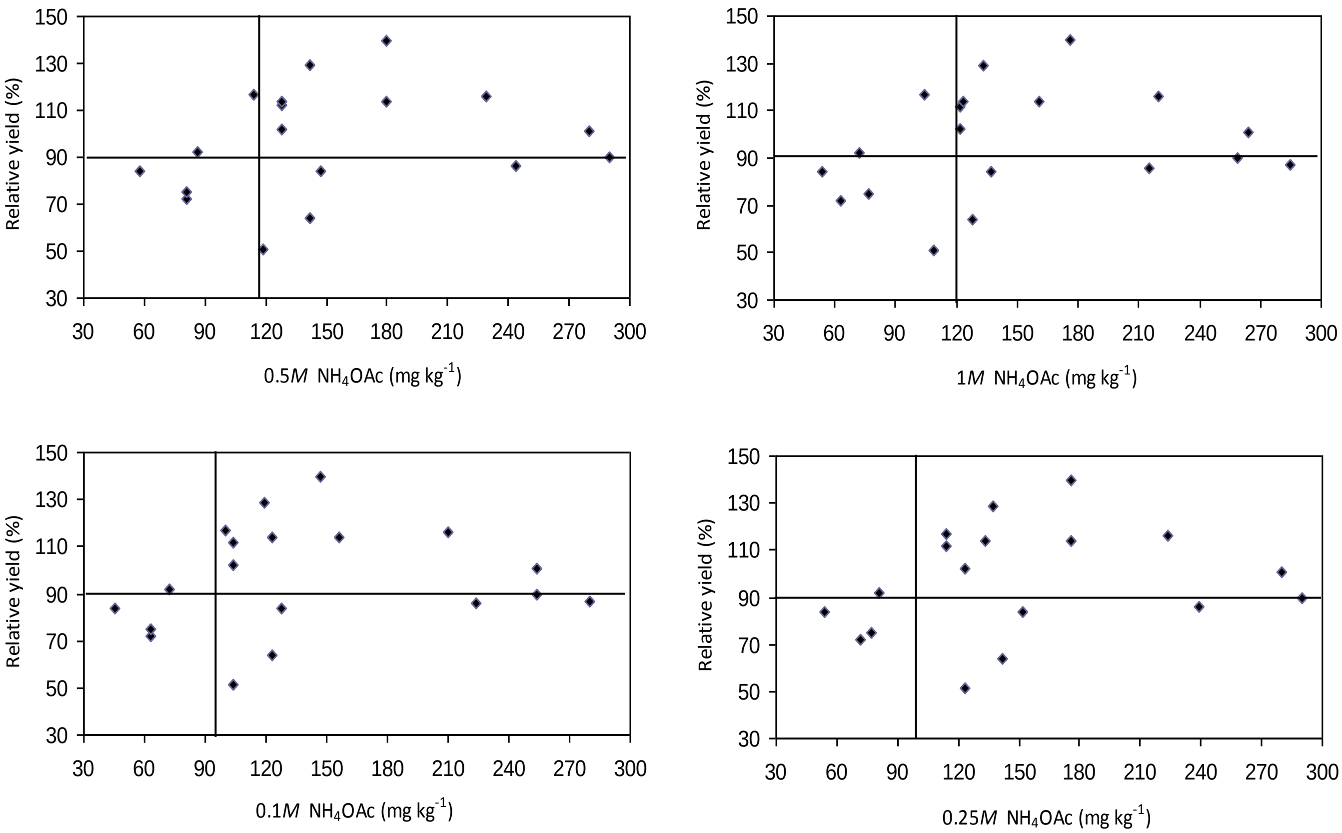

Figure1. Cate-Nelson plot and potassium critical levels in NH4OAC extractant

CONCLUSION

Potassium application increased grain yield by 36% and straw yield in 63% of soils. The average increase in rice yield, straw, potassium adsorption and potassium concentration in Hashemi cultivar was 8, 11, 85 and 65%, respectively, as compared to the control. Correlation coefficients (r) between ammonium acetate extractable potassium in different concentrations with plant indices were significant. The results indicate that this extracts can be a good indicator of the available soil potassium. The critical level of potassium was determined with 1*M* NH_4OAc, 0.5 *M* NH_4OAc, 0.25 *M* NH_4OAc, 0.1 *M* NH_4OAc, 120,119, 109, and 105 mg kg^{-1}, respectively, for the indigenous variety of Hashemi rice.

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