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Effect of Foliar Application of Potassium on Growth and Yield of Submergence Rice Grown in Calcareous Soil

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***Abstract* – A farmer field trial experiment was conducted at growth season of 2016 in Deraluk sub-district, Amadiya district, Dohuk province, Iraq to investigate the effect of foliar application of high levels K on growth and yield of submergence rice (Oryza sativa L.) grown in calcareous soil. A concentration of 0.5 and 1% of K was used as a foliar application in two splits: The first split was at the beginning of tillering (40 DAS) and the second split was just before anthesis (75DAS). The results showed that the spraying of the relatively high concentration of potassium on the green parts had insignificant advantages on both grain and straw yields despite the increasing of all studied parameters. The effect on many other plant parameters has been discussed.**

***Keywords* – Foliar, Rice, Submergence, Potassium, Calcareous Soil.**

I. INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal grain and widely grown in the world. It grows in a wide range of environments over more than a hundred countries. Yields range from less than 1 t ha^{-1} under very poor rainfed conditions to more than 10 t ha^{-1} in intensive temperate irrigated systems. Food and Agriculture Organization (FAO) estimates that the total harvest of paddy in 2010 was 701.13 million metric tons (near to 470 million tons of milled rice), harvested from 161.76 million hectares, more than 90% from Asia (FAOSTAT, 2013). An additional 116 million tons of rice will be needed by 2035 to feed growing populations. Rice farming will need to produce about 8–10 million tons more paddy per year over the next decade. Without area expansion, this will require an annual yield increase of about 1.2–1.5%, equivalent to an average yield increase of 0.6 t ha^{-1} world-wide during 2007–2011(Seck et al., 2012). The United States Department of Agriculture (USDA) estimates Iraq's rice production (the crop year 2014-2015) at 110,000 metric tons, down 59 percent from 267,000 tons of the previous year. Harvested area is estimated at 48,000 hectares, down 50 percent, with rough rice yield at 3.44 tons per hectare, a decrease of 17.7 percent from last year. The lower rice area was attributed to restricted water conditions, mainly associated with dryer weather and low Euphrates river flow (USDA, 2015).

Potassium is an essential element for plants and has an important role such as enzyme activation, protein synthesis, ion absorption and transport, photosynthesis and involves the respiration process as a regulator of stomata and the maintenance of turgor and osmotic equilibrium (Wiedenhoeft, 2006; Barker and Pilbeam, 2007). Potassium in the soil is found in four Fractions: (i) total potassium (mineral K); (ii) non-exchangeable K, or K fixed in between clay plates (but plant-available); (iii) exchangeable K; and (iv) K present in the soil solution (Roy et al., 2006; Barker and Pilbeam, 2007). The average of total potassium concentration of the earth's crust is 23 g kg^{-1}. The most important potassium-bearing minerals in soils are alkali feldspars (30 to 20 g K kg^{-1}), muscovite (K mica, 60 to 90 g K kg^{-1}), biotite (Mg mica, 36 to 80 g K kg^{-1}), and illite (32 to 56 g K kg^{-1}). These are the main natural potassium sources from which K^+ is released by weathering and which feed plants

(Barker and Pilbeam, 2007). Despite the high concentration of total potassium in the soil, however, only a small portion of the total potassium is available. Amount of 0.1–0.2% of the total soil K is directly available to plants (i.e. in soil solution), whereas the exchangeable fraction comprises 1–2% and the non-available fraction is about 96–99% (Wang et al., 2010; Britzke et al., 2012). Potassium is highly soluble in water, and the diffusibility in the medium strongly depends on soil moisture, thus it's easy to be leached from the root zone under waterlogged conditions (e.g. submergence rice cropping). In such conditions, Roy et al. (2006) suggested that the split application of K together with N fertilization can be a useful strategy where leaching losses of K are considerable.

Foliar feeding, a term referring to the application of essential plant nutrients to above-ground plant parts, has been documented as early as 1844 when an iron sulfate solution was sprayed as a possible remedy for “chlorosis sickness” (Gary, 1982). The Soil application method of essential plant nutrients is more common and most effective for nutrients, which required in higher amounts. However, under certain circumstances, foliar fertilization is more economic and effective (Fageria et al., 2009). The main advantage of foliar fertilization is the immediate uptake of the nutrients applied. Foliar fertilization is at the best a supplement to soil application and not a substitute for it (Roy et al., 2006). Good advantages were obtained from the foliar application of K on rice. Ebrahimi et al., (2012) reported that the best method of potassium application in salinity condition was soil intake plus spraying method. (Son et al., 2012) showed positive yield and net income responses from one to three foliar treatments of potassium nitrate with spring and summer rice grown on soils low in soil exchangeable K. Ali et al. (2007) stated that foliar application of K_2SO_4 at different concentrations significantly influenced the yield components and significantly increased K uptake by rice paddy and straw.

The purpose of the experiment was to investigate the effect of foliar application of potassium on growth and yield of submergence rice (*Oryza sativa*) grown in calcareous soil.

II. Materials and Methods

Field Location and Soil Characters

Farmer field trial experiment was conducted at the growth season of 2016 in the Deraluk sub-district (the field area was 1010 m^2 and GPS location: 38˚06"98'N; 41˚08"85' E; elevation: 666m), Amadiya district, Dohuk province, Iraq.

Land Preparation and Sowing

The land was plowed perpendicularly and horizontally, flooded with water, mixed well till becoming muddy and divided to uninformed plots according to the land topography to ensure the submergence conditions along the growth season. Nine plots from the beginning, middle and the end of the field were chosen and local rice cultivar (named “long retik” has along stalk and have no or very small awn) was sown after 72 hours water soaking at a rate of 100 kg ha^{-1} via hand broadcasting method at May 10th, 2016. The weeds manually controlled 45 days after sowing (DAS).

Fertilization

Basal nitrogen fertilizer was added at a rate of 80 kg N ha^{-1}, the fertilizer was divided into two equal amounts; the first dose was added with seeds and the second at active tillering. One time soil application of phosphorus f-

-ertilizer at a rate of 60 kg P_2O_5 ha^{-1} was added with seeds.

Treatments application

Potassium with two concentrations 0.5 and 1% (these concentrations calculated for net K not for the salt) from K_2SO_4 (here we used K_2SO_4 for having advantages over other K sources when used as a foliar spray as reported by Ali et al., 2005) in addition to the control (water) was used as a foliar application in three replications and two splits: the first split was at the beginning of tillering (40 DAS) and the second split was just before an thesis (75DAS). The knapsack sprayer of 8 litter's capacity was used and spraying time was at about two hours before sunset. The spraying was stopped just after the solution starting to flow over the shoots.

Harvesting

The crop was harvested on October 5^{th}, 2016. One square meter was chosen from each treatment and the plants were cut near the soil surface and the growth parameters were taken, then the whole plant has been threshed, the paddy was refined and both straw and grain yields were calculated on a base of air-dry weight. The harvest index (HI) is the ratio of harvested grain to total shoot dry matter, and this can be used as a measure of reproductive efficiency. It has been calculated from the equation below: HI = Grain yield/biomass.

Statistical Analysis

A randomized complete block design (RCBD) was used for the statistical analysis of the data. The treatment means were compared by determining the least significant difference (LSD) at 5% level of probability (P=0.05) using statistical analysis software SAS (2002).

III. Results and Discussion

Soil Properties

The soil was clayey (20.15, 20.58 and 59.27% sand, silt and clay respectively) with a bulk density of 1.81 Mgt^{-1}, pH of 7.71, EC of 0.31 Ds m^{-1}, organic matter of 11.52 g kg^{-1}, CEC of 27.61 $Cmole_c$ kg^{-1}. Available N and P were: 168 and 7 ppm respectively. Available dissolved ions (1:10 soil: water suspension) were: 0.17, 0.3, 4.36, 5.41, 0.4, 0.9 and 0.6 *meq* L^{-1} for K^+, Na^+, Ca^{++}, Mg^{++}, $CO_3^=$, $HCO_3^=$ and Cl^- respectively.

The clayey soil is good media for submergence rice but the somewhat high alkaline cations, CEC and pH conditions are the basic reasons for lowering the availability of potassium mainly through the compatibility of alkaline cations such as Ca and Mg with K and in turn affecting on the yield (Rhodes et al., 2018).

Plant Parameters

Concerning the plant heights (table-1), there was superiority of the sprayed treatments over the control by 7.6% for both 0.5 and 1% of K. There was no significant different in number of panicles between the control and sprayed treatments despite the increasing of the later by 7.4 and 8.7% respectively for 0.5 and 1% K over the control. The number of seeds per panicle for the treatment 1% K was significantly increased by 47.8% over the control and increased, but not significantly, with the treatment of 0.5% K while the later in turn was statistically not different with the control. The weight of 1000 seeds of the treatment 1% K was significantly increased over the control by 7.0% while the treatment 0.5%, without knowing the reason, significantly reduced compared to the others.

The grain and straw yields for the sprayed treatments were increased over the control but these increments were not statistically significant. The increasing ratio of the treatments as compared to the control respectively for 1 and 0.5% K was 35.3 and 14.4% for the grain yield, 24.7 and 9.0% for the straw yield. No significant values of (HI) were found between the treatments despite the superiority of the sprayed treatments over the control.

Table 1. Effect of foliar application of potassium on yield and parameters of submergence rice grown in calcareous soil.

Treatment	Plant Height (cm)	No. of Panicles Per Meter	No. of Seeds Per Panicle	1000 Seeds Weight (g)	Grain Yield (Mg ha^{-1})	Straw yield (Mg ha^{-1})	Harvest Index (HI%)
control	111.50 b	193.60	117.50b	24.30 b	5.89	9.76	33.42
K 0.5%	120.00 a	208.00	138.50 ab	22.10 c	6.74	10.64	34.54
K 1%	120.00 a	210.40	173.67 a	26.00 a	7.97	12.17	34.63
LSD	1.96	83.51	55.96	2.78	4.24	3.16	13.17

The spraying of the relatively high concentration of potassium on the green parts had insignificant advantages on both grain and straw yields despite the increasing of all studied parameters.

The K concentration in the soil (0.17 meq L^{-1}) ranged within the medium status according to Dobermann and Fairhurst (2000), means that the soil will response to K fertilization. But the hypoxic condition in the root zone following submergence will create a favor habitat for excess reduction of Fe and Mn. The competition between such cations and K for exchange sites results in more K displacement from the cation exchange sites into the soil solution. This may results in increased solution K concentration and enhanced K diffusion to rice roots.

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