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POTASSIUM USE EFFICIENCY OF MAIZE HYBRIDS

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ABSTRACT

Maize hybrids exhibit better potassium use efficiency (KUE) and utilize soil N in an efficient way, thus reduce input cost and conserve environment. For the screening of hybrids with proper dose of K, experiment were laid out in randomized complete block design with split plot arrangement, randomizing maize hybrids in main plots (H_1= Pioneer-3012, H_2= Pioneer-3062, H_3= Pioneer – 30D55) and K application levels (K_0=0, K_1=100, K_2=150, K_3=200 and K_4=250 Kg ha^{-1}) in subplots with four replications. It was observed that Pioneer-30D55 significantly gave higher KUE (1.94) than Pioneer-3012 (1.86), yet it was at par with Pioneer-3062 (1.92). K application at all levels significantly increased KUE over control. All K levels except control produced statistically similar KUE. As far as N present in soil after harvest, Pioneer-30D55, probably due to its efficient root system left minimum N (0.042 %) in the soil and significantly differed with Pioneer-3062 (0.043%) and Pioneer-3012 (0.044%), which also significantly differed with each other. Minimum N %age left in soil after crop harvest (0.046) was observed, when 200 kg K ha^{-1} was applied which significantly differed with N %age left in soil after harvest crop (0.045) obtained when 250 kg K ha^{-1} was applied, where as maximum N %age left in soil after harvest (0.042) was recorded in control. It was therefore concluded that Pioneer-30D55 was the most efficient hybrid with similar KUE with respect to K utilization and similar synergistic trend was recorded with N uptake from soil.

Key words: Maize hybrids, potassium use efficiency, soil nitrogen.

INTRODUCTION

Maize *(Zea mays* L.*)* is an important food and feed crop of the world and is often referred as "the king of grain crops". It ranks third in world production after wheat and rice and is important cereal crop of Pakistan. It forms major dietary part of the millions of the people in the form of bread, cake and porridge in many parts of the world Asia, Africa and America. Besides being an important food grain for human consumption, maize has also become a major component of livestock and poultry feed (Bukhsh *et al*., 2011).

In recent years a large quantity of corn has been used in the manufacturing of shortening compounds, soaps, ammunition, varnishes, paints and similar other products (Bukhsh, 2010), whereas the by-product seed cake is a valuable component of livestock feed (Ahmad *et al*., 2007a). Maize oil is used in cooking, bakery products, oleomargarine, salad dressing and pharmaceutical. Maize starch is used for producing bio-fuel (as ethanol) after its fermentation (Ahmad *et al.*, 2007b), making plastics, cellophane, photographic films, dying of clothes, manufacturing of paper, paper boards and tanning of the hides. It is also utilized for getting the important industrial by-products such as glucose, flakes, custard, jelly and energile etc., (Rajoo, 1998).

K plays a vital role as macronutrient in plant growth and sustainable crop production (Bukhsh *et al*., 2012). It maintains turgor pressure of cell which is essential for cell expansion. It helps in osmo-regulation of plant cell, assists in opening and closing of stomata (Mengel and Kirkby, 1987). It plays a key role in activation of more than 60 enzymes (Tisdale *et al.*, 1990). Its application has primitive effect on growth and development (Bukhsh *et al*., 2011) and grain yield in maize (Bukhsh *et al*., 2009). It not only affects the transport of assimilates but also regulates the rate of photosynthesis in maize. It is known for its interaction both antagonistic and synergistic with essential macro and micro nutrients (Dibb and Thomson, 1985). K is recognized important for efficient N utilization and have a fairly consistent effect on lowering tissue concentration of Ca and Mg (Bukhsh, 2010).

Modern maize cultivars respond to K application differently due to difference in its uptake, translocation, accumulation, growth and utilization (Nawaz *et al.,* 2006; Minjian *et al.,* 2007). The K-efficient phenotype is a complex one comprising a mixture of uptake and utilization efficiency mechanisms. Differential exudation of organic compounds to facilitate release of non-exchangeable K is one of the mechanisms of differential K uptake efficiency. Hybrids efficient in K uptake may have a larger surface area of leaf. Better translocation of

K into different organs, better capacity to uphold cytosolic K^+ concentration within optimal ranges and increased capacity to substitute Na^+ for K^+ are the main mechanisms underlying K utilization efficiency (Rengel and Damon, 2008).

Hybrids those had reduced harvest index under deficient K supply were K-inefficient. Capacity to tolerate low concentrations of K in shoot tissue where K supply was deficient was also important in determining K efficiency for grain yield. K-efficient hybrids have the potential to improve the efficiency and sustainability of cereal cropping systems (Damon and Rengel, 2007). Efficient plant cultivars could have better fertilizer use efficiency (FUE) (Epstein and Bloom, 2005) leave low soil nitrogen and K as it is now understood that both of these elements should be present in sufficient and balanced quantities for proper crop growth (Bukhsh *et al*., 2012) and hence may reduce input cost and conserve environment (Baligar *et al.,* 2001; Rengel and Damon, 2008).

Keeping in view the above findings it was imperative to conduct a study to evaluate different maize hybrids under different levels of K with its efficiency in the agro-ecological conditions of Bahawalpur, Pakistan.

MATERIALS AND METHODS

Description of site: The experiments were conducted on a sandy clay loam soil at Government Agricultural Extension Farm, Model Town – A, Bahawalpur. The climate of the region is semi-arid and subtropical. The experimental area is located at 30°12' North, 71'.26' East and at an altitude of 120 meters above sea level.

Soil Characteristics: As soil of the experimental area was quite uniform, a composite and representative soil sample to a depth of 30 cm was obtained with soil auger, prior to sowing of the crop. Percentage of sand, silt and clay was determined by Bouyoucos hydrometer method using one percent sodium hexametaphosphate as a dispersing agent. Textural class was determined by using the international textural triangle (Moodie *et al.*, 1959). Soil was analyzed for its various chemical properties by using the methods as described by Homer and Pratt (1961). The soil was analyzed for N and K. The soil was sandy clay loam containing 65% sand, 15% silt and 20% clay. Its chemical characteristics included saturation 36%, pH 7.9, EC_e 1.3 dS m^{-1}, organic matter 0.83%, total nitrogen 0.083%, available phosphorous 1 ppm and available K 125 ppm. It remained more or less homogenous during both years.

The meteorological data for the growing period of the crop were collected from the observatory of the Regional Agricultural Research Institute (RARI), Bahawalpur (Fig. 1). The meteorological station is about 400 m away from the experimental site. Total rain received during the growing period of the crop to and which was below average. It was almost same for both years.

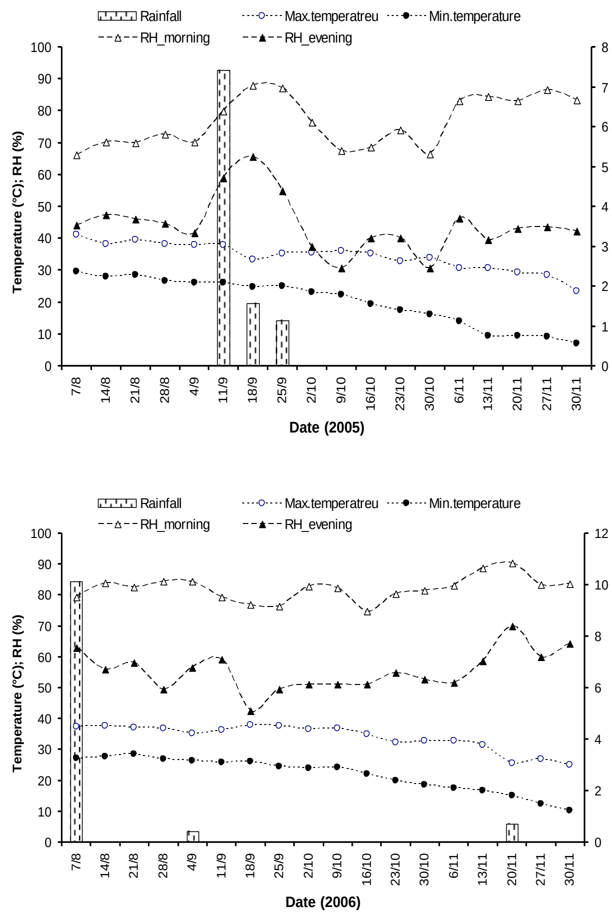

Fig. 1. Meteorological data recorded during 2005 and 2006.

The experiment was laid out in randomized complete block design with split plot arrangement, randomizing maize hybrids in main plots (H_1= Pioneer-3012, H_2= Pioneer-3062, H_3= Pioneer – 30D55) and K application levels (K_0=0, K_1=100, K_2=150, K_3=200 and K_4=250 Kg ha^{-1}) in subplots with four replications. The net plot size measured 3.5m x 7m.

Agro-management practices: Before seed bed preparation, presoaking irrigation of 10 cm was applied. When soil reached at proper moisture level locally called as "*Wattar*" condition, the seed bed was prepared by giving four cultivations with a tractor mounted cultivator. Each time soil was cultivated to a depth of 8-10 cm. Planking was given, after every two times cultivations. The crop was planted on August 3, 2005 and August 7, 2006. The seed was drilled with the help of single row-hand drill using seed rate 30 kg ha^{-1}. The NP was applied @ 300 and 200 kg ha^{-1}, respectively. Urea, diammonium phosphate and sulphate of potash were used as sources of N, P and K fertilizers, respectively. All potash and phosphatic and half dose of N fertilizer was applied at the time of sowing, while the remaining N was top dressed at first irrigation stage of the crop. In addition to rainfall received during the growing period of the crop, six irrigations were applied as and when needed at different plant developmental stages till the physiological maturity of the crop. Every irrigation turn was of 7.5 cm. The first irrigation was given ten days after sowing (DAS).

The crop was kept free of weeds by hoeing twice and hand weeding to avoid weed crop competition. Sunfuran was applied @ 20 kg ha^{-1} with second irrigation against stem borer control. Crop was harvested manually on November 11, 2005 and November 16, 2006. After harvesting, the plants were left in the field for two days and thereafter, tied into bundles and stalked for 4 weeks. Then the cobs were separated from the stalk and allowed to dry in sunshine for a few days before threshing.

Potassium Use Efficiency (KUE) according to Barber (1976) is defined as “the amount of increase in yield of the harvested portion of crop per unit of fertilizer nutrient applied.

$$\text{KUE} = \frac{\text{Grain yield F - grain yield C}}{\text{Fertilizer nutrient applied}} \text{kg kg}^{-1}$$

Where

Grain yield F = Grain yield of fertilized plots

Grain yield C = Grain yield of control or check plots

For post-harvest soil analysis for N %age and K, again composite sample to a depth of 30 cm was taken from each experimental unit immediately after harvest of the crop by using the methods as described by Homer and Pratt (1961)

Statistical analysis: The data were analyzed by the “Mstat” statistical package on a computer (Freed and Eisensmith, 1986). When a significant “F” value was obtained for treatment effect, least significant differences (LSD) test at 0.05 P was applied to determine the significance of the treatment means (Steel *et al.*, 1997).

RESULTS AND DISCUSSION

K Use Efficiency (kg kg^{-1}): Nutrient Use Efficiency (KUE) is also called nutrient to grain ratio. KUE was significantly affected by different maize hybrids during both years (Table 1). Although Pioneer-30D55 significantly gave higher KUE (1.94) than Pioneer-3012 (1.86), yet it was at par with Pioneer-3062 (1.92). These results are in line with the findings of Rengel and Damon, (2008), Bukhsh *et al*. (2009) and Bukhsh (2010) who stated that maize hybrids differed in their KUE due to their different genotypic larger surface area of contact between roots and soil and increased uptake at the root-soil interface to maintain a larger diffusive gradient towards roots or better translocation of K into different organs, greater capacity to maintain cytosolic K^+ concentration within optimal ranges and increased capacity to substitute Na^+ for K^+ are the main mechanisms underlying K utilization efficiency

KUE was significantly influenced by K levels. K application at all levels significantly increased KUE over control. All K levels except control produced statistically similar KUE. These results are in accordance with the findings of Pettigrew (2008), Bukhsh *et al*. (2011), Bukhsh *et al*. (2012) and Epstein and Bloom (2005), who reported that K application improved its efficiency over control in terms of quantity and quality in maize. It is obvious from the table that KUE seems to be very low. It supports the theory that K is catalytic and enzymatic in nature rather than involve in structural development (Tisdale *et al.* 1990). Interactive effects of maize hybrids and different K levels on KUE was found to be non significant during both years. The possible reason might the homogeneity of soil and weather for both years.

Soil N after crop harvest: Pioneer-30D55, probably due to its efficient root system left minimum N (0.042 %) in the soil and significantly differed with Pioneer-3062 (0.043%) and Pioneer-3012 (0.044%) which also significantly differed with each other (Table 2). Similar trends were seen by Lee and Tollenaar (2007), who stated that different maize hybrids have different root system and habits to explore the soil volume and to get benefit of N and K, as maize needed K in large quantity equal or more than N (Bukhsh, 2010)

N %age left in soil was significantly influenced by various K application levels as K facilitates uptake of N through roots. Minimum N %age left in soil after harvest of crop (0.046) was observed, when 200 kg K ha^{-1} was applied which significantly differed with N %age left in soil after harvest of crop (0.045) obtained when 250 kg K ha^{-1} was applied, where as maximum N %age left in soil after harvest of soil (0.042) was recorded in control. Interactive effects of maize hybrids and K levels on N %age in soil after harvest of crop were, found to be non-significant. These results are in agreement with the findings of Yaseen *et al.* (1994), and Bukhsh *et al*. (2012) who reported that K application in soil improved the uptake of N, due to which N %age left in soil was minimized with the increase of K levels. Fridgen and Varco (2004) have shown similar experience that N and K influence plant growth in a synergistic way. Interactive effects of maize hybrids and K levels applied in soil on soil nitrogen after harvest of crop was found non significant during both years. The possible reason might the homogeneity of soil and weather for both years.

Table 1: 'K' Use Efficiency (kg kg^{-1}) as influenced by maize hybrids and K levels

Treatments	Soil N (%)
A- Hybrids (H)	
H_1:Pioneer 3012	1.86 b
H_2:Pioneer 3062	1.92 a
H_3:Pioneer 30D55	1.94 a
LSD=0.05	0.0720*
B- K levels (kg ha^{-1})	
K_0=0	0.00 b
K_1=100	1.98 a
K_2=150	2.57 a
K_3=200	2.77 a
K_4=250	2.22 a
LSD=0.05	1.0478*
C- Interaction (H x K)	**N.S**
CV=%	56.44

Means followed by different letters in columns are significantly different at P=0.05
*=Significant
N.S= Non significant

Table 2: Soil N after crop harvest (%) as influenced by maize hybrids and K levels (Mean of two years)

Treatments	Soil N (%)
A- Hybrids (H)	
H_1:Pioneer 3012	0.044 c
H_2:Pioneer 3062	0.043 b
H_3:Pioneer 30D55	0.042 a
LSD=0.05	0.0005*
B- K levels (kg ha^{-1})	
K_0=0	0.042 e
K_1=100	0.043 d
K_2=150	0.044 c
K_3=200	0.046 a
K_4=250	0.045 b
LSD=0.05	0.0002*
C- Interaction (H x K)	N.S
CV=%	9.65

Means followed by different letters in columns are significantly different at P=0.05
*=Significant
N.S= Non significant

Conclusion: It was concluded that Pioneer-30D55 was the most efficient hybrid with respect to K utilization and similar synergistic trend was recorded with N uptake from soil.

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