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Phenology, Leaf Area and Yield of Spring Maize (Cv. Azam) as Affected by Levels and Timings of Potassium Application

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Abstract: Maize is one of the most important cereal crop of NWFP after wheat while potash is the third most important crop nutrient after nitrogen and phosphorus that increase yield of maize. The objective of our present experiment was to study phenology, leaf area and grain yield potential of spring maize (cv. Azam) to different rates and timings of potassium application under irrigated conditions of N.W.F.P Agricultural University, Peshawar. The factorial experiment consisted of four levels (0, 30, 60 and 90 kg ha^{-1}) and three timings of potassium application (T_1 = One split i.e. 100% at sowing time, T_2 = Two splits i.e. 50% at sowing and 50% at 15 DAE an T_3 = Three splits i.e. 33.3% at sowing, 33.3% at 15 DAE and 33.3% at30 DAE). The experiment was laid out in split plot design with three replications and a subplot size of 3×4 m^2 was maintained. Different potash levels were kept in the main plots while potash timings were assigned to the subplots. Our present results shows that potash levels and timings significantly affected phenology, flag leaf area and grain yield of spring maize. However average leaf area was significantly not affected by levels and timings of K application. Tasseling, silking and physiological maturity was delayed when potash levels was increased up to 60 kg ha^{-1}, while further increase of K level up to 90 kg ha^{-1} enhanced tasseling, silking and maturity. Tasseling, silking and physiological maturity showed positive relationship with increase in the number of splits. Mize took less time to tasseling, silking and maturity when full dose of K was applied at sowing time (T1), while delay in these characters was observed when K was applied in splits (T2 and T3). Flag and average leaf area increased to a maximum of 110.8 cm^2 and 512.2 cm^2, respectively when K was applied at the highest level (90 kg ha^{-1}). Flag and average leaf area increased to a maximum of 95.1 and 470.6 cm^2, respectively in those plots which received full dose of K at sowing time (T1). Grain yield showed positive relationship with increase in K levels and negative relationship with increase in number of K split application. Maximum grain yield of 1949.2 kg ha^{-1} was recorded when K was applied at the highest rate of 90 kg ha^{-1} while minimum grain yield of 1898.8 kg ha^{-1} was recorded when K was not applied. The highest grain yield of 1807.7 kg ha^{-1} was recorded in those plots which received 100% of K at sowing time (T1) while the lowest grain yield of 1613.5 kg ha^{-1} was recorded in those plots when K was applied in three splits i.e. 33.3% at sowing time, 33.3% at 15DAE and 33.3% at 30 DAE. It was concluded that increase in potash level enhanced tasseling, silking and maturity, increased flag leaf area, average leaf area as well as grain yield. Increase in K splits delayed tasseling, silking, maturity and decrease flag leaf area, leaf area and grain yield. It is recommended that K at the rate of 90 kg ha^{-1} must be applied at sowing time for maximizing maize productivity under the climatic condition of Peshawar. Further research work on levels and timings of K application is recommended on maize as well as on other exhaustive crops under different agro-climatic conditions to increase availability K for optimum growth and maximum production per unit area.

Key words: Maize · potassium · phenology · leaf area and grain yield

INTRODUCTION

Maize is one of the most important crops in Pakistan. It is second most important after wheat in N.W.F.P. More than 60% of the total production is contributed by N.W.F.P. In Pakistan 64% of maize is grown under irrigated area while the rest 36% is grown in rain fed area [1]. In the year 2003-04 total areas under maize in

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Pakistan was 941.6 thousand hectares with a total production of 1664 thousand tones and the average yield was 1768 kg ha^{-1}. In NWFP during the same year the total area under maize crop was 540.8 thousand hectares with total production of 1695 thousand tons [2]. Maize is a rich source of food and fodder and also used in industries for manufacturing of corn oil, corn flakes, corn syrups and corn sugar. The world leading maize growing countries are USA, Argentina, Russia, India, Brazil and China. To over this short fall in maize productivity, the latest production technologies, which emphasizes on the use of adequate inputs an other techniques should be adopted. The newly evolved synthetic varieties have a wide range of adaptability to the varying micro and macronutrients and environmental factors affecting plant growth and other physiological characteristics. Maize is an exhaustive crop and depletes the fertility of soil to greater extent. Nitrogen, Phosphorus and Potash are the major essential nutrients for growth and development of a crop. Lack of Nitrogen results in stunted growth, pale yellow leaves, grain remain small and yield is adversely affected. Phosphorus deficiency is responsible for crooked and missing rows as kernel twist and produce small ears in maize. Phosphorus in soil is mainly present as calcium phosphate, which becomes available to the plants at a very slow rate through various chemical reactions, thus rate of availability is usually much less than needed by a crop for good yield and is supplemented with chemical fertilizers. Potash requirements of maize are high as it absorbs potash in large quantities than any other element, except nitrogen. Potash is important for water status of plant and is involved in the growth of meristamatic tissue an maintenance of cell turgor pressure which is required, for cell expansion. Potash is not a constituent of organic structure but enzymatic activities and translocation of photosynthesis [3]. It is also involved in the of other nutrients across cell membranes. Potash content of many crops varied from 0.5 to 2.5% of total dry matter. Potash is essential for: growth of merestamatic tissue, strength of the stem/stalk, regulation of the opening and closing of stomata, transport of photoynthates from leaves, drought resistance, salt tolerance and disease resistance of crops. Some of the related research work previously reported on response of maize potash is briefly reviewed. Potash has no significant affect on the yield of maize when applied at the rate of 62 kg ha^{-1}, but a marked increase in the yield occurs when applied at the rate of 124 kg ha^{-1} [4]. Potash application to maize increase grain yield, reduce days to 50% tassling and silking but has no effect on 1000-grain weight [5]. Increase in K levels (0, 30, 60, 90 and 120 kg ha^{-1}) increase grain yield, 1000 grain weight and shelling percentage significantly over control plots [6]. Potash applied at the rate of 0, 40, 80, 120, 160 or 200 kg ha^{-1} to maize produce greatest grain yield and 1000-grain weight at 120 kg K ha^{-1}, greatest DM yield at 80 kg K ha^{-1} an the highest net return from applying 40 kg K ha^{-1} [7]. Potash rate and the response to K rate×hybrid interaction has significant effect on maize [8]. Potash rate has positive relationship with grain yield and he 60% increase in grain yield is due to the highest K doses [9]. The highest increase in maize yield of 20.9% occurs using the highest rate of 225 kg K ha^{-1} [10]. Potash is extremely significantly correlated ($r = 0.9851$) with the dose applied at 30-45 days after K application (silking stage) had their K uptake at the peak, the rapidly-available K in the surface soils decrease slightly while the slowly-available K decrease significantly. At the milking and maturation stage of maize, both the rapidly-and slowly-available K in the surface soils increased by some extent in all the treatments due to the decrease of K uptake by the maize plants [10]. Yield components in maize like ear length, 1000-grain weight and number of grains per ear remained un affected but ear yield was significantly affected by increasing potash rates. Similarly the parameters like plant height, days to tasseling and silking remained unaffected, however stalk yield and protein content were significantly affected. They recommended the optimum level of potash as 150-200 kg ha^{-1} beyond this the application of potash was not profitable [11]. Applying K, at the rate of 150-169 kg K ha^{-1}, increase yield and net profit, grain yield increased by 10.8 kg for each kg K applied [12]. Highest levels of potash application to maize significantly delay tasseling, silking, increase plant height,, ears per plant, grains per ear, grain weight per ear, thousand-grain weight, grain and stalk yields [13].

Average per hectare yield of maize is very low due to lack of scientific information and modern technology. Many factors are involved in obtaining maximum yield of maize crop but unsuitable fertilizer application and timing are among the factors, which contribute, allot to maize production. It was therefore imperative to design this experiment to find out the response of spring maize to various levels of potash and timing for the economic growth of maize under the agro climatic conditions of Peshawar.

MATERIALS AND TIMINGS

In order to study the response of maize phenology, leaf area and grain yield potential under different levels and timings (number of splits) application of potassium a field experiment was designed and planted during spring season 2005, at Agricultural Research Farm of N.W.F.P Agricultural University, Peshawar.

The details of the treatments are as follows.

Factor A: Potassium levels (Main plots)

$K_{0=}$ Control

K_1 = 30 Kg ha^{-1}

K_2 =60 kg ha^{-1}

K_3 = 90 kg ha^{-1}

Factor B: Potassium timings (Sub-plots)

$T_{1=}$ One split (100 % at sowing).

T_2 = Two splits (50 % at sowing + 50 % at 15 days after emergence).

T_3 = Three splits (33.33% at sowing + 33.33% at 15 DAE +33.3% at 30 DAE)

The experiment was laid out in a randomized Complete Block Design (RCB) April 16, 2007 with split plot arrangement having three replications. The combination of potash doses were allotted to main plots while different timings of potassium application were allotted to sub plots. There were 12 plots in each replication. The size of each sub plot was 3×4 m^2. Each sub plot consisted of 6 rows with row to row distance of 70 cm and plant to plant distance was maintained at 20 cm. Nitrogen and phosphorous were applied at the rate of 120 and 60 kg ha$^{-1.}$ All Phosphorous (SSP) was applied at seedbed preparation while nitrogen was applied in three timings that is 33.3% at seedbed preparation, 33.3% at first irrigation and 33.3% at second irrigation. Hoeing was done twice to keep the crop free of weeds. All other agronomic practices were kept normal and uniform for all the experimental units. The crop was harvested on 10th of August 2005 an kept in the field for few days to get dry. Data were recorded on days to tasseling, days to silking, days to physiological maturity, flag leaf area (cm^2), average leaf area (cm^2) and grain yield (kg ha^{-1}). The above-mentioned parameters were calculated by the following methodology.

Data on days to tasseling was recorded when more than 50% plants develop tassels in each treatment. Days were counted from date of sowing till the completion of more than 50% tassels. Data on days to silking was recorded when more than 50% plants develop silks in each treatment. Days were counted from date of sowing till the completion of more than 50% silks. Data on days to physiological maturity was recorded when more than 50% plants lost their green color in each treatment. Five plants were randomly selected from each treatment and leaf area of three leaves (Upper, Lower, Middle) from each plant were measured with the help of leaf area machine and average was worked out. The data on flag leaf was recorded by selecting 5 plants randomly and then the area of top leaf was measured with the help of leaf area machine and average was worked out. At harvest the ears were husked, dried and shelled. Grain yield was recorded on per plant basis and then converted in kg ha^{-1}.

RESULTS AND DISCUSSION

Days to tasseling: Data regarding days to tasseling is given in Table 1. Statistical analysis of data exhibited that different K levels as well as timings of K had a significant effect on days to tasseling. Tasseling was delayed to 59 days when K was applied at the rate of 60 kg ha^{-1}, followed by 57 days when K was applied at the rate of 30 kg ha^{-1} while earlier tasseling (52 days) was recorded when K was applied at the highest rate of 90 kg ha^{-1}. Tasseling was delayed to 59 days in those plots which received K in three equal timings i.e. 33.3% at sowing time, 33.3% at 15 DAE and 33.3% at 30 DAE, followed by 56 days in those plots which received K in two equal timings i.e. 50% at sowing time and 50% at 15 DAE, while earlier tasseling of 53 days was recorded in those plots when 100% K was applied at sowing time. Increase in number of splits delayed tasseling while, increase in levels up to 60 kg ha^{-1} delayed tasseling but further increase in K level up to 90 kg ha^{-1} decreased tassling significantly. These results are in confirmation with those of Sadiq and Jan [13] an Samad *et al.* [5] who reported delay in tasseling with increase in potash levels. However, Chaudhary and Malik [11] reported that days to tasseling remained unaffected by increase in potash levels.

Days to silking: Data regarding days to silking is given in Table 1. Statistical analysis of data showed that different K levels as well as timings of K had a significant effect on days to silking. Silking was delayed to 67days when K was applied at the rate of 60 kg ha^{-1}, followed by 65 days when K was applied at the rate of 30 kg ha^1 while earlier silking of 58 days was recorded when K was applied at the rate of 90 kg ha^{-1}. Days to silking was delayed when number of K split application was increased. Delayed silking of 65 days was observed in those plots which received 33.3% K at sowing time, 33.3% at 15 DAE and 33.3% at 30 DAE, followed by 64 days in those plots which received 50% K at sowing time and 50% K at 15 DAE, while earlier silking of 61 days was noted in those plots when 100% K was applied at sowing time. These results are in contrast with those of Sadiq and Jan [13] an

Table 1: Days to tasseling, silking, maturity, flag leaf area, average leaf area and gain yield of maize as affected by levels and timings of potassium application

Potash	Days to tasseling	Days to silking	Days to maturity	Flag leaf area	Average leaf area	Grain yield
Levels						
0	55c	63c	92c	84.0bc	420.4	1498.8a
30	57b	65b	95b	103.6c	357.3	1670.1bc
60	59a	67a	98a	105.6ab	499	1701.2b
90	52d	58d	89d	110.8a	512.2	1949.2a
LSD	0.58	0.73	0.37	22.6	ns	177.6
Timings						
T_1	53a	61c	99c	95.1a	470.6	1807.7a
T_2	56b	64b	101b	84.2c	430.4	1693.2b
T_3	59a	65a	105a	88.6b	440.7	1613.5b
LSD	0.38	0.34	0.57	36.71	ns	91.68

Means of the same category followed by different letters are significantly different at $p \leq 0.05$ using LSD test

Note: The interactions between potash levels and timings were non significant for all the parameters studied in the experiment

Samad *et al.* [5] who reported delay in silking with increase in potash levels. However, Chaudhary and Malik [11] reported that days to silking remained unaffected by potash levels but.

Days to physiological maturity: Data regarding days to physiological maturity is given in Table 1. Statistical analysis of data showed that different K levels as well as timings of K had a significant effect on physiological maturity. Earlier physiological maturity was obtained when K levels was increased. Maximum of 98 days to physiological maturity was recorded when K was applied at the rate of 60 kg ha^{-1}, followed by 95 days when K was applied at the rate of 30 kg ha^{1} while minimum of 89 days was recorded when K was applied at the rate of 90 kg ha^{-1}. Maximum of 105 days to maturity was recorded in those plots which received 33.3% K at sowing time, 33.3% at 15 DAE and 33.3% at 30 DAE, followed by 101 days in those plots which received 50% K at sowing time and 50% K at 15 DAE, while minimum of 99 days was recorded in those plots when 100% K was applied at sowing time. These results are in contrast to those of Sadiq and Jan [13] and Samad *et al.* [5] who reported delay in physiological maturity with increase in potash levels. However, Chaudhary and Malik [11] reported that days to maturity remained unaffected with increase in potash levels.

Flag leaf area (cm^2): Data regarding flag leaf area is given in Table 1. Statistical analysis of data revealed that different K levels and timings had a significant effect on flag leaf area. In case of potash levels maximum flag leaf area of 110.8 was recorded when K was applied at the rate of 90 kg ha^{-1}, followed by 105.6 flag leaf area when K was applied at the rate of 60 kg ha^{1} while minimum of 84.0 area was recorded when no K was applied. Flag leaf area has increased by increasing potassium application levels. In case of potash timings maximum flag leaf area of 95.1 was recorded in those plots which received full dose of K at sowing time, followed by 88.6 flag leaf area in those plots which received 33.3% K at sowing time, 33.3% K at 15 DAE and 33.3% K at 30 DAE, while minimum of 84.2 leaf area was recorded in those plots when 50% K was applied at sowing time and the remaining 50% K_2O was applied at 30 DAE. The increase in flag leaf area of maize might be due to the increase in the activation of enzymes due to the highest level of K application.

Average leaf area (cm^2): Data regarding Average area is given in Table 1. Statistical analysis of data showed that different K levels and timings had non significant effect on average leaf area. Maximum average leaf area of 512.2 was recorded when K was applied at the rate of 90 kg ha^{-1}, followed by 499.0 average leaf area when K was applied at the rate of 60 kg ha^{1} while minimum of 357.3 area was recorded when K was applied at the rate of 30 kg ha^{-1}. Average leaf area has increased by increasing potassium application. Maximum average leaf area of 470.6 was recorded in those plots which received full dose of K at sowing time, followed by 440.7 leaf area was recorded in those plots which received 33.3% K at sowing time, 33.3% K at 15 DAE and 33.3% Kat 30 DAE. while minimum average leaf area of 430.0 was recorded in those plots when 50% K was applied at sowing time and the remaining 50% K_2O was applied at 30 DAE. The increase in average leaf area of maize might be due to the increase in the activation of enzymes due to the highest level of K application.

Grain yield (kg ha^{-1}): Data regarding grain yield is given in Table 1. The analysis showed that different potash levels and potash timing had a significant effect on grain yield. Maximum grain yield of1949.2 was recorded when K was applied at the rate of 90 kg ha^{-1}, followed by grain yield of 1701.2 when K was applied at the rate of 60 kg ha^{-1} while minimum grain yield of 1898.8 was recorded when K was not applied. The possible reason for maximum grain yield might be due to proper utilization of potassium fertilizer by maize cultivar resulted in maximum number of plants at harvest and hence the grains yield kg ha^{-1}. These results are in line with those reported by Malik *et al*. [4], Chaudhry and Malik [11] an Stauffer *et al*. [9], who reported that grain yield was increased with the increasing potash doses. Maximum grain yield of 1807.7 was recorded in those plots which received 100% K at sowing time, followed by grain yield of 1693.2 in those plots which received 50% K at sowing time and 50% K at 15 DAE, while minimum grain yield of 1613.5 was recorded in those plots when 33.3% K was applied at sowing time, 33.3% Kat 15DAE, 33.3% K at 30 DAE. The application of all K at sowing time increased enzymes activation which increased flag and average leaf area thus resulted in the highest grain yield of maize.

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