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Influence of different potash levels on spring maize hybrids

Abstract

An experiment was conducted during 2014 on spring maize hybrids and potash levels at Agriculture university Peshawar research form in Khyberpakhtunkhwa Pakistan. A set of four hybrids and four potash levels were evaluated in randomized complete block (RCBD) design, having four replication for effect of various potash levels on spring maize hybrids. Analysis of variance results revealed significant differences for days to tessling, days to silking, mean single leaf area, plant height, and number of plant at harvest, thousand grains weight, grain yield and biological yield. Mean data ranged from days to tessling 62 to 67, days to silking 69 to 74, mean single leaf area 440.15cm^2 to 494.28cm^2, plant height 204cm to 215cm, number of plant at harvest not effected by potash level, grain ear 520g to 547g, 1000 grain weight 375g to 414g, grain yield 3424 kg ha^{-1} to 4192kg ha^{-1}, biological yield 11118kg ha^{-1} to 13580 kg ha^{-1}. Based on the result of this study significantly. Delay in tasseling was observed with 120 kg K ha^{-1}. Among the hybrids tasseling was delayed (67 days) in 30K08. Silking was delayed (74 days) with 120 kg K ha^{-1}. Potash applied at the rate of 120 kg ha^{-1} had the largest leaf area (494.28 cm^2). Among the hybrids, larger leaf area (479.73cm^2) was recorded for CS200. Plants height (215.25cm) was produced when potash was applied at the rate of 120 kg ha^{-1}. In case of hybrids, 30K08 produced taller plants (212.87cm). The hybrids, CS 200 produced higher number of grains ear^{-1} (538.87). Hybrids CS200 produced heavier thousand grains weight (395.18 g), followed by 3025 (384.87g). The hybrids higher grain yield (4143kg ha^{-1}) was produced by CS200, followed by 3025 (3873 kg ha^{-1}). Higher biological yield Application of potash at the rate of 90 kg ha^{-1} resulted in higher biological yield (13580kg ha^{-1}). Among the hybrids, CS200 produced higher biological yield (13630 kg ha^{-1}). In this experiment our study that application of potash at the rate of 90 kg ha^{-1} improved yield and yield components. Hybrid-CS200 performed well in terms of yield and yield components. Hence for obtaining higher grain yield, Hybrid-CS200 with application of potash at the rate of 90 kg ha^{-1} is recommended.

Keywords: potash levels, Maize hybrids, grain yield, biological yield

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Introduction

Maize (*Zea mays* L.) Belongs to *Gramineae* family of plant kingdom. It is an important position in the existing cropping systems of Pakistan. Maize is grown in almost all the provinces of the country, but Punjab and Khyber Pakhtunkhwa are the main areas of production.[1] It is not only consumed by human beings in the form of food grain but it is also used as feed for livestock and poultry besides being a good forage crop.[2] It is also gaining importance due to being a commercial/industrial crop, where a large number of products are being manufactured out of its grain. Maize grain contains about 72% starch, 10% protein, 4.8% oil, 5.8 % fiber, 3.0% sugar and 1.7% ash.[3] The area under maize cultivation in Pakistan and Khyber Pakhtunkhwa Province was 935.1 Kg/ha^{-1} and 421.9 Kg/ha^{-1}, respectively with production of 3261.5 Kg/ha^{-1} tones and 752.2 Kg/ha^{-1} tones and the average grain yields of 3488 kg/ha^{-1} and 1854 kg/ha^{-1}in Pakistan and Khyber Pakhtunkhwa, respectively.[4] Maize crop is planted more than 500,000 ha land area in high mountain and plains of Khyber Pakhtunkhwa but its production is much lower in these areas (Rahman *et al.,* 2012). Maize grains have great economic importance and are used for food, fodder, pharmaceutical and industrial purposes. Its grains contain starch, protein, fiber, oil and ash (Ahmad *et al*., 2007). In Pakistan maize is grown twice in a year (spring and autumn). There is a gradual increase in planting of maize during spring season, since the introduction of spring maize cultivation in Pakistan. Since the active involvement of multinationals in Pakistan, cultivation of spring maize has been increased. Though the climatic and soil conditions of Pakistan are satisfactory for maize production but it's per hectare yield is very low as compared to other maize growing countries of the world. Potassium as a macronutrient plays a vital role in plant growth and sustainable crop production.[5] It sustains turgor pressure of cell which is essential for cell expansion. It assists in opening and closing of stomata and helps in osmoregulation of plant cell.[6] It plays an important part in activation of more than 60 enzymes (Tisdale et al., 1990). Application of K 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 rate of photosynthesis but also regulates transport of assimilates in maize. It is well known for its interaction both synergistic and antagonistic with essential macro and micro nutrients (Dibb and Thomson, 1985). Application of K is known vital for effective N utilization and have a fairly consistent effect on lowering tissue concentration of Ca and Mg (Bukhsh*et al*., 2010). Maize genotypes respond to potassium application contrarily due to modification in its uptake, translocation, accumulation, growth and utilization.[7,8] K-efficient genotype is a complex one involving a mixture of uptake and utilization efficiency mechanisms. One of the mechanisms of differential K uptake efficiency is the exudation of organic compounds to facilitate release of non-exchangeable K. Cultivars effective in K uptake and its utilization may have a larger surface area of leaf. Improved translocation of K into different plant organs, enhanced capacity to uphold cytosolic K^+ concentration within optimal ranges and augmented capacity to substitute Na^+ for K^+

are the key mechanisms underlying K utilization efficiency (Rengel and Damon, 2008). Hybrids with reduced harvest index under poor K supply were K-inefficient. Ability to tolerate low concentrations of K in shoot tissue where K supply was scarce was also important in determining K efficiency for grain yield. Hybrids which are K-efficient could have the potential to improve the efficiency and sustainability of cereal cropping systems (Damon and Rengel, 2007). Proficient plant cultivars could have better fertilizer use efficiency (FUE)[9] and leave low soil K and nitrogen as it is now understood that both of these elements should be present in sufficient and balanced quantities for proper crop growth[5] and hence may reduce input cost and conserve environment.[10]

Potassium status of soils is rapidly declining at a stressful rate and net K draining rate is even steeper (0.3 kg ha^{-1} $year^{-1}$) in Pakistan. It might be due to the inappropriate (0.8 kg ha^{-1} $year^{-1}$) utilization of K in Pakistan in comparison to the world average K use (15.1 kg ha^{-1} $year^{-1}$).[11] Consequently, it was needed to recognize spring maize hybrids effective in K uptake to provide best opportunities for future breeding research towards low input, sustainable and environment friendly agriculture. Therefore, the present study was aimed at exploiting the genetic variation among four spring maize hybrids for their suitable K level.

Materials and methods

A field experiment entitled "influence of different potash levels on spring maize hybrids" was conducted during spring, 2014 at Agronomy Research Farm, The University of Agriculture Peshawar. The experiment was consisting of two factors i.e. potash levels and maize hybrids. A randomized complete block design (RCBD) was used. Plot size was kept 3.5 m by 3 m with row to row and plant to plant distance of 70 cm and 25 respectively, having 5 rows. A uniform dose of 150 kg N ha^{-1} and 90 kg P ha^{-1} in the form of urea and DAP was applied. Pre-sowing soil test was carried for the N and K. Nitrogen was applied in two equal splits i.e. 50% at sowing and 50% at 2nd irrigation. Sulphate of potash was used as a source of potash. All P and K dose was applied at the time of sowing. . All other agronomic practices were carried out uniformly for all the treatments. Pre-soil analysis was carried out for K, N and pH. The texture of the experimental area was silty clay loam with alkaline nature (pH 7.5-7.8). The soil was deficient in total N ($\leq$0.53g kg^{-1} soil) and K$\leq$92 mg kg^{-1} soil.

The details of the factors and their levels were as follows:

Factor A: Four K levels

K1 = 0 kg ha^{-1}

K2 = 60 kg ha^{-1}

K3 = 90 kg ha^{-1}

K4 = 120 kg ha^{-1}

Factor B: Four Hybrids

H1 = 30K08

H2 = 2031

H3 = CS 200

H4 = 3025

Data was recorded on the following parameters;

Days to tasseling: Data regarding days to tasseling was recorded by counting number of days from the date of sowing to the date on which 80% plants developed tassels.

Days to silking: Data regarding days to silking was recorded by counting number of days from sowing to the date on which 80% plants developed silks.

Mean Single Leaf Area (cm^2): Leaf area was taken manually of three plants in each plot at silking stage by using the following formulae:

L.A.=Leaf length (cm)xLeaf width (cm)x0.75

Plant height (cm): Plant height was recorded by recording the plant height of five plants from ground level to tip of each plot with the help of meter rod.

Number of plants at harvest ha^{-1}: Plants in every plot were recorded and then converted to ha^{-1} in order.

Grains per ear: The ears harvested for grains yield were used for the determination of number of grains per ear by selecting five ears randomly from each plot, dried and shelled for counting the grain ear^{-1}.

1000 grains weight: Data regarding 1000 grains weight was recorded by counting randomly selected grains from seed plot.

Grain yield (kg ha^{-1}): Grain yield was recorded after shelling of ears from each three rows and was converted into kg ha^{-1}.

Grain yield (kg) in three central rows X 10000

Grain yield (kg ha^{-1}) = Row-row distance x Row length x No. of rows

Biological yield (kg ha^{-1}): Biological yield was recorded by weighing all the plants harvested from three rows and then converted into kg ha^{-1}.

Biological yield (kg) in three central rows X 10000

Biological yield (kg ha^{-1}) =Row-row distance x Row length x No. of rows

Statistical analysis: The data was analyzed statistically using analysis of variance techniques appropriate for randomized complete block design. Significant differences among treatments were determined using least significant difference (LSD) test for main as well as interaction effects.[12]

Results and discussion

According to the procedures given in materials and methods, the data collected on various parameters are briefed as under.

Days to tasseling

Data concerning days to tasseling was significantly affected by potash (K) application and hybrids (H) (Table 1). The interaction between K x H was non-significant. Mean values for potash showed that tasseling was delayed with the increase in potash level. Delay in tasseling was observed with 120kg K ha^{-1} (67 days) while early tasseling was observed with no application of potash (63 days). Among the hybrids, tasseling was delayed (67 days) in 30K08 however it was statistically at par with 2031, followed by 3025 (64 days) whereas early tasseling was observed for CS200 (62 days). Finding of our results are in accordance with the findings of Bukhsh et al. (2011), Chanda et al.,[13] & Hussain et al.,[14]

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Table 1 Days to tasseling of spring maize hybrids as affected by levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	65	66	60	62	63 d
60	67	67	61	64	65 c
90	68	68	63	65	66 b
120	69	69	64	65	67 a
Mean	67a	67a	62 c	64 b	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=0.48

LSD for Hybrids (H)=0.48

LSD for K X H=ns

Days to silking

Data in accordance with days to silking was significantly affected by potash (K) application and hybrids (H) (Table 2). No K x H interaction occurred for days to silking. Mean values for potash indicated that silking was delayed (74 days) with 120 kg K ha^{-1}. Early silking (70 days) was observed in plots receiving no potash. In case of hybrids there was significant difference for days to silking. Late silking (74 days) was observed for hybrid 30K08 which was statistically similar to 2031, followed by 3025 (71 days), while early silking (69) was observed for CS200. Finding of our results are in accordance with the findings of Bukhsh *et al*. (2011), Chanda et al.,[13] & Hussain et al.,[14]

Table 2 Days to silking of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	72	73	67	69	70 d
60	74	74	68	71	72 c
90	75	75	70	72	73 b
120	76	76	71	72	74 a
Mean	74 a	74 a	69 c	71 b	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=0.529

LSD for Hybrids (H)=0.529

LSD for K X H=ns

Mean single leaf area (cm2)

Leaf area was significantly affected by potash (K) application and hybrids (H) and their interaction (K x H) (Table 3). Potash applied at the rate of 120kg ha^{-1} had the largest leaf area (494.28cm^2) which was statistically at par with 90 kg ha^{-1}, followed by 60kg ha^{-1} (475.21cm^2), whereas less leaf area (376.95cm^2) was obtained where potash was not applied. Among the hybrids, larger leaf area (479.73cm^2) was recorded for CS200, followed by 3025 (467.79cm^2) and 30K08 (451.79cm^2), while lower leaf area (440.15cm^2) was recorded for 2031. Interaction between K x H showed that all the hybrids produced larger leaf area when K was applied at the rate of 90 kg ha^{-1} (Figure 1). Findings of our study are in line with Ayub et al.,;[15] Hussain et al.,[16] Yang et al. (2004); Bukhsh et al.(2011) and Aslam et al.[17] who also found improvement in growth parameters in different cultivars with the application of potash.

Table 3 Mean single leaf area (cm^2) of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	371.8	372.9	381	377.9	375.9 c
60	478.3	443.1	494.5	484.8	475.2 b
90	478.2	472.8	521.7	503.2	494.0 a
120	478.7	471.6	521.5	505.1	494.2 a
Mean	451.7 c	440.1 d	479.7 a	467.7 b	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=5.57

LSD for Hybrids (H)=5.57

LSD for K X H =**

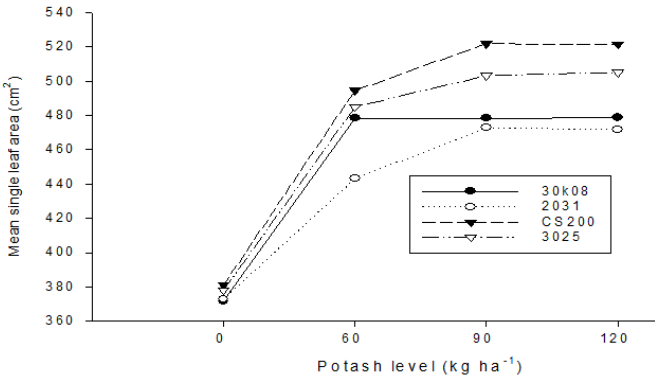

Figure 1 Interaction between K and H for mean single leaf area (cm^2)

Plant height (cm)

Potash (K) application and hybrids (H) as well as their interaction significantly affected plant height (Table 4). Long stature plants (215.25cm) were produced when potash was applied at the rate of 120kg ha^{-1} which was statistically similar to 90 kg ha^{-1}, followed by 60kg ha^{-1} (198.37cm) whereas short stature plants (179.43cm) were produced in plots where potash was not applied. In case of hybrids, 30K08 produced taller plants (212.87 cm), followed by CS200 (205.87cm) and 3025 (199.81cm) whereas short stature plants (189.62cm) where recorded for 2031. As for as concerned with the interaction between K x H, mean data revealed that plant height increased significantly with the increase in potash level up to 90 kg ha^{-1} in all hybrids (Figure 2). Findings of our study are in line with Ayub et al.,[15] Hussain et al., (2011); Yang et al., (2004); Bukhsh et al., (2011) and Aslam et al.,[17] who also found improvement in growth parameters in different cultivars with the application of potash.

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Table 4 Plant height (cm) of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	188	174	180.7	175	179.4 c
60	207	182.2	204	200.2	198.3 b
90	229.2	200.5	219	211.7	215.1 a
120	227.2	201.7	219.7	212.2	215.2 a
Mean	212.8 a	189.6 d	205.8 b	199.8 c	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=2.42

LSD for Hybrids (H)=2.42

LSD for K X H =**

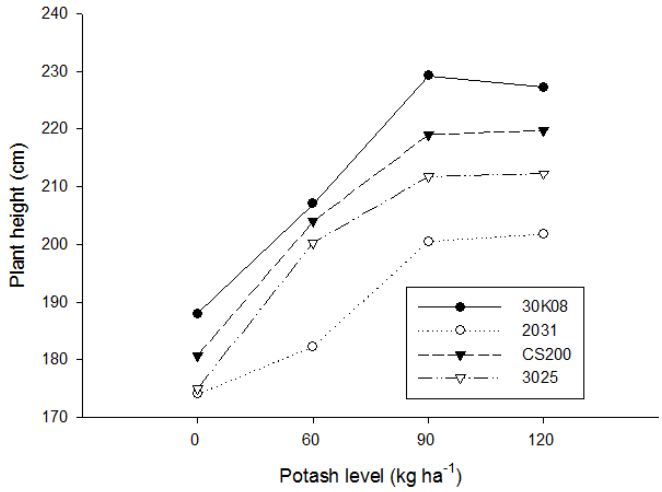

Figure 2 Interaction between K and H for plant height (cm)

Number of plants at harvest (ha-1)

Number of plants at harvest was neither affected by potash (K) application nor by hybrids (Table 5). Interaction between K x H also did not significantly affected number of plants at harvest.

Table 5 Number of plants at harvest (ha^{-1}) of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	54762	54285	54047	55714	54702
60	54761	54524	54524	54762	54642
90	41860	55238	54761	54523	51596
120	54762	54523	55000	54047	54583
Mean	51536	54642	5458	54761	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=ns

LSD for Hybrids (H)=ns

LSD for K X H=ns

Grains ear-1

Statistical analysis of the data revealed that potash (K) application and hybrids (H) had significantly affected grains ear^{-1} (Table 6). Interaction between K x H showed no significant difference for grains ear^{-1}. Application of potash at the rate of 120 kg ha^{-1} resulted in more number of grains ear^{-1} (547.37) however it was statistically at par with 90kg K ha^{-1}, followed by 60kg K ha^{-1} (515.31), while lower grains ear^{-1} (483.62) were recorded for the plots where potash was not applied. Among the hybrids, CS 200 produced higher number of grains ear^{-1} (538.87), followed by 3025 (530.87) then by 30K08 (518.87), while 2031 resulted in lower number of grains ear^{-1} (504.06). Similar trends were also reported by Rengel and Damon (2008); Minjian et al.,[8]; Akhtar et al.,[18] Shahzad[19] & Gozubenli et al.,[20]

Table 6 Grains ears^{-1} of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	479	462	501	491	483 c
60	511	500	530	518	515 b
90	541	526	561	556	546 a
120	543	527	562	557	547 a
Mean	518 c	504 d	538 a	530 b	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=5.52

LSD for Hybrids (H)=5.52

LSD for K X H=ns

Thousand grains weight (g)

Thousand grains weight was significantly affected by potash (K) application and hybrids (H) as well as their interaction (K x H) was also significant (Table 7). Application of potash at the rate of 120kg h^{-1} produced heavier thousand grains weight (414.87g), followed by 90kg ha^{-1} (391.68 d) then by 60kg ha^{-1} (378.12g), while no application of potash resulted in lighter thousand grains weight (354. 12g). In case of hybrids, CS200 produced heavier thousand grains weight (395.18g), followed by 3025 (384.87g) whereas 2031 produced lighter thousand grains weight (375.37g). As for as concerned with the interaction between K x H, mean data revealed that thousand grains weight increased significantly with increase in potash level in all hybrids (Figure 3). Similar trends were also reported by Rengel and Damon (2008); Minjian et al.;[8] Akhtar et al.;[18] Shahzad[19] and Gozubenli et al.[20]

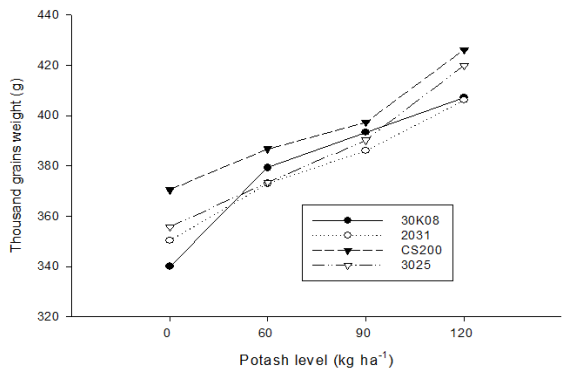

Figure 3 Interaction between K and H for thousand grains weight (g)

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Table 7 Thousand grains weight (g) of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	340	348.75	370.5	355.75	353.75 d
60	379.25	366	386.75	373.5	376.37 c
90	393.25	384	397.25	390.25	391.18 b
120	407.25	402.75	426.25	420	414.06 a
Mean	379.93 c	375.37 d	395.18 a	384.87 b	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=3.5

LSD for Hybrids (H)=3.5

LSD for K X H =**

Grain yield (kg ha-1)

Statistical analysis of the data showed that potash (K) application and hybrids (H) significantly affected grain yield (Table 8). Grain yield was also significantly affected by the interaction of K x H. Mean values for potash (K) indicated that higher grain yield (4192kg h^{-1}) was obtained with 120kg K ha^{-1} which was statistically similar to 90kg K ha^{-1}(4128kg h^{-1}), followed by 60kg K ha^{-1}(3515kg ha^{-1}), while no application of potash resulted in lower grain yield (3151kg ha^{-1}). Among the hybrids, higher grain yield (4143kg ha^{-1}) was produced by CS200, followed by 3025 (3873kg ha^{-1}) and 30K08 (3547kg ha^{-1}), whereas lower grain yield (3424kg ha^{-1}) was produced by 2031. Interaction between K x H showed that there was significant variation among the grain yield of hybrids, increase in grain yield of all hybrids was more pronounced up to 90 kg K ha^{-1}, but there was no significant increase in grain yield of all hybrids when potash level was increased above 90kg K ha^{-1} (Figure 4). Findings of our study are in line with Khan et al. (1999); Tahir et al.;[21] Saha et al.;[22] Alias et al. (2009) and Pettigrew.[23]

Table 8 Grain yield (kg ha^{-1}) of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	3077	2903	3410	3216	3151 c
60	3441	3239	3759	3623	3515 b
90	3800	3682	4707	4322	4128 a
120	3871	3871	4695	4331	4192 a
Mean	3547 c	3424 d	4143 a	3873 b	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=66

LSD for Hybrids (H)=66

LSD for K X H =**

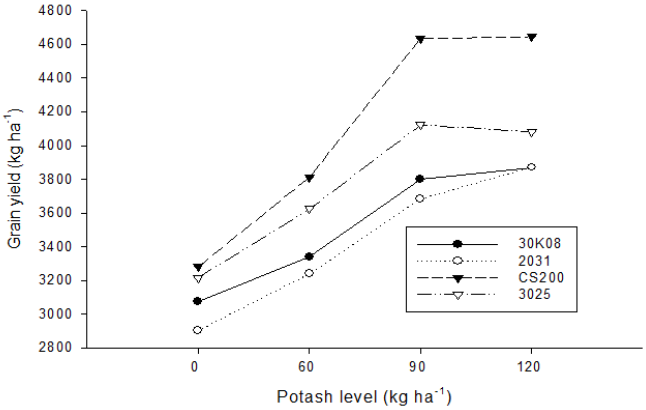

Figure 4 Interaction between K and H for grain yield (kg ha^{-1})

Biological yield (kg ha-1)

Data in association with biological yield revealed that there was significant variation for potash (K) application and hybrids (H) (Table 9). Data collected on this plant parameter also revealed that interaction between K x H had significant. Application of potash at the rate of 90kg ha^{-1} resulted in higher biological yield (13580kg ha^{-1}) however it was statistically at par with 120kg K ha^{-1}, followed by 60kg K ha^{-1} (11502kg ha^{-1}), while plots where potash was not applied resulted in lower biological yield (10496 kg ha^{-1}). Among the hybrids, CS200 produced higher biological yield (13630kg ha^{-1}), followed by 3025 (12776kg ha^{-1}) and 30K08 (11516kg ha^{-1}), whereas 2031 produced lower biological yield (11118kg ha^{-1}). As for as concerned with the interaction between K x H, biological yield tended to increase up to 90kg K ha^{-1} in all hybrids, however further increase did not significantly affected biological yield in all hybrids (Figure 5). Findings of our study are in line with Khan et al. (1999); Tahir et al.;[21] Saha et al.;[22] Alias et al. (2009) and Pettigrew.[23]

Table 9 Biological yield (kg ha^{-1}) of spring maize hybrids as affected by potash levels

K Level (kg ha^{-1})	Hybrids				Mean
	30K08	2031	CS200	3025	
0	10318	9830	11187	10649	10496 c
60	11421	10476	12149	11963	11502 b
90	12302	12262	15591	14167	13580 a
120	12024	11905	15595	14325	13462 a
Mean	11516 c	11118 d	13630 a	12776 b	

Means in similar category of columns and rows with different alphabets differ significantly from each other at p≤0.05 using LSD.

LSD for Potash (K)=327

LSD for Hybrids (H)=327

LSD for K X H =**

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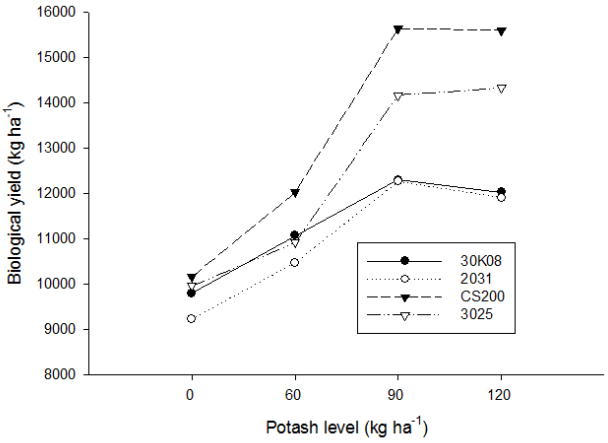

Figure 5 Interaction between K and H for biological yield (kg ha^{-1})

Conclusions and recommendation

It was concluded that Applying potash at the rate of 90kg ha^{-1} resulted in significantly higher mean single leaf area and plant height as compared to control plots. It was obtained in those plots which received potash at the rate of 90kg ha^{-1}. Hybrid-CS200 produced more grain yield and biological yield than the other hybrids. Interaction between K x H also occurred for grain yield and biological yield. Thenumber of grains per ear and thousand grains weight were significantly affected by the application of potash. More number of grains per ear was recorded in plots which received potash at the rate of 90 kg ha^{-1}. Heavier thousand grains weight was recorded in plots receiving potash at the rate of 120kg ha^{-1}. Hence for obtaining higher grain yield, Hybrid-CS200 with application of potash at the rate of 90kg ha^{-1} is recommended.

Acknowledgments

None.

Conflicts of interest

The author declares that there are no conflicts of interest.

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