RESPONSE OF MAIZE HYBRIDS AND ASSOCIATED WEEDS TO INTEGRATED POTASSIUM APPLICATION

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ABSTRACT

Maize (Zea mays L.) has high growth rate, produces large biomass and is highly susceptible to weed completion in its earlier growth stages till canopy closure. A Field experiment was conducted at Agronomy Research Farm of The University of Agriculture Peshawar, Pakistan during Kharif, 2016. Randomized complete block design (RCBD) with split plot arrangement was used keeping four replications. It was two factor study i.e. maize hybrids (DK-Garanon, Pioneer-3025, WS-666, and Pioneer-3164) allotted to main plots and potassium ratios (100% organic, 80% organic + 20% inorganic, 60% organic + 40% inorganic, 40% organic + 60% inorganic, 20% organic + 80% inorganic, 100% inorganic and control treatment) assigned to subplots. Potassium (K_2O) was applied to field in such an arrangement that 100, 80, 60, 40, 20 and 0% K_2O was acquired from the organic source (poultry manure) and the remaining was balanced form inorganic source (sulphate of potash) for supplying a total potassium of 80 kg ha^{-1}. Results indicated that among maize hybrids, lowest weed fresh weight (271.60 g m^{-2}), weed dry weight (80.53 g m^{-2}) with highest emergence m^{-2} (7.74), 1000 grains weight (291.1 g), and harvest index (32.84%) was recorded for DK-Garanon hybrid whereas more grains ear^{-1} (496) and rows ear^{-1} (15) were recorded for Pioneer-3164. Highest weeds fresh (364.20 g m^{-2}) and dry weight (114.4 g m^{-2}) was registered in plots which received 100% K_2O as organic source. Highest grains ear^{-1} (517), 1000 grains weight (300 g), and harvest index (36%) were recorded in plots where 40% K_2O was applied from organic and 60% from inorganic source. It can be concluded from the experiment that application of 80 kg K_2O ha^{-1} as 40% organic and 60% inorganic source to maize hybrid DK-Garanon resulted in better yield and yield components.

Keywords: Harvest index Maize hybrids, Poultry manure, Sulphate of potash, 1000 grains weight, Zea mays.

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INTRODUCTION

Maize (Zea mays L.) is the third important staple crop of Pakistan after wheat and rice. In Khyber Pakhtunkhwa province, it was cultivated on 0.46 million hectares that produced 0.91 million tons with mean yield of 1.965 tons $ha^{-1}$and its national average seed yield was 4.23 tons ha^{-1}. (MNFSR, 2015). Pakistan's climate is well suited for exploiting maize potential but still its yield is lower than other developed countries of the world. Various maize genotypes are planted throughout Pakistan. Their response to different factors like water, nutrients, and weeds vary greatly. This variable response is mainly due to differences in their emergence (Tahir et al., 2008), tasseling (Gozubenli, 2001), silking (Luque et al., 2006), leaf area (Nawaz et al., 2006), leaf area index (Minjian et al., 2007), plant height (Umakanth and Satyanarayana, 2000), grain ear^{-1} (Liu et al., 2004), 1000 grains weight (Sener et al., 2004), biological yield (Ali et al., 2012), grain yield (Damon and Rengel, 2008) and harvest index (Bangarwa et al., 1988). Undoubtedly, with increase in maize production life of farming community will improve and sowing of hybrid seed is an opening key for this. Globally hybrids account for 83% in the land under maize cultivation (FSCD, 2005)..

Organic manure is a renewable and cheap source for plant essential nutrients. Several studies have proved its positive effects on soil health and crop yield (Jedidi et al., 2004). Potassium after two major nutrients i.e. N and P has maintained its third position for a tremendous role in plant development. It helps in uptake of water and nutrients (Thomas and Thomas, 2009), protein and carbohydrate synthesis (Patil, 2011), and in increasing crop yield (Rasool et al., 2008). Application of K_2O significantly improves yield and yield components of maize (Thomas and Thomas, 2009). Maize growth significantly improves with the application of K_2O (Bukhsh et al., 2011). Several researchers (Liaqat et al., 2018; Jan et al., 2018) reported that K_2O application is unavoidable for obtaining higher yield of maize crop. Plant height (Stone et al., 2001), ear length (Amanullah et al., 2016) and thousand grains weight (Sadiq et al., 2017) of maize substantially increased with K_2O application. Crop productivity and sustainability can be achieved through the use of integrated fertilizers (Gosh et al., 2004). Paul and Mannan (2006) stated that combined use of organic with synthetic fertilizers can be a better approach to reduce nutrients depletion and to attain sustainability in crop production. Integrated use of organic manures and chemical fertilizers can help in optimizing crop yield & soil properties (Rautaray et al., 2003).

Weeds compete with field crops for natural and synthetic resources hence limit the crop productivity to a greater extent. They also decline the quantity and quality of agriculture produce (Rao et al., 2015). Approximately 32% yield reduces due to the presence of these unwanted plants (Bhan et al., 1999). They also have a negative effect on human, animal and environment health (DWSR. 2013). The losses due to weeds will increase if their indirect effect on nutrient and water depletion, grain quality and cost of their removal are taken into account. Study on integrated K_2O management for maize production has not yet been conducted so much in the study area. Due to lack of scientific work, scientific recommendations for integrated K_2O management from organic and synthetic fertilizer for maize are not available in the study area. Since synthetic fertilizers are costly and has several limitations while organic fertilizers are cheap and has long lasting effect on soil and hence it become necessary to study the combined effect of organic and inorganic K_2O sources on maize yield. Therefore, this study was carried out to evaluate the impact of K_2O applied as sole organic and inorganic as well as in combination of different organic and inorganic ratios on maize hybrids proutivity.

MATERIALS AND METHODS

Experimental Field description

The experiment was conducted at New Developmental Farm, the University of Agriculture Peshawar, Pakistan. The Physico-chemical Properties of the experimental field are detailed in Table-1. Whereas NPK content of Poultry Manure is supplied in Table-2 below.

Table-1. Physico-chemical properties of the the soil of experimental site (Ali et al., 2018)..

S. No.	Soil Variable	Value
1	Organic matter	0.730(%)
2	Total nitrogen (%)	0.044 (%)
3	Mineral nitrogen	0.843 (mg kg^{-1})
4	pH	8.02
5	EC	0.17 (dSm^{-1})
6	Bulk density	1.24 (g cm^{-3})
7	Textural class	Silty clay loam

Table 2. NPK content (%) of the Poultry manure (Ali et al., 2018).

Source	N	P	K
Poultry Manure (PM)	2.13	1.72	1.58

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Experimental details

Maize hybrids (DK-Garanon, Pioneer-3025, WS-666 and Pioneer-3164) and potassium ratios (100% organic, 80% organic + 20% inorganic, 60% organic + 40% inorganic, 40% organic + 60% inorganic, 20% organic + 80% inorganic, 100% inorganic and control) were taken for a field experiment to document their effect on weed fresh and dry weight along with crop productivity. The experiment was laid out in randomized complete block design under split pot arrangement. Hybrids were assigned to main plot and potassium ratios to sub plot. Poultry manure (PM) was used as organic while sulphate of potash (SOP) was applied as inorganic source of K_2O for obtaining 80 kg K_2O ha^{-1} from different combination as per proposed treatment structure. Poultry manure was applied to field as required three weeks prior to sowing. The experimental site was Agronomy Research Area of the University of Agriculture Peshawar. A sub plot of 4 m x 3.5 m was made. Sowing was done on ridges in July 2016. Nitrogen as a urea and phosphorous as a DAP (di-ammonium phosphate) was applied at the rate of 150 and 90 kg ha^{-1}, respectively keeping the amount already added from PM into consideration. Field was prepared on proper field capacity level through cultivator followed by rotavator. Ridges were made through Ridger. Complete sowing was done manually on the same day. Thinning was carried out manually in knee height stage to keep optimum plant population having 25 cm plant to plant distance. Irrigation were given according to crop water requirement and weather condition particularly rainfall. Other management practices (hoeing, pesticide) were kept same for all treatments.

Procedure for recording data

Data regarding weeds fresh weight (g m^{-2}) and dry weight (g m^{-2}) were determined by randomly throwing three times a 25cm x 25cm iron ring in each subplot. Weeds were harvested from each ring, weighed in the field with an electronic balance and averaged to determine weeds fresh weight per iron ring area. The harvested weeds were then kept in sunlight for drying till constant weight which were then weighed and averaged to determine weeds dry weight per iron ring area. The obtained data was converted into g m^{-2}.The number of plants emerged were recorded by randomly placing a meter rod at three places in each subplot and counting the number of plants which were then converted to plants m^{-2}. grains ear^{-1} of maize was calculated by taking five ears randomly in each experimental unit. Grains in these ears were counted manually and averaged to get mean value. Rows ear^{-1} was calculated by selecting five ears randomly in each experimental plot. Rows ear^{-1} was counted and then averaged to get mean value. Thousand grains were randomly taken after threshing and cleaning the grains in each experimental plot and weighed on a sensible balance in grams. Harvest index was calculated by using the following formula:

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \times 100$$

STATISTICAL ANALYSIS

The recorded data were statistically analyzed according to analysis of variance techniques through Statistix 8.1 software. Least significant difference (LSD) test was used at $P \leq 0.05$ upon significant F-test through the procedure described by Jan et al. (2009).

RESULTS AND DISCUSSION

Weeds fresh and dry weight (g m^{-2})

Substantial difference was observed in weeds fresh and dry weight for hybrids and potassium ratios (Table-3). The interaction between hybrids and potassium ratios was found non-significant. Means of hybrids indicated that highest weeds fresh weight (351.2) and dry weight (109.1) was observed in plots sown with WS-666 while lowest weeds fresh weight (271.6) and dry weight (80.53) was noted in DK-Garanon sown plots. Different hybrids have different potential to compete with weed species for soil and environmental resources, thus affects weeds fresh and dry weight. In case of potassium ratios highest weeds fresh weight (364.2) and dry weight (114.4) was recorded in plots which received sole organic potassium while lowest weeds fresh weight (277.3) and dry weight (82.7) was noted in plots which received potassium 40% from organic (poultry manure) and 60% from inorganic (sulphate of potash) source. Similar results are reported by Jama et al. (1997) who documented that application of organic manures resulted in higher weeds biomass. Weeds compete with maize for nutrients in the soil. Shah et al. (2016) reported that organic manure increases weeds fresh & dry weight due to presence of essentials nutrients in organic manure.

Emergence m^{-2}

Data presented in Table-4 showed significant difference in emergence m^{-2} for hybrids while potassium ratios and interaction of hybrids and potassium ratios remained non-significant for emergence m^{-2}. Mean values for hybrids indicated that more emergence m^{-2} (7.74) was recoded for DK-Garanon followed by Pioneer-3164 (7.71) which was statistically at par with Pioneer-3025 (7.51), while less emergence m^{-2} was recorded for WS-666 (7.15). Difference in hybrids regarding emergence per unit area might be due to difference in their germination percentage, viability, seed size, and seed vigour etc. (Tahir et al., 2008; Minjian et al., 2007).

Grains ear^{-1}

Hybrids and potassium ratios caused significant variations in grains ear^{-1} of maize (Table 4). However, interaction of hybrids and potassium ratio was found non-significant. Highest grains ear^{-1} (496) was counted in pioneer-3025 followed by Garanan hybrid (457) while lowest grains ear^{-1} (424) was calculated for WS-666 hybrid. Luque et al. (2006) stated that difference in grains ear^{-1} among maize hybrids might be due to the variation in their ear length, ear diameter, and grain size. Ali et al. (2015) and Liaqat et al. (2018) reported similar findings of different grains ear^{-1} for different hybrids due to variation in their ear length and grains per row. In case of potassium ratios, more grains ear^{-1} (517) was counted in plots which received potassium 40% from organic (PM) and 60% from inorganic (SOP) source while lowest grains ear^{-1} (421) was counted in control plots. It might be due to the synergistic effect of organic and mineral potassium. Ayoola and Adeniyan (2006) reported that integrated use of NP and K fertilizers along with poultry manure performed better than sole use of inorganic or organic sources for grains ear^{-1}. Application of K_2O enhances photosynthetic activity and helps in more translocation of assimilates towards developing sink and might resulted in more grains per ear. Hussain et al. (2007) documented higher grains per ear for 90 kg ha^{-1} K_2O application to maize.

No. of Rows ear^{-1}

The variation in rows ear^{-1} of maize in response to hybrids and potassium ratios is presented in Table-4. Statistical analysis of data reported that hybrids caused significant variation in rows ear^{-1} while potassium ratios and interaction of hybrids and K ratios was non-significant. Planned mean comparisons for hybrids indicated that hybrid pioneer-3025 produced more rows ear^{-1} (15) which was statistically at par with pioneer-3164 (15) followed by DK-Garanon (14). while lowest rows ear^{-1} (13) were recorded for WS-666. It might be due to differences in the genetic potential of hybrids.

Thousand grain weight (g)

Hybrids and potassium ratios significantly ($P \leq 0.05$) affected thousand grains weight while interaction of H x K remained non-significant (Table-4). Highest value for thousand grains weight (291.1 g) was noted for Garanan hybrid while lowest value for 1000 grains weight (259.8 g) was registered for WS-666 hybrid. Sener et al. (2004) reported that differences in thousand grain weight among hybrids could be due to their genetic potential. Liaqat et al. (2018) and Jing et al. (2003) documented similar findings of variation in grains weight among various maize hybrids and attributed this variation to the genetic constitution of different hybrids. In case of potassium ratios the highest 1000 grains weight (300 g) was recorded in plots which received potassium 40% from organic and 60% from inorganic source while lowest 1000 grains weight (231.8 g) was recorded in control plots. It might be due to the synergistic effect of organic and inorganic fertilizers which enhanced crop growth and thus produced heavy grains. Davis et al. (1996) reported that different potassium levels increased 1000 grains weight. Akhtar et al. (2003) reported that with application of K_2O, activity of enzymes related with translocation of prepared assimilates from source to sink increases which in turn might enhance grain weight. Our results are agree with Sadiq et al. (2017) who reported that K_2O application resulted in heavier grains than control.

Harvest index (%)

Statistical analysis showed that hybrids and potassium ratios significantly affected harvest index as reported in Table-4 while hybrids and potassium ratios interaction was found non-significant. Planned mean comparisons for hybrids indicated that DK-Garanon produced highest harvest index (33%) followed by pioneer-3164 (32%) which was statistically similar with pioneer-3025 (31%). Lowest harvest index (30%) was noted for WS-666 hybrid. Mean values across hybrids showed that in potassium ratios highest harvest index (36%) was recorded in plots which received potassium 40% from organic and 60% from inorganic sources. The sole inorganic potassium plots resulted in 33% harvest index which was statistically different from sole organic potassium plots (30%). Lowest harvest index (27%) was recorded in control. Sabir et al. (2000) and Bangarwa et al. (1988) reported that significant difference among hybrids for harvest index occur due to variations in their genetic potential. Similarly in potassium ratios the highest harvest index was noted in 40% organic + 60% inorganic K treatment plots while harvest index was lowest in control plots. The possible reason for higher harvest index could be the balanced supply of nutrients form combination of organic and inorganic sources of potassium. Cheema et al. (2010) stated that integrated management of fertilizers i.e 50% organic + 50% inorganic sources improved harvest index.

CONCLUSIONS

Among hybrids, DK-Garanon produced highest emergences m^{-2} (7.74), competed well with weeds for soil and environmental resources and resulted in lower weed fresh (271.60 g m^{-2}) and dry weight (80.53 g m^{-2}). In potassium ratios, highest thousand grains weight (300 g) and harvest index (36%) were recorded in plots which received 80 kg K_2O ha^{-1} as 40: 60 (organic and inorganic) combination, respectively. Therefore, potassium application at the rate of 80 kg ha^{-1} in such an arrangement that 40% K_2O is obtained from organic (poultry manure) and 60% from inorganic source (sulphate of potash) to hybrid DK-Garanon is recommended for minimum weed fresh weight, weeds dry weight and to achieve higher yield components.

Table-3. Weed fresh weight (g m^{-2}) and weed dry weight (g m^{-2}) of maize crop as influenced by maize hybrids and integrated potassium management.

Treatment	Weeds fresh weight (g m^{-2})	Weeds dry weight (g m^{-2})
Hybrids (H)		
Garanan	271.60 c	80.53 c
Pioneer-3025	297.50 b	91.16 b
WS-666	351.20 a	109.1 a
Pioneer-3164	321.40 b	98.13 b
LSD$_{(0.05)}$	24.33	10.21
Potassium Ratios (PR)		
100% organic	364.20 a	114.4 a
80% organic+ 20% inorganic	355.30 a	108.4 a
60% organic+ 40% inorganic	334.10 b	100.7 b
40% organic+ 60% inorganic	277.30 d	82.70 d
20% organic+ 80% inorganic	327.50 b	99.16 b
100% inorganic	320.60 b	97.86 b
Control	298.40 c	90.34 c
LSD$_{(0.05)}$	19.41	7.31
P value (Hybrids)	0.0028**	0.041*
P value (Potassium Ratios)	0.0015***	0.0031**
P value (H x PR)	0.695	0.861

LSD =Least significant difference H = Hybrids PR =Potassium ratios NS=non-significant
Means of the same category sharing different letters are significantly different at $P \leq 0.05$.
*= significant at 5% level of probability **= significant at 1% level of probability ***= significant at 0.01% level of probability

Table-4. Emergence m^{-2}, Grains ear^{-1}, Rows ear^{-1}, 1000 grains weight (g), and Harvest index (%) of maize as affected by hybrids and integrated potassium management.

Treatment	Emergence m^{-2}	Grains ear^{-1}	Row ear^{-1}	1000 Kernel Weight g	Harvest Index (%)
Hybrids					
Garanan	7.74 a	457 b	14 b	291.1 a	32.84 a
Pioneer-3025	7.51 b	496 a	15 a	265.8 b	31.63 b
WS-666	7.15 c	424 c	13 c	241.6 c	30.84 c
Pioneer-3164	7.71 a	488 a	15 a	259.8 b	31.48 b
$LSD_{0.05}$	0.33	29.74	0.48	7.99	1.01
Potassium Ratios					
100% organic	7.49	446 d	14	251.8 d	30 c
80% organic+ 20% inorganic	7.37	445 d	15	246.4 d	30 c
60% organic+ 40% inorganic	7.52	496 b	14	282.7 b	33 b
40% organic+ 60% inorganic	7.58	517 a	14	300.0 a	36 a
20% organic+ 80% inorganic	7.55	469 c	15	268.5 c	32 b
100% inorganic	7.70	471 c	14	271.0 c	33 b
Control	7.49	421 e	14	231.8 e	27 d
$LSD_{0.05}$	NS	20.43	NS	11.37	2.19
P value (Hybrids)	0.009**	0.0015**	0.00***	0.00***	0.0028**
P value (K Ratios)	0.521	0.00***	0.796	0.00***	0.00***
P value (H x PR)	0.773	0.999	0.452	0.647	0.991
Hybrids x K Ratios Interaction	NS	NS	NS	NS	NS

LSD =Least significant difference H = Hybrids PR =Potassium ratios NS=non-significant
Means of the same category having different letters in a column are significantly different at $P \leq 0.05$.
= significant at 1% level of probability *= significant at 0.01% level of probability

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