Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.25, 2014

Influence of Integrated Levels of Potassium and Zinc on the Green Fodder Yield of Miaze (Zea mays L.)

Muzaffar Ahmed[1] , Yingying Sun[2], Waseem Bashir[3], Shahbaz Khan[1],Sanaullah Baloch[2],YangYang,[2],Abdul Hafeez[4] , Aman Jan Baloch[4] and Shabeer Ahmed[4]
1. Agriculture Research Institute Saryab road Quetta Balochistan, Pakistan.
2. College of Plant Science and Technology, Huazhong Agricultural University, Wuhan, Hubei, China
3. Pakistan Agriculture Research Council Hub Balochistan Pakistan
4.Sindh Agriculture Univrsity, Tandojam,Pakistan
Corresponding Email:waseemrodeni2012@gmail.com

Abstract
A field study to evaluate the Influence of integrated levels of Potassium and Zinc on the green fodder yield of Miaze (Zea mays L.) was carried out at Agronomy Section, Agriculture Research Institute, Tandojam during Kharif, 2013. The experiment was laid out in a three replicated randomized complete block design (RCBD), having net plot size 5 x 4m (20 m2). The treatments consisted of No Potassium + No Zinc (Control), Potassium @ 40.0 kg ha-1, Potassium @ 60.0 kg ha-1, Zinc @ 5.0 kg ha-1, Zinc @ 10.0 kg ha-1, Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1, Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1. The analysis of variance showed that various levels of potassium and zinc either sole or integrated influenced positively and significantly ($P<0.05$) growth and fodder yield traits of maize as compared to No Potassium + No Zinc (Control). The integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 produced maximum plant population (9.00 m-2), plant height (180.67 cm), nodes plant-1 (5.91), green leaves plant-1 (15.89), leaf length (48.55 cm), stem girth (4.10 cm), biomass weight plant-1 (520.79 g) and green fodder yield (41.53 t ha-1), closely followed by integration of Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 with 8.67 m-2 plant population, 179.52 cm plant height, 5.80 nodes plant-1, 15.68 green leaves plant-1, 47.96 cm leaf length, 4.04 cm stem girth, 517.90 g biomass weight plant-1 and 38.90 t ha-1 green fodder yield as well as Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 almost in all the growth and yield traits, particularly green fodder yield (38.12 t ha-1) showing the non-significant ($P>0.05$) differences of above treatments with each other. Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1 ranked 4th, 5th, 6th, 7th and 8th in all the attributes, particularly green fodder yield (34.54, 24.39, 20.69, 15.76 and 14.79 t ha-1), respectively. However, minimum plant population (5.00 m-2), plant height (117.80 cm), nodes plant-1 (2.34), green leaves plant-1 (7.09), leaf length (23.66 cm), stem girth (2.51 cm), biomass weight plant-1 (209.12 g) and green fodder yield (11.85 t ha-1) were recorded in No Potassium + No Zinc (Control). Hence, the integration of Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 was found most suitable and economical for obtaining an optimum green fodder yield of maize because non-significant ($P>0.05$) differences with Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 and Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 for almost all the traits, particularly green fodder yield (t ha-1).
Keywords: Maize, green fodder, Integrated Levels, Potassium and Zinc.

1. Introduction

Green fodder is the most valuable and cheapest source of feed for the livestock. It is a very rich source of energy, nutrient elements, carbohydrates, proteins and water. Fodder shortage is the major limiting factor for livestock Production (Younas and Yaqoob, 2005). Maize occupies a key position as one of the most important fodder crop for animal consumption and grown under various conditions in different parts of the world. Maize is a crop plant characterized by a high potential of biomass, especially in comparison with other fodder crops. Maize makes high quality silage for dairy cattle at less cost than silage made from grass. Research has shown that maize silage in the diet of dairy cows increases milk yield and milk protein content. Supplementation with concentrates can be reduced and profitability is improved (Ali et al., 2012). Correct manuring is vital to the success of the crop because it greatly influences not only the yield of the crop and its nutritional content but also growing costs. To produce a good crop, maize plants need to grow very rapidly once they have germinated. They will do this if the soil moisture and structure are good, the temperature is warm and nutrition is adequate. To support this rapid growth it has a large demand for nutrients and any shortage will restrict early growth and final yield. Poor root growth means decreased uptake of nutrients and this can be a vicious circle as poor uptake of nutrients can restrict root growth (Xie et al., 2011). The soils of Pakistan are severely deficient of macro and micronutrients, because farmers are practicing continuous cropping and insufficient use of manures to the soil. Both macro- and micronutrients are essential for plant growth and if a plant does not get enough nutrients, the deficiency symptoms appear on the plant (Hussain and Ahmed, 2000). Potassium is the nutrient required in the greatest amount by maize. The demand for potash is particularly large in the period of rapid growth and the crop needs to take up about 8 kg ha-1 K2O day-1. Potassium plays an important role in regulating the water content of the plant and with an adequate supply of K plants can survive drought stress more easily. It is essential for the transport of sugar from the leaves to the storage organs where the sugar is converted to starch. It plays a major role in maintaining the turgor of plant tissue. Leaves need to be turgid to remain fully extended to maximize the surface exposed to sunlight that provides the energy to convert carbon dioxide in the atmosphere to sugars in the leaves. Plants well supplied with K also seem to be less susceptible to fungal and pest attacks (Salimi et al., 2012).

Zinc (Zn) is an essential component of various enzyme systems for energy production, protein synthesis, and growth regulation. Zinc-deficient plants also exhibit delayed maturity. Zinc is not mobile in plants so Zn deficiency symptoms occur mainly in new growth. Poor mobility in plants suggests the need for a constant supply of available Zn for optimum growth (Mortvedt, 2011). Zinc deficiency in plants does not only reduce the yield but also the nutritional quality. Hence soil conditions and agronomic practices are conducive to the incidence of micronutrient deficiencies in plants (Graham and Welch, 2002). Zinc deficiency is an important problem in some crops, especially corn and sorghum. It is especially a problem in soils with pH values over 7.5. Soil acidity (pH) influences the availability of Zn more than any other factor, with lower Zn solubility as the pH increases. Zn deficiency usually is limited to soils with a pH above 6.5.Over-liming of soils, especially sands, may induce Zn deficiency (Sturgul, 2010). Zinc fertilization increased both nitrogen uptake and yield of maize. Zinc (Zn) is an essential nutrient required in some fertilizer programs for crop production while, some soils are capable of supplying adequate amounts for crop production, addition of zinc fertilizers is needed for others. This nutrient is an important component of various enzymes that are responsible for driving many metabolic reactions in all crops. Growth and development would stop if specific enzymes were not present in plant tissue (Sajedi and Ardakani, 2008). Majlesy et al. (2012) found that soil application of potassium and zinc significantly increased fresh forage, biomass, concentration of Fe, Mn and Zn in grain, leaf and stalk. Foliar application of micronutrients with potassium in drought stress situation, significantly increased concentration of Fe and Mn in stalk and Zn in grain, leaf and stalk. Foliar application of micronutrients and drought stress without potassium increased concentration of Fe in grain. In normal irrigation form: foliar application of micronutrients without using potassium increased concentration of men in leaf, but soil application of micronutrients by using potassium increased biomass. Keeping in view the facts stated above, a study was designed under the agro-ecological conditions of Tandojam.

1.1 Material and Methods

The field study to evaluate the "Green fodder yield of maize (Zea mays L.) as influenced by integrated levels of potassium and zinc" was carried out at Agronomy Section, Agriculture Research Institute, Tandojam during Kharif, 2013. The experiment was laid out in a three replicated randomized complete block design (RCBD), having net plot size 5 x 4m (20 m2). The treatments consisted of No Potassium + No Zinc (Control), Potassium @ 40.0 kg ha-1, Potassium @ 60.0 kg ha-1, Zinc @ 5.0 kg ha-1, Zinc @ 10.0 kg ha-1, Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1, Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1. The land was prepared by giving two dry ploughings followed by precision land levelling. After soaking doze, when soil came in condition two crosswise ploughings with cultivator followed by planking was done to achieve the fine seedbed. The treatments were managed in such a way to separate the treatments and replications easily, while the channels and bunds were developed to facilitate the irrigation water application. The seed of maize variety Agaiti-2002 was sown with the help of single row hand drill. Fertilizers Nitrogen and Phosphorus were applied at the recommended rate of 130 and 60 kg ha-1 in the form of Urea and SSP. Full dose of SSP and 1/3rd of Urea was applied at the time of sowing, whereas remaining nitrogen was applied at the time of first irrigation was applied. Potassium and zinc doses were maintained as per treatments. The first irrigation as recommended was applied at 25 DAS, whereas the subsequent irrigations were applied at 15 day intervals, keeping in view the soil condition and crop requirement. The following observations were recorded.

1.1.1 Results

Plant population (m-2) The data in relation to plant population (m-2) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-1 and their analysis of variance as Appendix-I. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly ($P<0.05$) maize plant population (m-2) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum plant population (9.00 m-2) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with plant population of 8.67 and 8.33 m-2, respectively showing the non-significant ($P>0.05$) differences of above treatments with each other. The maize plant population reduced to 7.33, 6.67, 6.67, 6.33 and 6.00 m-2 in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum plant population (5.00 m-2) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on plant population of maize as compared to control plot but the integrated application of potassium and zinc was more effective than their sole application.

Table 1. Plant population (m^{-2}) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	5.00	5.00	5.00	**5.00 d**
Potassium @ 40.0 kg ha^{-1}	6.00	7.00	7.00	**6.67 bc**
Potassium @ 60.0 kg ha^{-1}	7.00	6.00	7.00	**6.67 bc**
Zinc @ 5.0 kg ha^{-1}	6.00	6.00	6.00	**6.00 c**
Zinc @ 10.0 kg ha^{-1}	6.00	6.00	7.00	**6.33 c**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	7.00	8.00	7.00	**7.33 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	8.00	9.00	8.00	**8.33 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	8.00	9.00	9.00	**8.67 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	9.00	9.00	9.00	**9.00 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	1.0885
$LSD_{0.05}$	0.3727
$LSD_{0.01}$	0.7900
CV%	1.03

Plant height (cm)

The results regarding plant height (cm) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-2 and their analysis of variance as Appendix-II. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly ($P<0.05$) maize plant height (cm) as compared to No Potassium + No Zinc (Control). The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum plant height (180.67 cm) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with plant height of 179.52 and 179.15 cm, respectively showing the non-significant ($P>0.05$) differences of the above treatments with each other. The maize plant height reduced to 171.54, 146.87, 143.60, 135.87 and 131.27 cm in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum plant height (117.80 cm) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on plant height of maize as compared to control plot, but the integrated application of potassium and zinc was more effective than their sole application.

Table 2. Plant height (cm) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	118.27	117.27	117.87	**117.80 g**
Potassium @ 40.0 kg ha^{-1}	147.07	141.67	142.07	**143.60 d**
Potassium @ 60.0 kg ha^{-1}	147.67	146.07	146.87	**146.87 c**
Zinc @ 5.0 kg ha^{-1}	131.67	130.87	131.27	**131.27 f**
Zinc @ 10.0 kg ha^{-1}	136.47	135.27	135.87	**135.87 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	172.07	170.87	171.67	**171.54 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	179.15	178.75	179.55	**179.15 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	179.52	179.12	179.92	**179.52 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	180.67	180.27	181.07	**180.67 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.7663
LSD $_{0.05}$	1.6246
LSD $_{0.01}$	2.2383
CV%	0.61

Nodes plant-1

The results pertaining to nodes plant-1 of maize as influenced by different integrated levels of potassium and zinc are presented in Table-3 and their analysis of variance as Appendix-III. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly (P<0.05) maize nodes plant-1 as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum nodes plant-1 (5.91) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with nodes plant-1 of 5.80 and 5.75, respectively showing the non-significant (P>0.05) differences of above treatments with each other. The maize nodes plant-1 reduced to 5.17, 3.61, 3.34, 3.01 and 2.74 in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum nodes plant-1 (2.34) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on nodes plant-1 of maize as compared to control plot, but the integrated application of potassium and zinc was more effective than their sole application.

Table 3. Nodes plant^{-1} of maize as influenced by integrated levels of potassium and zinc

Treatments	**R-I**	**R-II**	**R-III**	**Mean**
No Potassium + No Zinc (Control)	2.41	2.41	2.21	**2.34 g**
Potassium @ 40.0 kg ha^{-1}	3.41	3.21	3.41	**3.34 d**
Potassium @ 60.0 kg ha^{-1}	3.61	3.41	3.81	**3.61 c**
Zinc @ 5.0 kg ha^{-1}	2.61	2.81	2.81	**2.74 f**
Zinc @ 10.0 kg ha^{-1}	3.01	3.01	3.01	**3.01 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	5.01	5.00	5.50	**5.17 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	5.65	5.75	5.85	**5.75 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	5.70	5.80	5.90	**5.80 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	5.81	5.91	6.01	**5.91 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.1057
LSD $_{0.05}$	0.2241
LSD $_{0.01}$	0.3087
CV%	3.09

Number of green leaves per plant:

Number of green leaves in maize for fodder production is a quantity parameter; but this trait is generally influenced by level of input application. The results in regards to the number of green leave plant-1 of fodder maize as influenced by different irrigation intervals are shown in Fig.3. The analysis of variance Table 3 indicated significant (P≤0.05) impact of various irrigation intervals on the number of green leaves plant-1 of fodder maize. The results showed (Fig.3) that maximum number of green leaves plant-1 (13.42) on average was achieved in crop given 1st irrigation at 20 days after sowing, 2nd at 35 days and 3rd after 50 days of sowing (T1); by the delay in the first irrigation the number of green leaves plant-1 slightly decreased to (12.70) and (11.10) in T3 and T4 treatments, respectively.

Table 4. Green leaves plant^{-1} of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	7.29	7.09	6.89	**7.09 g**
Potassium @ 40.0 kg ha^{-1}	9.89	9.49	9.69	**9.69 d**
Potassium @ 60.0 kg ha^{-1}	11.09	10.69	10.89	**10.89 c**
Zinc @ 5.0 kg ha^{-1}	7.89	7.69	7.69	**7.76 f**
Zinc @ 10.0 kg ha^{-1}	8.89	8.69	8.49	**8.69 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	15.49	15.00	14.89	**15.13 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	15.85	15.45	15.65	**15.65 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	15.88	15.48	15.68	**15.68 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	16.09	15.69	15.89	**15.89 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.0861
LSD $_{0.05}$	0.1825
LSD $_{0.01}$	0.2514

Leaf length (cm)

The results regarding leaf length (cm) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-5 and their analysis of variance as Appendix-V. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly ($P<0.05$) maize leaf length(cm) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum leaf length (48.55 cm) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with leaf length of 47.96 and 47.48 cm, respectively showing the non-significant ($P>0.05$) differences of above treatments with each other. The maize leaf length reduced to 43.44, 41.66, 40.55, 29.00 and 27.55 cm in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, the minimum leaf length (23.66 cm) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on leaf length of maize as compared to control plot but the integrated application of potassium and zinc was more effective than their sole application.

Table 5. Leaf length (cm) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	24.00	23.33	23.66	**23.66 f**
Potassium @ 40.0 kg ha^{-1}	40.00	40.66	41.00	**40.55 c**
Potassium @ 60.0 kg ha^{-1}	41.66	42.00	41.33	**41.66 c**
Zinc @ 5.0 kg ha^{-1}	28.00	27.00	27.66	**27.55 e**
Zinc @ 10.0 kg ha^{-1}	30.00	29.00	28.00	**29.00 d**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	44.00	43.00	43.33	**43.44 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	47.26	46.59	48.59	**47.48 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	47.74	47.07	49.07	**47.96 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	48.33	47.66	49.66	**48.55 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.5779
LSD $_{0.05}$	1.2252
LSD $_{0.01}$	1.6881
CV%	1.82

Stem girth (cm)

The results regarding stem girth (cm) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-6 and their analysis of variance as Appendix-VI. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly (P<0.05) maize stem girth(cm) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum stem girth (4.10 cm) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with stem girth of 4.04 and 3.89 cm, respectively showing the non-significant (P>0.05) differences of above treatments with each other. The maize stem girth reduced to 3.45, 3.20, 3.05, 2.84 and 2.67 cm in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum stem girth (2.51 cm) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on stem girth of maize as compared to control plot, but the integrated application of potassium and zinc was more effective than their sole application.

Table 6. Stem girth (cm) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	2.52	2.49	2.50	2.51 f
Potassium @ 40.0 kg ha^{-1}	3.06	3.03	3.04	3.05 cd
Potassium @ 60.0 kg ha^{-1}	3.23	3.17	3.18	3.20 c
Zinc @ 5.0 kg ha^{-1}	2.67	2.66	2.67	2.67 ef
Zinc @ 10.0 kg ha^{-1}	2.86	2.82	2.83	2.84 de
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	3.40	3.46	3.47	3.45 b
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	3.94	3.90	3.84	3.89 a
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	4.01	4.21	3.91	4.04 a
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	3.67	4.41	4.21	4.10 a

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	0.1148
$LSD_{0.05}$	0.2433
$LSD_{0.01}$	0.3352
CV%	4.26

Biomass weight plant-1 (g)

The results pertaining to biomass weight plant-1 (g) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-7 and their analysis of variance as Appendix-VII. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly (P<0.05) maize biomass weight plant-1 (g) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum biomass weight plant-1 (520.79 g) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with biomass weight plant-1 of 517.90 and 515.16 g, respectively showing the non-significant (P>0.05) differences of above treatments with each other. The maize biomass weight plant-1 reduced to 504.79, 385.79, 346.12, 296.46 and 261.79 g in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum biomass weight plant-1 (209.12 g) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on biomass weight plant-1 (g) of maize as compared to control plot but the integrated application of potassium and zinc was more effective than their sole application.

Journal of Biology, Agriculture and Healthcare
ISSN 2224-3208 (Paper) ISSN 2225-093X (Online)
Vol.4, No.25, 2014

Table 7. Biomass weight plant^{-1} (g) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	200.79	209.79	216.79	**209.12 g**
Potassium @ 40.0 kg ha^{-1}	340.79	345.79	351.79	**346.12 d**
Potassium @ 60.0 kg ha^{-1}	382.79	376.79	397.79	**385.79 c**
Zinc @ 5.0 kg ha^{-1}	254.79	263.79	266.79	**261.79 f**
Zinc @ 10.0 kg ha^{-1}	295.79	294.79	298.79	**296.46 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	502.79	500.79	510.79	**504.79 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	505.16	514.16	526.16	**515.16 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	507.90	516.90	528.90	**517.90 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	510.79	519.79	531.79	**520.79 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level.

SE±	3.4314
LSD $_{0.05}$	7.2743
LSD $_{0.01}$	10.022
CV%	1.06

Green fodder yield (t ha-1)

The results pertaining to green fodder yield (t ha-1) of maize as influenced by different integrated levels of potassium and zinc are presented in Table-8 and their analysis of variance as Appendix-VIII. The analysis of variance showed that various levels of potassium and zinc either sole or integrated affected positively and significantly (P<0.05) maize green fodder yield (t ha-1) as compared to No Potassium + No Zinc (Control).The data indicated that integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum green fodder yield (41.53 t ha-1) of maize, closely followed by Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with green fodder yield of 38.90 and 38.12 t ha-1, respectively showing the non-significant (P>0.05) differences of above treatments with each other. The maize green fodder yield reduced to 34.54, 24.39, 20.69, 15.76 and 14.79 t ha-1 in plots receiving Potassium @ 40.0 kg ha-1 + Zinc @ 5.0 kg ha-1, Potassium @ 60.0 kg ha-1, Potassium @ 40.0 kg ha-1, Zinc @ 10.0 kg ha-1 and Zinc @ 5.0 kg ha-1, respectively. However, minimum green fodder yield (11.85 t ha-1) of maize was recorded in plots receiving No Potassium + No Zinc (Control). The overall data suggested that sole application of potassium and zinc also demonstrated significant effects on green fodder yield (t ha-1) of maize as compared to control plot but the integrated application of potassium and zinc was more effective than their sole application.

Table 8. Green fodder yield (t ha^{-1}) of maize as influenced by integrated levels of potassium and zinc

Treatments	R-I	R-II	R-III	Mean
No Potassium + No Zinc (Control)	10.45	13.17	11.94	**11.85 g**
Potassium @ 40.0 kg ha^{-1}	21.03	20.37	20.67	**20.69 d**
Potassium @ 60.0 kg ha^{-1}	27.74	22.89	22.53	**24.39 c**
Zinc @ 5.0 kg ha^{-1}	15.93	12.69	15.75	**14.79 f**
Zinc @ 10.0 kg ha^{-1}	17.85	14.74	14.69	**15.76 e**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	32.07	35.84	35.70	**34.54 b**
Potassium @ 40.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	39.00	37.32	38.04	**38.12 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 5.0 kg ha^{-1}	39.78	38.10	38.82	**38.90 a**
Potassium @ 60.0 kg ha^{-1} + Zinc @ 10.0 kg ha^{-1}	42.41	40.73	41.45	**41.53 a**

Means not sharing the same letter in a column differ significantly at 0.05 probability level

SE±	1.3112
LSD $_{0.05}$	2.7797
LSD $_{0.01}$	3.8299
CV%	5.96

Discussion

Fertilizer application with optimum doses is considered one of the major factors which can enhance the fodder production (Ali et al., 2012). Potassium is required in the greatest amount by maize. The demand for potassium is particularly large in the period of rapid growth and the crop needs to take up about 8 kg K2O ha 1 day-1. Potassium plays an important role in regulating the water content of the plant and with an adequate supply of K plants can survive drought stress more easily. It is essential for the transport of sugar from the leaves to the storage organs where the sugar is converted to starch. It plays a major role in maintaining the turgor of plant tissue. Among micronutrients, maize is especially sensitive to zinc deficiency. Zinc fertilization increases both nitrogen uptake and yield of maize. Different nutrients may interact with Zn by affecting the availability of each other from soils and their status in the plant through the process of growth or absorption, distribution and utilization. Application of potassium and zinc demonstrated significant enhancement in the fresh and dry weight of maize. The results indicated that all the doses of potassium and zinc either alone or in integration with each other affected positively and significantly ($P<0.05$) seed germination, growth and fodder yield traits of maize variety Agaiti-2002 over No Potassium and Zinc (Control). Integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 resulted in maximum plant population (9.00 m-2), plant height (180.67 cm), nodes plant-1 (5.91), green leaves plant-1 (15.89), leaf length (48.55 cm), stem girth (24.73 cm), biomass weight plant-1 (520.79 g) and green fodder yield (41.53 t ha-1), followed by integration of Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1, whereas minimum attributes were recorded in No Potassium and Zinc (Control). The higher growth and fodder yield traits of maize under integrated application of potassium and zinc at higher rates were possibly due to optimum availability and uptake of required nutrients at optimal concentration. The results are in line with the findings of Majlesy et al. (2012) who found that application of potassium and zinc showed marked increase in the fresh weight and dry weight of maize. In another study, Mahdi (2012) reported that zinc at 10 kg ha-1 markedly enhanced the plant height, leaf area index, dry matter production, chlorophyll content and number of functional leaves plant-1 of maize as compared to no zinc application. Stem diameter, leaf-stem ratio, green and dry fodder yield also increased significantly with zinc application @ 10 kg ha-1. Similarly, potassium fertilization significantly increased total yield of maize (Salimi et al., 2012). Zinc fertilization increased both nitrogen uptake and yield of maize (Sajedi and Ardakani, 2008). The results of this study are also in accordance with the findings of Tabrizi et al. (2011) who suggested that zinc had greatest impact on growth and yield of maize. In another study, Maqsood (2009) reported that with the application of potassium growth response of maize in terms of plant height and total biomass varied significantly compared to the control. It was found that fertilization with potassium improved the crop growth and biomass yield of maize. In a study, Nanjundappa and Manure (2002) assessed the response of fodder maize to fertilizer applications of nitrogen and potash and concluded that the application of N and K at the rate of 150 kg N ha-1 and 50 kg K2O ha-1 helps in increasing the dry fodder yield of fodder maize. The results of this study are supported with those of Osundare et al. (2008) who concluded that potassium substantially improved maize leaf area from 0.33 m2 plant¬1 for control to 0.60, 0.86, 1.05 and 1.19 m2 plant-1 for 100, 200, 300 and 400 kg K ha-1, respectively. Similarly, Barlog and Pawlak (2008) revealed that maize response to potassium fertilization depended on the vegetation season. In the year favorable for the establishment of a high maize yield, simultaneous potassium and magnesium fertilization @ 150 and 16.3 kg ha-1 induced a significant yield increase. The influence of zinc fertilization on yield depended both on the vegetative period and cultivar. In another study Saleem et al. (2006) found that different fertilizer levels played a significant role in boosting up the growth and yield parameters of maize. Potassium @ 275 kg ha-1 produced the highest leaf area (699 cm2) and yield efficiency ratio.

Conclusion

The results concluded that various levels of potassium and zinc either sole or integrated influenced positively and significantly ($P<0.05$) growth and fodder yield traits of maize as compared to No Potassium + No Zinc (Control). The integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 10.0 kg ha-1 produced maximum values for almost all the traits studied, particularly green fodder yield (41.53 t ha-1), closely followed by integrated application of Potassium @ 60.0 kg ha-1 + Zinc @ 5.0 kg ha-1 and Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 with 38.90 and 38.12 t ha-1 green fodder yield. Moreover, the integration of Potassium @ 40.0 kg ha-1 + Zinc @ 10.0 kg ha-1 proved to be the most promising and economical treatment for obtaining optimum green fodder yield of maize due to having non-significant ($P>0.05$) differences with other two treatments above.

References

Ali, S., Sahiba, M. A. Malik, F. Hassan and M. Ansar. 2012. Growth of rainfed fodder maize under different levels of nitrogen and phosphorus. Pakistan J. Agric. Res., 25 (3): 196-205.

Barlog, P. and K. F. Pawlak. 2008. Effect of mineral fertilization on yield of maize cultivars differing in maturity scale. Acta Sci. Pol. Agricultura, 7(4): 5-17.

Cao, G. N. Liu, L. Du, S. Chen, K. Li, and G. Li. 2008. A study on the correlation between NPK application and the yield and yield components of high yield spring maize. J. Jilin Agr.Uni., 30 (6): 830-833.
Graham, R. D., and R. M. Welch. 2002. Plant food micronutrient composition and human nutrition. Communications in Soil Science and Plant Analysis, 31: 1627–1640.
Hussain, T. I. and M. A. Ahmed. 2000. EM Technology-A new looks for IPNM. In: Proc. Symp., Integrated Plant Nutrient Management, NFDC, Islamabad, Pakistan.
Kins, V. and G. Gautam. 2006. Comparative study of maize cultivars (Zea mays L.) with intercrop (Vigna mungo L.) under two levels of fertilizers. Agricultural Science Digest, 26 (1): 109-113.
Mahdi, S. S. 2012. Response of fodder maize (Zea mays L.) to levels of nitrogen, zinc and seed rate under temperate conditions. Ph.D Dissertation, Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir.
Majlesy, A., F. Jalili, E. Valizadeghan and E. Gholynejad. 2012. Influence of potassium and micronutrients application on yield and micronutrients absorption of
forage maize under drought stress situation. International Research Journal of Applied and Basic Sciences, 3 (3): 619-625.
Malakouti, M. J. 2008. The effect of micronutrients in ensuring efficient use of macronutrients. Turk J Agric., 32: 215-220
Maqsood, T. 2009. Response of maize (Zea mays L.) to salinity and potassium supply. Ph.D Dissertation, Dept. Soil Science, Institute of Soil & Environmental Sciences, University of Agriculture, Faisalabad, Pakistan.
Mortvedt, J. 2011. Efficient Fertilizer Use Manual: Micronutrients. Available at: http://www.back-tobasics. net/efu/pdfs/Micronutrients.pdf (accessed 28 March 2012).
Nanjundappa, G. and G. R. Manure, 2002. Yield and quality attributes of fodder maize (Zea mays L.) as influenced by nitrogen and potassium applications. Mysore J. Agri. Sci., 36 (1): 36-38.
Osundare, B. 2008. Effects of different companion crops and increasing NPK fertilizer levels on the performance of maize (Zea mays L.) in southwestern Nigeria. Global J. Agri. Sci., 7 (1): 65-69.
Purushotham, S. R. Siddaraju, and N. Gopinathan, 2002. Response of fodder maize to different levels of N, P, K, and sulphur under irrigation during late Rabi. Current Research, Univ. Agri. Sci. (Bangalore), 31 (5/6): 87-88.
Ranjha, A. M., S. M. Mehdi and M. Iqbal. 2000. Response of maize fodder to muriate of potash. Int. J. Agri. Biol., 2 (3): 253-254.
Russel, D.F. and S.P. Eisensmith. 1983. MSTAT-C. Crop Soil Sci. Department Michigan State Univ. U.S.A.
Sajedi, N. A. and M. R. Ardakani. 2008. The effect of N, Zn and Fe fertilizer on physiological indexes of forage maize in Markazi, Iran. Iran Agronomy Researches Journal, 6 (1):99-109.
Saleem, M., A. Azim, M. Iqbal and A. Aziz. 2006. Performance of maize hybrids under different NPK regime. Sarhad Journal of Agriculture, 5 (3): 87-91.
Salimi, S., S. Moradi and A. G. Banipur. 2012. Effect among potassium and boron on quantitative traits of Maize (Single Cross 704). International Journal of Agronomy and Plant Production, 3 (10): 455-460.
Sturgul, S. J. 2010. Soil Micronutrients: From B to Z. Proceedings of the 2010 Wisconsin Crop Management Conference. Available at http://www.soils.wisc.edu/extension/wcmc/2010/ppt/Sturgul. pdf (accessed 28 March 2012).
Supradip, S., K.A. Gopinath, B. L. MINA and H. S. Gupta. 2008. Influence of continuous application of inorganic nutrients to a Maize-Wheat rotation on soil enzyme activity and grain quality in a rainfed Indian soil. European Journal of Soil Biology, 44 (5-6): 521-531.
Tabrizi, E. F. M., M. Yarnia, V. Ahmadzadeh and N. Farjzadeh. 2011. Priming effect of different times of maize seeds with nutrient elements in water stress on corn yield. Annals of Biological Research, 2 (3): 419-423.
Xie, W.J., H.Y., Wang, J.B., Xia, and Z.G. Yao. 2011. Influence of N, P, and K application on Zea mays L. growth an.d Cu and Pb accumulation. Plant Soil Environ., 57 (3): 128–134.
Younas, M. and M, Yaqoob. 2005. Feed resources of livestock in the Punjab, Pakistan. Livestock Research for Rural Development, http://www.irrd.org/Irrd17/2/youn17018.htm