Research Article

Improving growth and yield of potato through potassium and zinc fertilization

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Abstract

A trial was carried out to evaluate the impact of potassium and Zinc on the growth and production of potato at Agricultural Research Institute Mingora Swat, during winter 2014. The trial was carried out in RCBD with two factors, and 3 replications. Four levels of potassium (0, 90, 120 and 150 kg ha⁻¹) and three zinc levels (0, 5 and 10 kg ha⁻¹) were used in the experiment. The various parameters studied during experiment were tillers number plant⁻¹, leaves plant⁻¹, plant height, number of tubers plant⁻¹, and weight of tubers plant⁻¹. Potassium and zinc application at various levels were significant for all parameters except emergence percentage. 120 kg K ha⁻¹ increased number of tillers plant⁻¹ (3.0), leaves plant⁻¹ (15.7), plant height (28.0 cm), tubers plant⁻¹ (11.9), weight of tubers plant⁻¹ (524 g). Application at 10 kg Zn ha⁻¹ maximizes number of tillers plant⁻¹ (2.9), number of leaves plant⁻¹ (15.5), plant height (27.6 cm), number of tubers plant⁻¹ (11.3), tubers weight plant⁻¹ (503 g). Most of the parameters were not significantly different from that of 5 kg Zn ha⁻¹. None of the studied parameters was significantly affected by K and Zn interaction. On the basis of the current research, potassium 120 kg ha⁻¹ and zinc 5 kg ha⁻¹ gave maximum yield of potato in Swat valley.

Keywords: Potato; Potassium; Zinc

Introduction

Potato was originated from Bolivia and Peru. It belongs to family Solanaceae and its botanical name is (*Solanum tuberosum* L). In terms of production across the world potato is the fourth most main crop which occupies sixth place all over the world with the average being 15.3 ton ha⁻¹ [1]. After sugar beet and sugarcane, potato is the third uppermost yielding crop due to fresh matter.

In Pakistan from 2010 to 2011 on an area of 15.94 thousand hectare potato was grown

with the average yield of 18.5 ton ha⁻¹. In Khyber Pakhtunkhwa during the same season, potato cultivated area was 8900 hectare with average yield of 13.4 tons per hectare [2].

Potato is an exhaustive crop with high yield and short duration. Therefore it is very important to apply fair fertilizers for quantitative and qualitative production from this imperative crop. All necessary nourishing substances must be present with enough quantity to maintain the maximum production with quality tuber and to restore

soil fertility to attain advantageous development and growth of potato [3].

One of the most important factor in improving the quantity and quality of plants product is proper plant nutrition [4]. Potassium is one of the important plant nutrient that controls the translocation of the nutrients throughout the plant which effect both the general plant penology and also affects its quality and yield. It regulates nutrient solution which sustain the turgidity and thus control the movement and translocation of all components inside the plant body. Potassium plays an essential part during photosynthesis that facilitate the maximum energy level, maintaining stomatal conductance (opening and closing) on leaf, absorption of water, nutrients translocation, organic acid and vitamin contents in plants [5].

High doses of Nitrogen may lockup zinc as zinc protein complex in the root and these complexes may not be translocated to above plant [6]. The higher availability of phosphorous may prevent the translocation of zinc and render its metabolically inactive. The interaction of Cu^{+2} , Fe^{+2} , Mn^{+2} , Mg^{+2} , with zinc which may inhibits its uptake by plants [7].

Zinc is one of them that has a vital metabolic role in growth of plants and their development; therefore it is called as an essential micronutrient or trace element. In plants zinc is in the form of Zn^{2+} and is a crucial nutrient that has particular physiological purpose. Which act in all living systems, such as facilitation of protein creation, the maintenance of functional and structural integrity of biological membranes, gene expression, and production of energy, Krebs cycle and enzymes structure. Also has a positive effect on crops production. So crops qualitative and quantitative production strongly depends on Zinc in the soil [4]. To allow a number of key plant physiological passageways to function normally Zn is needed in minute but critical concentrations [8]. For crop yield and most favorable size of fruit, Zinc is a necessary element, also Zn

is needed in the carbonic enzyme which are present in every photosynthetic tissue and which is required for chlorophyll biosynthesis [9].

In the present study this particular research work has been designed to examine the combined impact of K and Zinc on growth, quality, yield and production of potato crop.

Materials and methods

Field trial was carried out to examined the effects of potassium (K) and zinc (Zn) application on growth, yield and quality of potato at the Agricultural Research Institute (North) Mingora Swat, during winter 2014. Experiment was conducted in RCBD in factorial arrangement with 3 replications. There were Four levels of potassium (0, 90, 120 and 150 kg ha^{-1}) and three zinc levels (0, 5 and 10 kg ha^{-1}) in the experiment. The plot size was 16 m^2 . The row to row and plant to plant distances were 75 and 25cm respectively. The potato (Variety Allauddin) was sown on 12th January, 2014. Potato cuts with diameter of 30mm were sown. Nitrogen and phosphorous were given at the rate of 150 and 100 kg ha^{-1} . Three split doses of Nitrogen were used. All other standard practices were kept uniform for all treatments.

Soil analysis

Soil physical analysis indicated that soil class is silt-loam. While chemical analysis showed that pH of soil is acidic (6.4) in nature. Organic matter was moderate (1.2%), lime (2.6%) content showed slightly calcareous in nature, Nitrogen was at low rate (0.03%), and phosphorus (30.6 ppm) showed medium range while potassium (70.0 ppm) was reordered. The Soil analysis shows that Zn is not deficient i.e. 7.06 mg kg^{-1} but the plant analysis shows Zn deficiency i.e. <20 ppm this may be due to the following reason.

Zn application with high Nitrogen from Zn protein complex in the root which causes translocation problem of Zn in plant and hence shows Zn deficient. Due to the cool and wet weather the availability of Zn reduced and plant shows deficiency.

Statistical analysis

Statistical data was analyzed and evaluated as recommended by Steel, Torei, (1980), all the result recorded on different parameters of plant growth and yield. Means was evaluated using LSD test.

Results and discussion

Number of tillers plant⁻¹

Potassium (K) and zinc (Zn) significantly affected number of tillers plant⁻¹ (Table 1). However, interaction between potassium and zinc was non-significant for number of tillers plant⁻¹. Mean values for potassium showed that numbers of tillers plant⁻¹ were increased with increase in potassium rate and maximum number of tillers plant⁻¹ (3.0) were obtained with 150 kg K ha⁻¹. However, it was similar statistically to that of 120 kg K ha⁻¹ (2.9). The minimum tillers plant⁻¹ (2.2) were recorded in K control plots, similar to 90 kg K ha⁻¹ (2.3). In case of zinc, the maximum number of tillers plant⁻¹ (2.9) were examined with 10 kg Zn ha⁻¹, however statistically similar with 5 kg Zn ha⁻¹ (2.7). Zinc control plots (0 kg Zn ha⁻¹) produced fewer number of tillers plant⁻¹ (2.3). Results are similar to the research of [10] who determined that tillers plant⁻¹ were higher when balanced nutrition to the potato crop were given. Potassium applied to crop enhances root growth and increase number of tillers plant⁻¹. However when plants were applied with zinc the maximum number of tillers plant⁻¹ were noted with 10 kg Zn ha⁻¹, which was similar to 5 kg Zn ha⁻¹. Zinc control plots produced fewer number of tillers plant⁻¹. [11] Supported our findings by reporting increase in number of tillers plant⁻¹ with increase in zinc level. [12] Also determined that K improve the plant health vigorous, showed resistance to diseases and also promote leaf number and aerial stems. It is obvious observed that potassium increase number of stems which directly enhance the leaf number further the number of leaves will more when plant height is increasing.

Number of leaves plant⁻¹

Leaves plant⁻¹ were considerably affected by potassium (K) and zinc (Zn) (Table 1),

while their interaction (K x Zn) were non-significant (Table 1). Plots treated with 150 kg K ha⁻¹ produced maximum leaves plant⁻¹ (15.7), which was similar to 120 kg K ha⁻¹ (15.6). Minimum leaves plant⁻¹ (14.1) were observed in potassium control plots. In case of zinc application, maximum leaves plant⁻¹ (15.5) and (15.3) were recorded with 10 and 5 kg Zn ha⁻¹, respectively. However, minimum leaves plant⁻¹ (14.2) were obtained in zinc check plots. [12] Also determined that K improve the plant health vigorous, showed resistance to diseases and also promote leaf number. It is obvious observed that increasing number of stems directly enhance the leaf number further the number of leaves will more when plant is tallest. Researchers revealed that K plays an essential part during photosynthesis [13] that facilitate the maximum energy level thus facilitate more number of leaves, maintaining stomatal conductance (opening and closing) on leaf, absorption of water, nutrients translocation, organic acid and vitamin contents concentration in plants. In case of zinc application, higher leaves plant⁻¹ were recorded with 10 and 5 kg Zn ha⁻¹. However, least number of leaves plant⁻¹ were obtained in zinc check plots. [14] Reported increase in number of leaves plant⁻¹ with increase in zinc concentration via foliar application. Zinc helps in the formation of auxin such as indole acetic acid. Plants with low Zinc concentration inhibits low levels of indole acetic acid. Zinc synthesized Typtophan which is require for IAA formation. In the absence of this plant hormone plant growth will be stunted mostly internode growth and leaf size and number of leaves will decreased.

Plant height (cm)

Statistical analysis of the data showed that potassium (K) and zinc (Zn) had significantly affected plant height (Table 1). While interaction between potassium and zinc (K x Zn) was non-significant for plant height. Plots received potassium @ 150 kg ha⁻¹, produced the taller plants

(28.0 cm), similar to 120 kg K ha⁻¹ (27.4 cm). The most dwarf plants (24.3 cm) were examined in potassium check plots. Similarly raise in zinc level increased plant tallness. Maximum plant stature (27.6 cm) was recorded when zinc was fed @ 10 kg ha⁻¹. However, it was somewhat similar that of 5 kg Zn ha⁻¹ (27.1 cm). Zinc check plots (0 kg Zn ha⁻¹) produced dwarf plants (24.9 cm). Potassium increase Nitrogen use efficiency hence potassium contributed to plant height due to increasing Nitrogen availability and uptake. These findings are supported by the work of [15], who investigate that with the treatment of potassium fertilizer, the taller potato plants were observed. There is increase in plant height, chlorophyll concentration, leaf area, K concentration, specific gravity, and carbohydrate content when potassium sulfate amount is increased [16]. Similarly increase in zinc level increased plant height. Highest plant was recorded from the plot which receive Zinc @ 10 kg ha⁻¹. However, it was similar to that of 5 kg Zn ha⁻¹. Zinc check plots gave dwarf plants. [17] Stated that zinc is needed for a plant's enzyme formation and associated with hormone (indole acetic acid) formation and deficiency of zinc has been found to reduce leaf size and shortened internodes and hence, limit plant growth.

Number of tubers plant⁻¹

Potassium (K) and zinc (Zn) had significantly affected number of tubers plant⁻¹ (Table 1). However, there interaction was non-significant for number of tubers plant⁻¹. Mean values for potassium showed that number of tubers plant⁻¹ were increased with increase in potassium rate and maximum number of tubers plant⁻¹ (11.9) were obtained with 150 kg K ha⁻¹. However, it was similar to that of 120 kg K ha⁻¹ (11.2). Lowest tubers plant⁻¹ (9.3) were noticed in K check plots, which is similar to 90 kg K ha⁻¹ (9.9). In case of zinc, maximum number of tubers plant⁻¹ (11.3) were recorded with 10 kg Zn ha⁻¹, which is similar to 5 kg Zn ha⁻¹ (10.8). Zinc control

plots (0 kg Zn ha⁻¹) produced fewer number of tubers plant⁻¹ (9.7). The results corroborate with the research of [18] who informed that increase in zinc level increased number of tubers plant⁻¹. For crop yield and most favorable size of fruit Zinc is a necessary element, also Zn is needed in the carbonic enzyme which are present in every photosynthetic tissue and which is required for chlorophyll biosynthesis [9]. Better induction of tubers by K₂O may be credited to short termed using of soil pH there by increasing beneficial elements like Nitrogen and potassium which facilitate in more number of tubers per plant. [19] Studied to find out the best potassium dose for potato maximum yield, nutrients use efficiency and quality potatoes under irrigated soil condition on sandy loam soil. Potassium application resulted the best tuber yield by increasing the large and medium grade tubers thus the number of tubers plant⁻¹ was increased.

Tuber weight plant⁻¹ (g)

Tuber weight plant⁻¹ significantly affected by potassium (K) and zinc (Zn) (Table 1), while their interaction (K x Zn) were non-significant. Plots treated with potassium 150 kg K ha⁻¹ produced maximum tuber weight plant⁻¹ (524 g), which is similar with 120 kg K ha⁻¹ (512 g). Lowest tuber weight plant⁻¹ (431 g) was observed in potassium control plots (0 kg K ha⁻¹). In case of zinc application, maximum tuber weight plant⁻¹ (503 g) and was noted with 10 kg Zn ha⁻¹ which is similar to that of 5 kg Zn ha⁻¹ (490 g), respectively. However, minimum tuber weight plant⁻¹ (452 g) was obtained in zinc control plots (0 kg Zn ha⁻¹). These results are somewhat similar with the research of [20] who examined that maximizing the tuber weight per plant directly increase the yield as potassium effect both value and amount of tubers indirectly synergistic interaction with rest of the nutrients (particularly with Nitrogen) and agronomic practices. [21] Reported that the weight and size of tubers were increased with the treatment of K which

in turn increased the amount of large sized profitable tubers. In case of zinc application, maximum tuber weight plant⁻¹ was recorded with 10 and 5 kg Zn ha⁻¹. However, minimum tuber weight plant⁻¹ was obtained in zinc control plots. The results showed similarities with the

research of [22] who examined that increasing in zinc level improved tuber weight plant⁻¹. Zn has particular physiological functions and also has a positive effect on crops production so crops qualitative and quantitative production strongly depends on Zinc in the soil.

Table 1. Number of tillers plant⁻¹, Number of leaves plant⁻¹, Plant height (cm), Number of tubers plant⁻¹ and Tuber weight plant⁻¹ (g) of potato as affected by potassium and zinc application

Potassium Levels (kg ha ⁻¹)	Number of tillers plant ⁻¹	Number of leaves plant ⁻¹	Plant height (cm)	Number of tubers plant ⁻¹	Tuber weight plant ⁻¹ (g)
0	2.2b	14.1c	24.3c	9.3b	431c
90	2.3b	14.6bc	26.3b	9.9b	459b
120	2.9a	15.6ab	27.4ab	11.2a	512a
150	3.0a	15.7a	28.0a	11.9a	524a
LSD (P ≤ 0.05)	0.54	1.08	1.22	1.00	19.36
Zinc Levels (kg ha ⁻¹)					
0	2.3b	14.2b	24.9b	9.7b	452b
05	2.7ab	15.3a	27.1a	10.8a	490a
10	2.9a	15.5a	27.6a	11.3a	503a
LSD (P ≤ 0.05)	0.46	0.94	1.06	0.86	16.76
Interaction (K x Zn)	ns	ns	ns	ns	ns

Conclusions

It can be concluded from the research work that increase in potassium rate up to 120 kg ha⁻¹, could improve potato quality, growth, and yield. Zinc used @ of 10 kg ha⁻¹, showed better performance in term of growth, quality and yield of potato. However, it wasn't significantly different from 5 kg Zn ha⁻¹. The interactive effect of potassium and zinc on growth, yield and quality of potato was not significant. According to the result it is recommended that application of zinc @ 5 kg ha⁻¹ and potassium @ 120 kg ha⁻¹ improve potato growth, productivity and quality significantly. Further research is required on potassium and zinc application in Khyber Pakhtunkhwa for superior crops productivity and profitability under different cropping pattern.

Authors' contributions

Conceived and designed the experiments: MW Khan & A Rab, Performed the experiments: MW Khan, Analyzed the data: R Ali & M Sajid, Contributed materials/ analysis/ tools: MN Khan, A Ali,

MA Khan, W Pervez & F Amin, Wrote the paper: MW Khan.

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