Research Article

Effect of Potassium and Zinc on Growth Yield and Tuber Quality of Potato

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Abstract | A field trial was carried out to evaluate the impact of Potassium (K) and Zinc (Zn) on quantitative and qualitative attributes of potato (*Solanum tuberosum* L.) at Agricultural Research Institute Mingora Swat, during winter 2014. The experiment was laid out in randomized complete block design using three replications. Four K levels (00, 90, 120 and 150 kg ha^{-1}) and three levels of Zn (00, 05 and 10 kg ha^{-1}) were used. The various parameters studied during experiment were tuber yield (ton ha^{-1}), total soluble solids (TTS), specific gravity and starch content. Potassium and zinc application at various levels were significant for all parameters. Potassium applied at the rate of 120 kg ha^{-1} increased tuber yield (27.9 ton ha^{-1}), TSS (5.099 °Brix), specific gravity (1.083) and starch content (14.83 %). Yield parameter was being maximum with 150 kg K ha^{-1}. Application of Zn at 10 kg ha^{-1} maximized tuber yield (26.9 ton ha^{-1}), TSS (4.879 °Brix), specific gravity (1.081) and starch content (14.83%). 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, 120 kg K ha^{-1} and 5 kg Zn ha^{-1} gave maximum yield of potato and thus the mentioned rates of these nutrients are suggested for general cultivation of potato in Swat valley.

Received | May 18, 2017; **Accepted** | January 22, 2019; **Published** | March 13, 2019
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Citation | Khan, M.W., A. Rab, R. Ali, M. Sajid, F. Aman, I. Khan, I. Hussain and A. Ali. 2019. Effect of potassium and zinc on growth yield and tuber quality of potato. *Sarhad Journal of Agriculture,* 35(2): 330-335.
DOI | http://dx.doi.org/10.17582/journal.sja/2019/35.2.330.335
Keywords | Potassium, Zinc, Solanum tuberosum L., Yield and quality of tuber

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 with the average production of 15.3 ton ha^{-1} (Spooner and Bamberg, 1994). In Pakistan from 2010 to 2011 on an area of 159400-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 ton ha^{-1} (MINFA, 2011). After sugar beet and sugarcane, potato is the third uppermost yielding crop due to fresh matter. Potato was valued both for qualitative and quantitative characteristics. Fresh potato tuber contains 80 ml of moisture, 17 g of CHO, 2 g of proteins, 0.4 g of crude fiber, 10 mg of Ca, 0.7 mg of Fe, 0.5 mg of nicotinamid, 0.1 mg of vitamin B and 0.03 mg of riboflaven, a small amount of vitamins A and C, negligible fats and ascorbic acid (Tindall, 1968).

Potato is an inexpensive source of energy containing large amount of carbohydrates, significant amount of vitamin B, vitamin C plus and other minerals. It is used in various industries for the production of alcohol and starch (Abdel-Aal et al., 1977).

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 (Bansal and Trehan, 2011). One of the most important factor in improving the quantity and quality of plants product is proper plant nutrition (Mousavi et al., 2013). Potassium is one of the important plat nutrient that controls the translocation of the nutrients throughout the plant which effect both the general plant penology and liveness but 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 (Bergmann, 1992). Compare to N and P, potassium only works as catalytic agent and not a constituent of plant molecules. Potassium mainly exists as an absorptive or free sticked cation and can thus be exchanged without difficulty in the whole plant and also on the cellular level (Lindhauer, 1985). Potassium also prevent diseases caused by bacteria and fungi, physiological disorders similar to hollow heart and internal blackening (Roberts and MeDole, 1985). Potassium also decreases probability of disease and facilitate the plants fast improvement from other diseases (Perrenoud, 1993). Potassium facilitate good storage life of potato and also facilitate distribution potato as well as maximizes their post-harvest life (Martin-Prevels, 1989).

High doses of Nitrogen may lockup zinc as zinc protein complex in the root and these complexes may not be translocated to above plant (Gupta et al., 1988). The higher availability of phosphorous may prevent the translocation of zinc and render its metabolically inactive. (Brown et al., 1980). The interaction of Cu^{+2}, Fe^{+2}, Mn^{+2}, $Mg^{+}2$, with zinc which may inhibits its uptake by plants (Millikan, 1953).

Crop production can also be significantly boost with the use of micronutrients. 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 (Mousavi et al., 2013). To allow a number of key plant physiological passageways to function normally Zn is needed in minute but critical concentrations (Yosefi et al., 2011). 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 (Ali et al., 2008).

Keeping the importance of K and Zn in mind, the research was designed to investigate the individual as well as the combine effect of the mentioned nutrients on yield and quality of potato. Also, different experiments were conducted on availability of Zn in different crops at Agricultural Research Institute (North) Mingora Swat.

Materials and Methods

Field trial was carried out to examine the effect of K and Zn application on yield and quality of potato at the Agricultural Research Institute (North) Mingora Swat, Khyber Pakhtunkhwa-Pakistan during winter 2014. Experiment was conducted in Randomize Complete Block Design with three replications. The plot size was 16 m^2. The row to row and plant to plant distances were 75 and 25cm respectively. Four levels of Potassium (0, 90.120 and 150 kg ha^{-1}) and three levels of Zinc (0, 5 and 10 kg ha^{-1}) were used. Potato (Variety Allauddin) cuts with diameter of 30 mm were sown on 12th January, 2014. Nitrogen (In three split doses) and phosphorous (at sowing) were given at the rate of 150 and 100 kg ha^{1} respectively. 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.

Results and Discussion

Tuber yield (ton ha^{-1})

Statistically analysis of the data showed that potassium (K) and zinc (Zn) had significantly affected tuber yield (Table 1). While interaction between potassium and zinc (K × Zn) was not significant for tuber yield. Plots received potassium @ 150 kg ha^{-1}, gave highest tuber yield (27.9 ton ha^{-1}), which is similar statistically to 120 kg K ha^{-1} (27.4ton ha^{-1}). Minimum tuber yield (23.0ton ha^{-1}) was observed in potassium check plots. Similarly increase in zinc level increased tuber yield. Maximum tuber yield (26.9 ton ha^{-1}) was recorded when zinc was treated@ 10 kg ha^{-1}. However similar statistically to that of 5 kg Zn ha^{-1} (26.0ton ha^{-1}). Zinc control plots (0 kg Zn ha^{-1}) produced minimum tuber yield (24.1 ton ha^{-1}).

The results are observed to be in line with the research of Perrenoud (1993) who studied that the diameter and weight of tubers was noted to be boosted with the K application to a certain extent. However, Chapman et al. (1992) studied that excessive applications of K to this crop was found needless for maximizing weight of tuber and its yield. Similarly increase in zinc level increased tuber yield. Maximum tuber productions were documented with the application of 10 kg Zn ha^{-1}. However, it was comparable to that of 5 kg Zn ha^{-1}. Zinc check plots gave highest tuber yield. These results were similar with the research of El-Baky et al. (2010) who examined that enhancing zinc level maximized tuber yield. Moreover, Acquaah (2002) mentioned that zinc has many important roles in plant growth, a constant and continuous supply is necessary for optimum growth and maximum yields. Singh and Lal (2012) study 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. Tuber yield was directly increased by increasing potassium application rate and also potassium were uptake at the time of harvest. Potassium application resulted the best tuber yield by increasing the large and medium grade yield and decreasing the small and very small sized tuber. Maximum yield of 39.83 ton ha^{-1} with 150 kg K ha^{-1} application, while the minimum tuber yield was obtained in K control treatment.

Total soluble solids (°Brix)

Total soluble solids (TSS) was affected significantly by potassium and zinc levels, however, its interaction was not significant for total soluble solids (Table 1). Mean values for potassium showed that total soluble solids were increased with increase in potassium rate and maximum total soluble solids (5.099 °Brix) were obtained with 150 kg K ha^{-1}. However, it was in consequences with that of 120 kg K ha^{-1} (4.914 °Brix). Minimum total soluble solids (4.331 °Brix) were recorded in K control plots. In case of zinc, maximum total soluble solids (4.879 °Brix) were observed with 10 kg Zn ha^{-1}. Zinc control plots (0 kg Zn ha^{-1}) produced minimum total soluble solids (4.597 °Brix), being at par with 5 kg Zn ha^{-1} (4.681 °Brix). Statistically analysis of the data showed that potassium and zinc had significantly affected total soluble solids. Tuber TSS is the principle to advances maturity and ripening of horticultural crops (fruit and vegetables).

Various research findings have uncovered the fact that potassium enhances both qualitative and quantitative parameters of potato crop. Potassium is also found to be effective for the enhancement of enzymatic activities, which in turns, helps in the synthesis of carbohydrates and amino acids (Mengel and Kirkby, 1987), which in turn produce the quality tubers. These findings had a little difference among various levels and are in not aligned with the research of Perrenoud (1993) who examined that K increased the size of tubers by enhancing water retention resulting in decreasing of total soluble solids and specific gravity.

Specific gravity

Specific gravity of potato significantly affected by potassium (K) and zinc (Zn), while their interaction (K × Zn) were non-significant (Table 1). Plots treated with 120 kg K ha^{-1} increased specific gravity to maximum point (1.084), being at par with 150 kg K ha^{-1} (1.083). Minimum specific gravity (1.067) was observed in potassium control plots (0 kg K ha^{-1}). In case of zinc application, maximum specific gravity (1.081) was noted with 10 kg Zn ha^{-1} however it was in line with that of 5 kg Zn ha^{-1} (1.078). While the lowest specific gravity (1.074) was recorded in zinc check plots (0 kg Zn ha^{-1}).

Table 1: *Tuber yield (ton ha^{-1}), Total soluble solids (°Brix), Specific gravity and Starch content (%) of potato as affected by potassium and zinc application.*

Potassium Levels (kg ha^{-1})	Tuber yield (ton ha^{-1})	Total soluble solids (°Brix)	Specific gravity	Starch content (%)
0	23.0c	4.331d	1.067c	11.39c
90	24.4b	4.531c	1.075b	13.11b
120	27.4a	4.914b	1.084a	15.07a
150	27.9a	5.099a	1.083a	14.83a
LSD (P ≤ 0.05)	1.12	0.0981	0.0040	0.785
Zinc Levels (kg ha^{-1})				
0	24.1b	4.597b	1.074b	12.97c
05	26.0a	4.681b	1.078a	13.49a
10	26.9a	4.879a	1.081a	14.34a
LSD (P ≤ 0.05)	0.97	0.0850	0.0035	0.679
Interaction (K×Zn)	ns	ns	ns	ns

Mean followed by the same letters within columns are not different statistically; ns: non-significant at P 0.05

It is quite noticeable that different levels reflecting good results for the most of the parameters increased superior quality tubers. Rhue et al. (1986) studied potato response to potassium fertilization and described that the decrease in specific gravity of potato was noted with the application of 100-pound K_2O per acre. These results are similar with the research of Borin et al. (1994) who investigated that different type of inorganic fertilizer had no effect on quality parameters of tuber. It is obvious that potassium use at a various level has proved to be effective of the feature studied for specific gravity. The potassium fertilizer application caused more specific gravity of tuber, percent of tuber starch (25%) and shoot Potassium content (46%) while had lower shoot dry weight (58.5%) and shoot K content (37%) (Sarikhani and Aliasgharzad, 2012). In potato tubers Potassium application increased nitrogen and phosphorus concentration. K fertilizer also effect these quality parameters like dry matter, specific gravity, starch contents, vitamin-C and ash contents (Khan et al., 2010). Perrenoud (1993) examined that K increased the size of tubers by enhancing water retention resulting in decreasing of total soluble solids and specific gravity.

Starch content (%)

Statistically analysis of the data showed that potassium and zinc had significantly affected starch (Table 1). While interaction between potassium and zinc was not significant for starch. Plots received potassium at the rate of 120 kg ha^{-1}, produced maximum starch (15.07%), similar with 150 kg K ha^{-1} (14.83%). Lowest starch (11.39%) was recorded in potassium check plots. Similarly, zinc application with variable rates had significant impact on potato quality. Maximum values of quality parameters of potato starch content (14.34%) were observed with 10 kg Zn ha^{1}.However, it was in line with 5 kg Zn ha^{-1} (13.49%). Zinc check plots (0 kg Zn ha^{-1}) produced minimum starch (12.97%) which was lowest values of starch content that were recorded in zinc control plots.

Zinc is required by plant in small amount but its arability is very important, especially for improving quality. The observed improvement in vegetative growth and the tuber quality parameters as affected by zinc nutrition can be explained on the basis of that zinc promotes growth hormone biosynthesis, the development of maturation and starch (Brady and Weil, 2002). In many experiments, starch content in tubers was positively linked to potassium application. In tuber dry matter about 1.8 % potassium is reported to be required for high starch concentration. Plants treated with K_2SO_4 translocate more photosynthesis from the leaves and stems to the tubers as compared with the plants treated with KCl. Generally, potassium under low K nutrition levels potassium appliance decreased reducing sugars and lighten chip color (Bansal and Trehan, 2011). The potassium fertilizer application caused an augment around 11% percent in starch and 16.1 percent in dry matter of tuber at level K3 as compared to the control (Sarikhani and Aliasgharzad, 2012).

Conclusions and Recommendations

From current research work it can be concluded that increase in potassium rate up to 120 kg ha^{-1}, could improve potato yield and quality. Zinc used at the rate of 10 kg ha^{-1}, showed better performance in term of yield and quality of potato. However, it wasn't significantly different from 5 kg Zn ha^{-1}. The interactive effect of potassium and zinc on yield and quality of potato was not significant.

According to the result it is recommended that application of potassium @ 120 kg ha^{-1} and zinc @ 5 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.

Author's Contribution

Mohammad Wasiullah Khan: Principal author, conceived the idea, conducted the research and prepared the 1st draft.
Abdur Rab: Planned and supervised the research and experiments.
Roshan Ali: Co-supervised the research
Muhammad Sajid: Helped in field and guided in writing up.
Faiza Aman: Help in field analysis.
Imran Khan: Assisted in lab work
Iqbal Hussain: Collected the data.
Akhtar Ali: Helped in field work.

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