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DETERMINATION OF PHYSIOMORPHOLOGICAL CHARACTERISTICS OF POTATO CROP REGULATED BY POTASSIUM MANAGEMENT

Muhammad Aslam Pervez, Choudhary Muhammad Ayyub, Muhammad Rashid Shaheen* and Munawar Ahamd Noor

Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Punjab, Pakistan
***Corresponding author's e-mail: rashid_uaf2004@yahoo.com**

Balanced use of nutrients is essential for sustainable productivity of crops. Nitrogen and phosphorus fertilizers are being used while potassium (K) application is ignored which causes serious decrease in the status of K in soils of potato growing areas. K has prodigious importance in improving quality and yield of potatoes. Therefore, the research project of field studies was designed with different levels K from SOP to determine its effects on some physio-morphological features of potato. A promising red potato cultivar "Desiree" was selected. Optimal recommended doses of nitrogen and phosphors (250 and125 kg ha^{-1} respectively) along with 6 levels of K, i.e. 50,100, 150, 200, 250, 300 kg K_2O ha^{-1} were applied. Data of different qualitative and quantitative characteristics was collected under the Randomized Complete Block Design with three replications and was analyzed by using standard statistical over the year techniques. The results revealed that SOP at the level of 150 kg ha^{-1} gave the best results in most of the parameters (i.e. total emergence percentage, plant height, number of tubers per plant, tuber weight per plant, yield per hectare, TSS, tuber dry weight per plant) while, extremely high dose of SOP showed the poor results as compared to control for some of the parameters. Number of aerial stems per plant, number of leaves per plant, specific gravity of tubers and tuber dry mass did not show any significant change with change in K levels.
Keywords: *Solanum tuberosum*, potassium, nutrition, physio-morphological

INTRODUCTION

Potato (*Solanum tuberosum* L) stands at 4th position after wheat, rice and maize among the major food crops in Pakistan. It is also considered as a cash crop among the vegetables. Three potato crops are grown annually in Pakistan; two in the plains and one in the mountainous areas. Potato is grown on an area of 172.00 million hectare with 3767.20 thousand tons of production averaging 21.90 tons ha^{-1} during the year 2007 in Pakistan (Anonymous, 2012-13) which was very low as compared to the yields of leading potato growing countries of the world like New Zealand, Netherland, Australia, Japan, Turkey and Iran which obtained 52.2 tons ha^{-1},41.67 tons ha^{-1}, 35.9 tons ha^{-1}, 31.9 tons ha^{-1}, 27.0 tons ha^{-1} and 25.1 tons ha^{-1} of tubers respectively during the year 2012 (FAO, 2013).

Potato is a short duration, high yielding and exhaustive tuberous crop. The judicious use of essential elements is very critical for harvesting of potatoes on sustainable basis. The application of N and P nutrients had been mainly considered while K is being ignored due to the common consensus that the soils of canal irrigated areas contains sufficient amount of K. In fact, K is depleting at the alarming rate in the soils of Pakistan (Umar and Moinuddin, 2001). Under this scenario, the balanced fertilizers in optimal dose becomes more essential and pre-requisite for obtaining better growth, development and higher yields (Malik, 1995).

Potassium has a crucial role in higher productivity of potato tubers because it plays an important role in photosynthesis, regulation of opening and closing of stomata, favors high energy status which helps in timely and appropriate nutrients translocation and water uptake in plants (Bergmann, 1992). It also affects yield, quality, general health and vigor of plant (Marschner, 1995). The element, however, is not incorporated component of plant molecules, in contrast to N and P, thus acts only as catalytic agent (Lindhauer, 1985). Potato genotypes have different processing and nutritional quality (Abbas *et al*., 2011). Potassium is found helpful in extending storage life of tubers (Martin- Prevel, 1989). The potato growers in Pakistan follow different practices and techniques for obtaining the best productivity from potato crop. They apply different manures and fertilizers with variable doses through different techniques.

Keeping in view, the existing management practices of potato growers in Pakistan, a prominent red cultivar of potato "Desiree" was selected and the present research project was undertaken to find out optimal dose, so that fertilizer use efficiency might improve with higher yields and economical returns to potato growers which will not only helpful for improving their life standard of the farming community due to high crop returns but will also ensure food security for ever increasing population of Pakistan and the world as well.

MATERIALS AND METHODS

Present research project was carried out at the Vegetable Research Area of the Institute of Horticultural sciences, University of Agriculture, Faisalabad, during the year 2009-10 and 2010-11. Five samples of soil at the depth of 15cm and 30cm each were taken; physico-chemical soil analysis was done at the Post Graduate laboratory of the Institute of Soil and Environmental Science, the University of Agriculture, Faisalabad (Table 1). This experiment was conducted to observe the effects of different levels of potassium on physio-morphological aspects of potato crop.

Table 1. Pre-sowing soil analysis of the site

Determinants	2009-10	2010-11
Sand (%)	65	65
Silt (%)	16	16
Clay (%)	19	19s
Soil texture	Sandy clay loam	Sandy clay loam
pH	7.9	7.8
EC (Saturated extract) (dS m^{-1})	0.95	0.94
Organic matter (%)	1.09	1.17
Total N (%)	0.049	0.050
Available P (mg kg^{-1})	7.0	7.3
Available K (mg kg^{-1})	1.38	1.43
Cation exchange capacity (c mol kg^{-1})	9.27	9.20
$CaCO_3$ (%)	8.66	8.71

Medium sized (40±5 mm diameter) seed tubers of "Desiree" cultivar were sown on ridges. Nitrogen and phosphorus were applied @ 250 and 125 kg ha^{-1} respectively, as urea and SSP (Malik, 1995) with potassium as a variable (in the form of SOP). The above mentioned recommended dose of P and half dose of N were supplemented at the time of planting while remaining half dose of N was applied after 30 days of planting. In this experiment, there were 7 treatments including control (T_0) and T_1 to T_6 containing 50, 100, 150, 200, 250 and 300 kg of SOP/ha (i.e., 0.36, 0.72, 0.108, 0.144, 0.180, 0.216 kg K_2O $plot^{-1}$ from SOP), respectively, with three replications under RCBD.

Seed tubers were sown at 20 cm spacing on ridges of 75 cm apart on 6-10- 2009. The dimension of each subplot was 8.0x 4.5 m with 36.0 m^2 area. Irrigation was applied immediately after sowing and subsequent irrigations were given as per need of the crop and climatic conditions. The subplots were separated by ridges to avoid mixing of inputs. To prevent from sucking insects and pests like aphids and whiteflies at the initial stages of crop, Imidaclorprid was sprayed twice at fortnight interval. Similarly, at the later stages of the crop, Dithene M-45 was sprayed twice in weekly interval against blight disease. All other cultural practices performed were uniform and same for all treatments. The crop was harvested on 24-01-2010 to collect the data for various yield and quality parameters. The experiment was repeated next year. Data on various growth and qualitative parameters were collected. Total emergence percentages in each treatment was taken 30 days after planting likewise the data for number of aerial stems $plant^{-1}$, number of leaves $plant^{-1}$ and plant height were taken 60 days after planting, whereas, the observations number of tubers $plant^{-1}$, tubers weight $plant^{-1}$ and yield ha^{-1}were obtained at the time of harvest by counting, weighing and subsequent calculations from randomly selected plants from each treatment. The specific gravity and tuber dry matter percentage were taken with the help of Hydrometer. TSS with the help of Refractometer and tuber dry weight $plant^{-1}$were observed by adopting the method prescribed by Srivastava and Sanjeev (2002). Data collected separately for both the years from individual treatments, were statistically analyzed through the analysis of variance over year's techniques and the tables of variance were constructed. The mean values of significant treatments were compared in accordance with Duncan's Multiple Range Test at 5% probability level (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

Total emergence %age varied significantly (Table 2) for

Table 2. Effect of different combinations of fertilizers on growth parameters of potato

Treatments	Total emergence (%)	No. of aerial stems $plant^{-1}$	No. of leaves $plant^{-1}$	Plant height (cm)	No. of tuber $plant^{-1}$	Tuber weight $plant^{-1}$ (g)
T_0 (Control)	91.264 c	2.970 NS	43.500 NS	40.950 c	5.650 abs	292.333 b
T_1 (50 kg/ha SOP)	92.294 bc	3.133	42.917	43.983 bc	5.925 ab	297.333 b
T_2 (100 kg/ha SOP)	96.685 ab	3.205	43.550	46.333 abs	6.120 a	339.833 a
T_3 (150 kg/ha SOP)	97.102 a	3.265	44.417	48.783 a	6.122 a	341.167 a
T_4 (200 kg/ha SOP)	94.446 abc	3.185	44.000	43.367 bc	5.953 ab	339.000 a
T_5 (250 kg/ha SOP)	94.248 abc	3.093	43.567	40.933 c	5.123 bc	275.000 b
T_6 (300 kg/ha SOP)	92.062 c	2.938	41.250	40.400 c	4.910 d	228.333 c

which T_3 (150 kg K_2O ha^{-1}) performed better with 97.102% of tuber emergence whereas, it was 91.264% in T_0 (control). The emergence mainly depends upon genetic makeup and micro climate.

The superiority of 150 kg K_2O ha^{-1} level could be judged with the maximum emergence percentage, and then there was a gradual decline. Excessive dose of 300 kg K_2O ha^{-1} might have negative impact on the emergence percentage as it performed even worse than the control. These results are in harmony with the findings of Ayyub *et al.* (1998) who reported that maximum tuber emergence percentage was obtained with the application of balanced nutrients, i.e. NPK while in case of under and over doses, tuber emergence %age was affected.

No. of aerial stems $plant^{-1}$ and number of leaves $plant^{-1}$ were found statistically non-significant (Table 2). However, for the number of aerial stems $plant^{-1}$, T_2 and T_3 were at the highest position while, T_6 was found at the bottom. Whereas, in case of number of leaves, T_3 was observed the best while, T_6 was found at the bottom.

The leaves are the food factories of plants while the stems support leaves of the plants for photosynthesis. The number of aerial stems and leaves were found increased up to the level of 200 kg ha^{-1}, but with the excessive doses (i.e. 250 kg and 300 kg ha^{-1}) reduction in the number of aerial stems and leaves was observed. These levels might have negative impact on the vegetative growth. These results are in conformity with the findings of Ayyub *et al.* (1997) who reported that number of aerial stems $plant^{-1}$ were found more with the application of balanced nutrition to the potato crop. As well as corroborate with the findings of Singh *et al.* (1996) who reported that numbers and chlorophyll contents of leaves were found more with the application of K_2O in combination with N. While these conclusions are contrary to the finding of Oliveira (2000) who claimed that higher levels of N increased the number of leaves in potato crop.

The results for plant height indicated significant superiority of T_3 with 48.78 cm whereas, T_0, T_5 and T_6 effected poorly with 40.95, 40.93 and 40.40 cm, respectively, in descending order as per their performance (Table 2). The excessive doses of K_2O, i.e. 250 kg and 300 kg ha^{-1}, produced shorter plants as compared to T_0 (control) which reflected negative impact of excessive phosphorus use on the vegetative growth and height of plants. These results are in concurrence with the findings of Singh and Singh (1995) who reported that a significant increase in plants height or shoot biomass of potato was observed with increasing the levels from 50-200 kg K_2O ha^{-1}.

The results for number of tubers $plant^{-1}$ showed that T_3 (150 kg K_2O ha^{-1}) secured the highest with 6.122 tubers while, T_6 (300 kg K_2O ha^{-1}) occupied the lowest position with 4.910 tubers per plant (Table 2). The results indicated that with the applications of K_2O to a certain limits, the number of tubers per plant was found promoted whereas, and the excessive doses produced negative impacts. These results are correlated with the findings of Singh *et al.* (1996) who reported that with the increasing levels from 0-188 kg K_2O ha^{-1}, the number of tubers per plant were increased significantly.

The results for weight of tuber $plant^{-1}$indicated significant superiority of T_3 (150 kg K_2O ha^{-1}) while, T_6 (300 kg K_2O ha^{-1}) secured the lowest position which revealed that with the level of 150 kg K_2O ha^{-1}, 341.2 grams tubers were produced (Table 2). Whereas, no significant differences could be visualized in between the levels of 100-200 kg K_2O $ha^{-1,}$. With the gradual increase in the doses of K_2O up to 150 kg K_2O ha^{-1}, enhanced tubers weight was observed, then a decline in weight which might be due to adverse effect of excessive doses on growth and yield. These results are in accordance with the findings of Perrenoud (1993) who reported that the size and weight of tubers were found enhanced with the application of potassium to a certain level. Chapman *et al.* (1992) reported that high K application to potato crop was found unnecessary for enhancing tuber weight and yield.

The results for yield ha^{-1} reflected significant superiority of T_3 and T_2 over other treatments while these two treatments stood statistically at par. No significant difference could be traced out among T_0, T_5 & T_6 and they occupied the bottom position. It was also observed from the results that 150 kg K_2O ha^{-1} and 100 kg K_2O ha^{-1} gave 23.44 tons ha^{-1} and 23.11 tons ha^{-1} of tubers yield. It is amazing that the combination, where no K_2O (control) was applied, gave statistically similar results rather more yield i.e. 19.15 tons ha^{-1} as compared to 18.20 tons ha^{-1} where 250 kg K_2O ha^{-1} was applied. These results corroborate with the findings of Singh (1999) who reported to achieve 134, 184, 202 q $ha^{-1}$of tubers with the applications 0, 75, 150, kg K_2O ha^{-1} respectively while Perrenoud (1993) reported 37 tons ha^{-1} yield was achieved with the application of 196 kg K_2O ha^{-1} in combination with N and P. Whereas, Grewal *et al.* (1991) also reported yield gain of 52 q ha^{-1} with the application of 113 kg K_2O ha^{-1} in alluvial soils.

Although results for specific gravity and tuber dry matter % age did not show significant difference among the treatments yet a small difference was traced. K levels had negligible affect related to these aspects of study. These results corroborate with the findings of Perrenoud (1993) who reported that the size of tuber was enhanced with the application of K. Larger size tubers were due to accumulation of water in tubers that resulted in lowering of specific gravity and dry matter percentage.

The mean values of TSS indicated significant superiority of T_3 while, T_1 and T_0 (control) were found at intermediary position whereas, T_4, T5 and T_6 were statistically grouped alike which occupied the last position but T_6 performed the lowest. The data (Table 3) indicated that the application of 150 kg K_2O ha^{-1} to potato crop favored maximum TSS (i.e.

Table 3. Effect of different combinations of fertilizers on quality parameters of potato

Treatments	Yield ha^{-1} (ton)	Specific gravity	Tuber dry matter (%)	TSS ($^{\circ}$Brix)	Tuber dry weight plant^{-1} (g)
T_0 (Control)	19.147 c	1.067 NS	17.533NS	5.842 c	62.183 c
T_1 (50 kg/ha SOP)	19.835 bc	1.068	18.067	5.862 bc	64.023 bc
T_2 (100 kg/ha SOP)	23.112 a	1.069	17.494	6.227 ab	68.583 ab
T_3 (150 kg/ha SOP)	23.438 a	1.071	18.759	6.375 a	68.748 a
T_4 (200 kg/ha SOP)	21.477 ab	1.072	18.534	5.463 d	65.931 abc
T_5 (250 kg/ha SOP)	18.198 c	1.072	18.100	5.463 d	59.791 d
T_6 (300 kg/ha SOP)	14.798 b	1.074	18.567	5.290 d	58.377 d

6.375°Brix) while, 100 kg K_2O ha^{-1} also produced similar results with 6.227°Brix. The effectiveness of K_2O at a certain level was proved to the aspect studied. These results corroborate with the findings of Mengel and Kirkby (1987) who reported that with the application of K_2O to potato crop at a certain level favored to enhance the quality and quantity of tubers as well as found effective for the activation of enzymes to synthesize starch and proteins. Potassium application improves plant growth (Asgharipour and Heidari, 2011; Quampah *et al*., 2011; Sattar *et al*., 2012) reported improved by. Potato growth is affected by potassium (Haile and Boke, 2011), plant population and seed tuber size (Masarirambi *et al*., 2012).

The information for tuber dry weight plant^{-1} (Table 3) showed that the best 68.75g was achieved from the level of T_3 (150 kg K_2O ha^{-1}) while, the excessive dose with 300 kg K_2O ha^{-1} gave the worse performance with 58.38 % as compared to control with 62.16 % dry weight plant^{-1} . The above scenario indicated that with the increasing of potassium levels up to a certain limit, the dry weight percentage was observed to be improved whereas, the excessive and under dosing of the element caused adverse effects by reducing dry weight percentage of the tubers. These results are correlated with the findings of Patricia and Bansal (1999) who reported that with the application of K to potato crop; it increased not only the yield but also improved quality aspects like tuber size with more dry matter percentage.

So, it is concluded that that the use of 150kg/ha SOP along with 250 kg/ha Urea and 125 kg/ha SSP can enhance the yield and quality parameters of potato. Judicious use of these fertilizers in appropriate ratio, as mentioned, can ensure the food security for the increasing population and life standards of the farming community.

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