EFFECT OF PHOSPHORUS DOSE AND POTASSIUM SOURCES ON YIELD AND EXPORT QUALITY OF POTATO

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BY

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CERTIFICATE

This is to certify that the thesis entitled **"Effect of Phosphorus Dose and Potassium Sources on Yield and Export Quality of Potato"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **Master of Science (MS)** in **Agronomy**, embodies the results of a piece of *bona fide* research work carried out by **Sujan Chandra Roy, Reg. No. 18-09114** under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma.

I, further, certify that such help or source of information as has been availed of during the course of this investigation has duly been acknowledged.

Dated:
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DEDICATED

TO

MY BELOVED

PARENTS

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LIST OF ACRONYMS

Acronyms	**Full word**
Agril.	Agricultural
BARI	Bangladesh Agricultural Research Institute
BBS	Bangladesh Bureau of Statistics
Bull.	Bulletin
cm	Centimeter
CV	Coefficient of Variation
DAS	Days After Storage
Env.	Environment
et al.	And others (*et alibi*)
FAO	Food and Agriculture organization
g	Gram
i.e.	Id est, in other words
J.	Journal
pH	Hydrogen ion concentration
LSD	Least Significance Difference
MSI	Membrane Stability Index
MT	Matric Ton
N	Nitrogen
NS	Non-Significant
%	Percent
Pharmacol	Pharmacolog*y*
Photosynth	Photosynthesis
Physiol	Physiology
PS	Potassium Silicate
Regul	Regulation
Res	Research
ROS	Reactive Oxygen Species
RWC	Relative Water Content
SAU	Sher-e- Bangla Agricultural University
Sci	*Science*
Sp. gravity	Specific gravity
TCRC	Tuber Crop Research Centre
TSP	Triple Superphosphate
TSS	Total Soluble Solid
viz.	videlicet (L.), Namely

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ABSTRACT

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka from the period of November, 2018 to February, 2019 to assess the effect of phosphorus dose and potassium sources on yield of processing and export quality of potato. The potato variety BARI Alu-28 (Courage) was used as test crop for this experiment. The experiment consisted of two factors: Factor A: Phosphorus dose (4 dose) as- P_1 = 200 $kgha^{-1}$ TSP @ 41.84 kg P ha^{-1} ; P_2 = 220 $kgha^{-1}$ TSP @ 46.03 kg P ha^{-1}, P_3 = 240 $kgha^{-1}$ TSP@ 50.21 kg P ha^{-1} and P_4 = 260 $kgha^{-1}$ TSP @ 54.39 kg P ha^{-1}, and potassium sources (3); K_1 = KCl (250 kg ha^{-1} KCl @130 kg K ha^{-1}), K_2 = KH_2PO_4 (452.19 $kgha^{-1}$ KH_2PO_4 @130 kg K ha^{-1}) and K_3 = K_2SO_4 (288.6 $kgha^{-1}$ K_2SO_4 @130 kg K ha^{-1}). The two factorial experiment was laid out in split-plot design with three replications. Data were recorded on different yield attributes, yield and quality of potato tuber. For different dose of phosphorus, number of tuber per hill, average tuber weight, yield, chips potato (45-75), french fry (>75), TSS, firmness, Reducing sugar, non-reducing sugar content, increased with increasing phosphorus dose and negative relation was observed increase of canned potato (20-45), dry matter content, specific gravity, starch, anti-oxidant and polyphenol content. In case of different sources of potassium, the highest yield of potato tubers (34.30 t ha^{-1}) from K_2, but dry matter content (21.10%), specific gravity (1.0808 gcm^{-3}), firmness (46.80), starch (15.985%), anti-oxidant (567.87 Trolox µ Mol 100 g^{-1} FW) and polyphenol (85.243 GA mg 100 g^{-1} FW) was recorded from K_3, whereas the lowest was found from K_2. Due to combined effect of different dose of phosphorus and different sources of potassium, the highest yield of potato tubers (35.35 tha^{-1}) from P_3k_2, but dry matter content (22.85%), specific gravity (1.0998 gcm^{-3}), starch (17.936%), anti-oxidant (630.12 Trolox µ Mol 100 g^{-1} FW) and polyphenol (92.994 GA mg 100 g^{-1} FW) were found from P_1K_3, whereas the lowest dry matter and specific gravity content were recorded from P_1K_2 treatment combination. Among potassium sources, inspite of KH_2PO_4 producing highest yield of potato, KCl and K_2SO_4 as a source of potassium and 50.21 kg P ha^{-1} produced good processing quality potato. However, considering economic condition of Bangladesh and availability, KCl would be used as a source of potassium for producing processing quality of potato without sacrificing yield.

CHAPTER I
INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the family Solanaceae is the fourth largest world food crop after rice, wheat, and maize (Ahmed, *et. al*., 2017; Chakraborty *et. al*.,2010; Haas *et. al*., 2009). The large per capita consumption can be easily justified because they are rich in carbohydrates, minerals but also contain a large amount of high quality of proteins, vitamin C and minerals (Brown, 2005). Potato is one of the major vegetable crops cultivated throughout the southern Mediterranean, with Spain and Italy being the main producers, with 2.0 and 1.3 million tons of annual tuber production, respectively (FAOSTAT, 2018). In Bangladesh, the total acreage, production and yield of potato is 0.48 million hectares, 0.974 crore MT and 20.41 t ha^{-1} respectively and the yield of potato is comparatively low in comparison with the other major potato producing countries viz., USA (47.15 t ha^{-1}) and France (54.19 t ha^{-1}) (FAOSTAT, 2018). Potato (*Solanum tuberosum* L.) is one of the most important vegetables in Egypt which gained a considerable importance as an export to European markets (Eleiwa *et. al.,* 2012). Potato is a short-cycle crop and present high production capacity, it is highly influenced by the application of different nutrients to the soil (Luz *et. al*., 2013). It has been usually applied high rates of phosphate fertilizers in the cultivation, aimed at achieving high levels of tuber yield and larger tuber (Luz *et. al*., 2013). Phosphorus has various effects on tuber quality, such as tuber size and percentage of dry matter (indicated by specific gravity) of the tuber (Freeman *et. al.,* 1998 and Rosen *et. al*., 2014). Phosphorus is the 2nd limiting nutrient after nitrogen. It is one of the key nutrient and sways the early crop development and tuber initiation, tuber size, tuber specific gravity. (Dyson and Watson, 1971). Phosphorus promotes rapid canopy development, root cell division, tuber set, and starch synthesis. Adequate P is essential for optimizing tuber yield, solids content, nutritional quality and resistance to some diseases (Rosen *et. al*., 2014). Potato is highly responsive to soil-applied nutrients, especially to phosphorus (P), due to its short cycle and high yield potential. Phosphorus is essential for plants, mainly for the metabolic processes related to energy uptake, and therefore limiting for potato development. Therefore, there is a need plant growth is delayed at low-P levels already in initial stages; besides, number and length of roots and stolon are reduced as well as tuber yield (Fontes, 1997) . Phosphorus nutritional status affects the absorption of other nutrients and, consequently, influence crop nutrition and production. The plant requirement of magnesium (Mg) can be related to the P levels in nutrient solution (Vichiato *et. al.*, 2009). Phosphorus also interacts positively with nitrogen (N) uptake and plant growth (Fageria, 2001), and P deficiency reduces the uptake of both nitrate (Araújo & Machado, 2006) and ammonium. The application of high P levels increases the severity of zinc (Zn) deficiency in soils with low Zn levels (Fageria, 2001). Physico-chemical characteristics and the nutritional composition of potato tubers may vary depending on various factors, such as cultivar, availability of nutrients in the soil, fertilization process, plant maturity, climate, etc. (Evangelista *et. al*., 2011; Feltran *et. al.*, 2004; Fernandes *et. al*., 2010; Klein *et. al*., 1980; Lachman *et. al.*, 2005; Quadros *et. al.*, 2009; Rosen *et. al.*, 2014). According to Klein *et. al*. (1980), P fertilization increases the concentrations of ascorbic acid, nitrogen (N), and protein in tubers. In addition to increasing the specific gravity of tubers, P fertilization can also change the texture, color, and flavor of cooked tubers (Sheard & Johnston, 1958). However, there is little research evaluating the effect of P on the nutritional composition of potato tubers (Rosen *et. al*., 2014).

Potatoes are short-lived, high yields and comprehensive yields. The balanced use of nutrients is essential for sustainable crop productivity. In many potato producing areas, nitrogen fertilizers (N) and phosphorus (P) are used, while the application of potassium (K), which leads to a serious reduction in the potassium state in the soil from potato growing areas (Pervez *et. al*., 2013). Potato cultivars have different strategies for dealing with potassium (K) deficiency in soil, and their response to different forms andrates of K fertilization may vary because of differences in soil K availability (Yakimenko and Naumova, 2018). A number of research has been devoted to studying the effect of type, rates and forms of fertilizers on potato tuber yields and quality (Davenport and Bentley, 2001; Ewais *et al*., 2010; Zorb *et. al*., 2014). Potassium influences both quantity and quality of potatoes (Karam *et al*., 2011; Lakshmi *et. al*., 2012) through various mechanisms such as enzyme activation, stomatal conductance, photosynthesis, protein synthesis, and transport of sugars and starch (Werij *et. al*., 2007). Various sources of K salts are used for plants nutrition such as potassium chloride (KCl), potassium sulfate (K2SO4), mono potassium phosphate (KH2PO4), potassium nitrate (KNO3) and potassium silicate (K2O.4SiO2) (Magen, 2004). Among them potassium silicate (K2O.4SiO2) caused very good results to improve the growth and yield of plants (Salim *et. al*., 2011; Rytel *et. al.*, 2013; Salim, 2014). The quality of potato tubers and their chemical composition are influenced by many factors - genetics, soil fertility, weather conditions and applied nutrients (Rytel *et. al*., 2013). Potassium deficiency is observed the plants are short, leaves become pale-green and later in the vegetation at leaves ends and tops they become necrotic (Kerin and Berova, 2008; Kumar and Sharma, 2013). Potassium application resulted in higher leaf area, increased plant height, prolonged bulking duration, enhanced tuber size, and a higher proportion of medium and large size grades and higher yields (Trehan *et. al*., 2001). Potassium also affects dry matter percentage, increases ascorbic acid content, decreases reducing sugars, phenol contents, and enzymatic degradation (Chen *et. al*., 2004; Werij *et. al*., 2007). Many potato producers for fry industry changed from the use of potassium chloride to potassium sulfate, as there is a concept that the use of this source improves tuber quality (Silva *et. al.*, 2018). With this background and situation the present study was conducted for fulfilling the following objectives:

- To study the effect of level of phosphorus and/ or sources of potassium on yield and export quality of potato.

CHAPTER II

REVIEW OF LITERATURE

Potato is a crop of major significance in human nutrition, ranking 4rth in food production, after wheat, maize, and rice. This crops demand high investment in fertilizers, and depending on price and growing season, it can account for more than 30% of total cost of crop production. Therefore, there is a need to develop fertilizer management techniques for potato, increasing the efficiency of fertilizer use. Organic and inorganic fertilizer management is the important factor that greatly affects the growth and yield of potato. Among different Organic and inorganic fertilizers, Phosphorus Dose and Potassium Sources play an important role for the yield and quality of potato. However, very limited research work have been conducted on the performance of potato in response to Phosphorus Dose and potassium source in various part of the world including Bangladesh and the work so far done in Bangladesh is not adequate and conclusive. However, some of the important and informative works conducted at home and abroad in this aspect reviewed in this chapter under the following headings:

1.1 Effect of Phosphorus Dose on growth and yield of potato

Dharmendra Gaur *et. al*. (2017) conducted this experiment during Rabi season, to evaluate the effect of different phosphorus levels on growth attributes, physiological parameter and grading of tuber in potato crop (*Solanum tuberosum* L.). The experiment consisted of 10 treatments with four replications. The results revealed that both farmers practice and application of 120 Kg P2O5/ha through fertilizer produced significantly higher dry matter/plant, tuber dry matter/plant, AGR and RGR and both these treatments were statistically at par to each other. On the other hand 100% P2O5 through FYM recorded significantly higher number of leaves/plant whereas application of 100% P2O5 through FYM recorded minimum number and weight of crack tuber as compared to other treatments. Control treatment recorded significantly higher root length and root shoot: ratio, tuber number and tuber yield under < 25 g while application of 120 kg P2O5/ha through fertilizer was higher in case of total number of tuber (per plot), number of tuber and yield of tuber under 20-50 and 50-75 g. However, number and yield of tuber under <75 g was highest in farmers practice. However, quadratic equation line (Y = 21.748 + 5.489 X –0.587X2) for inorganic doses of phosphorus resulted in, 116.93 and 63.42 kg P2O5/ha were the optimum physical and economical levels, respectively for getting higher yield of tuber. Therefore, it is concluded that application of 120 and 60 Kg P2O5/ha through fertilizer was the best dose of phosphorus for achieving higher optimum physical and economical productivity, respectively.

Fernades *et.al.(*2015) conducted this experiment to evaluate the effect of P fertilization on the quality and nutritional composition of marketable tubers of potato cultivars. Experiments in soils with low, medium and high P availability were conducted in a randomized block design, with four replications. Treatments consisted of a 2×5 factorial arrangement of two potato cultivars (Agata and Mondial) and five $P_2 O_5$ rates (0, 125, 250, 500, and 1,000 kg ha^{-1}). Phosphorus fertilization increased the contents of P and starch, the size and yield of marketable tubers, with more expressive response to higher P rates in the soils with low and medium P availability. The Mondial cultivar had the highest yield, due to a greater tuber weight and greater increases in this characteristic in response to P fertilization. The Mondial cultivar produced tubers with firmer pulp, with higher dry matter percentage and higher contents of Ca, Cu, and Zn than Agata. In the soil with low P availability, P fertilization reduced Zn content, but, in general, had little influence on the nutritional composition of potato tubers.

Qadri *et. al.*(2015) conducted this study to evaluate the Phosphorous and Foliar Applied Nitrogen Improved Productivity and Quality of Potato. Experiment was comprised of four different treatments of phosphorus (DAP, 46% P) and nitrogen (urea, 46% N) including a control. Treatments were T0 (DAP 160 + Urea 300 kg/acre), T1 (DAP 160 + Urea 5 kg/acre), T2 (DAP 100 + Urea 6 kg/acre) and T3 (DAP 120 + Urea 8 kg/acre). DAP fertilizer was given as basal dressing at the time of sowing. Foliar applications of nitrogenous fertilizer (urea) were given after 30 of sowing with one week interval in five split doses. Results indicated that T3 remained better regarding productivity and quality of potato. The overall fertilizer efficacy regarding yield and quality was: T3 > T2 > T1 > T0. However, Vitamin C was found maximum in T0.

Yohana *et. al.* (2011) conducted an experiment to evaluate the Effects of phosphorus and potassium levels on the yield of the tuber variety Criolla Colombia in the department of Cundinamarca. The design used a completely randomized block with three replications and a 4 x 4 factorial structure, where the first factor corresponds to phosphorus (0, 50, 100 and 150 kg ha^{-1} P_2O_5), and the second, potassium (0, 50, 100 and 150 kg K2O ha^{-1}). The variables evaluated were specific gravity and tuber yield in the categories: first (PT1), second (PT2), third (PT3) and total (PTT). In Zipaquirá, there were differences in the phosphorus factor for the yield variables PT1, PT2 and PTT, while in the town of Cogua, the only difference for this factor was found in the variable PTT. In these variables, the levels of 50, 100 and 150 kg ha^{-1} of P2O5 produced higher yields that were equal and above that of the 0 kg ha-1 P2O5 level. In the potassium factor, differences were found only for the yield variable PT3 in the town of Cogua. The specific gravity did not respond to the P or K factors evaluated.

Rosen *et.al*.(2008) conducted an experiment on Potato Yield and Tuber Set as Affected by Phosphorus Fertilization .Nine fertilizer treatments compared banded P rates of 0, 37, 42, and 74 kg P ha$^{−1}$, the P sources mono-ammonium phosphate (MAP) and di-ammonium phosphate (DAP), P banded at planting vs. split applications at planting and emergence, and starter N rates of 38 and 66 kg N ha$^{−1}$. Phosphorus fertilizer application increased total tuber yield and yield of undersized tubers (tubers less than 85 g), but decreased the proportion of large-sized tubers (greater than 285 g). Due to the increases in small, unmarketable tubers, P fertilizer application did not have a significant effect on marketable tuber yield (tubers greater than 85 g). The total number of tubers per plant and the number of undersized tubers were also higher, and the number of large tubers was lower, when P was applied compared with the zero P control. Both the number and yield of undersized tubers increased as P application rate increased. Petiole P concentrations were generally consistent with the rate of P applied, but they varied by year in magnitude and their pattern through the season. Petiole P was positively correlated with the number of tubers per plant, but only correlated for 1 year with differences in total yield. Phosphorus application increased total P uptake due primarily to an increase in tuber P concentration

Parveen *et. al.(*2007) conducted a field study on the optimizing phosphorus requirement of chipsona varieties for west-central plains of india at CPRI Campus, Modipuram during 2000-2002 indicated that stem number, plant height, leaf number, processing grade (> 45 mm) as well as total tuber number of potato cvs. Kufri Chipsona-1 and Kufri Chipsona2 increased with the application of phosphorus upto 80 kg P_2O_5 ha^{-1}. Processing quality parameters like specific gravity, tuber dry matter and chip colour at harvest and after five-month storage remained unchanged by P. Highest tuber yield (386.6 q/ha), maximum net returns (Rs. 59,503) and the highest benefit cost ratio (2.43) were recorded at 80 kg P_2O_5 ha^{-1}.

1.2 Effect of potassium sources on growth and yield of potato.

Singh *et. al*. (2020) conducted an experiment to study on influence of potassium on the productivity and quality of potato. Potassium nutrition plays an important role in increasing the potato yield, either due to the formation of large tubers or the increase in the number of tubers per plant. Among the integrated nutrient management in potatoes, farmyard manure promotes the absorption and availability of potassium for potato plants. Potassium protects against frost and drought stress in plants and decreases the incidence of diseases or pests. Potassium availability also decreases the concentration of reducing sugar and improves the colour and quality of potato chips. Potassium sulfate improves potato quality better than sources of potassium chloride.

Silva *et al.* (2018) conducted an experiment to evaluate the effect of these two potassium sources on yield, specific gravity and chip color of potato chipping cultivars on a Dystrophic Red Latosol, in Canoinhas, Brazil. Treatments consisted of two potato cultivars, BRSIPR Bel and Atlantic, and two sources of potassium, chloride and sulfate, applied in the furrow at the planting time, in rates based on soil analysis. 100 days after planting each sub-plot was evaluated for yield, specific gravity and chip color and observed that there was no significant effect of potassium source on yield components, specific gravity and chip color of BRSIPR Bel and Atlantic.

Mello *et al.* (2018) conducted an experiment to evaluate PH (Polyhalite is a hydrated sulfate evaporite mineral containing potassium) as a fertilizer for potato production in the weathered tropical soils in Brazil with either muriate of potash (MOP), sulfate of potash (SOP), or PH as the K source; with kieserite and gypsum added to the SOP to make a synthetic PH with similar composition; P either as single super phosphate (SSP) for the MOP blend or mono ammonium phosphate (MAP) for the PH and SOP blends; and N as urea adjusted for the N in MAP. All were applied at four application rates of 62, 125, 187, and 249 kg K ha-1 and a control was also included consisting of N and P as urea and MAP but no K, Ca, Mg, or S. Findings revealed that the potato yields increased linearly with increasing K application rate from 22.4 t ha^{-1} for the control to the highest yield of 29.2 t ha^{-1} and were higher for PH and SOP than MOP (28.8, 29.2, and 25.3 t ha^{-1} , respectively). Polyhalite blend increased dry matter and starch at the higher application rates compared with MOP and SOP at Tapira and increased potato 8 hardness and crunchiness at the optimum 62 kg K ha^{-1} application rate at Casa Branca. Yield response was similar for PH and SOP but quality differences between these two fertilizer blends were observed even though they were similar in composition.

Yakimenko and Naumova (2018) conducted a study was performed to evaluate the effect of K fertilization rates (0, 30, 60, 90, 120 and 150 kg K ha^{-1}) on tuber yield and quality (dry matter, starch, sugar and ascorbic acid content, taste) of two potato cultivars (Roco and Rosara) grown in the micro plot field experiment on Luvisol in the forest-steppe zone in southern West Siberia, Russia. The tuber yield of both potato cultivars increased with increase in K application rate up to 2.1 and 2.9 kg m^{-2} for Roco and Rosara, respectively. Sugar content, averaging 3.5%, was mostly determined by cultivar; however, in both cultivars it tended to decrease with increasing K application rate. The application of K fertilizer in the form of sulphate as compared to chloride increased dry matter content from 22.4 to 23.8% and ascorbic acid content from 13.2 to 14.6 mg 100 g^{-1} fresh mass. Potassium application rate did not affect Roco tubers' taste, while improving Rosara tubers' taste under moderate application rates. The results underscore the importance to adjust fertilizer recommendations concerning potassium application rates and source on the basis of biological requirements and intended utilization of individual potato cultivars.

Mohan *et. al.* (2017) conducted this field experiment at KVK Kandali, UAS, Bengaluru to study the effect of different rates and sources of potassium on growth, yield and quality of potato. Results revealed that highest growth parameters like plant height (49.0), number of branches (2.83), and total dry matter production (6366.04 kg ha^{-1}) recorded with application of 75:75:175 kg ha-1 NPK with K as Bio K + Sulphur (S). Significantly lower growth parameters like plant height (31.67), number of branches (1.99), and total dry matter production (2063.02 kg ha^{-1}) recorded in control. Number of tuber and tuber 7 weight per plant were significantly higher due to application of 75:75:175 kg ha^{-1} NPK with K as Bio K + S (4.80 and 560.67) and was on par with 75:75:175 kg ha^{-1} NPK with K as SOP + Sulphur (4.6 and 545.67). Maximum tuber yield was recorded with 75:75:175 kg ha^{-1} N P K with K as Bio-K+ S (31.15t ha^{-1}) and significantly lower tuber yield recorded in absolute control (11.0). Significantly highest protein (8.50%) and starch (79.27%) content were recorded in treatment 75:75:175 kg ha^{-1} NPK with K as Bio K + S. Total N, P, K content in haulm

(1.35, 0.27 and 2.87) and tuber (1.34,0.43 and 1.75) was significantly higher due to application of 75:75:175 kg ha^{-1} NPK with K as Bio-K + S and was on par with application of 75:75:175 kg ha^{-1} NPK with K as SOP+S. As regard to micronutrients, significantly higher Fe, Mn, Zn Cu and B content in haulm (277.63, 152.41, 44.54, 32.85 and 9.82) and tuber (147.06, 53.6, 12.37, 26.65 and 16.53) was recorded due to application of 75:75:175 kg ha^{-1} NPK with K as Bio K + S. B:C ratio of 4.74 was recorded with the application of (75:75:175 kg ha^{-1} NPK) K as Bio K + Sulphur is found to be more profitable compared to other treatments in potato cultivation.

Neshev and Manolov (2016) carried out a field experiment included two fertilizer rates- 100 and 200 kg K2O ha^{-1} supplied as K2SO4 or KCl. Increased content of nitrogen in roots at variants fertilized with KCl was observed 3.01% for KCl (100) and 3.13% for KCl (200). Potassium fertilization have no effect on seedling emergence but increased K content in roots compared to control. The N content in aboveground biomass was the lowest for KCl (100) (4.13%) and for KCl (200) (3.84%). The appliedpotassium fertilizers increased K content in aboveground biomass compared to control. The high KCl rate at variant KCl (200) increased K content in aboveground biomass upto 5.16%. The fertilization with K2SO4 led to slight decrease of N content in the tubers compared to control (2.32%), but he KCl increased tuber N content from 2.60% at variant KCl (100) to 2.89% at KCl (200). The K content in tubers was not considerably influenced by the fertilization but an exception was observed for variant KCl (200) where it (2.70%) exceeded the one at the other variants.

Salim *et. al.* (2014) conducted two field experiments to study the effect of foliar spray with potassium nitrate, potassium silicate, potassium chloride and mono potassium phosphate at the rates 1000 ppm and 2000 ppm on growth, yield parameters and some biochemical constituents of potato plant. Two samples were taken after 65 days from sowing and at harvest. At the 1st sample date, plant length, shoot fresh weight, shoot dry weight, total chlorophyll reading, total nitrogen and proteins, P, K, Mg, Fe, Mn and Zn concentrations (in potato leaves) 6 were determined. At the 2nd sample date (harvesting stage), tubers number per plant, tubers weight/plant, yield/plant and yield/fadden were recorded. The higher rate of potassium silicate and potassium nitrate were more effective than the rest treatments on enhancing the vegetative growth parameters and yield components. In general, all potassium treatments have strongly stimulating effect on mineral nutrients (N, P, K, Mg, Zn, Mn and Fe) and protein concentration of potato leaves in both seasons.

Gunadi (2009) conducted an experiment to determine the response of potato to potassium (K) fertilizer sources and application methods in Andisols of West Java was conducted at a farmer's field in the highland area of Pangalengan, West Java. The treatments consisted of two K fertilizer sources (potassium chloride-KCl and potassium sulphate-K_2SO_4), two K rates (150 and 250 kg K2O ha $^{-1}$), and three application methods (single, split, and split combined with foliar application). In the single application treatment, K was applied at planting, while in the split application treatment the K was applied half rate at planting and the rest at 6 weeks after planting (WAP). In the split combined with foliar application treatment, the K fertilizer was applied half rate at planting, a quarter rate at 6 WAP and another quarter rate by foliar spraying at 7, 8 and 9 WAP. The results showed that plant height was not significantly affected by the treatment. However, the sources and application methods of K fertilizer affected canopy cover, crop cover weeks (CCW), tuber dry weight (DW), and total plant DW at 10 WAP. Potatoes supplied with K_2SO_4 either in split or split combined with foliar application had significantly higher percent canopy cover, CCW, tuber DW, and total plant DW than those supplied with K fertilizer in single application. Potatoes supplied with K_2SO_4 had a higher tuber yield compared to those fertilized with KCl, especially under split or split combined with foliar application. To attain the same level of tuber yield as in the split combined with foliar application method, the rate of K_2SO_4 should be increased from 150 to 250 kg K_2O ha^{-1} when using single application. It is therefore suggested that K_2SO_4 for potatoes should be used in split application combined with foliar application.

Manolov *et. al.* (2005) conducted and studied the influence of potassium fertilizer source (K_2SO_4 and KCl) on potato yield and quality under pot experimental conditions at the Agricultural University, Mendeleev, Bulgaria. Experiments included increasing rates of the potassium fertilizers providing 200, 400 and 600 mg kg^{-1} soil K_2O and K_2SO_4 and KCl were the sources. Data indicated no statistical differences in potato yield as a result of potassium fertilizer sources. In contrast, all studied quality parameters with the except for reducing sugars were influenced by potassium sources. Increasing rates of KCl decreased most severely dry matter, starch and vitamin C contents in potato tubers which were diminished with 15%, 46% and 50% by potassium 600 treatment, respectively when compared to control.

CHAPTER III
MATERIALS AND METHODS

The experiment was conducted during the period from November 2018 to February 2019 to study the mollifying effect of Phosphorus Dose and Potassium Source on potato tuber. The materials and methods describe a short description of the experimental site, climate condition of the storage room, experimental materials, experimental treatments and design, methods of the study, data collection procedure and procedure of data analysis. The detailed materials and methods that were used to conduct the study is presented below under the following heading:

3.1 Site Description

3.1.1 Geographical location

The experimental area was situated at 23077´ N latitude and 90033´ E longitude at an altitude of 8.6 meter above the sea level (Anon., 2004).

3.1.2 Agro-Ecological Region

The experimental site belongs to the Agro-ecological zone of "Modhupur Tract", AEZ-28 (Anon., 1988). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as "islands" surrounded by floodplain (Anon., 1988). Appendix I represents the map of the experimental site.

3.13 Climate

Experimental site was located in the subtropical monsoon climatic zone, set aparted by winter during the months from November to February (Rabi season). Plenty of sunshine and moderately low temperature prevails during experimental period, which is suitable for potato growing in Bangladesh. Appendix III represents monthly record 11 of air temperature, relative humidity, railfall and sunshine hour from November'18 to February'19.

3.1.4 Soil characteristics

The soil of the experimental location belongs to the Tejgaon series under the Agro ecological Zone, Madhupur Tract (AEZ-28) and the General Soil Type is Deep Red Brown Terrace Soils (FAO, 1988). In texture, the top soil was Silty Clay, olive-gray with common fine to medium distinct dark yellowish brown mottles.

The experimental site having available irrigation and drainage facilities and situated above flood level. The soil was composed of 26% sand, 43% silt and 31% clay particles and having a texture of sandy loam with organic matter 1.15%.

3.2 Details of the experimental treatment and design

3.2.1 Treatments

The experiment consisted of 2 factors:

Factor A: Doses of Phosphorus (4)

1. P_1: 41.84 kg P ha^{-1} @200 $kgha^{-1}$ TSP
2. P_2: 46.03 kg P ha^{-1} @220 kg $kgha^{-1}$ TSP
3. P_3: 50.21 kg P ha^{-1}@240 $kgha^{-1}$ TSP
4. P_4: 54.39 kg P ha^{-1} @260 $kgha^{-1}$ TSP

Factor B: Potassium Sources (3)

1. K_1: KCl (250 kg KCl ha^{-1} @130 kg K ha^{-1})
2. K_2: KH_2PO_4 (452.19 kg KH_2PO_4 ha^{-1} @130 kg K ha^{-1})
3. K_3: K_2SO_4 (288.6 kg K_2SO_4 ha^{-1} @130 kg K ha^{-1})

There were 12 treatment combinations: viz., P_1K_1, P_1K_2, P_1K_3, P_2K_1, P_2K_2, P_2K_3,P_3K_1, P_3K_2, P_3K_3, P_4K_1, P_4K_2, P_4K_3

3.2.2 Experimental design

The two factorial experiment was laid out in split-plot design with three replications. The total area was 300 m^2 with length 24 m and width 11.33 m. The four doses of Phosphorus were assigned in the main plot and three sources of potassium in the sub-plot. There were 36 unit plots with the size of 2.6 m × 1.2 m. The distance between two blocks and two plots were 1 m and 0.8 m, respectively. The layout of the experiment has been shown in Appendix II.

3.3 Crop / Planting material

The planting materials comprised the certified seed tubers of BARI alu-29 (Courages) varieties of potato.

3.4 Growing of crops

3.4.1 Preparation of the main field

The experimental plot was opened in the 15th November 2019 with a power tiller and left exposed to the sun for a week. Subsequently cross ploughing was done five times followed by laddering to make the land suitable for planting of tubers with eliminated all weeds, stubbles and residues. The soil was treated with insecticides (Cinocarb 3G @ 4 kgha^{-1}) at the time of final land preparation to protect young plants from the attackof insects such as cutworm and mole cricket.

3.4.2 Application of manure and fertilizer

Manures and fertilizers were applied to the experimental plot considering the recommended fertilizer doses of potato and presented in Table 1.

Table 1. Doses and methods of application of manure and fertilizers in the potato field

Manures and fertilizers	Dose ha^{-1}	Application (%)	
		Basal	50 DAP
Urea	325 kg	50	50
TSP	200 kg	100	--
Zypsum	100 kg	100	--
Zinc Suphate	8 kg	100	--

Source: BARI, 2019

All fertilizers and half urea were applied during final land preparation. Rest amount of urea was applied during 2nd earthing up at 50 DAP. Potassium fertilizer was applied as per treatment and 250, 452.19 and 288.6 kg KCl, KH_2PO_4 and K_2SO_4 , respectively was applied for 130 kg K ha^{-1} .

3.4.3 Planting of potato tubers

The seed tubers were planted at a depth of 5 cm in the experimental plots at 15th November, 2019 with maintaining a distance of 50 cm × 25 cm. The soil along the rows of seed tubers were ridged up immediately after planting.

3.4.4 Intercultural operations

When the seedlings started to emerge in the beds mulch materials were clean-up for easy growth and development of potato seedlings. The crop was always kept under careful observation. After emergence of potato seedlings, various intercultural operations were accomplished for better growth and development.

3.4.4.1 Weeding and mulching

Weeding was done at 30 and 50 DAP (days after planting) to remove the unwanted weeds and mulching was done to conserve soil moisture. Manual weeding was done as and when necessary to keep the plots free from weeds. The soil was mulched by breaking the crust of the soil for easy aeration and to conserve soil moisture as and when needed. Mulching also helped to disturb the emergence of Bathua plants (*Chenopodium album*) and other weeds. These two operations were done carefully without hampering the luxurious crop health.

3.4.4.2 Earthing-up

Two times earthing up was done at 30 and 50 DAP. The soil along the rows of seed tubers were ridged up immediately after planting. The earthing which was preceded by top dressing of the remaining half of urea and also it was treated as a final earthing-up.

3.4.4.3 Irrigation

Pre emergence irrigation was done seven days after planting of potato tubers as because moisture was not optimum for germination before emergence, light irrigation was done for even emergence of seed tuber. After emergence, four times irrigation was given throughout the growing period.

3.4.4.4 Pests and diseases control

Except cutworm, no other insects were found harmful for potato in growing season. To protect the soil borne insects Furadan 5G was applied @10kg ha^{-1} during the final land preparation. Dithane M-45 was applied @ 2 g L^{-1} at 10 days interval as a preventive measure against late blight (*Phytophthora infestans*) of potato. This plant growing time was very cold so Dithane M 45 and Rovral 50 WP were applied alternatively at 3 days interval.

3.4.4.5 Haulm cutting

When the potato plants attained maturity the upper portion of the plants were cut down and tubers were kept under the soil for 07 days for skin hardening of potato. This haulm cutting was done at 5th February, 2020.

3.5 Harvesting

The maturity of the tuber crops was determined by the appearance of the yellowish color of the leaves, falling of the stems on the ground and finally drying of leaves. Harvesting was done at 12th February 2020. The tubers from each plot were harvested manually.

3.6 Data collection

Five plants were randomly selected from the middle rows of each unit plot for avoiding border effect and tagged with a sample card, which was done in plot wise for data recording. Data were collected in respect of the following parameters to estimate the plant growth; yield attributes, yields and quality of potato tubers as affected by different treatments that were used in this experiment. Data on plant height, number of leaves plant^{-1} , number of stems plant^{-1} were collected at 30, 45, 60, 75 DAP and at harvest and recorded accordingly. All other yield contributing characters, yield parameters were recorded during harvest and after harvest as per suitability. Quality parameters of potato tubers was estimated in laboratory condition following the standard procedures of estimation as per different quality measures.

3.6.1 Growth, yield parameters and yield of potato

3.6.1.1 Days required for 1 st emergence

Each plot of the experiment was kept under close observation from 10 DAPs to count days required for 1 st emergence of potato seedlings. Total number of days from the date of planting to the visible emergence was counted and recorded accordingly.

3.6.1.2 Days required for 80% emergence

Each plot of the experiment was kept under close observation to count days required for planting to 80% emergence of potato seedlings. Total number of days from planting to 80% emergence was recorded.

3.6.1.3 Days required for planting to harvest

Each plot of the experiment was kept under close observation to count days required for planting to maturity of potato plants. Total number of days from the date of planting to the harvesting was recorded.

3.6.1.4 Plant height

Plant height was measured from sample plants in centimeter from the ground level to the tip of the longest leaf and mean value was calculated. Plant height was also recorded at 15 days interval starting from 30 DAP upto 75 DAP and also at harvest to observe the growth rate of the potato plants.

3.6.1.5 Number of leaves plant^{-1}

The total number of leaves plant^{-1} was counted from each selected potato plants. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot at 15 days interval starting from 30 DAP upto 75 DAP and also at harvest.

3.6.1.6 Number of stems plant^{-1}

The total number of stems plant^{-1} was counted from each selected plants. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot at 15 days interval from 30 DAP to 75 DAP and also at harvest.

3.6.1.7 SPAD value of leaf

The SPAD value of leaves was measured at stolen initiation stage at 30 DAP by placing the Spadometer in middle point of any five leaves of each 5 previously tagged plants from in each plot and then the percentage showed by the Spadometer was observed and recorded.

3.6.1.8 Number of tubers hill^{-1}

Total number of potato tubers hill^{-1} was recorded as the average of 5 plants selected at random from each unit plot at harvest. The total number of tubers were recorded by counting the entire potato hill^{-1} .

3.6.1.9 Weight of tubers hill^{-1}

Five earlier tagged hills from middle row was selected from each unit plot, and the yield of potato tubers obtained from the hills was collected and weighted and recorded according with expressed in g hill^{-1}.

3.6.1.10 Average weight of individual tuber

Average weight of individual tubers were estimated by dividing the weight of tubers hill $^{-1}$ with the number of tubers hill^{-1} as the average of 5 plants selected at random from each unit plot at harvest.

3.6.1.11 Yield of tubers hectare^{-1}

Tubers yield per hectare of potato was calculated by converting the weight of individual tubers yield from a plot and converted yield of tubers into hectare and was expressed in t ha^{-1} .

3.6.1.12 Seed Potato

The harvested potato tubers from 5 plants of each unit plot were graded as seed potato (28-55 mm) and expressed in percentage.

3.6.1.13 Non-seed potato

The harvested potato tubers from 5 plants of each unit plot were graded as non-seed potato (55 mm) and expressed in percentage.

3.6.2 Quality of potato

3.6.2.1 Grading of potato tubers

The harvested potato tubers from 1 m^2 area of each unit plot were graded in to four size grades (55 mm) and expressed in percentage.

3.6.2.2. Category of potato tubers for different uses

The harvested potato tubers from 1 m^2 area of each unit plot were classified for different purposive uses i.e. Canned (25-35 mm), Chips (>45 mm) and French fry (>75 mm), potato and expressed in percentage.

3.6.2.3 Firmness score in potato tubers

Firmness score was estimated by using pressure gauge. For the estimation of firmness firstly the potato tubers was divided into two then created pressure using pressure gauge and recorded the reading from pressure gauge.

3.6.2.4 Estimation of Total Soluble Solids (TSS) in potato tubers

Total Soluble Solids (TSS) of harvested tubers was determined after harvest in a drop of potato juice by using Hand Sugar Refractometer "ERMA" Japan, Range: 0-32% according to (AOAC, 1990) and recorded as obrix from direct reading of the instrument.

3.6.2.5 Dry matter content of potato tubers

At first selected tubers were collected, cut into pieces and was dried under sunshine for a 3 days and then dried in an oven at 700C for 72 hours. The sample was then transferred into desiccators and allowed to cool down at room temperature. The final weight of the sample was taken. The dry matter contents in potato tubers were computed by simple calculation from the weight recorded using the following formula:

Dry matter content in stem (%) $=\frac{\text{Dry weight of potato tubers}}{\text{Fresh weight of potato tubers}} \times 100$

3.6.2.6 Estimation of specific gravity of potato tubers

Specific gravity of potato tubers was measured by using the following formula (Gould, 1995). Five tubers were taken from each plot after harvest of treatment and then the means were taken.

Specific Gravity $=\frac{\text{Wa}}{\text{Ww}} 100$

Where,

Wa= Weight of tuber (g) in air and

Ww= Weight of tubers (g) in fresh water at 4^0C

3.6.2.7 Estimation of starch content of potato tubers

Starch content of potato tubers was determined after harvest by Somogyi-Nelson method (Nelson, 1944). Phosphate buffer solution was prepared through diluted 0.74g $NaH_2PO_4·2H_2O$ and 0.09 g $Na_2HPO_4.12H_2O$ into 100 ml Distilled water. Added 0.1g Enzyme (Amyloglucosidase) and mixed well. Kept at 200C for the preservation. The residue remained after extraction for sugar was washed for several times with water to ensure that there was no more soluble sugar in the residues. After that using tap water and mark up to 250 ml beaker. Stirred well on a magnetic stirrer. Then 0.5 mL solution was taken from the beaker during stirring into 3 test tubes. Boil the test tubes for 10 min at 1000C. Add 1 ml Amyloglucosidase solution, mix well, and heat at 50-600C for 2 hours in hot water. After cooling, add 0.5 ml Copper solution, mix well, heat at 1000C for 10 min., cool in tap water, add 0.5 ml Nelson solution, mix well, add 7 ml distilled water, mix well (Final volume = 9.5 ml), and measure the absorbance at 660 nm (Abs) Starch content was calculated using the glucose standard curve.

3.6.2.8 Estimation of vitamin C (ascorbic acid) content in potato tubers

Quantitative determination of ascorbic acid content of potato tubers from different treatment was estimated (AOAC, 1990) at Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka. The applied method was as follows:

Reagents

i) Metaphosphoric acid solution (3% HPO_3): Prepared by dissolving pellets of HPO_3 in glass distilled water.

ii) Standard ascorbic acid solution: 100 mg of ascorbic acid was weighted,dissolved and made up to 100 ml with 3% HPO_3 and diluted to 0.1 mg/ml (10 ml HPO_3 of 1 mg/ml) immediately before use.

iii) Dye solution: Fifty milligram of 2, 6-Dichlorophenol indophenol was dissolved in approximately 150 ml of hot glass distilled water containing 42 mg of sodium bicarbonate. The mixture was cooled, diluted with distilled water upto 200 ml, stored in a refrigerator and standardizes every day before use.

Procedure

Five (5) grams of fresh potato tuber sample was crushed in a mortar and mixed well with 3% HPO_3 upto 100 ml in a volumetric flask. It was filtered with whatman filter paper 40. Then 5 ml aliquot of HPO_3 extract of the sample was taken and titrated with dye solution.

3.6.2.9 Estimation of sugar content of potato tubers

For the analysis of sugar content like reducing sugar glucose potato flesh was extracted. For each extraction, 1 g fresh sample of chopped potato was taken from uniform tuber samples and smashed well in a motor. Sugar was extracted using 5 ml of 80% ethanol heat at 800C for 30 min using a dry block heat bath and the extracts was centrifuged at 5000 rpm for 10 min and decanted the supernatant. 8 mL 80% EtOH, was added and it was repeated 4 and 5 times in total. All the supernatants were mixed well and the final volume was made up to 25 mL using 80% EtOH. The residue is used for sugar analysis. Reducing sugar was estimated by the photometric adaptation of the Somogyi method (Nelson, 1944) with some modification. Copper solution and Nelson reagent and standard glucose solution (0.5 ml) were used. 3 mL sample solution was put into a small glass container. Then it was completely dried up on an electric heater, 3 mL distilled water was added and then mixed well. Then 0.5 ml solution was taken from that, two times and was put in different test tubes. In one test tube, 0.5 ml Copper solution was added and was boiled (1000C) for 10 min. After boiling, immediately the test tube was cooled in tap water. 0.5 mL Nelson reagent in the test tube was added, and mixed them well. After 20 min, 8 mL distilled water was added and mixed well (Total volume = 9.5 ml). After that the absorbance at 660 nm (Abs1) was measured and the reducing sugar content was calculated.

3.7 Statistical analysis

The data obtained for different characters were statistically analyzed to find out effect and the significance of the difference for Phosphorus dose and Potassium Sources on yield, yield contributing characters and quality of potato. The mean values of all the recorded parameters were evaluated and analysis of variance was performed by the ‘F’ (variance ratio) test using MSTAT-C software. The significance of the difference among the treatment and treatment combinations of means under the experiment was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV
RESULT AND DISCUSSION

The research work was accomplished to investigate the effect of phosphorus dose and potassium source on yield of processing and export quality potato.. Some of the data have been presented and expressed in table(s) and others in figures for easy discussion, comparison and understanding. The analysis of variance of data respect of all the parameters has been shown in Appendix IV-XI. The results of each parameter have been discussed and possible interpretations where ever necessary have been given under following headings.

4.1 Days to 80% emergence

Different dose of Phosphorus varied non-significantly in terms of days required for 80% emergence (Appendix IV). The maximum days required for 80% emergence (14.33) was observed from P_2, whereas the minimum days (13.00) was obtained from P_1 (Table 1).

Days required for 80% emergence of potato seedlings varied significantly due to different sources of potassium (Appendix IV). The maximum days required for 80% emergence (14.41) was found from K_1, while the minimum days (12.91) was recorded from K_2 source of potassium (Table 2).

Statistically non-significant variation was recorded in terms of days required for 80% emergence due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix IV). The maximum days required for 80% emergence (15.33) was found from P_3K_1 and the minimum days (12.33) was recorded from P_1K_2, P_1K_3 and P_3K_2 treatment combinations (Table 3).

4.2 Plant vigor

Different dose of Phosphorus varied significantly in case of plant vigor (Appendix IV). The maximum plant vigor (8.77) was observed from P_3, whereas the minimum vigor (6.67) was obtained from P_1 (Table 2).

The plant vigor varied significantly due to different sources of potassium (Appendix IV). The maximum plant vigor (8.18) was found from K_2, while the minimum vigor (7.33) was recorded from K_3 source of potassium (Table 2).

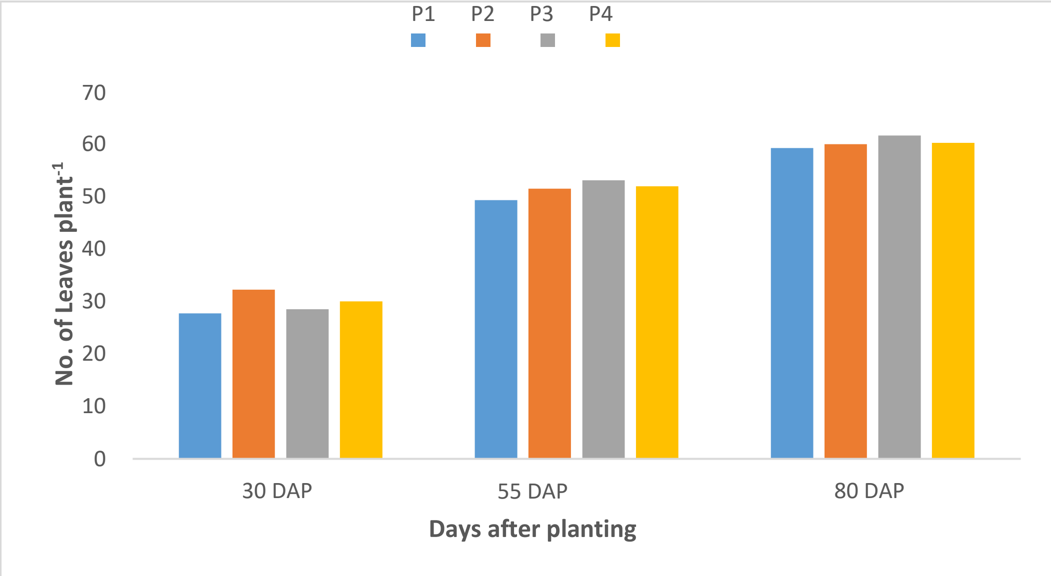
Statistically significant variation was recorded in case of plant vigor due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix IV). The maximum plant vigor (9.1) was found from P_3K_2 and the minimum vigor (6.1)was recorded from P_1K_3 treatment combination (Table 3).

4.3 No. of leaves plant^{-1}

Number of leaves plant^{-1} of potato at 30, 55, and 80 DAP varied non-significantly due to different dose of Phosphorus (Appendix IV). At 30, 55, and 80 DAP, the highest number of leaves plant^{-1} (32.29, 53.13, and 61.67, respectively) was found from P_2 and P_3, whereas the lowest number (27.76, 49.36 and 59.31, respectively) was observed from P_1 (Figure 1).

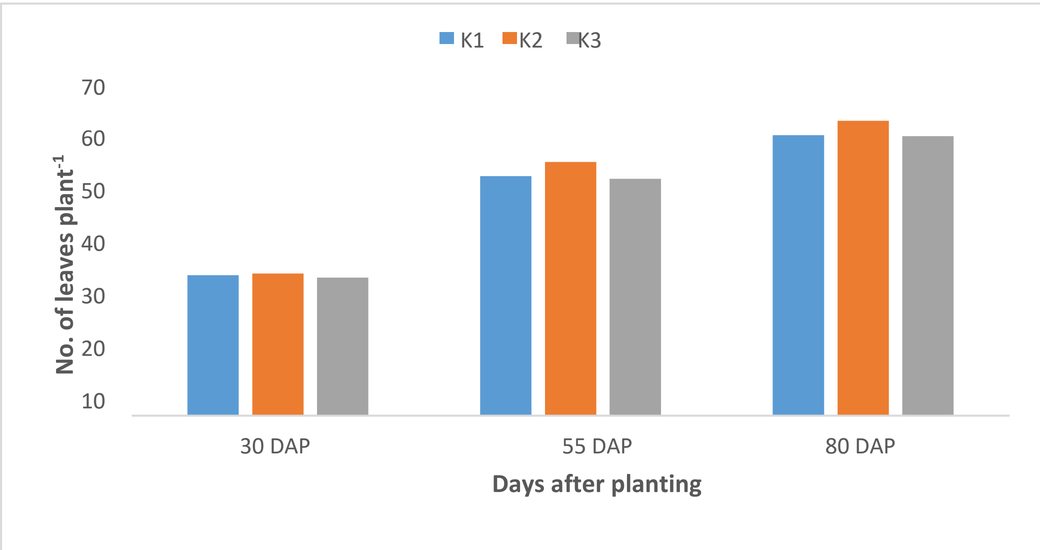
Number of leaves plant^{-1} of potato at 30, 55, and 80 DAP varied non-significantly due to different sources of potassium (Appendix IV). At 30, 55, and 80 DAP, the highest number of leaves plant^{-1} (30.05, 53.67 and 62.41, respectively) was found from K_2, whereas the lowest number (29.22, 50.13 and 59.19, respectively) was observed from K_3 (Figure 2).

At 30 DAP, Statistically significant variation was recorded in No. of leaves plant^{-1} due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix IV). The highest number of leaves plant^{-1} (34.93) was found from P_2K_2 which was statically similar to the rest of treatments except P_1K_2, whereas the lowest number (26.60) was observed from P_1K_2. But at 55 and 80 DAP, non- significant variation was recorded in no. of leaves plant-1 due to the combined effect of different dose of Phosphorus and sources of potassium (Table 3). The highest number of leaves plant^{-1} (54.93 and 65.13, respectively) was found from P_3K_2 and P_1K_2, whereas the lowest number (46.53 and 55.24, respectively) was observed from P_1K_3 (Table 3)



P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 1. Effect of phosphorus dose on no. of leaves of potato at different days after planting (DAP)



K1: KCl @130 kg K ha^{-1} K2: KH_2PO_4 @130 kg K ha^{-1} K3:K_2SO_4 @130 kg K ha^{-1}

Figure 2. Effect of sources of potassium on no. of leaves of potato at different days after planting (DAP)

Table 2. Effect of phosphorus dose and sources of potassium on days required for 80% emergence of seedlings, plant vigor and no. of leaves of potato at different days after planting (DAP)

Treatments	Days to 80% emergence	Plant vigor (1-10)	Number of leaves plant^{-1} at		
			30 DAP	55 DAP	80 DAP
Phosphorus Dose					
P_1	13.00	6.67 c	27.76	49.36	59.31
P_2	14.33	7.73 b	32.29	51.53	60.01
P_3	13.77	8.77 a	28.56	53.13	61.67
P_4	13.11	7.87 b	30.00	51.96	60.26
LSD	________	0.350	________	________	________
Level of Significance	NS	**	NS	NS	NS
CV(%)	13.09	3.91	16.49	7.79	5.31
Source of Potassium					
K_1	14.41 a	7.78 ab	29.68	50.68	59.34
K_2	12.91 b	8.18 a	30.05	53.67	62.41
K_3	13.33 b	7.33 b	29.22	50.13	59.19
LSD	0.957	0.546	________	________	________
Level of Significance	*	*	NS	NS	NS
CV(%)	8.16	8.13	12.09	17.33	9.91

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha $^{-1}$ K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha $^{-1}$ K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

Table 3. Combine effect of phosphorus dose and sources of potassium on days requiredfor 80% emergence of seedlings, plant vigor and no. of leaves of potato at different days after planting (DAP)

Treatments	Days to 80% emergence	Plant vigor (1-10)	Number of leaves $plant^{-1}$ at		
			30 DAP	55 DAP	80 DAP
P_1K_1	14.33	6.9 ef	29.133 ab	48.333	57.562
P_1K_2	12.33	7.0 ef	26.60 b	53.20	65.13
P_1K_3	12.33	6.1 f	27.53 ab	46.53	55.24
P_2K_1	14.66	7.5 cde	30.53 ab	53.00	63.33
P_2K_2	14.33	8.5 abc	34.93 a	51.87	56.13
P_2K_3	14.00	7.2 de	31.40 ab	49.73	60.57
P_3K_1	15.33	8.7 ab	27.47 ab	50.60	57.33
P_3K_2	12.33	9.1 a	30.33 ab	54.93	64.27
P_3K_3	13.66	8.5 abc	27.87 ab	53.87	63.41
P_4K_1	13.33	8.0 bcd	31.60 ab	50.80	59.12
P_4K_2	12.66	8.1 bcd	28.33 ab	54.67	64.11
P_4K_3	13.33	7.5 de	30.07 ab	50.40	57.56
LSD(0.05)	________	0.956	7.562	________	________
Level of sigficance	NS	*	*	NS	NS
CV(%)	8.16	8.13	12.09	17.33	9.91

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

4.4 Crop stand at 30 DAP

Different dose of Phosphorus varied non-significantly in case of Crop stand (Appendix V). The maximum Crop stand (97.03) was observed from P_3, whereas the minimum Crop stand (96.07) was obtained from P_1 (Table 4).

The Crop stand varied non-significantly due to different sources of potassium (Appendix V). The maximum Crop stand (96.93) was found from K_2, while the minimum Crop stand (95.98) was recorded from K_3 source of potassium (Table 4).

Non-significant variation was recorded in case of Crop stand due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix V). The maximum Crop stand (97.30) was found from P_3K_2 and the minimum Crop stand (95.10) was recorded from P_1K_3 treatment combination (Table 5).

4.5 Number of stem plant^{-1} at 80 DAP

Number of stem plant^{-1} of potato at DAP varied non-significantly due to different dose of Phosphorus (Appendix V). At 80 DAP, the highest Number of stem plant^{-1} (4.22) was found from P_3, whereas the lowest number (4.02) was observed from P_1 (Table 4).

Number of stem plant^{-1} of potato at 80 DAP varied significantly due to different sources of potassium (Appendix V). At 80 DAP, the highest Number of stem plant^{-1} (4.48) was found from K_3, whereas the lowest number (3.93) was observed from K_1 (Table 4).

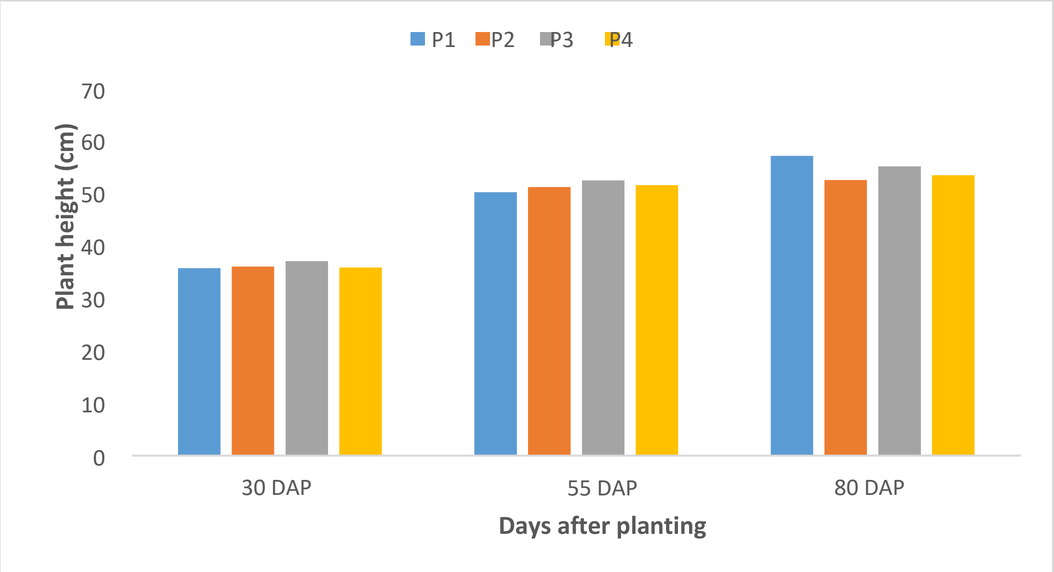
At 80 DAP, Statistically significant variation was recorded in Number of stem plant^{-1} due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix V). The highest Number of stem plant^{-1} (5.07) was found from P_1K_3 which was statically similar to the P_2K_2, P_3K_1, P_3K_3, P_4K_1, P_4K_2 and P_4K_3 treatments combination respectfully, whereas the lowest number (3.33) was observed from P_1K_2 (Table 5).

4.6 Plant height (cm)

Plant height (cm) of potato at 30, 55, and 80 DAP varied non-significantly due to different dose of Phosphorus (Appendix V). At 30, 55, and 80 DAP, the tallest plant height (cm) of potato (37.27, 52.73, and 57.44, respectively) was found from P_3, P_3 and P_1, whereas the shortest height (35.91, 50.48 and 52.80, respectively) was observed from P_1, P_1 and P_2 respectfully (Figure 3).

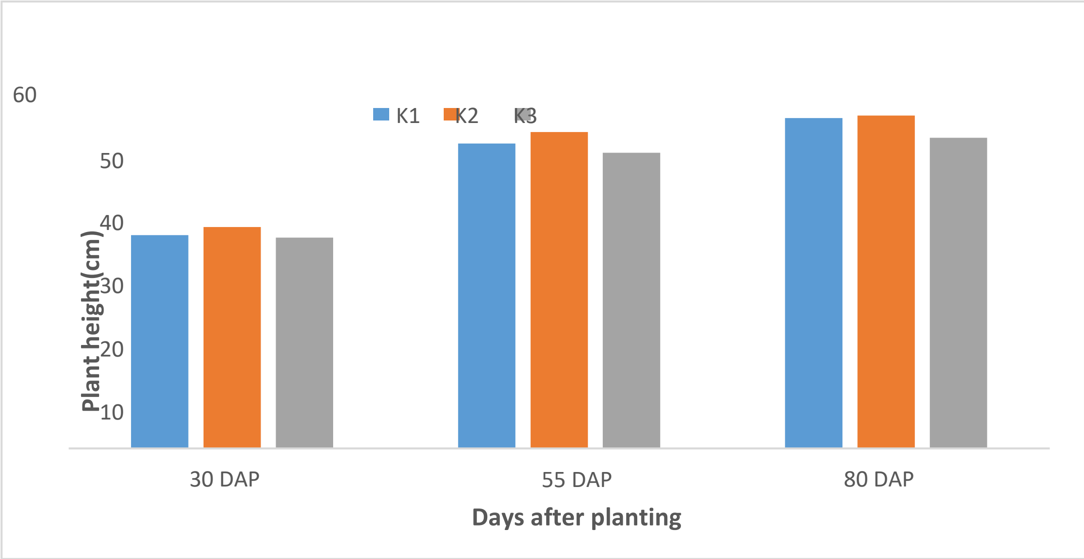
Plant height (cm) of potato at 30, 55, and 80 DAP varied non-significantly due to different sources of potassium (Appendix V). At 30, 55, and 80 DAP, the the tallest plant height (cm) of potato (37.42, 53.45 and 56.21, respectively) was found from K_2, whereas the shortest height (35.64, 49.95 and 52.48, respectively) was observed from K_3 (Figure 4).

At 30 and 55 DAP, non- significant variation was recorded in plant height (cm) of potato due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix V). The plant highest height (cm) of potato (39.15 and 55.06, respectively) was found from P_3K_2, whereas the shortest height (35.35 and 48.98, respectively) was observed from P_1K_3, P_4K_3 and P_1K_3, respectively. But at 80 DAP, Statistically significant variation was recorded in plant height (cm) of potato due to the combined effect of different dose of Phosphorus and sources of potassium. The tallest plant height (cm) of potato (61.93) was found from P_1K_2 which was statically similar to the rest of combinations treatments except P_2K_2 P_2K_3, whereas the shortest height (51.53) was observed from P_1K_3 which was statically similar to the P_2K_2 P_2K_3 combinations treatments (Table 5).



P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 3. Effect of phosphorus dose on plant height of potato at different days after planting (DAP)



K1: KCl @130 kg K ha^{-1} K2: KH_2PO_4 @130 kg K ha^{-1} K3: K_2SO_4 @130 kg K ha^{-1}

Figure 4. Effect of source of potassium on plant height of potato at different days after planting (DAP)

Table 4. Effect of phosphorus dose and sources of potassium on crop stand at 30 DAP, number of stem at 80 DAP and plant height of potato at different days after planting (DAP)

Treatments	Crop stand at 30 DAP	No. of stem at 80 DAP	Plant height(cm)		
			30 DAP	55 DAP	80 DAP
Phosphorus Dose					
P_1	96.07	4.02	35.91	50.48	57.44
P_2	96.53	4.11	36.21	51.48	52.80
P_3	97.03	4.22	37.27	52.73	55.43
P_4	96.37	4.16	36.06	51.87	53.71
LSD	________	________	________	________	________
Level of Significance	NS	NS	NS	NS	NS
CV(%)	3.85	17.26	6.15	4.84	9.82
Source of Potassium					
K_1	96.60	3.93 b	36.03	51.53	55.85
K_2	96.93	3.97 b	37.42	53.45	56.21
K_3	95.98	4.48 a	35.64	49.95	52.48
LSD	________	0.453	________	________	________
Level of Significance	NS	*	NS	NS	NS
CV(%)	6.69	12.69	11.40	9.09	7.88

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

Table 5. Combine effect of phosphorus dose and sources of potassium on Crop Stand at 30 DAP, number of stem at 80 DAP and plant height of potato at different days after planting (DAP)

Treatments	Crop stand at 30 DAP	No. of stem at 80 DAP	Plant height(cm)		
			30 DAP	55 DAP	80 DAP
P_1K_1	96.40	3.67 cd	35.73	50.38	58.87 ab
P_1K_2	96.70	3.33 d	36.65	52.08	61.93 a
P_1K_3	95.10	5.07 a	35.35	48.98	51.53 b
P_2K_1	96.80	3.93 bcd	35.74	51.34	54.50 ab
P_2K_2	96.80	4.47 abc	37.17	53.16	52.30 b
P_2K_3	96.00	3.93 bcd	35.73	49.95	51.60 b
P_3K_1	96.90	4.07 a-d	36.53	52.39	56.70 ab
P_3K_2	97.30	3.67 cd	39.15	55.06	56.40 ab
P_3K_3	96.90	4.93 ab	36.13	50.74	53.20 b
P_4K_1	96.30	4.07 a-d	36.11	52.00	53.32 ab
P_4K_2	96.90	4.40 a-d	36.71	53.51	54.20 ab
P_4K_3	95.90	4.00 a-d	35.35	50.12	53.60 ab
LSD(0.05)	________	1.103	________	________	8.692
Level of significance	NS	*	NS	NS	*
CV(%)	6.69	12.69	11.40	9.09	7.88

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

4.7 Tuber number hill^{-1}

Different dose of phosphorus varied significantly ($P \leq 0.05$) in terms of number of tubers plant $^{-1}$ of potato (Appendix 6). Figure 5 showed that the maximum number of tuber plant^{-1} (8.73) was observed from P_3, while the minimum number (7.73) was recorded from P_1 (Table 6).

Number of tubers plant^{-1} showed statistically significant ($P \leq 0.05$) differences due to different sources of potassium (Appendix 6). Figure 6 showed that the maximum number of tubers plant^{-1} (8.50) was recorded from K_2, whereas the minimum number (7.63) was observed from K_3 (Table 6).

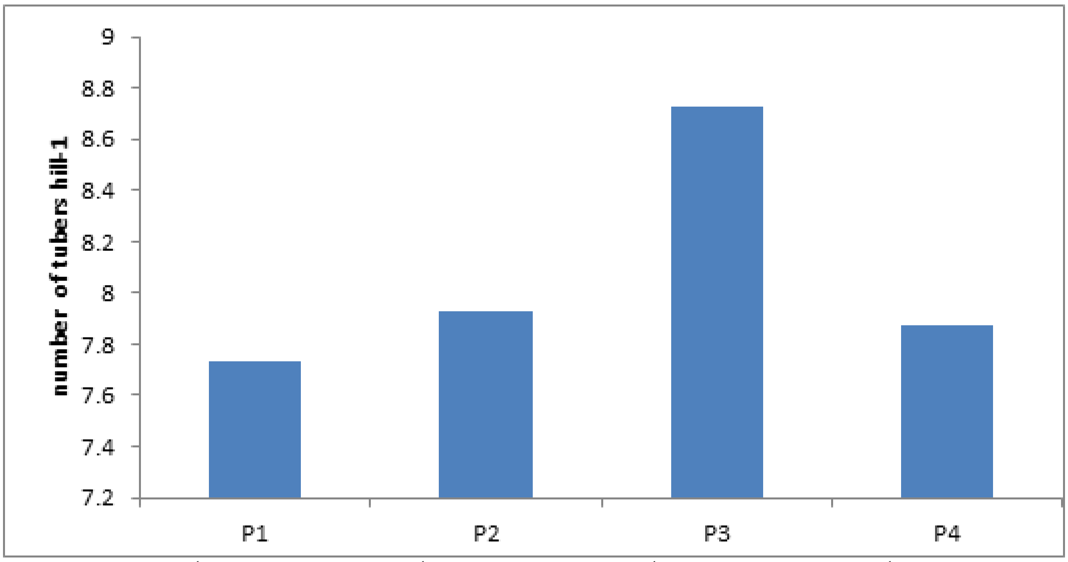
Statistically significant variation was recorded in terms of number of tubers plant^{-1} of potato due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix 6). The maximum number of tubers plant^{-1} (9.40) was found from P_3K_2 which is statistically similar to P_3K_1 P_3K_3 and P_4K_2 , respectfully, while the minimum number (7.00) was observed from P_4K_3 treatment combination, which is statistically similar to the rest of combinations treatment except P_3K_1, P_3K_3 and P_4K_2 (Table 7).

4.8 Average weight of tuber (g)

Different dose of Phosphorus varied non-significantly in case of average weight of tuber (Appendix 6).The maximum average weight of tuber (47.62 g) was observed from P_3, whereas the minimum average weight of tuber (45.59 g) was obtained from P_2 (Table 6).

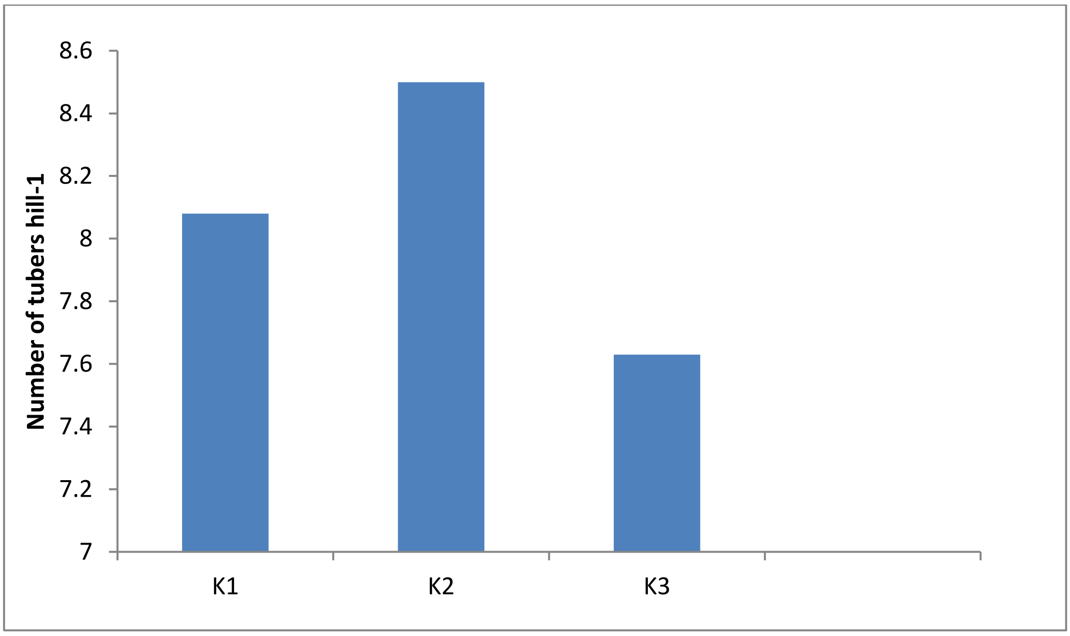
The average weight of tuber (g) varied non-significantly due to different sources of potassium (Appendix 6).The maximum average weight of tuber (46.70 g) was found from K_1, while the minimum average weight of tuber (45.73 g) was recorded from K_3 source of potassium (Table 6).

Significantly variation was recorded in case of average weight of tuber (g) due to the combined effect of different dose of phosphorus and sources of potassium (Appendix 6).The maximum average weight of tuber (50.65 g) was found from P_3K_2 and the minimum average weight of tuber (42.92 g) was recorded from P_4K_2 treatment combination (Table 7).



P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 5. Effect of phosphorus dose on number of tubers $hill^{-1}$



K1: KCl @130 kg K ha^{-1} K2: KH_2PO_4 @130 kg K ha^{-1} K3:K_2SO_4 @130 kg K ha^{-1}

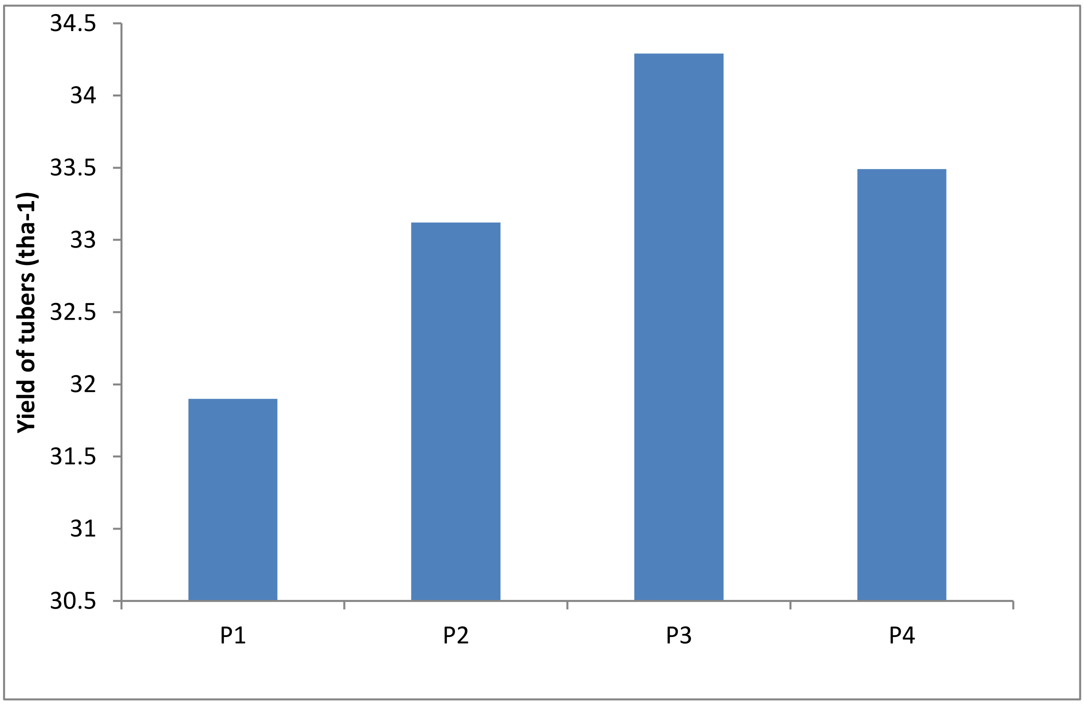
Figure 6. Effect of sources of potassium on number of tubers $hill^{-1}$

4.9 Yield of potato (tha^{-1})

Different dose of phosphorus varied significantly in case of yield of potato (Appendix 6).The maximum yield of potato (34.29 tha^{-1}) was observed from P_3, whereas the minimum yield of potato (31.90 t/ha) was obtained from P_1 (Figure 7). Potatoes are responsive to P fertilization on soils testing low in P, but yield increases from P application have also been found on soils testing very high in P (Sanderson *et al.* 2003).

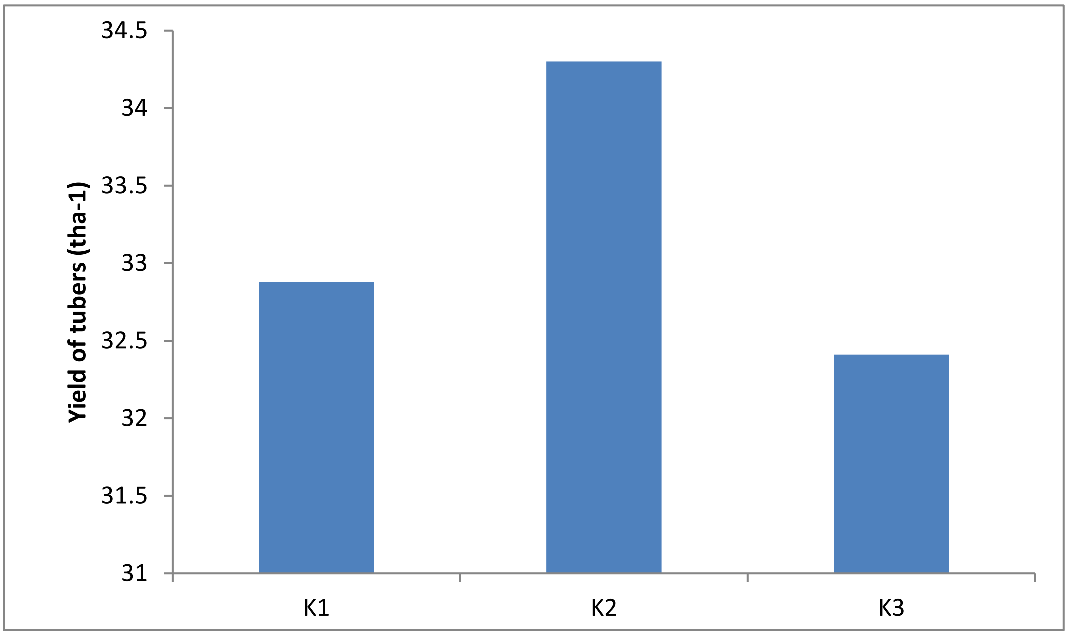
The yield of potato varied significantly due to different sources of potassium (Appendix 6).The maximum average weight of tuber (34.30 tha^{-1}) was found from K_2, while the minimum yield of potato (32.41tha^{-1}) was recorded from K_3 source of potassium (Figure 8).

Significantly variation was recorded in case of yield of potato due to the combined effect of different dose of phosphorus and sources of potassium (Appendix 6).The maximum yield of potato (35.35 tha^{-1}) was found from P_3K_2 which was statistically similar to P_4K_2 and the minimum yield of potato (31.76 tha^{-1}) was recorded from P_1K_1 treatment combination (Table 7).



P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 7. Effect of phosphorus dose on yield of potato (tha^{-1})



K_1: KCl @130 kg K ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1} K_3:K_2SO_4 @130 kg K ha^{-1}

Figure 8. Effect of sources of potassium on yield of potato (tha^{-1})

Table 6. Effect of phosphorus dose and sources of potassium on number of tubers hill-1, average weight of individual tuber, yield of potato

Treatments	No. of tubers $hill^{-1}$	Average weight of tuber (g)	Yield of potato (t/ha)
Phosphorus Dose			
P_1	7.73 b	45.69	31.90 c
P_2	7.93 b	45.59	33.12 b
P_3	8.73 a	47.62	34.29 a
P_4	7.87 b	45.66	33.49 b
LSD (0.05)	0.443	________	0.434
Level of Significance	*	NS	**
CV(%)	4.76	5.24	3.13
Source of Potassium			
K_1	8.08 ab	46.70	32.88 b
K_2	8.50 a	45.99	34.30 a
K_3	7.63 b	45.73	32.41 c
LSD (0.05)	0.632	________	0.308
Level of Significance	*	NS	**
CV(%)	9.05	9.01	4.07

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

Table 7. Combine effect of phosphorus dose and sources of potassium on number of tubers $hill^{-1}$, average weight of individual tuber, yield of potato

Treatments	No. of tubers $hill^{-1}$	Average weight of tuber (g)	Yield of potato (t/ha)
P_1K_1	7.70 bc	46.14 ab	31.76 f
P_1K_2	7.90 bc	45.35 ab	33.03 de
P_1K_3	7.60 bc	45.57 ab	30.90 g
P_2K_1	8.20 b	46.49 ab	32.67 e
P_2K_2	8.00 bc	45.05 ab	34.00 bc
P_2K_3	7.60 bc	45.24 ab	32.69 e
P_3K_1	8.50 ab	48.33 ab	34.07 b
P_3K_2	9.40 a	50.65 a	35.35 a
P_3K_3	8.30 ab	43.88 ab	33.45 cd
P_4K_1	7.90 bc	45.85 ab	33.04 de
P_4K_2	8.70 ab	42.92 b	34.82 a
P_4K_3	7.00 c	48.23 ab	32.61 e
LSD(0.05)	1.122	6.493	0.662
Level of significance	*	*	*
CV(%)	9.05	9.01	4.07

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

4.10 Yield of table potato >20 g (tha^{-1})

Different dose of phosphorus varied significantly in case of yield of potato (Appendix 7). The maximum yield of potato (32.88 tha^{-1}) was observed from P_3, whereas the minimum yield of potato (30.30) was obtained from P_1 which was statistically similar to P_4 (Table 8).

The yield of potato varied significantly due to different sources of potassium (Appendix 7). The maximum average weight of tuber (32.43 tha^{-1}) was found from K_2, while the minimum yield of potato (29.75 t/ha) was recorded from K_3 source of potassium (Table 8).

Significantly variation was recorded in case of yield of potato due to the combined effect of different dose of phosphorus and sources of potassium (Appendix 7). The maximum yield of potato (34.21 tha-1) was found from P3K2 and the minimum yield of potato (28.93 tha-1) was recorded from P1K3 which was statistically similar to P2K3 and P4K3 treatment combination (Table 9).

4.11 Category of different tubers to different uses (tha^{-1})

In aspect of Canned, 25-35 mm, different dose of Phosphorus was found statistically significant (Appendix 7). For Canned potato, the highest (7.35 tha^{-1}) was observed from P_1, which was statistically similar to P_4. whereas the lowest (6.15 tha^{-1}) was recorded from P_3 (Table 8).

In aspect of Canned, 25-35 mm, different sources of potassium was found statistically significant (Appendix 7). For Canned potato, the highest (7.38 tha^{-1}) was observed fromK_2, whereas the lowest (6.26 tha^{-1}) was recorded from K_1(Table 8).

In aspect of canned, 25-35 mm, different combination of phosphorus dose and different sources of potassium was found statistically significant (Appendix 7). For canned potato, the highest (10.35 tha^{-1}) was observed from P_4K_2, whereas the lowest (5.59 tha^{-1})was recorded from P_4K_1 which was statistically similar to P_4K_3 , P_4K_1 , P_3K_3 , P_3K_2 , P_2K_2 and P_1K_1 treatment combination (Table 9).

In aspect of Chips, 45-75 mm, different dose of phosphorus was found statistically significant (Appendix 7). For Chips potato, the highest (26.39) was observed from P_3,.whereas the lowest (22.94 tha^{-1}) was recorded from P_1 which was statistically similar to P_4 (Table 8).

In aspect of Chips, 45-75 mm, different sources of potassium was found statistically significant (Appendix 7). For Chips potato, the highest (24.98 tha^{-1}) was observed from K_1, which was statistically similar to K_2 whereas the lowest (22.81 tha^{-1}) was recorded from K_3 (Table 8).

In aspect of Chips, 45-75 mm , different combination of phosphorus dose and different sources of potassium was found statistically significant (Appendix 7). For Chips potato, the highest (28.06 tha^{-1}) was observed from P_3K_2, which was statistically similar to P_2K_1, P_2K_2 , P_3K_1 , P_3K_3 , and P_4K_1 treatment combination whereas the lowest (20.01 tha^{-1}) was recorded from P_1K_3 which was statistically similar to P_2K_3 , P_4K_2 , and

P_4K_3 treatment combination (Table 9).

In aspect of French fry, >75 mm, different dose of phosphorus was found statistically significant (Appendix 7). For French fry, the highest (0.341 tha^{-1}) was observed from P_3,. whereas the lowest (0.00 tha^{-1}) was recorded from P_1 (Table 8).

In aspect of French fry, >75 mm, different sources of potassium was found non-statistically significant (Appendix 7). For French fry potato, the highest (0.153 tha^{-1}) was observed from K_2, whereas the lowest (0.151 tha^{-1}) was recorded from K_3 (Table 8).

In aspect of French fry, >75 mm, different combination of phosphorus dose and different sources of potassium was found statistically significant (Appendix 7). For French fry potato, the highest (0.367 tha^{-1}) was observed from P_3K_1, which was statistically similar to P_3K_2 whereas the lowest (0.00) was recorded from P_1K_1 which was statistically similar to P_1K_2 , P_1K_3 , P_2K_3 , P_4K_1 , and P_4K_2 treatment combination (Table 9).

Table 8. Effect of phosphorus dose and sources of potassium on yield of table potato and category of different tubers to different uses

Treatments	Yield of table potato >20 g ($t ha^{-1}$)	Category of different tubers to different uses		
		Cane Potato (25-45 mm)	Chips Potato (45-75mm)	French Fry (>75mm)
Phosphorus Dose				
P_1	30.30 c	7.35 a	22.94 c	0.00 d
P_2	31.12 b	6.50 b	24.43 b	0.167 b
P_3	32.88 a	6.15 c	26.39 a	0.341 a
P_4	30.47 c	7.22 a	23.14 bc	0.099 c
LSD (0.05)	0.425	0.315	1.380	0.012
Level of Significance	**	**	**	**
CV(%)	2.18	4.01	4.94	7.09
Source of Potassium				
K_1	31.39 b	6.26 c	24.98 a	0.152
K_2	32.43 a	7.38 a	24.90 a	0.153
K_3	29.75 c	6.79 b	22.81 b	0.151
LSD (0.05)	0.181	0.476	1.908	
Level of Significance	**	**	*	NS
CV(%)	3.67	8.08	9.10	13.28

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly
** indicates 1% level of significance NS = Non-significance
*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} | K_1: KCl @130 kg K ha^{-1}
P_2: 46.03 kg P ha^{-1} | K_2: KH_2PO_4 @130 kg K ha^{-1}
P_3: 50.21 kg P ha^{-1} | K_3: K_2SO_4 @130 kg K ha^{-1}
P_4: 54.39 kg P ha^{-1}

Table 9. Combine effect of phosphorus dose and sources of potassium on yield of table potato and category of different tubers to different uses

Treatments	Yield of table potato >20 g (t/ha)	Category of different tubers to different uses (t/ha)		
		Caned Potato (25-45 mm)	Chips Potato (45-75mm)	French Fry (>75mm)
P_1K_1	30.41 e	6.22 c-f	24.19 bc	0.000 d
P_1K_2	31.56 d	6.93 c	24.63 bc	0.000 d
P_1K_3	28.93 f	8.91 b	20.01 d	0.000 d
P_2K_1	31.56 d	6.66 cd	24.66 abc	0.240 c
P_2K_2	32.36 c	6.42 c-f	25.68 ab	0.260 c
P_2K_3	29.40 f	6.44 cde	22.97 bcd	0.000 d
P_3K_1	33.09 b	6.56 cde	26.17 ab	0.367 a
P_3K_2	34.21 a	5.80 ef	28.06 a	0.350 a
P_3K_3	31.33 d	6.08 def	24.94 ab	0.307 b
P_4K_1	30.49 e	5.59 f	24.90 abc	0.000 d
P_4K_2	31.58 d	10.35 a	21.23 cd	0.000 d
P_4K_3	29.34 f	5.73 ef	23.31 bcd	0.297 b
LSD(0.05)	0.517	0.838	3.403	0.031
Level of significance	*	**	*	**
CV(%)	3.67	8.08	9.10	13.28

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

4.12 Dry matter contents in potato tubers

Different dose of phosphorus varied significantly in case of dry matter contents (Appendix 8). The highest dry matter content in potato tubers (22.19%) was recorded from P_1 which was statistically similar (21.59%) to P_2, whereas the lowest (18.72%) was found from P_4 (Figure 9). Israel Zewide *et. al.* observed found reduction in tuber dry matter with increased rate of P.

Dry matter contents in potato tubers varied non-significantly due to different sources of potassium (Appendix 8). The highest dry matter content in potato tubers (21.10%) was recorded from K_3 whereas the lowest (20.67%) was found from K_2 (Figure 10).

Significantly variation was recorded in case of dry matter contents due to the combined effect of different dose of phosphorus and sources of potassium (Appendix 8). The highest dry matter content in potato tubers (22.85%) was observed from P_1K_3 which was statistically similar to P_1K_1, P_1K_2, P_1K_2, P_2K_1, P_2K_2, P_2K_3, P_3K_1, and P_3K_3 treatment combination and the lowest (17.45%) was recorded from P4K3 treatment combination (Table 11). Assefa found significant reduction in dry matter content of potato tuber dueto increased P application rate and similarly Daniel found reduction in tuber dry matterwith increased rate of P.

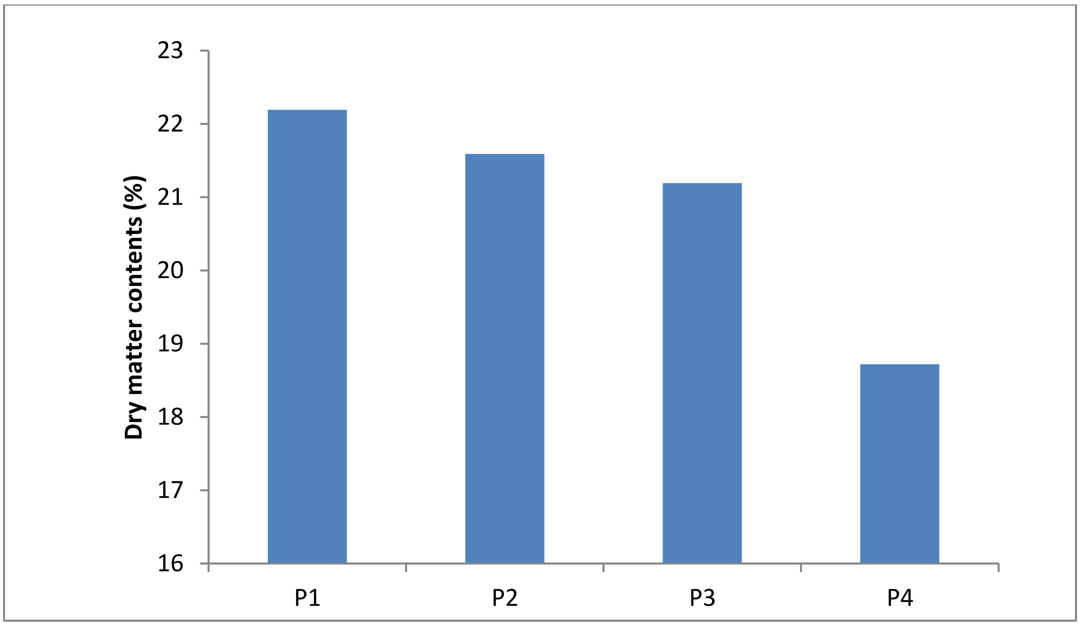
4.13 Specific gravity in potato tubers

Different dose of phosphorus varied non-significantly in case of specific gravity in potato tubers (Appendix 8). The highest specific gravity in potato tubers (1.0798 gm-3) was recorded from P_1, whereas the lowest (1.0556 gm-3) was found from P_4 . Israel Zewide *et. al.* observed found reduction in specific gravity of tuber with increased rateof P (Figure 11).

Specific gravity in potato tubers varied non-significantly due to different sources of potassium (Appendix 8). The highest specific gravity in potato tubers (1.0808 gm-3) was recorded from K_3 whereas the lowest (1.0519 gm-3) was found from K_2. Silva *et al.* (2018) observed no significant effect of potassium source on specific gravity (Figure 12).

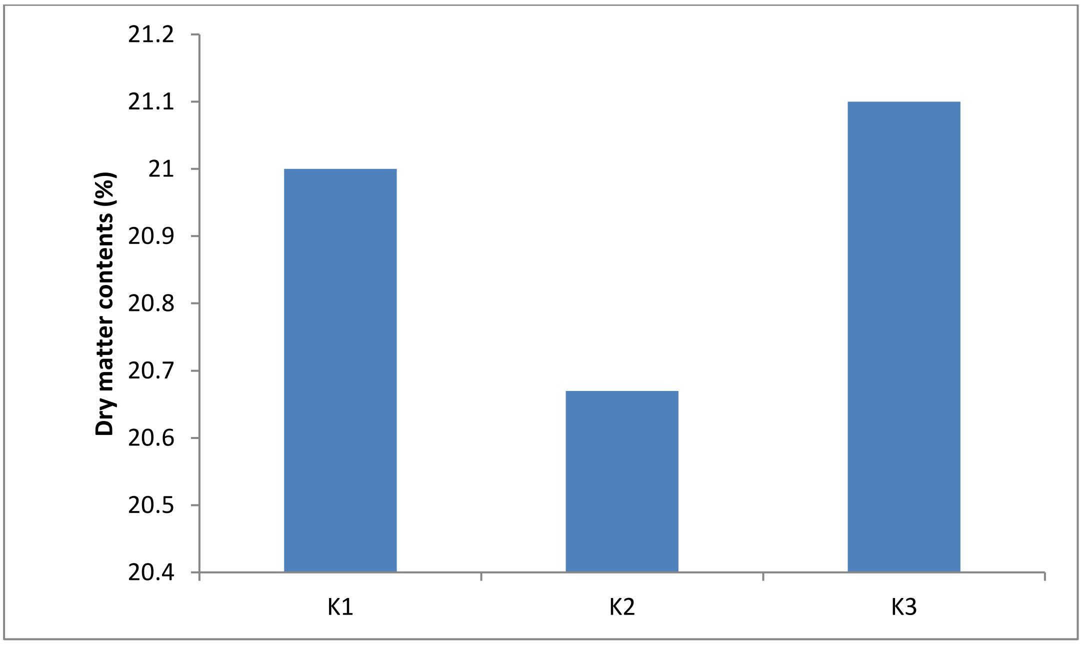
Non-significantly variation was recorded in case of specific gravity due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix 8). The highest highest specific gravity in potato tubers (1.0998 gm^{-3}) was observed from P_1K_3 whereas the lowest (1.0474gm^{-3}) was found from P_4K_2 treatment combination (Table

11).



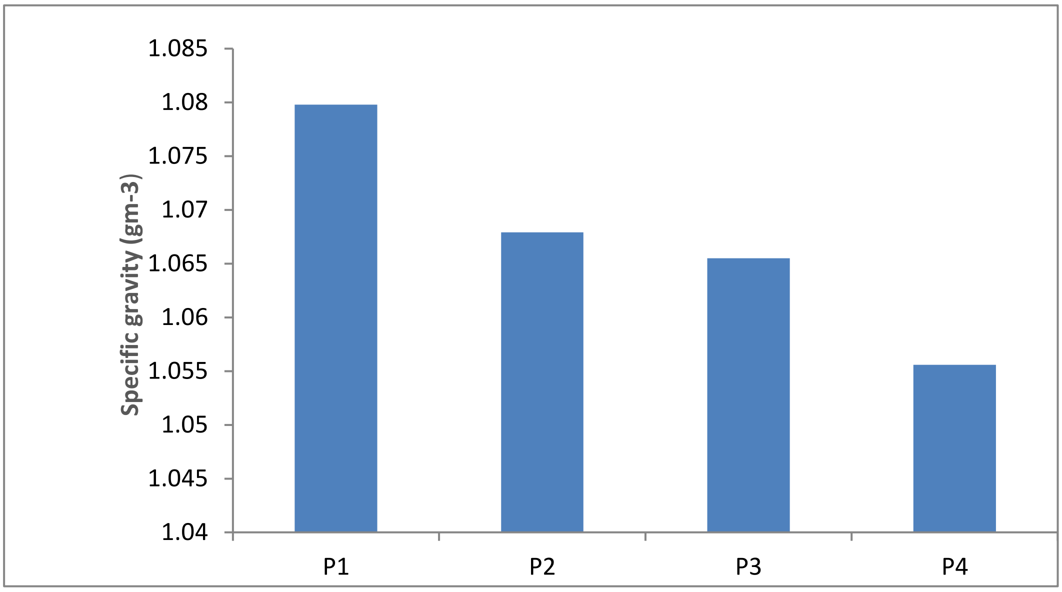
P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 9. Effect of Phosphorus Dose on Dry matter contents of potato



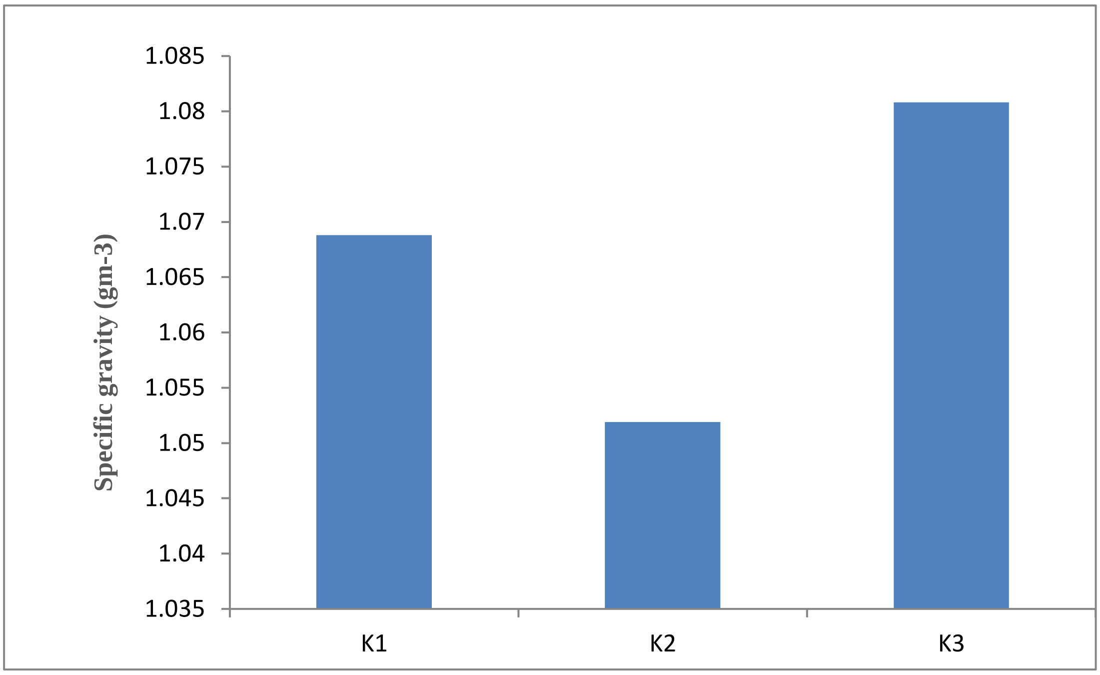
K1: KCl @130 kg K ha^{-1} K2: KH_2PO_4 @130 kg K ha^{-1} K3:K_2SO_4 @130 kg K ha^{-1}

Figure 10. Effect of sources of potassium on dry matter contents of potato



P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 11. Effect of phosphorus dose on Specific gravity(gm^{-3}) of potato



K1: KCl @130 kg K ha^{-1} K2: KH_2PO_4 @130 kg K ha^{-1} K3:K_2SO_4 @130 kg K ha^{-1}

Figure 12. Effect of sources of potassium on Specific gravity (gm^{-3}) of potato

4.14 Content of total soluble solid in potato tubers –TSS (Brix)

Different dose of phosphorus varied significantly in case of total soluble solids in potato tubers (Appendix 8). The highest TSS in potato tubers (4.93) was recorded from P_4 whereas the lowest (3.97) was found from P_1 (Table 10).

Content of total soluble solid in potato tubers –TSS (Brix) varied significantly due to different sources of potassium (Appendix 8). The highest TSS in potato tubers (4.65) was recorded from K_2 whereas the lowest (4.30) was found from K_3 which was statistically similar to K_1 (Table 10).

Significantly variation was recorded in case of total soluble solids in potato tubers due to the combined effect of different dose of Phosphorus and sources of potassium (Appendix 8). The highest TSS in potato tubers (5.10) was observed from P_4K_2 which was statistically similar to P_3K_2, P_4K_1 and P_4K_3 treatment combination and the lowest (3.90) was recorded from P_1K_1 which was statistically similar to P_1K_2, P_1K_3 and P_2K_3 treatment combination (Table 11).

4.15 Firmness

Different dose of phosphorus varied non-significantly in case of firmness in potato tubers (Appendix 8). The highest firmness in potato tubers (45.89) was recorded from P_4, whereas the lowest (44.75) was found from P_3 (Table 10).

Firmness in potato tubers varied non-significantly due to different sources of potassium (Appendix 8). The highest firmness in potato tubers (46.80) was recorded from K_3 whereas the lowest (44.11) was found from K_2 (Table 10).

Non-significantly variation was recorded in case of firmness due to the combined effect of different dose of phosphorus and sources of potassium (Appendix 8). The highest firmness in potato tubers (47.78) was observed from P_4K_3 whereas the lowest (42.36) was found from P_4K_1 treatment combination (Table 11).

Table 10. Effect of phosphorus dose and sources of potassium on dry matter contents, specific gravity (gm^{-3}), content of total soluble solid (TSS) and firmness score in potato tubers

Treatments	Dry matter contents (%)	Specifc gravity (gm^{-3})	Content of total soluble solid-TSS (Brix)	Firmness score(N)
Phosphorus Dose				
P_1	22.19 a	1.0798	3.97 d	44.86
P_2	21.59 ab	1.0679	4.27 c	44.94
P_3	21.19 b	1.0655	4.70 b	44.75
P_4	18.72 c	1.0556	4.93 a	45.89
LSD (0.05)	0.962	________	0.122	________
Level of Significance	**	NS	**	NS
CV(%)	3.98	2.74	2.36	11.30
Source of Potassium				
K_1	21.00	1.0688	4.45 b	44.42
K_2	20.67	1.0519	4.65 a	44.11
K_3	21.10	1.0808	4.30 b	46.80
LSD (0.05)	________	________	0.175	________
Level of Significance	NS	NS	**	NS
CV(%)	6.69	4.60	4.52	7.12

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} — K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} — K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} — K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

Table 11. Combine effect of phosphorus dose and sources of potassium on dry matter contents, specific gravity, content of total soluble solid (TSS) and firmness score in potato tubers

Treatments	Dry matter contents	Specific gravity (gm^{-3})	Content of total soluble solid-TSS (Brix)	Firmness score(N)
P_1K_1	22.15 ab	1.0829	3.90 e	45.02
P_1K_2	21.58 abc	1.0566	4.10 de	43.18
P_1K_3	22.85 a	1.0998	3.90 e	46.37
P_2K_1	21.55 abc	1.0693	4.30 cd	47.02
P_2K_2	20.98 a-d	1.0525	4.60 bc	42.45
P_2K_3	22.25 ab	1.0819	3.90 e	45.35
P_3K_1	21.15 a-d	1.0654	4.70 b	43.28
P_3K_2	20.58 bcd	1.0513	4.80 ab	43.27
P_3K_3	21.85 ab	1.0797	4.60 bc	47.70
P_4K_1	19.15 de	1.0578	4.90 ab	42.36
P_4K_2	19.55 cde	1.0474	5.10 a	47.52
P_4K_3	17.45 e	1.0617	4.80 ab	47.78
LSD(0.05)	2.196	________	0.310	________
Level of significance	*	NS	*	NS
CV(%)	6.69	4.60	4.52	7.12

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

4.16 Skin color of tubers

Remarkable dissimilarity was got among different dose of phosphorus on lightness (L *), green-red chromaticity (a*), blue-yellow chromaticity (b*), c* and H* of potato skin (Appendix IX). The highest L * value (75.35) of tuber skin was taken by P_1 and the lowest (74.35) was taken by P_1. In case of highest a* value (0.69) of tuber skin was taken by P_1 and the lowest (0.42) was taken by P_1. In case of highest b* value (31.36) of tuber skin was taken by P_1 and the lowest (30.38) was taken by P_2. . In case of highest c* value (31.36) of tuber skin was taken by P_4 and the lowest (30.38) was taken by P_2. In case of highest H* value (89.24) of tuber skin was taken by P_1 which was statisticallysimilar to the P_2 and P_2 respectfully and the lowest (88.69) was taken by P_2 (Table 12).

Remarkable dissimilarity was got among different sources of potassium on lightness (L *), green-red chromaticity (a*), blue-yellow chromaticity (b*), c* and H* of potato skin (Appendix IX). The highest L * value (75.20) of tuber skin was taken by K_3 and the lowest (74.52) was taken by K_1. In case of highest a* value (0.668) of tuber skin was taken by K_2 and the lowest (0.432) was taken by K_1. In case of highest b* value (31.27)of tuber skin was taken by K_2 and the lowest (30.51) was taken by K_1 . In case of highest c* value (31.28) of tuber skin was taken by K_2 and the lowest (30.52) was taken by K_1.In case of highest H* value (89.18) of tuber skin was taken by K_1 and the lowest (88.77)was taken by K_2 (Table 12).

Noteworthy dissimilarity was found among the combined effect of different dose of phosphorus and sources of potassium on lightness (L *), green-red chromaticity (a*) and blue-yellow chromaticity (b*), c* and H* of potato skin (Appendix IX). The highest L * value (75.93) of tuber skin was taken by P_1K_2 and the lowest (73.64) was taken by P_2K_1. In case of highest a* value (0.980) of tuber skin was taken by P_2K_2 and the lowest(0.203) was taken by P_1K_1. In case of highest b* value (32.45) of tuber skin was takenby P_1K_3 and the lowest (29.71) was taken by P_1K_1. In case of highest c* value (32.45) of tuber skin was taken by P_1K_3 and the lowest (29.71) was taken by P_1K_1. In case of highest H* value (89.58) of tuber skin was taken by P_1K_1 and the lowest (88.10) was taken by P_4K_3 (Table 13).

Table 12. Effect of phosphorus dose and sources of potassium on skin color of potato tubers

Treatments	Lightness (L)	Reedness to greenness (a)	Blueness to yellowness (b)	Chromaticity ©	Hue augh (H)
Phosphorus Dose					
P_1	75.35	0.42	31.16	31.17	89.24 a
P_2	74.35	0.69	30.38	30.38	88.69 b
P_3	74.66	0.58	31.09	31.09	88.94 ab
P_4	75.20	0.53	31.36	31.36	89.02 ab
LSD (0.05)	________	________	________	________	0.476
Level of Significance	NS	NS	NS	NS	*
CV(%)	1.16	43.65	6.46	6.46	0.46
Source of Potassium					
K_1	74.52	0.432	30.51	30.52	89.18
K_2	74.94	0.668	31.27	31.28	88.77
K_3	75.20	0.567	31.21	31.21	88.95
LSD (0.05)	________	________	________	________	________
Level of Significance	NS	NS	NS	NS	NS
CV(%)	1.53	50.80	4.84	4.84	0.57

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

Table 13. Combine effect of phosphorus dose and sources of potassium on skin colorof potato tubers

Treatments	Lightness (L)	Reedness to greenness (a)	Blueness to yellowness (b)	Chromaticity©	Hue augh (H)
P_1K_1	74.67 abc	0.203 b	29.92	29.92	89.58 a
P_1K_2	75.93 a	0.553 ab	31.14	31.14	88.99 a
P_1K_3	75.44 abc	0.500 ab	32.45	32.45	89.13 a
P_2K_1	73.64 c	0.467 b	30.91	30.91	89.14 a
P_2K_2	73.72 bc	0.980 a	29.71	29.72	88.10 b
P_2K_3	75.69 ab	0.630 ab	30.52	30.53	88.81 ab
P_3K_1	74.49 abc	0.387 b	30.14	30.14	89.25 a
P_3K_2	75.16 abc	0.673 ab	32.36	32.36	88.81 ab
P_3K_3	74.34 abc	0.677 ab	30.77	30.78	88.74 ab
P4K1	75.28 abc	0.673 ab	31.09	31.10	88.77 ab
P4K2	74.97 abc	0.467 b	31.90	31.90	89.17 a
P4K3	75.36 abc	0.463 b	31.10	31.09	89.13 a
LSD(0.05)	1.902	0.487	________	________	0.858
Level of significance	*	*	NS	NS	*
CV(%)	1.53	50.80	4.84	4.84	0.57

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha $^{-1}$ K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha $^{-1}$ K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

4.17 Flesh color of tubers

Remarkable dissimilarity was got among different dose of phosphorus on lightness (L *), green-red chromaticity (a*), blue-yellow chromaticity (b*), c* and H* of potato flesh (Appendix X). The highest L * value (56.85) of tuber flesh was taken by P_4 whichwas statistically similar to the P_2 and P_3 respectfully and the lowest (55.57) was taken by P_1. In case of highest a* value (10.91) of tuber flesh was taken by P_3 and the lowest(10.41) was taken by P_2. In case of highest b* value (12.62) of tuber flesh was taken by P_3 and the lowest (11.88) was taken by P_2. . In case of highest c* value (17.72) of tuberflesh was taken by P_3 and the lowest (15.83) was taken by P_2. In case of highest H* value (51.74) of tuber flesh was taken by P_4 and the lowest (48.65) was taken by P_2 (Table 14).

Remarkable dissimilarity was got among different sources of potassium on lightness (L *), green-red chromaticity (a*), blue-yellow chromaticity (b*), c* and H* of potato flesh (Appendix X). The highest L * value (56.97) of tuber flesh was taken by K_2 and the lowest (55.92) was taken by K_1. In case of highest a* value (10.94) of tuber flesh was taken by K_2 which was statistically similar to the K_3 and the lowest (10.01) was taken by K_1. In case of highest b* value (13.08) of tuber flesh was taken by K_2 and the lowest (11.94) was taken by K1. In case of highest c* value (17.10) of tuber flesh was taken by K_2 which was statistically similar to the K3 and the lowest (15.62) was taken by K_1. In case of highest H* value (49.98) of tuber flesh was taken by K_2 and the lowest(49.36) was taken by K_3 (Table 14).

Noteworthy dissimilarity was found among the combined effect of different dose of phosphorus and sources of potassium on lightness (L *), green-red chromaticity (a*) and blue-yellow chromaticity (b*), c* and H* of potato skin (Appendix X). The highest L * value (57.17) of tuber flesh taken by P_3K_2 and the lowest (54.75) was taken by P_1K_1. In case of highest a* value (11.89) of tuber flesh was taken by P_3K_2 and the lowest (9.75) was taken by P_3K_1. In case of highest b* value (13.90) of tuber flesh was taken by P_3K_3 and the lowest (11.20) was taken by P_1K_1. In case of highest c* value (18.37) of tuber flesh was taken by P_4K_3 and the lowest (15.07) was taken by P_1K_1. In case of highest H* value (52.87) of tuber flesh was taken by P_4K_2 and the lowest (46.76) was taken by P_3K_2 (Table 15).

Table 14. Effect of phosphorus dose and sources of potassium on flesh color of potato tubers

Treatments	Lightness (L)	Reedness to greenness (a)	Blueness to yellowness (b)	Chromaticity©	Hue augh (H)
Phosphorus Dose					
P_1	55.57 b	10.54	12.36	16.33	49.22
P_2	56.08 ab	10.41	11.88	15.83	48.65
P_3	56.77 a	10.91	12.62	16.72	49.25
P_4	56.85 a	10.59	13.42	17.22	51.74
LSD (0.05)	1.133	________	________	________	________
Level of Significance	*	NS	NS	NS	NS
CV(%)	1.74	16.58	11.75	9.37	12.30
Source of Potassium					
K_1	55.92	10.01 b	11.94	15.62 b	49.81
K_2	56.97	10.94 a	13.08	17.10 a	49.98
K_3	56.07	10.89 a	12.71	16.85 a	49.36
LSD (0.05)	________	0.766	________	1.093	________
Level of Significance	NS	*	NS	*	NS
CV(%)	2.57	8.34	11.50	7.65	7.73

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha $^{-1}$ K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha $^{-1}$ K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

Table 15. Combine effect of phosphorus dose and sources of potassium on flesh colorof potato tubers

Treatments	Lightness (L)	Reedness to greenness (a)	Blueness to yellowness (b)	Chromaticity©	Hue augh (H)
P_1K_1	54.75 b	9.92	11.20 b	15.07 c	47.76
P_1K_2	56.69 ab	11.01	13.53 ab	17.50 ab	50.94
P_1K_3	55.27 ab	10.68	12.33 ab	16.42 abc	48.95
P_2K_1	55.50 ab	10.41	11.56 ab	15.58 bc	47.94
P2K2	57.08 ab	10.55	12.37 ab	16.30 abc	49.14
P2K3	55.67 ab	10.28	11.73 ab	15.60 bc	48.86
P3K1	56.35 ab	9.75	12.23 ab	15.66 bc	51.52
P3K2	57.17 a	11.89	12.78 ab	17.50 abc	46.96
P3K3	56.80 ab	11.10	12.87 ab	17.01 abc	49.26
P4K1	57.07 ab	9.96	12.75 ab	16.18 abc	52.00
P4K2	56.92 ab	10.30	13.64 ab	17.10 abc	52.87
P4K3	56.55 ab	11.50	13.90 a	18.37 a	50.35
LSD(0.05)	2.335	________	2.655	2.519	________
Level of significance	*	NS	*	*	NS
CV(%)	2.57	8.34	11.50	7.65	7.73

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1}
P_2: 46.03 kg P ha^{-1}
P_3: 50.21 kg P ha^{-1}
P_4: 54.39 kg P ha^{-1}

K_1: KCl @130 kg K ha^{-1}
K_2: KH_2PO_4 @130 kg K ha^{-1}
K_3: K_2SO_4 @130 kg K ha^{-1}

4.18 Starch contents (%)

Statistically significant variation was observed in terms of starch content in potato tubers due to different dose of Phosphorus (Appendix XI). The highest starch content in potato tubers (17.075) was recorded from P_1 while the lowest (12.579) was obtainedfrom P_4 (Figure 13).

Starch content in potato tubers varied significantly due to the different sources of potassium (Appendix XI).The highest starch content in potato tubers (15.985) was observed from K_3, whereas the lowest starch content (14.333) from K_2 which was statistically similar (14.875) to K_1 (Figure 14).

Combined effect of different dose of phosphorus and sources of potassium showed statistically significant differences in terms of starch content in potato tubers (Appendix XI). The highest starch content in potato tubers (17.936) was recorded from P_1K_3, which was statistically similar to P_1K_1, P_1K_2, P_2K_3, P_3K_1 and P_3K_3,whereas the lowest (12.136) was observed from P4K1 which was statistically similar to P_4K_2 and P_4K_3 treatment combination (Table 17).

4.19 Reducing sugar content ($mgg^{-1}FW$)

Statistically significant variation was observed in terms of reducing sugar content in potato tubers due to different dose of Phosphorus (Appendix XI).The highest reducing sugar content in potato tubers (0.3482) was recorded from P_4 while the lowest (0.1745) was obtained from P_1 (Figure 15).

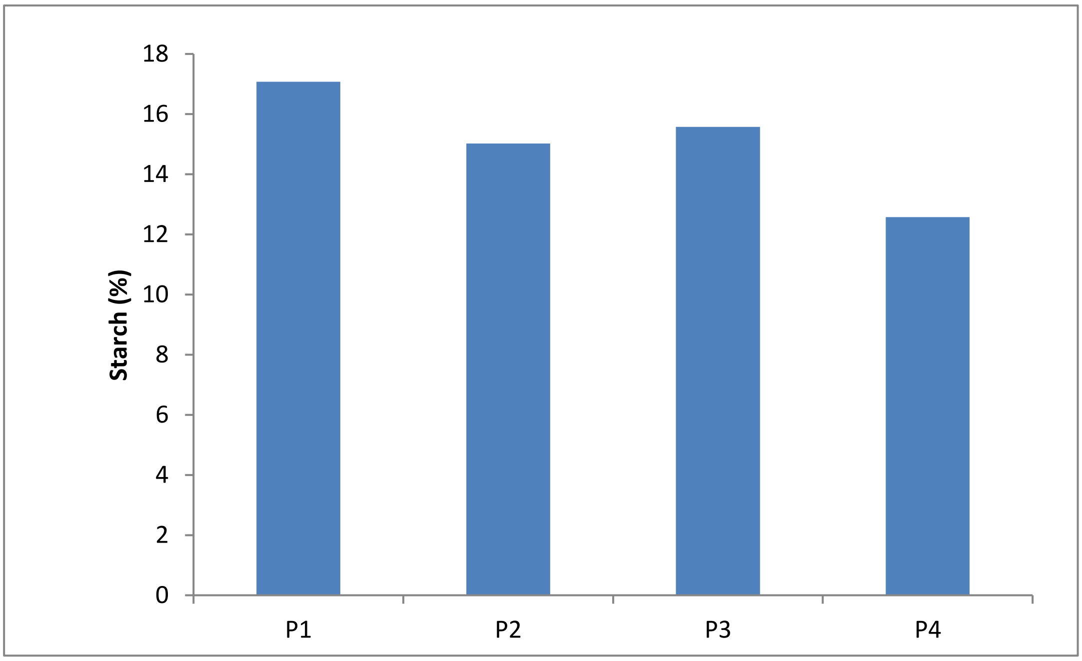
Reducing sugar content in potato tubers varied significantly due to the different sources of potassium (Appendix XI).The highest reducing sugar content in potato tubers (0.2307) was observed from K_2, which was statistically similar (0.2267) to K_1 whereasthe lowest reducing sugar content (0.2166) from K_3 (Figure 16).

Combined effect of different dose of Phosphorus and sources of potassium showed statistically significant differences in terms of reducing sugar content in potato tubers (Appendix XI).The highest reducing sugar content in potato tubers (0.3558) was recorded from P_4K_1, which was statistically similar to P_4K_2 whereas the lowest (0.1713)was observed from P_1K_3 which was statistically similar to P_3K_1, P_1K_1, P_1K_2 and P_2K_3 treatment combination (Table 17).

4.20 Non-reducing sugar content ($mgg^{-1}FW$)

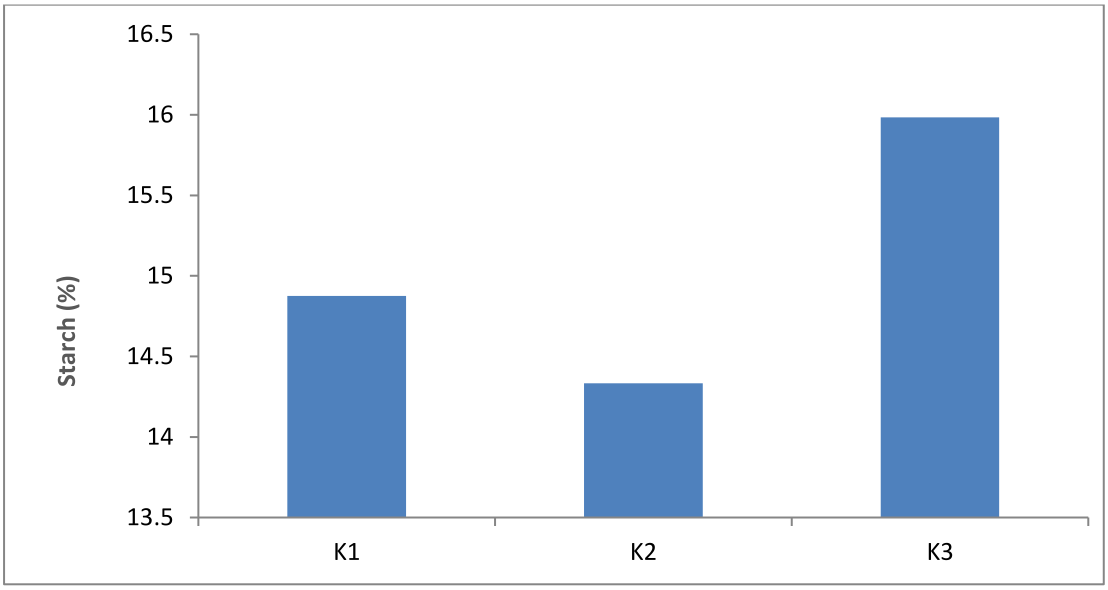
Statistically significant variation was observed in terms of non-reducing sugar content in potato tubers due to different dose of Phosphorus (Appendix XI).The highest non-reducing sugar content in potato tubers (0.5348) was recorded from P_4 while the lowest(0.3333) was obtained from P_1 (Table 16).

Non-reducing sugar content in potato tubers varied significantly due to the different sources of potassium (Appendix XI). The highest non-reducing sugar content in potato tubers (0.4176) was observed from K_1, whereas the lowest non-reducing sugar content (0.3855) from K_3, which was statistically similar (0.3990) to K_2 (Table 16).



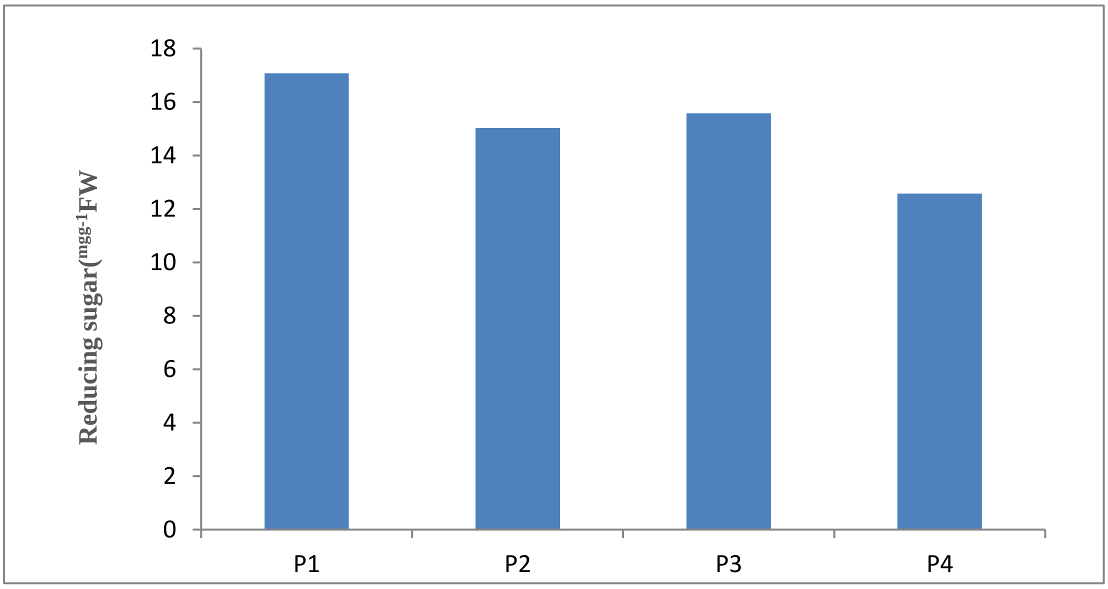
P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 13. Effect of phosphorus dose on starch (%) of potato tuber



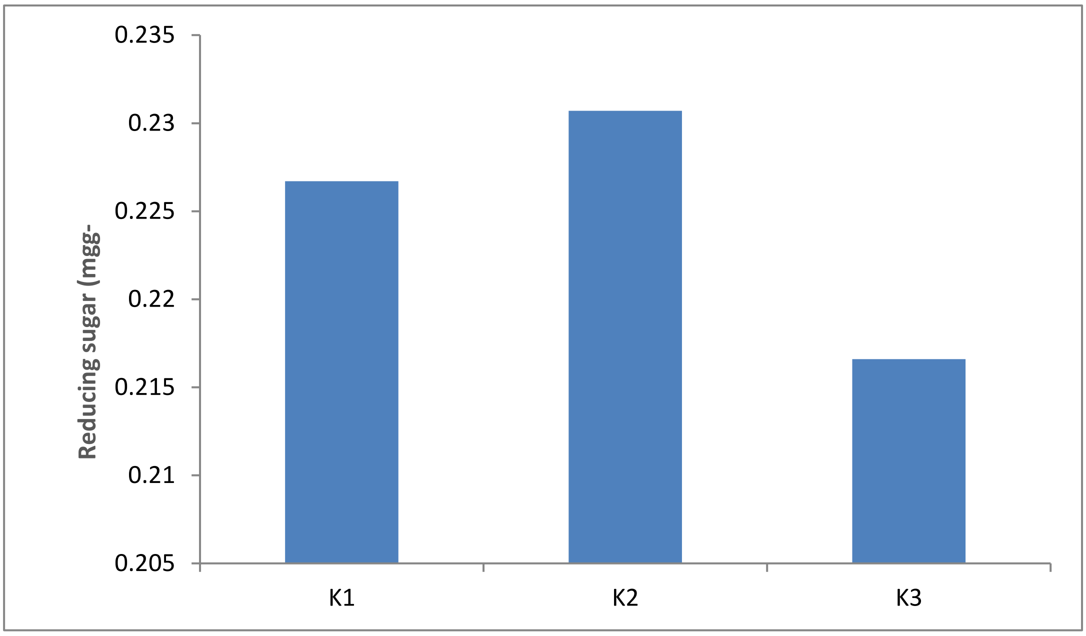
K1: KCl @130 kg K ha^{-1} K2: KH_2PO_4 @130 kg K ha^{-1} K3:K_2SO_4 @130 kg K ha^{-1}

Figure 14. Effect of sources of potassium on starch (%) of potato tuber



P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 15. Effect of phosphorus dose on reducing sugar (mgg^{-1}FW) of potato tuber



K1: KCl @130 kg K ha^{-1} K2: KH2PO4 @130 kg K ha^{-1} K3:K2SO4 @130 kg K ha^{-1}

Figure 16. Effect of sources of potassium on reducing sugar (mgg^{-1}FW) of potato tuber

Combined effect of different dose of phosphorus and sources of potassium showed statistically significant differences in terms of non-reducing sugar content in potato tubers (Appendix XI). The highest non-reducing sugar content in potato tubers (0.5610) was recorded from P_4K_1 which was statistically similar to P_4K_2 whereas the lowest (0.3290) was observed from P_1K_3 which was statistically similar to P_1K_1, P_1K_2 and P_2K_3 treatment combination (Table 17).

4.21 Antioxidant content (Troloxμ Mol 100 g^{-1} FW)

Statistically significant variation was observed in terms of antioxidant content in potato tubers due to different dose of phosphorus (Appendix XI). The highest antioxidant content in potato tubers (601.17) was recorded from P_1 while the lowest (497.06) was obtained from P_4 (Table 16).

Antioxidant content in potato tubers varied significantly due to the different sources of potassium (Appendix XI).The highest antioxidant content in potato tubers (567.87) was observed from K_3, whereas the lowest antioxidant content (532.92) from K_2, which was statistically similar (541.42) to K_1 (Table 16).

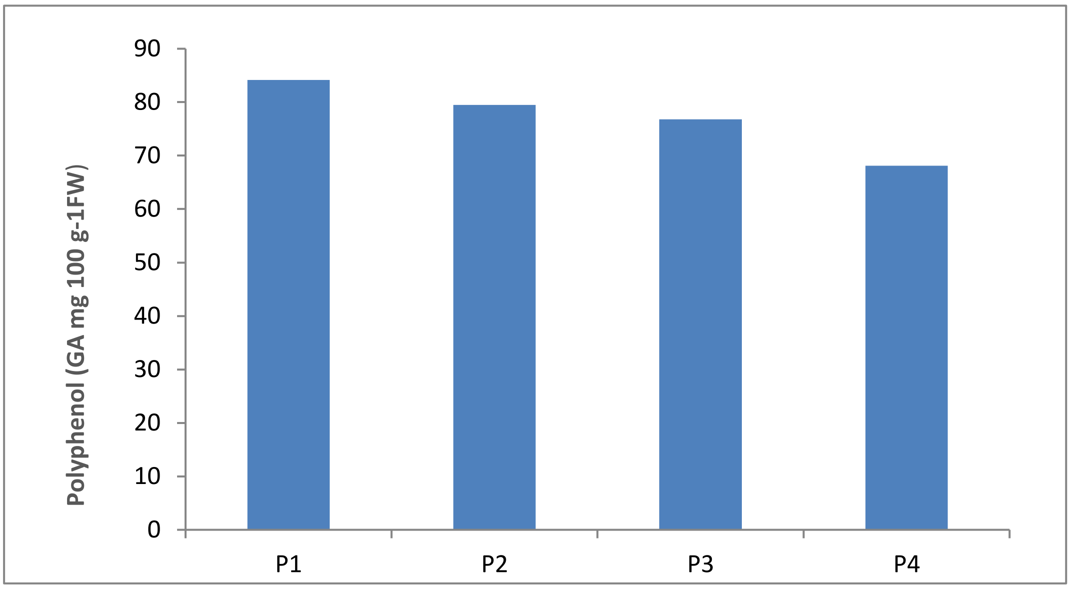
Combined effect of different dose of phosphorus and sources of potassium showed statistically significant differences in terms of antioxidant content in potato tubers (Appendix XI).The highest antioxidant content in potato tubers (630.12) was recorded from P_1K_3, which was statistically similar to P_1K_2 and P_3K_1 whereas the lowest (478.92)was observed from P_4K_1 which was statistically similar to P_2K_1, P_2K_2, P_4K_2, and P_4K_3,treatment combination (Table 17).

4.22 Polyphenol content (GA mg 100 g^{-1} FW)

Statistically significant variation was observed in terms of polyphenol content in potato tubers due to different dose of phosphorus (Appendix XI).The highest polyphenol content in potato tubers (84.137) was recorded from P_1 which was statistically similar (79.468) to P_2 while the lowest (68.135) was obtained from P4 (Figure 17).

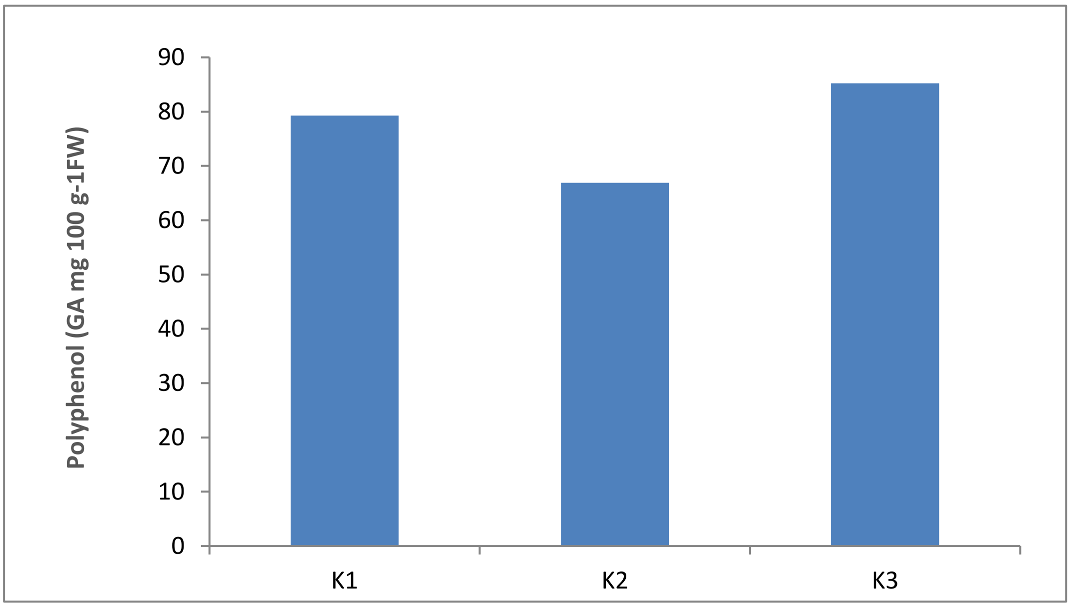
Polyphenol content in potato tubers varied significantly due to the different sources of potassium (Appendix XI).The highest polyphenol content in potato tubers (85.243) was observed from K_3, which was statistically similar (79.271) to K_1 whereas the lowest polyphenol content (66.891) from K_2 (Figure 18).

Combined effect of different dose of Phosphorus and sources of potassium showed statistically significant differences in terms of polyphenol content in potato tubers (Appendix XI). The highest polyphenol content in potato tubers (92.994) was recorded from P_1K_3, which was statistically similar to P_1K_1, P_2K_1, P_2K_3, P_3K_1, and P_3K_3 whereasthe lowest (58.641) was observed from P_4K_2 which was statistically similar to P_2K_2, P_3K_2, and P_4K_1, treatment combination (Table 17).



P_1: 41.84 kg P ha^{-1} P_3: 46.03 kg P ha^{-1} P_2: 50.21 kg P ha^{-1} P_4: 54.39 kg P ha^{-1}

Figure 17. Effect of phosphorus dose on polyphenol (GA mg 100 g^{-1} FW) of potato tuber



K1: KCl @130 kg K ha^{-1} K2: KH_2PO_4 @130 kg K ha^{-1} K3:K_2SO_4 @130 kg K ha^{-1}

Figure 18. Effect of sources of potassium on polyphenol (GA mg 100 g^{-1} FW) of potato tuber

Table 16. Effect of phosphorus dose and sources of potassium on some bio-chemicalparameters of potato tubers

Treatments	Starch (%)	Reducing sugar ($mgg^{-1}FW$)	Non-reducing sugar ($mgg^{-1}FW$)	Antioxidant (Troloxµ Mol 100 g^{-1} FW)	Polyphenol (GA mg 100 g^{-1} FW)
Phosphorus Dose					
P_1	17.075 a	0.1745 c	0.3333 d	601.17 a	84.137 a
P_2	15.024 b	0.1885 b	0.3534 c	522.17 c	79.468 ab
P_3	15.579 b	0.1875 b	0.3814 b	569.21 b	76.800 b
P_4	12.579 c	0.3482 a	0.5348 a	497.06 d	68.135 c
LSD (0.05)	0.8660	0.0050	0.0126	17.736	6.6142
Level of Significance	**	**	**	**	*
CV(%)	4.98	1.96	2.74	2.81	7.43
Source of Potassium					
K_1	14.875 b	0.2267 a	0.4176 a	541.42 b	79.271 a
K_2	14.333 b	0.2307 a	0.3990 b	532.92 b	66.891 b
K_3	15.985 a	0.2166 b	0.3855 b	567.87 a	85.243 a
LSD (0.05)	1.0175	0.0071	0.0163	21.798	6.5815
Level of Significance	*	**	**	*	**
CV(%)	7.80	3.66	4.70	4.60	9.86

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

Table 17. Combine effect of phosphorus dose and sources of potassium on some bio-chemical parameters of potato tubers

Treatments	Starch (%)	Reducing sugar ($mgg^{-1}FW$)	Non-reducing sugar ($mgg^{-1}FW$)	Antioxidant (Troloxµ Mol 100 g^{-1} FW)	Polyphenol (GA mg 100 g^{-1} FW)
P_1K_1	16.834 a	0.1788 ef	0.3399 efg	582.25 b	85.774 abc
P_1K_2	16.455 a	0.1735 ef	0.3310 fg	591.14 ab	73.642 cde
P_1K_3	17.936 a	0.1713 f	0.3290 g	630.12 a	92.994 a
P_2K_1	14.432 bcd	0.1998 c	0.3655 de	512.25 cde	80.771 a-d
P_2K_2	14.473 bcd	0.1933 cd	0.3590 def	513.14 cde	69.639 def
P_2K_3	16.167 ab	0.1723 ef	0.3358 efg	541.12 c	87.995 ab
P_3K_1	16.098 abc	0.1725 ef	0.4041 c	592.25 ab	80.767 a-d
P_3K_2	14.167 cd	0.2055 c	0.3749 cd	526.25 cd	65.640 ef
P_3K_3	16.473 a	0.1845 de	0.3651 de	589.12 b	83.992 abc
P_4K_1	12.136 e	0.3558 a	0.5610 a	478.92 e	69.772 def
P_4K_2	12.238 e	0.3505 ab	0.5312 ab	501.14 de	58.641 f
P_4K_3	13.363 de	0.3383 b	0.5121 b	511.12 cde	75.993 b-e
LSD(0.0 5)	1.8707	0.0127	0.0294	39.711	12.596
Level of significance	*	**	*	*	*
CV(%)	7.80	3.66	4.70	4.60	9.86

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly

** indicates 1% level of significance NS = Non-significance

*indicates 5% level of significance

P_1: 41.84 kg P ha^{-1} K_1: KCl @130 kg K ha^{-1}

P_2: 46.03 kg P ha^{-1} K_2: KH_2PO_4 @130 kg K ha^{-1}

P_3: 50.21 kg P ha^{-1} K_3: K_2SO_4 @130 kg K ha^{-1}

P_4: 54.39 kg P ha^{-1}

4.23 Correlation coefficient (r) and coefficient of determinant (R^2) for different quality parameters

A positive relation (r=0.65) was found specific gravity and dry matter content of potato tuber (Figure 19). In Figure 19 , a strong negative relation (r= -0.86) was found between non-reducing sugar content and starch of potato tuber. A strong positive relation (r=0.84) was found starch and dry matter content of potato tuber (Figure 20). In Figure 20, A strong negative relation (r=-0.82) was found between starch and total soluble solid of potato tuber. A strong negative relation (r= -0.87)) was found reducing sugar content and starch of potato tuber (Figure 21). In Figure 21, A highly strong positive relation (r=0.97) was found between non-reducing sugar content and reducing sugar content of potato tuber.

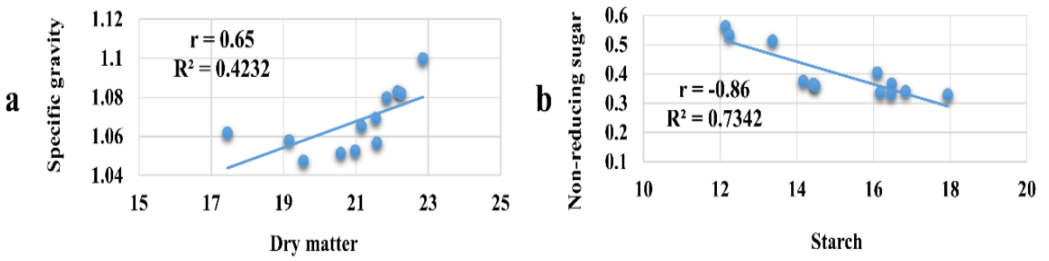


Figure 19. Correlation coefficient (r) and coefficient of determinant (R2) for different quality parameters a. Relation between specific gravity and dry matter content of potato tuber, b. Relation between non-reducing sugar content and starch of potato tuber

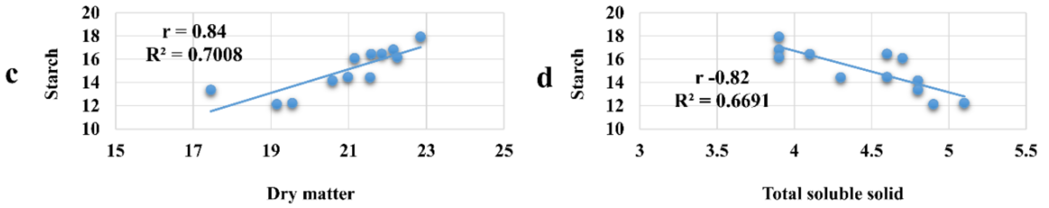


Figure 20. Correlation coefficient (r) and coefficient of determinant (R2) for different quality parameters c. Relation between starch and dry matter content of potato tuber, d. Relation between starch and total soluble solid of potato tuber

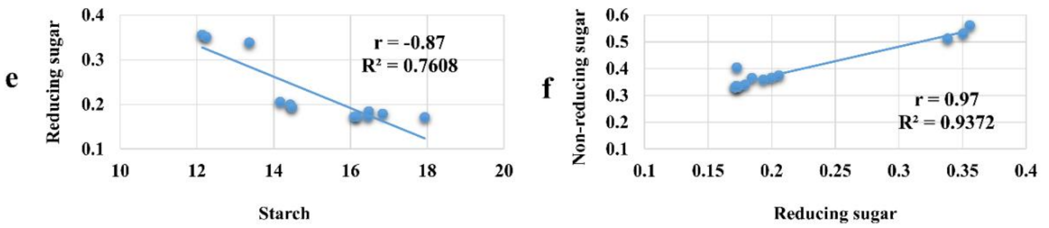


Figure 21. Correlation coefficient (r) and coefficient of determinant (R2) for different quality parameters. e. Relation between reducing sugar content and starch of potato tuber, f. Relation between non-reducing sugar content and reducing sugar content of potato tuber

CHAPTER V
SUMMARY AND CONCLUSION

The experiment was conducted in the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka from the period of November, 2018 to February, 2019 to assess the effect of phosphorus dose and potassium sources on yield of processing and export quality of potato. The potato variety BARI Alu-28 (Courage) were used as test crop for this experiment. The experiment consisted of two factors: Factor A: Phosphorus dose (4 dose) as- P_1: 41.84 kg P ha^{-1}, P_2: 46.03 kg P ha^{-1}, P_3: 50.21 kg P ha^{-1} and P_4: 54.39 kg P ha^{-1}. Factor B: Potassium sources (3 sources) as - K_1: KCl, K_2: KH_2PO_4, K_3: K_2SO_4. The two factorial experiment was laid out in split-plot design with three replications. Data were recorded on different yield attributes, yield and quality of potato and non-significant variations ware observed for different sources of potassium and significant differences were recorded for different dose of phosphorus and the combined effect of different dose of phosphorus and different sources of potassium.

In case of different dose of phosphorus, The maximum days required for 80% emergence (14.33) was observed from P_2, whereas the minimum days (13.00) was obtained from P_1. The maximum plant vigor (8.77) was observed from P_3, whereas theminimum vigor (6.67) was obtained from P_1 . At 30, 55, and 80 DAP, the highest number of leaves $plant^{-1}$ (32.29, 53.13, and 61.67, respectively) was found from P_2 and P_3, whereas the lowest number (27.76, 49.36 and 59.31, respectively) was observed from P_1. The maximum Crop stand (97.03) was observed from P_3, whereas the minimum Crop stand (96.07) was obtained from P_1. At 80 DAP, the highest Number of stem $plant^{-1}$ (4.22) was found from P_3, whereas the lowest number (4.02) was observedfrom P_1.At 30, 55, and 80 DAP, the tallest plant height (cm) of potato (37.27, 52.73, and 57.44, respectively) was found from P_3, P_3 and P1, whereas the shortest height (35.91, 50.48 and 52.80, respectively) was observed from P_1, P_1 and P_2 respectfully. The maximum number of tuber $plant^{-1}$ (8.73) was observed from P_3, while the minimum number (7.73) was recorded from P_1. The maximum average weight of tuber (47.62) was observed from P_3, whereas the minimum average weight of tuber (g) (45.59) was obtained from P_2. The maximum yield of potato (34.29) was observed from P_3, whereasthe minimum yield of potato (31.90) was obtained from

P_1. The maximum yield of potato (32.88) was observed from P_3, whereas the minimum yield of potato (30.30) was obtained from P_1 which was statistically similar to P_4. For canned potato, the highest (7.35) was observed from P_1, which was statistically similar to P_4. whereas the lowest (6.15) was recorded from P_3. For Chips potato, the highest (26.39) was observed from P_3,.whereas the lowest (22.94) was recorded from P_1 which was statistically similar to P_4. For French fry, the highest (0.341) was observed from P_3,. whereas the lowest (0.00) was recorded from P_1. The highest dry matter content in potato tubers (22.19%) was recorded from P_1 which was statistically similar (21.59%) to P_2, whereas the lowest (18.72%) was found from P_4. The highest specific gravity in potato tubers (1.0798 gm^{-3}) was recorded from P1, whereas the lowest (1.0556 gm^{-3}) was found from P_4. The highest TSS in potato tubers (4.93) was recorded from P_4 whereas the lowest (3.97) was found from P_1. The highest firmness in potato tubers (45.89) was recorded from P_4, whereas the lowest (44.75) was found from P_3. The highest L * value (75.35) of tuber skin was taken by P_1 and the lowest (74.35) was taken by P_1. In case of highest a* value(0.69) of tuber skin was taken by P_1 and the lowest (0.42) was taken by P_1. In case of highest b* value (31.36) of tuber skin was taken by P_1 and the lowest (30.38) was taken by P_2. . In case of highest c* value (31.36) of tuber skin was taken by P_4 and the lowest (30.38) was taken by P_2. In case of highest H* value (89.24) of tuber skin was taken by P_1 which was statistically similar to the P_2 and P_2 respectfully and the lowest (88.69) was taken by P_2. The highest L * value (56.85) of tuber flesh was taken by P_4 which was statistically similar to the P_2 and P_3 respectfully and the lowest (55.57) was taken by P_1. In case of highest a* value (10.91) of tuber flesh was taken by P_3 and the lowest (10.41) was taken by P_2. In case of highest b* value (12.62) of tuber flesh was taken by P_3 and the lowest (11.88) was taken by P_2. . In case of highest c* value (17.72) of tuber flesh was taken by P_3 and the lowest (15.83) was taken by P_2. In case of highest H* value (51.74) of tuber flesh was taken by P_4 and the lowest (48.65) was taken by P_2. The highest starch content in potato tubers (17.075) was recorded from P_1 while the lowest (12.579) was obtained from P_4. The highest reducing sugar content in potato tubers (0.3482) was recorded from P_4 while the lowest (0.1745) was obtained from P_1.The highest non-reducing sugar content in potato tubers (0.5348) was recorded from P_4 while the lowest (0.3333) was obtained from P_1. The highest antioxidant content in potato tubers (601.17) was recorded from P_1 while the lowest (497.06) was obtained from P_4. The highest polyphenol content in potato tubers (84.137) was recorded from P_1 which was statistically similar (79.468) to P_2 while the lowest (68.135) was obtainedfrom P_4.

In case of potassium sources, The maximum days required for 80% emergence (14.41) was found from K_1, while the minimum days (12.91) was recorded from K_2 source of potassium. The maximum plant vigor (8.18) was found from K_2, while the minimum vigor (7.33) was recorded from K_3 source of potassium. At 30, 55, and 80 DAP, the highest number of leaves plant-1 (30.05, 53.67 and 62.41, respectively) was found from K_2, whereas the lowest number (29.22, 50.13 and 59.19, respectively) was observed from K_3. The maximum Crop stand (96.93) was found from K_2, while the minimum Crop stand (95.98) was recorded from K_3 source of potassium. At 80 DAP, the highestNumber of stem plant-1 (4.48) was found from K_3, whereas the lowest number (3.93) was observed from K_1. At 30, 55, and 80 DAP, the the tallest plant height (cm) of potato (37.42, 53.45 and 56.21, respectively) was found from K_2, whereas the shortest height (35.64, 49.95 and 52.48, respectively) was observed from K_3. The maximum number of tubers plant^{-1} (8.50) was recorded from K_2, whereas the minimum number (7.63) was observed from K_3. The maximum average weight of tuber (47.62) was observed fromP_3, whereas the minimum average weight of tuber (g) (45.59) was obtained from P_2. The maximum average weight of tuber (34.30) was found from K_2, while the minimum yield of potato (32.41) was recorded from K_3 source of potassium. The maximum average weight of tuber (32.43) was found from K_2, while the minimum yield of potato (29.75) was recorded from K_3 source of potassium. For Canned potato, the highest (7.38) was observed from K_2, whereas the lowest (6.26) was recorded from K_1. For Chips potato, the highest (24.98) was observed from K_1, which was statistically similarto K_2 whereas the lowest (22.81) was recorded from K_3. For French fry potato, the highest (0.153) was observed from K_2, whereas the lowest (0.151) was recorded from K_3. The highest dry matter content in potato tubers (21.10%) was recorded from K_3 whereas the lowest (20.67%) was found from K_2. The highest specific gravity in potato tubers (1.0808 gm-3) was recorded from K_3 whereas the lowest (1.0519 gm^{-3}) was found from K_2. The highest TSS in potato tubers (4.65) was recorded from K_2 whereas the lowest (4.30) was found from K_3 which was statistically similar to K_1. The highest firmness in potato tubers (46.80) was recorded from K_3 whereas the lowest (44.11) wasfound from K_2.

The highest L * value (75.20) of tuber skin was taken by K_3 and the lowest (74.52) was taken by K_1. In case of highest a* value (0.668) of tuber skin was taken by K_2 and the lowest (0.432) was taken by K_1. In case of highest b* value (31.27) of tuber skin was taken by K_2 and the lowest (30.51) was taken by K_1 . In case of highest c* value (31.28) of tuber skin was taken by K_2 and the lowest (30.52) was taken by K_1.In case of highest H* value (89.18) of tuber skin was taken by K_1 and the lowest (88.77) was taken by K_2. The highest L * value (56.97) of tuber flesh was taken by K_2 and the lowest (55.92) was taken by K_1. In case of highest a* value (10.94) of tuber flesh was taken by K_2 which was statistically similar to the K_3 and the lowest (10.01) was taken by K_1. In case of highest b* value (13.08) of tuber flesh was taken by K_2 and the lowest(11.94) was taken by K_1. In case of highest c* value (17.10) of tuber flesh was taken byK_2 which was statistically similar to the K_3 and the lowest (15.62) was taken by K_1. In case of highest H* value (49.98) of tuber flesh was taken by K_2 and the lowest (49.36)was taken by K_3. The highest starch content in potato tubers (15.985) was observed from K_3, whereas the lowest starch content (14.333) from K_2 which was statistically similar(14.875) to K_1. The highest reducing sugar content in potato tubers (0.2307) was observed from K_2, which was statistically similar (0.2267) to K_1 whereas the lowest reducing sugar content (0.2166) from K_3. The highest non-reducing sugar content in potato tubers (0.4176) was observed from K_1, whereas the lowest non-reducing sugar content (0.3855) from K_3, which was statistically similar (0.3990) to K_2. The highest antioxidant content in potato tubers (567.87) was observed from K_3, whereas the lowest antioxidant content (532.92) from K_2, which was statistically similar (541.42) to K_1. The highest polyphenol content in potato tubers (85.243) was observed from K_3, which was statistically similar (79.271) to K_1 whereas the lowest polyphenol content (66.891)from K_2.

In case of combine effect of different dose of phosphorus and potassium sources, The maximum days required for 80% emergence (15.33) was found from P_3K_1 and the minimum days (12.33) was recorded from P_1K_2, P_1K_3 and P_3K_2 treatment combinations. The maximum plant vigor (9.1) was found from P_3K_2 and the minimum vigor (6.1) was recorded from P_1K_3 treatment combination. The highest number of leaves plant-1 (34.93) was found from P_2K_2 which was statically similar to the rest of treatments except P_1K_2, whereas the lowest number (26.60) was observed from P_1K_2. But at 55 and 80 DAP, non- significant variation was recorded in no. of leaves plant-1 due to the combined effect of different dose of phosphorus and sources of potassium (Table 3). The highest number of leaves plant-1 (54.93 and 65.13, respectively) was found from P_3K_2 and P_1K_2, whereas the lowest number (46.53 and 55.24, respectively) was observed from P_1K_3. The maximum Crop stand (97.30) was found from P_3K_2 and the minimum Crop stand (95.10) was recorded from P_1K_3 treatment combination. The highest Number of stem plant-1 (5.07) was found from P_1K_3 which was statically similar to the P_2K_2, P_3K_1, P_3K_3, P_4K_1, P_4K_2 and P_4K_3 treatments combination respectfully, whereas the lowest number (3.33) was observed from P_1K_2. The plant highest height (cm) of potato (39.15 and 55.06, respectively) was found from P_3K_2, whereas the shortest height (35.35 and 48.98, respectively) was observed from P_1K_3, P_4K_3 and P_1K_3, respectively. But at 80 DAP, Statistically significant variation was recorded in plant height (cm) of potato due to the combined effect of different dose of phosphorus and sources of potassium. The tallest plant height (cm) of potato (61.93) was found from P_1K_2 which was statically similar to the rest of combinations treatments except P_2K_2, P_2K_3, whereas the shortest height (51.53) was observed from P_1K_3 which was statically similar to the P_2K_2 P_2K_3 combinations treatments. The maximum numberof tubers plant^{-1} (9.40) was found from P_3K_2 which is statistically similar to P_3K_1, P_3K_3 and P_4K_2 , respectfully, while the minimum number (7.00) was observed from P_4K_3 treatment combination, which is statistically similar to the rest of combinations treatment except P_3K_1, P_3K_3 and P_4K_2. The maximum average weight of tuber (50.65) was found from P_3K_2 and the minimum average weight of tuber (42.92) was recorded from P_4K_2 treatment combination. The maximum yield of potato (35.35) was found from P_3K_2 which was statistically similar to P_4K_2 and the minimum yield of potato (31.76) was recorded from P_1K_1 treatment combination. The maximum yield of potato (34.21) was found from P_3K_2 and the minimum yield of potato (28.93) was recorded from P1K3 which was statistically similar to P_2K_3 and P_4K_3 treatment combination. For Canned potato, the highest (10.35) was observed from P_4K_2, whereas the lowest (5.59) was recorded from P_4K_1 which was statistically similar to P_4K_3 , P_4K_1 , P_3K_3 , P_3K_2 , P_2K_2 and P_1K_1 treatment combination. For chips potato, the highest (28.06) was observed from P_3K_2, which was statistically similar to P_2K_1 , P_2K_2 , P_3K_1 , P_3K_3 , and P_4K_1 treatment combination whereas the lowest (20.01) was recorded from P_1K_3 which was statistically similar to P_2K_3 , P_4K_2 , and P_4K_3 treatment combination. For French fry potato, the highest (0.367) was observed from P_3K_1, which was statistically similar to P_3K_2 whereas the lowest (0.00) was recorded from P_1K_1 which was statistically similar to P_1K_2 , P_1K_3 , P_2K_3 , P_4K_1 , and P_4K_2 treatment combination. The highest dry matter content in potato tubers (22.85%) was observed from P_1K_3 which was statistically similar to P_1K_1, P_1K_2, P_1K_2, P_2K_1, P_2K_2, P_2K_3, P_3K_1, and P_3K_3 treatment combination and the lowest (17.45%) was recorded from P_4K_3 treatment combination. The highest highest specific gravity in potato tubers (1.0998 gm-3) was observed from P_1K_3 whereas the lowest (1.0474) was found from P_4K_2treatment combination. The highest TSS in potato tubers (5.10) was observed from P_4K_2 which was statistically similar to P_3K_2, P_4K_1, and P_4K_3 treatment combination and the lowest (3.90) was recorded from P_1K_1 which was statistically similar to P_1K_2, P_1K_3 and P_2K_3 treatment combination. The highest firmness in potato tubers (47.78) was observed from P_4K_3 whereas the lowest (42.36) was found from P_4K_1 treatment combination. The highest L * value (75.93) of tuber skin was taken by P_1K_2 and the lowest (73.64) was taken by P_2K_1. In case of highest a* value (0.980) of tuber skin was taken by P_2K_2 and the lowest (0.203) was taken by P_1K_1. In case of highest b* value (32.45) of tuber skin was taken by P_1K_3 andthe lowest (29.71) was taken by P_1K_1. In case of highest c* value (32.45) of tuber skinwas taken by P_1K_3 and the lowest (29.71) was taken by P_1K_1. In case of highest H* value (89.58) of tuber skin was taken by P_1K_1 and the lowest (88.10) was taken by P_4K_3. The highest L * value (57.17) of tuber flesh taken by P_3K_2 and the lowest (54.75) was taken by P_1K_1. In case of highest a* value (11.89) of tuber flesh was taken by P_3K_2 andthe lowest (9.75) was taken by P_3K_1. In case of highest b* value (13.90) of tuber flesh was taken by P_3K_3 and the lowest (11.20) was taken by P_1K_1. In case of highest c* value (18.37) of tuber flesh was taken by P_4K_3 and the lowest (15.07) was taken by P_1K_1. In case of highest H* value (52.87) of tuber flesh was taken by P_4K_2 and the lowest (46.76)was taken by P_3K_2. The highest starch content in potato tubers (17.936) was recorded from P_1K_3, which was statistically similar to P_1K_1, P_1K_2, P_2K_3, P_3K_1, and P_3K_3,whereasthe lowest (12.136) was observed from P_4K_1 which was statistically similar to P_4K_2 and P_4K_3 treatment combination. The highest reducing sugar content in potato tubers (0.3558) was recorded from P_4K_1, which was statistically similar to P_4K_2 whereas the lowest (0.1713) was observed from P_1K_3 which was statistically similar to P_3K_1, P_1K_1, P_1K_2, and P_2K_3 treatment combination. The highest non-reducing sugar content in potato tubers (0.5610) was recorded from P_4K_1, which was statistically similar to P4K2 whereas the lowest (0.3290) was observed from P_1K_3 which was statistically similar to P_1K_1, P_1K_2, and P_2K_3, treatment combination. The highest antioxidant content in potato tubers (630.12) was recorded from P_1K_3, which was statistically similar to P_1K_2 and P_3K_1 whereas the lowest (478.92) was observed from P_4K_1 which was statistically similar to P_2K_1, P_2K_2, P_4K_2, and P_4K_3, treatment combination. The highest polyphenol content in potato tubers (92.994) was recorded from P_1K_3, which was statistically similar to P_1K_1, P_2K_1, P_2K_3, P_3K_1, and P_3K_3 whereas the lowest (58.641) was observedfrom P_4K_2 which was statistically similar to P_2K_2, P_3K_2, and P_4K_1 treatment combination.

Conclusion:

1. Among different dose of phosphorus, 50.21 kg P ha^{-1} performed better than the others dose of phosphorus in consideration yield arrributes, yield and quality of potato.

2. Reviews and literature revealed that sources of potassium varied non-significantly for different growth parameter but significantly varied for different yield attributes, yield and quality of potato and among the sources, K_2SO_4 performed better than the others sources of potassium in consideration yield attributes, yield and quality of potato although KCl performed better in some growth parameters.

3. Most of the yield and quality contributing parameters KCl and K_2SO_4 as a source of potassium and 50.21 kg P ha^{-1} produced good processing quality potato. However, considering economic condition of Bangladesh and availability, KCl would be used as a source of potassium on yield and quality of potato without sacrificing yield.

Considering the results of the present experiment, further studies in the following areas may be suggested:

1. For regional adaptability, such study is needed to be repeated in different agro-ecological zones (AEZ) of Bangladesh;

2. Other management of treatments may be included for further study, and

3. Other sources and doses of organic and inorganic fertilizer may be used for further study to specify the specific combination.

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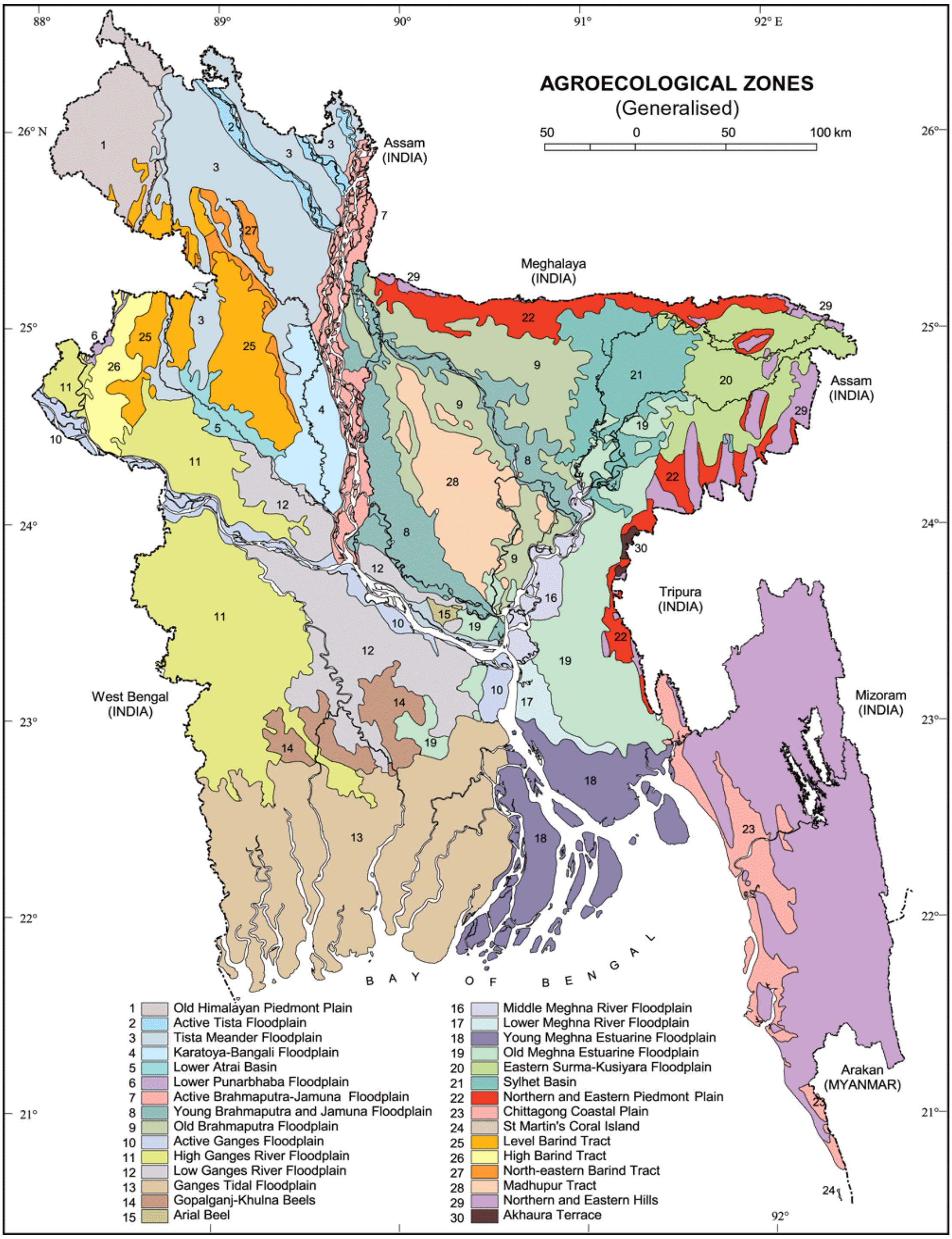
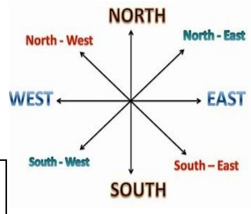
APPENDICES

Appendix I The Map of the experimental site





Appendix II Layout of the Experiment

R 1	R 2	R 3
P_1K_1	P_2K_2	P_4K_3
P_1K_3	P_2K_1	P_4K_1
P_1K_2	P_2K_3	P_4K_2
P_3K_3	P_4K_3	P_3K_3
P_3K_1	P_4K_1	P_3K_1
P_3K_2	P_4K_2	P_3K_2
P_2K_2	P_3K_3	P_1K_1
P_2K_1	P_3K_1	P_1K_3
P_2K_3	P_3K_2	P_1K_2
P_4K_3	P_1K_1	P_2K_2
P_4K_1	P_1K_3	P_2K_1
P_4K_2	P_1K_2	P_2K_3

0.8m; 1.2 m; 2.6 m; 1m; 1m

LEGEND

P_1: 42.55 kg P ha^{-1}
P_2: 46.81 kg P ha $^{-1}$
P_3: 51.06 kg P ha $^{-1}$
P_4: 55.32 kg P ha^{-1}

K_1: KCl @130 kg K ha^{-1}
K_2: KH2PO4 @130 kg K ha^{-1}
K_3: K2SO4@130 kg K ha^{-1}

Appendix III Monthly record of air temperature, relative humidity, rainfall and sunshine hour of the experimental site duringthe period from November 2018 to February 2019

Month	Air temperature(^{0}C)		Relative humidity (%)	Total rainfall (mm)	Sunshine (hr)
	Maximun	Minimum			
November'18	25.6	16.5	77	00	6.9
December'18	22.7	13.2	76	08	6.7
January'19	25.2	12.5	65	05	6.1
February'19	27.9	17.4	67	43	6.8

Source: Bangladesh Meteorological Department (Climate and weather division)Agargoan, Dhaka-1207

Appendix IV. Analysis of variance of the data on days required for 80% emergence ofseedlings, plant vigor and No. of leaves of potato at different days after planting (DAP)

Source of variation	Degrees of freedom	Mean Square				
		Days to 80% emergence	Plant vigor(1 -10)	Number of leaves plant^{-1}		
				30 DAP	55 DAP	80 DAP
Replication	2	13.444	0.003	71.443	121.288	0.158
Phosphoru sdose (A)	3	3.482	6.662**	35.619	22.425	8.822
Error	6	3.148	0.092	23.901	16.080	10.238
Source of potassium (B)	2	7.194*	2.170*	2.093	43.374	39.625
Interaction (AXB)	6	1.453	2.180*	38.458*	10.838	52.761
Error	16	1.222	0.398	12.857	79.636	35.692
Total	35					

Appendix V. Analysis of variance of the data on Crop Stand at 30 DAP, Number ofstem at 80 DAP and Plant height of potato at different days after planting (DAP)

Source of variation	Degrees of freedom	Mean Square				
		Crop Stand at 30 DAP	No. of Stem at 80 DAP	Plant Height(cm)		
				30 DAP	55 DAP	80 DAP
Replication	2	0.0008	0.1744	0.0008	0.0008	89.571
Phosphoru sdose (A)	3	1.473	0.063	3.412	7.843	37.743
Error	6	13.814	0.508	5.003	6.246	29.001
Source of potassium (B)	2	2.798	1.141*	10.527	36.949*	50.637
Interactin (AXB)	6	0.311	1.026*	0.779	0.314	56.934
Error	16	41.721	0.2744	17.175	22.019	18.701
Total	35					

Appendix VI. Analysis of variance of the data on number of tubers hill-1, averageweight of individual tuber, yield of potato

Source of variation	Degrees of freedom	Mean square		
		No. of tubers hill-1	average weight of tuber (g)	yield of potato (tha^{-1})
Replication	2	0.00083	0.0507	4.5398
Phosphorus dose (A)	3	1.840*	8.750	8.918**
Error	6	0.148	5.846	0.141
Source of potassium (B)	2	2.298*	3.052	11.546**
Interaction (AXB)	6	2.418*	53.686*	0.481*
Error	16	0.533	17.268	0.127
Total	35			

Appendix VII. Analysis of variance of the data on yield of table potato and category ofdifferent tubers to different uses

Source of variation	Degrees of freedom	Mean square			
		Yield of table potato >20 g (tha^{-1})	Category of different tubers to different uses		
			Cane Potato (25-45 mm)	Chips Potato (45-75mm)	French Fry (>75mm)
Replication	2	1.148	0.022	0.020	0.00001
Phosphorus dose (A)	3	12.521**	2.999**	22.636**	0.186**
Error	6	0.136	0.074	1.431	0.0001
Source of potassium (B)	2	21.896**	3.763**	18.179*	0.00001
Interaction (AXB)	6	0.157*	8.196**	14.165	0.0512**
Error	16	0.044	0.303	4.86	0.0004
Total	35				

Appendix VIII. Analysis of variance of the data on dry matter contents, specific gravity, content of total soluble solid (TSS) and firmness score in potato tubers

Source of variation	Degrees of freedom	Mean square			
		Dry matter contents	Specific gravity	Content of total soluble solid	Firmness score
Replication	2	0.011	2.725E-07	6.145E-31	19.993
Phosphorus dose (A)	3	21.012**	0.00089	1.687**	2.479
Error	6	0.695	0.00086	0.011	25.967
Source of potassium (B)	2	0.600	0.00252	0.370**	26.077
Interaction (AXB)	6	6.257*	0.00011	0.147*	15.108
Error	16	1.958	0.00241	0.041	10.322
Total	35				

Appendix IX. Analysis of variance of the data on skin color of potato tubers

Source of variation	Degrees of freedm	Mean square				
		L	A	b	c	H
Replication	2	1.037	0.200	2.225	2.188	0.801
Phosphorus dose (A)	3	1.941	0.115	1.662	1.650	0.564*
Error	6	0.754	0.059	4.007	4.017	0.170
Source of potassium (B)	2	1.443	0.168*	2.138	2.139*	0.523
Interaction (AXB)	6	4.492*	0.291*	2.783	2.783	0.880*
Error	16	1.315	0.080	2.252	2.255	0.257
Total	35					

Appendix X. Analysis of variance of the data on flesh color of potato tubers

Source of variation	Degrees of freedom	Mean square				
		L	A	b	c	H
Replication	2	6.742	2.719	13.347	12.496	30.264
Phosphorus dose (A)	3	3.293*	0.406	3.754	3.136	17.144
Error	6	0.964	3.095	2.182	2.396	37.403
Source of potassium (B)	2	3.859	3.279*	4.096	7.514*	1.238
Interaction (AXB)	6	6.717*	1.056	6.658*	5.264*	9.390
Error	16	2.097	0.783	2.093	1.596	14.767
Total	35					

Appendix XI. Analysis of variance of the data on some bio-chemical parameters ofpotato tubers

Source of variation	Degrees of freedom	Mean square				
		Starch (%)	Reducing sugar (mgg^{-1}FW)	Non-reducing sugar(mg g^{-1}FW)	Antioxidant (Troloxµ Mol 100 g^{-1} FW)	Polyphenol (GA mg 100 g^{-1} FW)
Replication	2	0.021	0.000002	0.000009	8.2	0.21
Phosphors dose (A)	3	31.460**	0.061**	0.0754**	19612.2**	406.72*
Error	6	0.564	0.00009	0.00012	236.4	32.88
Source of potassium (B)	2	8.505*	0.00063**	0.0031**	3987.3*	1051.56**
Interaction (AXB)	6	4.732*	0.00037**	0.0026*	1946.9*	193.91*
Error	16	1.382	0.000068	0.00036	634.4	57.83
Total	35					

PLATES

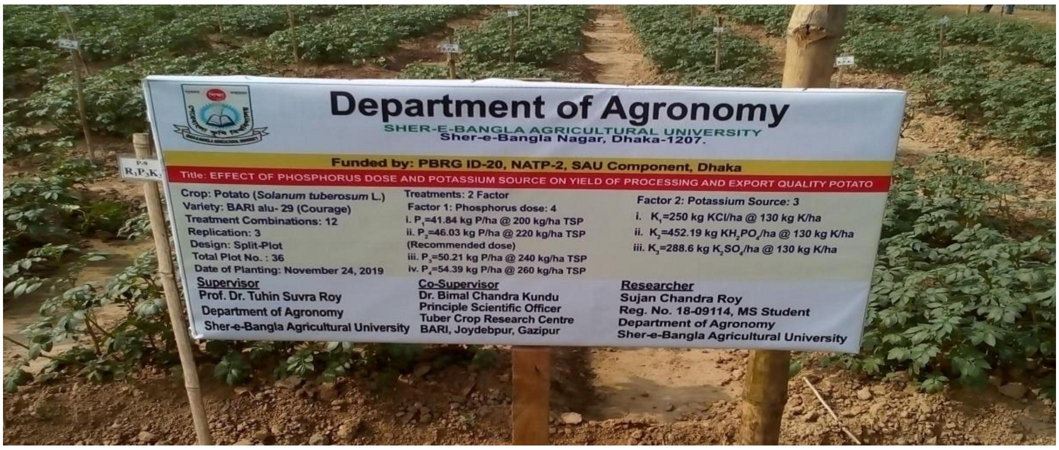


Plate 1. Overview of the whole experiment

Plate 2. Land preparation

Plate 3. Sowing of potato tubers

Plate 4. Investigation disease infection with supervisor

Plate 5. Data collection in field

Plate 6. Bagging and carrying of potato tuber to store house

CONT'D

Plate 7. Potatoes from different combinations

Plate 8. Chemical analysis in lab