EFFECT OF POTASSIUM AND BORON FERTILIZERS ON THE GROWTH AND YIELD OF POTATO

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CERTIFICATE

*This is to certify that the thesis entitled, "***EFFECT OF POTASSIUM AND BORON FERTILIZERS ON THE GROWTH AND YIELD OF POTATO***" submitted to the Department of Soil Science, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka-1207. In partial fulfilment of the requirements for the degree of* **MASTER OF SCIENCE in SOIL SCIENCE***, embodies the result of a piece of bona fide research work carried out by* ***Urmi Rani Mondal,*** *Registration No.* ***18-09229*** *under my supervision and guidance. No part of the 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 this investigation has duly been acknowledged.

Dated:
Dhaka, Bangladesh

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Dedicated to

My Beloved Parents

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The Author

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ABSTRACT

A field experiment was conducted to assess the effect of potassium and boron on the growth and yield of potato during Rabi season from November, 2019 to February 2020 at research field of Sher-e-Bangla Agricultural University, Dhaka-1207. The experimental design was Randomized Completely Block Design (RCBD) with three replications. There were used nine treatments of as $T_1 = N_{180}P_{30}S_{10}Zn_2$ Kg/ha; $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); T_6 = T1 + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha). Data were collected on several parameters like the yield and yield contributing characters, quality parameters and soil parameters. The collected data were statistically analyzed for evaluation of the treatment effect. A significant variation among the treatment in respect of majority of the parameters were observed. The longest plant (73.78 cm), the maximum stem numbers hill^{-1} (9.33), the maximum number of tubers hill^{-1} (8.67), the highest tuber yield plot^{-1} (17.43 kg), the highest tuber yield 34.86 t ha^{-1} were obtained from T_6 treatment due to different level of potassium and boron application. The highest specific gravity of tuber, the maximum (68.44%) marketable tuber (>20gm) were produced from T_6 treatment. The maximum number of seed tuber (66.13%) between 38 mm to 55 mm, the maximum number of tubers for chips (71.52%) were obtained from T_5 treatments due to different level of K and B application. The highest soil pH (6.40), the highest organic carbon (0.85%), the highest organic matter (1.42%), the maximum total nitrogen (0.087%), the highest available phosphorus (28.5 ppm) were recorded from T_5, $T_{8,}$ $T_{8,}$ T_4, $T_{3,}$ treatment respectively. The highest exchangeable potassium (0.48%) and the maximum available Sulphur (36.54 ppm) were found from T_6 treatment. The maximum weight loss at storage was recorded from T_1 (Control) treatment whereas the minimum weight loss was recorded from T_6 treatment. From this study, it may be concluded that Potassium and Boron application along with other inorganic fertilizers had significant positive response for improving yield, quality, and shelf life of potato.

CONTENTS

CHAPTER I
INTRODUCTION

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the major food crops of the world. Potato provides a critically important element to the diets of many people in Bangladesh as a source of vitamin C and amino acid not provided by rice. It is a source of cash income to farmers and laborers which complements other staple crops. It contains practically all the essential dietary constituents. Carbohydrates are the major constituents of potato. Besides, it contains essential nutrients such as proteins and minerals like calcium, phosphorus and iron, and vitamins (B_1, B_2, B_6 and C) (Ensminger *et al.*, 1983). There is great potential of exporting potatoes from Bangladesh both for seed and table purposes to South-East Asia and to Middle East countries. Potatoes can even be exported to some of the European countries during March-May when fresh potatoes are not available in these countries. The root and tuber crops commonly grown in Bangladesh comprise potato, sweet potato, aroids, yam, arrowroot, and cassava. Among them, potato and sweet potato are the principal crops. It is used primarily as a vegetable and has potential as a staple food. Bangladesh ranks fifth in area in the world. From each hectare of land, it produces about 16-19 tons of potatoes. In European and American countries, the potato productivity is about 30-40 tons per hectare (Griffiths and Zitter, 2008). Potato is one of the principal cash crops and it also contributes to Bangladeshi economy in several ways.

Yield increases because of new and improved production agro- technologies involve fertilization. Low use of fertilizers and serious imbalances in the N, P, K application ratio are partially responsible for low yields in India. Current fertilization rates are insufficient to sustain high yields and to replenish nutrient removal by the crop. According to Grewal et al (1992), potato yield could be increased by almost 50% only by improved nutrient management. Marketable yield is a function of total biomass production, the percentage of biomass that is partitioned to the tubers, the moisture content of the tubers and the proportion of tubers that are acceptable to the market, in terms of size and lack of defects (Ewing, 1997). Great opportunities exist to increase potato yield and quality by improving nutrient management. Potato demands high level of soil nutrients due to relative poorly developed and shallow root system in relation to yield (Perrenoud, 1983). Compared with cereal crops, potato produces much more dry matter in a shorter cycle (Singh and Trehan, 1998). This high rate of dry matter production results in large amounts of nutrients removed per unit time, which generally most of the soils are not able to supply. Hence, nutrient application from external sources as fertilizers becomes essential. High yields can only be sustained through the application of optimal NPK doses in balanced proportion. Potato crop is a heavy remover of soil potassium and is the nutrient taken up in the greatest quantity - the tubers remove 1.5 times as much potassium as nitrogen and 4-5 times the amount of phosphate (Perrenoud, 1993). Potato is regarded as an indicator crop for K availability because of the high K requirement (Roberts and McDole, 1985). Few soils could produce high potato yields for very many seasons without replenishing removed K. Potato is a very sensitive crop to nitrogen fertilization. Excess nitrogen may prolong the vegetative phase and thus, interfere with the initiation of tuberization, decreasing yield and dry matter accumulation in the tubers. On the other hand, a low nitrogen application rate may produce premature senescence in the plants due to early translocation of nitrogen from the leaves to the tubers (Saluzzo *et al*., 1999**;** Kleinkopf *et al*., 1981). Tuber Crop Research Center (TCRC) during the last decade and recommended 20 varieties after screening for cultivation under Bangladesh conditions (Hussain, 1993). These existing varieties occupy in about 68% of the total potato growing areas of this country (Anonymous, 1998). Hence, the study was undertaken to evaluate the performance of 1 potato variety under Bangladesh conditions with response to different fertilizer management practices.

Considering the above situation, present study was undertaken with the following objectives:

1. To observe the effect of potassium and boron on the growth and yield of potato.
2. To find out the suitable doses of potassium and boron for maximum growth and yield potato.

REVIEW OF LITERATURE

A good number of works have been done by different researchers on the effect of macro and micro nutrients on different varieties of potato. But little information is available about the effect of potassium and boron on the variety Cardinal the present climatic condition of Dhaka district. Some important and informative works have been done at home and abroad on these aspects are presented in this chapter.

Rainys *et al.,* (2005) studied the effects of farmyard manure, straw, NPK/ha, micronutrients on the yield, starch and dry matter content of early (Goda and Voke), moderately early (Lady Rosetta) and moderately late (Saturna and Heres) potato cultivars in Lithuania during 2000-02. Tuber yield was significantly affected by the fertilizers, genotype and weather conditions. Over the three years, the highest yield was obtained (21.8-27.4 t/ha) among the cultivars. The cultivars had the highest yields in 2000 (19.3-36.0 t/ha).

Makaraviciute (2003) conducted an experiment during 1997-99 in Lithuania, 10 potato cultivars, i.e., Venta and Ukama, Voke, Mirta and Karolin early Hertha, Saturna and Agria, Aistes and Speci, were grown on plots with different fertilizers. The different fertilizers, varietal properties and meteorological conditions during the potato vegetation period significantly influenced the yield and quality of different potato cultivars. The highest potato tuber yields (20.1-29.6 t/ha) were harvested when one component and complex mineral fertilizers with microelements were applied, while the lowest tuber yield (14.6-21.7 t/ha) was obtained when manure (60 t/ha) was used in spring. Fang (2003) conducted a field test with cv. Dabaihua in a semiarid region of China, to investigate the yield-related indices under different K application rates. Seven treatments were with N: P_2O_5: K_2O ratios of 0:0:0 (control 1), 90:90:0 (control 2), 90:90:30, 90:90:45, 90:90:60, 90:90:75 and 90:90:90 kg/ha. The tuber yields in the treatments with K fertilizer were significantly higher than those in the control treatments. The highest tuber yiled was recorded at 90 kg K_2O/ha, marked with 75 and 60 kg K_2O/ha, and the lowest in the control.

Suman (2003) conducted an experiment with potato cv. fufri Sutlej in Hisar, India in 2001, involving three fertilizer levels (100:60:60, 150:75:75 and 150:90:90 kg NPK/ha), three plant spacing (10, 15 and 20 cm) and two crop durations (75 and 85 days). Decrease in plant spacing increased stems per unit area, plant height, haulm weight, total as well as number of different size tubers per unit area, and yield of total as well as of >25-50, >50-75 and >75 g size tubers. The fertilizer rates used could not affect any of these parameters. With an increase in crop duration, there was a significant increase in haulm weight and yield of >75 g and total tubers, while the other parameters were not affected.

Fifteen exotic potato varieties were evaluated in Bangladesh for yield potential over three generations. Both the yield was significantly higher in 2nd generation than 1st and 3rd generations. The average reduction of yield over 1st generation was found to be higher in Alkon, Granola, Obelix, and Origo ranging (-10.3 to -38.8%) but very lower in Mondial (-0.7%) and Producent (0.5%).On an average, the high increase in yiled in subsequent generatins over 1st generation was boticed in Bartina, Diamant, Liseta, and Morene (17.3 to 64.5%). Similarly the degeneration was observed in Granola, Obelix, Origo and Producent (1.1 to 40.5%) whiles the yield increased in Bartina, Diamant, Liseta, Escort, Morene and Thebes (17.5 to 38.8%). Considering the parameters studied, varieties viz., Ajiba, Bartina, Liseta, Mondial, Morene and Thebes showed acceptable performance in comparison to recommended variety Diamant(Rasul *et al.*, 1993).

Nandekar (2003) evaluated the yield of seven potato cultivars in Chandangaon, Chhindwara, Madhya Pradesh, India, during the rabi season of 1994/95 and 1995/96. H.P.S. 1/13 (32.5 t/ha) had the highest yield, marked with H.P.S. 1/67 (31 t/ha) and H.P.S. 11/13 (29.5-36.5 t/ha). The yields of these cultivars were higher by 30.5, 25.4 and 20.0% respectively than the yield of Kufri Badshah (24.7 t/ha).

A field experiment was conducted during rabi 1999-2000 in Akola, Maharashtra, India to investigate the effects of roe spacing (45 and 60 cm), tuber size (6-25 and 26-45 g) and NPK level (100:75:50 and 125:100:75 kg/ha) on yield and yield components of potato cv. Kufri Jyoti. Weight of tubers per plant and average weight of tubers per plant were significantly higher with 60cm row spacing, whereas number of fresh tubers, haulm yield and biological yield were significantly higher with 45cm row spacing. Tuber yield was not affected by the two row spacing treatments. Tuber size of 26-45g recorded significantly higher tuber yield but average weight of tuber was significantly higher with 6-25g tuber size. Application of 125:100:75 kg NPK/ha recorded higher number of fresh tubers per plant, haulm yield and biological yield.

Silva *et al.,* (2005) conducted this study to establish the relationship between the duration of the growth cycle and the yield potential of potato genotypes in southern Minas Gerais State, Brazil. This study evaluated the tuberization process, the dry matter partitioning at the different plant development stages, and estimated genetic parameters for these traits. One hundred twenty-one genotypes were evaluated in two experiments which were harvested at 80 days after planting (DAP) and at the end of the growth cycle. In a second study, 23 genotypes were harvested at 58, 83, 108, and 133 DAP. Results suggest that a possible strategy to increase potato tuber yield in the tropics is to select for late clones. Late clones can be harvested around 100 DAP with no reduction in tuber yield and tuber dry matter content.

Nine advanced generation promising potato hybrids along with control varieties Kufri Chandramukhi and Kufri Badshah were evaluated for tuber yield at 75 and 90 days after planting during the 1990-91 and 1991-92 crop seasons in Satpura, Madhya Pradesh. Wide variability was observed among genotypes for tuber yield at 90 DAP. The hybrids MS/79-10, JN1758 and J155857 produced greater yields than Kufri Chandramukhi at 75 DAP. J155857 also produced a higher yield than the high-yielding control Kufri Badshah at 90 DAPS.

Vos *et al.* (2000) managed comparably to conventional farming practices in the Nederland. There were four nutrient treatments (T_1-T_4). Treatments T_1 received chemical fertilizer only. T_2 received processed organic manure, supplying 50% of the crop N requirement, supplemented by chemical fertilizers. In treatments, T_1 AND T_2 the soil was grow during winter. In T_3 and T_4 the crops were fertilized as in T_1 and T_2 respectively, nitrogen catch crops were grown in autumn and winter. The initially high soil fertility indices for both P and K declined over the experimental period. Catch crops and organic manure did not affect crop yields or nutrient balances, except that their combination in T_4 resulted in 1.5t/ha extra dry matter yield of sugar beet roots. Between spring and harvest, potato and sugar beet showed positive N balances and the cereals negative N balances.

Koppel (2001) set an experiment with special emphasis organic agriculture on the choice of cultivars where adaptation regional soil, climate and production systems are important characteristics. The necessary traits for a potato variety suitable for organic farming include stronger rooting system, quicker haulm development, high and durable resistance to the main diseases and pests. A trial consisting of 45 potato cultivars and advanced clones was established at Jogeva Plant Breeding Institute in Estonia in 2000 to identity the most suitable cultivar for organic fanning in the country. Organic manure at 60 t/ha and mechanical weed control were used no pest and disease control measures were undertaken in both years. Both growing seasons were very suitable for late blight development. High late blight pressure was the main cause of yield reduction from 9.9 to 37.4 t/ha. The higher marketable tuber yields were obtained from the early cultivars or from the late cultivars that are resistant to late blight.

Ghosh and Das (1998) reported that the potatoes grown at Sriniketan (West Bengal) in winter 1995-96 and 1996-97 were given different biofertilizers and growth regulators. Treatments included combinations of Buckup (Well matured cattle manure containing vesicular arbuscular mycorrhizas and phosphate solu7bilizing bacteria), Elecra (liquid organic manure extracted from marigold plants), Bioplin (liquid suspension of Azotobecter), Micrin (liquid organic manure containing humic and fulvic acid), Vitormone (liquid suspension of several dormant Azotobecter species) and protein hydrolysate (plant growth regulators containing amino acids). Plant height and number of shoots/plant increased considerably when the crop received both biofertilizer and growth regulators together. Crop growth rate, tuber bulking rate, large and medium sized tubers and total tuber yield were greatest from combinations of both biofertilizers and growth regulator. Among the single applications, Vitormone gave the greatest yield improvement (22.6%) followed by protein hydrolysate (22.1%). Combined application of Bioplin along with protein hydrolysate or Micrin and Elecra along with Vitormone, gave 38-42% yield improvement over controls.

Blecharezyk and Skrzypezak (1995) observed that FYM reduced tuber dry matter and starch contents, but increased their yield. Another field experiment was conducted by Khalak and Kumaraswamy (1994) in red loam soil at Bangalore, potatoes cv. Kufri Jyoti to assess the effect on dry mater accumulation and growth attributes of potato as influenced by irrigation and fertilizer (50, 100, or 150 kg/ha each of N, P_2O_5 and K_2O). They found that leaf area index, leaf area duration, total dry matter accumulation increased with the rate of $N+P_2O_5+K_2O$ application.

Siddique and Rashid (1990) stated that under Bangladesh Agricultural University farm condition, fertilizer does of 207 kg Urea, 139 kg TSP and 242 kg MP for indigenous potato varieties. Hussain (1985) reported that use of oil cake at the rate of 700-900kg/ha is better for higher potato production. Kehr *et at.*, (1964) mentioned that potato tubers develop and maintain their normal shape better in soils with high organic matter. A field experiment was carried out by Sarker *et al.* (1996) at the Gangachra Series of Mithapukur, Rangpur to assess the effect of fertilizers alone and in combination with cow dung on the growth and yield of potato. They found that the highest tuber yields of 29.97 and 28.72 t/ha were produced by the combined effect of 150kg N + 60kg P + 120kg K + 20 kg S + 40 kg Zn + 2 kg B + 15 kg Mg/ha + 5 t/ha of cow dung respectively.

Belous (1996) worked on fertilizer for zero, single or double doses, 40 t FYM + 60 Kg N + 60Kg P+60 Kg K, 80 t FYM + 120 Kg N -f 120 Kg P+120Kg K and 120t FYM +180kg P +180 Kg K per hectare. They found that NPK without FYM was highly effective especially if straw or green manure had been ploughed in and the use of FYM greatly reduces the effectiveness of complete NPK.

Guarda and Tassoni (1994) carried out an experiment on a clay-loam soil where they applied 0, 100, 200 or 300Kg N/ha in organic or mineral forms. Farmyard manure was applied in two split doses (30% immediately often planting and the rest 50 days later). They found that yield responses to N rate were dissimilar between the N sources. However, potatoes given organic nitrogen yielded 1-2t/ha less than where mineral nitrogen was applied.

In another experiment Zavalin *et al.* (1993) also stated that them optimum potato yield of 27.l t /ha was given by the plants having 9.0 Kg N+ 60KgP + 120 Kg K+ 50t peat manure compost/ha. Karmanpov *et al.* (1982) conducted an experiment with 0-135 Kg N, 0-210 Kg P_20_5 and 0-165 Kg K_2O/ha on a leached chernozem soil given 20 t FYM /ha in the penza region and found that application of 135 Kg N +210 Kg P_2O_5+165 Kg K_2O/ha gave the highest average yields of 36 t/ha without irrigation and 42 t with irrigation.

Krishnamurthy et *al., (*2001) conducted field experiments in Bangalore, Karnataka, India, during the rabi seasons of 1996-97 and 1997-98 and investigated the effect of integrated use of organic manures and fertilizers on potato crops grown from true seed. The experiments consisted of 12 treatments combinations of organic sources: green pus at four t/ha (organic manure), biofcrtilizcrs (Azotobcctcr chroococcum), city compost and control (no organic manure) and fertilizer levels (100, 125 and 150 % of recommended dose of NPK). The highest seed yield of 20.8% was recorded with green and followed by city compost (13.9%) and biofertilizer application (11.6%). The highest total tuber yield of 28.7 t/ha was observed with city compost, followed by green plus (27.4% t/ha) and biofertilizer (20.4% t/ha). Application of 150 %recommended dose of NPK recorded the highest seed yield of 33.3 Kg /has and tuber yield of 29.8 t/ha, closely followed by application of 125% of recommended doses of NPK. Combination of city compost and 150% recommended dose of NPK recorded the highest seed and tuber yield compared to all other treatment combinations.

Toomsoo and leedu (2002) investigated the effect of a combined fertilizer. Hydro complex (12:11:18), on the yield of Potato cv. Anti, grown in potato spring wheat springy barley rotation, in a long term field experiment established in autumn 1989, in Tartu, Estonia. Five rates of mineral N (0, 40, 80, 120 and 160 Kg/ha) were used against three backgrounds of organic manure (no manure, cattle manure + Liter and straw). The results of three experimental years (1999-2001) showed that the yield of cv. Anti was stable during 1999-2001. Yield was found to depend on the fertilizer rather than on the weather conditions. The optimum N rate was 95-120 Kg/ha. In rainy seasons, the use of chemicals to control potato late blight *(Phytopthora infestans)* was very important to improve the yield of potato cv. Anti.

Krupkin *et al.* (1994) carried out an experiment to study effect of poultry manure, a mixture of poultry manure plus hydrolysis lignin, and a compost of poultry manure plus hydrolysis lignin organic fertilizers for potatoes, carrots and cabbage with and without irrigation. The results should that these organic fertilizers improved yield and quality of the crop, especially on soil having a low content of nitrate N, but had only little effect on soils well supplied with nitrate N. the lignin based fertilizers i.e. a mixture of poultry manure hydrolysis lignin and a compost of poultry manure plus hydrolysis lignin were similar in their effect to poultry manure.

Datta and Chakraborty (1995) conducted a field experiment with or 100 Kg/ha each of N, P2O5$_i$K$_2$O, and manure with 5 tons rice husk ash, 0.5 tons mustard oilcake or 10 tons FYM/ha. The highest potato tuber yield (27 t/ha) was obtained from the highest NPK rate used. Amongst the manures the tuber yield were in the under of FYM > rice husk ash> mustard oil cake.

Adhikari *et al*, (1992) in a field trial on potatoes cv. Kufri gave 150 g nitrogen as urea or ammonia sulphate + 40 tons cowdung manure 302 tons mustard oilcake or 20 tons poultry litter or 230 kg nitrogen as urea or ammonium sulphate + 20 tons cowdung manure 1.6 tons mustard oilcake or 10 tons poultry litter /ha to gave total nitrogen application in each treatment of about 310 Kg /ha. Tuber yield percentage of tuber > 45 mm and net profit were maximum with the application of 150 Kg nitrogen as ammonium sulphate + 20 tons poultry litter/ha.

Neher (1999) conducted a field experiment at the Horticulture Farm, Bangladesh Agricultural University, Mymensingh during the period from November 1997 to February, 1998 in order to study the effect of fertilizer viz., no fertilizer, organic, inorganic, organic +inorganic and irrigation viz. no irrigation, irrigation at 20, 15 and 10 days interval. The results demonstrated that fertilizer management practices had significant effects on the yield and yield contributing characters. The maximum plant highest (52.0cm), fresh weight of haulm (0.102 Kg/hill), dry weight of haulm (10.078 g/hill), weight of tuber (396g/hill) and yield of tuber (27.09t/ha) were recorded when inorganic fertilizer managements were applied. However, the maximum number of main stems (3.65) per hill and dry matter of tubers (21.08%) were obtained from organic fertilizer management practices. Inorganic fertilizer management practices gave the highest percentage of >55mm (20.27) and 46-55mm (47.49) grade tubers. Inorganic fertilizer management practices gave significantly better result compared to other treatment.

Arafa (2004) conducted an experiment of different NPK treatments oil growth, yield, quality and chemical components of two potato cultivars. The effects of 3 levels of NPK fertilizers, i.e. 125+30+100, 150+45+150 and 175+60+200 kg/ha, on the growth, yield and its components, quality as well as chemical compositions (N, P, K, Fe, Mn_3 Zn, reducing, no reducing and total sugars) of foliage and tubers of 2 potato cultivars (lady Rosetta and Hermis)'were investigated under sandy soil conditions in Ismaalia Governorate, Egypt, during the summer seasons of 2002 and 2003.

The second level of NPK significantly increased plant height, number of branches per plant, fresh and dry weights of plant foliage, numbers of tubers per plant, tuber weight, plant yield, total yield, marketable yield, large (more than 55 mm in diameter) tuber percentage and chemical composition of foliage and tubers. Hermis compared with Lady Rosetta significantly increased the vegetative growth, yield and its components as well as chemical composition of plant foliage and tubers. The data concerning the interaction showed that Hermis in combination with the second level of NPK significantly increased all the studied character; Lady Rosetta in combination with the highest level of NPK increased the percentage of medium sized (35-55mm in diameter) tubers and dry matter content of tubers.

Marks and Krzysztofik (2001) observed the effect of different forms of organic manure and cultivation techniques on the quality of potato tuber yield. The application of organic manure (processed biomass form) and patch growing of potatoes improved the quality of potato yield compared with farmyard manure and ridge cultivation.

Gladkikh *et al.* (2001) conducted a trial with mineral fertilizer (various rates and combinations of N, P and K) and organic fertilizer in a farm of pet/manure compost. The crop rotations comprised tomatoes, cabbage, carrots, potatoes and cucumbers. The results were given from the 10^{th} rotation (1993-98). Yields were greatest in the treatments with complete mineral fertilizer, and with combined mineral and organic fertilizer.

MATERIALS AND METHOD

The study was conducted to examine the effect of potassium and boron fertilizers on the growth and yield of potato. This chapter presents a brief description about experimental period, site description, soil and climate condition of the experimental area, crop or planting materials, treatments, experimental design and layout, crop growing procedure, intercultural operations, data collection and statistical analysis, The details of experimental and methods are described below-

3.1 Experimental period

The experiment was carried out during the from November, 2019 to February 2020 in Rabi season.

3.2 Site description

3.2.1 Geographical location

The present research work was conducted in the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka – 1207. The experimental area was located at $23^0 74^{'}$N latitude and $90^0 33^{'}$E longitude at an altitude of 8.6 meter above the sea level.

3.2.2 Agro-Ecological Region

The experimental site belongs to the agro-ecological zone of “Modhupur Tract”, AEZ-28 (Amon, 1988). This was a region of complex relief and soils developed over the modhupur clay, where floodplain sediments buried the separated over the Modhupur Tract (Amon, 1988). The experimental site was shown in the map of AEZ of Bangladesh in Appendix I.

3.2.3 Climate Characteristics

Experimental site was situated at the sub-topical monsoon climate zone, set imparted by winter during the months from November, 2019 to February 2020 . Abundantly sunshine and moderately low temperature prevails during experimental period, which is suitable for potato growing in Bangladesh. The weather data during the study period at the experimental site are shown in Appendix II.

3.2.4 Soil Characteristics

The soil of the experimental site belongs to the general soil type, Shallow Red Brown Terrace Soil under Tejgaon Series. Top soils were clay loam in texture, olive-gray with common fine to medium distinct dark yellowish brown motels. Soil pH was 5.6 and had organic matter 1.3% The experimental area was flat having available irrigation and drainage system and above flood level. Soil samples from 0-15 cm depths were collected from experimental field. The properties studied included pH, organic matter, total N, available P and exchangeable K. The morphological, physical, and chemical characteristics of initial soil are presented in appendix I(A) and I(B).

3.3 Experimental details

3.3.1 Treatments of the experimental

Treatments:

$T_1 = N_{180}P_{30}S_{10}Zn_2$ Kg/ha

$T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha)

$T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha)

$T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha)

$T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha)

$T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha)

$T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha)

$T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha)

$T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

3.3.2 Experimental design and layout

The experiment was laid in Randomized Complete Block Design (RCBD) with three replications. Total research area was divided into 3 blocks. The size of each unit plot was (2.5m ×1.65m) or 4.125 m^2. The space between two blocks and two plots were 0.5 m and 0.75, respectively.

3.4 Planting materials

The seed tubers of selected potato varieties were collected from Bangladesh Agricultural Development Corporation (BADC) office, Gabtoli, Dhaka-1207. BARI ALU – 8 (Cardinal) was used as test crop in this experiment which was developed in 1973 by the Bangladesh Agricultural Research Institute. It is proposed for rabi season. It needs about 90-95 days to complete its life cycle with an average yield of around 25-35 t $ha^{-1.}$

3.5 Crop Management

3.5.1 Preparation of seed

Collected seed tubers were kept in room temperature to facilitate sprouting. Finally sprouted potato tubers were used as a planting material.

3.5.2 Land preparation

The experimental land was opened with a power tiller on 10 November 2019.

Ploughing and cross ploughing were done with power tiller followed by laddering. Land preparation was completed on 16 November, 2019 making soil adequate tilth. The soil was treated with Furadan 5g @ 10kg ha^{-1} when the plot was finally ploughed to protect the young plant from the attack of cut worm.

3.5.3 Fertilizer application

The crop was fertilized as per recommendation of REG, 2012. The N, P, K, S, Zn were used as Urea, Triple Super Phosphate (TSP), Muriate of Potash (MoP), gypsum and zinc sulphate respectively.

Fertilizers	Dose (Kg ha^{-1})
N	150
P	30
K	140
S	15
Zn	3

Source: FRG, 2012

The entire amount of triple super phosphate, MoP, gypsum, zinc sulphate and half of urea were applied as basal dose at 2 days before potato planting. Rest of the urea was side dressed in two equal splits at 35 and 50 Days after a Planting (DAP) during first and second earthing up.

3.5.4 Planting of seed tuber

The well sprouted healthy and uniform sized potato tubers were planted according to treatment and one fourth of a potato was used for one hill. Plant spacing was maintained 40 cm×20cm. Seed potatoes were planted in such a way that potato does not go much under soil or does not remain in shallow. On an average, potatoes were planted at 4-5 cm depth in soil on 17 November, 2019.

3.5.5 Intercultural operations

3.5.5.1 Weeding

Weeding was necessary to keep the plant free from weeds. The newly emerged weeds were uprooted carefully in the entire field after complete emergence of sprouts and afterwards when necessary.

3.5.5.3 Irrigation

Surface irrigation method was used to irrigate the potato field. Frequency of watering was done upon moisture status of soil retained as requirement of plants. Excess water was not given, because it always harmful for potato plant.

3.5.5.3 Earthing up

Earthing up to potato field was done to increase productivity and improve the quality of the tubers by protecting them from exposure to the sun. Earthing up process was done in the plot at two times, during crop growing period. First was done at 35 DAP and second was at 50 DAP.

3.5.5.4 Plant protection measures

Diathane M-45 was applied at 30 DAP as a preventive measure for controlling fungal infection. Ridomil (0.25%) was sprayed at 45 DAP to protect the crop from the attack of the late blight.

3.5.5.5 Harvesting of potatoes

Harvesting of potato was done on February , 2020. The potatoes of each treatment were separately harvested, bagged and tagged and brought to laboratory. Harvesting was done manually by hand.

3.6 Recording of data

The following data were collected during the experimentation.

A. Crop growth characters

i. Plant height (cm)
ii. Number of stem hill^{-1}

B. Yield and yield components

i. Number of tubers hill^{-1}

ii. Average weight of tuber hill^{-1}

iii. Yield of tubers kg plot^{-1}

iv. Yield of tubers t ha^{-1}

C. Quality characters

i. Tuber dry matter content

ii. Specific gravity

iii. Grading of tubers according to size and diameter

D. Postharvest soil analysis

i. Soil pH

ii. Organic carbon (%)

iii. Organic matter (%)

iv. Total N (%)

v. Available P (ppm)

vi. Exchangeable K (me/100 g soil)

vii. Available s (ppm)

A. Crop growth characters

i. Plant height (cm)

Plant height refers to the length of the plant from ground level to the tip of the tallest stem. It was measured at harvesting. The height of selected plant was measured in cm with help of a meter scale and mean was calculated.

ii. Number of stems hill^{-1}

Number of stems hill^{-1} was counted at the time of haulm cutting. Stem numbers hill^{-1} was recorded by counting all stem from each plot .

B. Yield and yield components

iii. Number of tubers hill^{-1}

Number of tubers hill^{-1} was counted at harvest. Tuber numbers hill^{-1} was recorded by counting all tubers from sample planting.

iv. Average weight of tubers (g hill^{-1})

Weight of tubers hill^{-1} was measure at harvest. Tuber weight hill^{-1} was recorded. by measuring all tubers from sample plant. Average weight of tubers (gm hill^{-1}) = Weight of tubers gm hill^{-1} ÷ No. of tubers hill^{-1}.

v. Yield of tuber (kg plot^{-1})

Tuber yield was recorded on the basis of total harvested tuber plot^{-1}

vi. Yield of tubers (t ha^{-1})

Tuber yield was recorded on the basis of total harvested tuber plot^{-1} and was expressed in terms of t ha^{-1}

C. Quality characters

vii. Tuber dry matter content (%)

The samples of tuber were collected from each treatment. After peel off the tubers the samples were dried in oven at 72^0C for 72 hours. From which the weights of tuber flesh dry matter content (%) were recorded. From which the dry matter percentage of tuber was calculated with the following formula:

Dry matter content (%) = (Dry weight ÷ Fresh weight) × 100 (Elfinesh et al., 2011)

viii. Specific Gravity

The specific gravity of potato tuber was measured for one sample per treatment. Tubers were randomly taken from each plot and washed with water, following which these tubers was then calculated using the following equation:

Specific gravity = (weight in air)/(weight in air – weight in water)

(Mohammed, 2016)

ix. Grading of tuber according to size and diameter (% by number)

Tubers harvested from each treatment were graded by number on the basis of diameter into the > 55 mm, 45-55 mm, 28-55 mm, <28 mm, >20 mm, <20 mm and converted to percentages (Hussain, 1995). A special type of frame (potato riddle) was used for grading of tuber.

D. Post-harvest soil sampling and analysis

After harvest of crop, soil samples were collected from each plot at a depth of 0 to 15 cm. Soil samples of each plot was air-dried, crushed, and passed through a two mm (10 meshes) sieve. The soil samples were kept in plastic container to determine the physical and chemical properties of soil.

Soil samples were analyzed for both physical and chemical characteristics viz. PH, organic matter, total N, available P and Exchangeable K contents. The soil samples were analyzed by the following standard methods as follows:

x. Soil pH

Soil pH was measured with the help of a glass electrode pH meter, the soil water ratio being maintained at 1:25 as described by Page et al., 1982

xi. Organic carbon

Organic carbon in soil sample was determined by wet oxidation method (Page et al., 1982). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$

xii. Organic matter

To obtain the content of organic matter was calculated by multiplying the percent organic carbon by 1.724 (Van Bemmelen factor) and the results were expressed in percentage.

xiii. Total nitrogen

Total N content of soil were determined followed by the Micro Kjeldahl method. One gram of oven dry ground soil sample was taken into micro Kjeldahl flask to which 1.1 gm catalyst mixture (K2SO_4: $CuSO_4$. 5$H_2$0: Se in the ratio of 100:10:1), and 6 ml H_2SO_4 were added. The flasks were swirled and heated 2000c and added 3 ml H_2O_2 and then heating at 3600c was continued until the digest was clear and colorless. After cooling, the content was taken into 100 ml volumetric flask and the volume was made up to the mark with distilled water. A reagent blank was prepared in a similar manner. These digests were used for nitrogen determination (Page at al., 1982). Then 20 ml digest solution was transferred into the distillation flask, Then 10 ml of H_3BO_3 indicator solution was taken into a 250 ml conical flask which is marked to indicator solution was taken into a 250 ml conical flask which is marked to indicate a volume of 50 ml and placed the flask under the condenser outlet of the distillation apparatus so that the delivery end dipped in the acid. Add enough 10N-NaOH solutions in the container connecting with distillation apparatus. Water runs through the condenser of distillation apparatus was checked. Operating switch of the distillation apparatus collected the distillate. The conical flask was removed by washing the delivery outlet of the distillation apparatus with distilled water. Finally, the distillates were titrated with standard 0.01 N H_2SO_4 until the color changes from green to pink.

The amount of N was calculated using the following formula:

$$\%N = (T - B) \times N \times 0.014 \times 100/W$$

Where,

T = Sample titration (ml) values of standard H_2SO_4

B = Blank titration (ml) value of standard H_2SO_4

N = Strength of H_2SO_4

W = Sample weight in gram

xiv. Available phosphorus

Available P was extracted from the soil with 0.5 M $NaHCO_3$ solutions, pH 8.5 (Olsen et al., 1954). Phosphorus in the extract was then determined by developing blue color with reduction of phospho-molybdate complex and the color intensity were measured calorimetrically at 660 nm wavelength and readings were calibrated with the standard P curve (Page et al., 1982)

xv. Exchangeable potassium

Exchangeable K was determined by 1N NH_4OAC (pH7) extraction methods and by using flame photometer and calibrated with a standard curve (Page et al., 1982).

xvi. Available Sulphur

Available Sulphur was determined by $CaCl_2$ extraction method and by using spectrophotometer at a wavelength 420nm and calibrated with a standard curve (Page et al., 1982).

3.7 Statistical Analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference the results of different levels of potassium and boron application on growth, yield, and shelf life of potato. The mean values of all the characters were calculated and analysis of variance was performed by the “F” (variance ratio) test.

The significant of the difference among the treatment was estimated by Duncan's Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez 1984)

RESULTS AND DISCUSSION

The experiment was conducted to know the effect of potassium and boron on yield, quality and shelf life of potato. This chapter comprises the presentation and discussion of the findings obtained from the experiment. The data were collected from the seedling stage to after harvesting stage. The data pertaining to yield contributing characters have been presented and statistically analyzed with the possible interpretations given under the following headings.

4.1 Crop growth characters

4.1.1 Plant height (cm)

The plant height of potato was measured at harvesting. It was shown from Table 1 and Figure 1 that the height of plant was significantly influenced by different treatment of potassium and boron at the sampling times. After potassium and boron application showed the longest plant (73.78 cm) from treatment (T_6) which was statistically identical with T_2 (60.88 cm), T_3 (64.36 cm), T_4 (60.41 cm), T_5 (57.97 cm), T_7 (59.97 cm), T_8 (64.19 cm), T_9 (61.23 cm)whereas the shortest plant (14 cm) from the T_1 treatment was found in this study. Plant height of a crop depends on the plant vigor, cultural practices, growing environment and the varietal characters and nutrition. In the present experiment since all the treatment were applied in the same environment and were given same cultural practices, the variation in the plant height among the treatments might be due to the nutrition deficiencies.

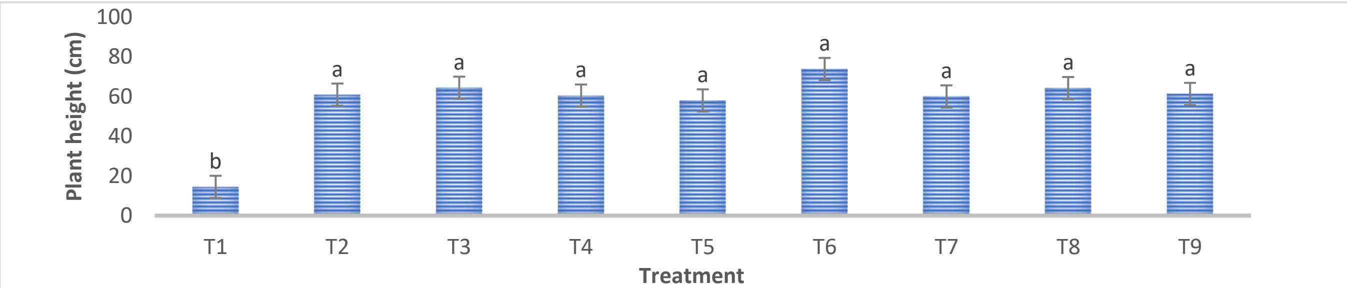

Figure 1. Effect of different treatments of potassium and boron on plant height

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.1.2 Average number of stems per hill

The number of stems hill^{-1} was significant among different potassium doses. The maximum stem numbers hill^{-1} (9.33) was obtained from $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha) treatment and the minimum (4.00) was obtained from T_1 (control) treatment. This might be due to different doses of potassium and boron fertilization application effect. Stem number per hill increased positively. From linear relation between that the yield of potato tuber will be increased if the stem number increases.

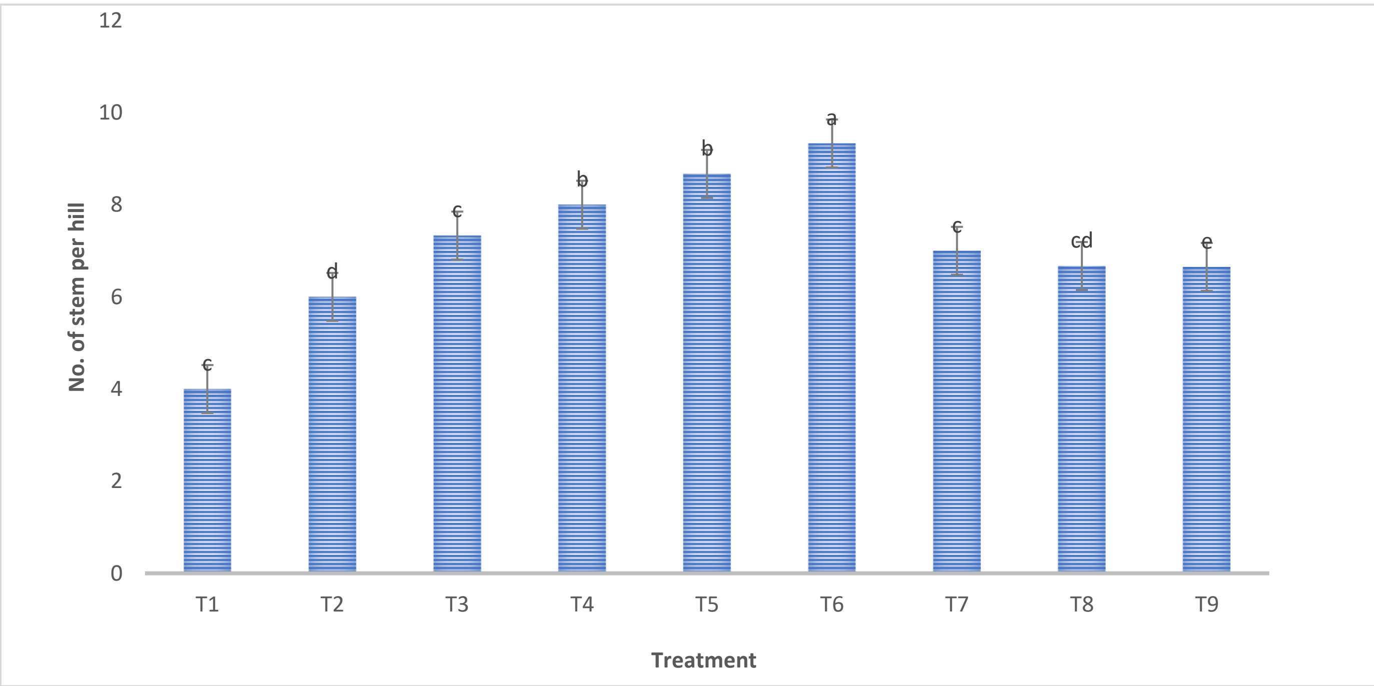

Figure 2. Effect of different doses of potassium and boron on no. of stem per hill

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.1.3 Average number of tubers per hill

Number of tubers hill^{-1} was significantly increased by different K and B doses. The maximum number of tubers hill^{-1} (8.67) was recorded $T_6 = T_1 +$ K (135 Kg/ha) + B (1 Kg/ha) treatment which was statistically similar with T_2 (7.00), T_3 (6.33), T_4(7.00), T_5(6.67), T_7(6.67), T_8(6.67), T_9(6.54) Whereas the minimum (5.32) was found from T_1 (control) treatment.

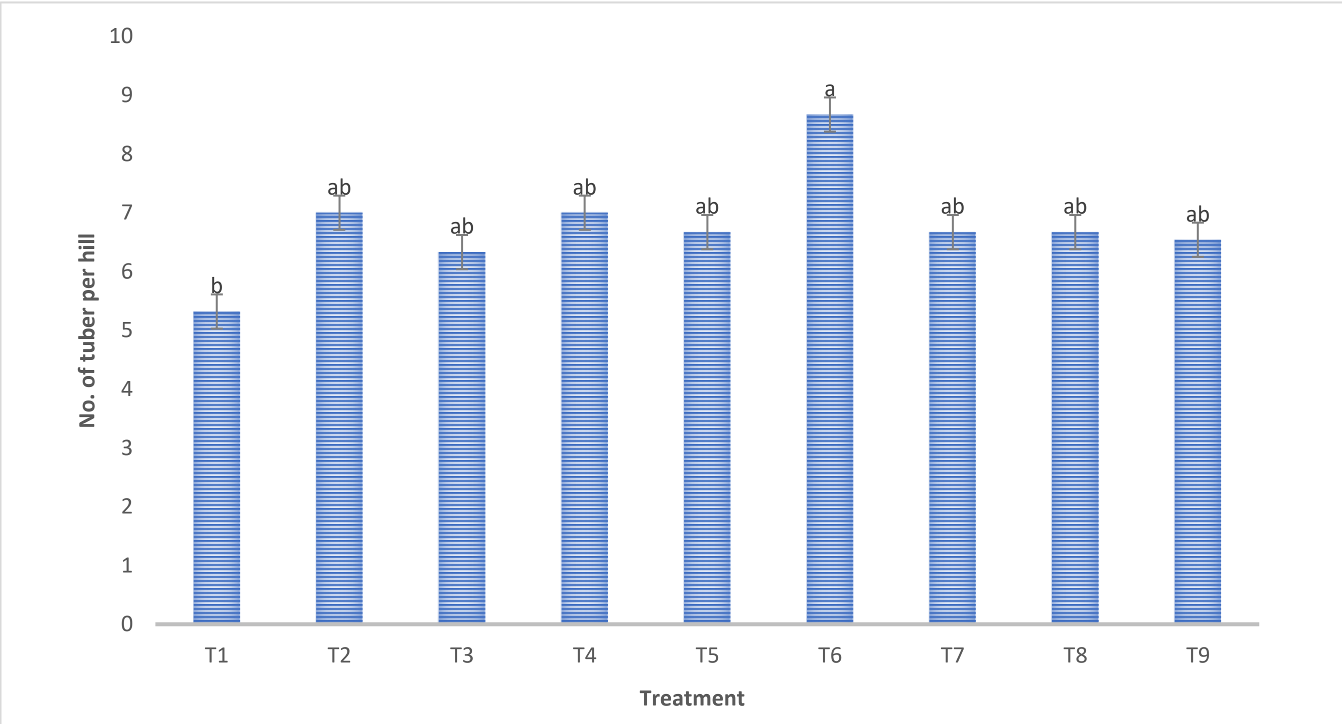

Figure 3. Effect of different treatments of potassium and boron on no. of tuber per hill

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.1.4 Average weight of tuber per hill

The average tuber weight enhanced positively due to application of different doses of K and B fertilizer. The maximum average tuber weight (0.45 kg) was recorded from treatment $T_5 = T_1 + K$ (90 Kg/ha) + B (1.5 Kg/ha); treatment which was statistically similar with T_2 (0.37 Kg), T_3 (0.35 Kg), T_4(0.32 Kg), T_6(0.41 Kg), T_7(0.34 Kg), T_8(0.40 Kg), T_9(0.43 Kg) treatment whereas the minimum weight (0.17 Kg) was obtained from T_1 (control) treatment.

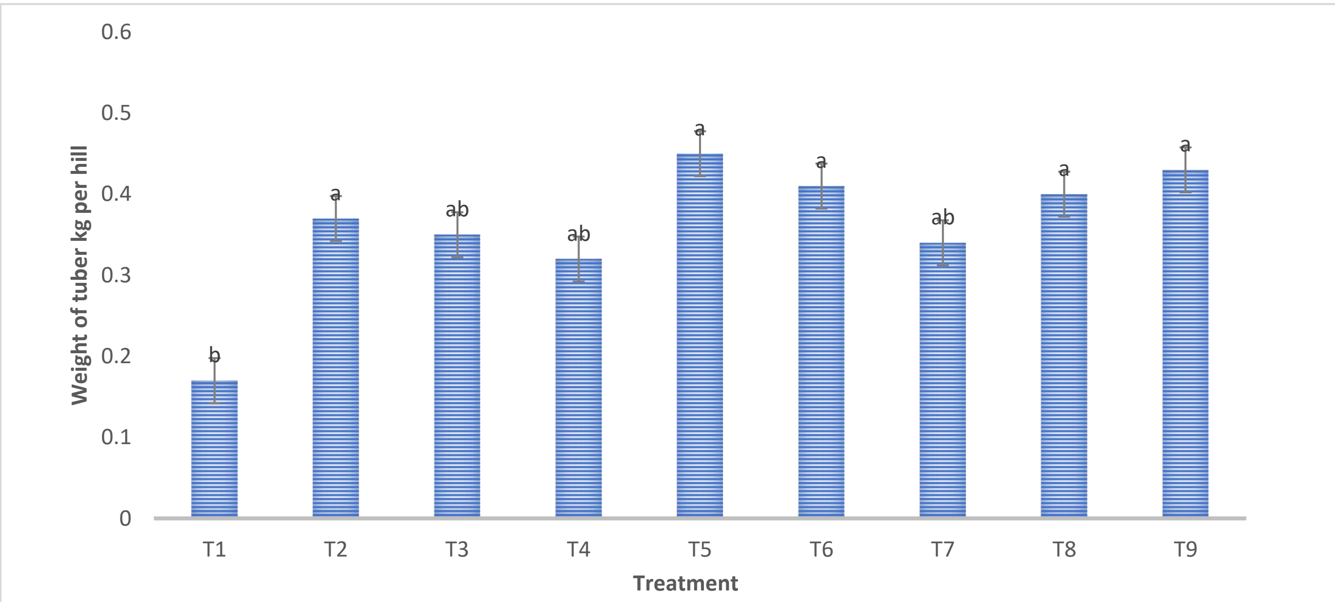

Figure 4. Effect of different treatments of potassium and boron on average weight of tuber per hill

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.1.5 Average tuber yield kg/plot

Different doses of K and B fertilizer application significantly increased the potato tuber yield. The highest tuber yield $plot^{-1}$ (17.43 kg) was obtained from treatment $T_6 = T_1 +$ K (135 Kg/ha) + B (1 Kg/ha) treatment while, the minimum (5.97 kg) was obtained from T_1 (control) treatment. Panique et al., (1997). Found that significant yield increases up to 332 kg K ha^{-1} and the increase in tuber yield was associated with an increase of tuber size (170 to 370 g).

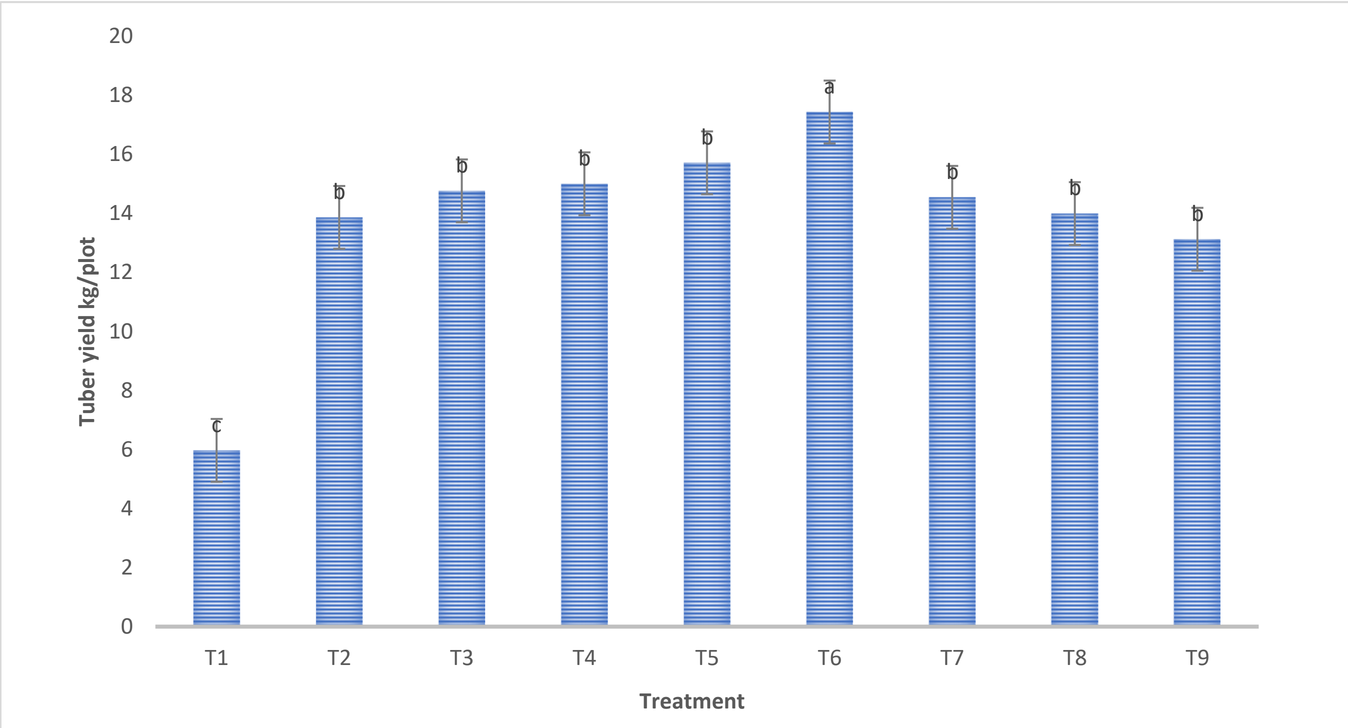

Figure 5. Effect of different treatments of potassium and boron on tuber yield (kg/plot)

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.1.6 Average tuber yield t/ha

Different K and B doses significant effect on the yield of tuber ha^{-1}. Data pertaining to tuber yield ton/ha. The highest tuber yield 34.86 t ha^{-1} was obtained from treatment $T_6 = T_1 + K$ (135 Kg/ha) + B (1 Kg/ha); treatment while, the minimum (11.95kg) was found from T_1 (control) treatment. Potassium and Boron significantly increase tuber yield with increasing potassium application rate up to 160 kg/ha. Haddad et al., (2016). revealed that water use efficiency increased from 3.43 to 4.33 kg m^{-3} using potassium nitrate fertilizer at rate of 380 kg/ha which in increased the potato tuber yield. Similar result was demonstrated by Pushpalatha et al., 2017

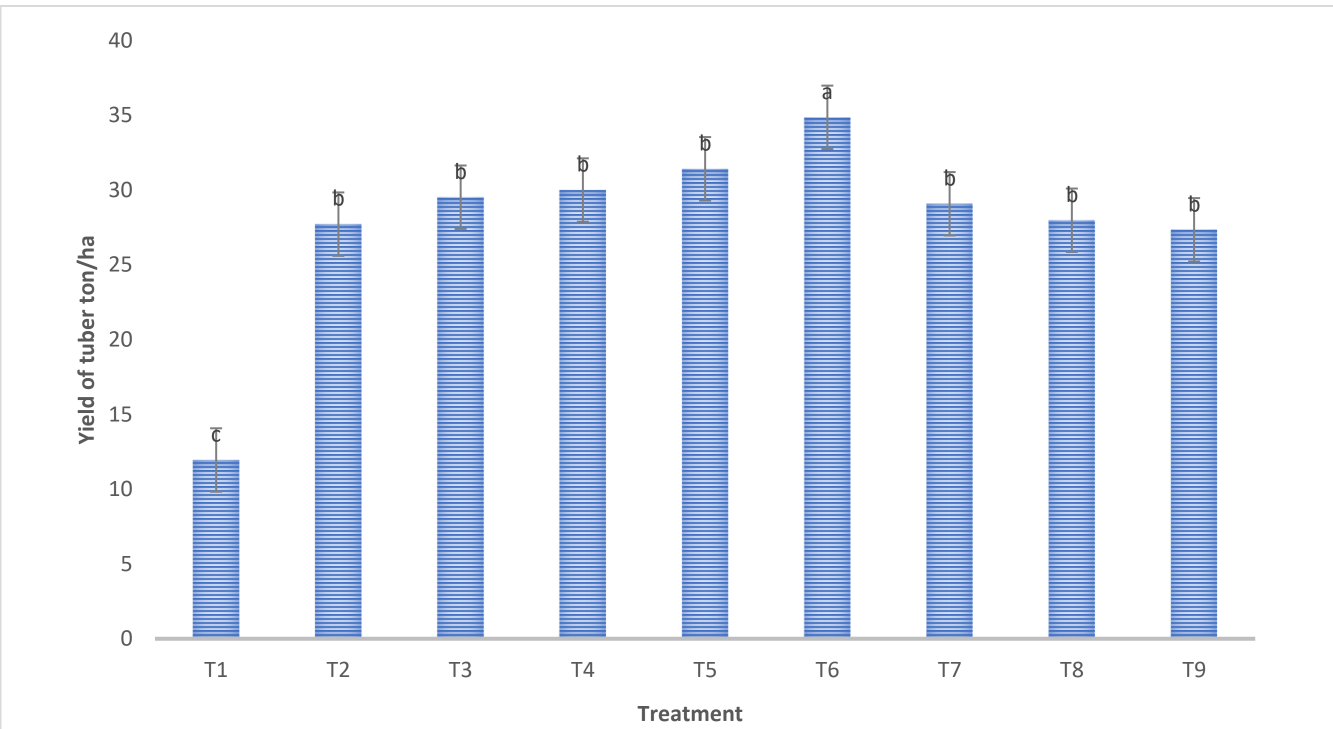

Figure 6. Effect of different treatments of potassium and boron on tuber yield ton/ha

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

Table 1. Effect of Potassium and boron on yield and yield contributing characters

Treatment	Plant height (cm)	Average no. of stem per hill	Average no. tuber per hill	Average weight of tuber per hill (kg)	Average tuber yield (kg/plot)	Average tuber yield (t/ha)
T1	14.47 b	4.00 e	5.32 b	0.17 b	5.97 c	11.95 c
T2	60.88a	6.00 d	7.00 ab	0.37 a	13.86 b	27.72 b
T3	64.36 a	7.33 c	6.33 ab	0.35 ab	14.76 b	29.52 b
T4	60.41 a	8.00 b	7.00 ab	0.32 ab	15.00 b	30.00 b
T5	57.97 a	8.67 b	6.67 ab	0.45 a	15.71 b	31.42 b
T6	73.78 a	9.33 b	8.67 a	0.41 a	17.43 a	34.86 a
T7	59.97 a	7.00 c	6.67 ab	0.34 ab	14.54 b	29.08 b
T8	64.19 a	6.67 cd	6.67 ab	0.40 a	13.99 b	27.98 b
T9	61.23 a	6.65 cd	6.54 ab	0.43 a	13.12 b	27.34 b
CV%	16.71	7.02	21.43	31.72	14.64b	14.64
$LSD_{0.05}$	16.67	0.81	2.55	0.13	0.20	3.20

4.2. Quality characters

4.2.1 Tuber Specific Gravity

Specific gravity of tuber significantly with increased with different levels of K and B application. The highest specific gravity of tuber was recorded (1.10) from $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); treatment which was statistically similar with T_7 treatment and the minimum was found from T_1 (1.05) treatment which was statistically similar with T_2 (1.05), T_3 (1.06), T_4(1.07), T_5(1.06), T_6(1.10), T_7(1.07), T_8(1.07) and T_9(1.06) treatment. The specific gravity is one of the quality measure of potato tuber. It is associated with starch content, total solids or dry matter or ash content and mealiness of potato tubers (Teich, A., and Menzies, J., 1964)

4.2.2 Tuber dry matter content (%)

Dry matter content (%) of tubers significantly increased with different levels of K and B application. The higher tuber dry matter content (23.67%) was recorded from $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha) treatment which was statistically with T_4(20.33), T_5(20.33), T_6 (23.33) and T_7 (22.0) treatment. The lower tuber dry matter content (14.67%) was recorded from T_1 (control) treatment. Similar result was found by Bourke, 1985.

Table 2: Effect of potassium on tuber dry matter content (%) and tuber specific gravity

Treatment	Specific gravity	Dry matter content (%)
T_1	1.05 b	14.67c
T_2	1.05 b	17.00 bc
T_3	1.06 b	15.00 c
T_4	1.07 b	20.33 ab
T_5	1.06 b	20.33 ab
T_6	1.10 b	23.33 a
T_7	1.07 b	22.0 a
T_8	1.07 b	23.67 a
T_9	1.06 b	13.33 c
CV%	1.47	10.53
$LSD_{0.05}$	0.027	3.60

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

4.2.3 Grading of tuber according to size (% by weight)

Based on weight, tubers have been graded into marketable tuber (>20gm) and non-marketable tuber (<20 gm). The results indicate that there was significant difference in the treatments in respect of production of different grades of tubers. The highest (54.4%) nonmarketable tuber (<20 gm) was produced from T_1 (control) treatment and the lowest (31.73%) no marketable tuber (<20 gm) was produced from T_6 treatment. The maximum (54.4%) marketable tuber (<20 gm) was produced from T_6 treatment while the minimum (41.16%) marketable tuber was produced from T_1 treatment. K and B positively increased the marketable yield with increasing rate up to 160 kg/ha Al-Moshileh et al. (2005) found that marketable tuber yield was significantly improved with increasing K_2SO_4 rates up to 450 kg/ha.

4.2.4 Grading of tubers on the basis of diameter (% by number)

On the basis of size diameter tubers have been graded into seed tuber 28-55 mm, non-seed tuber <28 mm and > 55 mm. The results indicate that there was significantly difference in different levels of potassium application in respect of production of different grades of tubers (Fig 10 & Table 3) , The maximum percentage of non-seed tuber <28 mm and > 55 mm (61.38%) obtained from T_7 treatment which was statistically similar T_1 (51.49%), T_2(51.49%), T3(51.49%), T_1 (51.49%),T_1 (51.49%) treatment and minimum percentage of non-seed tuber (61.13%) obtained from T_5 treatment. The maximum percentage of seed tuber (66.13%) between 28 mm to 55mm and minimum percentage of seed tuber (38.63%) were obtained from T_5 and T_7 treatment respectively Medium size potato tuber between 28 mm to 55mm used as seed tuber increased due to potassium and boron application.

4.2.5 Grading of tubers on the basis of diameter (% by number) for chips and non-chips

On the basis of size in diameter tubers have been graded into tuber for chips 45-55 mm, non-chips tuber <45 mm and >55 mm. The results indicate that there was significant difference in different levels of potassium and boron application in respect of production of different grades of tubers. The maximum percentage of tuber for non-chips (60.72%) obtained from T_1 treatment and minimum percentage of non-chips tuber (24.48%) obtained from T_5 treatment. The maximum percentage of tuber for chips (23.32%) and minimum percentage of chips tuber (32.32%) were obtained from T_5 and T_1 treatment respectively. Tuber for chips is processing quality of potato which was increased due to K and B application. Parveen et al, (2004) reveaked that, 124.5 kg K ha^{-1} give the highest yields of process grade tubers. K and B improves dry matter content of potato. Dry matter content is an essential quality parameter for potato processing. High dry matter content improves the quality of potatoes designated for human nutrition. It corresponds to high chips yield and low oil absorption during frying. (Wibowo et. al., 2014)

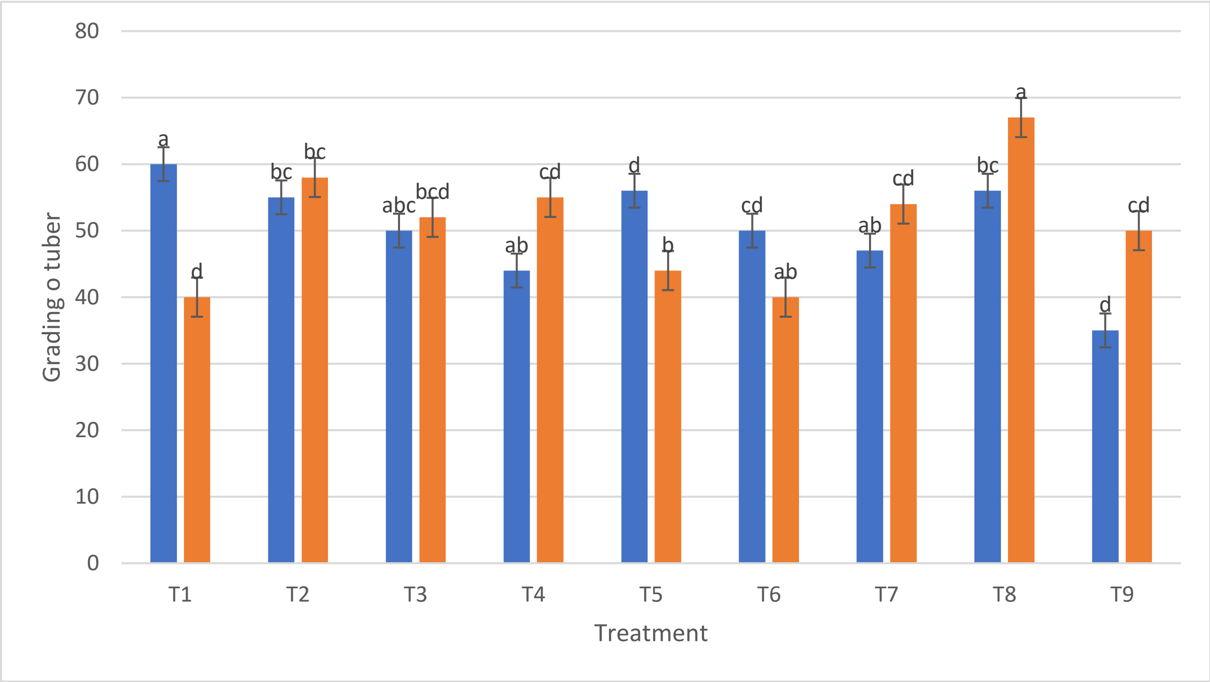

Figure 7: Effect of potassium and boron on grading of tuber according to size (% by number)

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha);

$T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha);

$T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha);

$T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha);

$T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha);

$T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha);

$T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha);

$T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha);

$T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.4 Effect of different levels of K and B on different chemical properties of post-harvest soil

4.4.1 Soil pH

Soil pH was not significantly influenced due to application of potassium and boron at different level among the treatment. The highest soil pH (6.40) was recorded in T_5 treatment while the lowest soil pH (6.13) was found from control (T_1) treatment.

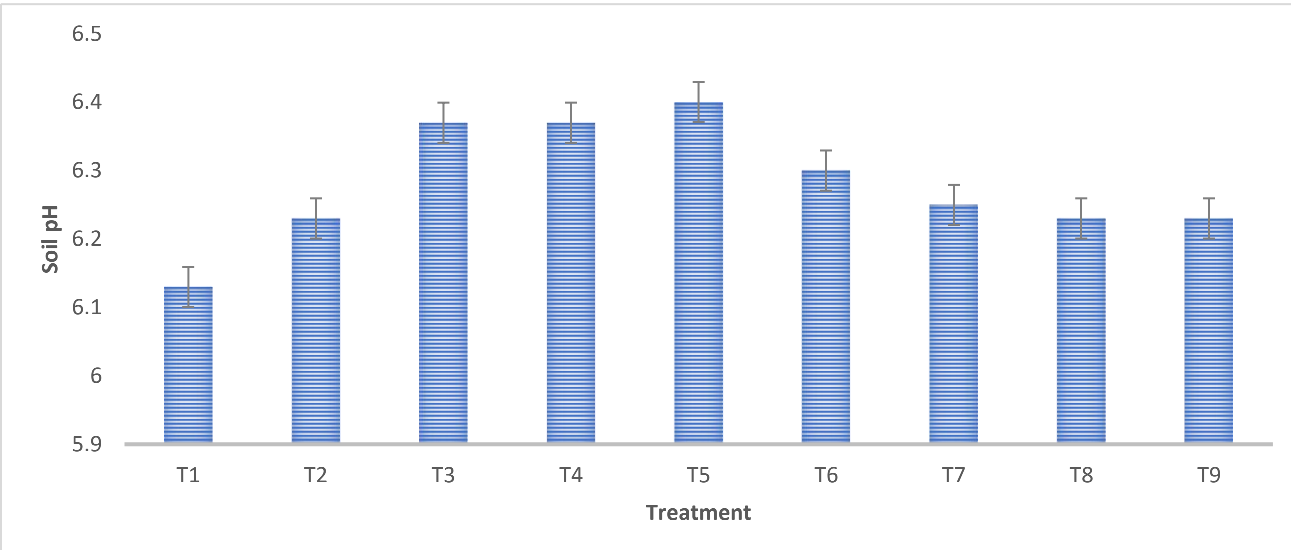

Figure 8: Effect of potassium and boron on soil pH

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha);

$T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha);

$T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha);

$T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha);

$T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha);

$T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha);

$T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha);

$T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha);

$T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.4.2 Organic carbon

Soil organic carbon found due to potassium application from different treatment was not statistically significant. The highest organic carbon (0.85%) was recorded in T_8 treatment while the lowest organic carbon (0.80%) was recorder from T_3 treatment.

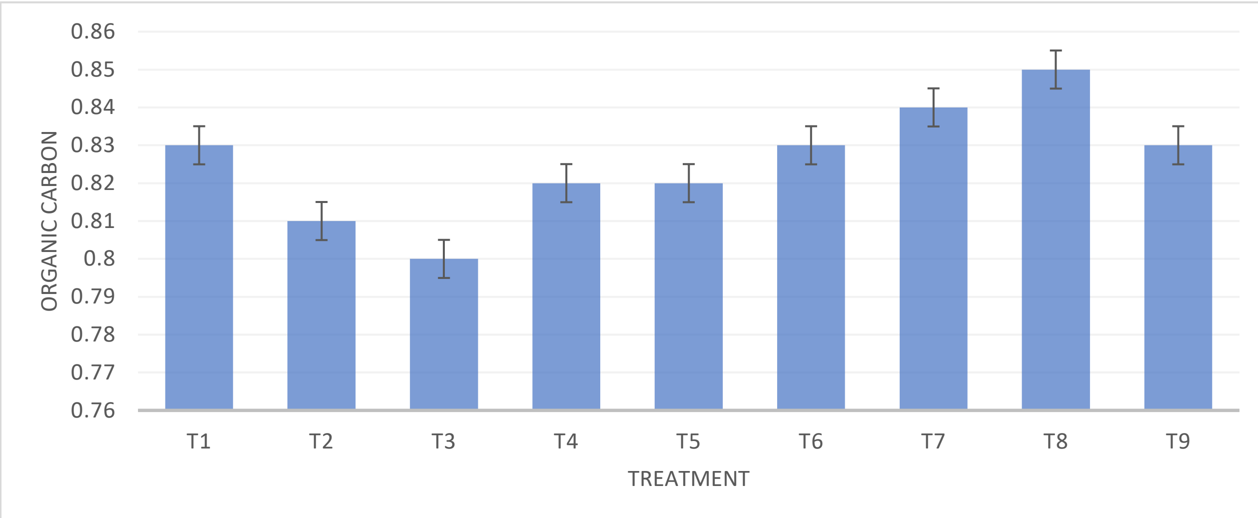

Figure 9: Effect of different levels of potassium and boron on organic carbon

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha);

$T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha);

$T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha);

$T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha);

$T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha);

$T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha);

$T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha);

$T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha);

$T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.4.3 Organic matter

Significant variation in the organic matter was not found from different level of potassium and boron application but organic matter was increased over control. The highest organic matter (1.42%) was recorded in T_8 treatment while the lowest organic matter (1.33%) was recorded in T_4 treatment. Fertilizers are applied to soils in order to maintain or improve crop yields, In the long-term, increased crop yields and organic matter returns with regular fertilizer applications result in a higher soil organic matter content and biological activity being attained than where no fertilizers are applied (Haynes and Naidu, 1998).

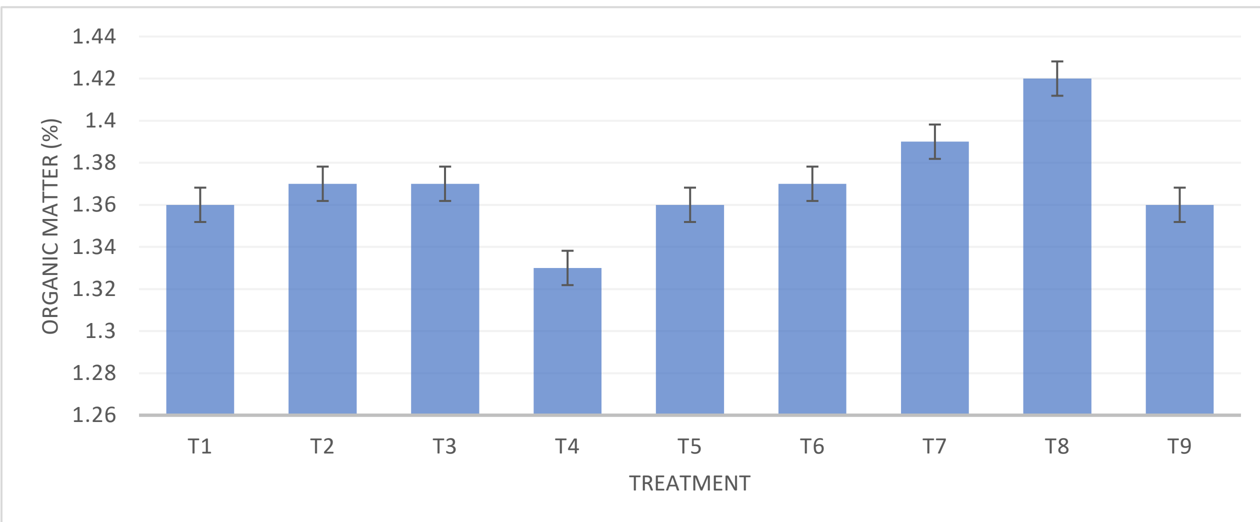

Figure 10: Effect of different levels of potassium and boron on organic matter (%)

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.4.4 Total Nitrogen

Different doses of potassium and boron application significantly increased the total nitrogen (%) content of soil. The maximum total nitrogen (0.087%) was recorded in T_4 treatment which was statistically similar with T_3 (0.082%) and minimum was recorded from control treatment. Potassium modifies ammonium (NH_4^+) ion fixation in soil to restrict nitrogen (N) availability which contributes to low nitrogen loss thus increased the total nitrogen in soil (Daliparthy et al., 1994).

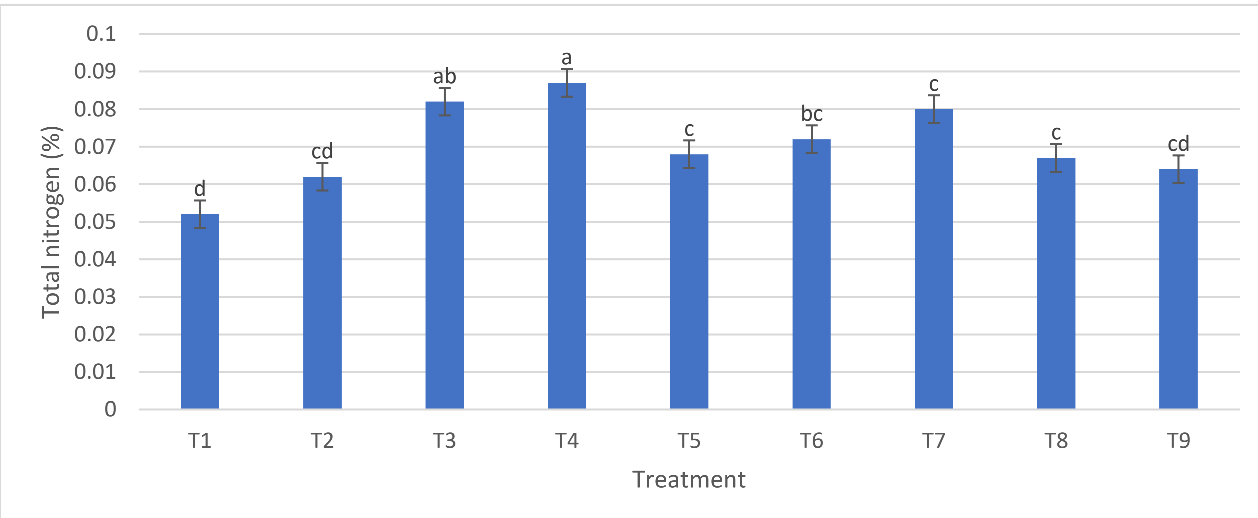

Figure 11: Effect of potassium and boron on total nitrogen (%)

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.4.5 Available Phosphorus

The different treatment significantly showed variation in the Available phosphorus. The highest available phosphorus (28.5 ppm) was recorded from T_3 which was statistically similar with T_4 (27.3 ppm) and T_6 (26.0 ppm) treatment while the lowest available phosphorus (14.73 ppm) was recorded from T_7 treatment.

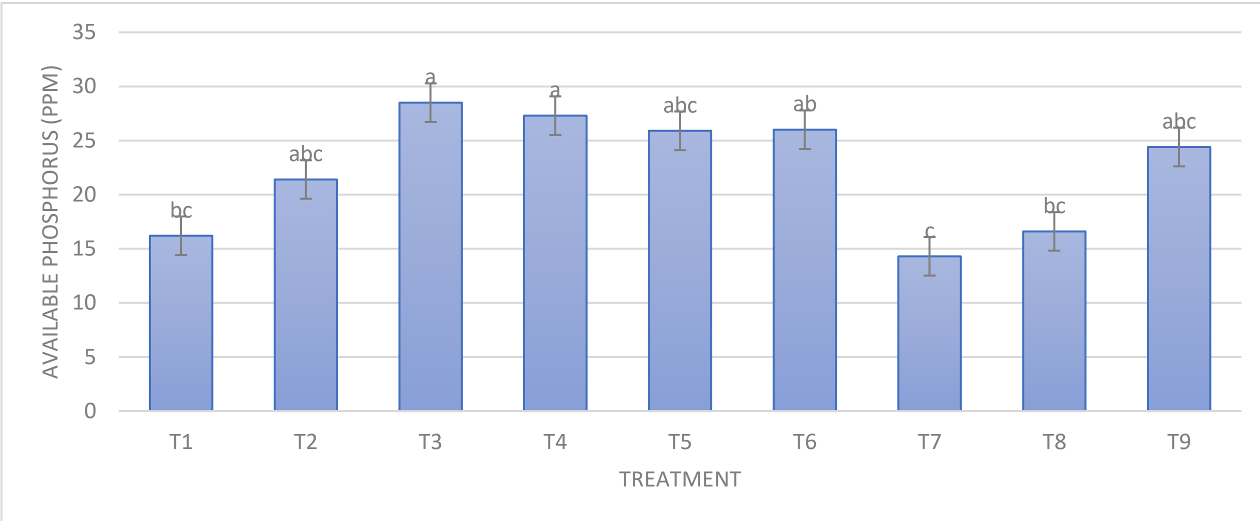

Figure 12: Effect of different treatment on available phosphorus (ppm)

T_1 = $N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); T_2 = T_1 + K (45 Kg/ha) + B (1 Kg/ha); T_3 = T_1+ K (45 Kg/ha) + B (1.5 Kg/ha); T_4 = T_1 + K (90 Kg/ha) + B (1 Kg/ha); T_5 = T_1 + K (90 Kg/ha) + B (1.5 Kg/ha); T_6 = T_1 + K (135 Kg/ha) + B (1 Kg/ha); T_7 = T_1+ K (135 Kg/ha) + B (1.5 Kg/ha); T_8 = T_1 + K (180 Kg/ha) + B (1 Kg/ha); T_9 = T_1+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.4.6 Exchangeable potassium

Exchangeable potassium was significantly influenced by different treatment. The highest exchangeable potassium (0.48%) was recorded in T_6 (160kg K ha^{-1} + N, P, S , Zn at RFD) treatment which was statistically similar with T_4 (0.45) while the lowest exchangeable potassium (0.18%) was recorded in T_1 (control) treatment. Exchangeable K was positively increased due to different level of K application. Zeng et al., (2001) found that soil NH_4^+ extractable K increased significantly as a result of K fertilization at the annual rate of 110 to 330 kg/ha.

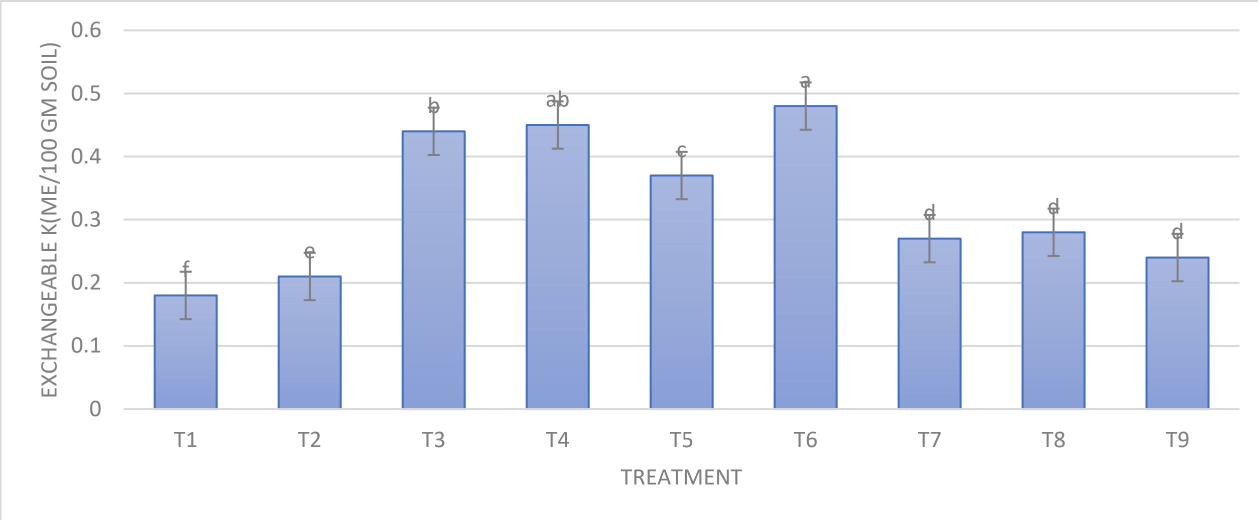

Figure 13: Effect of different treatment on exchangeable K (ME/100 GM soil)

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

4.4.7 Available Sulphur

Application of different level of potassium and boron was not significantly influence the available Sulphur (ppm) in soil. The maximum available Sulphur found from T_6 (160 kg ha^{-1} + N, P, S, Zn at RFD) treatment while the minimum was found from T_9 treatment.

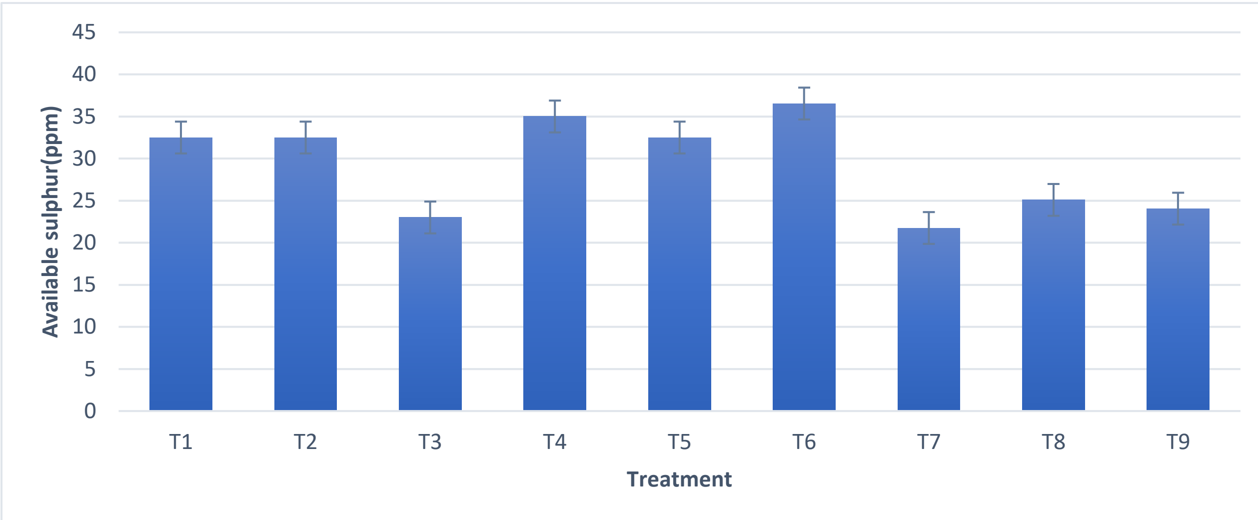

Figure 14: Effect of different treatment on available Sulphur

$T_1 = N_{180}P_{30}S_{10}Zn_2$(Kg/ha);

$T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha);

$T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha);

$T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha);

$T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha);

$T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha);

$T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha);

$T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha);

$T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

Table 3. Effect of Potassium and boron on postharvest soil properties

Treatment	Soil pH	Organic carbon	Organic matter	Total N (%)	Available P (ppm)	Exchangeable K (me/100 gm soil)	Available Sulphur (ppm)
T_1	6.13 a	0.83 a	1.36 a	0.052 d	16.2 bc	0.18 f	32.5 a
T_2	6.23 a	0.81 a	1.37 a	0.062 cd	21.4 abc	0.21 e	32.5 a
T_3	6.37 a	0.8 a	1.37 a	0.082 ab	28.5 a	0.44b	23 a
T_4	6.37 a	0.82 a	1.33 a	0.087 a	27.3 a	0.45 ab	35 a
T_5	6.4 a	0.82 a	1.36 a	0.068 c	25.9 abc	0.37 c	32.5 a
T_6	6.3 a	0.83 a	1.37 a	0.072 bc	26 ab	0.48 a	36.54 a
T_7	6.25 a	0.84 a	1.39 a	0.08 c	14.3 c	0.27 d	21.75 a
T_8	6.23 a	0.85 a	1.42 a	0.067 c	16.6 bc	0.28 d	25.09 a
T_9	6.23 a	0.83 a	1.36 a	0.064 b	24.4 b	0.24 d	24.05 a
CV%	3.17	4.34	5.29	9.17	27.93	5.45	30.18
$LSD_{0.05}$	NS	NS	NS	0.011	10.75	0.032	NS

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 level of probability.

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

SUMMARY AND CONCLUSION

A field experiment was done with potato variant ‘Cardinal at the Experimental plot of Sher-e-Bangla Agricultural University during the period from November, 2019 to February 2020 to find out the effect of potassium and boron on the performance of growth and yield of potato. The experiment consisting of 9 treatment combinations was laid out in the Randomized Complete Block Design (RCBD) with three replications. The treatments were

$T_1 = N_{180}P_{30}S_{10}Zn_2$ (Kg/ha); $T_2 = T_1$ + K (45 Kg/ha) + B (1 Kg/ha); $T_3 = T_1$+ K (45 Kg/ha) + B (1.5 Kg/ha); $T_4 = T_1$ + K (90 Kg/ha) + B (1 Kg/ha); $T_5 = T_1$ + K (90 Kg/ha) + B (1.5 Kg/ha); $T_6 = T_1$ + K (135 Kg/ha) + B (1 Kg/ha); $T_7 = T_1$+ K (135 Kg/ha) + B (1.5 Kg/ha); $T_8 = T_1$ + K (180 Kg/ha) + B (1 Kg/ha); $T_9 = T_1$+ K (180 Kg/ha) + B (1.5 Kg/ha)

Data were collected on several parameters that the yield and yield contributing characters like 1. Plant height, 2. Average number of stems per hill, 3. Average number tuber per hill 4. Average weight of tuber per hill 5. Average weight of tuber kg/plot, 6. Average tuber yield t/ha. Quality parameters like 1. Marketable yield (%), 2. Non-marketable yield (%), 3. Seed yield (%), 4. Non-Seed yield (%), 5. Chips yield (%), 6. Non-hips yield (%), 7. Specific gravity (%), 8. Dry matter content. Soil parameters like 1. pH, 2. Organic carbon, 3. Organic matter, 4. Total Nitrogen, 5. Available phosphorous, 6. Exchangeable potassium, 7. Available Sulphur. The data were collected from the seedling stage to after harvest storage. Weight loss at storage was recorded at 15, 30,45, 60 days after storage. The data pertaining to yield contributing characters have been presented and statistically analyzed by statistical 10 software program with the possible interpretations.

Potassium and boron application influenced most of the parameters observed in this study. Compared to control, K resulted showed vigorous plant growth, increased number of potato tubers, greater tuber weight and maximum tuber yield. It was postulated that among the treatments used in this study, T_6 treatment was superior, where longest plant (73.78 m), maximum stem numbers hill^{-1} (9.33), maximum number of tubers hill^{-1} (8.67), highest tuber yield plot^{-1} (17.43 kg) and highest tuber yield 34.86 t ha $^{-1}$ were recorded.

Different treatment of potassium showed variation for quality attributes of potato tuber. Tuber specific gravity tuber dry matter content and tuber size were impacted significantly by K and B application. Compared to control, the highest specific gravity (1.10), higher tuber dry matter (23.67), maximum (68.44%) marketable tuber (>20 g) and maximum number of potato for chips (71.52%) were observed from the $T_{6,}$ T_8, T_6 and T_5 treatments, respectively.

Soil quality parameters such as pH, organic carbon, total N, available P and S were not significantly influenced by K and B application except exchangeable K in this experiment. The highest soil pH (6.40), the highest organic carbon (0.85%), the highest organic matter (1.42%), the maximum total nitrogen (0.087%), the highest available phosphorus (28.5 ppm), were recorded from T_5, T_8,$T_{8,}$$T_4$,$T_3$ treatment respectively. The highest exchangeable potassium (0.48%) and the maximum available Sulphur (36.54 ppm) were found from T_6. The maximum weight loss due to potassium application recorded from T_1 (control) treatment whereas the minimum weight loss was recorded from T_6 treatment.

From the findings of the present study, the following recommendations could be provided:

- Treatment T_1 was found lowest yield and other characters so there was clear that potassium and Boron had influence on growth and yield of potato.
- Based on different agronomic performance treatment T_6 was best treatment.

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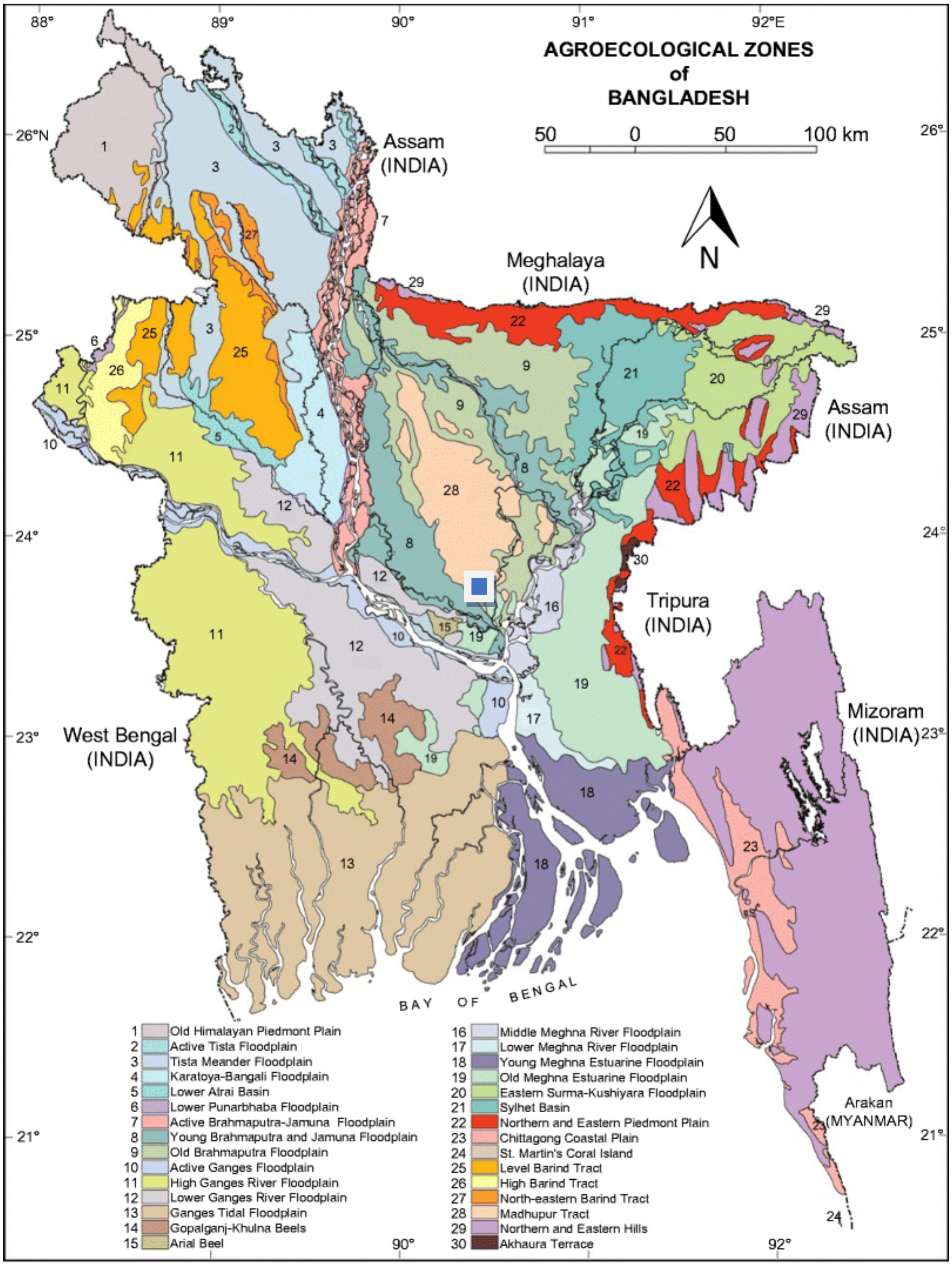
APPENDICES

Appendix I. Map showing the experimental site under the study



The experimental site under study

Appendix: I(A) Morphological characteristics of the experimental field

Morphological features	Characteristics
Location	Experimental Field, SAU, Dhaka
AEZ and name	AEZ-28
Physiography	High Ganges River floodplain
Soil series	Tejgaon
Topography	Fairly leveled
Land type	High land, Medium high land
Drainage condition	Well drained

Appendix II: Physical and chemical characteristics of the initial soil (0-15 cm depth)

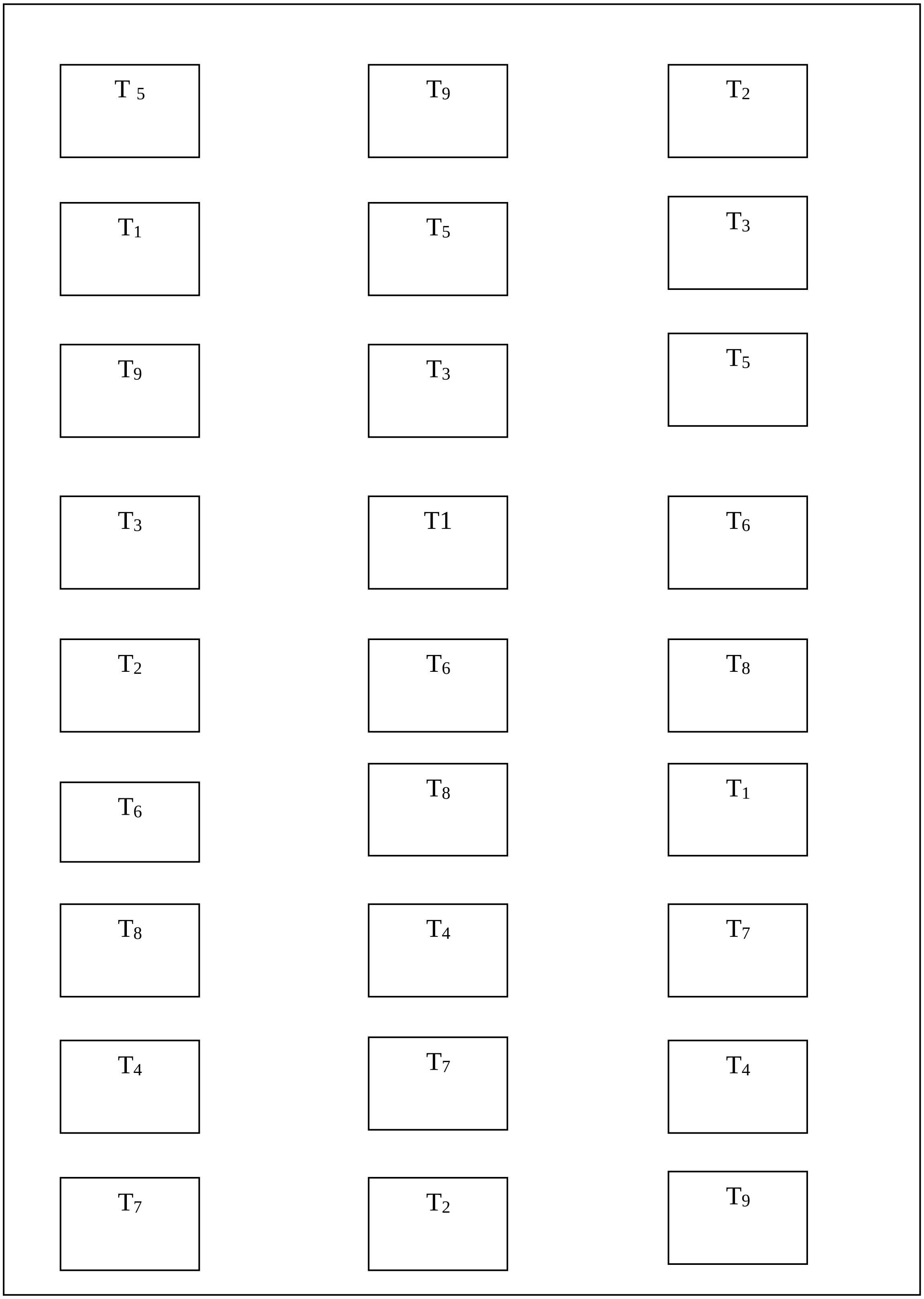
Characteristics	Value
Mechanical fractions: % sand (2.0-0.2 mm) % Silt (0.02-0.002 mm) % Clay (<0.002mm)	 26 43 30
Textural class	Clay loam
pH	5.6
Organic carbon	0.76
Organic matter (%)	1.3
Total N (%)	0.06
Available P (ppm)	18.49
Exchangeable K (me/100g soil)	0.10
Available S (ppm)	15.6

Appendix III: Layout of the experimental plot

Plot size: 2.5 m × 1.65 m (4.125m^2)

Plot to plot distance: 0.75 m

Block to block distance: 0.5 m



Appendix: IV Monthly record of year temperature, rainfall, air temperature and relative humidity during the period from November 2019 to February 2020

Month	Year	**Air Temperature (°C)			**Humidity (%)	*Rainfall (mm)
		Max.	Min.	Average		
November	2019	32.3	13.2	22.75	80.5	0.00
December	2019	28.3	5.8	17.05	78.75	17.2
January	2020	28.2	7	17.6	77	0.00
February	2020	31.6	8.9	20.25	77	47.1

**= Monthly average

* = Monthly total

Appendix: V Analysis of Variance for different parameters
Randomized Complete Block AOV Table for plant height

Source of variation	DF	SS	MS	F	P
Replication	3	164.57	82.286		
Treatment	9	6698.88	956.983	10.55	0.0001
Error	27	1269.73	90.695		
Total	39	8133.18			

Randomized Complete Block AOV Table for number of stem per hill

Source of variation	DF	SS	MS	F	P
Replication	3	0.3333	0.16667		
Treatment	9	30.6250	4.3750	20.42	0.0000
Error	27	3.0000	0.2149		
Total	39	33.9583			

Randomized Complete Block AOV Table for number of tuber per hill

Source of variation	DF	SS	MS	F	P
Replication	3	12.3333	6.16667		
Treatment	9	17.9583	2.56548	1.21	0.3589
Error	27	29.6667	2.11905		
Total	39	59.9583			

Randomized Complete Block AOV Table for average weight of tuber per hill

Source of variation	DF	SS	MS	F	P
Replication	3	0.01136	0.00568		
Treatment	9	0.14877	0.02125	1.71	0.1849
Error	27	0.17352	0.01239		
Total	39	0.33366			

Randomized Complete Block AOV Table for tuber yield (kg/plot)

Source of variation	DF	SS	MS	F	P
Replication	3	36.218	18.1089		
Treatment	9	225.442	32.2061	9.66	0.0002
Error	27	46.691	3.3350		
Total	39	308.351			

Randomized Complete Block AOV Table for tuber yield ton/ha

Source of variation	DF	SS	MS	F	P
Replication	3	144.87	72.436		
Treatment	9	901.77	128.824	9.66	0.0002
Error	27	186.76	13.340		
Total	39	1233.40			

Randomized Complete Block AOV Table for specific gravity

Source of variation	DF	SS	MS	F	P
Replication	3	0.001512	7.62E-04		
Treatment	9	0.00647	9.238E-04	3.79	0.01612
Error	27	0.00341	2.435E-04		
Total	39	0.01140			

Randomized Complete Block AOV Table for dry matter content

Source of variation	DF	SS	MS	F	P
Replication	3	30.083	15.0417		
Treatment	9	268.625	38.3750	9.07	0.0003
Error	27	59.250	4.2312		
Total	39	357.958			

Appendix: VI Photographs that were captured during research work on the experimental field

Plate: 1 Photograph showing the sprouted seed tubers at the time of planting

Plate: 2 Photograph showing the planting of seed tuber

Plate: 3 Photograph showing the young seedling of Cardinal variety

Plate: 5 Photograph showing the experimental plot at 70 days after planting

Plate: 6 Photograph showing the experimental plot before harvesting

Plate: 7 Photograph showing the tuber number per plant at harvest for Cardinal variety