INFLUENCE OF POTASSIUM AND SULFUR ON GROWTH AND YIELD OF POTATO DERIVED FROM TPS SEEDLING TUBER

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CERTIFICATE

This is to certify that the thesis entitled "**INFLUENCE OF POTASSIUM AND SULFUR ON GROWTH AND YIELD OF POTATO CROP DERIVED FROM TPS SEEDLING TUBER**" submitted to the DEPARTMENT OF AGRONOMY, Sher-e-Bangla Agricultural University, Dhaka in partial fulfillment of the requirements for the degree of MASTER OF SCIENCE (M.S.) in AGRONOMY, embodies the results of a piece of bonafide research work carried out by MD.RAFIQUL ISLAM, Registration No. 05-1660, under my supervision and guidance. No part of this thesis has been submitted for any other degree or diploma in any other institution.

I further certify that any help or sources of information received during the course of this investigation have been duly acknowledged.

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DEDICATION

To My Grandfathers

Haji Abdul Aziz Hawladar

Principal A.K.M.Nurul Haq

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INFLUENCE OF POTASSIUM AND SULFUR ON GROWTH AND YIELD OF POTATO CROP DERIVED FROM TPS SEEDLING TUBER[1]

ABSTRACT

The experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from 10 November 2010 to 10 March 2011 to investigate the effect of potassium and sulfur on morpho-physiological characters, yield attributes and yield of potato. The experiment comprised of four different doses of potassium (0, 117, 130, 43 kg ha^{-1}) along with sulfur (0, 24, 29 and 34 kg ha^{-1}). The experiment was laid out in split plot design with three replications. The growth parameters such as plant height, stems hill^{-1}, leaves hill^{-1}, total dry mass (TDM) plant^{-1} and TDM m^{-2}, yield attributes such as tubers hill^{-1} and single tuber weight and tuber yield and marketable yield were significantly influenced by potassium and sulfur. Results revealed that, number of leaves hill^{-1}, stems hill^{-1}, plant dry matter content, tuber dry matter content, tubers m^{-2}, seed yield, marketable yield significantly increased with increasing potassium levels, whereas, plant height decreased with increasing potassium level. On the other hand plant dry matter content, tuber dry matter content, stems hill^{-1}, tubers m^{-2}, seed yield, marketable yield increased significantly with increasing sulfur level. While plant height, number of leaves hill^{-1} and tubers m^{-2} decreased with increasing sulfur level. Combined effect of potassium and sulfur reveled taht the highest number of tubers m^{-2} was achieved by 130 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}. But 130 kg potassium ha^{-1} with 29 kg sulfur ha^{-1} produced more 45-55 mm sized tuber than 130 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}. Application of 130 kg potassium ha^{-1} with 34 kg sulfur ha^{-1} produces more <28 mm sized tuber than that of 130 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}. Finally 130 kg potassium ha^{-1} with 29 kg sulfur ha^{-1} produced numerically highest yield but statistically similar with 130 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}.

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CHAPTER I

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops of the world and holds the fourth position in production next to wheat, rice and maize (FAO, 2009). It is grown almost all countries of the world. In Bangladesh, potato is one of the major crops next to rice and wheat and covers an area of about 403.4 thousand ha of land producing 5.95 million tons of potato with 14.74 tons of average yield ha^{-1} (MOA, 2009). It is considered as a vegetable crop and contributes as much 55 % of the total vegetable production in Bangladesh (BBS, 2009).

Potato has acquired great importance in rural economy in Bangladesh. It is not only a cash crop but also an alternative of food crop against rice and wheat. Bangladesh has a great agro-ecological potential of growing potato. The area and production of potato in Bangladesh has been increasing during the last decades but the yield per unit area remains more or less static. The yield is very low in comparison to that of the other leading potato growing countries of the world, 40.16 t ha^{-1} in USA, 42.1 t ha^{-1} in Denmark and 40.0 t ha^{-1} in UK, (FAO, 2009). The reasons for such a low yield of potato in Bangladesh are imbalanced fertilizer application, use of low quality seed and use of sub-optimal production practices. Available reports indicated that potato production in Bangladesh can be increased by improving cultural practices among which optimization of manure and fertilizer, planting time, spacing and use of optimal sized seed are important which influences the yield of potato. (Divis and Barta 2001). In Bangladesh 434562 ha land is under potato cultivation. (BBS, 2009)

Potassium is the only essential plant nutrient that is not a constituent of any plant part. Potassium is a key nutrient in the plants tolerance to stresses such as cold/hot temperatures, drought, and wear and pest problems. In potato K can plays important role on it's growth yield and yield contributing characters.

Sulfur is one of the 16 essential nutrient elements. This is the 4th among major nutrients required for potato's growth and yield. Sulfur deficiency have poor utilization of NPK and significant reduces of plant growth and development, decrease in tuber dry matter and concentration of dry matter were observed with sulfur deficiency (Epprnderfer and Eggum. 1994)

i) To find out the effect of potassium on growth and yield of potato derived from TPS

ii) To find out the effect of sulfur on growth and yield of potato derived from TPS

iii) To study the combined effect of potassium and sulfur on growth and yield of potato derived from TPS.

CHAPTER II

REVIEW OF LITERATURE

Roy *et al.* (2007) conducted an experiment to find out the relationship of Nitrogen and potassium on quality of TPS. Three levels of nitrogen (0, 225 and 300 kg N ha^{-1}) and 4 levels of potassium (0, 125, 175 and 225 kg K ha^{-1}) fertilizers were applied to potato mother plants (MF-II) for the production of high quality True Potato Seed (TPS). The author showed that, increase in K application significantly increased N, P and K concentrations, while decreases in Ca, Mg and Na concentrations in TPS. Increase in N application significantly increased N, P, Ca, Mg and Na concentrations in TPS but K did not increase. Tuber weight was the highest (10.4) when 300 kg N and 125 kg K ha^{-1} were applied. Large TPS also showed high emergence rate (94%), seedling vigor (4.8) and dry matter content (10.5%) in nursery beds when 300 kg N and 125 kg K ha^{-1} was applied. Large TPS always showed better performance than small TPS. In conclusion, the combination of 300 kg N and 125 kg K ha^{-1} was the best combination for application to potato mother plants for the production of high quality TPS.

Karam *et al* . *(* 2005) showed that, in some cultivars potassium fertilization significantly increased the yield of medium (25-75 g) and large size tubers (>75 g) at the cost of small size tubers (<25 g). A Field experiments were conducted in 1999 and 2001 at Tal Amara Research Station in the Bekaa Valley of Lebanon to determine the response of yield and tuber quality of four potato cultivars ('Spunta', 'Derby', 'Shepody' and 'Umatilla') to added potassium rates: K_0 (0 potassium), K_1 (96 kg K ha^{-1}), K_2 (192 kg K ha^{-1}) and K_3 (288 kg K ha^{-1}) in absence of water and nitrogen limitations. Data from this study showed that responsive K treatments were evident in both years. The significant increases of tuber yield in response to K rates that were observed in 1999 for 'Spunta' and 'Derby' were associated with a lowering, for the former, and an increase, for the latter, in tuber dry matter. Similar increases in tuber yield were obtained in 2001 in the potassium treatments for 'Shepody' and 'Umatilla'. However, while for 'Shepody' tuber yield increase was associated with an increase in dry matter content, no increase in this parameter was obtained with 'Umatilla'. Finally, results showed no significant differences between the two potassium levels K_2 and K_3 either for tuber yield or dry matter content.

Lalitha *et al. (*2002*)* showed that, application of 150 kg K ha^{-1} gave the highest tuber yield. The productivity of potato cultivars HPS-1/13 and Kufri Jyothi, propagated through true seeds and seed tubers, was evaluated on alfisol in Bangalore, Karnataka, India, under 3 K levels (100, 125 and 150 kg ha^{-1}) and 2 S levels (0 and 25 kg ha^{-1}).The tuber yield of both cultivars did not differ significantly (20.22 and 20.08 t ha^{-1} for HPS-1/13 and Kufri Jyothi, respectively). HPS-1/13 produced higher C (25-50 g) and D (<25 g) grade tubers with higher starch and protein contents, while A (75 g) and B (50-75 g) grade tubers, bulking rate and harvest index were higher with Kufri Jyothi. Dry matter production of HPS-1/13 was higher than Kufri Jyothi. Application of 25 kg S ha^{-1} increased the yield and quality, but not to the significant level.

A field experiment was conducted in Karnataka, India in 1994 to determine the effects of different potassium (100, 125 and 150 kg ha^{-1}) and sulfur rates (0 and 25 kg ha^{-1}) on the concentration and uptake of nutrients of true potato seed and seed tuber cultivars HPS-1/13 and Kufri Jyothi. Lalitha *et al.* (2000) showed that, potassium fertilizer application reduce the nitrogen concentration, HPS-1/13 produced more dry matter than Kufri Jyothi. Kufri Jyothi had more nitrogen, phosphorus, potassium and sulfur content than HPS-1/13. However, uptake of these nutrients was higher in HPS-1/13 than in Kufri Jyothi.

Kanzikwera *et al.* (2001) showed that, K application significantly decreased shoot dry matter yield in some genotypes of potato. Field experiments were conducted at Namulonge, Uganda, during 1995-96 and 1999 to assess the effect of N and K on dry matter yield and nutrient partitioning in true potato (Solanum tuberosum) seed (TPS) mother plants. Three N (0, 120, 240 kg ha^{-1}) and K (0, 132.8 and 265.6 kg ha^{-1}) rates were applied to mother plants of three potato genotypes, CIP 800212, CIP 381379.9 (Kisoro) and CIP 381403.1. N application, however, had no significant effect on shoot dry matter yield although N x genotype interactions were significant on the parameter. Fresh tuber yield ranged from 21.0 to 37.5 t ha^{-1}, and was significantly ($P<=0.05$) increased by both N and K application. Leaf N concentration varied significantly ($P<=0.05$) among genotypes and K rates higher than 132.8 kg ha^{-1} increased this parameter in potato genotype CIP 381403. High N and K rates also increased stem N concentration in this genotype. Nitrogen application significantly ($P<=0.05$) increased foliar Ca concentration.

Eugenia (2008) shows that, potato emergence depends on 1)Soil Moisture. Sprouts grow faster in soils that are close to field capacity than in drier soils. 2) Soil Temperature. Sprout development and elongation occur more rapidly at 17-19°C than at 10-15°C. 3) Seed Warming. Seed tubers warmed (10-15°C) prior to planting will emerge more rapidly and uniformly. The warming period needs to be controlled carefully so that the seed has sprouts just emerging (white points). Longer sprouts are tender and susceptible to mechanical damage. 4) Physiological Age of Seed, temperature is the main factor that determines the physiological age of a seed tuber. The physiological age of a potato tuber is determined not from harvest but from tuber initiation. Seed grown during a season with stressful weather conditions, will be physiologically older at harvest than tubers from a more favorable growing season. It is possible to determine the physiological age of a seed lot by taking a representative sample of tubers from cold storage and warming them to 15-17°C in the dark. The length of time required for sprout emergence (white point stage) will provide an estimate of the amount of time and warming that will be required in storage for that particular variety and seed lot. If the seed is physiological old the sprouts are weak and form branches. This results in weak plants that will mature before maximum yield. This results in a lot of small sized tubers 5) Diseases. Developing sprouts are susceptible to Rhizoctonia canker and soft rot. Rhizoctonia can be reduced by applying Quadris in-furrow.

Soft rot bacteria cause serious problems when soils become saturated after heavy rains. Cold seed is highly susceptible to seed-piece decay when planted in warm soil or in light, sandy soil that warms quickly. When a cold seed piece is surrounded by warm, moist soil, water will condense on the seed piece. This creates the anaerobic environment that favors soft rot.

A field experiment was conducted during the rabi season of 2000-01 and 2001-02 in the sandy clay loam soil of West Bengal, India, to investigate the effect of K fertilizer sources (KCL and K_2SO_4) and NPK rates (75 and 100% of the recommended, N:P:K at 180:150:150 kg ha^{-1}) with or without farmyard manure (FYM) at 10 t ha^{-1} on potato cv. Kufri Badshah production. Chettri and Thapa (2002) concluded that K as K_2SO_4 produced higher dry matter production compared to KCl. The highest dry matter production (360.3, 570.4 and 825.3 g/m at 60, 80 and 100 days after planting), tuber bulking rate (12.83 and 8.78 g/m per day at 80 and 100 days after planting, respectively) and yield (275.7 q ha^{-1}) were obtained with 100% NPK + FYM. Higher nutrient uptake was observed with high or low rates of NPK in combination with FYM.

Sobhani *et al.* (2002) showed that yield and some agronomic characteristics of potato. potassium had a minimal effect on plant height and number of stems and tubers per plant, but increased the average tuber weight. An experiment was conducted in Iran to determine the effects of water deficit and potassium nutrition on the yield and agronomic characteristics of potato. Water deficit decreased crop yield and biological yield, while potassium application increased both yields. Water deficit had a negative effect on the number of stems and tubers per plant, average tuber weight, and plant height.

The K requirements of potato (S. tuberosum) cultivars Kufri Chipsona 1 and Kufri Chipsona 2 (intended for processing) were studied by during 2000-01 and 2001-02 in Modipuram, Uttar Pradesh, India, in relation to their processing grade tuber yield and quality parameters. Parveen *et al.* (2004) showed that, 124.5 kg K ha^{-1} give the highest yields of process grade tubers (32.8 and 29.5 t ha^{-1} in Kufri Chipsona 1 and Kufri Chipsona 2, respectively) . The K levels (0, 41.5, 83.0, 124.5 and 166 kg K ha^{-1}) affected the yield of process grade tubers in both cultivars. However, K did not significantly affect the quality parameters for processing (tuber dry matter, specific gravity, reducing sugar content and chip colour). The K requirements of Kufri Chipsona 1 and Kufri Chipsona 2 (124.5 kg K ha^{-1}) were 50% higher than the K requirements of table-purpose potato cultivars, such as Kufri Bahar.

Moinuddin, and Shahid, (2004) showed that 8 meq K L L^{-1} give the highest tuber yield and percent dry matter content. An experiment was carried out in a sand culture, potato (Solanum tuberosum L.) was grown to maturity in the greenhouse to study the effects of factorial application of four levels, each of potassium (K) (2, 4, 8, and 12 meq L^{-1}) and sulfur (S) (1, 2, 4, and 6 meq L^{-1}), on yield, quality, and storage behavior of tubers. In general, the effect of K was more pronounced than that of S on overall crop performance. Increasing K and S levels in the nutrient medium increased tuber yield as well as dry matter content. As compared to the lowest S level, application at 4 and 6 meq S L-1 enhanced average tuber yield and percent dry matter content by 28 and 0.41%, respectively.

An experiment was conducted with the high-yielding and cold-resistant variety Mila field plots in Zhijin, Guizhou, China.Lu, (2003) showed that K fertilizer increase plant height, stem diameter, branches/plant, weight/tuber and yield/plant, but decreased tubers/hill. The highest yield was recorded in the treatment with 150 kg K_2O ha^{-1}, followed by the treatment with 60 kg P_2O_5 and 100 kg K_2O ha^{-1}. The highest output: input ratio was noted in the treatment with 150 kg K_2O ha^{-1}, followed by the treatment with 60 kg P_2O_5 and 100 kg K_2O ha^{-1}. K fertilizer increased plant height, stem diameter, branches/plant, weight/tuber and yield/plant, but decreased tubers/hill. The highest starch and the highest crude protein contents were found in the treatment with 60 kg P_2O_5 and 100 kg K_2O ha^{-1}, followed by the treatment with 150 kg K_2O ha^{-1}. It is concluded that the balanced application of NPK fertilizers can increase potato yield, improve tuber quality and promote plant growth, thus obtaining higher economic benefits.

A field experiment was conducted in Lithuania during 2000-2002 to study the effects of various fertilizers on potato tuber yield, starch and dry matter content. Makaraviciute (2003) commented that Meteorological conditions during the vegetation period and varietal characteristics significantly affected the starch and dry matter contents of tubers. The fertilizers had no significant effect on these indices. The application of compound mineral fertilizers NPK at 90:90:180 kg ha^{-1} and complex mineral fertilizers NPK at 90:90:180 with microelements resulted in the highest yields (20.6-26.1 t ha^{-1} and 21.4-27.4 t ha^{-1}, respectively). The complex mineral fertilizers with microelements were superior to the compound mineral fertilizers with regard to tuber yield. On average, the highest contents of starch and dry matter were recorded for Lady Rosetta (17.0-17.9% and 23.2-24.21%) and Saturna (17.1-17.4% and 23.5-23.8%). The highest starch and dry matter contents were observed in 2002 (14.9-21.0% and 21.3-27.1%). The application of manure (40 t ha^{-1}) gave the highest starch and dry matter contents (14.9-17.9% and 21.2-24.2%) of tubers in most of the cultivars.

An experiment was conducted with potato cv. Kufri Sutlej in Hisar, by Haryana, India, in 2001, involving 3 fertilizer levels (100:60:60, 125:75:75 and 150:90:90 kg NPK ha^{-1}), 3 plant spacings (10, 15 and 20 cm) and 2 crop durations (75 and 85 days)Suman *et al. (*2003) concluded that, decreasing 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.. Decrease in plant spacing 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.

Cao, S. (2003) showed that, top dressing of K fertilizer enhance tuber yield, starch content, tuber size and photosynthetic rate of leaves, chlorophyll content in leaves at late growth stage, as well as prolonged growth period .An experiment on Virus-free seed tubers of cv. Kexing were sown in 1999 in Keshan, Heilongjiang, China. Their plants were subjected to 4 fertilizer treatments.

A study was conducted to assess the effects of different levels of cow dung and NPK on growth, yield and postharvest behaviour of TPS seedling tubers raised from true potato (Solanum tuberosum) seeds. Rahman *et al. (*2002) showed that, moderate dose of cow dung manure (50 t ha^{-1}) and the highest doses of NPK fertilizers (375 kg urea, 225 kg TSP and 300 kg MP ha^{-1}) increase Plant height, foliage coverage, number of seedling tubers per plant, size of seedling tubers and give highest yield 38.91 t ha^{-1}). The yield (37.14 t ha^{-1}) and net return (Tk.169 110 ha^{-1}) were significantly higher under the treatment combination receiving a moderate dose of cow dung manure (50 t ha^{-1}) and the highest doses of NPK fertilizers (375 kg urea, 225 kg TSP and 300 kg MP ha^{-1}). Use of a moderate dose of NPK fertilizers (275 kg urea, 185 kg TSP and 250 kg MP ha^{-1}) in presence of cow dung manure at 25 t ha^{-1} gave highest (2.36) benefit cost ratio with a moderate investment. The postharvest loss in weight and sprouting of tubers during storage increased significantly with increasing doses of cow dung manure and NPK fertilizers applied during production.

A field test with potato cv. Kexin No. 1 was conducted by Song (2004) on chernozem in Baiyin, Gansu, China. N fertilizer was applied at 0 and 15 kg/mu, and K_2O at 0, 8, 16, 24 and 32 kg/mu. The relationships between application rates and tuber yield were studied. No N application combined with increasing K fertilizer rates did not increase tuber yield. However, combining 15 kg N/mu with increasing rates of K increased tuber yield. The highest fresh tuber yield (2600 kg/mu) was obtained with 12.25 kg K_2O/mu. The optimum applied amount of K_2O was 8.7 kg/mu, resulting in a fresh tuber yield of 2580 kg/mu. [1 mu = 0.067 ha] .

A study was conducted by Khandakhar *et al.* (2004) in strongly acidic sandy loam soil at the Potato Breeder Seed Production farm, BARI, Debigonge, Panchogar, Bangladesh to investigate the effect of different application rates of lime (0, 0.5, 1.0 and 2.0 t ha^{-1}) and potassium fertilizer (0, 60, 80 and 100 kg K ha^{-1}) on tuber yield of potato cv. Cardinal. Lime and potassium treatments significantly increased tuber yield. The highest increased yield was recorded ~86.54% over the control. The optimum rate of lime and potassium in acidic sandy-loam soils that could be recommended for potato cultivation is 2 t ha^{-1} and 100 kg ha^{-1}, respectively.

A field test with cv. Dabaihua was conducted by Qin-Fang in a semiarid region of Dingxi, Gansu, China, to investigate the yield-related indices under different K application rates. Qin, (2003) showed that the highest tuber yield can be obtained by 90 kg K_2O ha^{-1}, followed by 75 and 60 kg K_2O ha^{-1}, and the lowest in the control. Seven treatments were used 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^{-1}. The tuber yields in the treatments with K fertilizer were significantly higher than those in the control treatments. The highest tuber yield was recorded at 90 kg K_2O ha^{-1}, followed by 75 and 60 kg K_2O ha^{-1}, and the lowest in the control 1. The highest economic benefits was found for 75 kg K_2O ha^{-1}, followed by 60 and 90 kg K_2O ha^{-1}, and the lowest in the control 1. The highest marketable tuber percentage was found at 75 kg K_2O ha^{-1}, followed by 60 and 90 kg K_2O ha^{-1}, and the lowest in the control 1. The optimum K application rate was 60-90 kg ha^{-1} in this semiarid region.

Jenkins and Mahmood (2003) examined effects on growth, dry matter partitioning and nutrient uptake in potato plants grown in large pots under different combinations of adequate and deficient levels of nitrogen, phosphorus and potassium. N supply affected the growth of all leaves, with low N reducing both the size of individual leaves and the extent of branch growth. P and K availability affected the growth of later formed leaves and only when both were deficient was branch growth substantially reduced. At later stages of growth, total green leaf area was significantly reduced by deficiency of each of the nutrients. Partitioning of dry matter to tubers was markedly reduced by K deficiency and increased in one experiment by P deficiency. When both P and K were deficient, partitioning approximated that under non-limiting conditions.

The effects of different levels of NPK fertilizers on seedling tuber production from true potato seeds were investigated on a sandy loam soil in Sriniketan, West Bengal, India. Nandi *et al.* (2002) Shows that Tuber yield increased with increasing fertilizer rates up to 210 kg N ha^{-1}, 175 kg P ha^{-1} and 175 kg K ha^{-1}. Increasing the fertilizer rates to 300 kg N ha^{-1}, 250 kg P ha^{-1} and 250 kg K ha^{-1} had no beneficial effect and, in most cases, exhibited a declining trend. Tuber yield increased with increasing fertilizer rates up to 210 kg N ha^{-1}, 175 kg P ha^{-1} and 175 kg K ha^{-1} in all three years of study. The highest yield (17.67 t ha^{-1}) was recorded with the application of 240 kg N ha^{-1}, 200 kg P ha^{-1} and 200 kg K ha^{-1}, which was at par with the yield (17.24 t ha^{-1}) obtained with 210 kg N ha^{-1}, 175 kg P ha^{-1} and 175 kg K ha^{-1}. Based on the pooled data, the optimum fertilizer rates were set at 242 kg N ha^{-1}, 202 kg P ha^{-1} and 202 kg K ha^{-1}, and these rates were expected to yield 14.51 tonnes of tubers ha^{-1}, with a net profit of Rs. 89.173 ha^{-1} and benefit:cost ratio of 3.31.

Wijkmark *et al.* (2005) showed that, site-specific K fertilizer application led to improved potato quality with regards to after-cooking darkening, strong sogginess and weak sogginess. On the other hand, site-specific k fertilizer application had no influence on yield levels. The economic and qualitative effects of site-specific application of potassium (K) fertilizer to potato fields based from the farmer's perspective was studied in a pilot experiment conducted in Halland, Sweden, during the 2002, 2003 and 2004 cropping seasons. In 2003, 3 ordinary plot trials with different K fertilizer applications (90, 120 and 150 kg K ha^{-1}) were performed and in 2004, the trial was performed once again, this time in a different field.

CHAPTER III

MATERIALS AND METHODS

In this chapter the details of different materials used and methodologies followed during the experimental period are presented under the following heads

3.1 Experimental site

The experiment was carried out at the research field of Sher-e-Bangla Agricultural University, Dhaka, during the period from 10 November 2010 to 10 March 2011. Geographically the experimental area is located at $23^{0}41'$ N latitude and $90^{0}22'$ E longitudes at the elevation of 8.6 m above the sea level. The experimental field was medium high land belonging to the Madhupur Tract. The soil was silty loam. Fertility status of soil in experimental site has been showen in the Appendix I.

3.2 Climate and weather

The experimental field was under subtropical climates characterized by heavy rainfall during the month of April to September and scanty rainfall during October to March. The monthly means of daily maximum, minimum and average temperature, relative humidity, total rainfall and sunshine hours received at the experimental site during the period between October 2010 to April 2011 have been presented in Appendix II.

3.3 Plating material

The first generation TPS seedling tubers of BARI TPS-1 were collected from the Tuber Research Centre, Bangladesh Agricultural Research Institute, Joydebpur, Gazipur.

3.4 Land preparation

The land of the experimental site was first opened in the last week of October with power tiller. Later on, the land was ploughed and cross-ploughed four times followed by laddering to obtain the desirable tilth. The corners of the land were spaded and weeds and stubbles were removed from the field. The land was finally prepared on 13 November 2010 three days before planting the seed. In order to avoid water logging due to rainfall during the study period, drainage channels were made around the land. The soil was treated with Furadan 5G @10 kg ha^{-1} when the plot was finally ploughed to protect the young seedlings from the attack of cut worm.

3.5 Experimental design and lay out

The two-factor experiment was laid out in a split plot design with 3 replications. Potassium was assigned to main plot and sulfur to sub-plot. The size of the unit plot was 2.0 m × 1.5 m. Plot to plot distances were 0.75 m. Treatments were randomly distributed within the blocks. The plots were raised up to 10 cm.

3.6 Treatments

The experiment comprised of two factors

Factor A: Potassium (K) Fertilizer -4 levels

K_0 0 kg potassium ha^{-1} = 0 kg ha^{-1} Muriate of potash (MOP)
K_1 117 kg potassium ha^{-1} = 225 kg ha^{-1} MOP
K_2 130 kg potassium ha^{-1} = 250 kg ha^{-1} MOP
K_3 143 kg potassium ha^{-1} = 275 kg ha^{-1} MOP

Factor B: Sulfur (S) Fertilizer – 4 levels

S_0 0 kg sulfur ha^{-1} = 0 kg ha^{-1} Gypsum
S_1 24 kg sulfur ha^{-1} = 100 kg ha^{-1} Gypsum
S_2 29 kg sulfur ha^{-1} = 120 kg ha^{-1} Gypsum
S_3 34 kg sulfur ha^{-1} = 140 kg ha^{-1} Gypsum

Sixteen treatment combinations were as follows

K_0S_0 =0 kg potassium ha^{-1} with 0 kg sulfur ha^{-1}
K_0S_1 =0 kg potassium ha^{-1} with 24 kg sulfur ha^{-1}
K_0S_2 =0 kg potassium ha^{-1} with 29 kg sulfur ha^{-1}
K_0S_3 =0 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}
K_1S_0 =117 kg potassium ha^{-1} with 0 kg sulfur ha^{-1}
K_1S_1 =117 kg potassium ha^{-1} with 24 kg sulfur ha^{-1}
K_1S_2= 117 kg potassium ha^{-1} with 29 kg sulfur ha^{-1}
K_1S_3 =117 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}
K_2S_0= 130 kg potassium ha^{-1} with 0 kg sulfur ha^{-1}
K_2S_1= 130 kg potassium ha^{-1} with 24 kg sulfur ha^{-1}
K_2S_2= 130 kg potassium ha^{-1} with 29 kg sulfur ha^{-1}
K_2S_3 =130 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}
K_3S_0 =143 kg potassium ha^{-1} with 0 kg sulfur ha^{-1}
K_3S_1 =143 kg potassium ha^{-1} with 24 kg sulfur ha^{-1}
K_3S_2= 143 kg potassium ha^{-1} with 29 kg sulfur ha^{-1}
K_3S_3 =143 kg potassium ha^{-1} with 34 kg sulfur ha^{-1}

3.7 Manure and fertilizer application

The crop was fertilized as per recommendation of TCRC (2004). Urea, triple superphosphate (TSP), zinc oxide and boric acid were used as sources of nitrogen, phosphorus, zinc and boron, respectively. The doses of fertilizers were 320, 232, 10, 10 and 10000 kg ha^{-1} for urea, TSP, ZnO, boric acid and cowdung respectively. Cowdung was applied 10 days before final land preparation. Total amount of TSP, ZnO, boric acid and half of urea was applied at basal doses during final land preparation. The remaining 50% urea was side dressed in two equal splits at 25 and 45 days after planting (DAP) during first and second earthing up. Different dose of MOP and zipsum fertilizer were applied as per treatment advised.

3.8 Seed preparation and sowing

The seedling tubers were taken out of the cold store about three weeks before planting. The tubers were kept under diffuse light conditions to have healthy and good sprouts. Planting was done on November 10, 2009. The well sprouted seed tubers were planted at a depth of 5-7 cm in furrow made 60 cm apart. Hill to hill distance was 20 cm. After planting, the seed tubers were covered with soil.

3.9 Intercultural operations

3.9.1 Weeding

First weeding was done two weeks after emergence 30 November, 2010. Another weeding was done before 2^{nd} top dressing of urea on 20 November, 2010.

3.9.2 Earthing up

Earthing up was done twice during growing period. The first earthing up was done at 25 DAP on 29 November,2010 and second earthing up was done after 15 days of first earthing up on14 December,2010.

3.9.3 Irrigation

Three irrigations were provided through out the growing period in controlled way. The first irrigation was given at 25 DAP on 29 November,2010. Subsequently, another two irrigations were given at 45 and 60 DAP on 19 December,2010.

3.9.4 Plant protection

Furadan 5G @ 10 kg ha^{-1} was applied in soil at the time of final land reparation on 10 November, 2010 to control cut worm. Dithane M-45 was sprayed in 2 installments at an interval of 15 days from 50 DAP on 24 December, 2010 as preventive measure against late blight disease.

3.10 Harvesting

The crop was harvested to study growth and development rate from 40 DAP to 90 DAP at 15 days interval and the final harvest was taken at 85 DAP. The harvested plants were tagged separately plot wise. Ten sample plants were randomly selected from each plot and tagged for recording necessary data and then the all plots was harvested with the help of spade. The maturity of plant was indicated by the plants showing 80 to 90% of leaf senescence and the top started drying. Haulm cutting was done before 7 days of harvesting. The yield of tuber was taken plot wise and converted into tons ha^{-1}. Care was taken to avoid injury in potatoes during harvesting.

3.11 Data collection

The following parameters were recorded and their mean values were calculated from the sample plants.

i) Plant height: Plant height was taken to be the length between the base of the plant to the tip at 40, 55, 70 and 85 DAP.

ii) Stems $hill^{-1}$: The number of stems $hill^{-1}$ was calculated from the average of 5 plants selected randomly from each unit plot at 40, 55, 70 and 85 DAP.

iii) Leaves $plant^{-1}$: The number of leaves was counted from five plants of each plot periodically after every 15 days starting from 40, 55, 70 and 85 DAP and mean value was calculated.

viii) Total dry matter: The total dry matter was recorded by drying parts (80 ^{0}C ± 2) for 72 hours and calculated from summation of leaves, stem, tuber weights was taken in an electronic balance.

iv) Tubers $hill^{-1}$: The number of tubers $hill^{-1}$ was determined from the average of 10 plants selected from each unit plot.

v) Tuber yield: The weight of tuber $hill^{-1}$ was calculated from 10 plants from each unit plot at harvest. All the tubers weight per plot was recorded and the tuber weight was finally converted into tons ha^{-1}.

vi) Grade of tubers: The grading of tubers was done in the following manner:

> 55 mm in diameter

35 - < 55 mm in diameter

20 - < 35 mm in diameter

< 20 mm in diameter

3.12 Statistical analysis

The collected data were analyzed statistically following the analysis of variance (ANOVA) technique and the means were seperated by Duncan's Multiple Range Test (DMRT) using the statistical computer package program, MSTAT-C (Russell, 1986) at 5% and 1% level of significant.

CHAPTER IV

RESULTS AND DISCUSSION

4.1. Emergence

The effect of potassium (K) and/ or sulfur (S) as individual or in combination factor had no significant effect on first and final emergence of potato derived from TPS (Table 4.1.1, 4.1.2 & 4.1.3). Emergence depends on soil moisture, soil temperature, seed temperature, disease and physiological age of seed. Fertilizer affects the plant when plant had root. Roots are being developed after emergence. This result was supported by the result of Eugenia (2008).

Table 4.1.1 Effect of potassium on days of emergence of potato derived from TPS

Treatments (potassium)	**Days of emergence**	
	1st emergence	**Final emergence**
K_0 K_1 K_2 K_3	20.91 19.41 20.50 20.08	25.41 24.50 24.91 24.75
F-test	Ns	ns
CV (%)	5.25	2.5

ns= Non significant; K_0 =0 kg K ha^{-1} ; K_1 =117 kg K ha^{-1}; K_2 130 kg ha^{-1} potassium ; K_3 =143 kg K ha^{-1}.

Table 4.1.2. Effect of sulfur on days of emergence of potato derived from TPS

Treatments (sulfur)	Days of emergence	
	1st emergence	Final emergence
S_0	20.58	24.75
S_1	20.58	25.00
S_2	20.50	25.08
S_3	19.25	24.75
F-test	ns	ns
CV (%)	3.89	2.74

ns= Non significant; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3=34 kg S ha^{-1};

Table 4.1.3. Combined effect of potassium and sulfur on days of emergence of potato derived from TPS

Treatments (potassium x sulfur)	Days of emergence	
	1st emergence	Final emergence
K_0S_0	20.66	25.33
K_0S_1	22.33	26.00
K_0S_2	21.66	25.33
K_0S_3	19.00	25.00
K_1S_0	20.00	25.00
K_1S_1	19.66	24.33
K_1S_2	20.00	24.66
K_1S_3	18.00	24.00
K_2S_0	21.00	24.33
K_2S_1	19.33	24.66
K_2S_2	20.66	25.66
K_2S_3	21.00	25.00
K_3S_0	20.66	24.33
K_3S_1	21.00	25.00
K_3S_2	19.66	24.66
K_3S_3	19.00	25.00
F-test	ns	ns
CV (%)	3.89	2.74

ns= Non significant; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1}.

4.2. Plant height

Effect of potassium

Plant height was significantly influenced by potassium, at different days after planting except for 40 DAP (Table 4.2.1). At 55 DAP, K_0 produced the longest plant (37.22 cm) which was statistically similar to K_1 and K_3 (36.97 cm and 36.55 cm, respectively). The application of K_2 produced the shortest plant (34.55 cm). At 70 DAP and 85 DAP, K_1 gave the longest plant (71.61 cm) which were statistically similar to K_0. Application of K_2 produced the shortest plant (68.52cm) which was statistically similar to K_3. This result was agreed with Lu (2003); Rahman *et al. (*2002) Sobhani *et al. (*2002).

Table 4.2.1 Effect of potassium on plant height of potato derived from TPS

Treatments	Plant height (cm)			
potassium	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
K_0	19.22	37.22 a	71.02 a	72.41 a
K_1	18.72	36.97 a	71.22 a	72.61 a
K_2	18.89	34.55 b	68.53 b	69.92 b
K_3	18.55	36.55 a	68.80 b	70.19 b
F-test	ns	*	*	*
SE	-	0.0023	0.0304	0.0146
CV (%)	12.34	7.76	4.87	5.87

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;* indicate significant at 5% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}.

Effect of sulfur

Sulfur had significant effect on plant height of potato, (Table 4.2.2). At earlier stage (40 DAP), S_2 gave the longest plant (19.64 cm) which was statistically similar to S_3 and S_1 (19.08 cm and 18.94 cm, respectively). At 55 DAP, 70 DAP and 85 DAP the longest plant was obtained by application of S_2, S_1 and S_1 (37.55 cm, 71.84 cm and 73.23 cm, respectively.) The result showed that zero and over dose of sulfur reduced the plant height.

Table 4.2.2. Effect of sulfur on plant height of potato derived from TPS

Treatments	**Plant height (cm)**			
sulfur	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
S_0	17.72 b	35.47 b	68.10 c	69.49 c
S_1	18.94 a	36.07 b	71.84 a	73.23 a
S_2	19.64 a	37.55 a	70.68 b	72.07 b
S_3	19.08 a	36.21 b	68.96 c	70.35 c
F-test	*	*	**	**
SE	0.0042	0.0076	0.0387	0.0187
CV (%)	11.73	6.07	3.15	3.09

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; *, ** indicate significant at 5% and 1% levels of probability, respectively; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1}.

Combined effect of potassium and sulfur

Combination of K and S had significant effect on plant height of potato derived from TPS at different days (Figure 4.2.1-4.2.4). At 40 DAP, the longest plant (21.44 cm) was observed from the combination of K_0S_1 (21.44) which was statistically similar to K_2S_2 (20.89 cm), whereas K_0S_0 gave the shortest plant (15.44 cm) (Figure 4.2.1). At 55 DAP, similar trend of plant height was also recorded from K_0S_1, K_0S_2, and K_1S_0 (41.44, 40.55, 40.55 cm, respectively). The shortest plant (31.11 cm) was observed K_2 S_1(Figure 4.2.2). At 70 DAP, the longest plant (76.55 cm) was obtained from K_1S_0. K_1S_3 gave the shortest one (Figure 4.2.3). At 85 DAP, the maximum plant height (77.94 cm) was observed in combination of K_1S_0 which was statistically similar to K_2S_2 (76.14 cm).The minimum plant height (62.05 cm) was observed from K_2S_0 combination (Figure 4.2.4). Potato plant height varies from variety to variety. Plant height is a genetical character. Vegetative growth mainly depends on nitrogen fertilizer (Sobhani *et al.*, 2002). So there is little relation between plant height and potassium or sulfur.

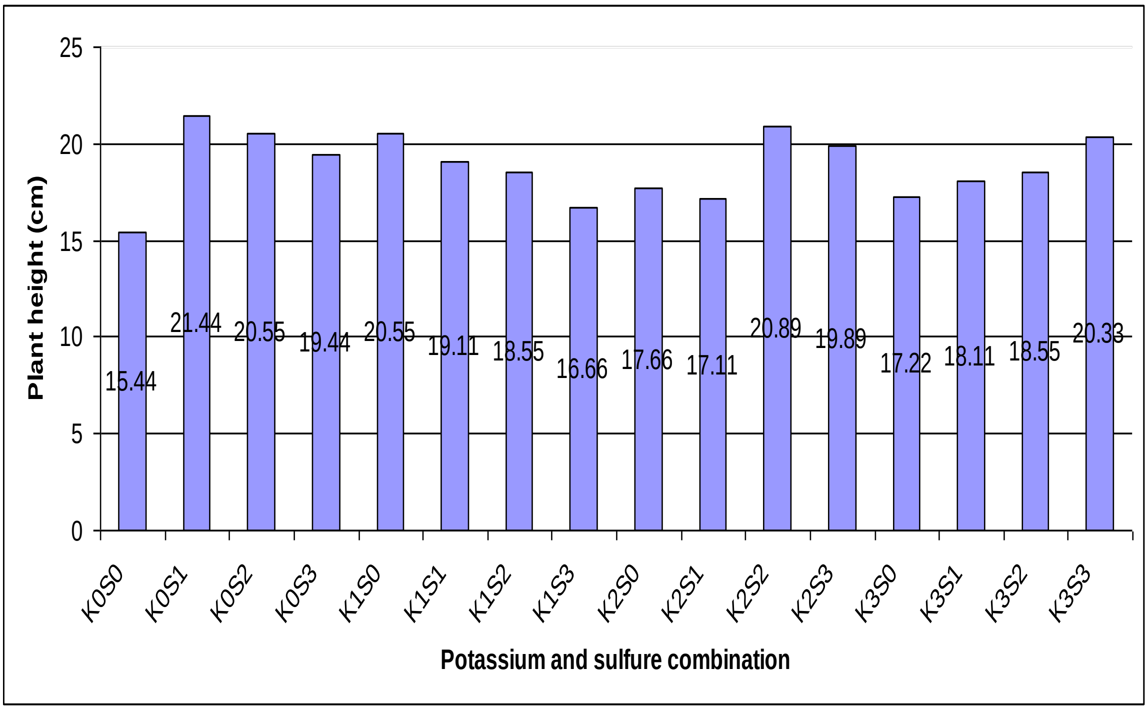

Figure 4.2.1. Combined effect of potassium and sulfur on plant height of potato derived from TPS at 40 DAP. (SE=0.48)

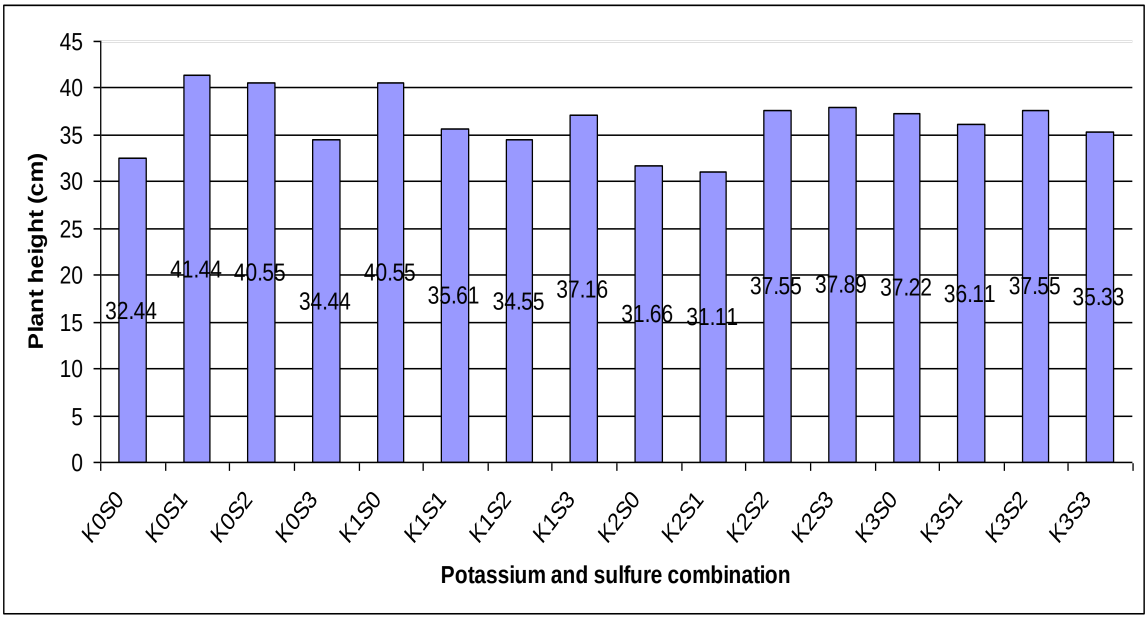

Figure 4.2.2. Combined effect of potassium and sulfur on plant height of potato derived from TPS at 55 DAP. (SE=0.48)

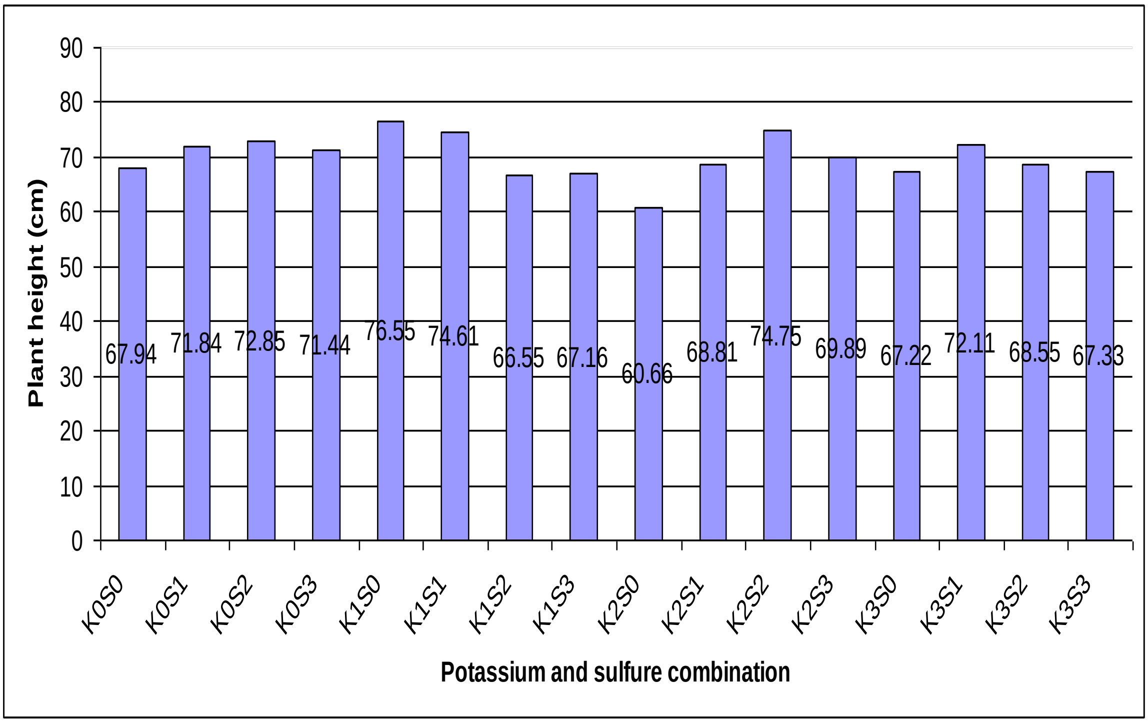

Figure 4.2.3. Combined effect of potassium and sulfur on plant height of potato derived from TPS at 70 DAP. (SE=0.48)

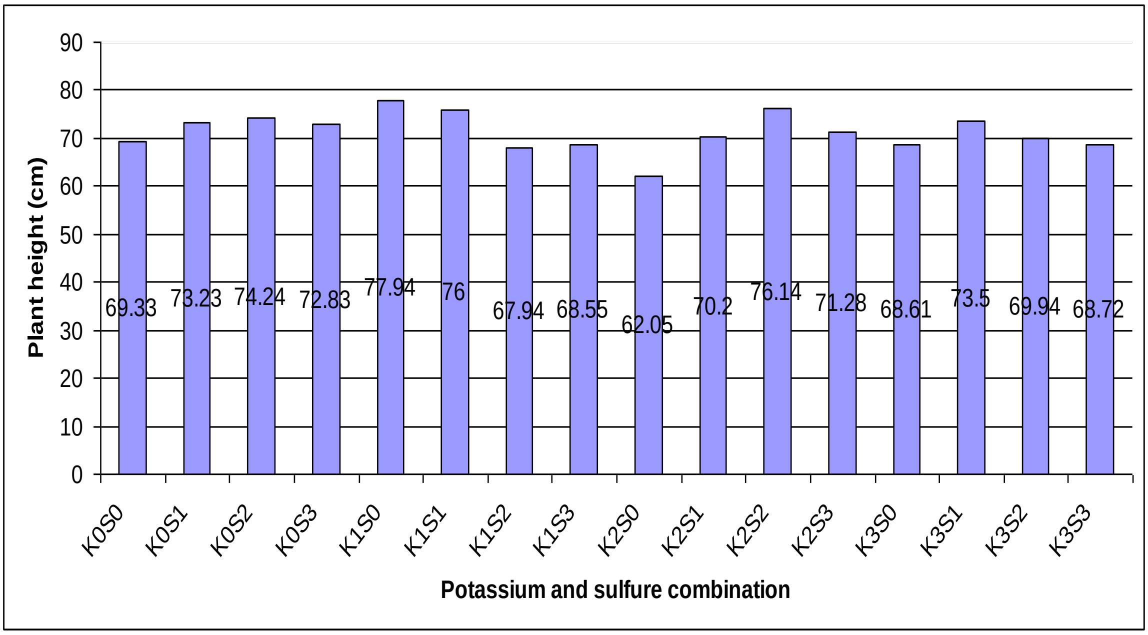

Figure 4.2.4. Combined effect of potassium and sulfur on plant height of potato derived from TPS at 85 DAP. (SE=0.48)

4.3. Number of stems hill^{-1}

Effect of potassium

Up to 55 DAP, there was no significant effect of potassium on number of stems hill^{-1} of potato derived from TPS but latter stage i.e., at 70 DAP, K_2 produced the maximum number of stems hill^{-1} (6.12) which was statistically similar to K_1 and K_3 those produced 5.67 and 5.59 stems hill^{-1},respectively whereas the lowest number of stem was observed in $K_{0.}$ (Table 4. 3.1). At 85 DAP, same trend was also shown in 85 DAP. This result matched with findings of Lu (2003) and Kanzikwera *et al.* (2001).

Table 4.3.1. Effect of potassium on number of stems hill^{-1} of potato derived from TPS at different days after planting.

Treatments	**Number of stems hill^{-1}**			
Potassium	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
K_0	2.85	4.54	5.39 b	6.01 b
K_1	3.13	4.82	5.67 ab	6.29 ab
K_2	2.80	5.02	6.12 a	6.73 a
K_3	3.33	4.49	5.59 ab	6.20 ab
F-test	ns	ns	*	*
SE	-	-	0.1937	0.1937
CV (%)	22.13	14.21	11.78	9.62

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; * indicate significant at 5% levels of probability; K_0 =0 kg ha^{-1} potassium ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg ha^{-1} potassium;

Effect of sulfur

Sulfur had significant effect on number of stems hill^{-1} (Table 4. 3.2). Result showed that number of stems hill^{-1} increased with increasing rate of sulfur application up to S_2 and thereafter, decrease little bit, at all growth stage. At 40 DAP, 55 DAP, 70 DAP, 85 DAP. The maximum number of stems hill^{-1} produced by S_2 which was statistically similar to S_1 and S_3. The minimum number of stems hill^{-1} (2.74) was recorded in S_0.Same trend was observed at 55, 70 and 85 DAP. The maximum number of stems hill^{-1} was recorded in S_2 at 85 DAP.

Table 4.3.2 Effect of sulfur on number of stems hill^{-1} of potato derived from TPS at different days after planting.

Treatments	**Number of stems hill^{-1} at**			
Sulfur	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP,**
S_0	2.74 b	4.43 b	5.41 b	6.02 b
S_1	2.99 ab	4.68 ab	5.66 ab	6.27 ab
S_2	3.38 a	5.07 a	6.05 a	6.66 a
S_3	2.99 ab	4.68 ab	5.66 ab	6.27 ab
F-test	*	*	*	*
SE	0.9731	0.1754	0.1754	0.1754
CV (%)	20.04	12.87	10.67	9.62

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; * indicate significant at 5% levels of probability; S_0 =0 kg ha^{-1} sulfur; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Combined effect of potassium and sulfur

Combination of potassium and sulfur had significant effect on number of stems hill^{-1} all through the growing period (Figure 4.3.1-4.3.4). Data showed that at 40 DAP, the highest number of stems hill^{-1} (4.22) was observed in K_2S_2 which was statistically similar to K_0S_2, K_0S_3, K_1S_1, K_1S_2, K_1S_3, K_3S_1, K_2S_0 and K_3S_3 (3.22, 3.33.3.32, 3.22, 3.10, 3.33, 3.10, 3.10, respectively) whereas the lowest was recorded in K_0S_0 (2.33) (Figure 4.3.1). Same trend was observed in 55 DAP (Figure 4.3.2).

At 70 DAP, the highest number of stem (7.01) was observed at K_3S_2 which was statistically similar to K_3S_1, $K_3S_{3,}$ K_2S_0, K_0S_3 (6.12, 5.89, 5.89, 5.87 respectively) whereas the lowest number of stem (4.87) was recorded in K_0S_0 (Figure 4.3.3). Similar trend was observed at 85 DAP (Figure 4.3.4).

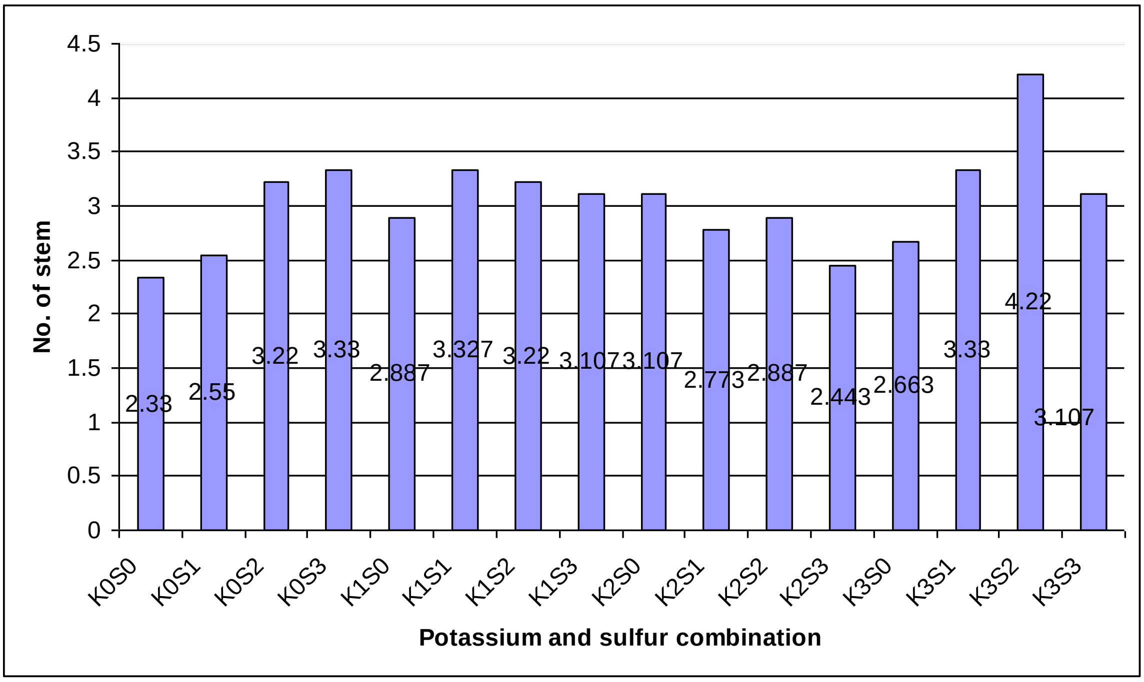

Figure 4.3.1. Combined effect of potassium and sulfur on number of stems hill^{-1} of potato derived from TPS at 40 DAP. (SE=0.369)

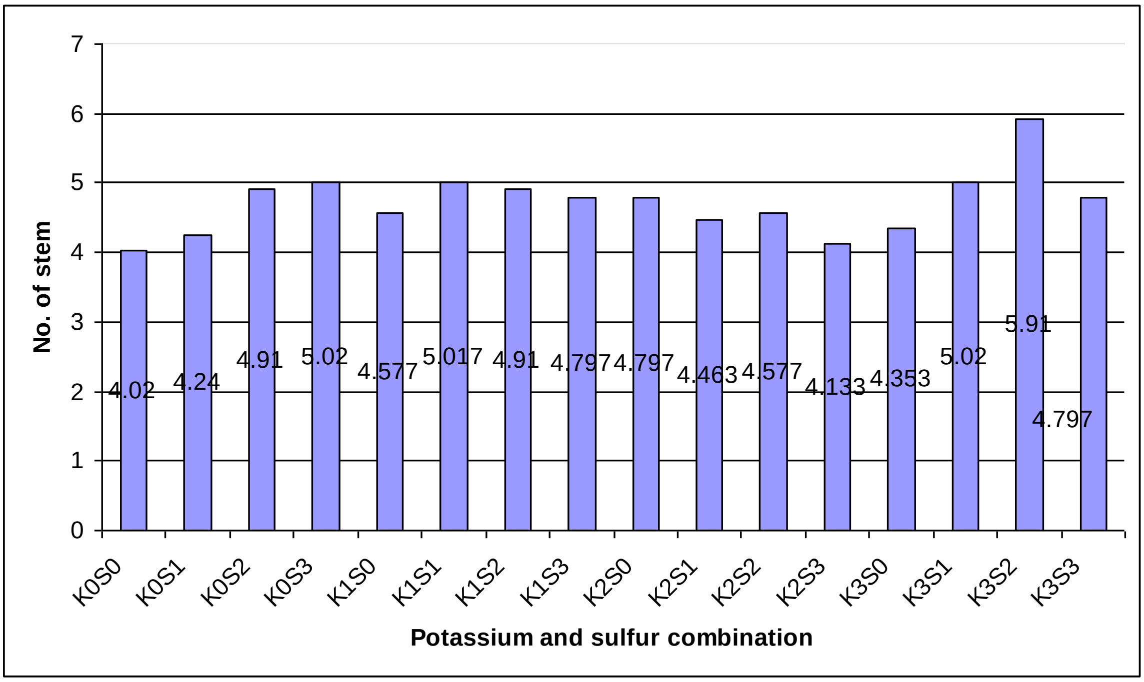

Figure 4.3.2 Combined effect of potassium and sulfur on number of stems hill^{-1} of potato derived from TPS at 55 DAP (SE=0.369)

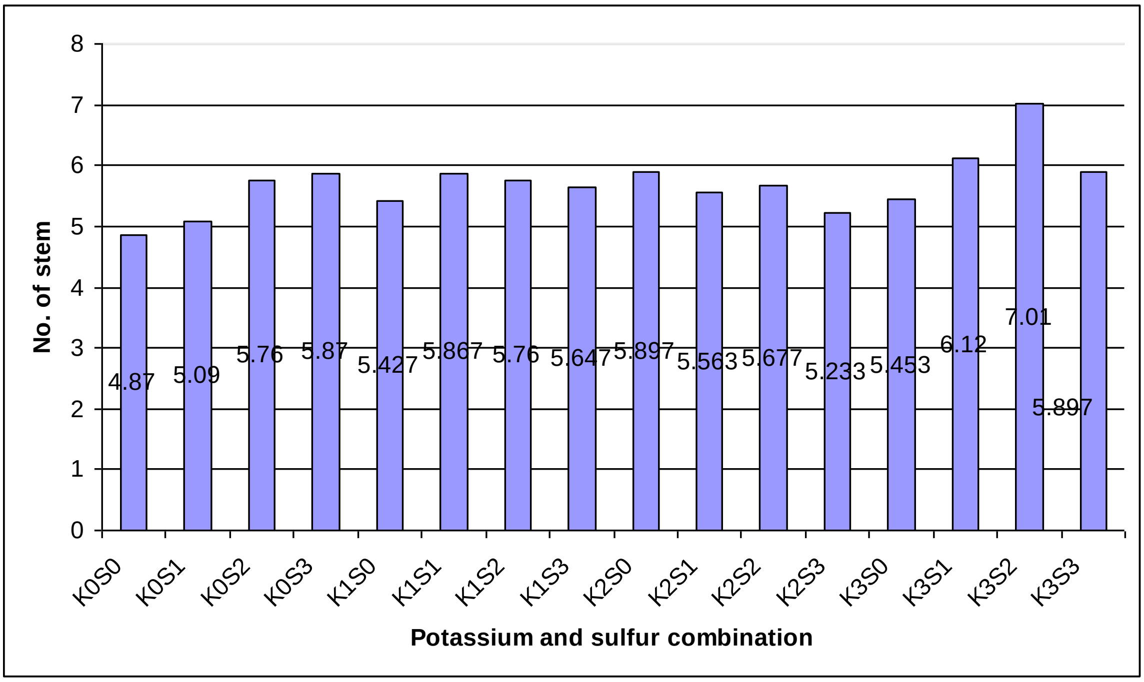

Figure 4.3.3. Combined effect of potassium and sulfur on number of stems hill^{-1} of potato derived from TPS at 70 DAP (SE= 0.369)

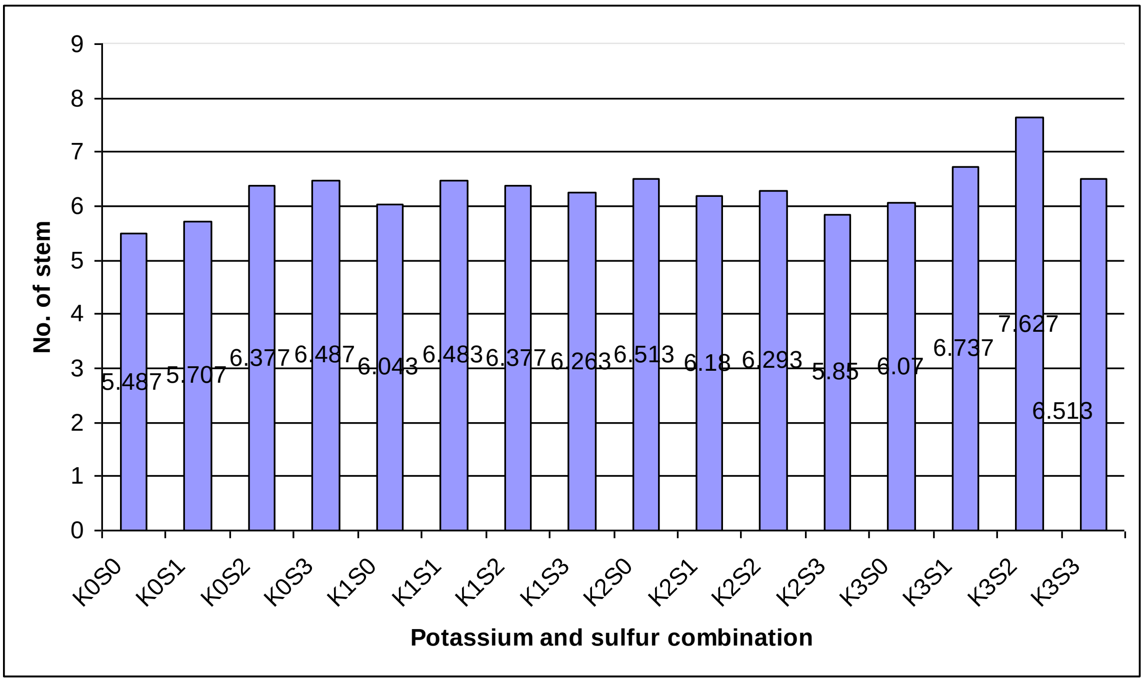

Figure 4.3.4. Combined effect of potassium and sulfur on number of stems hill^{-1} of potato derived from TPS at 85 DAP. **(SE=0.369)**

4.4. Number of leaves hill^{-1}

Effect of potassium

Maximum number of leaves hill^{-1} was observed at 40, 55, 70 & 85 DAP (24.58, 40.30, 53.05, 52.21 respectively) at all growth stage when K_3 produced similar number of at 70 and 85 DAP. K_1 produced lowest number of leaves at 40 and 55 DAP (23.89, 37.14 respectively) K_0 at 70 and 85 DAP (44.30 & 43.46 respectively).

Table 4.4.1. Effect of potassium on number of leaves hill^{-1} of potato derived from TPS

Treatments	**Number of leaves hill^{-1} at**			
Potassium	**40 DAP**	**55 DAP,**	**70 DAP**	**85 DAP**
K_0	19.30 d	31.80 d	44.30 c	43.46 c
K_1	23.89 c	37.14 c	50.39 b	49.55 b
K_2	29.58 a	40.30 a	53.05 a	52.21 a
K_3	25.75 b	38.75 b	51.75 ab	50.90 ab
F-test	**	*	*	*
SE	0.5786	1.3497	1.3497	1.3497
CV (%)	8.13	12.64	9.37	9.53

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; *, ** indicate significant at 5% and 1% levels of probability, respectively; K_0 =0 kg K ha^{-1} ; K_1 =117 kg K ha^{-1}; K_2 130 kg ha^{-1} potassium ; K_3 =143 kg K ha^{-1};

Effect of sulfur

Sulfur had significant effect on number of leaves hill^{-1} (Table 4.4.2). Data showed that, at 40 DAP, the highest number of leaves hill^{-1} (26.78) was observed at S_2 whereas the lowest number of leaves hill^{-1} (22.22) was observed at S_0. This trend was observed also at 55 DAP. At 70 DAP, the highest number of leaves hill^{-1} (52.78) was observed in S_1 and the lowest number of leaves hill^{-1} (45.19) was observed at S_0. This trend was also observed at 85 DAP

Table 4.4.2. Effect of sulfur on number of leaves of potato derived from TPS

Treatments	Number of leaves hill^{-1} at			
Sulfur	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
S_0	22.22 c	32.69 c	45.19 c	44.35 c
S_1	26.78 a	39.78 a	52.78 a	51.94 a
S_2	24.75 b	37.50 b	50.25 b	49.40 b
S_3	24.77 b	38.03 b	51.28 b	50.43 b
F-test	**	**	**	**
SE	0.361	0.973	0.973	0.973
CV (%)	5.08	9.11	6.76	6.88

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; *, ** indicate significant at 5% and 1% levels of probability, respectively; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Combined effect of potassium and sulfur

Combination of potassium and sulfur had important role on number of leaves hill^{-1} (Table 4.4.3). Data showed that, at 40 DAP, the highest number of leaves (39.55) was observed at K_2S_2 whereas the lowest number of leaves (18.33) was observed at K_0S_2.

At 55 DAP, maximum number of leaves (53.55) was obtained by K_2S_2 and the minimum number of leaves hill^{-1} was observed in K_0S_0 (28.11), same trend was observed at 70 and 85 DAP. This result agreed with the results of different scientists (Jenkins and Mahmood, 2003).

Table 4.4.3. Combined effect of potassium and sulfur on number of leaves hill^{-1} of potato derived from TPS

Treatments	Number of leaves hill^{-1} at			
Potassium X sulfur	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
K_0S_0	16.11 j	28.11 k	40.11 i	39.26 i
K_0S_1	19.66 hi	32.66 h-j	45.66 fg	44.82 fg
K_0S_2	18.33 i	30.33 jk	42.33 hi	41.48 hi
K_0S_3	23.11 g	36.11 e-g	49.11 e	48.27 e
K_1S_0	25.66 de	39.66 cd	53.66 cd	52.82 cd
K_1S_1	24.91 ef	36.91 ef	48.91 e	48.07 e
K_1S_2	21.11 h	34.11 g-i	47.11 ef	46.26 ef
K_1S_3	23.89 fg	37.89 de	51.89 d	51.04 d
K_2S_0	24.33 e-g	28.22 k	40.22 i	39.38 i
K_2S_1	29.00 c	42.00 c	55.00 c	54.16 c
K_2S_2	39.55 a	53.55 a	67.55 a	66.71 a
K_2S_3	25.44 d-f	37.44 de	49.44 e	48.60 e
K_3S_0	22.78 g	34.78 f-h	46.78 ef	45.93 ef
K_3S_1	33.55 b	47.55 b	61.55 b	60.71 b
K_3S_2	20.00 h	32.00 ij	44.00 gh	43.16 gh
K_3S_3	26.66 d	40.66 c	54.66 c	53.82 c
F-test	**	**	**	**
SE	0.722	1.946	1.946	1.946
CV (%)	5.08	9.11	6.76	6.88

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ** indicate significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

4.5. Plant dry matter content

Effect of potassium

(Table 4.5.1) shows that Potassium had significant effect on plant dry matter content. At 55, 70, 85 DAP, the highest plant dry matter content (10.36, 14.91, 20.92 %, respectively) were obtained by K_2 whereas the lowest were recorded in K_0 (7.80, 8.92, 14.24 %) at all growth stage. This result was agreed with the result of Kanzikwera *et al.* (2001).

Table 4.5.1. Effect of potassium on % plant dry matter content of potato derived from TPS at different days after planting

Treatments	Plant dry matter (%)			
potassium	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
K_0	6.56	7.80 d	8.92 d	10.14 d
K_1	7.89	9.33 c	12.38 c	16.06 c
K_2	8.67	10.36 a	14.91 a	20.92 a
K_3	8.14	9.48 b	12.61 b	16.41 b
F-test	ns	**	**	**
SE	-	0.002	0.030	0.014
CV (%)	0	4.08	3.07	2.09

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ** indicate significant at 1% levels of probability; K_0 =0 kg ha^{-1} potassium ; K_1 =117 kg K ha^{-1}; K_2 =130 kg K ha^{-1} ; K_3 =143 kg ha^{-1} potassium;

Effect of sulfur

Sulfur had significant role on plant dry matter content at 55, 70 and 85 DAP (Table 4.5.2). Except 40 DAP, at 55 DAP, the maximum plant dry matter content (9.29%) was obtained by S_2 which was statistically similar to S_1 (9.26 %) whereas the lowest plant dry matter content (9.20) was obtained by S_0 at 55 DAP. At 70 DAP, the highest plant dry matter content was obtained by S_2 (12.25) which was statistically similar to results of S_3 and S_0 (12.19 % for each) plant dry matter content, on the other hand the lowest plant dry matter content (12.15%) was obtained by S_1. At 85 DAP, the highest plant dry matter content (15.99%) was observed in S_3 which was statistically similar to S_2 (15.92 %) plant dry matter content. The lowest plant dry matter content was observed in S_1 (15.72%).

Table 4.5.2. Effect of sulfur on % plant dry matter content of potato derived from TPS at different days after planting

Treatments	Plant dry matter (%) at			
Sulfur	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
S_0	7.74	9.20 c	12.19 ab	15.90 b
S_1	7.90	9.26 ab	12.15 b	15.72 c
S_2	7.87	9.29 a	12.25 a	15.92 ab
S_3	7.74	9.22 bc	12.23 a	15.99 a
F-test	ns	**	**	**
SE	-	0.002	0.002	0.004
CV (%)	0	0.08	0.07	0.09

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;** indicate significant at 1% levels of probability; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Combined effect of potassium and sulfur

Combination of potassium and sulfur had significant effect on plant dry matter content of potato derived from TPS (Table 4.5.3). At earlier stage (40 DAP), combined dose of K and S did not affected plant dry matter content of potato but at 55, 70and 85 DAP, combined dose had some effect on plant dry matter content, this result is agreed with the result of Makaraviciute (2003).

From table 4.5.3, it is reveled that, at 55 DAP, the highest plant dry matter content was obtained at K_2S_2 (10.44%) which was statistically similar to the result of K_2S_1 and K_2S_3 (10.36% for both). One the other hand the lowest plant dry matter content was observed on K_0S_1 (7.49%). At 70 DAP, the highest plant dry matter content was observed in K_2S_2 (15.13%) whereas the lowest plant dry matter content was obtained by K_1S_1 (8.60%). At 85 DAP, the highest plant dry matter content (21.37%) was observed at K_2S_2 whereas the lowest plant dry matter content (9.82%), this result agreed with results of Jenkins and Mahmood (2003) and Makaraviciute (2003).

Table 4.5.3. Combined effect of potassium and sulfur on % plant dry matter content of potato derived from TPS at different days after planting

Treatments	Plant dry matter (%)			
Potassium X sulfur	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
K_0S_0	6.67	7.91 g	9.02 i	10.24 i
K_0S_1	6.25	7.49 h	8.60 j	9.82 j
K_0S_2	6.67	7.91 g	9.03 i	10.25 i
K_0S_3	6.67	7.91 g	9.02 i	10.24 i
K_1S_0	7.50	8.98 f	12.02 h	15.70 h
K_1S_1	8.57	9.89 c	12.88 e	16.45 f
K_1S_2	8.00	9.40 e	12.41 f	16.04 g
K_1S_3	7.50	9.06 f	12.21 g	16.05 g
K_2S_0	8.67	10.26 b	14.69 c	20.48 c
K_2S_1	8.67	10.36 ab	14.91 b	20.92 b
K_2S_2	8.67	10.44 a	15.13 a	21.37 a
K_2S_3	8.67	10.33 ab	14.91 b	20.92 b
K_3S_0	8.14	9.64 d	13.02 d	17.18 d
K_3S_1	8.14	9.32 e	12.21 g	15.67 h
K_3S_2	8.14	9.40 e	12.41 f	16.03 g
K_3S_3	8.14	9.55 d	12.79 e	16.76 e
F-test	ns	**	**	**
SE	-	0.0042	0.00522	0.0086
CV (%)	0	0.08	0.07	0.09

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;** indicates significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

4.6. Tuber dry matter content (%)

Effect of potassium

Potassium had significant effect on tuber dry matter content of potato derived from TPS (Table 4.6.1). At earlier stage (40 DAP) potassium did not affect tuber dry matter content. Similar result was found by Karam *et al.* (2005). Table 4.6.1 showed that at 55 DAP, 70 DAP, 85 DAP, the highest tuber dry matter content were obtained by K_2 (14.48, 19.41, 23.04 %, respectively) whereas the lowest tuber dry matter content were obtained by K_0 (11.93, 13.42, 12.26 %, respectively) , this result was agreed with the result of Kanzikwera *et al.* (2001).

Table 4.6.1. Effect of potassium on dry matter content of tuber derived from TPS

Treatments	**Tuber dry matter (%) at**			
Potassium	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
K_0	6.56	11.93 d	13.42 d	12.26 d
K_1	7.89	13.46 c	16.88 c	18.18 c
K_2	8.67	14.48 a	19.41 a	23.04 a
K_3	8.14	13.60 b	17.11 b	18.53 b
F-test	ns	**	**	**
SE	-	0.0023	0.030	0.014
CV (%)	0	5.06	3.05	2.08

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant; ** indicates significant at 5% levels of probability; K_0 =0 kg K ha^{-1} ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1};

Effect of sulfur

In this experiment S also showed the significant effect on dry matter content of potato (Table 4.6.2). Data showed that at 55 DAP, S_2 produced the highest tuber dry matter content (13.41%) which was similar to of S_1 (13.39%). The lowest tuber dry matter content was observed in S_0 (13.32%). At 70 DAP, the highest tuber dry matter content was obtained by S_2 (16.75%) which was statistically similar with S_3 (16.73%) and whereas the lowest tuber dry matter content (16.65%) was recorded in S_1.

At 85 DAP, the highest of tuber dry matter content was obtained by S_3 (18.11%) which was statistically similar to the tuber dry matter content of S_2 (18.04%) whereas the lowest of tuber dry matter content was recorded in S_1 (17.84%). This result agreed with the result of other scientists (Jenkins and Mahmood, 2003, Moinuddin and Shahid, 2004).

Table 4.6.2. Effect of sulfur on % dry matter content of tuber of potato derived from TPS

Treatments	Tuber dry matter (%) at			
Sulfur	**40 DAP**	**55 DAP**	**70 DAP**	**85 DAP**
S_0	7.74	13.32 c	16.69 ab	18.02 b
S_1	7.90	13.39 ab	16.65 b	17.84 c
S_2	7.87	13.41 a	16.75 a	18.04 ab
S_3	7.74	13.34 bc	16.73 a	18.11 a
F-test	ns	**	**	**
SE	-	0.0021	0.0026	0.004
CV (%)	0	0.06	0.05	0.08

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant; ** indicate significant at 1% levels of probability; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Interaction effect of potassium and sulfur

Interaction of potassium and sulfur had significant role on of tuber dry matter content (%) of potato derived from TPS except for 40 DAP (Table 4.6.3) Data showed that at 55 DAP, the highest percentage of tuber dry matter content was obtained by K_2S_2 which was statistically similar to K_2S_1 and K_2S_3 (14.48% each),

At 70 DAP, the highest tuber dry matter content (19.83 %) was recorded in K_2S_2 whereas the lowest tuber dry matter content was obtained from K_0S_1 (13.10%).

At 85 DAP, the highest tuber dry matter content was observed in K_2S_2 (23.49%) whereas the lowest tuber dry matter content was observed in K_0S_1 (11.94%).

Table 4.6.3. Combined effect of potassium and sulfur on % dry matter content of tuber of potato derived from TPS

Treatments	Tuber dry matter (%) at			
	40 DAP	55 DAP	70 DAP	85 DAP
K_0S_0	6.67	12.03 g	13.52 i	12.36 i
K_0S_1	6.25	11.61 h	13.10 j	11.94 j
K_0S_2	6.67	12.03 g	13.53 i	12.37 i
K_0S_3	6.67	12.03 g	13.52 i	12.36 i
K_1S_0	7.50	13.11 f	16.52 h	17.82 h
K_1S_1	8.57	14.01 c	17.38 e	18.57 f
K_1S_2	8.00	13.53 e	16.91 f	18.16 g
K_1S_3	7.50	13.19 f	16.71 g	18.17 g
K_2S_0	8.67	14.40 b	19.19 c	22.60 c
K_2S_1	8.67	14.48 ab	19.41 b	23.04 b
K_2S_2	8.67	14.56 a	19.63 a	23.49 a
K_2S_3	8.67	14.48 ab	19.41 b	23.04 b
K_3S_0	8.14	13.77 d	17.52 d	19.30 d
K_3S_1	8.14	13.45 e	16.71 g	17.79 h
K_3S_2	8.14	13.53 e	16.91 f	18.15 g
K_3S_3	8.14	13.67 d	17.29 e	18.88 e
F-test	ns	**	**	**
SE	-	0.0042	0.0052	0.0086
CV (%)	0	0.06	0.05	0.08

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;** indicate significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

4.7. Number of tuber

Effect of potassium

The number of tubers hill^{-1} and tubers m^{-2} were significantly influenced by the application of potassium (Table 4.7.1) The result showed that number of tuber increased with increasing the rate of potassium up to K_2 and there after decreased with decreasing the application rate. Highest number of tuber (13.33 tubers hill^{-1}) was obtained from K_2 whereas the lowest number of tuber (8.41 tuber hill^{-1}) was obtained by K_3. Number of tuber per square meter was directly affected by potassium dose. It was observed that the highest number of tuber (133.30 tubers m^{-2}) was obtained from K_2 whereas the lowest number of tuber (84.17 tuber m^{-2}) was obtained by K_3 (Table 4.7.1). This result was agreed with the experiment of different scientist (Sobhani *et al.*, 2002 , Roy *et al.*, 2007, Lalitha *et al.* ,2002).

Table 4.7.1. Effect of potassium on number of tubers hill^{-1} and tubers m^{-2} of potato derived from TPS

Treatments	Number of tubers/hill	Number of tubers/ m^2
K_0	9.25 c	92.50 c
K_1	11.25 b	112.50 b
K_2	13.33 a	133.30 a
K_3	8.41 d	84.17 d
F-test	**	**
SE	0.45	4
CV (%)	4.87	4.87

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT;** indicates significant at 1% levels of probability; K_0 =0 kg K ha^{-1} ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1};

Effect of sulfur

Table 4.7.2 showed that number of tuber increased with increasing the rate of sulfur. Highest number of tuber (10.91) was observed in S_3. Number of tuber m^{-2} was significantly affected by sulfur. Table 4.7.2 showed that the highest number of tuber (109.20) was observed at S_3 whereas the lowest number of tuber (103.30) was observed at S_1 and S_2.

Table 4.7.2. Effect of sulfur on number of tubers hill^{-1} and tubers m^{-2} of potato derived from TPS

Treatments	**Number of tubers hill^{-2}**	**Number of tubers m^{-2}**
S_0	10.66 b	106.70 b
S_1	10.33 c	103.30 c
S_2	10.33 c	103.30 c
S_3	10.91 a	109.20 a
F-test	*	*
SE	0.25	2
CV (%)	5.52	5.52

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; * indicate significant at 5% levels of probability; S_0 =0 kg ha^{-1} sulfur; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Interactive effect of potassium and sulfur

Combination of potassium and sulfur had significant effect on number of tubers per hill^{-1} (Table 4.7.3) Table 4.7.3 showed that the highest number of tuber per square meter (143.30) was obtained at K_2S_3 whereas the lowest number of tuber per square meter (73.33) was observed at K_0S_0. Similar type of recorded by Lu (2003) and Moinuddin and Shahid (2004).

Table 4.7.3. Combined effect of potassium and sulfur on number of tubers hill^{-1} and tubers m^{-2} of potato derived from TPS

Treatments	Number of tubers hill^{-2}	Number of tubers m^{-2}
K_0S_0	7.33 k	73.330 k
K_0S_1	10.00 f	100.00 f
K_0S_2	9.66 g	96.670 g
K_0S_3	10.00 f	100.00 f
K_1S_0	13.33 b	133.30 b
K_1S_1	10.33 e	103.30 e
K_1S_2	10.33 e	103.30 e
K_1S_3	11.00 d	110.00 d
K_2S_0	13.33 b	133.30 b
K_2S_1	12.33 c	123.30 c
K_2S_2	13.33 b	133.30 b
K_2S_3	14.33 a	143.30 a
K_3S_0	8.66 h	86.67 h
K_3S_1	8.66 h	86.67 h
K_3S_2	8.00 j	80.00 j
K_3S_3	8.33 i	83.33 i
F-test	**	**
SE	0.35	3
CV (%)	5.52	5.52

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;** indicate significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

4.8. Number of different tuber size

Effect of potassium

Potassium had significant effect on number tubers of <28 mm size (Table 4.8.2). K_0 gave numerically the highest number of <28 mm size tuber (3.33) and statistically similar with K_1 and K_2 (3.00 and 3.08) whereas maximum dose of potassium i.e., K_3 produced the lowest number of <28 mm tuber (2). Lower dose of potassium produced smaller sized tuber that negatively affected total yield. This result agreed with the experiment of Karam *et al.* (2005). Potassium did not affected significantly on other size of tuber.

Table 4.8.1. Effect of potassium on tuber size of potato derived from TPS

Treatments	Number of tubers hill^{-1}			
	< 28 mm	28-45 mm	45-55 mm	>55 mm
K_0	3.33 a	2.83	1.91	1.16
K_1	3.00 a	5.00	1.41	1.83
K_2	3.08 a	4.58	2.08	3.58
K_3	2.00 b	4.16	1.25	1.00
F-test	*	Ns	ns	ns
SE	0.1	-	-	-
CV (%)	69.61	5014	12.6	14.87

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;* indicate significant at 5% levels of probability; K_0 =0 kg K ha^{-1} ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1};

Effect of sulfur

Sulfur had no significant role on number of tuber size (Table 4.8.2)

Table 4.8.2. Effect of sulfur on tuber size of potato derived from TPS

Treatments	Number of tubers hill^{-1}			
	< 28 mm	28-45 mm	45-55 mm	>55 mm
S_0	2.75	4.08	1.75	2.08
S_1	3.08	4.16	1.50	1.58
S_2	2.83	4.16	1.50	1.83
S_3	2.75	4.16	1.91	2.08
F-test	ns	Ns	ns	ns
SE	-	-	-	-
CV (%)	14.30	12.06	22.36	17.58

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Interactive effect of potassium and sulfur

Interaction of potassium and sulfur had no significant effect in production of smaller sized tuber. Data showed that K_0S_0 gave the highest number of <28 mm size tuber (4.33) whereas K_3S_0, $K_3S_{1,}$ $K_3S_{2,}$ K_3S_3 produced same number of tuber and that was the lowest value (2). Combination of potassium and sulfur had no effect on other size of tuber.

Table 4.8.3. Combined effect of potassium and sulfur on tuber size of potato derived from TPS

Treatments	Number of tubers $hill^{-1}$			
	< 28 mm	28-45 mm	45-55 mm	>55 mm
K_0S_0	3.00 b	2.33	1.00	1.00
K_0S_1	4.33 a	3.00	1.66	1.00
K_0S_2	3.00 b	3.00	2.33	1.33
K_0S_3	3.00 b	3.00	2.66	1.33
K_1S_0	3.00 b	5.00	2.00	3.33
K_1S_1	3.00 b	5.00	1.33	1.00
K_1S_2	3.00 b	5.00	1.33	1.00
K_1S_3	3.00 b	5.00	1.00	2.00
K_2S_0	3.00 b	4.33	3.00	3.00
K_2S_1	3.00 b	4.00	2.00	3.33
K_2S_2	3.33 b	5.00	1.00	4.00
K_2S_3	3.00 b	5.00	2.33	4.00
K_3S_0	2.00 c	4.66	1.00	1.00
K_3S_1	2.00 c	4.66	1.00	1.00
K_3S_2	2.00 c	3.66	1.33	1.00
K_3S_3	2.00 c	3.66	1.66	1.00
F-test	**	ns	ns	Ns
SE	0.20	-	-	-
CV (%)	14.30	12.06	22.36	17.58

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;** indicates significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 =130 kg K ha^{-1} ; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

4.9. Tuber yield

Effect of potassium

Potassium showed significant role on yield of potato derived from TPS (Table 4.9.1). Tuber yield increased with increasing application of potassium rate up to K_2 and thereafter decreased with increasing K. Data showed that K_2 gave the highest yield (27.43 t ha^{-1}) whereas the lowest yield (18.12 t ha^{-1}) was obtained from K_0 & K_3 (18.12 & 18.44 t ha_{-1} respectively)

Table 4.9.1. Effect of potassium on yield t ha^{-1} of potato derived from TPS

Treatments	Yield (t ha^{-1})
K_0	18.12 c
K_1	22.78 b
K_2	27.43 a
K_3	18.44 c
F-test	**
SE	0.2288
CV (%)	3.65

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ** indicate significant at 1% levels of probability; K_0 =0 kg ha^{-1} potassium ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1};

Effect of sulfur

Sulfur level had effect on yield of potato derived from TPS. Table 4.9.2 showed that S_2 produced the highest yield (22.22 t ha^{-1}) which was similar to S_1 and S_3 (21.83 t ha^{-1} and 21.82 t ha^{-1}, respectively) whereas S_0 gave the lowest yield. This result disagree with Karam *et al. (* 2005) and agreed with Lalitha *et al. (*2002).

Table 4.9.2. Effect of sulfur on yield t ha^{-1} of potato derived from TPS

Treatments	Yield (t ha^{-1})
S_0 S_1 S_2 S_3	20.91 b 21.83 a 22.22 a 21.82 a
F-test	*
SE	0.2661
CV (%)	4.25

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; * indicates significant at 5% levels of probability; S_0 =0 kg ha^{-1} sulfur; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Combined effect of potassium and sulfur

Yield of potato derived from TPS was significantly influenced by different combination potassium and sulfur (Figure 4.9.1). Data Showed that the highest yield was obtained by K_2S_2 (29.41 t ha^{-1}) combination that was statistically similar to K_2S_3 (29.20 t ha^{-1}). On the other hand the lowest yield was obtained by K_3S_3 (17.07 t ha^{-1}).

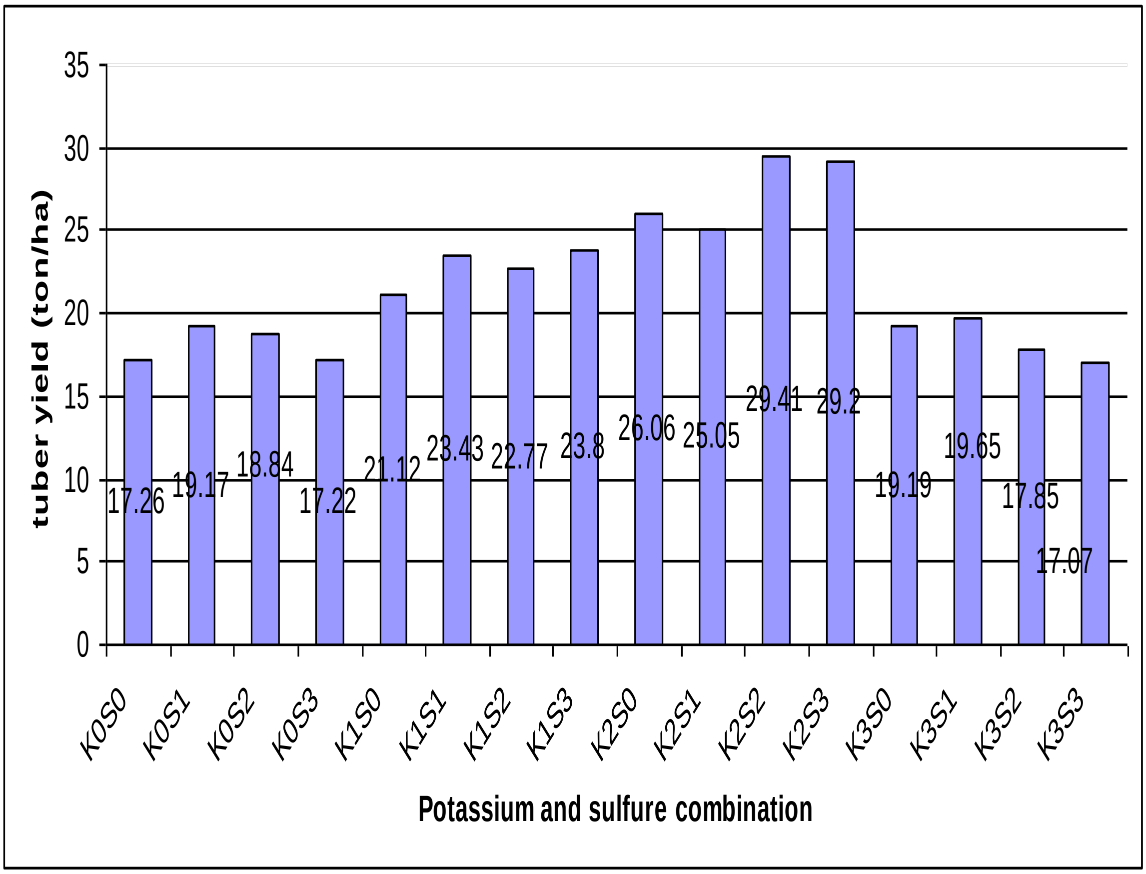

Figure 4.9.1. Combined effect of potassium and sulfur on yield t ha^{-1} of potato derived from TPS. (SE=0.850)

10. Different size yield

Effect of potassium

Potassium had significant effect on yield (kg ha^{-1}) 4 grade of tuber size. K_2 gave the highest result of all four grades. K_2 produced 5.63, 14.35, 4.82, 2.62 t ha^{-1} of <28 mm, 28-45 mm, 45-55 mm, >55 mm sized tuber, respectively.

Over dose of potassium K_3 gave the lowest yield in 2 grades *i.e.*, <28 mm (2.81 t ha^{-1}) and 45-55 mm (2.97 t ha^{-1}). But 0 kg K ha^{-1} gave the lowest yield 8.78, 1.14 t ha^{-1} in 28-45 mm and >55mm grade.

Table 4.10.1. Effect of potassium on yield of different size of potato derived from TPS

Treatments	Tuber weight (t ha^{-1})			
	<28 mm	**28-45 mm**	**45-55 mm**	**>55 mm**
K_0	3.75 b	8.78 d	4.44 ab	1.14 c
K_1	3.95 b	13.14 b	3.89 b	1.78 b
K_2	5.63 a	14.35 a	4.82 a	2.62 a
K_3	2.81 c	10.79 c	2.97 c	1.86 b
F-test	**	**	**	**
SE	0.1177	0.1432	0.1913	0.0560
CV (%)	10.75	3.27	13.11	9.66

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ** indicate significant at 1% levels of probability; K_0 =0 kg ha^{-1} potassium ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg ha^{-1} potassium;

Effect of sulfur

Sulfur gave different result to different grade tuber. In case of <28 mm size tuber there was no significant effect of sulfur dose. S_1, S_2, S_3 dose gave same result that was higher than S_0 in case of 28-45 mm graded tuber. In case of 45-55 mm grade S_1 and S_2 gave same yield (4.254 and 4.227 t ha^{-1}) which was statistically similar to no sulfur dose. Over dose of sulfur i.e., S_3 gave the lowest yield (3.584 t ha^{-1}) of 45-55 mm grade. Over dose of sulfur i.e., S_3 gave the highest result (2.25 t ha^{-1}) in >55 mm grade of tuber. Other three dose of sulfur gave statistically similar yield.

Table 4.10.2. Effect of sulfur on yield of different size of potato derived from TPS

Treatments	Tuber weight (t ha^{-1})			
	<28 mm	28-45 mm	45-55 mm	>55 mm
S_0	4.17 a	10.91 b	4.07 ab	1.75 b
S_1	3.91 a	11.94 a	4.25 a	1.71 b
S_2	4.25 a	12.04 a	4.22 a	1.69 b
S_3	3.80 a	12.18 a	3.58 b	2.25 a
F-test	*	**	*	**
SE	0.12	0.11	0.15	0.05
CV (%)	10.75	3.27	13.11	9.66

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; *, ** indicate significant at 5% and 1% levels of probability, respectively; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Combined effect of potassium and sulfur on different size of tuber

Combined dose of potassium and sulfur had significant effect on four grades of tuber derived from TPS (Table10.3). K_2S_2, produced the maximum yield (6.27 t ha^{-1}) which is statistically similar with, K_2S_0, K_2S_1, K_2S_3 ((5.33, 5.48, 5.43 t ha^{-1}, respectively) in <28 mm grade tubers. K_3S_3 gave the lowest result (2.40, 2.36 t ha^{-1}).

In case of 28- 45 mm tuber size, the highest yields (15.72 t ha^{-1}) were obtained from K_2S_3. The lowest yield (6.32t ha^{-1}) was obtained if no potassium and no sulfur was used.

In case of 45-55 mm graded tuber, the highest yield (5.35 t ha^{-1}) was obtained at no potassium- sulfur combination. K_0S_2 showed statistically similar result with K_0S_0. Largest sized tuber (>55 mm) tuber was obtained mostly from four dose i.e., K_2S_0, K_2 S_1, K_2S_2, K_2S_3 produced same yield which were statistically similar to K_1S_3. These five combination produced 2.55, 2.66, 2.50, 2.66, 2.26 t ha^{-1}, respectively.

Table 4.10.3. Combined effect and sulfur on yield of different size of potato

derived from TPS

Treatments	Tuber weight (t ha^{-1})			
	<28 mm	**28-45 mm**	**45-55 mm**	**>55 mm**
K_0S_0	4.43 b	6.32 g	5.35 a	1.16 ef
K_0S_1	2.82 ef	11.26 d	4.62 a-c	0.46 g
K_0S_2	4.09 b-d	8.61 f	5.03 ab	1.09 f
K_0S_3	3.67 b-e	8.92 f	2.75 f	1.87 b-d
K_1S_0	3.56 b-e	13.00 bc	3.12 ef	1.42 df
K_1S_1	4.21 bc	12.98 bc	4.38 a-c	1.85 b-d
K_1S_2	4.26 bc	13.04 bc	3.89 c-e	1.58 c-f
K_1S_3	3.77 b-e	13.56 b	4.20 b-d	2.26 ab
K_2S_0	5.33 a	13.15 b	4.91 a-c	2.66 a
K_2S_1	5.48 a	12.23 c	4.68 a-c	2.66 a
K_2S_2	6.27 a	15.72 a	4.91 a-c	2.50 a
K_2S_3	5.43 a	16.30 a	4.79 a-c	2.66 a
K_3S_0	3.35 c-e	11.16 d	2.92 ef	1.75 b-e
K_3S_1	3.13 df	11.30 d	3.33 df	1.88 b-d
K_3S_2	2.40 f	10.77 d	3.07 ef	1.60 c-f
K_3S_3	2.36 f	9.91 e	2.58 f	2.21 a-c
F-test	**	**	**	**
SE	0.25	0.22	0.30	0.10
CV (%)	10.75	3.27	13.11	9.66

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant;** indicates significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

4.11. Seed Yield

Effect of potassium

Seed yield was significantly affected by potassium dose (Table 4.11.1). Application of K_2 produced the highest seed yield (19.18 t ha^{-1}). K_0 and K_3 produced the lowest yield (13.22 t ha^{-1} & 13.77 t ha^{-1}).

Non seed yield was affected the same way to seed yield by potassium. The highest non seed yield (8.25 t ha^{-1}) was obtained by K_2. Two the lowest yields (4.90 t ha^{-1} and 4.67 t ha^{-1}) was reported in zero dose and over dose of potassium (K_3)

Table 4.11.1. Effect of potassium on Seed yield of potato derived from TPS

Treatments	**Seed yield (t ha^{-1})**	**Non seed (t ha^{-1})**
K_0	13.22 c	4.90 c
K_1	17.04 b	5.73 b
K_2	19.18 a	8.25 a
K_3	13.77 c	4.67 c
F-test	**	**
SE	0.2799	0.1297
CV (%)	6.13	7.59

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ** indicates significant at 1% levels of probability; K_0 =0 kg ha^{-1} potassium ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg ha^{-1} potassium;

Effect of sulfur

Seed yield did not increase with the increase of sulfur dose (Table 4.11.2). Result showed that seed yield after using sulfur was higher than that of seed yield in zero sulfur. S_1, S_2, S_3 dose of sulfur gave statistically similar seed yield (16.20, 16.26, 15.76 t ha^{-1}, respectively). Zero sulfur gave the lowest yield (14.98 t ha^{-1}). Sulfur had no significant effect on non seed yield.

Table 4.11.2. Effect of sulfur on Seed yield of potato derived from TPS

Treatments	Seed yield (t ha^{-1})	Non seed (t ha^{-1})
S_0	14.98 b	5.92 a
S_1	16.20 a	5.62 a
S_2	16.26 a	5.95 a
S_3	15.76 a	6.06 a
F-test	**	*
SE	0.19	0.13
CV (%)	4.25	7.85

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; *, ** indicate significant at 5% and 1% levels of probability, respectively; S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Interaction effect of potassium and sulfur

Combined dose of potassium and sulfur had significant effect on seed yield and non seed yield of potato derived from TPS. K_2S_2 and K_2S_3 dose gave the highest seed yield (20.64 and 21.11 t ha^{-1}). K_0S_0 and K_0S_3 gave the lowest result (11.68 t ha^{-1}). In case of non seed, statistically the highest yield was observed in four doses i.e., K_2S_0, K_2 S_1, K_2S_2 and K_2S_3whiche were 8.00, 8.14, 8.77, 8.10 t ha^{-1} respectively.The lowest non seed yield (3.28 t ha^{-1}) was obtained by K_0S_1 dose.

Table 4.11.3. Combined effect of potassium and sulfur on Seed yield of potato derived from TPS

Treatments	Seed yield ($t\ ha^{-1}$)	Non seed ($t\ ha^{-1}$)
K_0S_0	11.68 e	5.59 bc
K_0S_1	15.89 c	3.28 f
K_0S_2	13.65 d	5.19 b-d
K_0S_3	11.68 e	5.53 b-d
K_1S_0	16.12 c	4.99 cd
K_1S_1	17.36 b	6.06 b
K_1S_2	16.93 bc	5.84 bc
K_1S_3	17.76 b	6.04 b
K_2S_0	18.06 b	8.00 a
K_2S_1	16.91 bc	8.14 a
K_2S_2	20.64 a	8.77 a
K_2S_3	21.11 a	8.10 a
K_3S_0	14.08 d	5.11 b-d
K_3S_1	14.64 d	5.01 cd
K_3S_2	13.84 d	4.00 ef
K_3S_3	12.49 e	4.57 de
F-test	**	**
SE	0.3875	0.2670
CV (%)	4.25	7.85

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ns= Non significant; ** indicate significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

4.12. Marketable yield

Potato tuber size was not uniform in shape and size. Tuber of less weight had less market value. >20 g potato was considered as marketable tuber. In this experiment marketable tubers were isolated from non marketable tubers.

Effect of potassium

Dose of potassium had significant effect on marketable tubers. The highest yield of marketable yield was recorded in K_2 of potassium. No potassium (K_0) and over dose of potassium (K_3) gave statistically similar yield and those was the lowest yields (12.99 and 13.21 t ha^{-1} respectively)

Table 4.12.1. Effect of potassium on Marketable yield of potato derived from TPS

Treatments	Marketable yield (t ha^{-1})
K_0	12.99 c
K_1	16.32 b
K_2	19.66 a
K_3	13.21 c
F-test	**
SE	0.1523
CV (%)	3.39

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; ** indicate significant at 1% levels of probability; K_0 =0 kg ha^{-1} potassium ; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg ha^{-1} potassium;

Effect of sulfur

Marketable yield did not increase with the increase of sulfur dose. Result showed that marketable yield after using sulfur was higher than that of marketable yield in zero sulfur. S_1, S_2, S_3 dose of sulfur gave statistically similar marketable yield (15.64, 15.91, 15.63 t ha^{-1}, respectively). Zero sulfur gave the lowest yield (14.98 t ha^{-1}).

Table 4.12.2. Effect of sulfur on Marketable yield t ha^{-1} of potato derived from TPS

Treatments	Marketable yield (t ha^{-1})
S_0 S_1 S_2 S_3	14.98 b 15.64 a 15.91 a 15.63 a
F-test	*
SE	0.1900
CV (%)	4.23

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT; * indicate significant at 5% levels of probability; S_0 =0 kg ha^{-1} sulfur; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

Combined effect of potassium and sulfur

Combined dose of potassium and sulfur had significant effect on marketable tuber of potato derived from TPS. K_2S_2 and K_2S_3 gave the similar the highest yield (21.07 and 20.92, respectively).The lowest yield of marketable tuber yield was recorded in over dose i.e., K_3S_3. The lowest yield was statistically similar to K_0S_0 dose.

Table 4.12.3. Combined effect of potassium and sulfur on Marketable yield t ha^{-1} of potato derived from TPS

Treatments	Marketable yield (t ha^{-1})
K_0S_0	12.38 hi
K_0S_1	13.73 fg
K_0S_2	13.49 f-h
K_0S_3	12.34 hi
K_1S_0	15.12 e
K_1S_1	16.79 d
K_1S_2	16.32 d
K_1S_3	17.06 cd
K_2S_0	18.68 b
K_2S_1	17.95 bc
K_2S_2	21.07 a
K_2S_3	20.92 a
K_3S_0	13.75 fg
K_3S_1	14.08 ef
K_3S_2	12.78 g-i
K_3S_3	12.22 i
F-test	**
SE	0.38
CV (%)	4.23

In a column, means followed by same letter (s) do not differ significantly at 5% level of significant by DMRT;** indicate significant at 1% levels of probability; K_0 =0 kg K ha^{-1}; K_1 =117 kg K ha^{-1}; K_2 130 kg K ha^{-1} =; K_3 =143 kg K ha^{-1}. S_0 =0 kg S ha^{-1}; S_1 =24 kg S ha^{-1}; S_2 =29 kg S ha^{-1}; S_3 =34 kg S ha^{-1};

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at the field of Sher-e-Bangla Agricultural University, Dhaka, during the period from 10 November 2010 to 10 March 2011 to investigate the effect of potassium and sulfur on morpho-physiological characters, yield attributes and yield of potato derived from TPS. The experiment comprised of 4 doses of potassium *viz*., 0, 117, 130, 143 kg ha^{-1} and 4 doses of sulfur viz., 0, 24, 29, 34 kg ha^{-1}. The experiment was laid out in split plot design factorial with three replications. The collected data were analyzed statistically and the means were separated by DMRT at 5% level of probability.

The morpho-physiological parameters and yield attributes such as, plant height, stems $hill^{-1}$, number of leaves $hill^{-1}$, total dry mass (TDM) $plant^{-1}$ and TDM m^{-2} were significantly influenced by potassium at different growth stages in potato. Results revealed that, plant dry matter percentage, number of leaves, tuber dry matter percentage, stems $hill^{-1}$, tuber/m^2, seed yield, marketable yield increased significantly with increasing potassium level. Plant height decreased with increasing potassium level.

In case of plant height, 0 kg ha^{-1} and 117 kg ha^{-1} and 143 kg ha^{-1} potassium showed the highest result but 130 kg ha^{-1} potassium showed lowest plant height. Up to 55 DAP, there is no significant effect of potassium on number of stem, but latter stages i.e., at 70 DAP, and 85 DAP 130 kg ha^{-1} potassium produces the highest number of stem. zero kg ha^{-1} potassium produce the lowest number of stem/hill. The highest number of leaves is observed at 130 kg ha^{-1} potassium and 0 kg ha^{-1} potassium produce lowest number of leaves. There is no significant effect of potassium on plant dry matter and tuber dry matter percentage at earlier stage (40 DAP) but at latter stage (55, 70, 85 DAP) 130 kg ha^{-1} potassium produce highest plant dry matter percentage and tuber dry matter percentage. zero kg ha^{-1} potassium gives lowest plant dry matter and tuber dry matter percentage. Highest number of tuber is obtained from 130 kg ha^{-1} potassium whereas the lowest number of tuber is obtained by 143 kg ha^{-1} potassium. Lower dose of potassium produce smaller sized tuber that negatively affects total yield. Potassium does not affect significantly the comparatively bigger size tube. 130 kg ha^{-1} potassium gives the highest yield whereas the lowest potassium i.e., 0 kg ha^{-1} potassium produces the lowest yield. 130 kg ha^{-1} potassium gives the highest result of all four grades. Over dose of potassium i.e., 143 kg ha^{-1} potassium gives the lowest result in 3 smaller grades and 0 kg ha^{-1} potassium produce lowest bigger size tuber and seed yield. Marketable tuber i.e., >20 g tuber is produced higher by 130 kg ha^{-1} potassium, 0 kg ha^{-1} and over dose of potassium reduce marketable yield.

The morpho-physiological parameters and yield attributes such as, plant height, stems $hill^{-1}$, number of leaves $hill^{-1}$, total dry mass (TDM) $plant^{-1}$ and TDM m^{-2} were significantly influenced by sulfur at different growth stages in potato. Results revealed that, plant dry matter percentage, tuber dry matter percentage, stems $hill^{-1}$, tuber/m^2, seed yield, marketable yield increased significantly with increasing sulfur level. Plant height, number of leaves and tuber/m^2 decreased with increasing sulfur level.

At earlier stage (40 DAP) 29 kg ha^{-1} sulfur gives numerically the highest plant height and Zero and over dose of sulfur reduce the plant height and give similar plant height. At all growth stage 29 kg ha^{-1} sulfur produces maximum number of stem. Number of leaves decrease with increasing sulfur dose. 24 kg ha^{-1} sulfur produces maximum number of leaves in all growth stages. Plant dry matter percentage increase with increasing sulfur dose up to 29 kg ha^{-1} sulfur at 40 and 55 DAP, but up to 34 kg ha^{-1} sulfur at 70 and 85 DAP. Tuber dry matter percentage increase with increasing sulfur dose up to 29 kg ha^{-1} sulfur at 40 and 55 DAP, but up to 34 kg ha^{-1} sulfur at 70 and 85 DAP. Number of tuber per m^2 increases with increasing sulfur dose, and it is maximum at over dose of sulfur. Sulfur has no significant effect on number of different size of tuber. 24 kg ha^{-1}, 29 kg ha^{-1} and 34 kg ha^{-1} sulfur increased the yield but not to the significant level. Over dose of sulfur i.e., 34 kg ha^{-1} sulfur produces maximum largest graded tuber. Seed yield does not increase with the increase of sulfur dose. Seed yield after using sulfur is higher than that of seed yield in zero sulfur. Marketable yield does not increase with the increase of sulfur dose.

The morpho-physiological parameters and yield attributes such as, plant height, stems $hill^{-1}$, number of leaves $hill^{-1}$, total dry mass (TDM) $plant^{-1}$ and TDM m^{-2} were significantly influenced by potassium-sulfur combination at different growth stages in potato.

At 40 DAP 0 kg ha^{-1} potassium with 24 kg ha^{-1} sulfur combination produce highest plant height but 117 kg ha^{-1} potassium with 0 kg ha^{-1} sulfur produces highest plant height at 55, 70, 85 DAP. Finally minimum plant height was observed at 130 kg ha^{-1} potassium with 0 kg ha^{-1} sulfur.

Maximum number of stem is observed at 130 kg ha^{-1} potassium with 29 kg ha^{-1} sulfur combination, at final stage control dose of potassium and sulfur produces minimum number of stem. Same trend is observed in number of leaves $hill^{-1}$. At the latter stage minimum number of leaves is observed in control dose of potassium and sulfur.

The highest plant dry matter and tuber dry matter percentage was achieved from 130 kg ha^{-1} potassium with 29 kg ha^{-1} sulfur and minimum plant dry matter and tuber dry matter percentage by control potassium and sulfur.

Maximum tuber per square meter is achieved by 130 kg ha^{-1} potassium with 34 kg ha^{-1} sulfur followed by 130 kg ha^{-1} potassium with 29 kg ha^{-1} sulfur combination. 130 kg ha^{-1} potassium with 29 kg ha^{-1} sulfur and 130 kg ha^{-1} potassium with 34 kg ha^{-1} sulfur produce the highest number of largest size of tuber. Thus 130 kg ha^{-1} potassium with 29 kg ha^{-1} sulfur and 130 kg ha^{-1} potassium with 34 kg ha^{-1} sulfur combination produce maximum tuber yield. The highest seed yield and marketable yield is also produced by 130 kg ha^{-1} potassium with 34 kg ha^{-1} sulfur and 130 kg ha^{-1} potassium with 34 kg ha^{-1} sulfur combination.

Based on the experimental results, it may be concluded that-

i) The effect of potassium and sulfur had positive effect on morphological and growth characters, yield attributes and yield in potato.

ii) Application of 130 kg ha^{-1} potassium with 29 kg ha^{-1} sulfur and 130 kg ha^{-1} potassium with 34 kg ha^{-1} sulfur combination seemed to be more suitable for getting higher tuber yield.

REFERENCE

BBS (Bangladesh Bureau of Statistics). (2009). Monthly statistical year book. Ministry of Planning, Govt. People's Repub. Bangladesh. p. 64.

Cao, S.M. (2003). Yield-increasing effects of top dressing of K fertilizer on potato (*Solanum tuberosum*). *Chinese Potato J.* **17**(1): 15-16.

Chettri, M. and Thapa,U. (2002). Response of potato to different sources of potassium with or without farm yard manure in new alluvial zone of West Bengal. *Haryana J. Hort. Sci*. **31**(3-4): 253-255.

Divis, J. and Barta, J. (2001). Influence of the seed-tuber size on yield and yield parameters in potatoes. *Rostlinna Vyroba,* **47**(6): 271-275.

Epprnderfer, A and Eggum, E 1994. Production and utilization of seed tubers derived from true potato seed. Thesis paper submitted for degree of Doctor of philosophy, International potato center.

Eugenia, B. (2008). Ontario Potato Conference, March 6, 2012.

FAO (Food And Agricultural organization). (2009). Production Year Book No. 65. Food and Agriculture Organization FAO , Rome, Italy. p. 97.

Jenkins, P.D. and Mahmood, S. (2003). Dry matter production and partitioning in potato plants subjected to combined deficiencies of nitrogen, phosphorus and potassium. *Ann. Appl. Biol.***143**(2): 215-229.

Kanzikwera, C.R., Tenywa, J.S., Osiru, D.S.O., Adipala, E.and Bhagsari, A.S. (2001). Interactive effect of nitrogen and potassium on dry matter and nutrient partitioning in true potato seed mother plants. *African Crop Sci. J.* **9**(1): 127-146

Karam, F., Lahoud, R., Masaad, R., Stephan, C., Rouphael, Y., Colla, G. D., Casa, R., Viola, R. (2005). Yield and tuber quality of potassium treated potato under optimum irrigation conditions. *Acta Hort.* **684**: 103-108.

Khandakhar, S.M.A.T., Rahman,M.M., Uddin,M.J., Khan,S.A.K.U., Quddus,K.G. (2004). Effect of lime and potassium on potato yield in acid soil. *Pak. J. Bio. Sci.* **7**(3): 380-383.

Lalitha, B.S., Nagaraj, K.H., Lalitha, K.C., Anand, T.N., (2000). Levels of potassium and sulphur on concentration and uptake of nutrients by true potato seed (TPS) and seed tuber. *Current Research University of Agri. Sci. Bangalore*. **29**(5-6): 82-83.

Lalitha, B.S., Nagaraj, K.H., Anand,T.N., (2002). Effect of source propagation, level of potassium and sulphur on potato (Solanum tuberosum L.). *Mysore J. Agri. Sci.* **36**(2): 148-153.

Lu, Y.G. (2003). Effects of K fertilizer application on potato yield in high altitude localities. *Chinese Potato J.* **17**(2): 67-69.

Makaraviciute, A. (2003) Effects of fertilization on potato tuber yield, starch and dry matter content. *Zemes ukio Mokslai.* **2**: 35-42.

MOA. (Ministry of Agriculture) (2009). Hand Book of Agricultural Statistics, December, 2005. Market Monitoring and Information System, Ministry of Agriculture (MOA), Govt. People's Repub. Bangladesh. p. 493.

Moinuddin, A. and Shahid, U. (2004). Influence of combined application of potassium and sulfur on yield, quality, and storage behavior of potato. *Commu. in Soil Sci. Plant Analy*. **35**(7/8): 1047-1060.

Nandi, P., Mandal, D. and Ghosh, D.C. (2002). Fertility management in seedling tuber production from true potato seed (TPS). *Hort. J.* 15(3): 43-52.

Parveen, K., Pandey, S.K., Singh, S.V., Sanjay, R. and Dinesh, K. (2004). Effect of potassium fertilization on processing grade tuber yield and quality parameters in potato (Solanum tuberosum). *Indian J. Agric. Sci.* **74**(4): 177-179.

Qin, F. (2003). Effects of K fertilizer application on yield of potato. *Chinese Potato J.* **17**(3): 171-173.

Rahman, E.H.M.S., Siddique, M.A. and Rabbani, M.G. (2002). Effects of cowdung and NPK on the yield and storability of seedling tubers raised from true potato seeds. *Bangladesh J. Training Deve.* **15**(1-2): 151-156.

Roy, T.S., Nishizawa,T. and Ali, M.H. (2007). Seed quality as affected by nitrogen and potassium during true potato seed production. *Asian J. Plant Sci. 6(8): 1269- 1275.*

Russell, D. F. (1986). MSTAT-C Pakage Programme. Crop and Soil Science Department, Michigan University, USA.

Sobhani, A.R. Rahimian,H., Majidi,E. and Noormohamadi, G. (2002) Effects of water deficit and potassium nutrition on yield and some agronomic characteristics of potato. *J. Agric. Sci. Islamic Azad Univ.* **8**(3): Ar23-Ar34, 3-4.

Song, J.B. (2004). Effects of K fertilizer application on yield of early-maturing potato under irrigation conditions. *Chinese Potato J.* **23**(2): 86-87.

Suman, M.Y.S. and Khurana,S.C. (2003). Effect of fertilizer, spacing and crop duration on growth and yield of potato. *J. Indian Potato Assoc.* **30**(1-2): 87-88.

TCRC. (Tuber crop research center) (2004). Annual Report of 2003-04. Tuber Crops Research Centre, Bangladesh Agricultural Research Institute, Gazipur-1701. p. 13.

Wijkmark, L., Lindholm, R. and Nissen, K. (2005) Uniform potato quality with site-specific potassium application. Precision agriculture'05. Papers presented at the 5th European Conference on Precision Agriculture, Uppsala, Sweden. 393-400.

APPENDICES

Appendix I. Physical and chemical properties of soil of the experimental plots

A. Physical properties of soil	
% sand (0.2-.02 mm)	21.75
% silt (0.02-.002 mm)	66.60
% clay (< 0.002 mm)	11.65
Textural class	Silty loam
Consistency	Granular
B. Chemical properties of soil	
Soil pH	6.53
Organic carbon (%)	1.68
Organic matter (%)	1.28
Total nitrogen (%)	0.17
Available phosphorus (ppm)	8.05
Exchangeable potassium (me/100 g soil)	0.16
Available sulphur (ppm)	11.43

Appendix II. Average monthly rainfall, air temperature and relative humidity and sunlight during the experimental period between November 2010 to March, 2011 at the SAU area, Dhaka

Month	Monthly average air temperature (^{0}C)			Average rainfall (mm)	Average relative humidity (%)	Average daily sunshine (hrs)
	Maximum	Minimum	Average			
October	31.27	24.14	27.71	18.0	86.2	8.65
November	29.49	19.55	24.52	00.0	84.3	8.45
December	26.52	13.19	19.85	00.0	80.8	6.67
January	23.43	12.93	18.18	00.0	78.0	7.20
February	27.34	16.41	21.87	06.6	73.9	8.18
March	29.61	20.57	25.09	13.6	80.6	7.66
April	30.56	22.14	26.35	96.6	78.57	7.42

Source: Weather Yard, SAU, Dhaka

Appendix III. Analysis of variance (mean square) and yield t ha^{-1}

Source of variation	df	Yield (t ha^{-1})
Replication	2	3.323
potassium (A)	3	229.926 **
Error	6	0.628
sulfur (B)	3	3.695 *
A×B	9	7.509 *
Error	24	0.850

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix IV. Analysis of variance (mean square) of number of leaves at different DAP

Source of variation	df,	Number of leaves			
		40 DAP	55 DAP	70 DAP	85 DAP
Replication	2	5.714	31.924	31.924	47.341
potassium (A)	3	218.758**	164.024*	179.739*	179.739*
Error	6	4.017	21.861	21.861	21.861
sulfur (B)	3	41.905**	110.384**	129.919**	129.919**
A×B	9	81.296**	138.665**	174.521**	174.521**
Error	24	1.566	11.364	11.364	11.364

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix V. Analysis of variance (mean square) of number of stems at different DAP

Source of variation	df	Number of stems			
		40 DAP	55 DAP	70 DAP	85 DAP
Replication	2	0.212	1.007	0.530	0.779
potassium (A)	3	0.730*	0.730*	1.120 *	1.120*
Error	6	0.450	0.450	0.450	0.450
sulfur (B)	3	0.839 *	0.839*	0.839 *	0.839*
A×B	9	0.504*	0.504*	0.504*	0.504*
Error	24	0.369	0.369	0.369	0.369

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix VI. Analysis of variance (mean square) of plant dry matter percentage at different DAP

Source of variation	df,	Plant dry matter %			
		40 DAP	55 DAP	70 DAP	85 DAP
Replication	2	0.000	0.014	0.122	0.043
potassium (A)	3	9.621	13.498 **	73.172 **	234.741**
Error	6	0.032	0.023	0.031	0.031
sulfur (B)	3	0.085	0.019 **	0.023**	0.168**
A×B	9	0.275	0.233**	0.338**	0.685**
Error	24	0.000	0.012	0.031	0.003

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix VII. Analysis of variance (mean square) of tuber dry matter percentage at different DAP

Source of variation	df	Tuber dry matter %			
		40 DAP	55 DAP	70 DAP	85 DAP
Replication	2	0.000	0.029	0.122	0.043
potassium (A)	3	9.621	40.494**	73.172**	234.741**
Error	6	0.545	0.054	0.011	0.003
sulfur (B)	3	0.085	0.056**	0.023**	0.168 **
A×B	9	0.275	2.094**	0.338**	0.685**
Error	24	0.000	0.001	0.040	0.060

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix VIII. Analysis of variance (mean square) of yield of different size of tuber

Source of variation	df,	number of tuber $hill^{-1}$			
		<28 mm	28-45 mm	45-55 mm	>55 mm
Replication	2	0.176	0.462	0.660	0.063
potassium (A)	3	16.496*	73.811*	7.705*	4.385*
Error	6	3.872	4.316	4.316	350.715
sulfur (B)	3	0.541*	4.030*	1.160**	0.854**
A×B	9	0.862	7.080	1.384	0.254
Error	24	0.188	0.148	0.280	0.032

*, ** indicate significant at 5% and 1% level of probability, respectively

Appendix IX. Analysis of variance (mean square) seed yield (t ha^{-1}) and marketable yield (t ha^{-1})

Source of variation	df	seed yield (t ha^{-1})	marketable yield (t ha^{-1})
Replication	2	2.220	0.117
potassium (A)	3	94.983**	32.302**
Error	6	0.940	0.278
sulfur (B)	3	4.168 **	0.414*
A×B	9	8.034 **	1.684 **
Error	24	0.450	0.214

*, ** indicate significant at 5% and 1% level of probability, respectively