Journal of Agriculture and Crops
ISSN(e): 2412-6381, ISSN(p): 2413-886X
Vol. 5, Issue. 5, pp: 65-70, 2019
URL: https://arpgweb.com/journal/journal/14
DOI: https://doi.org/10.32861/jac.55.65.70

Academic Research Publishing Group

Original Research **Open Access**

Response of Potato (*Solanum Tuberosum L.*), To Nps Fertilizer Application on Growth Parameters at Mizan -Aman, South West Ethiopia

Simon Koroto
Lecturer and Researcher at Department of Horticulture, College of Agriculture and Natural Resources, Mizan-Tepi University)

Selemawit Dula*
Lecturer at Department of Horticulture, College of Agriculture and Natural Resources, Mizan-Tepi University

Abstract

Potato (Solanum tuberosum L.) is one of the most important crops globally. There is little information on balanced use of chemical fertilizer on potato production in Benchi-Maji Zone. Thus, a field experiment was conducted with the objective to investigate the effect of NPS fertilizer rate on the growth parameters of potato. The treatment consisted of four levels of NPS fertilizer (0, 50, 100 and 150 kg ha-1) which were laid out in RCBD with three replications. Improved potato variety "Gudene" was used as a test crop. NPS fertilizer rate had significantly influenced almost all the tested parameters of potato. Day's to 50% flowering was highly significantly affected by NPS rate. Early day to flower were obtained with the application of 100 kg ha-1 of NPS fertilizer and late flowering recorded at 150 kg ha-1 NPS fertilizer application rate. Significantly highest plant height of potato was obtained from application of 150 kg ha-1 NPS fertilizer and the smallest height is obtained from application of 50 kg ha-1 NPS fertilizer.

Keywords: Day's to 50% flowering; Plant height; Average stem number per hill.

1. Introduction

The potato (S*olanum tuberosum* L.) belongs to familiy *solanaceae* and genus of *solanum* is a starchy, perennial tuberous crop. It is the world's fourth largest food crops following maize, wheat and rice [1]. It was introduced to Ethiopia in 1958 by the German botanist Shimper [2]. Since then, it serves as food and cash crop for small scale farmers.

Potato (*Solanum tuberosum* L.) is one of the most important crops globally [3, 4]. In Ethiopia, among root and tuber crops potato ranks first in volume produced and consumed followed by sweet potato, enset, yam and taro [5]. Potato is an important nutrient source in human nutrition as it contains about 79% water, 18% starch as good sources of energy, 2% protein and 1% vitamins including C minerals including, calcium and magnesium and many trace elements [6]. It produces approximately twice as many calories per hectare as rice or wheat and is highly nutritious due to its high concentrations of vitamin C and other essential amino acids for balanced human nutrition.

Ethiopia is endowed with suitable climatic and edaphic conditions for potato production. About 70% of the available agricultural land is located at an altitude of 1800-2500 meters above sea level and receives an annual rainfall of more than 600 mm, which is suitable for potato production [7]. Besides, potato is also suited to smallholder farmers in developing countries for the labour requirement for its production is less than that of cereals. Its shorter growing period makes it possible for smallholder farmers to use this crop in a system where more than one crop is possible on the same land per season [8].

The total area cropped with potato in Ethiopia is 160,000 ha [9], which is very low compared to the existing potential as the crop can be grown on about 70% of the 10 million hectares of arable land in the country [3]. The national average yield is 8.2 tons ha^{-1}, which is very low compared to the world's average of 17.4 tons ha^{-1} and to other potato producing countries of the world, such as the Netherlands (40 tons ha^{-1}), Germany (28 tons ha^{-1}), Egypt (17.4tons ha^{-1}) and Burundi (11 tons ha^{-1}) [10].

Potato is a short cycle crop, requiring sufficient macro and micro nutrients at all stages of development for optimum yield. Among the macro nutrients nitrogen (N) generally represents the greatest limitation in potato production [11]. Nitrogen plays an important role in the balance between vegetative and reproductive growth of potato [12]. Application of N fertilizer can increase the yield and yield components of potato [13]. On the other hand application of excess nitrogen fertilizer ma influences various growth and yield parameters of potato. According to Sebastiani, *et al.* [14] for instance excessive nitrogen fertilization reduced starch, dry matter and sugar contents in potato tubers and so on.

Phosphorous is one of the largely required nutrients for the production of potato. It plays a significant role in physiological and biochemical reactions such as photosynthesis, conversion of sugar in to starch [15]. Phosphorous application significantly increased plant height, marketable tuber number and yield and tuber size of potato at Bako [13].

Plants require a variety of elements for growth and development of which N, P and K are the most important because they are required in large quantities. Sulfur is fourth major nutrient after NPK, required by plants. Sulfur

*Corresponding Author

plays an important role in chlorophyll formation and therefore helps to give plants their green color. Sulfur is known to take part in many reactions in all living cells [16]. Thus it is the key component of balanced nutrition required for the production of potato where intensive cropping and use if high grade fertilizers resulted in depletion of soil sulfur. Therefore deficiency of N, P, K and S elements in manifested in the detrimental effects on the growth and development of the plants [17].

In 2014, world potato production was 382 million tonnes, as increasing of 4% over 2013 amount and led by china with 25% of the world total [18]. Potato is fastest growing food crop in sub- Saharan Africa with the total production in some countries more than doubled during the last 15 years.

The total area under potato cultivation in 2016/2017 (2009) in Ethiopia is about 66,923.33 ha with an average productivity of 13.768 ton/ha and the crop is grown by approximately 1,197,018 private holders [19]. The country has very huge agricultural potential, favorable climate and productive soil for potato production [20].

Potato has been also considered as a strategic crop by the Ethiopian government aiming at enhancing food security and economic benefits to the country. As the population grows rapidly, increased productivity of potatoes can improve the livelihood of smallholder potato producer and is required to meet the growing demand [21].

In Ethiopia, potato production in 2015/2016 main cropping season was about 9, 432, 33.443 tones with yield of 13.768 tonnes per hectare. This shows a considerable reduction of potato productivity in 4.5% from 2016/2017 year [19]. Despite 70% of Ethiopian land have a potential for potato production the national average potato yield is about 8.2 t/ha, which is very low compared to the worlds average production [10] of 17.67 t/ha. Low soil fertility in general and the deficiency of nitrogen (N) and phosphorous (p) in most Ethiopian soils [22] in particular is the most important factor limiting potato production in Ethiopia [23]. The yield and quality of potato are affected by planting material, environmental conditions and cultural practices where fertilizer application has prominent effects on the quality and tuber yield of potato [24].

The soil in the southwestern part of Ethiopia is low in soil organic matter, cation exchange capacity in acidity [25]. Low level of soil organic matter combined with poor land coverage have resulted in many production problems accounted for the low yield of potato in this region. On top of this, since information on soil fertility studies for potato production studies for potato production in this region is limited [26] and hence, there is inadequate site specific fertilizer recommendation to apply on different soil types with patch of high and low fertilizer application for many years. Due to this reason fertilizer application practices in southwestern region is based on the experiences of other regions and these could be one of the reason for low yield of potato in the region. Since N and P are the most important among the essential plant nutrients required by the potato plant [22] area specific N and P rates should be identified to increase tuber yield of potato.

Chemical fertilizer sources in Ethiopia agriculture have been limited to Urea and Dap over the past five decades. This type of fertilization delivers only N and P which may not satisfy the nutrient requirement of the crops including potato in the agricultural soils. According to Hailu [27] Ethiopian soil lacks most of the macro and micro nutrients that are required to sustain optimal growth and development crops. Consequently, the yield and productivity of crops in Ethiopia including potato decreased. To solve this problem the Ministry of Agriculture (MOA) currently popularize the implementation of soil test based fertilizer application system through the use of soil fertility information [28] and thus introduced a new fertilizer (NPS) which contain Nitrogen, Phosphorous and Sulfur in the country's farming System to increase productivity since sulfur is the fourth essential nutrient next to N, P and K. However its rate of application for the production of most of the crop including potato is not yet known [29].

Experiment conducted by Habtam [30] at Assosa, Benishangul Gumuz Regional state of western Ethiopia, the interaction effect of phosphorus and potassium was insignificant on all growth, yield, and yield components of potato, and tuber quality parameters except the yield of small-sized tuber at which the maximum (16.5 t $ha^{-1)}$, and minimum (8.52 t ha-1) yields were attained at the application of 230 kg P_2O_5 and 200 kg K2O ha^{-1}, and 0 kg P_2O_5 and 0 kg K_2O ha^{-1} treatment combinations, respectively. Another experiment carried by Firew Gebremariam [31] at Dire-Dawa, Eastern Ethiopia, revealed that growth, yield, and yield components of the potato were significantly responded to application of 56 kg N ha^{-1} and 138 kg P_2O_5 ha^{-1}.

Although potato is one of the major crop produced in Benchi-Maji Zone, it's productivity is less than its potential due to poor fertility of the soil, leaching of major nutrients which enhance production of the crops, fixation of P, constraints of soil acidity, high cost of planting materials, disease and pest, unavailability of high yielding improved variety, shortage of information in relation to blended fertilizer rate. Generally, there is little information on balanced use of chemical fertilizer on potato production in Benchi-Maji Zone. Hence, conducting systematic investigation in this line is vital to come up with conclusive information that would help to increase the yield of the crop in the study area. Thus, this experiment was conducted with the objective of assessing the effects of NPS fertilizers application on growth parameters of potato.

2. Material and Methods

2.1. Description of the Study Site

The experiment was conducted in Mizan-Aman at Mizan-Tepi university, Horticultural demonstration site during March to May in 2018; Bench-Maji zone, SNNPRS. Mizan-Aman is located at 561km Southwest of A.A and 4km from Mizan town. It is found at absolute location of 06°58'30"N latitude and 35°33'0"E longitude. The altitude of the area is 1600 meter above sea level (m.a.s.l). The area receives an annual rainfall of 1710mm/year in bi-modal pattern which extends from March to October and the mean annual maximum and minimum temperatures are 30.5°c and 15°c respectively.

2.2. Experimental Materials

Crop: the improved potato variety gudene was used as a study crop. The variety is released from Holleta Agricultural Research Center (HARC) in 2006.The adaptation area of variety gudene is 1600-2800 altitude (m.a.s.l), the variety matures at 110-120 days after planting.

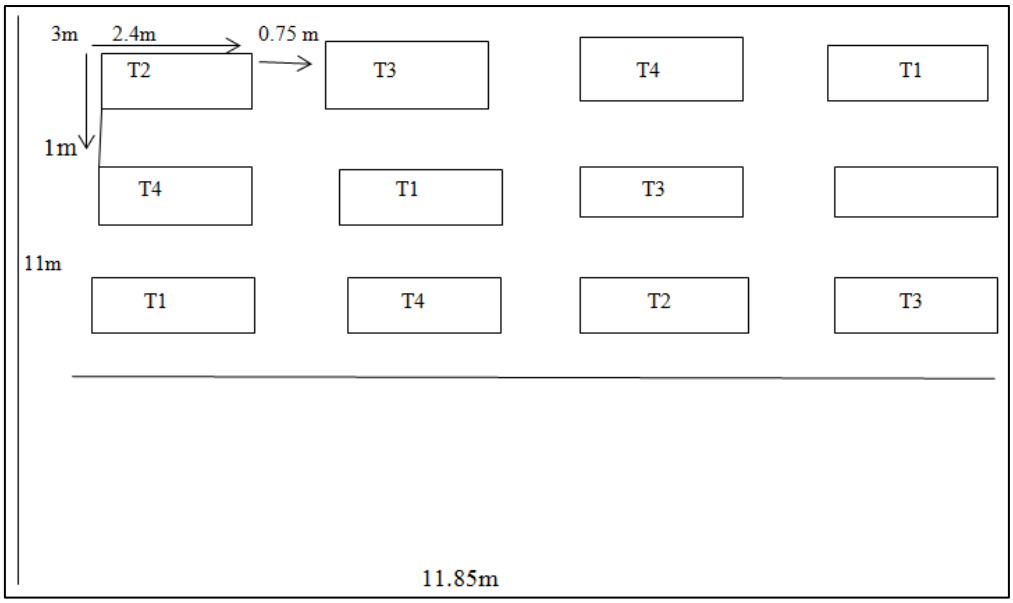
Fertilizer: - NPS in the form of blended fertilizer was used as inorganic fertilizer.

2.3. Treatment and Experimental Design

There were four treatments consisting of four levels of NPS fertilizer (0, 50kg ha^{-1}, 100kg ha^{-1} and 150kg ha^{-1}). 165 Kg/ha of urea was used in each plot as a constant rate based on blanket recommendation. The treatments were laid in randomized complete block design (RCBD) with three replication. Each block and plot within the block was spaced 1m and 0.75cm apart respectively. Each plot was consisted of four rows of 75cm apart between rows and plants were spaced 30cm apart each other. There were five (5) plants per row. The gross plot size was, 2.4m×3m ($7.2m^2$). In each plot, one plant at both end of each row was left to avoid border effect and from each plot, the two central rows were considered for determination of growth parameters of potato. Therefore, the net plot size was 1.8m×1.5m ($2.7m^2$).

2.4. Randomization and Layout of Treatments

The layout was done by lottery method of randomization of the treatment in each plot.



2.5. Experimental Procedure

In order to have a better seed for proper root development the experimental field was ploughed by oxen. A total of 12 experimental plots were laid out and required numbers of ridges were marked and ridges were formed manually in each plot with the spacing of 75cm between ridges. When there was sufficient soil moisture, well sprouted medium sized (40-60g) tubers of potato variety was planted on the ridges at the spacing of 75cm between ridges and the intra row spacing of 30cm on March 2018. The NPS was placed in bands below the seed piece and covered with soil on each ridge. All agronomic practices such as weed control, disease management and earthning up was done regularly during the growing seasons.

2.6. Data to be Collected

2.6.1. Phenological Parameters

Days to 50% flowering:-days to 50% flowering was recorded as the number of days from planting when 50% of the plants in each plot produce flowers.

2.6.2. Growth Parameters

Average stem number per hill: - the actual numbers of main stems per hill was recorded as the average stem count of five hills per plot at 90% physiological maturity. Only stems that emerged independently above the soil as single stems considered as the main stem. Stems branching from other stems above the soil were not considered as main stems.

Plant height (cm):- refers to the height from the base to the apex of the plant. It was measured using a measuring tape at 75% physiological maturity from the main stem originating directly from mother tubers to the apex of the plant by taking ten sample plants from each plot.

2.7. Statistical Data Analysis

All the measured parameters were subjected to analysis of variance (ANOVA) appropriate to single factor experiment in RCBD according to the General Liner Model (GLM) of the GeneStat 16th edition (GenStat, 2012) and interpretation was made following the procedure described by Gomez and Gomez [32].

3. Result and Discussion

3.1. Growth Parameters of Potato as Influenced by NPS Fertilizer Application Rates

3.1.1. Phenological Parameter

Day's to 50% flowering

Day's to 50% flowering of potato plant was highly significantly (P<0.01) affected by NPS fertilizer application rate (Appendix Table 1). The longest day's to 50% flowering (65.33 day's) of potato plant was observed at 150kg ha^{-1} of NPS fertilizer application rate while the shortest day's to 50% flowering (52 day's) was observed at 100Kg ha^{-1} of NPS fertilizer application rate (Table 1). This might be due to that flowering of potato doesn't require that much quantity of NPS fertilizer by this shortest applied rate flower earlyer than the longest one.

The present findings is in line with the findings of Amir, *et al.* [33] Geremew, *et al.* [34] where NP fertilizer rates delayed days to flowering. The result is also in agreement with findings of Minwyelet [29] who reported that application of 272 Kg NPS ha^{-1} prolonged days (82.8 days) to flower by 15.6 days as compared to the control (67.2 days).

3.1.2. Growth Parameter

3.1.2.1. Plant Height

The analysis of variance revealed that the plant height of potato was significantly (P< 0.05) influenced by NPS fertilizer (Appendix Table 1). The application of NPS fertilizer at the rate of 150kg ha^{-1} showed the highest plant height of potato (96.83cm) while the shortest plant height was observed on plants at 50Kg ha^{-1} NPS fertilizer rate (70.83cm) as indicated in (Table 1).This might be due to the effect of NPS for the growth of potato is high by this high applied rate larger plant height than the lowest.

The present study in line with the findings of various researchers where they found an increased potato plant height with the application of sulfur containing fertilizers [16, 17, 35, 36]. Similarly, increasing of plant heights with the application of NPS fertilizers were also observed in other vegetables including garlic and onion [37].The result was in agreement with finding [29] who reported that application of 272 kg NPS ha-1 produced the highest stem number per hill (10.37) as compared to the control (5.17).

3.2. Average Stem Number Per Hill

Number of stem per hill was not significantly influenced by applied factor (P< 0.05) (Appendix Table 1).This might be due to that stem number is not associated with fertilizer application. It is associated with physiological age of tuber and the number of spouts (eyes) found on the tuber.

The result was in agreement with many investigators reported the absence of close relationship between mineral nutrition and the number of stems per plant. Lynch and Tai [38] and Van den Berg, *et al.* [39] from their studies on yield development of potato as influenced by N fertilizer, observed that the yield difference due to N treatment was not attributed to its effect on stem density as the number of stems was not significantly influenced by N nutrition. Similarly, Lugt, *et al.* [40] observed non-significant difference in plant establishment as a result of increased application of N, P and K fertilizers.

Table-1. Effect of NPS fertilizer rate on day's to 50% flowering, plant height and Average

NPS Fertilizer rate (Kg/ha)	Day's to 50% flowering	Plant height (cm)	Average steam number per hill
0	58.33b	72cd	7
50	57.33bc	70.83c	5.83
100	52d	83.17b	7.17
150	65.33a	96.83a	7.42
LSD (5%)	3.03	14.14	3.41ns
CV (%)	4	2	25

where, NPS= Nitrogen, Phosphorus and sulfur; LSD= Least significance difference at 5% Level of significancy; CV= coefficient of variation; Means sharing the same letter in column are not significantly different

4. Summary and Conclusion

Although potato is one of the major crops cultivated in Benchi-Maji Zone, there is little information on balanced use of chemical fertilizer on potato production in Benchi-Maji Zone. Thus, conducting systematic investigation in this line is vital to come up with conclusive information that would help to increase the productivity of the crop in the study area. Therefore, this experiment was conducted with the objective of assessing the effects of NPS fertilizers application on growth parameters of potato. The experiment was conducted at Mizan-Aman, Benchi-Maji Zone,Southwest Ethiopia on the response of potato to the application of NPS fertilizer application. Four rates of

NPS (0, 50, 100 and 150 kg NPS ha^{-1}) were laid out in RCBD with three replication and the variety gudene was used as test crop.

The study showed that NPS fertilizer rates had highly significant effect on days to 50% days to 50% flowering. The longest days to flowering (65.33) were obtained from application of 150 kg NPS ha^{-1} while the shortest (52) were recorded from application of 100 kg NPS ha^{-1}.Application of NPS fertilizer significantly influenced plant height .The tallest plant height(96.83) were obtained at 150 kg NPS ha^{-1} and the shortest(70.83) were obtained at application of 50 kg NPS ha^{-1}. Application of 100 and 150 kg NPS ha^{-1} can be tentatively concluded for the study area. However this experiment was conducted for one season at one location and also only focused on the phenology and growth parameters, it advisable to carry the same experiment at different location with yield trials and yield to come up with conclusive recommendation.

References

[1] FAO, 2009. "International year of the potato 2008- The potato. United Nations Food and Agricultural Organization."

[2] Debela, A., 2003. *Influence of nitrogen ans phosphorous on yield attributes of potato (Solanum tuberosum L.) Varieties Tolcha and Menagesha on Nitosol of Jimma Area. pp 21*. Unpublished Bsc Thesis-Jimma University College of Agriculture. Ethiopia.

[3] FAO, 2008. "Potato world: Africa-International Year of the Potato." Available: http://www.potato2008.org/en/world/africa.html

[4] Tekalign, 2005. *Response of potato to paclobutrazol and manipulation of reproductive growth under tropical condition*. PhD dissertation, University of Pretoria (etd.), South Africa.

[5] Olango, T., 2008. *Ware Potato Production in Ethiopia: Current Status and Future Prospects Co-innovation for Quality in Agri-food Chains (CoQA). Workshop, November* Wageningen, the Netherlands, pp. 3-4.

[6] Ahmad, N., Khan, M. A., Khan, N. A., Binyaminand, R., and Khan, M. A., 2011. "Identification of resistance source in potato germplasm against PVX and PVY." *Pak. J. Bot.*, vol. 43, pp. 2745-2749. Available: https://www.researchgate.net/publication/224975518_Identification_of_resistance_source_in_potato_germplasm_against_PVX_and_PVY

[7] Solomon, Y., 1985. "Review of potato research in Ethiopia. W. Godefrey-Sam-Aggrey, Bereketshai Tilu eds.,." In *Proc. of 1st Ethiopian Hort. Workshop. 20-22 Febr. 1985. FAO-ILCA-IAR, Addis Ababa, Ethiopia*. pp. 294-307.

[8] Majisu, B. N., 1982. *Role of the potato production course: General considerations. S. Nganga and F. Shideler eds., Potato seed production for Tropical Africa*. CIP Lima, Peru, pp. 121-139.

[9] Gildemacher, P. R., Kaguongo, W., Ortiz, O., Tesfaye, A., Gebremedhin, W. W., Wagoire, W., Kakuhenzire, R., Kinyae, P. M., Nyongesa, M., *et al.*, 2009. "Improving potato production in Kenya, Uganda and Ethiopia: A System diagnosis." *Potato Research Journal*, vol. 52, pp. 173-205.

[10] FAOSTAT, 2010. *Agricultural data. Provisional 2009 Production and Production Indices Data. Crop primary*. Rome, Italy: FAO.

[11] Hendrickson, L. and Douglass, E., 1993. "Metabolism of the Urea Inhibitor N-(N- Butyl) Thiophosphoric Triamide (nBPT) in Soils." *Soil biol. Biochem.*, vol. 25, pp. 1613-1618.

[12] Alva, A., 2004. "Potato Nitrogen Management." *J. Veg. Crop Prod.*, vol. 10, pp. 97-130.

[13] Zelalem, A., Tekalign, T., and Nigussie, D., 2009. "Response of potato (Solanum tuberosum L.) to different rates of nitrogen and phosphorus fertilization on vertisols at Debre Berhan, in the central highlands of Ethiopia." *African Journal of Plant Science*, vol. 3, pp. 016-024.

[14] Sebastiani, S., Mgonja, A., Urio, F., and Ndondi, T., 2007. "Agronomic and Economic Benefits of Sweet Potato (Ipomoea batata L.) Response to Application of Nitrogen and Phosphorous Fertilizer in the Northern Highlands of Tanzania." *African Crop Science Conference Proceedings*, vol. 8, pp. 1207-1210.

[15] Taheri, N., Sharif-Abad, H., Yousefi, K., and Mousavi, R., 2011. "Effect of organic manure with phosphorus and zinc on yield of seed potato." *Australian Journal of Basic and Applied Sciences*, vol. 5, pp. 775-780.

[16] Sharma, D., 2015. "Effect of Sulphur on Growth, Yield and Economic of Potato Cultivar." *Annals of Plant and Soil Research*, vol. 17, pp. 45-49.

[17] Tisdale, S., Nelson, W., Beato, J., and Halvin, J., 1995. *Soil Fertility and Fertilizers*. 5th ed. New York: Macmillan Publishing Co. Inc. . pp. 109-229.

[18] FAOSTAT, 2016. "Statistical Database. Date of accession."

[19] CSA, 2017. "Agricultural Sample Survey: Report on area and production of crops. Addia Abeba, Ethiopia." pp. 14-19.

[20] Tolessa, D. and Beshir, A., 2009. "Sustainable Land Management and Agricultural Practices Research in Ethiopia. United Nations Expert Group Meeting On SLM and AP, Gothenburg, Sweden."

[21] Gildemacher, P. R., 2012. *Innovation in seed potato systems in eastern africa*. Thesis submitted in fulfilment of the requirements for the degree of doctor at Wageningen University. The Netherlands.

[22] Tekalign, Teklu, E., and Balesh, 2001. "Soil fertility and plan tnutrition research on teff in Ethiopia. Proceedings of the International Workshop on Teff Genetics and Improvement, October 16-19, 2001, Debre Zeit, Ethiopia." pp. 191-200.

[23] Muriithi, L. M. M. and Irungu, J. W., 2004. "Effectof integrateduse of inorganic fertilizer and organic manures on Bacterial Wilt Incidence (BWI) and tuber yield in potato production systems on hill slopes of central Kenya." *J. Mountain Sci.*, vol. 1, pp. 81-88.

[24] Westermann, D., 2005. "Nutritional requirements of potatoes." *American Journal of Potato Research*, vol. 82, pp. 301-307.

[25] Wakene, N., 2001. *Assessment of important physicochemical properties of dystric udalf (dystric Nitosols) under different management system in Bako area, Western Ethiopia*. M.Sc. Thesis, School of Graduate Studies, Alemaya University, Ethiopia.

[26] Israel, Z., Ali, M., and Solomon, T., 2012. "Effect of different rates of nitrogen and phosphorus fertilization on Yield and yield component of potato (Solanum tuberosum L.) at Mashan, Southwestern of Ethiopia." *African Journal of Plant Science*, vol. 3, pp. 016-024.

[27] Hailu, S., 2014. "Digital Soil Mapping: Soil Fertility Status and Fertilizer Recommendation for Ethiopian Agricultural Land." In *Ethiopian Economic Association Conference, Addis Ababa, Ethiopia.*

[28] MoA, 2013. *Ethiopia is transitioning into the implementation of soil test based fertilizer use system*. Ethiopia: Addis Ababa.

[29] Minwyelet, J., 2017. *Effects of NPS Fertilizer Rate and Irrigation FrequencyDetermination Method on the Growth and Tuber Yield of Potato (Solanum tuberosum L.) in Koga Irrigation Scheme, West Gojjam, North Western Ethiopia*. MSc Thesis, Bahir Dar University, Bahir Dar, Ethiopia.

[30] Habtam, S., 2012. *Response of Potato (Solanum tuberosum L.) to the Application of Phosphorous and Potassium Fertilizers at Assoca, Benishangul Gumuz Regional State, Western Ethiopia*. MSc Thesis. Haramaya University, Haramaya, Ethiopia.

[31] Firew Gebremariam, 2014. *Response of Potato (Solanum tuberosum L.) to Nitrogen and Phosphorous Application under Irrigation in Dire Dawa, Eastern Ethiopia*. MSc Thesis, Haramaya University, Haramaya, Ethiopia.

[32] Gomez, K. A. and Gomez, A. A., 1984. "Statistical procedures for agricultural research."

[33] Amir, A., Mohammad, R., Mohammad, T., and Feaza, F., 2014. "Influence of nitrogen fertilizer and cattle manure on the vegetative growth and tuber production of potato." *International Journal of Agriculture and Crop Sciences*, vol. 4, pp. 232-242.

[34] Geremew, Eticha, S. J., and Annandale, J., 2008. "Comparison between traditional and scientific irrigation scheduling practices for furrow irrigated potatoes (solanum tuberosum l.) in ethiopia." *S. Afr. J. Plant Soil*, vol. 25, pp. 23-30.

[35] Chettri, M., Mondal, S., and Roy, B., 2002. "Influence of potassium and sulphur with and without FYM on growth, productivity and diseases index of potato in soil of West Bangal." *J. Indian potato Assoc.*, vol. 29, pp. 61-69.

[36] Choudhary, R., 2013. "Impact of nitrogen and sulphur fertilization on yield, quality and uptake of nutrient by maize in Southern Rajasthan." *Annals of Plant and Soil Research*, vol. 15, pp. 118-121.

[37] Muluneh, N., 2015. *Assessment of Onion Production Practice and Effect of NPS Fertilizer Rates on Yield and Yield Components of Onion (Allium cepa L.). under Irrigation Farming System in Dembiya District, Amhara Region, Ethiopia*. MSc. Thesis Bahir Dar University.

[38] Lynch, D. R. and Tai, G. C., 1989. "Yield and yield component response of eight potato genotypes to water stress." *Crop Science*, vol. 29, pp. 1207-1211.

[39] Van den Berg, J. H., Vreugdenhil, D., Ludford, P. M., Hillman, L. L., and Ewing, E. E., 1991. "Changes in starch, sugar, and abscisic acid contents associated with second growth in tubers of potato (Solanum tuberosum L.) one-leaf cuttings." *American Journal of Plant Physiology*, vol. 139, pp. 86-89.

[40] Lugt, C., Bodlaender, K. B. A., and Goodjic, G., 1964. "Observations on the induction of second growth in potato tubers." *European Potato Journal*, vol. 7, pp. 219-227.

Appendix

Table-1. Mean squares of ANOVA for phenological and growth parameters of potato plant as affected by NPS rate

			Mean squares	
Source	Df	DF 50%	AvSno.	Ph
Block	2	25.75	0.69	63.90
NPS	3	90.08**	1.48ns	429.97*
Error	6	5.42	2.94	50.02
CV (%)		4%	25%	2%

Where, Df=degree of freedom, DF 50%=Days to 50% flowering, AvSno.=Average Stem number per plant, Ph= Plant height CV(%)= coefficient of variation in percent; *=significant, **=highly significant, ns=not significant.