

Review on Production Status of Potato and Response of Varieties to Blended Fertilizers in Ethiopia

Damtew Girma Legese

Department of Horticulture, Wolkite University, Wolkite, Ethiopia

Email address:

damtewg616@gmail.com

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Abstract: In Ethiopia, potato is one of the most economically significant crops since they are a source of both food and income, coupled with relatively short growing season, and widely adaptable and cultivated tuber crops. Many studies carried out in the country shows that the low tuber yield of potato is due to inadequate and blanket fertilizer applications, particularly recently introduced blended fertilizers, and improper variety selection for various agro-ecological zones. Due to genotypic diversity, potato yield differed between locations and seasons as well as in response to the rates at which blended fertilizers were applied. Improved potato varieties produced the highest tuber yield as compared to local cultivars due to genetic variation in nutrient utilization and their tolerance to late blight disease, one of the most common potato diseases. The potato is a high nutrient feeder that uses a substantial amount of nutrients per unit of time due to its shallow and underdeveloped root systems. In all parts of the country, increasing the rate at which blended fertilizers like NPS, NPSB, and NPSZnB are applied can maximize potato production. Nonetheless, the majority of farmers are understood the importance using fertilizers and planting improved varieties can have on yields. However, because of high cost of fertilizers, they do not use it as a recommendation, and they do not use varieties that are appropriate for their regions and the seasons. Therefore, the application of optimum fertilizer and use of improved varieties can maximize the production of potato for smallholder farmers to make their food security sustainable.

Keywords: Potato, Variety, Blended Fertilizers, Tuber Yield

1. Introduction

Potato (*Solanum tuberosum* L.) is the most important vegetable crop in *Solanaceae* family originated in South America, and was first cultivated in the Andes in the vicinity of Lake Titicaca near the present border of Peru and Bolivia [24, 25]. It is the fourth most important food crop after wheat, maize and rice [23], and globally consumed more than three billion peoples. In addition, it is among the most important food security crop recommended by FAO (Food and Agriculture Organization) [6] because of its ability to provide a high yield with a high quality per unit input with a shorter crop cycle.

In Ethiopia, potato is most economically important crop as a source of food and income coupled with relatively short growing period and wider adaptability [42]. Among African countries, it has suitable climatic and edaphic conditions for potato production, particularly in highland areas that covers

about 70% of the arable land of the country [41]. However, currently productivity of potato is very low (13.28 t ha^{-1}) as compared to world average (21.77 t ha^{-1}) [16]. There are different reasons for lowering the productivity of potato. The major reasons are lack of good quality tuber seed, inadequate application of fertilizer, inappropriate variety selection, pests and disease [10]. Especially, variety and fertilizer have a great role on potato tuber yield. There are different varieties of potato including old cultivars (local) that farmer's plant. However, locally produced potatoes are low in tuber yield and poor in quality as compared to the improved varieties. Improved varieties are good in drought tolerance, late blight resistance, yield potential, marketability, food value and storage quality [19]. Potato plant require both macro and micronutrients for proper growth and development, due to this blended fertilizers (NPS, NPSB, NPSBCu, NPSCu and NPSZnBCu) contains those elements like N, P, S, B, Zn and Cu satisfy crop nutrient requirement. Adequate application of nutrient enhances many aspects of plant physiology,

including the fundamental processes of photosynthesis, flowering, tuber formation and bulking [5]. Therefore, appropriate variety selection to the environment and adequate fertilizer application are the means to maximize tuber yield. The objectives of this paper are review on production status of potato and response of varieties to blended fertilizers.

2. Literature Review

2.1. Potato Production in Ethiopia

Potato was first introduced to Ethiopia in 1858 by a German botanist, Schimper [32] and it is rapidly becoming a popular which occupies relatively largest area compared to other vegetable crops and produces more food per unit area and time compared to cereal crops [45]. Currently, potato is an important food and cash crop for Ethiopian farmers; hence it is grown in various parts of the country for local consumption and regional export [30].

Potato production has increased considerably through the twentieth century in Ethiopia. In 1975, the area of cultivation was estimated to 30,000ha with an average productivity of about 5t ha⁻¹ [18]. According to the authors, the area allocated to potato in Ethiopia increased from 50,000 hectares by the mid of 1980's to 160,000 hectares in the early 2001's. Currently, the annual production of potato in *Meher* season is around 1,141,871.73 tons from 85,988.43 hectares of land with the productivity of 13.28 t ha⁻¹ [13]. An upward trend in potato production might be partly due to the continuing increase in population and subsequent decline in the average farm holdings which forced the implementation of improved technologies for the production of potato.

Potato cultivation is possible due to the country's diversified agro-climatic conditions, which cover about 70% of the arable land of country's [41]. Potatoes are cultivated in rain feed and irrigation systems by both small scale farmers and commercial producers. The major potato producing regions of Ethiopia are Oromia, Amhara and Southern Nations, Nationalities and Peoples (SNNP) in the order of production levels [13]. About 85,988.43 ha of land are under potato cultivations in Ethiopia where Oromia Region is the leading followed by Amhara and SNNPR with production of 502,791.90; 395,429.50 and 222,477.70 tons, respectively. Potato is predominantly produced in Oromia Regional States (44.03%), Amhara (34.63%) and SNNP (19.28%) and the remaining is produced by other Regions [13].

2.2. The Importance of Blended Fertilizers (Nutrients) for Potato Production

Blended fertilizer is the mechanical mixture of two or more granular fertilizer materials which may contain nitrogen (N), phosphorus (P), sulfur (S), boron (B) and other essential plant nutrients [8]. Application of balanced fertilizers is the basis to produce more crop output from existing land under cultivation [5]. Previous fertilizer research in Ethiopia has mostly concentrated on nitrogen (N) and phosphorus (P) fertilizer sources under varied soil types and climatic

conditions, with very little work on other key macro and micronutrients (K, S, Fe, Zn, B, etc).

Understanding the plant nutrient requirement of a specific area is critical to increasing crop yield and productivity on a long term basis. Fertilizers are an effective exogenous source of plant nutrients [3], since plant development and crop production require a sufficient and balanced supply of nutrients to improve productivity by maximizing plant nutrient uptake. According to several researches, chemical fertilizers are the most important nutrient sources for increasing crop productivity [3]. This indicates that the actual amount of fertilizer to apply depends on soil fertility, crop variety and the variety's fertilizer efficiency. In addition to N and P, recent soil inventory data from Ethiopian Soil Information System (EthioSIS) revealed other nutrients including S, B, and Zn are deficient in most Ethiopian soils. Therefore, currently Agricultural Transformation Agency recommends using different blended fertilizers in different parts of the country to satisfy crop nutrient requirements [7].

2.2.1. Role of Nitrogen on Potato Production

Nitrogen is one of the most yield limiting nutrients for crop production in the world, and it also applied in the largest quantity for most annual crops to increase yield both in quantity and quality [26]. Efficient use nitrogen is important for the economic sustainability of cropping systems. In a temperate climate, usually 50% of N applied is effectively used by plants, while a considerable part is lost by leaching and contaminates ground and surface waters [15].

Higher nitrogen levels are linked to greater foliage, increased photosynthetic activity, and tuber translocation [27]. However, an excess of this nutrient in relation to other nutrients such as P, K, and S leads to excessive stolon and leaf growth, delayed leaf maturation, tuber differentiation, extended tuber bulking period, and ultimately reduced yield and tuber dry matter [22]. Whereas a lack of nitrogen inhibits the growth of all plant organs, roots, stems, leaves, and flowers, resulting in reduced plant growth, yellowing, and low fruit and seed harvests. Shortage of N also restricts tuber size due to reduced leaf area and early defoliation [22].

2.2.2. Role of Phosphorus on Potato Production

Phosphorus is one of the most essential mobile macronutrients that have an impact on root growth, plant vigor, flowering and plant production. It is important especially during the reproductive stage of plants [11]. Phosphorous is an important component of energy transfer chemicals (ATP), DNA molecules, the genetic information system, cell membranes, and phospho-proteins [12].

Phosphorus plays significant role in physiological and biochemical reactions such as photosynthesis, conversion of sugar into starch [38]. The increase in tuber dry matter content in response to increasing the rate of phosphorous application signify that it is an important nutrient for enhancing production of photo-assimilate and starch storage in tubers. Application of P has a great role on tuber set, numbers and size of tubers, marketable tuber yield [46].

2.2.3. Role of Sulfur on Potato Production

Sulphur is a vital nutrient for life and essential for plant growth due to synthesis of proteins, vitamins containing amino acids and associated with nitrogen metabolism for chlorophyll formation [47] and it accumulates 0.2 to 0.5% in plant tissue on dry matter basis. The increase in growth and yield of potato with application of sulfur can be explained with increased metabolic activities, photosynthesis, and assimilation and bulking rate [36]. On the other hand, decrease in tuber dry matter, starch and essential amino acids particular cystine and leucine with sulfur deficiency. Sulfur deficiency may also result poor utilization of nitrogen, phosphorus, potash and a significant reduction of catalase activities at all age of plants. Moreover, sulfur has direct effect on soil properties as it may reduce soil pH which may improve the availability of micro elements such as Fe, Zn, Mn and Cu [39].

2.2.4. Role of Boron on Potato Production

Boron is a micronutrient that is required for optimal plant growth and development. It is involved in many plant processes such as cell wall synthesis, sugar transport, cell division, cell development, auxin metabolism, good pollination and fruit set, seed development, synthesis of amino acids and proteins, nodule formation in legumes and regulation of carbohydrate metabolism. Boron deficiencies occur over a much wide range of soils and crops than deficiencies are found most often in light soils, low organic matter contents and high soil pH levels [29].

Availability of boron in soil is affected considerably by soil pH. Most boron compounds are soluble at low pH, however if rainfall is considerable, B is lost down the profile via leaching in sandy soils with low pH. It is usually found in organic matter in soil surface, and when the B concentration declines in the profile, a bushy plant with droopy leaves develops [31]. Boron fertilization increased the number of tubers as well as the production of potatoes [34]. Potato plants require balanced amounts of macronutrients and micronutrients such as boron, sulphur, zinc, and manganese to increase productivity [37].

2.3. Varietal Differences in Potato Growth and Yield Parameters

Potato varieties differ in terms of growth, development, and overall yield performance, as well as the shape, size, and weight of their tubers. According to many researches, there is a significant difference in days to emergence among potato cultivars [2]. These variations is probably because of the varieties inherent characteristics like dormancy of tubers also as sprouting, fertilizer rate and storage conditions in relation to environmental conditions [1].

Different researchers have reported that improved varieties of potato longer in plant height than local variety. According to [43], Gudanie variety was significantly longer in height compared to Guasa, Jalenie and Degemegn varieties. The genetic differences among varieties influence the number of main stems as well as sprouts or eyes on the tubers.

Consistently, [33] reported that variety significantly influenced stem number as Gudanie variety produced maximum stem number per hill compared to Jalenie and local varieties due to a greater number of sprouts observed in Gudanie variety at planting. The difference in stem number among the varieties was explained by the genetic variability and adaptation history of the varieties [35].

Many authors reported that different potato varieties had different potential in tuber yield across locations and seasons. Generally, tuber yields of improved varieties produced higher than local (farmer) variety [4]. The differences in marketable and unmarketable, and total tuber yields are generally related to their differences in genetic makeup and tuber sizes of the potato varieties [35].

2.4. Growth and Yield Response of Potato to Blended Fertilizers

Growth and tuber yield of potato is influenced by types and rates of applied fertilizer which observed by the findings of different researchers. According to [21, 44] reported, increasing the application rates of blended fertilizers can be delay days to flowering and maturity of potato might due to sufficient supply of nutrient that promotes vegetative growth and delayed reproductive stage of crops. Furthermore, higher phosphorus application extended days to flowering of potato [14], and application of nitrogen fertilizer at higher rates enhanced vegetative growth by helping the plant to absorb sunlight and produce carbohydrates, but delay the production of reproductive part and thereby maturity [40].

According to many researchers, increasing application rate of blended fertilizers increased plant height and main stem number per hill linearly. With fertilizer treatment rates ranging from 0 to 350 kg NPSB ha⁻¹, plant height and main stems number per hill increased by 18.58% and 100%, respectively [21], and also the application rates of blended NPSB fertilizer increased from 0 to 350 kg ha⁻¹, number of main stems increased from 4.99 to 6.48 per hill [20]. These could be attributed that increased nitrogen and boron availability in the soil for uptake by plant roots, which could have resulted in higher cellular division and elongation, resulting in increased vegetative growth [21].

Tuber number per hill and average tuber weight of potato increased with increased blended fertilizers rates according to different findings. These might be due to more fast growth, more foliage and increase in leaf area due to a higher supply of phosphorous containing fertilizer which may have induced the formation of bigger tubers thereby resulting in higher average tuber weight. However, application of blended fertilizers should be kept moderately rather than insufficient and maximum application to maximize number of tubers that prevent nutrient translocation to the vegetative parts [21, 20].

According to [44] findings, increased application rates of blended fertilizers (NPS, NPSB and NPSZnB) as well as DAP can be increased marketable yield, but it decreased unmarketable tuber yield. The increment of marketable tuber yield in the response to increasing application rates indicated that the crop require the essential or important nutrients for

growth and development. The more growth, more foliage and increased leaf area and the higher supply of phosphorous containing fertilizer, which induced formation of total tuber number and bigger potato tubers thereby leading to higher marketable tuber yield.

2.5. Interaction Effect of Varieties and Blended Fertilizer on Growth and Yield of Potato

Different investigators have been reported that growth and yield as well as tuber quality of potato is affected by varieties with blended fertilizers. Days to flowering, days to maturity, plant height, leaf area index, marketable tuber yield, total tuber yield, tuber dry matter and tuber specific gravity of different varieties are responded positively with increasing application rates of different blended fertilizers [9, 28]. The combinations of improved varieties and optimum application of blended fertilizers shows good performance in growth and yield performance as compared to unfertilized and local varieties of potato plants.

The interaction effects of varieties and blended fertilizers on tuber yield might be related to their genetic makeup in the efficient utilization of inputs like nutrients, which is one of the four major categories of the factors (soil, climatic, genetic and management practices). According to the finding of [21] report, total tuber yields of Gudanie and Bubu varieties were increased in response to increasing application rates of NPSB fertilizers as compared to their respective unfertilized plots, which might be the role of fertilizers in enhancing photosynthetic activity and translocation of photosynthetic product to the root, which could have helped in the initiation of more stolon on potatoes varieties. Generally, all potato varieties have a positive response for tuber yields with increasing levels of blended fertilizers rates at different location [28, 9]. Furthermore, the rates of nitrogen increased from 100 to 150 kg N ha⁻¹, the marketable tuber yields of Gudanie, Jalenie and Zengena significantly increased [17].

3. Summary and Conclusion

Potato is one of the most widely cultivated vegetable crops in midland and highlands of Ethiopia. Yield and productivity of potato in Ethiopia are far below the world average yield. Among different factors, lack of improved tuber seed, inappropriate variety selection and nutrient management are the key factors affecting crop productivity. To enhance potato productivity, variety selection and nutrient management have to be the primary role of the producers. Different researches conducted in Ethiopia show that application of nutrient has a positive relation to producing a higher yield of potato. The experiments confirmed that adequate application of blended fertilizers increases potato production. The productivity of potato also improves by selecting improved varieties and variety specific to location and season. Therefore, application of adequate nutrient and appropriate variety selection are the options to maximize production and productivity of potato.

Therefore, from these review the following points are

suggested as a future line of work:

- 1) The researcher should be evaluate the effect of different types and rates of blended fertilizers on different varieties of potato at different location and season.
- 2) Awareness should be done for potato producers about the advantage of using variety specific recommendation rates over using only as a general rate and fertilizer type for all potato varieties, and its effect on the production and productivity of potato.

References

- [1] Abubaker S., Aburayyan A., Amre Ayed, Alzu'bil Y. and Hadidi N. 2011. Impact of cultivar and growing season on potato (*Solanum tuberosum* L.) under center pivot irrigation system. *World Journal of Agricultural Science*, 7 (6): 718-721.
- [2] Addisu Fekadu, Yohannes Petros and Habtamu Zeleke. 2013. Genetic variability and association between agronomic characters in some potato (*Solanum tuberosum* L.) genotypes in SNNPR, Ethiopia. *International Journal of Biodiversity and Conservation*, 5 (8): 523-528.
- [3] Akram, A., Fatima, M., Ali, S., Jilani, G. and Asghar, R. 2007. Growth, yield and nutrients uptake of sorghum in response to integrated phosphorus and potassium management. *Pakistan Journal of Botany*, 39 (4): 1083-1087.
- [4] Alemayehu Tilahun, Miliion Paulos and Seman Abrar. 2018. Evaluation of growth, yield and quality of potato (*Solanum tuberosum* L.) varieties at Bule, Southern Ethiopia. *African Journal of Plant Science*, 12 (11): 277-283.
- [5] Amalfitano, C. A., Del Vacchio, L. D. V., Somma, S., Cuciniello, A. C. and Caruso, G., 2017. Effects of cultural cycle and nutrient solution electrical conductivity on plant growth, yield and quality of Friariello'pepper grown in hydroponics. *Horticultural Science*, 44 (2): 91-98.
- [6] André, D., Peter, K. and Oscar, O. 2014. Potatoes for Sustainable Global Food Security. *European Association for Potato Research*, 57 (3-4): 185-199.
- [7] ATA (Agricultural Transformation Agency). 2016. Transforming the use of fertilizer in Ethiopia: Launching the national fertilizer blending program, Addis Ababa.
- [8] Beaton, J. D. 1997. Bulk blending of dry fertilizer materials for China. *Better Crops International*, 11 (1): 18-19.
- [9] Bewket Bekele. 2020. Effect of Blended NPSZnB Fertilizer and Cattle Manure Rates on Growth, Yield and Quality of Potato (*Solanum tuberosum* L.) at Banja District, Awi Zone, North western Ethiopia. *International Journal of Research Studies in Agricultural Sciences (IJRSAS)*, 5 (5): 27-36.
- [10] Bezabih Emana and Mengistu Nigusie. 2011. Potato value chain analysis and development in Ethiopia. International Potato Center (CIP-Ethiopia), Addis Abeba, Ethiopia.
- [11] Brady, N. C., Weil, R. R. and Weil, R. R. 2008. The nature and properties of soils, 13: 662-710. Upper Saddle River, NJ: Prentice Hall.
- [12] Bsawas, T. D., and S. K. Mukherjee. 1993. Text book of Soil Science (5th Ed). Tata Mac Hall, New Delhi. 170-197.

- [13] CSA (Central Statistical Agency of Ethiopia). 2021. Agricultural sample survey: Report on area and production of major crops (Private peasant holdings, Meher season), Addis Ababa; Statistical Bulletin 1: 19-86.
- [14] Desta Bekele. 2018. Evaluation of blended and non-blended fertilizer types and rates on potato (*Solanum tuberosum* L.) yield and yield components at Assosa, Western Ethiopia. MSc. Thesis, Hawasa University, Hawasa.
- [15] Fageria, N. K., Baligar V. C. and Li Y. C. 2005. The role of nutrient efficient plants in improving crop yields in the twenty first century. *Journal of plant nutrition*, 31 (6): 1121-1157.
- [16] FAOSTAT (Food and Agricultural Organization Corporate Statistical Database). 2021. Food and Agriculture Organization of the United Nations Statistics Division. Rome: FAO. Available online: <http://faostat3.fao.org/home/e>. Accessed on 21 December 2021.
- [17] Fikre Dessie. 2012. Influence of Nitrogen Supply on Yield and Yield Components of Potato Cultivars (*Solanum tuberosum* L.) and Nitrogen use Efficiency of the Cultivars at Debark District, North Western Ethiopia (Doctoral Dissertation, Haramaya University).
- [18] Gebremedhin Woldegiorgis, Endale Gebre, Kiflu Bedane and Bekele Kassa. 2001. Country profile on potato production and utilization in Ethiopia. Holetta, Ethiopia. Ethiopian Agricultural Research Organization.
- [19] Gebremedhin Woldegiorgis, Kasaye Negash, Atsede Solomon, Abebe Chindi and Berga Lemaga. 2013. Participatory potato seed production: Experiences from West and Southwest Shewa, and Gurage zones, Proc. of the national workshop on seed potato tuber production and dissemination, Bahir Dar, Ethiopia, ARARI, 152-172.
- [20] Getachew Kahsay. 2016. Response of Potato (*Solanum tuberosum* L.) Varieties to Nitrogen and Blended Fertilizers under Irrigation at Maichew, Southern Tigray, Ethiopia. *An M. Sc Thesis, Haramaya University, Haramaya, Ethiopia*.
- [21] Gezahegn Assefa, Yibekal Alemayehu, Wassu Mohammed. 2021. Effects of Blended NPSB Fertilizer on Yield and Yield Related Traits of Potato (*Solanum tuberosum* L.) Varieties in Oda Bultum District, Eastern Ethiopia. *American Journal of Bioscience and Bioengineering*, 9 (1): 21-32.
- [22] Goffart, J. P., Olivier, M. and Frankinet, M. 2008. Potato crop nitrogen status assessment to improve N fertilization management and efficiency: Past-present-future. *Potato Research*, 51: 355-383.
- [23] Haan, S. and Rodriguez, F. 2016. Potato origin and production. In *Advances in Potato Chemistry and Technology*. London, UK: Academic Press, Elsevier: 1-32.
- [24] Haward, H. W. 1969. Genetics of potato (*Solanum tuberosum* L.) Logos press Ltd., Cambridge, England: 1-7.
- [25] Horton. 1987. Potato: production, Marketing and programs for developing countries. West view Press, London: 235.
- [26] Huber, D. M. and Thompson, I. A. 2007. Mineral nutrition and plant disease. *The American Psychopathological society*: 31-44.
- [27] Kumar S., Khade H. D., Dhokane V. S., Bethere A. G. and Sharma A. 2007. Irradiation in combination with higher storage temperatures maintains chip-making quality of potato. *Journal of Food Science*, 72: 402-406.
- [28] Mekides Mekashaw. 2016. Assessment of farmer's production practices and effects of different rates of NPS fertilizer on yield and yield components of potato (*Solanum tuberosum* L.) variety under irrigated farming system in Dessie Zuria District, Amhara Region, Ethiopia (MSc thesis). Bahir Dar University, Ethiopia.
- [29] Mengel, K. and Kirkby, E. A. 1978. Nutrition and plant growth. Principles of plant nutrition. *International Potash Institute*, Berne, Switzerland: 211-256.
- [30] MoARD (Ministry of Agriculture and Rural Development). 2005. Irrigation development package.
- [31] Muthanna, M. A., Singh, A. K., Tiwari, A., Jain, V. K. and Padhi, M. 2017. Effect of boron and sulphur application on plant growth and yield attributes of potato (*Solanum tuberosum* L.). *International Journal of Current Microbiology and Applied Science*, 6 (10): 399-404.
- [32] Pankrust R. 1964. Notes on a history of Ethiopian Agriculture. *Ethiopian Observer*, 7: 210-240.
- [33] Sadik Ebrahim, Hussien Mohammed and Tewodros Ayalew. 2018. Effects of seed tuber size on growth and yield performance of potato (*Solanum tuberosum* L.) varieties under field conditions. *African Journal of Agricultural Research*, 13: 2077-2086.
- [34] Sarkar, S., Banerjee, H., Chakraborty, I., Sau, S., Ray, K., Ghosh, D. and Deb, P. 2018. Assessment of growth, yield, tuber quality and profitability of potato upon boron fertilization. *Journal of Environmental Biology*, 39 (3): 365-372.
- [35] Seifu Fetena and Betewulign Eshetu. 2017. Evaluation of released and local potato (*Solanum tuberosum* L.) varieties for growth performance, ArbaMinch, Ethiopia. *Journal of Agronomy*, 16 (1): 40-44.
- [36] Sharma, D. 2015. Effect of Sulphur on Growth, Yield and Economic of Potato Cultivar. *Annals of Plant and Soil Research*, 17 (1): 45-49.
- [37] Singh, N. and Kathayak K. 2018. Integrated Application of Micronutrients to Improve Growth, Yield, Quality and Economic Yield in Potato; a Review, *International Journal of Current Microbiology and Applied Sciences*: 7.
- [38] 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*, 5 (8): 775-780.
- [39] Tantawy, E. and Beik, E. 2009. Relationship between Growth, Yield and Storability of Onion with Fertilization of Nitrogen, Sulphur and Copper under Calcareous Soil Conditions. *Journal of Agricultural research and biology*, 5 (6): 361-371.
- [40] Tantowijoyo, W. and van de Fliert, E. 2006. All about Potatoes Handbook to the Ecology and Integrated Management of Potato. *International Potato Centre*: 6.
- [41] Tekalign Tsegaw. 2006. Response of potato to paclobutrazol and manipulation of reproductive growth under-tropical conditions. A Ph.D. Dissertation presented to the department of production and soil science, University of Pretoria, Pretoria, South Africa.
- [42] Tewodros Ayalew. 2014. Analysis of seed potato (*Solanum tuberosum* L.) systems with special focus in Ethiopia: Review. *Asian Journal of Agricultural Research*, 8 (3): 122-135.

- [43] Tibebe Simon, Abraham Tadele and Helen Teshome. 2016. Effects of variety and tuber size on yield and yield component of potato (*Solanum tuberosum* L.) in Wolaita Zone Southern Ethiopia Wolaita Sodo University. *Journal of Natural Science Research*, 6: 2224-3186.
- [44] Tilaye Batu and Diriba Shiferaw. 2021. Effects of Different Rates of Blended Fertilizers on Growth, Yield and Quality Attributes of Potato (*Solanum tuberosum* L.). *Journal of Horticultural Science and Ornamental Plants*, 13 (1): 01-14.
- [45] Yigzaw Dessalegn, Fentahun Mengistu and Tesfaye Abebe. 2008. Performance stability analysis of potato varieties under rain fed and irrigated potato production systems in Northwestern Ethiopia. *Ethiopian Journal of Science and Technology*, 5: 90-98.
- [46] Zelalem Ayichew, Tekalign Tsegaw and Nigussie Dessacha. 2009. Response of potato (*Solanum tuberosum* L.) to different rates of nitrogen and phosphorus fertilization on Vertisol at Debre Berhan in the central highlands of Ethiopia. *African Journal of Plant Science*, 3 (2): 16-24.
- [47] Zhao F. J., Hawkesford M. J., and McGrath S. P. 1999. Sulfur assimilation and effects on yield and quality of wheat. *Journal of Cereal Science*, 30: 1-17.