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A REVIEW ON RESPONSES OF POTATO TO MAJOR MACRO AND MICRO PLANT NUTRIENT

***Egata Shunka Tolessa**

Ethiopian Institute of Agricultural Research, Holleta Agricultural Research Center, Crop Research Process, Potato Research Program, Addis Ababa, Ethiopia.

Corresponding Author: Egata Shunka Tolessa
Ethiopian Institute of Agricultural Research, Holleta Agricultural Research Center, Crop Research Process, Potato Research Program, Addis Ababa, Ethiopia.

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ABSTRACT

Potato was considered as a food security crop in Ethiopia because of its high yielding potential, high nutritional quality, short growing period and wider adaptability. In area coverage, it is the second widely grown crop next to 'Enset' (Ensete ventricosum L.). Its production is affected by many factors. Among these factors, optimum fertilizer application is the main factor degrading the productivity of the crop. Achieving optimum fertilizer application depends on the climate, soil, variety and availability of the water. This review was aimed to access all available fertilizer trials to point out the types of fertilizers soil is deficient in relation to potato crop response and needed additional application during production cycles for boosting yield. Almost all soils of arable lands of Ethiopia were deficient in nitrogen (N), phosphorus (P), and sulfur(S). In addition, a larger part of arable land was deficient in N, P, S, and boron (B). Some lands' soils require addition of either of potassium or zinc or both. Potato is requiring both macro and micro elements for high yield and better quality product. It is concluded that, most reviewed sources indicate that there was less recommendation concerning micro and macro elements for potato in the country in relation to the variable ecology of the country owned.

INTRODUCTION

Potato (Solanum tuberosum L) is classified under family solanaceae and genus solanum (Van den Berg and Jacobs, 2007). It is originated in the Andes of South America and cultivated for the first time in the border of Peru and Bolivia (Horton, 1987). It was introduced to Ethiopia before 163 years ago by the German botanist Schimper (Pankhurst, 1964). Since then, its production grew gradually from high land garden lands to the field crop status in high land and mid-land under both irrigation and rain fed production systems. Now, it is an important food security crop in many parts of the country. On global scale, there was a production volume of 368 million metric tons annually from an estimated area of 17.58 million hectares (FAOSTAT, 2018). Potato has become an important crop in many parts of Ethiopia, and it ranks first among root and tuber crops in volume produced and consumed followed by Cassava, Sweet potato and Yam (CSA, 2017). It was considered as a food security crop in Ethiopia because of its high yielding potential, high nutritional quality, short growing period and wider adaptability (Tewodros *et al*., 2014 and Brasesco *et al*., 2019). In area coverage it is the second widely grown crop next to 'Enset' (Ensete ventricosum L.)(Girma, 2001).

Potato has been highly recommended by the Food and Agriculture Organization (FAO) as a food security crop. Potato helped smallholder farmers by providing direct access to nutritious food, increasing household incomes and minimized their danger to face the food price instability (André *et al*., 2014). In Ethiopia, its meher season production area has reached about 70,362.22 ha, with total production of 924,528.361 tones cultivated by over 1.068 million households (CSA, 2019). On the other hand, the productivity of this crop in the country is very low (13.14 t ha-1) compared to the world's average yield of 19 t ha-1 (CSA, 2019). According to Brasesco *et al*. (2019), model farmers those using full technology (good quality seeds and optimum fertilizer application accompanied by good agronomic practice) potato yield potential reach up to 50 t/ha. Balanced fertilizers applications sustain optimal crop production, better quality product and ensues profitability. Nutrients such as N, P, K, S, B, Zn and Fe are plant nutrients found deficient in Ethiopian cultivable land soil though there are variations among location types. Newly developed fertilizer formula of the Ethiopian soils comprised these elements as well. In area coverage most soils are deficient in N, P, S, and B followed by those locations lacking N, P, and S (EthioSIS, 2016) and in general all cultivated land soils lack N, P and S. According to EthioSIS(2016), the soil content of different elements were said deficient whenever each of them was below 30 ppm for P, 190ppm for K, 20 ppm for S, 0.5 ppm for Zn , 0.9 ppm Cu and 0.8 ppm for B, based on the soil critical point concept. Fertilizers application based on crop needs and soil deficiency, reduce soil nutrient imbalance and satisfy crop needs, improve crop productivity and reduce poverty. Fertilizer rates determination and recommendation should base on climate, soil factors, and crop needs. In Ethiopia, research works carried earlier have been limited to the two common macronutrients (N and P) for long time that resulted in soil nutrient imbalance and degrade soil ecology as well as harvesting of unsustainable yield.

Based on the crop needs and soil shortages new fertilizing materials with secondary and micronutrients would be required to ensure balanced fertilizer use involving most of the nutrients required by crops (Bewketet al., 2018). That is why many fertilizer formula such as NPS, NPSB, NPSFeB, NPSFeZn, NPSFeBZn, NPSZn, NPSB, NPKSB, NPKSFeB, NPKSFeZn, NPKFeZnB, NPKSZn and NPKSZnB and soon are developed in the country based on soil shortage and crop needs (EthioSIS, 2015). Not only developing the formula but also ensuring the availability with affordable cost also plays a significant role in utilization of the developed technology and converting the opportunity for improving productivity and reducing poverty. One of the problems of our farmers facing now is a problem similar to these mentioned ones. There is developed formula but some of them are not available in the amount required and the available ones are high cost while some are available, but there is less attention to utilize them. This review was conducted to collect available information about fertilizers effect on potato crop and indicate the gap for researchers and users.

Nitrogen

Nitrogen is one of the major plant nutrients that control growth and development of green plants because of its high requirement and amount as well as types available in the soil. Plants exert considerable amount of forces taking in this nutrient in sufficient quantity that satisfy their demand for all processes. Nitrogen is mobile in plant and soil matrixes which can be moving from one locality to other due to different natural phenomena. In plants, nitrogen moves from its higher concentrations to the lower concentrations most probably from lower leaves to upper actively growing leaves by evaporation pool and force plants apply where it is used for the process of making other plant structure. In the soil, it is moving by water movement forces which take it to the water table found deep in the earth and moves it to the surface by erosion from higher topography to lower topography. In the plant, nitrogen is mainly found in the plant cell wall, chlorophyll, protein content, DNA and RNA. Generally, it is a plant nutrient that the plant uses it to carry out tissue growth, cell expansion, formation of organs and systems. The Plant contains about 2-7% of nitrogen. There is variation among plants in their nitrogen requirement. Those plants requiring in high amount are high in their vegetative growth and stored food or reproductive structure. The primary nitrogen sources for plants are nitrate and ammonium in soils (Owen and Jones, 2001).

Nitrogen is a crucial element for all living organisms because it is a constituent of numerous bio-molecules, including proteins, nucleic acids, and secondary metabolites (Miller and Cramer, 2005). Inadequate supply of usable nitrogen reduces plant growth and crop yield. Plants require abundant amounts of nitrogen to sustain growth, and thus, nitrogen acquisition is frequently a limiting factor of plant growth and crop production in both natural and agricultural ecosystems. Symptoms of nutrient deficiency may include stunted growth, death of plant tissue, or yellowing of the leaves caused by a reduced production of chlorophyll, a pigment needed for photosynthesis. Nutrient deficiency can have a significant impact on agriculture, resulting in reduced crop yield and yield quality. Nutrient deficiency can also lead to reduced overall biodiversity since plants serve as the producers that support most food webs. In agriculture loss of nitrogen from soils is minimized using inhibitors. Urease inhibitors are decreasing loss of urea in the form of ammonia. According to Noura *et al.* (2016) report polymer-coated urea reduced N losses and increase nitrogen use efficiency. Manufactured urea is alike with urea in animal urine. Currently, nitrogen in agriculture efficient utilization interest is raising (Wikipedia, 2016). Potato can remove 50 to 80 kg N ha^{-1}, 20 to 30 kg P_2O_5 ha^{-1}, and 80 to 100 kg K_2O ha^{-1} from the soil in tropical regions (Sikka, 1982). The amount of nutrient removed varies based on soil characteristics, cultivar, crop rotation, soil moisture, and other management practices (Zaeen, 2020). Developing countries' fertilizers application amounts to potato crops are scanty and inadequate (Zaeen, 2020). Hailu *et al.* (2019) confirmed presence of low application of fertilizers in developing countries such as Ethiopia, Kenya, and Uganda. Inadequate application of N limits the growth of all plant organs, roots, stems, leaves, flowers, stunted plant growth, yellowing of the color of leaf leading to low photosynthesis and low yield (Barker and Bryson, 2007). According to Goffart *et al.* (2008) shortage of N also reduces tuber size due to reduced leaf area and early defoliations. Optimum nitrogen application realizes the value of other inputs applied (Ruža *et al.*, 2013). In contrary, an adequate delivery of N is associated with energetic vegetative growth and a dark green color with high foliage development, higher photosynthetic action and translocation to tubers (Kumar *et al.*, 2007). However, an excess of this nutrient in relation to other nutrients, such as P, K, and S leads to excessive stolen and leaf growth, delayed leaf maturation, tuber differentiation, extended tuber bulking period, and ultimately reduced yield and tuber dry matter (Goffart *et al.*, 2008). Nitrogen applied up to the crop needs and soil nutrient balance significantly increased tuber number and yield (Zewide *et al.*, 2012 and Masrie *et al*., 2015). Optimum application is crucial for economic and environment safety. According to Pinochet et al. (2018) report, optimum nitrogen application reached at 228 kg/ha while below this rate, it was found deficit and above this rate at 300 kg/ha, it was reported excessive due to yield reduction. Potato nitrogen rate recommendation for Ethiopia worked for long time was 110 kg/ha which is very small compared to the value mentioned above. It needs to be tested again and again for the cost, soil nutrient balance and yield advantages relating with location, production system and variety.

Phosphorus

Phosphorus (P) is the second most limiting mineral nutrient for crop production in potato plant after N (K. Mokrani *et al*., 2018). According to Jasim *et al*. (2020) P is the most serious major nutrient limiting factor for potato growth after nitrogen and potassium. Lack of P in leaf mesophyll cells has a direct effect on photosynthesis through the availability of inorganic P in the chloroplast and leads to reduced carbon assimilation (Hermans *et al*. 2006). According to Hermans *et al*. (2006) early phases of phosphorus deficiency maintain sucrose translocation into the phloem. Reduction of sugar in the stem was positively correlated with inorganic P (Nitsos and Evans 1969). Phosphorus deficiency promotes increased photo assimilate provision to the roots (Hammond and White, 2008). Phosphorus deficiency causes early vine death and hurrying maturity (Soratto *et al*., 2015). Crops production for food, fiber and raw materials for industry depends on a P supply (Hopkins *et al*., 2008; Syers *et al*., 2008). So that phosphorus efficient use is extremely important for minimizing losses of P from agro ecosystems (Syers *et al*., 2008; Hart *et al*., 2004a). According to Fernandes and Soratto (2016) in soils of low, medium and high P availability tuber yield of all potato cultivars increased with increasing P fertilizer application up to rates of 500, 250, and 125 kg P_2O_5 per hectare, respectively. Ethiopian P recommendation is 90 kg/ha in the form of P_2O_5 regardless of continues cropping going with low application and high run off as well as soil available P.

Phosphorus is critically necessary during early growth stage when rapid cell division and elongation, meristem development, and vine growth take place. Potato requires large amounts of P for starch phosphorylation. Potato tubers contain 23% of total plant P at 50 day after planting while it contains about 83% at 123 days after planting (Houghland, 1960). On the other hand, according to Hopkins (2015) potato take up 0.2–0.4% P at mid-growth, 0.38–0.45% P at tuber initiation and 0.14–0.17% P at maturity. The potato crop demands high amount of phosphorus [Hopkins and Hansen, 2019, Rosen *et al*., 2014, Fixen and Bruulsema, 2014, Hopkins *et al*., 2018), because of its shallow roots, low root density, minimal root hairs (Hopkins and Hansen, 2019, Fernandes and Soratto, 2016). Potato take up P in the form of both HPO_4^{2-} below pH 6 and $H_2PO_4^{-}$ above pH 6 (Hopkins and Hansen, 2019 and Hopkins *et al*., 2018). The main function of phosphorus in plant is energy storage and transformation (Bruulsema *et al*., 2019 and Hopkins, 2015). The large amount of plant P required for forming sufficient amounts of adenosine triphosphate (ATP) and adenosine diphosphate (ADP) which participate in energy-transforming processes (Rosen et al., 2014, Havlin *et al*., 2016, Hopkins, 2015). In addition, Phosphorus is the functional forming blocks of phospholipids, phosphoproteins, coenzymes, nucleic acids, and nucleotides (Havlin *et al*., 2016 and Hopkins *et al*., 2015). Presence of high P promotes enough plant roots growth (Faucon *et al*., 2015, Balemi, 2009 and Hailu *et al*., 2017) and the yield is increasing as root growth is more and more due to high water and nutrient up take.

As potato cultivars differ in their canopy growth (Griffith *et al*., 1984) the amounts required vary not only due to canopy difference but also due to the depth and density of their root growth (Allen and Scott, 1992). Cultivars with more limited root system usually associated with earlier maturing and reduced capacity to explore the soil profile for nutrients. As the recommended amount of P_2O_5 was 90 kg/ha for highland of Ethiopia regardless of the variety and soil components, it has to be checked again and again as it is related to cost and gradual depletion of nutrient, continues cropping and leaching as well as erosion. On the other hand, previous recommendation was done on DAP as p-source and due to soil nutrient change, blended fertilizer which contain nitrogen, phosphorus, sulfur and Boron was recommended as p-source for some highland like Holetta; in different chemical formula which can vary the needs of crop. Therefore, it is important to evaluate the variety responses to the different rates of NPSB blended fertilizer and recommend economically optimum rate for production in relation to variety, locations and production systems like irrigation as well as rain fed.

Role of Sulfur on the growth and yield of potato

Deficiencies of S and B were found one production problem of soils of Ethiopian (Assefa *et al*., 2020). According to ATA (2016) micro elements like Zn, Cu, B and macro element S and K depleted and deficiency symptoms on many commonly producing crops in Ethiopia in different locality were observed. Majority of the cultivated lands of Ethiopian soils are deficit in macronutrients (N, P, and S) (EthioSIS, 2014). Sulfur is classified as a secondary element and the 4th major nutrient. Some crops utilize equal amount of S and P. It is taken up from the soil solution by the plant in the sulfate form SO_4^{2-}. Sulfur is required by plants for proper growth and yield in many reactions of all living cell (Sud and Sharma, 2002). Poor utilization of nitrogen, phosphorus and potash as well as reduced catalyze activities at all ages were common symptoms of sulfur deficient plant (Nasreen *et al*., 2003). The effect of sulfur application on quality parameters of potato after harvesting was studied by many authors. According to

Jaiswal *et al.*, (2008) and Ullah and Saikia (2008) reports tuber yield per plant showed maximum values at 45 kg ha^{-1} sulfur compared to control, 15 and 30 kg ha^{-1}sulfur applications. Minimum small size tuber % and maximum medium and large size tuber % were reported at 45 kg ha^{-1} than control, 60, 30 and 15 kg ha^{-1} sulfur applications (Mani *et al*., 2014). Sud and Sharma (2002) reported the reason for the increase in tuber yield with increasing sulfur levels. The Significant effect of sulfur on tuber sizes and balking rate increase with increased sulfur application was reported by Lalitha *et al*., (2002). Most soils of Ethiopia was found short of sulfur, so that blended fertilizer like NPSB was formulated for such soils and the need of crops grown for food on this soil has to be assessed on the base of yield and yield component traits. According to Bewket *et al*., (2018), increasing the rates of sulfur resulted in the significant total tuber and marketable yield increase probably because of sulfur effect on the synthesis of sulfur containing amino acids, proteins, energy transformation, and activation of enzymes. Sulfur rates recommendation for potato grown in Ethiopia is limited.

Potassium effect on potato

Potassium was found increasing both marketable and total tuber weight by increasing tuber sizes (Shunka *et al*, 2016). On an average, potato removed about 91 kg K_2O ha^{-1} at the yield of 29 Mg ha^{-1} (Moinuddin *et al*., 2005). Duan *et al*. (2013) found that the average uptake of K by rain fed potato and irrigated potato in Inner Mongolia of China was 82.2 and 221.7 kg K_2O ha^{-1} at the yield of 14.9 and 35.7 Mg ha^{-1}, respectively. The positive effect of K fertilization is greater on tuber quality than on yield (Kavvadias *et al*., 2012). The commonly used methods for K recommendations for crops are based on soil testing and sometimes can be used effectively for guiding fertilizer applications (Hannan *et al*., 2011), but the critical level of soil test K should be determined. The alternative way is to make fertilizer recommendation based on yield response and agronomic efficiency, which was successfully used in fertilizer recommendation for wheat and maize (Chuan *et al*., 2013; Xu *et al*., 2014). Another method for K recommendation is based on K balance in soil-plant systems and the recommended rate of K should be at least the amount of K removed by crop products (Shutian *et al*., 2015). Similarly, nutrient uptake by the potato crops also depends on the climatic condition, soil type and fertility status, variety cultivated and crop management practice (Sedera and Shetata, 1994). Potassium (K) aids in maintaining osmotic potential which enhances water uptake and root permeability, control ionic balances, regulate plant stomata and activate enzymatic processes(Bishwoyog and Swarnima, 2016). According to Bishwoyog and Swarnima (2016) potassium (K) plays a significant role in quality as well as yield attributes of potato such as reducing sugar, vitamin C content, specific gravity, shelf life and total yield. Because of higher loss and low replacement of potassium, widespread deficiency of potassium have been reported in many of the intensively cultivated soil (Adhikary and Karki, 2006) and application of K fertilizers have responded satisfactorily (Regmi *et al*.,2002). Potassium is one of the most essential nutrients required for plant development. It plays a vital role in several physiological processes such as photosynthesis, translocation of photosynthates, control of ionic balance, regulation of plant stomata and transpiration, activation of plant enzymes and many other processes (Thompson, 2010). The quality parameters such as dry matter, specific gravity, starch contents, vitamin-C and ash contents are affected with application of P and K (Khan *et al*., 2012). Application of Potassium is not only responsible to increase K concentration but also improve the concentration of N and P in potato tubers (Muhammad *et al*., 2015). According to Singh and Lal (2012) potassium significantly affect plant height, number of leaves per plant and marketable yield of potato tubers. Application of potassium fertilizer plays a vital role in yield of potato. It increases yield of potato tubers either due to the formation of large size tubers or increasing in the number of tubers per plant or both. In line with this, Westennann (2005) stated that insufficient K resulted in smaller-sized tubers. Potassium increases the size but not the total number of tubers (Trehan *et al*., 2001). Potassium helps to increase the content of carbohydrate significantly which ultimately helps to increase the tuber size (A-Moshileh & Errebi, 2004). Compared to other vegetables commonly found in grocery stores, potatoes are the largest and most affordable source of potassium (Drewnowski, 2013) with zero mg of sodium per serving, and 2 g of fiber. In human case, according to Bethke and Jansky (2018), potassium control high blood pressure and decrease risk of stroke when taken in high amount. The adequate intake of potassium for adult peoples was 4700 mg per day which 100g boiled potato can supply 16% of this requirement. So that, use of potassium for potato productions need to be customized for soil nutrient balance, yield increase and quality of yield improvement.

Boron effect

Boron is an essential micronutrient for plants, and plant requirements for this nutrient are lower than the requirements for all other nutrients except molybdenum and copper. It is the only non-metal among the micronutrients and also the only micronutrient present over a wide pH range as a neutral rather than an ion (Epstein and Bloom, 2005). Boron has been found to play a key role in reproductive processes affecting anthers' development, pollen germination and pollen tube growth (Loomis and Durst, 1992). Besides, Kaisher *et al*. (2010) reported a synergistic effect while working on sulfur and boron with respect to yield and yield contributing characters in addition to quality of the crop yield. Boron deficiency can be confused with Ca deficiency, which also affects the growing points and leads to their 'dying off.' Some symptoms of boron deficiency in potato appear as a chlorosis in the interveinal areas of new leaves, leaf and plant growth stunting, death of leaves and fall of the plant (Raskshya and Arjun, 2019). The primary role of boron is in the cell walls, where it provides cross-links between polysaccharides to give structure to cell walls. Micro nutrient shortage decrease both crop yield and the crop yield micronutrient content that have great influence on human health (Graham and Welch, 2000). According to Anita et al. (2020) foliar application of micro nutrient resulted in a significant increase of N level from 162 to 200 mg kg−1. Boron application positive correlation with N-content of yield was reported for wheat (Malakouti, 2008). Boron application directly affect yield and yield related attributes modifying the root development and facilitates nutrient-up take by initiating new root as well as stolen development which resulted in more tubers production (Egata *et al*., 2021). According to Ierna *et al*. (2011) B application resulted in significant increase in tuber number and yield in addition to boron-up take, available nitrogen and boron in the soil after harvest. Boron fertilization effect was significant to improve plant resistance to disease, pest, and environmental stresses (Ierna *et al*., 2017). Fassil and Phil (2010) found that 25.7% of irrigated semi arid north Ethiopia was boron deficient. Other trace element deficiencies occurrence were less than Boron deficiencies in both crops and climatic conditions ranges (Reisenauer *et al*., 1973). In other words, micron nutrient, in addition to boron, deficiencies were more genotype and location specific than macro nutrient deficiencies (Rashid and Ryan, 2004). Most potato growing highlands of central Ethiopia and Gurage zone Chaha district was reported the presence of boron deficiency (Hillette *et al*., 2015 and Mohammed *et al*., 2016). Most previously reported Authors showed that variation in occurrence of problems of micronutrient deficiency. According to Asgelil *et al*. (2007) 65% and 89%of soil and plant samples collected from different parts of the Ethiopian country had got Cu and Zn deficiencies, respectively while Fe and Mn in soils were found to be above the satisfactory limit. In accordance with this, different authors (Sahlemedhin *et al.,* 2003; Demeke and Abayneh, 2003; Abayneh and Ashenafi, 2006; Abebe and Endalckachew, 2012) indicated presence of deficiencies of Cu and Zn while Mn and Fe were above the critical limits in different parts of Ethiopia. In boron case, contrary to these, recent reports confirmed occurrences of boron deficiency in most productive lands of the Ethiopia (Samuel, 2014). Due to these all importance of the micro nutrient, blended form of fertilizer developed in the country when soil was found deficient in boron which encourage the rate determination for Blended fertilizer that contain boron become one area of work for researchers in Ethiopia. Not only rate determination but also the variety effect evaluation in relation to their boron requirement is also basic information to be obtained. Boron application also significantly increased tuber yield probably due to its role in regulation of carbohydrate metabolism and its transport within the plant besides the synthesis of amino acids and proteins (Walter and Rao, 2015). Furthermore, crops differ in their micronutrient contents depending on species, variety and physiological features (Oury *et al.*, 2006). Among the important factors regulating the crop nutrient supply, the root system temperature and fluctuations in plant physiological processes balance control the plant nutrient supply (Baghour *et al*., 2002).

Zinc, Iron and Copper effect on potato

According to the Food and Agriculture Organization (FAO), about 30% of the cultivable soils of the world contain low levels of plant available Zn (Hafeeze *et al.*, 2013). Zinc is an important micro-nutrient needed for good growth and performance of potato (Raskshya and Arjun, 2019). Zinc exerts a great influence on basic plant life processes, such as: Nitrogen metabolism and uptake, photosynthesis and chlorophyll synthesis (Tahmorespour *et al.*, 2013). Genotypes were variable in the concentration of mineral elements (copper, iron, manganese, zinc) in potato tubers (Subramanian *et al*., 2017 and Asrat *et al*., 2018). Potatoes are an excellent candidate for tackling malnourishment in developing countries and easily satisfying micronutrient needs of fast growing global population. According to Raskshya and Arjun (2019), foliar application of Zn significantly affected the potato height, stem number, canopy coverage and tuber yield. The mineral composition of potato was improved by foliar application of Fe and Zn by Fe (+70%) and Zn (+27%) over the control (Anita *et al*., 2020) and they recommended 200 g serving of potatoes for one day dietary need of micro nutrient.

Fe and Zn facilitate the functioning of different enzymes, including DNA/RNA polymerases, N-metabolizing enzymes and numerous other enzymes involved in redox processes (Broadley *et al*., 2012). In sugar beet (Barłóg *et al*.,2016) there was Zn treatments significant impact on total uptake of N and significant positive correlation between tuber Zn and N concentration(White *et al*., 2012). According to Buono *et al*. (2009) potato tubers are source of vital minerals like potassium in higher amount and lesser amount of magnesium, phosphorus, manganese, zinc and iron. These essential elements are nutritionally important which play critical roles in various biological processes of both plants (Maathuis, 2009) and human beings (Martinez-Ballesta,*et al*.,2010). In humans, the deficiencies cause metabolic disorders and organ damage, leading to acute and chronic diseases and even death (Dos *et al*., 2013). Its deficiency is a worldwide common problem and the most important global challenges for human nutrition (Pinto *et al*., 2015). Over three billion people are currently malnourished, with the highest rates in developing countries where iron (Fe), zinc (Zn) and vitamin A are the most critical deficiencies (Gabriela *et al*., 2007). According to Renata *et al*. (2020), balanced micronutrient supply is the prerequisite to ensure normal plant growth no less than the supply of essential macronutrients. In the plant metabolism, the mutual proportions between the individual macro and micronutrients are of greater importance than the absolute element contents (Fageria *et al*., 2008). According to Renate *et al*. (2020), there was significant effect of zinc applied with sulfate potassium in the variety bred for crisps. Zinc affected 52% of protein content (Zhang *et al*., 2008). According to Zeaan (200) micronutrients (e.g., zinc (Zn), copper (Cu), iron (Fe), manganese (Mn)) bind firmly to the surface of soil particles and precipitate with calcium (Ca) compounds at high pH(low H-concentration) and are not readily available in the soil solution i.e. inadequately available for plant uptake while at low pH (high H-concentration) the reverse processes take place. Average tuber number and weight per plant as well as total tuber number were improved as a result of zinc sulfate application (Mousavi *et al*., 2007). Puzina (2004) indicated the importance of Zn in improving the ratio of the indole-3-acetic acid (IAA) to abscisic acid (ABA) and cytokinin to ABA which promotes the formation and growth of stolons due to increased gibberellin content as result of reduced ABA content. Low level of Zn associate with decline in alcohol dehydrogenase enzyme because the molecule of the enzyme consists of two atoms of Zn which directly reduce the root development (Sati *et al*., 2017). Murthy *et al*. (1979) mentioned the increase of photosynthetic rate by 72% and 80% in the presence of 10 mg kg^{-1} of Zn and 10 mg kg^{-1} Mn, respectively, which also occurred to increase the amount of chlorophyll and carotenoids in the leaves. Roques *et al*. (2013) showed that Cu is involved in processes related to the reduction of nitrate-N to ammonium in plants. Copper are an essential component of many proteins that are required for a reduction and oxidation processes within metabolic pathways such as respiration, photosynthesis, and the regulation of plant hormones (MAFF, 1976). Trehan (1999) reported that the application of Fe increased the yield of the fourth size class of tubers but decreased the yield of the first size class where Fe is a component of hemoglobin structure and cytochrome (Tisdale *et al*., 1985; Mousavi *et al*., 2007).

Iron element is found to be increasing tuber yield from 40-45 % (Renata *et al*., 2020). According to Gabriela *et al*. (2007) application of Iron resulted in yield increases of potato though some research indicated that there is considerable variation among genotypes in the concentration of mineral elements (copper, iron, manganese, zinc) in potato tubers (Subramanian *et al*., 2017 and Asrat *et al*., 2018). In line with this, Gebriela *et al*. (2021) reported significantly different iron concentration difference among potato varieties, location and variety interaction with environment. Micronutrients fertilization improved mineral composition of raw potatoes (Anita *et al*., 2020). According to Broadley *et al*. (2012), Fe (Iron) involved as facilitator of different enzymes, including DNA/RNA polymerases, N-metabolizing enzymes and numerous other enzymes. Potato is a good source of vitamin C, vitamin B6 and iron (Buono *et al*., 2009).

Food is the best means of getting iron in human beings. More than three billion people are reported to be malnourished with the greater amount in developing countries especially iron (Fe) and vitamin A are the most critical deficiencies (Gabriela *et al*., 2007). Iron deficiency weaken physical growth, cognitive development, immunity and poor school performance in young children, while in pregnant women, it causes fetal growth retardation and is responsible for a large proportion of maternal deaths (Gabriela *et al*., 2007). In adults, Fe deficiency causes fatigue and reduced work capacity (Ruel and Levin, 2000). Significant levels of Fe and Zn (Casanas *et al*. 2003) and moderate availability of Fe have been reported for potato (Fair Weather-Tait, 1983).

CONCUSSION

Potato is responsive to both micro and macro element applications. It is highly productive and a food security crop of the Ethiopian peoples. Achieving optimum fertilizer application is important agronomic activities that encourage the crop to provide the yield to its maximum potentials. Almost all Ethiopian soils are in generally deficient in macro element N, P, and S while some locations lack micro elements B, Zn as well as macro element K. It is concluded that, most reviewed sources indicate that there was less recommendation concerning micro and macro elements for potato in the country in relation to the variable ecology the country owned.

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