



Effects of Blended NPSB Fertilizer on Growth and Yield of Potato: A Review

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Abstract

Potato, an essential vegetable crop to the global food security, yet in many regions, including Ethiopia, their productivity is constrained by lack of high yielding varieties, tolerant to late blight, climatic limitation, inadequate seeds, lack of appropriate cultural practices, poor post-harvest management & storage problems, high cost of farm inputs, diseases and insect pest problems and low soil fertility. The advantages of applying secondary and micronutrients like sulfur and boron together are becoming more commonly recommended, even if the sole impacts of macronutrients like nitrogen and phosphorus are well known. This review summarizes the findings of studies on the sole and synergetic impacts of nitrogen, phosphorus, sulfur and boron on potato growth and yield. According to various researches, applying each nutrient in a sole manner significantly improves growth and yield of potato. At the same time, these nutrients are applied synergistically in blended NPSB fertilizers; the highest plant height, stem count, marketable, and total yield are also recorded. The review concludes that there is a need to a paradigm shift from conventional fertilization to balanced nutrient management using blended NPSB to boost sustainable potato productivity in Ethiopia as well as other similar agro-ecologies.

Keywords: Blended Fertilizer, Potato, Yield



1. Introduction

The potato (*Solanum tuberosum* L.) is the third important food crop in terms of consumption and the fourth most vital crop in the world after rice, wheat and maize (Kennedy *et al.*, 2019). Potato is a source of both food and income in the developing countries of the world which able to change greatly the food security of countries because of high productivity per unit area and time in relation to other crops (Tufa, 2013). Moreover, it has high potential for the expansion of the fresh potato market (Scott *et al.*, 2000); make the commodity fundamental for rural development, especially in countries where there is a steep rise in the price of cereals.

Potato has high potential for improving food security, increasing household income and poverty reduction as well as provides important nutrients. It has a high content of carbohydrates, significant amounts of quality protein, and substantial amounts of vitamins, especially vitamin C (FAO, 2008). In respect to production and consumption volume, it is the most root crops followed by yam, cassava and sweet potato (Bikila *et al.*, 2014). In the highland populations of Sub-Saharan Africa, potato provides both food and cash income. With this dual role it contributes significantly to the rural livelihood system (Bekele *et al.*, 2016).

More than a billion people worldwide consume potatoes, and 300 million metric tons of potatoes are produced globally (International Potato Center, 2024). The leading producer is China, delivering over 93 million metric tons. In addition to China,

India, Ukraine, Russia, the United States, and Germany are prominent contributors, illustrating the widespread capability for potato cultivation. China as the top producer with 93,491,818 metric tons, followed by India with 60,142,000 metric tons, and Ukraine with 21,358,630 metric tons (FAOSTAT, 2023).

Potato production in Africa plays a vital role in food security and economic development, with key producers including Egypt, South Africa, Algeria, Kenya, Morocco, Rwanda, Ethiopia, and Nigeria (Muthoni and Shimelis 2023). According to Tadesse *et al.* (2017) around 70% of Ethiopia's cultivated farming area is ideal for the production of potato, indicating that the country has favorable environmental conditions. However, there is a yield gap exists between actual and potential farm-level production since the existing agri-food systems frequently fails to provide nutritious food in a sustainable manner (Folberth *et al.*, 2020).

Despite the potato's significant importance to the country's farming system, Ethiopia's average productivity (16.69 t ha⁻¹) is below the average global (20 t ha⁻¹), (CSA, 2022). Various factor including inadequate fertilizer management, low soil fertility, lack of high yielding and late blight-tolerant varieties, climatic limitation, shortage of quality seeds, inappropriate cultural practices, poor post-harvest handling and storage facilities, and high cost of farm inputs (Gebremedhin, 2013) (Mohammed & Dawa, 2018), diseases and insect pest problems, limit the

productivity of potato (Seid-Sani & Chalchisa, 2017).

Alternatively, soil nutrient status is also the most significant factor limiting the yield potentials of several crops including potato. Under those circumstances, the application of blended fertilizers is believed to increase the nutrient use efficiency and crop productivity (Abdeta *et al.*, 2023). EthioSIS (2016) reported that Ethiopian soils are deficient in nutrients including nitrogen (86%), phosphorus (99%), sulfur (92%) and boron (65%). to resolve this problem, the application of balanced fertilizers in blended form is essential.

Without blended fertilization, continual cultivation depletes soil reserves of vital nutrients, resulting in yield reduction. Conventional fertilizers like urea and DAP may be applied by farmers, but omitting other essential elements like boron and sulfur has become a major limiting factor. Due to this imbalance, a paradigm shift from traditional fertilization techniques to blended fertilizer is crucial. This balanced fertilization is a key tool for sustainable agricultural productivity (Mengesha *et al.*, 2024). Thus, this paper aims to review various research findings on the individual and synergistic impacts of nitrogen, phosphorous, sulphur, and boron on the growth and potato tuber yield.

2. Literature Review

2.1. Origin and Distribution of Potato

Potato has been cultivated for more than 13,000 years in the Andes mountains of South America, which include Bolivia,

Chile, Colombia, Ecuador and Peru (De Jong *et al.*, 2011). There is still no definitive explanation for the cultivated potato's evolutionary origin (Spooner *et al.*, 2014). It was introduced to Europe in the 17th Century (Sponner, 2010). Missionaries may have played a crucial role in the distribution of *Solanum tuberosum* from Europe throughout the world (Sauer, 1993). It is cultivated worldwide in over one hundred countries throughout Africa, Asia, Australia, Europe, and North and South America and is native to South America (Eskin, 1989). It was introduced to Ethiopia in 1858 by the German Botanist, Schimper (Pankhurst, 1964). The distribution of potatoes in Ethiopia was found to be 48% in Oromia, 31% in Amhara, 20% in South Nation and Nationality Peoples Region, and 1% in Tigray (CSA, 2018).

2.2. Agro-ecology of Potato

As a cool-season crop, potato thrives in temperatures between 15 and 20 °C (Van Dam *et al.*, 1996), with yields ranging from 12 to 60 tons of tubers per hectare. It can be cultivated on any soil that has high organic matter content, although it needs sandy loam or loamy sand soils that are well-drained, aerated, and porous, with a pH between 5.5 and 6.0 (Muthoni *et al.*, 2015). It needs high rainfall of 1000-1500 mm per year, and a high elevation of around 1200 m.a.s.l. (Gusha, 2014). Compared with other crops, potato has a very shallow root zone and lower tolerance for water stress, therefore irrigation may be imperative to replace little rainfall (Makani *et al.*, 2013).

2.3. Importance of Potato

Owing to its adaptability, producing ability, nutritiousness, and diverse cropping systems, potato has a long history of reducing food scarcity and boosting household incomes throughout times of crisis and existing population growth (Devaux *et al.*, 2020). For small-scale growers, it is a cash and food crop. In contrast to other vegetable and cereal crops, it occupies largest area and gives more food per unit area (Tesfaye *et al.*, 2008). As a food crop, it is a great source of energy for human being because of their high protein, carbohydrate and substantial amounts of vitamins as well as low fat content (Hussain, 2016). It gives quality food in a short period of time and is the cheapest sources of energy. While as a cash crop, it is produced extensively in the nation with maximum rate of growth because of rising demand of consumption (Bekele, 2024). This gives resource-poor farmers a great opportunity to generate extra income and poverty reduction (Woldegiorgis *et al.*, 2013). In general, it significantly contributes to the food security of rural households that grows potato (Ermias, 2010).

2.4. The individual and Synergistic

Impact of Nitrogen, Phosphorus, Sulphur and Boron on Growth and Yield of Potato

2.4.1. The individual impact of nitrogen, phosphorus, sulphur, and boron on potato Growth and Yield

Nitrogen (N)

Nitrogen is necessary for plant growth due to integral component of chlorophyll, nucleotides, alkaloids, enzymes, hormones,

and vitamins. It frequently restricts growth and yield of potato (Solomon *et al.*, 2019), also reported that the highest plant height (70.16cm), number of stems per plant (5.65), marketable (28.32 t ha⁻¹) and total tuber yield (35.5 t ha⁻¹) resulted from the application of Nitrogen 110 kg ha⁻¹. Similarly, Alemayehu *et al.* (2015) found that the highest plant height, maximum number of stems, aboveground dry biomass, total number of tubers, and tuber yield (large-sized, marketable and total) were recorded from applying 110 kg N ha⁻¹. The tallest plant (63.73cm), marketable (20.96 t ha⁻¹), and total potato tuber yield (22.22 t ha⁻¹) found from 150 kg ha⁻¹ of N application (Akter, 2020). The highest plant height (71.6 cm), total number of tuber (13.7 hill⁻¹) and total yield of potato (42.27 t ha⁻¹) were found from 165 kg ha⁻¹ of N application (Belachew *et al.*, 2016). According to Khatun (2018), applying 170 kg N ha⁻¹ resulted the tallest plant (72.17cm), number of stem (5.29 hill⁻¹), average weight of tuber (54.20g), and total yield of potato (21.60 t ha⁻¹). Furthermore, Fazily and Alemi (2019), revealed that applying 250 kg N ha⁻¹ resulted in tallest plant (41.83cm), number of leaves (30.41 plant⁻¹), number of branches (4.73 plant⁻¹), and a higher yield (14.70 t ha⁻¹). Sebnie *et al.*, (2021) reported that the highest plant height of potato (72.58 cm), highest marketable yield (45.55 t ha⁻¹) and Total yield (38.82 t ha⁻¹) was recorded from 138 kg ha⁻¹ N.

Phosphorus (P)

Phosphorus is the mineral element that restricts potato growth and productivity after nitrogen. Potato physiological activities like

vine growth, tuber development, bulking and starch synthesis depends on phosphorus (Jasim *et al.*, 2020). The tallest plant (71.6cm), tuber total number (13.7hill⁻¹) and total potato yield (42.27 t ha⁻¹) were gained from 135 kg ha⁻¹ of P application (Belachew *et al.*, 2016). Similarly, Regassa *et al.* (2016), who reported that applying 135 kg P ha⁻¹ produced the tallest plant (64.07cm), average tuber weight (44.08g), marketable yield (13.09 t ha⁻¹) and total yield (15.66 t ha⁻¹). The tallest plant (96.64cm), number of stem (32.24 hill⁻¹), leaf number (784.04 plant⁻¹), average tuber weight (4268.4g), marketable yield (35.52 t ha⁻¹) and potato yield (38.68 t ha⁻¹) were found from 115 kg ha⁻¹ phosphorus application (Chala *et al.*, 2017). Khatun (2018) reports that applying 55 kg P ha⁻¹ produced the tallest plant (66.22cm), number of stem (4.94 hill⁻¹), average tuber weight (47.99g), marketable yield (20.91 t ha⁻¹), and total yield (25.08 t ha⁻¹). Fazily and Alemi (2019), also revealed that applying 175 kg P ha⁻¹ resulted in highest plant height (41.83cm), number of leaves (30.41 plant⁻¹), number of branches (4.73 plant⁻¹), leaf area (113.43cm), and a higher yield (14.70 t ha⁻¹).

Sulphur (S)

Sulphur is one of the most important and the fourth key nutrient next to nitrogen, phosphorus and potassium that crops need for healthy growth and productivity due to it plays a major role in the chlorophyll synthesis (Solomon *et al.*, 2019). It is a beneficial part of the balanced nutrition needed for potato production in areas where extensive cropping and the application of high-grade fertilizers led to the depletion of sulphur in the soil (Arega *et al.*, 2018).

Applying sulphur at a rate of 45 kg ha⁻¹ resulted maximum plant height (59.2cm), average tuber weight (166.56g) and total potato yield (37.74 t ha⁻¹) (Sharma *et al.*, 2015). According to Singh *et al.* (2016) using 50 kg S ha⁻¹ fertilizer resulted the tallest potato plant (65.50cm) and total tuber yield (16.06 t ha⁻¹). Applying sulphur at a rate of 40 kg ha⁻¹ recorded maximum plant height (82.00cm) and total potato tuber yield (27.00 t ha⁻¹) (Muthanna *et al.*, 2017). The maximum number of stems per plant (5.65), marketable (31.37 t ha⁻¹) and total tuber yield (35.5 t ha⁻¹) resulted from the application of sulphur 19.74 kg ha⁻¹ (Solomon *et al.*, 2019). Similarly, Bewket, (2019), increasing the rates of sulfur resulted in to significant total tuber and marketable yield increased probably due to sulfur role in the synthesis of sulfur containing amino acids, proteins, energy transformation, and activation of enzymes which leads to enhances carbohydrate metabolism and photosynthetic activity of plant with increased chlorophyll synthesis.

Boron (B)

Boron has a direct impact on growth, yield and yield related features by altering root development and facilitates nutrient-up take by promoting both new and stolen root formation, which increases the production of potato tubers (Solomon *et al.*, 2021). According to various reports, boron application significantly affects the amount of chlorophyll in potato plants, which in turn affect photosynthetic activity (Singh *et al.*, 2018). Also, its effect was significant to improve plant resistance to disease, pest, and environmental stresses (Ierna *et al.*, 2017). Applying boron at a rate of 2 kg ha⁻¹ resulted

highest plant height of potato (82.00cm) and total yield (27.00 t ha⁻¹) (Muthanna *et al.*, 2017). The highest plant height (58.51cm), number of stems (4.37 hill⁻¹), marketable yield (20.32 t ha⁻¹), and total potato yield (21.73 t ha⁻¹) were recorded by applying 2 kg B ha⁻¹ (Akter, 2020). Boron application at 100 mg/l resulted in the highest plant height (76.67cm), stem number (5.60 hill⁻¹), and total potato yield (15.54 t ha⁻¹) (Alkharpotly *et al.*, 2018). (Ewais *et al.*, 2020) showed that applying boron at 100 ppm produced the maximum average weight (144.00g) and potato tuber yield (15.19 t ha⁻¹).

2.4.2. Synergistic Effect of NPSB on potato Growth and Yield

A national issue that significantly reduces crop yield is the absence of suitable secondary and micronutrients in a fertilizer blend (Fufa *et al.*, 2011). Production management techniques and the use of other nutrient sources particularly that contain sulfur, and other micronutrients like boron beyond the blanket recommendations of urea and DAP are essential for increasing desirable attributes and productivity of crops (EthioSIS, 2015). Diriba and Tilaye (2020) reported that the tallest plant (62.03cm), number of stem (7.23 hill⁻¹), marketable yield (17.20 t ha⁻¹), and total tuber weight (18.56 t ha⁻¹) were recorded when 200 kg ha⁻¹ of NPSB were applied. Similarly, Teshome *et al.* (2023) found that applying 200 kg ha⁻¹ of NPSB produced the tallest plant (96cm), number of stems per plant (9.94), marketable yield (21.6 t ha⁻¹), and potato tuber yield (24.76 t ha⁻¹). In addition, Mengesha and Tamiru (2025) found that applying 200 kg NPSB ha⁻¹ resulted in the

highest plant (87.33cm), marketable yield (51.68 t ha⁻¹), and total potato yield (51.68 t ha⁻¹). Furthermore, Kebede (2025) reported that the tallest plant (63.89cm), number of stem (7.05 hill⁻¹), marketable yield (35.34 t ha⁻¹), and total potato yield (42.34 t ha⁻¹) were recorded when 250 kg ha⁻¹ of NPSB were applied. Assefa *et al.* (2021) revealed that 300 kg NPSB ha⁻¹ application resulted in the maximum plant height (64.83cm), average tuber weight (72.33g), main stem number (8.33 hill⁻¹), and marketable yield of potato (22.72 t ha⁻¹). The highest plant height (69.54 cm), Number of main stems (8.38 hill⁻¹), marketable yield (33.91 t ha⁻¹) and total tuber yield (35.65 t ha⁻¹) were recorded by applying 357 kg NPSB ha⁻¹ (Girma *et al.*, 2023).

2.5. Economic Benefit of NPSB on potato production

Increased Profitability: Applying 150-250 kg NPSB ha⁻¹ has been shown to produce the highest net benefits (Assefa *et al.*, 2021; Abdeta and Tamiru 2025 and Mekonen *et al.*, 2019). Arega *et al.* (2025) reported that the application of 250 kg NPSB fertilizer per hectare resulted in the highest net benefit of Birr 1,002,560 and 5545.45% marginal rate of return.

Sustainability: NPSB fertilizer addresses nutrient deficiencies in degraded soils, increasing the agronomic efficiency and sustainability of production (Daniel *et al.*, 2025). Alemu and Biratu (2026) reported that the Blended fertilization enhances yield, tuber quality, and farmer income, contributing to sustainable potato production and food security.

3. Summary and Conclusion

Potato is a vital crop for global food security, particularly in Ethiopia and Sub-Saharan Africa, where it is a major source of cash income and food for rural households. Despite Ethiopia's significant potential for potato production the average national productivity is lower than the world average. This yield gap is attributed to inadequate fertilizer application, especially the traditional reliance on urea and DAP which depletes soil and neglects other vital elements like boron and sulphur. The review conclusively shows that balanced nutrition management is the key to boosting potato yield. According to various researches, applying nitrogen, phosphorus, sulphur, and boron independently improve growth and yield potato. More significantly, application of these nutrients in a blended NPSB fertilizer has a synergistic effect that consistently produces the highest performance in every parameter like plant height, stem number, marketable and total tuber yield. Therefore, a crucial shift from conventional to balanced nutrient management using blended NPSB fertilizer is essential to bridge the yield gap and enhance sustainable potato productivity in Ethiopia.

As a general, blended fertilizer has its own side effect on potato production. The following points are suggested as a future line of work in the current review area and other areas like:

a. Assessment of effect of different management practices on yield and yield related character of potato

b. Potato producers should be awarded, about the advantage of using blended NPSB fertilizer and its effect on the production and productivity of potato.

Data Availability

The data used to support the findings of this study are included within the article.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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