



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

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Abstract: Potato (*Solanum tuberosum* L.) is a high potential food security crop in Ethiopia due to its high yield potential, nutritional quality, short growing period and wider adaptability. However its productivity is very low mainly due to low soil fertility. Based on the national soil database, most of North West Ethiopian soils are deficient in macronutrients (N, P and S) and micronutrients (Cu, B and Zn) affecting growth, yield and quality of vegetables in general and potato in particular. Thus far, emphasis has not been given on assessing influence of combined application of inorganic and organic fertilizer on the growth, yield and quality of potato. Therefore, a field experiment was conducted to determine the appropriate rate of blended NPSZnB fertilizer and cattle manure (CM) on nitisol of Awi zone in 2017 under rainfed condition. The treatments consisted of four blended NPSZnB fertilizer rates (0, 65.7, 133 and 199 kg ha⁻¹) and four CM rates (0, 10, 20 and 30 t ha⁻¹). The experiment was laid out in 4x4 factorial arrangements in randomized complete block design with three replications. Data on growth, yield and quality variables were collected and analyzed using SAS version 9.3 software. Results revealed that combined application of blended NPSZnB fertilizer and CM significantly ($P < 0.05$) influenced days to 50% flowering, days to maturity, plant height, leaf area index, marketable tuber yield, total tuber yield, tuber dry matter content and tuber starch content. However, main stem number and unmarketable yield were not affected by the combined application of NPSZnB blended fertilizer and CM. The highest marketable tuber yield (31.7 t ha⁻¹) and total tuber yield (34.1 t ha⁻¹) were recorded from combined application of 199 kg ha⁻¹ of blended NPSZnB fertilizer and 30 t ha⁻¹ of CM; while the lowest values (9.8 t ha⁻¹ and 12.29 t ha⁻¹ respectively) were recorded from the control. Tuber dry matter content and tuber starch content showed significant ($p < 0.05$) reduction with increased rate of combined application of blended NPSZnB fertilizer and CM. Correlation analysis showed that total tuber yield was highly significantly and positively correlated with plant height ($r = 0.903$), leaf area index ($r = 0.899$), marketable yield ($r = 0.950$) and tuber starch content ($r = 0.485$). The result of this study verified that growth, yield and quality of potato were influenced by different blended NPSZnB fertilizer and CM rates. In conclusion, the above findings indicated that the growth and productivity of potato (Dagim variety) at study area can be improved by the combined application of blended NPSZnB fertilizer and CM.

Keywords: Blended fertilizer, Inorganic fertilizer, Organic fertilizer, Tuber yield

1. INTRODUCTION

Potato (*Solanum tuberosum* L.) belongs to the family of Solanaceae and genus Solanum (Haward, 1969). It is the most important vegetable crop, constituting the fourth most important food crop in the world following wheat, maize and rice and first among root and tuber crops (Douches, 2013). More than a billion people consume potatoes and the total global potato production exceeds 374 million metric tons per year. Potato has been highly recommended by the Food and Agriculture Organization (FAO) as a food security crop. Potato cropping systems help to improve resilience especially among smallholder farmers by providing direct access to nutritious food, increasing household incomes and reducing their vulnerability to food price volatility (André *et al.*, 2014).

It is a high potential food security crop in Ethiopia due to its high yield potential, nutritional quality, short growing period and wider adaptability (Tewodros *et al.*, 2014). It has been cultivated in Ethiopia for over 150 years; currently it is grown in many parts of the country. In Ethiopia, its *meher* season

production area has reached about 66, 926 ha, total production of 921,403.2 ton cultivated by over 1.2 million households (CSA, 2017). On the other hand, the productivity of this crop in the country is very low (13.8 t ha^{-1}) compared to the world's average yield of 19 t ha^{-1} (CSA, 2017).

Low actual yield of potato in Ethiopia is related to different factors, such as poor soil fertility (for example, low level of organic matter and /or low pH, binding of phosphorus and not mineralizing nitrate), and sub-optimal fertilizer application rates are most determining factors (Haverkort *et al.*, 2012). Soil fertility depletion owing to high rates of erosion is considered to be the fundamental biophysical root cause for declining per capita food production in Africa, including Ethiopia in the fields of smallholders (Tesfaye *et al.*, 2011). Potato demands high levels of soil nutrients due to its relatively poorly developed, coarse, and shallow root system (Dechassa *et al.*, 2003). The crop produces much more dry matter in a shorter life cycle that results in large amounts of nutrients removed per unit time, which generally most of the soils are not able to supply (Islam *et al.*, 2013).

Thus far, soil fertility management research outputs using cattle manure and inorganic fertilizer is unavailable and has not been conducted at Banja District (Banja District Agriculture Office, 2017 annual report). On the contrary, soil of the study area is deficient in nitrogen, phosphorus, sulfur, zinc and boron nutrients as indicated in the Ethio-SIS map (ATA, 2015).

Application of organic manure and inorganic fertilizers could substantially influence the yield of potato (Biruk *et al.* 2015). Organic manures and their extracts have been reported to improve soil fertility, soil structure and furthermore help plants in combating pests and diseases (Khadem *et al.*, 2010).

Although mineral NP fertilizers can be used to replenish soil nutrients and increase crop yields, concerns about soil exhaustion and nutritional imbalances, arising from increased and indiscriminate use of such fertilizers necessitate research on organic manure (Bayu *et al.*, 2006). However, the use of organic fertilizer alone may not fully satisfy crop nutrient demand due to low available nutrient, relatively low nutrient content, high application rates and high labour requirements unless it is integrated with inorganic fertilizers (Peter *et al.*, 2009). Therefore, integrated use of organic and inorganic fertilizers is important to improve soil fertility and in turn attain maximum yield. For example, in the nearby district (Burie), yields of 37 t ha^{-1} have been produced in an on farm demonstration activity (Tesfaye *et al.*, 2015).

Fertilizer determination research works carried earlier have been limited to the two common macronutrients (N and P) and hence the effects of blended fertilizers have not been studied. New fertilizer materials with value addition and fortification with secondary and micronutrients would be required to ensure balanced fertilizer use involving most of the nutrients required by crops soil fertility status of a given areas. Balanced fertilization guarantees optimal crop production, better quality product and benefits growers and is also the best solution for minimizing the risk of nutrient imbalances. Nutrients such as N, P, K, S, B, Zn and others can often be included in new fertilizer formula (ATA, 2015). Use of balanced fertilizers in deficient soils can improve fertilizer-use efficiency and crop profitability.

Fertilizer use in Ethiopia has increased notably since 1990, but there is no concomitant attainable yield increase, especially in potato (Haverkort *et al.*, 2012). This is mainly due to use of the two types of fertilizers (DAP and Urea) alone that may have resulted in unbalanced nutrient levels in the soil and use of specific area recommendation to wide areas (Chillot and Hassan, 2010). The effectiveness of cattle manure and other organic nutrient sources in maintaining soil fertility, improving crop yields and sustaining productivity when applied along with mineral fertilizers has been reported by different authors (Bayu *et al.*, 2006). Cattle manure is among the easily accessible organic nutrient sources in the study zone due to high cattle population (Agegnehu *et al.*, 2014). Despite the availability of CM in the crop-livestock farming systems of Awi zone, the use of CM for soil fertility maintenance and potato production is limited to homestead (Banja District Agriculture Office, 2017 annual report). Moreover, information on the effect of cattle manure application along with blended NPSZnB fertilizer on the growth, yield and quality of potato in Awi zone is not available (Banja District Agriculture Office, 2017 annual report). This study was therefore initiated to assess the effects of integrated use of cattle manure and blended NPSZnB fertilizer sources on growth, yield and quality of potato under Banja District.

2. MATERIALS AND METHODS

Description of the Experimental Site: The experiment was conducted in Amhara Region at Banja district of Awi Zone, Chewusa kebele farmers training center in 2017 under rain fed condition. The site is geographically located at 454 km North West of Addis Ababa at an elevation of 2560 meters above sea level and at latitude $10^{\circ} 57'N$ and longitude $36^{\circ} 56' E$. The experimental site receives 1700 mm average annual rainfall, $5^{\circ}C$ minimum and $25^{\circ}C$ maximum temperatures with nitisol soil type (Agegnehu *et al.*, 2014).

Experimental Materials, treatments and experimental design: The experiment was conducted using the improved potato variety Dagim. This variety was released by Adet Agricultural Research Center (AARC) in 2012. It is characterized by white tuber skin color, shallow pink eye color, round tuber shape and erect growth habit. The treatments were set from different rates of blended NPSZnB fertilizer and cattle manure, CM (prepared from two to eight months of age). Sixteen treatments were obtained by combination of four NPSZnB fertilizer rates (0 , 65.7 kg ha^{-1} , 133 kg ha^{-1} and 199 kg ha^{-1}) which have been set based on $69 \text{ kg ha}^{-1} P_2O_5$ and $81 \text{ kg ha}^{-1} N_2$ recommendation (Tesfaye *et al.*, 2015) and four levels of CM rates (0 , 10 t ha^{-1} , 20 t ha^{-1} and 30 t ha^{-1}) which have been set based on 20 t ha^{-1} recommendation (Balemi, 2012). These treatments were tested in randomized complete block design (RCBD) with three replications.

Experimental Procedures: The land was well prepared and experimental plots were cultivated to the depth of 15 to 20 cm by oxen plow. The size of each plot was $2.4 \text{ m} \times 3.75 \text{ m}$ (9 m^2) and plots were leveled and ridges were prepared using hand tools to provide a medium fine soil for the growth of the crop. Each plot consists five rows that were 2.4 m length and spaced 75 cm apart and well sprouted medium size seed tubers were planted manually by placing in a row at spacing of 30 cm (EIAR, 2004). The two outer rows were considered as border. The blocks were separated by a 1.5 m distance whereas the unit plots were separated by one meter distance. Then seed tubers were hilled up with soil and buried at depth of 15 cm (Mohammad *et al.*, 2013) in prepared ridges during the main cropping season after the rain commenced and the soil become moist enough to support emergence. Blended NPSZnB fertilizer was used as a source of mineral nutrients and full doses, which varied depending on treatments, was applied at time of sowing and cattle manure also used as sources of nutrients and full doses, which varied depending on treatments, was applied two weeks before sowing and thoroughly incorporated with the soil. The experiment was conducted under rain fed condition and agronomic practices were kept uniform for all treatments as recommended and adopted for the location.

Data Collected: Data collected on days to 50% flowering, days to maturity, plant height, main stem number, leaf area index, total tuber yield, marketable tuber yield, tuber dry matter content specific gravity of tubers and tuber starch content and checked for normality and subjected to analysis of variance using SAS version 9.3 statistical software (SAS Institute Inc. 2012). The difference between treatments means were compared using least significant difference (LSD) at 5% level of significance.

3. RESULTS AND DISCUSSION

Days to 50% Flowering (DF): The number of days to 50% flowering was highly significantly ($P=0.001$) influenced by blended NPSZnB fertilizer application, cattle manure (CM) application and their interaction. The maximum period required to reach days to 50% flowering (73 days) was recorded from combined application of 133 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure which was statistically similar with application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure. The shortest duration to 50 % flowering (57 days) was recorded from the control treatment, which was statistically in parity with applications of blended NPSZnB fertilizer of 65.7 kg ha^{-1} , 133 kg ha^{-1} and 199 kg ha^{-1} .

The significant difference among the treatments might be attributed to the characteristics of nitrogen and phosphorus nutrients which enhanced vegetative growth of the crop and prolonged days required to attain 50 % of flowering. In addition, cattle manure may improve soil structure which increases nutrient uptake of crop and releases nutrients like nitrogen and phosphorus. In line with this, Alemayehu *et al.* (2015) and Biruk (2015) have also reported that increasing nitrogen and phosphorus fertilization levels significantly delayed days required reaching flowering in potato.

Days to maturity (DM): The number of days to 75% maturity was highly significantly ($P=0.001$) influenced by blended NPSZnB fertilizer application, cattle manure (CM) application and their interaction. The maximum period required to attain days to 75% maturity (97.67 days) was recorded from combined application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure which was statistically similar with application of 199 kg ha^{-1} blended NPSZnB fertilizer and 20 t ha^{-1} cattle manure. While the shortest duration (86 days) was recorded from the control, 65.7 kg ha^{-1} blended NPSZnB fertilizer application and 133 kg ha^{-1} blended NPSZnB fertilizer applications alone.

This may be due to the fact that increased rate of nitrogen stimulated haulm growth, prolonged the growing period and delayed tuber formation (crop maturity). Therefore, a crop with more nitrogen will mature later in the season than a crop with less nitrogen because late growth (maturity) is related to excessive haulm development while early tuber growth (maturity) is related to less abundant haulm growth (Mulubrhan, 2004). Cattle manure increases soil moisture holding capacity and decrease leaching of nutrients, in addition to releasing nutrients like nitrogen and phosphorus. Phosphorus, sulfur and boron increases uptake of nitrogen since they are used for chlorophyll synthesis and initial root development (Rao *et al.*, 2001). Alemayehu *et al.* (2015) and Biruk (2015) also reported that increasing nitrogen and phosphorus fertilization levels significantly delayed days required reaching flowering and maturity in potato.

Plant height (PH): Plant height was highly significantly ($P=0.001$) influenced by blended NPSZnB fertilizer and cattle manure rate and significantly ($p=0.04$) affected by their interaction effect. The highest plant height (63.73 cm) was recorded from plants which grow with combined application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure. The shortest plant height (36.5 cm) was observed from control treatment. The significant increase in plant height observed by plants treated with combined use of highest rates of blended NPSZnB fertilizer and cattle manure could be due to the fact that nitrogen is considered as one of the major limiting nutrients in plant growth and the adequate supply of it promotes the formation of chlorophyll which in turn resulted in higher photosynthetic activity, vigorous vegetative growth and taller plants. Phosphorus is required in large quantities in shoot and root tips where metabolism is high and cell division is rapid. Similarly, sulfur promotes the formation of chlorophyll, higher photosynthetic activity, vigorous vegetative growth and taller plants. The presence of boron in the blended fertilizer nutrient source also significantly increased plant height due to its important role in the cell division and nitrogen absorption from the soil, enhancing plant growth ultimately increased plant height. Zinc enhances nitrogen uptake and metabolism, photosynthesis and chlorophyll synthesis (Potarzycki, 2009).

In addition to these, the current investigation is also consistent with the findings of Yourtchi *et al.* (2013), Alemayehu *et al.* (2015) and Biruk (2015) who indicated that plant height increased very significantly with increasing amount of nitrogen fertilizer in potato. Gezahegn (2011) has also reported that plant height increased in response to increased application rate of N and P fertilizers, which could be related to the role of nitrogen in promoting vegetative growth and that of phosphate in favoring leaf expansion and stem elongation.

Leaf area index (LAI): Leaf area index per hill was highly significantly ($P=0.001$) influenced by blended NPSZnB fertilizer application, cattle manure (CM) application and interaction of these two sources. The highest total leaf area index per hill (7.55) was recorded from combined application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure. On the other hand, the lowest value for leaf area index per hill (1.73) was obtained from the control treatment. Application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure increased leaf area index by 336.42%. Similarly, application of 199 kg ha^{-1} blended NPSZnB fertilizer without cattle manure increased leaf area index by 242.7% and application of 30 t ha^{-1} cattle manure alone increased leaf area index by 172.83% over the control.

The reason for the increased leaf area index per hill could be attributed to development of more above ground biomass with the expanded leaves produced in response to nitrogen (Firew, 2014).

Phosphorus also promotes rapid canopy development, contributing to root cell division tuber set and starch synthesis. Cattle manure possibly improved soil physical properties such as bulk density and porosity (Garo *et al.*, 2014), moisture holding capacity, thereby, promoted early root growth. Enhanced root growth could have enhanced the ability of plants to access nutrients. Sulfur, zinc and

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boron increases uptake of nitrogen since they are used for chlorophyll synthesis, activate enzymes, increase resistance to abiotic and biotic stresses and protection against oxidative damage (Potarzycki, 2009).

Table1. Days to 50% flowering (DF), Days to maturity (DM), Plant height (PH) and Leaf area index (LAI) as influenced by application of blended NPSZnB fertilizer, cattle manure and interaction during the 2017 growing season at Chewusa, Banja district.

| Factors | | Variables | | | |
|----------|---------------|---------------------|--------------------|---------------------|--------------------|
| NPSZnB | Cattle Manure | DF | DM | PH(cm) | LAI |
| 0 | 0 | 57.00 ^g | 86.00 ^d | 36.50 ^j | 1.73 ^k |
| | 10 | 61.33 ^f | 90.67 ^c | 42.17 ⁱ | 2.10 ^j |
| | 20 | 67.00 ^d | 90.67 ^c | 46.60 ^h | 2.49 ⁱ |
| | 30 | 71.67 ^{bc} | 93.33 ^b | 48.83 ^{gh} | 2.99 ^h |
| 65.7 | 0 | 57.00 ^g | 86.00 ^d | 42.03 ⁱ | 2.66 ⁱ |
| | 10 | 61.33 ^f | 90.67 ^c | 50.63 ^{fg} | 3.02 ^h |
| | 20 | 67.00 ^d | 91.00 ^c | 51.03 ^{ef} | 3.74 ^f |
| | 30 | 71.33 ^c | 93.33 ^b | 53.70 ^{de} | 4.78 ^d |
| 133 | 0 | 57.67 ^g | 86.00 ^d | 48.10 ^{gh} | 3.07 ^{gh} |
| | 10 | 64.67 ^e | 90.67 ^c | 51.07 ^{ef} | 3.36 ^g |
| | 20 | 67.00 ^d | 91.67 ^c | 54.50 ^d | 4.67 ^d |
| | 30 | 73.00 ^a | 91.05 ^c | 59.00 ^b | 6.20 ^c |
| 199 | 0 | 57.33 ^g | 91.67 ^c | 48.17 ^{gh} | 4.20 ^e |
| | 10 | 64.67 ^e | 90.67 ^c | 55.90 ^{cd} | 4.85 ^d |
| | 20 | 71.00 ^c | 97.00 ^a | 57.50 ^{bc} | 6.54 ^b |
| | 30 | 72.67 ^{ab} | 97.67 ^a | 63.73 ^a | 7.55 ^a |
| LSD (5%) | | 1.10 | 1.20 | 2.92 | 0.29 |
| CV (%) | | 1.02 | 1.60 | 3.30 | 3.74 |

Means in the column followed by the same letter(s) are not significantly different at 5% level of significance. LSD (0.05) = Least significant difference at 5% level and CV (%) = coefficient of variation in percent.

Marketable tuber yield (MTY): Marketable tuber yield was highly significantly (P=0.007) influenced by the application of blended NPSZnB fertilizer, cattle manure (CM) and their interaction. The highest marketable tuber yield (31.7 t ha⁻¹) was obtained from the combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure. While, the lowest yield (9.81 t ha⁻¹) was recorded from the control treatment. The combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure increased marketable tuber yield by 62.8% over 199 kg ha⁻¹ blended NPSZnB fertilizer alone, 119.4% over 30 t ha⁻¹ cattle manure alone and 223.1% over the control. Increasing rate of blended NPSZnB fertilizer and cattle manure alone also positively influenced marketable tuber weight.

The possible reason for the highest marketable tuber yield observed from the combined application of inorganic and organic fertilizer was related with the increased nutrients in the soil that resulted in better vegetative growth which in turn enabled the crop to produce greater photosynthate. Increase in marketable tuber yield with increasing rates of blended NPSZnB fertilizers was due to the positive effect of both nitrogen and phosphorus on marketable tuber weight (Israel *et al.*, 2012). This could be attributable to the fact that in such conditions, vegetative growth of the aerial parts can be enhanced and translocation of photosynthetic matters in to the storage parts increased (Alemayehu *et al.*, 2015). The current finding is in line with investigations of Alemayehu *et al.* (2015) and Yourtchi *et al.* (2013) who reported that nitrogen fertilization significantly influenced marketable tuber yield. Zelalem *et al.* (2009) and Israel *et al.* (2012) also reported that N and P fertilization significantly influenced productivity of potato measured in terms of marketable and total tuber yields.

Total tuber yield (TTY): Total tuber yield was highly significantly (P=0.001) influenced by the application of blended NPSZnB fertilizer and cattle manure (CM) independently, and significantly (P=0.04) affected by the interaction of these two sources. The highest total tuber yield (34.1 t ha⁻¹) was obtained from the combined application of 199 k gha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure, however, this result was statistically similar with the combined application of 199 kg

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ha⁻¹ blended NPSZnB fertilizer and 20 t ha⁻¹ cattle manure. On the other hand, the lowest total tuber yield (12.29 t ha⁻¹) was recorded from the control treatment.

Combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure increased total tuber yield by 44.31% over 199 kg ha⁻¹ blended NPSZnB fertilizer alone, 84.32% over 30 t ha⁻¹ cattle manure alone and 177.46% over the control. Increasing rate of blended NPSZnB fertilizer and cattle manure alone also positively influenced total tuber yield. The possible reasons for the highest total tuber yield observed from the combined application of blended NPSZnB fertilizer and cattle manure was related with increased nutrients in the soil and modification of soil environment that resulted in better vegetative growth which in turn enabled the crops to produce greater photosynthate of the crop. Increasing in total tuber yield with increasing rates of blended NPSZnB fertilizer was due to the positive effect of both nitrogen and phosphorus on total tuber weight (Israel *et al.*, 2012). This is probably attributed to the improvement in conditions that enhanced vegetative growth of the aerial parts and, hence, translocation of photosynthate into the storage parts (Alemayehu *et al.*, 2015). Similarly, total tuber yield and marketable tuber yield increased significantly as the rate of sulfur increased, probably due to sulfur's role in the synthesis of sulfur containing amino acids, proteins, energy transformation, activation of enzymes which in turn enhances carbohydrate metabolism and photosynthetic activity of plant with increased chlorophyll synthesis (Juszczuk and Ostaszewska, 2011). Zinc exerts a great influence on basic plant life processes, such as: nitrogen metabolism and uptake of nitrogen and protein quality; photosynthesis and chlorophyll synthesis (Potarzycki, 2009) which resulted in high marketable and total tuber yield. Boron application showed significant increase in yield in this study probably due to its role in regulation of carbohydrate metabolism and its transport within the plant besides the synthesis of amino acids and proteins (Debnath and Ghosh, 2011). This result is in agreement with the findings of Alemayehu *et al.* (2015) and Yourtchi *et al.* (2013) who reported that application of nitrogen significantly increases both total and marketable tuber yield. Firew (2014) and Israel *et al.* (2012) also reported that total tuber yield was highly significantly influenced by nitrogen and phosphorus.

Table2. Marketable tuber yield (MTY) and total tuber yield (TTY) as influenced by application of blended NPSZnB fertilizer, cattle manure and interaction during the 2017 growing season at Chewusa, Banja district.

| Factors | | | |
|----------|---------------|--------------------------|--------------------------|
| NPSZnB | Cattle Manure | MTY(t ha ⁻¹) | TTY(t ha ⁻¹) |
| 0 | 0 | 9.81 ⁱ | 12.29 ^k |
| | 10 | 13.79 ^b | 17.66 ^j |
| | 20 | 13.89 ^b | 18.04 ^j |
| | 30 | 14.45 ^b | 18.50 ^{ij} |
| 65.7 | 0 | 13.61 ^h | 17.29 ^j |
| | 10 | 15.14 ^{gh} | 21.73 ^{gh} |
| | 20 | 17.77 ^{gf} | 21.72 ^{gh} |
| | 30 | 18.61 ^f | 23.00 ^{gh} |
| 133 | 0 | 18.17 ^f | 21.00 ^{hi} |
| | 10 | 21.63 ^{de} | 26.70 ^{de} |
| | 20 | 22.35 ^d | 26.23 ^{ef} |
| | 30 | 25.97 ^{bc} | 29.07 ^{cd} |
| 199 | 0 | 19.47 ^{ef} | 23.63 ^{fg} |
| | 10 | 24.05 ^{cd} | 29.83 ^{bc} |
| | 20 | 27.85 ^b | 31.82 ^{ab} |
| | 30 | 31.70 ^a | 34.10 ^a |
| LSD (5%) | | 2.78 | 2.62 |
| CV (%) | | 8.31 | 6.45 |

Tuber dry matter content (%): Tuber dry matter content was highly significantly (P=0.001) affected by blended NPSZnB fertilizer, cattle manure and interaction of these two nutrient sources. The highest tuber dry matter content (24.37%) was obtained from the control treatment. On the other hand, the lowest tuber dry matter content (17.13%) was recorded from the combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure.

The tuber dry matter content of the control treatment was 42.27% greater than the combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure. Application of 199

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kg ha⁻¹ blended NPSZnB fertilizer alone, reduced tuber dry matter content from 24.37% to 22.07% and application of 30 t ha⁻¹ cattle manure alone, reduced tuber dry matter content from 24.37% to 19.33%. The possible reason for the highest tuber dry matter content observed from the control treatment and the difference for each treatment may be associated with high nitrogen and micro nutrients application that may have resulted in low partitioning of assimilate to tubers and phosphorus that have inverse relation with tuber dry matter content. This result is in line with the results of Zelalem *et al.*, (2009) and Israel *et al.* (2012) who reported that high nitrogen level and phosphorus reduces the dry matter content of potato tubers.

Tuber starch content (%): Tuber starch content per 100g was significantly (P=0.03) influenced by blended NPSZnB fertilizer application, cattle manure application and their interaction. The highest tuber starch content (15.7 g/100g) was obtained from the control treatment. On the other hand, the lowest tuber starch content (8.4 g/100g) was obtained from the combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure.

The starch content recorded from the control treatment was 86.90% greater than that obtained from the combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure. The possible reason may be the fact that nitrogen application might have resulted in low partitioning of assimilate to tubers and availability of sulfur, zinc and boron facilitates uptake and use efficiency of plants to nitrogen. In addition, cattle manure increases availability of nitrogen and phosphorus by favoring soil physicochemical property and releasing nitrogen, phosphorus and other nutrients (S, Zn, B etc). This result is in line with the results of Mousavi *et al.* (2007) and Verma *et al.* (2005) who reported that high nitrogen and organic matter level decreases starch content of potato tuber.

Table3. Tuber dry matter content (TDMC) and tuber starch content (TSC) as influenced by application of blended NPSZnB fertilizer, cattle manure and interaction during the 2017 growing season at Chewusa, Banja district.

| Factors | | | |
|----------|---------------|---------------------|----------------------|
| NPSZnB | Cattle Manure | TDMC (%) | TSC (%) |
| 0 | 0 | 24.37 ^a | 15.70 ^a |
| | 10 | 22.37 ^c | 15.34 ^a |
| | 20 | 20.73 ^d | 13.27 ^{abc} |
| | 30 | 19.33 ^e | 9.45 ^{bcd} |
| 65.7 | 0 | 23.27 ^b | 13.81 ^{ab} |
| | 10 | 22.07 ^c | 13.54 ^{abc} |
| | 20 | 21.00 ^d | 13.73 ^{abc} |
| | 30 | 18.93 ^e | 9.29 ^{cd} |
| 133 | 0 | 22.56 ^{bc} | 9.79 ^{bcd} |
| | 10 | 20.67 ^d | 11.38 ^{abc} |
| | 20 | 20.60 ^d | 10.78 ^{bcd} |
| | 30 | 18.17 ^f | 9.68 ^{bcd} |
| 199 | 0 | 22.07 ^c | 12.93 ^{abc} |
| | 10 | 20.63 ^d | 10.81 ^{bcd} |
| | 20 | 20.47 ^d | 10.04 ^{bcd} |
| | 30 | 17.13 ^g | 8.40 ^d |
| LSD (5%) | | 0.7 | 4.52 |
| CV (%) | | 1.9 | 21.45 |

Means in the column followed by the same letter(s) are not significantly different at 5% level of significance. LSD (0.05) = Least significant difference at 5% level and CV (%) = coefficient of variation in percent.

Specific gravity (g/cm³): The specific gravity of tubers was significantly (P=0.012) affected by blended NPSZnB fertilizer and highly significantly (P=0.002) affected by cattle manure. However, there was no significant (P=0.16) effect from the interaction of blended NPSZnB fertilizer and cattle manure application. The maximum tuber specific gravity (1.089) was obtained from control treatment which is statistically not different from application of 65.7 kg ha⁻¹ blended NPSZnB fertilizer, 133 kg ha⁻¹ blended NPSZnB fertilizer, 10 t ha⁻¹ cattle manure and 20 t ha⁻¹ cattle manure. On other hand the,

lowest value was recorded from application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure. This might be due to the fact that nitrogen decreases the solid constituent of tuber and increases the water content of tubers and this result agrees with Kandil *et al.* (2011) who found the highest specific gravity (1.064) from treatment combination of 60% mineral nitrogen (238 kg N ha⁻¹) and 40% organic cattle manure (158 kg N ha⁻¹).

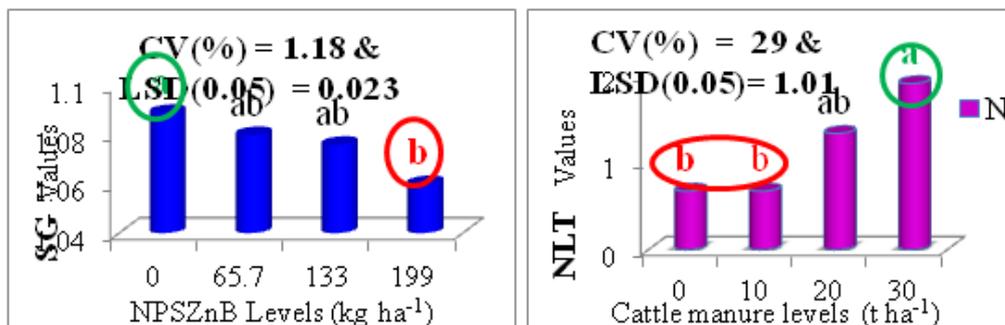


Figure 1. Main effects of blended NPSZnB fertilizer and cattle manure on specific gravity (SG)

4. SUMMARY AND CONCLUSION

Potato (*Solanum tuberosum* L.) is one of the most popular and widely cultivated vegetable crops in Ethiopia. It grows in short period, staple food and income source for small holder farmers. A study was conducted to investigate the effects of combined application of blended NPSZnB fertilizer and cattle manure rates on growth, yield and quality of potato at Banja district of Awi zone, Northwestern Ethiopia. The experiment was set as a 4 x 4 factorial with four levels of blended NPSZnB fertilizer (0, 65.7, 133 and 199 kg ha⁻¹) and four levels of cattle manure (0, 10, 20 and 30 t ha⁻¹) with three replications. Data on growth, yield and quality variables were collected and analyzed using SAS Version 9.3. The result indicated that application of blended NPSZnB fertilizer in combination with cattle manure was found to be important for the growth, yield and quality of potato in the study area. Application of blended NPSZnB fertilizer and cattle manure resulted in better performances for some growth, yield and quality variables.

The results indicated that a combined application of blended NPSZnB fertilizer and cattle manure showed significant increase in days to flowering, days to maturity, plant height, leaf area index, marketable tuber yield and total tuber yield, while application of combined blended NPSZnB fertilizer and cattle manure resulted in significant reduction in tuber dry matter content and tuber starch content. The combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure resulted in longest days to maturity (97.67 days), longest plant height (63.73 cm), largest leaf area index (7.55), maximum marketable tuber yield (31.7 t ha⁻¹) and maximum total tuber yield (34.1 t ha⁻¹).

Increasing application rates of blended NPSZnB fertilizer alone from zero to 199 kg ha⁻¹ resulted in significant increase in days to flowering, days to maturity, plant height, leaf area index, marketable tuber number, marketable tuber yield and total tuber yield. Increasing the application rates of cattle manure fertilizer alone from zero to 30 t ha⁻¹ resulted in significant increase in days to flowering, days to maturity, plant height, leaf area index, marketable tuber yield and total tuber yield, but number of main stem and unmarketable tuber yield were not affected by blended NPSZnB fertilizer, cattle manure application and interaction. More importantly, total tuber yield was highly significantly and positively correlated with plant height, leaf area index and marketable tuber yield. Generally the strong positive correlation was observed among most growth and yield variables of potato.

According to the current investigation, combined application of 199 kg ha⁻¹ blended NPSZnB fertilizer and 30 t ha⁻¹ cattle manure fertilizer gave best result in terms of growth and yield variables of potato. Additionally, the integrated approach has a long term benefit in that it also improves the physicochemical properties of the soil for sustainable crop production.

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