International Journal of Soil Science and Agronomy ISSN 1725-3497 Vol. 7(1),pp. 206-213, May, 2020.
Available online at www.advancedscholarsjournals.org © Advanced Scholars Journals

Full length Research paper

Effect of Blended NPSZnB Fertilizer and Cattle Manure Effect on Potato (*Solanum Tuberosum L.*) Growth Performance and Quality in Awi Zone, North Western Ethiopia

Bewket Getachew Bekele

Ethiopian Institute of Agricultural Research (EIAR), Pawe Agricultural Research Center, P.O. Box-25
Author: e-mail: bewgeta@gmail.com

Accepted 26 May 2020.

ABSTRACT

Potato (Solanum tuberosum L.) is one of theimportant crops in the Northwestern parts of Ethiopia, and particularly in Awi zone and it grows three times per annum. Potato production in Awi zone focuses more on productivity, which results unbalance diet for people who use potato as their day today food source. However, its growth performance and tuber quality are poor due to absence of integrated use of organic and inorganic fertilizers rather use of only phosphorus and nitrogen source fertilizers for area worth mention.So, aim of this study involves on determining better fertilizer combination for highest growth performance and best quality of potato.Theexperiment was conducted at Banja district, Awi Zone during rainy season of 2017. Four different levels of CM (0, 10 t ha^{-1}, 20 t ha^{-1} and 30 t ha^{-1}) and four different levels of blended NPSZnB fertilizer (0, 65.7 kgha^{-1}, 133 kgha^{-1} and 199 kgha^{-1}) were factorially combined and tested for the effect on growth performance and quality of tuber in a randomized complete block design (RCBD).Results of analysis of variance revealed that the highest numberof days to 50% flowering, days to 75% maturity, plant height and leaf area index were recorded from combined application of 199 kgha^{-1} blended NPSZnB fertilizer and 30 tha^{-1} cattle manure buthighest value of tuber dry matter content and tuber starch content were scored from control.Specific gravity and number of large tubers were significantly affected by application of blended NPSZnB fertilizer and cattle manure alone. Production of potato without fertilizer application is better for quality potato production, but application of 199 kgha^{-1} blended NPSZnBfertilizer level with 30 tha^{-1}cattle manure should be used for better growth performance potato production.

Key words: Blended fertilizer, Cattle manure, Growth performance, Potato, Tuber quality

INTRODUCTION

Potato is a dicotyledonous, herbaceous perennial plant, that is treated as annual, since the edible portion of the plant is uprooted and used each year(Decoteou, 2005). The chromosome number of wild potatoes is 2n = 24, while the cultivated has 2n = 48and it is the most important vegetable crop, constituting the fourth most important food crop in the world following wheat, maize, and rice and popular among root and tuber crops(Douches, 2013). It has been cultivated in many parts of Ethiopia for over 150 years, sinceEthiopia is endowed with suitable climatic and edaphic conditions for potato production (MOA, 2015). It is grown at different times of the year, main rainy season (June to October), small rainy season (February/March to May) and irrigation (December/January to April). Over these periods' potato has shown a sharp increase in both area coverage and volume of production but improvement of thequality is not such considered though it is important and too essential for health of humans. 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 and use of balanced fertilizers in deficient soils can improve fertilizer-use efficiency and crop profitability. Potatoes demand high levels of soil nutrients due to a relatively poorly developed, coarse and shallow root system (Dechassa *et al*. 2003).

Besides, the crop produces much dry matter in a shorter cycle that results in the removal of large amounts of nutrients per unit time, which generally most of the soils are not able to supply (Islam *et al*.2013). Review of earlier research works done and recommendations made in the area by Adet Agricultural Research Center found to be old in one hand and considered only N and P nutrients sources alonein other hand (Banja District Agriculture Office, 2017).

Moreover, it did not consider readily available organic sources that are economical and could improve the efficiency of inorganic sources of fertilizer (Banja District Agriculture Office 2017).

On study area more researches weredone on productivity of potato and there are no enoughresearches on quality of potato though it is important for human balance dieted food supply and criteria for factories to be used for production of chips and other products. Therefore, the present study is initiated to assess the influence of integrated use of cattle manure and blended (NPSZnB) fertilizer on growth performance and quality of potato under most areas of Banja district, Awi zone.

MATERIALS AND METHODS

Experimental site description

The experiment was conducted at Banja district of Awi Zone, Chewusa kebele in 2017 under rain fed condition. The site is geographically located at 454 km Northwest of Addis Ababa at an elevation of 2560 meters above sea level and situated at latitude 10^0 57'N and longitude 36^0 56' E. The experimental site receives 1700mm average annual rainfall, temperature range between 5 ^oC and 25 ^oC, and nitisol soil type (Agegnehu *et al.* 2014).

Treatments and Experimental Design

Sixteen treatments were obtained by a factorial combination of fourblended NPSZnB fertilizer levels(0, 65.7 tha^{-1}, 133 tha^{-1} and 199 tha^{-1}) and fourcattle manure levels (0, 10 tha^{-1}, 20 tha^{-1} and 30 tha^{-1}). These treatments were laid out in randomized complete block design (RCBD) with three replications.

Experimental Procedures

The land was prepared in accordance with the standard practice used by farmers by plowing at a depth of 15 to 20 cm. Plots were leveled and ridges prepared using hand tools to provide a medium fine soil for the crop growth.

Each plot hasfive rows that are spaced 75 cm apart and planted with tubers that are placed in a row at 30cm to each other(EIAR, 2004). The space between plots within a block was 1m while that between blocks was 1.5m. Then mediumsizedandwellsprouted seed

tubers were planted by manually placing 30 cm apart (Mohammad *et al*.2013) in prepared ridges during the main cropping season after the rain commenced and the soil becomes moist enough to support emergence. The Cattle manure which was used as an organic nutrient source was applied two weeks before sowing and incorporated into the soil at a depth 15cm. The blended NPSZnB fertilizer used as inorganic mineral nutrient source was applied at sowing time depending on the treatment. The experiment was done under rain-fed condition and agronomic practices were kept uniform for all treatments as recommended and adopted for the location.

Data Collected

Data on days to 50% flowering(from planting date when half of plant bloom), days to 75% maturity(from planting date when 75% of plants haulm senescence), plant height(from ten randomly selected plants at full flowering stage), leaf area index, tuber dry matter content, tuber starch content, specific gravity, number of large tubers, number of medium tubersand number of small tuberswere recorded.

Statistical Analysis

All data were subjected to analysis of variance using SAS program version 9.4 (SAS Institute Inc. 2012)and effect of blended fertilizer and cattle manure on each parameter of potato has been checked. The difference between treatments means were compared using Least Significant Difference (LSD) at 5% level of significance.

RESULTS AND DISCUSSION

Growth Variables of Potato

Days to 50% Flowering (DF): The number of days required for 50% flowering was highlysignificantly (P=0.001) influenced by blended NPSZnB fertilizer application, cattlemanure (CM) application and their interaction. The maximum period required to reach days to 50% flowering (73 days) was recorded from combined application of 199 $kgha^{-1}$ blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure which was statistically similar with application of 133kg 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 application of 65.7 kg ha^{-1} NPSZnB blended fertilizer, 133 kg ha^{-1} blended NPSZnB fertilizer and 199 kg ha^{-1} blended NPSZnB fertilizer.The significant difference among the treatments might be attributed to the characteristics ofnitrogen 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. Increasing nitrogen and phosphorus fertilization levels significantly delayed days required to flowering in potato (Alemayehu *et al.,* 2015 and Biruk, 2015).

Days to maturity (DM)

The number of days required for 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 and application of 199 kg ha^{-1}blended NPSZnB fertilizer and 20 t ha^{-1} cattle manure. 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 (Table 1).

It was 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 which fertilized withmore 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, decrease leaching of nutrients and it releases 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). Increasing nitrogen and phosphorus fertilization levels significantly delayed days required to flowering and maturity in potato (Alemayehu *et al.*2015 and Biruk, 2015).

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 smallest plant height (36.5 cm) was observed in the control treatment (Table 1). The significant increase in plant height observed by plants treated with combined use of highest blended NPSZnB fertilizer and cattle manure could be due to the fact that nitrogen isone of the major yield creating nutrient 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). Plant height increased very significantly with increasing amount of nitrogen fertilizer in potato (Alemayehu *et al.*2015 and Biruk, 2015).It also 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 (Gezahegn, 2011).

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 $kgha^{-1}$ 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 (Table 1). 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 ability of plants to uptake nutrients. Sulfur, zinc

Tuber Quality Variables

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 nutrients sources.

Table 1: Effect of blended NPSZnB fertilizer and cattle manure fertilizer

Factors		Variables			
	Cattle Manure				
NPSZnB		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^{fgh}	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	72.67^{ab}	91.05^{c}	59.00^{b}	6.20^{c}
199	0	57.33^{g}	91.67^{c}	48.17^{fgh}	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	73.00^{a}	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. DF = days to flowering, DM = days to maturity, PH = plant height, LAI = leaf area index, LSD (0.05) = Least significant difference at 5% level and CV (%) = coefficient of variation in percent.

The highest tuber dry matter content (24.37%) was obtained from the control treatment. On 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 (Table 2).

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 that high nitrogen level and phosphorus reduces the dry matter content of potato tubers (Zelalem *et al.*2009 and Israel *et al.*2012).

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 (Table 2).

On 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 possible reason may be the fact that nitrogen application results 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 physico chemical property and releasing nitrogen, phosphorus and other nutrients (S, Zn, B etc).

This result is in line with the results that high nitrogen

Table 2: Effect of blended NPSZnB fertilizer and cattle manure fertilizer application on tuber dry matter content (TDMC) and tuber starch content (TSC) 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.

and organic matter level decreases starch content of potato tuber (Verma *et al*.2005 and Mousavi *et al*.2007).

Specific gravity (g/cm^{3})

The specific gravity of tubers was significantly ($P<0.05$) affected by blended NPSZnB fertilizer and highly significantly ($P<0.01$) affected bycattle manure. However, there was no significant ($P>0.05$)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 not statistically 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 at application of 199 kg ha^{-1} blended NPSZnB fertilizer and 30 t ha^{-1} cattle manure (Table 3).This might be due to the fact that nitrogen decreases the solid constituent like Protein, Carbohydrate and Fiber of tuber and increases the water content of tubers (Kandil *et al*. 2011) and this result agrees with that 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}) (Kandi l*et al*. 2011).

Number of large tubers

The main factors blended NPSZnB fertilizer(P=0.001) and cattle manure application(P=0.016) affected number of larger tuber size grades. However, the interaction of blended NPSZnB fertilizerand cattle manure did not influence the number of larger tuber sizegrades. The highest number of large-sized tubers was recorded (2.43/hill) from application of 199 kg ha^{-1} blended NPSZnB fertilizeralone while the lowestnumber (0.67/hill) was obtained from the control treatment.

Table 3. Effect of blended NPSZnB fertilizer and cattle manure fertilizer application on specific gravity (SG)during the 2017 growing season at chewusa, Banja district.

Factors	
NPSZnB	**SG(g/cm^3)**
0	1.089^{a}
65.7	1.080^{ab}
133	1.076^{ab}
199	1.060^{b}
Cattle Manure	
0	1.089^{a}
10	1.088^{a}
20	1.077^{ab}
30	1.058^{b}
LSD (5%)	0.023
CV (%)	1.18

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.

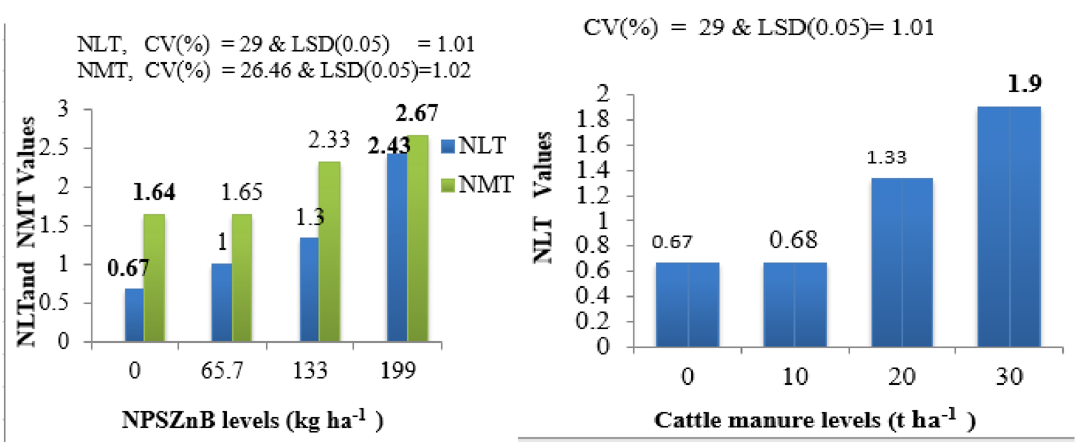

Figure 1a Figure 1b

Figure 1. Effect of NPSZnB fertilizer and cattle manure application on number of large tuber size (NLT) and medium tuber size (NMT),

When blended NPSZnB fertilizer application increased, number of large tuber size was also increased. This might be relative competition reduction between plants for nutrients and growth factors. This result agrees with the results that the production of large tubers increased due to less competition for nutrients and moisture. Plants grown at 30 t ha^{-1} cattle manure application produced highest number of large tuber sizes, which was statistically not different from that recorded at the application of 20 t ha^{-1} cattle manure. This result might be due to nutrient and moisture availability difference since as nutrient availability increases number of large tuber size also increases (Tafi*et al.*2010).

Number of medium tubers

The analysis of variance showed that the effect of main factor blended NPSZnB fertilizer treatment was highly significantly (P>0.01 influenced number of medium tuber size, but the effects of cattle manure and interaction of these two nutrient sources did not influence this variable.
The highest numbers of medium sized tubers were recorded (2.67/hill) from the application of 199 kg ha^{-1} blended NPSZnB fertilizer whereas the lowest numbers of tubers (1.64/hill) were obtained from the control treatment. Application of 199 kg ha^{-1} blended NPSZnB fertilizerproduced highest number of medium tuber sizes which was statistically not different from that recorded at 133 kg ha^{-1} blended NPSZnB fertilizer application (Figure. 1b). When blended NPSZnB fertilizer application increased numbers of medium tuber size also increased. This might be due to the presence of relatively better nutrient supply which results in production of large and medium tuber production. This result agrees with the results reported that the production of medium tubers increased due to relatively less competition for nutrients and moisture (Tafi*et al.*2010).

CONCLUSION

ANOVA of the study indicated that significant incremental effect of blendedNPSZnBfertilizer and cattle manure application on days to 50% flowering, days to 75% maturity, plant height and leaf area index, but decrease mental effect on tuber dry matter content and tuber starch content.The interaction of 199 $kgha^{-1}$ NPSZnBfertilizer level combined with 30 tha^{-1}cattle manure gave maximum days to 50% flowering (73 days), maximum days to 75% maturity (97.67 days), maximum plant height (63.73 cm)and maximum leaf area index (7.55/hill).
According to this study, combined application of 199 $kgha^{-1}$ blendedNPSZnBfertilizer level with 30 tha^{-1}cattle manure can be used for large tuber production and production without fertilizer for high tuber dry matter content and starch content. Generally, this study indicates NPSZnB fertilizer applied with cattle manure results dry matter content and starch content reduction, but increment of tuber size and growth performance variables.

REFERENCES

Agegnehu S, Getachew A, Yigzaw D, Enyew A, Yoseph T, Yeshitla M (2014). Exploratory Survey on Climate Change Effects, Value Chain Processes and Supportive Services: Case Study from Potato Based Farming System of Awi-Zone, Ethiopia. International Journal of Agriculture Innovations and Research Volume 2, Issue 4, ISSN (Online) 2319-1473.

Alemayehu TG, Nigussie D, Tamado T (2015). Response of potato (Solanum tuberosum L.) yield and yield components to nitrogen fertilizer and planting density at Haramaya, Eastern Ethiopia. Journal of Plant Sciences, **3(6),** pp.320-328.

Biruk M (2015). Response of Potato (Solanum tuberosum L.) to Fertilizer Application and Post-Harvest Tuber Treatment with Plant Essential Oil Extracts in North-Eastern Ethiopia. Ph.D. Dissertation. School of Graduate Studies Haramaya University, Haramaya, Ethiopia.

Dechassa N, Schenk MK, Steingrobe N (2003). Phosphorus efficiency of cabbage (Brassica oleraceaeL. var. capitata), carrot (Daucus carotaL.), and potato (SolanumtuberosumL). Plant and Soil, 250: 215-224.

Decoteau RD (2005). Principles of plant science. Educational factors and technology in growiing plants. Pearson education.inc. New Jersey. P. 412.

Douches DS (2013). Breeding and genetics for the improvement of potato (solanum tuberosum L.) for yield, quality and pest resistance. http://potatobg.msu.edu/program
mover view. shtml.

EIAR (Ethiopian Institute of Agricultural Research), (2004). Ethiopian Institute of Agricultural Research directory of released crop varieties and their recommended cultural practices, Addis Ababa, Ethiopia.

Firew GW (2014). Response of potato (solanum tuberosum l.) to nitrogen and phosphorus application under irrigation in Dire Dawa, eastern Ethiopia. A thesis submitted to the School of Graduate Studies, School of Plant Sciences, Haramaya University, Ethiopia.

Garo G, Gedebo A, Kena K (2014). Combined effects of inorganic (NP) and farm yard manure (FYM) fertilizers on root yield and above ground biomass of sweet potato (Ipomoea batatas(l.) lam.) at Delbo watershed Wolaita zone, Southern Ethiopia. Journal of Scientific Research and Reviews, **3(2):** 028-033.

Gezahegn W (2011). Response of Potato (solanum tuberosum l.) to Application of Nitrogen, Phosphorus, and Farmyard Manure at Debark, Northwestern Ethiopia. M.Sc. Thesis, Haramaya University, Ethiopia.

Islam MdM, Akhter S, Majid NM, Ferdous J, Alma MS (2013). Integrated nutrient management for potato (Solanum tuberosum) in grey terrace soil (Aric Albaquipt). Australian Journal of Crop Science, **7(9):** 1235-1241.

Israel Z, Ali M, Solomon T (2012). Effect of different rates of nitrogen and phosphorous on yield and yield components of potato (Solanum tuberosum L.)

Kandil AA, Attia AN, Badawi MA, Sharief AE, Abido WAE (2011). Influence of water stress and organic and inorganic fertilization on quality, storability and chemical analysis of potato (Solanum tuberosum L). Journal of Applied Sciences Research, **7(3):** 187-199.

Mohammad A, Mohammad N, Safarzadeh V, Peyman S, Ali S (2013). Effect of plant density, date and depth of cultivation on yield and yield components of potato planting in the chabahar. International journal of agronomy and plant production. vol., **4 (8),** 1890-1897.

Mousavi SR, Galavi M, Ahmadvand (2007). Effect of zinc and manganese foliar application on yield, quality and enrichment on potato (Solanum tuberosum L.). Asian Journal of Plant Sciences, 6: 1256-1260.

Mulubrhan H (2004). The Effect of N, P, K Fertilization on Yield and Yield Components of Potato (Solanum tuberosum L.) Grown on Vertisols of Mekelle Area, Ethiopia. M.Sc. Thesis, the University of Haremaya, p.15.

Potarzycki J, Grzebisz W (2009). Effect of zinc foliar application on grain yield of maize and its yielding components. Plant Soil Environ, **55(12)**: 519-527.

Rao S, Singh KK, Ali M (2001). Sulphur: A key nutrient for higher pulse production. Fert. News 46:31-48.

SAS (Statistical Analysis Software), institute INC., (2012). SAS/STAT, statically software, version 9.3, Cary N.C., SAS, North Carolina.pp.25-22.

Tafi M, Siyadat SA, Radjabi R, Majadam M (2010). The effect of earthing up on the potato yield in Dezful (Khouzestan,Iran) weather condition. Middle East journal of scientificresearch, **5(5)**: 392-393.

Tegbaru B (2015). Soil Fertility Mapping and Fertilizer Recommendation in Ethiopia: Update of Ethio SIS project and status of fertilizer blending plants

Verma A, Nepalia V, Kanthaliya PC (2005). Effect of continuous cropping and fertilization on crop yields and nutrient status of a Typic Haplustept. Journal of the Indian Society of Soil Science, 53: 365-368.

Zelalem A, Tekalign T, Nigussie D (2009). Response of potato (Solanum tuberosum L.) to different rates of nitrogen and phosphorus fertilization on vertisols at Debre Berhan, in the central highlands of Ethiopia. African Journal of Plant Science, **3(2)**:016-024.