Blended Fertilizer effect on Quality of Orange fleshed sweet potato (*Ipomoea batatas* (L.) Lam) Varieties

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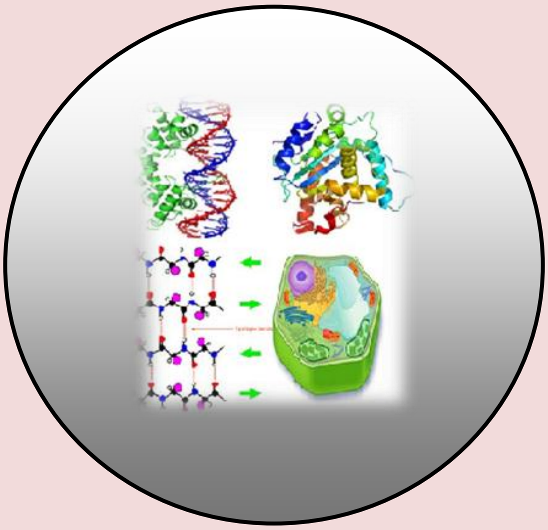

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RESEARCH PAPER

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Blended Fertilizer effect on Quality of Orange fleshed sweet potato (*Ipomoea batatas* (L.) Lam) Varieties

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ABSTRACT

Orange fleshed sweet potato (OFSP) is the cheapest source of β-carotene which is a precursor of Vitamin A whose deficiency is a serious public health problem in Ethiopia. Its quality and yield is very low due to low soil fertility, lack of information on type and appropriate rate of fertilizers. Hence, a field experiment was conducted at Jimma Agricultural Research Center in 2017 cropping season to evaluate the effect of NPSB fertilizer rate kg ha^{-1} (0,100 ,159, 214 and 239) on quality of three orange fleshed sweet potato varieties (Kulfo, Tulla and Guntutie). The experiment was arranged in 3X5 factorial RCBD with three replications. Data on selected qualities were collected and subjected to various data analyses. Results revealed that, the interaction effect of varieties and NPSB rates were highly significant influenced storage root dry matter content, β-carotene, ash, crude fiber and flour moisture content (P <0.01); Specific gravity and Starch (P<0.05). Significantly highest difference of β-carotene contents was scored in the variety Guntutie, that received 100 kg ha^{-1} NPSB fertilizer (1.4298mg/100g fwb). But the highest yield of β-carotene in terms RAE or RDA retinol μg ha^{-1}(g ha^{-1}) was obtained in Guntutie with 159 kg ha^{-1} NPSB fertilizer (46.4 g ha^{-1} RAE) which was enough for 84.5 households (507 peoples) for 6 months. Tulla with 159 kg ha^{-1} resulted in significantly highest difference in storage root dry matter (35.4%) and Starch (28.21%). β- Carotene positively correlated to MY ton ha^{-1} (r=0.495). Storage root dry matter positively correlate with SRG(r=0.768), Starch (r=0.771). Overall, 159 kg ha^{-1} NPSB should be recommended with Guntutie for highest significant β-carotene and with Tulla for its highest significant starch content.

Key words: β-carotene, Dry matter, NPSB, RAE and Starch.

INTRODUCTION

Globally sweet potato is the 7th most important food crop after wheat, rice, maize, potato, barley and cassava (FAO, 2014). In Africa, sweet potato is the 2nd most important root crop after cassava (Ndole *et al.*, 2001; Dantata *et al.*, 2010). In Ethiopia, sweet potato is food security and economically important food crop. It is the 2nd most important root crop after ensete. The crop is mostly used for human consumption either alone or blended with other crops (Kidane *et al.*, 2013). It is mainly grown by small scale and resource poor farmers in the South Western, Eastern, western and Southern parts of the country. It is a major subsistence crop in the periods of drought (Fite *et al.*, 2008; CSA, 2016). Orange fleshed sweet potato (OFSP) varieties have high β-Carotene and can potentially reduce the effects of vitamin A deficiency. Currently they are at high demand in all developing nations including Ethiopia (Tofu *et al.*, 2007). Through campaign of vitamin A for Africa (VITAA); OFSP clones were introduced from CIP-Nairobi to Ethiopia for evaluation. Besides these, trials had been done on the sensitization of farmers about OFSP and their nutritional advantages.

Including these effort, for last 30 years, five OFSP (Kulfo, Tulla, Kero, Guntutie and Birtukane) were registered as pure orange fleshed variety which are very few (MoARD, 2009; Gurmu and Mekonnine, 2017).

Vitamin A deficiency (VAD) is a serious public health problem in Ethiopia (Demissie *et al*., 2010; Kurabachew, 2015). OFSP varieties are a solution combat the malnutrition problems mainly VAD; however, they have low dry matter content (Kidane *et al.,* 2013; Gurmu *et al*., 2015b). In Ethiopia, the average national yield of sweet potato is about 8 ton ha^{-1} (Tesfaye *et al.,* 2011) which is low compared to the world's average production of about 14.8 ton ha^{-1}(FAO, 2014). The major causes of the low yield and quality are: scarcity of information on the appropriate rates of fertilizers recommendations, low soil fertility, shortage of improved varieties having high nutritional value, pests and others (Kidane *et al.,* 2013). Fertilizer use in Ethiopia on sweet potato seems very limited. Out of 54,017 hectares, only 1073 hectares (1.986%) were treated with 239.1 tons of DAP and 156 tons of Urea fertilizer (CSA, 2016). Splitting of sweet potato tuberous root due to Boron (B) deficiency can reduce the quality of marketable storage tuber yields by 40–60% (O'Sullivan *et al.,* 1997; Swamy *et al.,* 2002). Inadequate sulfur supply will not only reduce yield and crop quality, but also, it will decrease N use efficiency and enhance the risk of N loss to the environment (Norton *et al.,* 2013).

The use of biofortified OFSP rich in β-carotenes are a proven cost effective strategy for providing vitamin A and cheep most accessible than other food items to vulnerable populations, particularly in young children, pregnant and lactating women (Kassaye *et al.,* 2001; Tofu *et al.,* 2007; Low *et al.,* 2009; Kaguongo *et al.,* 2012; Kurabachew, 2015). It is a good source of energy, a number of vitamin B, vitamin C, K and other micronutrients (Ji *et al*., 2015; Alam *et al*., 2016). They are qualified to solve malnutrition problem (Ndunguru *et al*., 2009; Emmanuel *et al*., 2010). Therefore, enhancing awareness on the importance of OFSP as a source of β-carotene is very essential with an increase of its dry matter through targeted agronomic practice.

Abdissa *et al. (*2011) reported that, sweet potato yields up to 64.4 ton ha^{-1} by using appropriate agronomic practices. Boron (B) prevents the splitting of sweet potato tubers and increases marketable tuber yield (Byju *et al.,* 2007). Adequate sulfur supply will increase yield, crop quality, N use efficiency and reduce the risk of N loss to the environment (Norton *et al.,* 2013). It stimulates the uptake of micronutrients (Cu, Mn, Zn, Fe, and Ni) due to rhizospheres acidification as S oxidation occurs (Norton *et al.,* 2013).

Currently, the ammonium fertilizer representatives, Sulfur and Boron containing blended fertilizers had been availed in Ethiopia. These are: NPS, NPSB and NPSBZn are being used all over Country and 100 kg ha^{-1} is recommended to improve yield and quality of crop (Ethio SIS, 2014; Bellete, 2016). Even though, a number of experiments had been conducted on variety evaluation of OFSP in different areas of Ethiopia mainly on yield improvement, less emphasis was given to quality aspect. A number of experiments were conducted to determine the response of sweet potato to NP, P, N, NPK and different organic fertilizer rates in different parts of the country. Yield responses vary from variety to variety and from place to place. Up to date, no research undertakings were reported on the effects of inorganic fertilizer on yield and quality of OFSP in Jimma area. To address the gaps, the present work was initiated with the following objectives:

Objectives

- To assess the effect of NPSB blended fertilizer and variety on quality of orange fleshed sweet potato.
- To assess interaction effect of NPSB blended fertilizer and variety on β-carotene and other qualities of orange fleshed sweet potato.

MATERIALS AND METHODS

Descriptions of the Study Site

The experiment was conducted at Jimma Agricultural Research Center located 366 km South West of Addis Ababa. It is geographically located at latitude 7° 46' N and longitude 36° 47'E having an altitude of 1750 m.a.s.l. The soil of the study area is Nitisol which is the dominant with a pH of 5.3 (Beyene, 2013). The area receives mean annual rainfall of 1737 mm with maximum and minimum temperature of 25.21°C and 12.21°C, respectively

Description of Experimental Materials

Experimental materials were three nationally released orange fleshed sweet potato varieties: Kulfo (LO-323), Tulla (CIP 420027) and Guntutie (AJAC-I), and five levels of NPSB blended fertilizer: 0, 100, 159, 214 and 239 kg ha^{-1}, comprising a total of 15 treatment combinations. The element content of 100 kg NPSB were: N=18.9 kg, P_2O_5=37.7 kg, S=6.95 kg and B=0.1 kg (Bellete, 2016) (Table 1). Fertilizer NPSB had been recommended in blanket recommendation for over 50%, for 11 districts of Jimma zone, including experimental site (Ethio SIS, 2014; CSA, 2016). Uniform application of 45 Kg N ha^{-1} (97.82 Kg ha^{-1} Urea) to each treatment was applied by subtracting the amount found in the treatments of NPSB rate tested (Table 1), which is the optimum recommendation for sweet potato based on various research recommendations.

Table 1. Rate of NPSB formulated and tested.

NPSB Treatment Rate		Element content				N added	UREA in kg	N Recommended
Treatments	NPSB ha^{-1}	N	P_2O_5 (P)	S	B			
Control	0	0	0(0)	0	0	0	0	0
$NPSB_1$	100	18.9	37.7(16.58)	6.95	0.1	26.1	56.73	45
$NPSB_2$	159	30.07	60(26.4)	11.06	0.159	14.93	32.45	45
$NPSB_3$	214	40.355	80.5 (35.4)	14.83	0.21	4.645	10.09	45
NPSB4	239	45.11	90(39.6)	16.59	0.238	0	0	45

Treatments and Experimental Design

The experiment was set as a 3x5 factorial arranged in randomized complete block design with three replications. Lay out was done considering the slope gradients. The land was divided in three equal blocks, each having 15 equal plots and received 15 treatment combinations. Distance between block was 1.10 m and 80cm between plots. The gross plot size for each treatment was 2.4m x 3.6m (8.64m^2). Each plot had six ridge 60cm apart. The height of ridge was 25 cm. The spacing between rows and plants was 60cm x 30cm, respectively and each plot received 48 plants. The 15 treatments were assigned to each plot by random using SAS. The treatment combinations were: Kulfo X 0, Kulfo X 100, Kulfo X 159, Kulfo X 214, Kulfo X 239, Tulla X 0, Tulla X 100, Tulla X 159, Tulla X 214, Tulla X 239, Guntutie X 0, Guntutie X 100, Guntutie X 159, Guntutie X 214 and Guntutie X 239 kg ha^{-1} NPSB.

Pre-planting Soil Sampling and Analysis

One composite soil sample was collected from selected area of 47.2m X 14.1m, at the depth of 0-20 cm from a diagonal of 49.26m in 2 ways at 10m interval with staring bench mark of 0.5m out of the selected area. A uniform volume of soil was obtained in each sample by vertical insertion of an auger. Then, the soil sample was analyzed for its chemicals property (pH, OC, N, P, and OM) (AOAC, 2005). The organic matter was calculated by multiplying the result of OC by 1.73 (OM = OC *1.73) (Page, 1982). The samples were air dried, ground using a pestle and a mortar and allowed to pass through a 2 mm sieve for organic carbon to pass through 0.2 mm sieve to remove the coarser materials. Soil laboratory analyses were made at Jimma Agricultural Research.

Procedures for Pre-planting Soil Chemical Analysis

Soil pH: was measured in a 1:2.5 (soil: water) ratio using a glass electrode pH meter by the method described by (McLean, 1982).

Organic Carbon: was determined by the modified Walkley and Black procedure as described by Olson and Sommers (1982).

Total Nitrogen: was determined by the Kjeldahl digestion and distillation procedure as described by van Reeuwijk (1992).

Available Phosphorus: The readily acid-soluble forms of P were extracted with HC1:NH4F mixture (Bray's No. II method) as described by Olsen and Sommers (1982).

Pre-planting Soil Chemical Properties Result

The pre planting soil sample was resulted in pH of 5.11 which fall in classes of strongly acidic according to Scianna *et al.* (2007), who classify soil acidity on the bases of crop tolerance and performance as ultra-acidic (pH< 3.5), extremely acidic (pH=3.5 - 4.4), very strongly acidic (pH=4.5 - 5.0), strongly acidic (pH=5.1-5.5), moderately acidic (pH=5.6 - 6.0), slightly acid (pH=6.1- 6.5),neutral(pH = 6.6-7.3), slightly alkaline (pH = 7.4-7.8), moderately alkaline (pH =7.9 - 8.4),strongly alkaline (pH = 8.5- 9.0), and very strongly alkaline (pH > 9.0). It had a total nitrogen of 0.117% which fall in low class level according to the rating by Landon(2014), who classified soils having total N of greater than 1.0% as very high, 0.5-1.0% high, 0.2- 0.5% medium, 0.1- 0.2% low and less than 0.1% as very low in total nitrogen content. Available phosphorus content was 3.923 ppm which was fall in low rate according to the rating by Karltun *et al.* (2013), who described soils with available P content of <15 ppm as very low. The organic carbon was 2.447% which was a medium level according to the Netherlands commissioned study by Ministry of Agriculture and Fisheries(1985) which classify soil with organic carbon contents (%) >3.50, 2.51-3.5, 1.26-2.50, 0.60-1.25 and <0.60 as very high, high, medium, low and very low respectively. Generally, analyzed soil result was fall in class of low soil fertility and fertilizer use was the right way.

Treatment Management

Vines of 30 cm long having 3 internodes were prepared from the top but not succulent one and lasted for 48 hours, before planting. Vines were planted on July 20, 2017 at 45^{O} slant on the prepared ridge and one third of them were covered by soil or inserted in ridge. Fertilizer NPSB was applied after 15 days of planting or after checking the success of survival vine and remaining nitrogen rate was applied after 21 days after planting (DAP) in ring placement in slight shallow made ring and covered by light fine soil. All agronomic practices were followed according to the recommendation (hoeing, earthling up, irrigation when necessary, weeding, Pest, and disease protection).

Data Collection Procedures

Ten plants were tagged from each plot from four interior rows excluding the border rows all yield and yield related data were collected from sample plants. Vegetative data were collected at start flowering and when it fully covered space 105 days after planting. All data collections were done in the morning. Data on quality were collected after the required amount of samples of storage roots were collected and prepared according to the laboratory recommendation from the tagged plant sample. The samples were freshly prepared for β-carotene; chopped and dried partially by sun and by oven dry method to 11% moisture content and grounded by machine for flour moisture, Ash, crude fiber and fat each 105 gram weighed, packed and sent to laboratory for analysis.

Data Collected

Tuber grade: Tubers were graded into marketable by measuring root diameter from the middle portion of the storage root using Digital Calipers. Storage roots with a diameter of less than 3 cm (30mm) were considered unmarketable, while those with root diameter of 3 cm(30mm) or more were considered as marketable roots (Yeng *et al*., 2012).

Marketable Storage Root Weight ton per hectare (MSRY t ha^{-1}): was measured by hanging digital balance in kg from ten plants per plot and converted to ton per hectare.

Unmarketable Storage Root Weight ton per hectare (UNMSRY t ha^{-1}): was measured by hanging digital balance in kg from ten plants per plot and converted to ton per hectare.

Total Storage Root Yield ton per hectare (TSRY t ha^{-1}): was measured from an average sum of marketable + unmarketable storage root weight per plant and converted to ton per hectare.

Storage Root Dry Matter (SRDM): samples from marketable categories of tubers were taken at random from each harvested plot, sliced, chopped, composited and prepared to 100gm fresh weight and dried in an oven dry forced air circulation at 70°C for 24-72 hours until they attained constant weight.

$$\text{SRDM\%} = \frac{\text{Dry weight of sample}}{\text{Fresh weight of Sample}} * 100 \quad \text{.....................} \textit{Equation (1)}$$

Specific Gravity (SG): Two kg of tubers from marketable category were randomly selected from each harvested plot, and used for the determination of specific gravity. They were washed and air-dried to remove soil particles and to obtain accurate values by weighing first in air and, then, in water, using an electronic weighing balance.

$$\text{Specific gravity (SG gcm}^{-3}\text{)} = \frac{\text{Weight of tubrs in air}}{\text{weight of tuber in air- weight under water}} \text{.....} \textit{Equation (2)}$$

Starch Content (SC): Determination of Starch was computed by using the equation of Simmond (1977) which based on specific gravity. It is an indirect way of obtaining dry matter and Starch content of sweet potato, which was cited by Namo and Babalola (2016). Therefore, Starch content was computed as a regression model:

$$\text{Starch content \%} = -2.86 + 47.1U \quad \text{..............................} \textit{Equation (3)}$$

$$U = \frac{5G - 5}{G} \quad \text{...} \textit{Equation (4)}$$

Where G = Specific gravity; U=weight under water

Crude fibre: Crude fibre was determined at Debre Zayt Agricultural Research Center (DZARC) using dilute acid and alkali hydrolysis using Fibertec (2010) by Weende method. Exactly 1.5 g of the sample was accurately taken into glass crucible, about 200 ml of boiled 1.25% H_2SO_4 was poured into the flask and the mixture boiled for 30 minutes under reflux condenser. The insoluble matter was washed with boiling 4 times until the residue was free from acid. About 200 ml of boiling 1.25% KOH solution was added into the residue and then heated for 30 minute under reflux condenser. The residue was filtered, washed with boiling water and then the crucible was transferred to the cold extraction unit and washed with acetone. After digestion, the residue was dried at 105°C in an air-convectional oven, cooled in a desiccator until constant weight was obtained. The residue was incinerated in an electric furnace at 525°C until all the carbonaceous matters were burnt. The crucible was left to cool down to below 250°C, then removed from the furnace and transferred to the desiccator, cooled to room temperature and weighed. The crude fibre was calculated and expressed as percentage (AOAC, 2005).

$$\text{Crude fiber (\%)} = \frac{\text{M1-M2}}{\text{W}} \quad \text{..............................} \textit{Equation (5)}$$

Where M1=mass of the crucible (the sand and wet residue); M2 = mass of the crucible (the sand and ash); W = sample weight dry matter basis.

Ash content: The ash content was determined by heating a sample in a muffle furnace (AOAC, 2005). Five grams of sample was weighed and transferred to a furnace at 550°C. It was stayed for minimum of five hours. The ash was weighed and expressed as percentage of the original sample weight on dry weight basis.

Ash (%) = $\frac{M3\text{-}M1}{M2\text{-}M1}$*100 …………………………….………………*Equation (6)*

Where M1 =Weight of the dish; M2 =Weight of fresh sample and dish; M3 =Weight of ash and dish.

Moisture Content (MC): The flour moisture contents of the experimental samples were determined according to AOAC (2005) method 925.09 at MARC. The empty dish with its lid was dried in the oven (Leicester, LE67 5FT, England) for 15 min and then transferred into desiccators for cooling before it was weighed to the nearest milligram. About 5g of the sample was transferred to the dish and then the dish was placed inside the oven (Leicester; LE675FT; England) at 103℃ in order to dry the samples to a constant weight, cooled in desiccators and re-weighed. Then, the moisture content was estimated by the following formula:

Moisture (%) = $\frac{M2\text{-}M1}{M2}$*100 ……………………….……………………..……….*Equation (7)*

Where M1 = mass of sample after drying; M2 = mass of sample before drying

β-carotene: Extraction of total β-carotene content was done at JUCAVM, by the method described by Sadler *et al.*(1990).Three fresh tubers were chosen from 45 plots, sliced, washed, dried, chopped and 3g were homogenized. Briefly, 1g of sample was mixed with 1 g $CaCl_2.2H_2O$ and 50 ml extraction solvent (50% hexane, 25% acetone, and 25% ethanol, containing 0.1% BHT) and gently shaken for 30 min. After adding 15 ml of distilled water, the solution was frequently shaken again for a further 15 min. The organic phase, containing the β-carotene was separated from the water phase, using a separation funnel, and filtered using what man filter paper No.1. The extraction procedure was carried out under subdued light to avoid degradation of carotenoids and the extracted samples were stored for analysis. Then, sample was estimated from absorbance read at 450nm using UV-visible spectrophotometer model "V-630 JU companies, Serial No A112761148.T80 China" and compared with β-carotene standard. Pure β-carotene standard (Sigma Aldrich) was used as a standard and the measurement was compared to a standard solution (Appendix Figure 1). To draw the calibration curve, β-carotene standard stock solution was prepared by accurately weight 0.01g β-carotene standard and dissolved in 20 ml solvent which was similar to extraction solvent used to extract samples (50 % hexane, 25 % acetone, and 25 % ethanol) and made the volume to 100 ml using the same solvent. From the stock solution 0, 2, 3, 4 and 5ml were added in to 100ml flask and diluted to give 0, 0.1, 0.2, 0.4, and 0.8 mg/L of β- carotene standard in the same solvent. Then, 0.5 ml of each sample was introduced into5 test tubes, covered with aluminum foil and the absorbance was read 450nm using (UV-Vis spectrophotometer, T80 China).

β- Carotene conversions

β-carotene conversion in the body is estimated to be 6-µg β-carotene = 1µg VA or 12-µg β-carotene =1-µg VA (Trumbo *et al.*, 2001; WHO and FAO, 2005). Trumbo *et al.* (2001); WHO and FAO (2005); van Jaarsveld *et al.* (2006) reported that, the contribution of one hectare of orange fleshed sweet potato to vitamin A requirements for a households of six family members(one adult male= 600 µg RAE/day; one adult female= 500 µg RAE/day; one 1–3 year old children = 400 µg RAE/day; one 4–6 year old children= 450 µg RAE/day; one 7–9 year old children=500 µg RAE/day and one 10–18 year old adolescent= 600 µg RAE/day. This total of 3050 µg RAE per day per house hold was calculated after assuming 20% loss of β-carotene during cooking which was based on the recommended dietary allowance (RDA). The vitamin A value was expressed in µg RAEs (retinol activity equivalents) based on conversion scale which is 12 µg β-carotene = 1 µg retinol = 1 µg VA=1 µg RAE. Based on this, β-carotene yield was calculated as kg or gram or µg β-carotene produced per unit area (ha) per duration.

Data Analysis

All data were subjected to analysis of variance (ANOVA) using the linear model (Lm) SAS statistical software package (SAS, Version 9.3). The total variability was detected using the following model:

$T_{ijk} = \mu + R_i + V_j + F_k + (VF)_{jk} + \varepsilon_{ijk}$ ………………… *Equation (8)*

Where = T_{ijk} is the total variation for a given yield component, µ is the overall mean, R_i is the i^{th} replication, V_j is the j^{th} variety treatment effect, F_k is k^{th} NPSB blended fertilizer level treatment effect, $(VF)_{jk}$ is the interaction between variety and NPSB blended fertilizer level, and ε_{ijk} is the variation due to random error.

The differences between the mean values were established with Least Significant Difference (LSD) at 1% and 5% of probability level using GLM. Correlations of the variables were tested by SAS statistical software package (SAS, Version 9.3). Besides, partial budget, marginal rate of return, and sensitivity analysis were adopted by using the manual developed by CIMMYT (1988).

RESULTS AND DISCUSSIONS

Marketable, Unmarketable and Total Fresh storage root yield ton per hectare

The interactions of varieties with NPSB fertilizer rates were resulted in significantly highest difference in mean of marketable, unmarketable and total fresh storage root yield ton per hectare ($p<0.01$) (Table 2). Mean of marketable fresh storage root yield ton per hectare was significantly highest different by variety Guntutie, that received 159 kg ha^{-1}, 214 kg ha^{-1} and 239 kg ha^{-1} NPSB fertilizer (63.33 ton ha^{-1}, 60.16 ton ha^{-1} and 63.44 ton ha^{-1}) respectively (Table 2). Following these, variety Kulfo and Tulla, that received 159 kg ha^{-1} NPSB fertilizer, scored 47.68 ton ha^{-1} and 47.21 ton ha^{-1} yield respectively, however, they did not significant difference from each other and from Guntutie with 100 kg ha^{-1} NPSB which scored 46.67 ton ha^{-1} marketable yield. At 159 kg ha^{-1} NPSB, Kulfo scored 39.84%, Tulla scored 34.56 % and Guntutie scored 41.7% marketable yield advantage over the control. At this rate, Kulfo scored 9.6%, Tulla scored 8.7% and Guntutie scored 31.9% marketable yield advantage over all the interaction mean of treatments. In line with this, El-Sayed *et al.* (2011) reported that, P rates resulted in a significant effect on total marketable yield at 15, 30 and 45 kg /fed P_2O_5 (15 .7 P kg ha^{-1}; 31.42 P kg ha^{-1} and 47.1P kg ha^{-1}) on “Beaure Gard” cultivar of sweet potato. Similarly, Yeng *et al.* (2012) reported that, the sole inorganic fertilizer 30:30:30.N.P.K (200 kg ha^{-1}) produced marketable storage root yield 76 % more than the control, which can be very significant for a small holder farmer in Guinea savanna. Hassan *et al.* (2005) found that, fertilization of sweet potato with P fertilizer caused significant increase in marketable and total yield.

Table 2. Interaction effect of OFSP varieties and NPSB blended fertilizer on means of marketable, unmarketable and total storage root yield.

Variety	NPSB kg ha^{-1}	MSRY (ton ha^{-1})	UnMSRY (ton ha^{-1})	TSRY (ton ha^{-1})
Kulfo (LO-323)	0	28.68^{f}	0.35^{cde}	29.02^{h}
	100	35.26^{cde}	0.33^{cde}	35.59^{efg}
	159	47.68^{b}	0.22^{ef}	47.899^{b}
	214	32.34^{def}	0.35^{cde}	32.69^{fgh}
	239	36.3^{cde}	0.54^{b}	36.84^{defg}
Tulla (CIP 20027)	0	30.89^{ef}	0.38^{cd}	31.27^{gh}
	100	40.71^{c}	0.82^{a}	41.53^{cd}
	159	47.21^{b}	0.38^{cd}	47.59^{b}
	214	33.45^{def}	0.25^{def}	33.70^{fgh}
	239	39.49^{c}	0.14^{f}	39.63^{de}
Guntutie (AJAC-I)	0	36.92^{cd}	0.38^{cd}	37.30^{def}
	100	46.67^{b}	0.54^{b}	47.21^{bc}
	159	63.33^{a}	0.65^{b}	63.98^{a}
	214	60.16^{a}	0.67^{b}	60.83^{a}
	239	63.44^{a}	0.39^{c}	63.83^{a}
Mean		43.09	0.42	43.51
CV (%)		7.95	20.29	7.82
LSD(0.05)		5.74	0.14	5.69

Means with the same letters in same column are not significantly different
N=Nitrogen, P=Phosphorus, S=Sulfur, B=Boron, MSRY=Marketable Storage Root Yield,
UnMSRY= Unmarketable Storage Root Yield, TSRY = Total Storage Root Yield,
CV =Coefficient of Variations, LSD= Least Significance Difference,

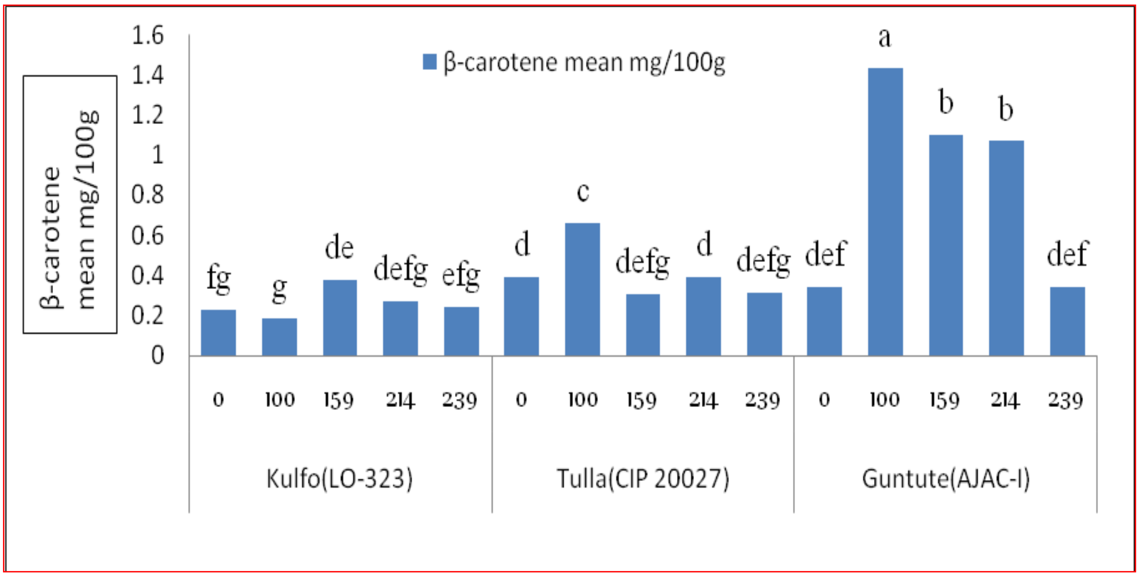
Means of total fresh storage root yield ton per hectare was significantly highest different by variety Guntutie, that received 159 kg ha^{-1}, 214 kg ha^{-1}, and 239 kg ha^{-1} NPSB which scored 63.98 ton ha^{-1}, 60.83 ton ha^{-1} and 63.83 ton ha^{-1} respectively(Table.2). Following this, Kulfo and Tulla which received 159 kg ha^{-1} NPSB fertilizers scored 47.899 ton ha^{-1} and 47.59 ton ha^{-1} respectively; however, they did not significant difference from each other and Guntutie with 100 kg ha^{-1} NPSB which scored 47.21 ton ha^{-1} (Table 2). At 159 kg ha^{-1} NPSB, Kulfo scored 39.41%, Tulla scored 34.2 % and Guntutie scored 47.7% total yield advantage over the controle. In line with this, Dumbuya *et al.*(2016) reported that, among 0, 30, 60, 90 and 120 kg ha^{-1} P_2O_5 treatments with Okumkom variety in Ghana, significant highest root yield was recorded at 60 kg ha^{-1} P_2O_5 fertilizer. Yeng *et al.* (2012) reported that, sole inorganic fertilizer 30:30:30NPK (200 kg ha^{-1}) produced total root yield 79% more than the control. El-Sayed *et al.* (2011) indicated that, yield was increased with increasing P rate at 15, 30 and 45 kg /fed (15 .7 P kg ha^{-1}; 31.42 P kg ha^{-1} and 47.1 P kg ha^{-1}) on “Beaure Gard” cultivar of sweet potato respectively. Busha (2006) also reported that, increasing P levels from 0 to 25 P kg ha^{-1} increased total tuber yield by 20 % with Koka-18 on ridge.

Ambecha (2001) found that, application of 46 N kg ha^{-1} along with 23 P kg ha^{-1} recorded significantly the highest total tuber yields on sweet potato which was further supported by the positive correlation between total tuber yield and the N and P applied. Again Busha (2006) reported that, increasing N level from 0 to 45 N kg ha^{-1} and P level from 0 to 25 P kg ha^{-1} significantly increased total tuber yield (ton ha^{-1}). He further indicate that, increasing N and P supply beyond 45 kg ha^{-1} and 25 kg ha^{-1} respectively did not bring about significant increase in total tuber yield. Essilfie (2015) reported that, a significant difference occurred between Okumkom grown on the different rate of amendments of fertilizer.

Application of NPSB fertilizer was effective to this experiment on yield and quality of OFSP, being, it contains S and B nutrients. In line with this, Byju *et al.*(2007) reported that, boron prevent splitting of tubers; as a result, total tuber yield increased significantly in application B up to 1.5 kg ha^{-1} and further increase in the rate of B fertilizer did not yield any further significant increase in total tuber yield . Saif-EI-Dean (2005); El-Sayed *et al.* (2011) found that, weight loss and decay were negatively correlated with P rates application. Increasing P rate up to 60 kg /fed P_2O_5 or 62.85 P kg ha^{-1} significantly decreased the percentages of weight loss during storage.

Beta Carotene (β-carotene) Content

β-carotene content of fresh storage root of OFSP significantly highest different in interactions of OFSP varieties and NPSB fertilizer ($p<0.01$) (Fig 1). OFSP variety Guntutie, that received 100 kg ha^{-1} NPSB was scored 1.4298mg/100g fwb β-carotene, which was significantly highest different. It was followed by Guntutie with 159 kg ha^{-1} and 214 kg ha^{-1} which scored 1.098mg/100g fwb and 1.065 mg/100g fwb β-carotene content respectively (Figure 1). OFSP variety Kulfo, that received 159 kg ha^{-1} and 214 kg ha^{-1} NPSB fertilize were scored 0.376mg/100g fwb and 0.267mg/100g fwb of β-carotene respectively. OFSP variety Tulla that received 100 kg ha^{-1} scored 0.6619 mg/100g of β-carotene (Figure 1).



Mean= 0.51236, CV (%) =15.58, LSD (0.05) = 0.1375

Means with the same letters on the top of bar are not significantly different

CV = Coefficient of Variations, LSD= Least Significance Difference,

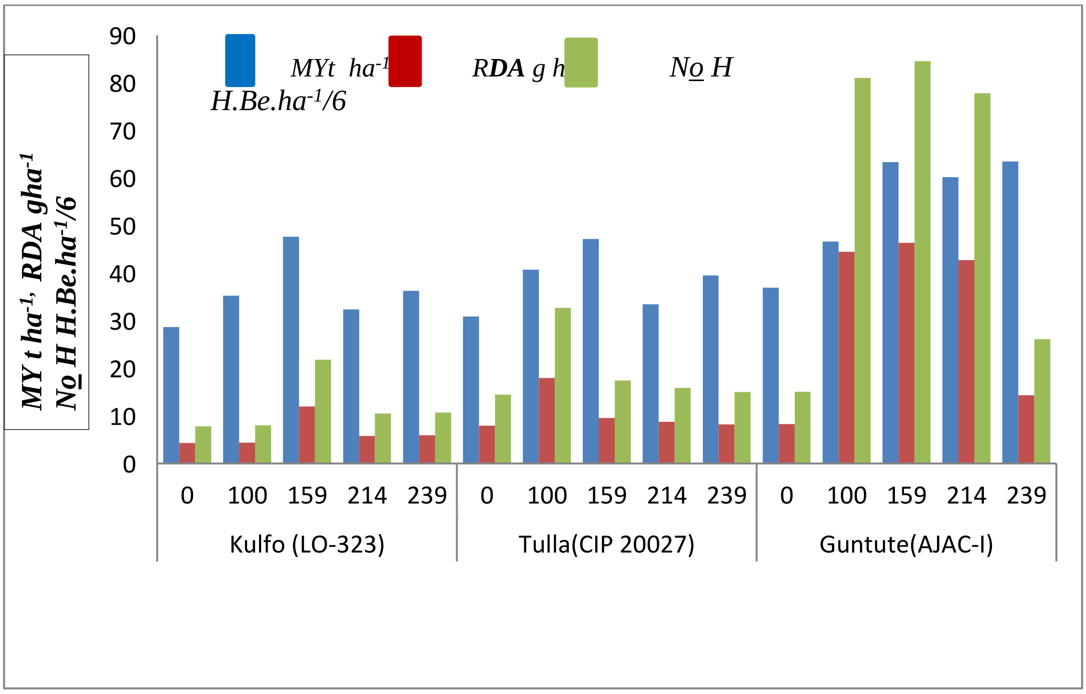
Figure 1. Interaction effect of variety and NPSB blended fertilizer on means β-carotene concentrations of orange flashed sweet potatoes.

In terms of β-carotene yield per hectare, high β-carotene contents were obtained from OFSP variety Guntutie with 159 kg ha^{-1}, 214 kg ha^{-1}, and 239 kg ha^{-1} NPSB fertilizer. Following this, variety Kulfo, which received 159 kg ha^{-1} and Tulla, which received 100 kg ha^{-1} NPSB fertilizer, scored high β-carotene content due to indirect influence of mean marketable fresh storage root yield in ton ha^{-1}(Figure 2). Therefore, 159 kg ha^{-1} NPSB fertilizer with these OFSP varieties is important for further harvest of high β-carotene content mg/100g per hectare.

The β-carotene contents were varying within variety and fertilizer level. In line with this, Degras (2003) reported that, applications of phosphorus increase the carotene content of tuberous roots of sweet potato in higher yield and affects the unit weight of root tubers. Afuape *et al*. (2014) reported that, β-carotene between 0.58 µg/g or 0.058mg/100g fwb (NRSP/05/3D) and 20.82 µg/g or 2.1mg/100 fwb (CIP440293) in his evaluation of 14 sweet potato genotypes with application of NPK (60: 60: 60) fertilizer 400 kg ha^{-1} in Nigeria. Essilfie (2015) indicated that, organic and inorganic fertilizers either singly or in combination resulted in significant effect on β-carotene content of tubers which varies from 1.1-14.9 mg/100g for Apomuden and 0.2- 0.7 mg/100g for Okumkom.

He further indicates that, Okumkom grown on 30-60-60 kg ha^{-1} NPK plot had the highest β-carotene content (2.87mg/100g). Nyarko (2015) found that, the β-carotene content at 200 kg ha^{-1} (30:30:30) NPK treatment effect was highest which scored 32.9% its dry matter. Laurie *et al.*(2012) reported that, β-carotene yield increased two-fold at the intermediate 50% (75, 15 and 95 kg ha^{-1}) and four-fold at the high 100% treatment (150, 30 and 190 kg ha^{-1}) NPK fertilization treatment respectively with Resisto and W-119 orange fleshed sweet potatoes. He also reported that β-carotene content was 14% higher for both intermediate (50%) and high (100%) fertilizer treatments, compared to the 0% fertilizer treatment with Resisto and W-119 OFSP.
The genotype Guntutie scored highest β-carotene. Similarly, Mbwaga (2007) reported that, among genotypes, β-carotene concentration was significantly different and the concentration in roots varied from 0.13 to 55.27 µg/100g. Variety 101055 SPK004 and Resisto resulted in high average β-carotene concentration across sites and the lowest varieties were 440443 and SPNO that accumulated low β-carotene concentration of 6.37µg/100g (0.00637mg/100g) and 0.70 µg/100g (0.00070mg/100g), respectively. This is very low concentration as compared to this experiment result even at zero fertilizer level. The β-carotene amounts found in mango (*Mangifera indica*) (245-625 µg/100g fwb) which by less than this experiment (Mulokozi, 2003).

Conversion of β-carotene to Retinol activity equivalent (RAE) or Recommended dietary allowance (RDA)/day in µg (g) and Benefited households.
Carotenoids in the body are less effective. Isotopic dilution studies of β-carotene conversion in healthy well-nourished and unnourished peoples showed variable conversion ratios (Ho *et al.*, 2009). The reason for the relatively poor conversion of β-carotene to VA is multi-factorial. Among these, carotenoids are poorly absorbed from most foods (Veda *et al.*, 2006). Carotenoid absorption a highly variable and depends on the carotenoids, its food matrix and the individual. β-carotene is better absorbed from orange colored fruits and vegetables than from leafy green vegetables (Connell *et al.*, 2007). People and animal with low VA status appear to convert a greater percentage of β-carotene to VA (Tanumihardjo, 2008).



MY ton ha^{-1} = Marketable Yield tone per hectare; g ha^{-1}=gram per hectare; RDA= Recommended Dietary Allowance; No H H.Be.ha^{-1}/6=Number of House Hold Benefited from a hectare for six months

Figure 2. Marketable yield, amount of RAE gram per hectare and number of house hold benefited for six months in interaction of variety and NPSB blended fertilizer OFSP.

Currently, carotenoids conversion in the body is estimated to be 6-µg β -carotene: 1-µg VA or 12-µg β-carotene: 1-µg VA (Trumbo *et al.*, 2001; WHO and FAO, 2005). Trumbo *et al.*(2001); WHO and FAO (2005); van Jaarsveld *et al.*(2006) reported that, the contribution of one hectare of orange fleshed sweet potato to vitamin A requirements for a households of six (one adult male = 600 µg RAE/day; one adult female = 500 µg RAE/day; one 1–3 year old children = 400 µg RAE/day; one 4–6 year old children = 450 µg RAE/day; one 7–9 year old children = 500 µg

RAE/day and one 10–18 year old adolescent = 600 µg RAE/day. These totals of 3050 µg RAE/day/hh were calculated after assuming 20% loss of β-Carotene during cooking which was based on the recommended dietary allowance (RDA). The vitamin A value was expressed in µg RAEs (retinol activity equivalents) based on conversion scale which is 12 µg trans-β-Carotene = 1 µg retinol = 1 µg RAE). Based on this, β-Carotene yield was calculated as kg (g) β-Carotene produced per unit area (ha).

Based on this principles stated, this experiment was resulted in high yield of RAE (RDA) retinol g ha^{-1} by Guntutie, which received 100 kg ha^{-1}, 159 kg ha^{-1} and 214 kg ha^{-1} NPSB, that scored RAE of 44.49, 46.4 and 42.74 g ha^{-1}, which allowed enough for house hold of 81, 84.5 and 77.8 (486, 507 and 466.8 peoples) for six months (Figure 2). Kulfo with NPSB fertilizer had resulted in 4.37 g ha^{-1} to 11.95 g ha^{-1} which allowed enough for 8 to 21.8 households (48 to 130.8 Peoples) for six (6) months. Tulla with NPSB fertilizer had resulted in 8.22 g ha^{-1} to 17.96 g ha^{-1}, which allowed enough for 15 to 32.7 households (90 to 196.2 peoples) for six (6) moths (Figure 2). In line with this, Laurie *et al.* (2012) reported that, one hectare of orange fleshed sweet potato produced a yield of 24.6–28.4 ton ha^{-1}, at the intermediate water application, which can potentially provide vitamin A for maximum up to 452–730 members of households (of six persons) for over a period of 180 days. Kurabachew (2015) reported that, OFSP which is rich in β-carotene has the potential to mitigate vitamin A deficiency problem in families those vulnerable to this problems and other food items.

Storage root dry matter, specific gravity, Starch, Crude fiber, Ash and Flour moisture content

The interaction of variety with NPSB fertilizer resulted in significantly highest different in storage root dry matter, specific gravity and starch ($p<0.05$); Crude fiber, ash and flour moisture content ($P<0.01$) (Table 3).

Mean dry matter of storage root 35.4% was recorded as significantly highest different by variety Tulla, which received 159 kg ha^{-1} NPSB fertilizer. This was not significantly different from Tulla with 239 kg ha^{-1} (33.39%), Kulfo with 159 kg ha^{-1} (33.48%) and 214 kg ha^{-1} (33.23%) (Table 3). The dry matter increased from 24.23 to 33.48% as NPSB fertilizer increased from 0 to 159 kg ha^{-1} with Kulfo variety, from 25 to 35% as NPSB fertilizer rate increased from 0 to159 kg ha^{-1} with Tulla and from 22.07 to 30.52% as NPSB fertilizer increased from 0 to 214 kg ha^{-1} with Guntutie (Table.3). In line with this study, Dumbuya *et al.* (2016) reported that, among 0,30,60,90 and 120 kg ha^{-1} P_2O_5 treatments with Okumkom variety in Ghana, root dry matter content at 60 kg ha^{-1} P_2O_5 (36.42%) was significantly higher than other treatments, except for the 90 kg ha^{-1} P_2O_5 (35%). Dry matter is one of primary important in any food and feed crops. Most scholars' literatures sated that, orange fleshed sweet potatoes had a lower dry matter which was less than white fleshed sweet potatoes. Those varieties of sweet potato scored more than 25% dry matter are said to be more important, mainly orange fleshed sweet potatoes. From this experiment result, we founded that, 22.1% - 35.4% of dry matter by varieties with NPSB fertilizer (Table 3).

This experiment was resulted in an improvement of dry matter, in application of NPSB fertilizer to sweet potato varieties (Kulfo, Tulla and Guntutie), which is important for fresh storage root of OFSP. Similar to this experiment, Afuape *et al.* (2014), found that, dry matter ranged between 24.16 (CIP 199034.1) and 34.17% (TIS 87/0087) in his evaluation of 14 sweet potato genotypes with application of NPK (60:60:60) fertilizer 400 kg ha^{-1} in Nigeria. In terms of coast benefit analysis on yield and quality, varieties with 159 kg ha^{-1} NPSB are more important for best harvest of yield as well as dry matte, being it improved to preferred level. Closely to this, Alemayehu and Jemberie (2018) reported that, dry matter was significantly influenced by interaction effect of NPS fertilizer and Potato variety (NPS rate × variety). El-Sayed *et al.* (2011) found that, P rates reflected a significant effect on storage root dry matter which scored 26.84 - 30. 47 % at 15 .7 P kg ha^{-1}, 31.42 P kg ha^{-1} and 47.1 P kg ha^{-1} with "Beaure Gard" cultivar of sweet potato respectively. Boru *et al.* (2017) reported that, the highest percent of dry matter response at 69 kg ha^{-1} P_2O_5 and the least dry matter was recorded at control. Kareem (2013) indicated that, application of phosphorus lead to trapping enough solar energy for higher food production which will finally be translocated to the roots for appreciable tuber development, better root dry matter and bulking which is the ultimate target of crop production. Increased P level from 0 to 25 P kg ha^{-1} resulted in increased root dry matter over the control by 46 % g per hill on ridge. But when N levels were increased beyond 45 N kg ha^{-1} and P levels increased from 50 to 75 P kg ha^{-1} respectively, there was no significant variation in root dry matter of sweet potato Koka-18 (Busha, 2006). He further indicated that, N levels increased beyond 45N kg ha^{-1}, significant decreased storage root dry matter by 12% or by 49 g hill $^{-1}$. Yeng *et al.*(2012) reported that, storage root dry matter content ranged from 11.5 to 34.3% and varied significantly in different fertilizer treatments. In general, a good supply of P and P containing fertilizer is associated with increased root growth, roots proliferate extensively, encourage extensive exploitation of immobile nutrients and increase root dry matter through efficient uses.

Specific gravity is the weight of the tuber compared to the weight of the same volume of water. It is one way of determinants of dry matter, starch and yield. Specific gravity of storage root (1.15 g cm^{-3}) was significantly highest by variety Tulla, which received 159 kg ha^{-1} NPSB fertilizer, however, it was statistical parity with Kulfo with 159 kg ha^{-1}(1.143), 214 kg ha^{-1} (1.140 g cm^{-3}) and Tulla with 239 kg ha^{-1}(1.143 g cm^{-3}) (Table 3). Guntutie without fertilizer resulted in least score (1.088 gcm^{-3}).

Specific gravity was lowest for Guntutie which was inversely to both fresh moisture and flour moisture content. NPSB fertilizer was an effect on specific gravity, as it was stated above. It was increased, as the rate of NPSB fertilizer increased with varieties. An agreement to this, Degras (2003) reported that, Phosphorus deficient potato plants typically produce tubers with lower specific gravity compared to those with adequate P nutrition. Namo and Babalola (2016) reported that, the specific gravity in the clone TIS.2532.OP.I.13 significantly different from that of clone TIS.44R1 68 with application of 15:15:15 kg ha^{-1} N P K fertilizer. He further indicates that a linear positive relationship observed between the specific gravity and the dry matter content during the wet season as well as starch content. Specific gravity, Starch and dry matter contents are the widely accepted measurements of potato quality and root crops and these may be affected by genotype and agronomic practice (Mebratu, 2014; Mbah *et al.*, 2015).

Starch content was significantly highest different by variety Tulla, that received 159 kg ha^{-1} (28.21%), however, it was statistical parity with Tulla with 239 kg ha^{-1} (26.47%), Kulfo with 159 kg ha^{-1} and 214 kg ha^{-1}, that scored 26.58% and 26.36% Starch content (Table 3). Even though, an improvement in starch content of variety with NPSB fertilizer, Guntutie had the lowest. This may it be influenced by genetic. Closely to this experiment, Afuape *et al*. (2014) reported that, starch content ranged from 17.58% (EX-OYUNGA) and 22.0%, (NRSP/05/1 B) in his evaluation of 14 sweet potato genotypes with application of NPK (60:60:60) fertilizer 400 kg ha^{-1} in Nigeria. Namo and Babalola (2016) reported that, the mean starch content across the clones varied from 17.42% in the clone TIS.44R168 to 19.77% in the clone TIS.8441 with application of the fertilizer per hectare (NPK 15:15:15). Afuape (2014) stated that, variety UM USP/2 which is pure white-fleshed sweet potato scored mean starch of fresh roots 18.24% and variety Mother's Delight (UMUSPO/3) which deep orange fleshed sweet potato scored starch of 17-19%. In general with application of fertilizer we can further improve the Starch content of orange flashed sweet potatoes.

Table 3. Interaction effect of OFSP varieties and NPSB blended fertilizer on specific gravity, Starch, crude fiber, Ash and flour moisture.

Variety	NPSB kg ha^{-1}	SRDM (%)	SG (gcm^{-3})	Starch (%)	Crude fiber (%)	Ash (%)	Flour Moisture (%)
Kulfo (LO-323)	0	24.23^{ij}	1.100^{gh}	18.38^{ij}	8.98^{a}	4.474^{bcd}	5.7985^{fgh}
	100	28.18^{efg}	1.120^{cde}	21.95^{efg}	6.95^{cd}	4.525^{bc}	7.6347^{ab}
	159	33.48^{ab}	1.143^{ab}	26.58^{ab}	5.98^{ef}	4.684^{b}	6.369^{efg}
	214	33.23^{abc}	1.140^{ab}	26.36^{abc}	5.82^{ef}	4.649^{b}	5.416^{h}
	239	27.25^{fgh}	1.115 ^{ef}	21.12^{fgh}	8.29^{ab}	5.112^{a}	6.850^{bcde}
Tulla (CIP 20027)	0	25.05^{hi}	1.103^{fg}	19.11^{hi}	5.26^{f}	4.150^{de}	7.284^{abcd}
	100	31.26^{bcd}	1.133 ^{bc}	24.65^{bcd}	5.59^{f}	4.483^{bcd}	5.632^{gh}
	159	35.40^{a}	1.150 ^{a}	28.21^{a}	7.82^{bc}	4.016^{e}	7.448^{abc}
	214	30.67^{bcde}	1.130^{bcd}	24.15^{bcde}	6.69^{de}	3.959^{e}	6.150^{efgh}
	239	33.39^{abc}	1.143^{ab}	26.47^{abc}	7.28^{cd}	4.494^{bc}	6.737^{cde}
Guntutie (AJAC-I)	0	22.078^{j}	1.088^{h}	16.36^{j}	7.55^{bcd}	4.469^{bcd}	6.425^{efg}
	100	25.77^{ghi}	1.103^{fg}	19.77^{ghi}	5.66^{f}	4.208^{cde}	6.968^{abcde}
	159	29.31^{def}	1.123^{cde}	22.957^{def}	5.66^{f}	4.500^{bc}	6.514^{def}
	214	30.52^{cde}	1.130^{bcd}	24.02^{cde}	5.86^{ef}	4.701^{b}	7.796^{a}
	239	28.19^{efg}	1.117^{def}	21.96^{efg}	5.8^{ef}	4.358^{bcd}	7.432^{abc}
Mean		29.29	1.123	0.42	6.56	4.438	6.708
CV (%)		5.95	0.78	6.6	8.18	4.55	7.46
LSD (0.05)		2.89	0.0145	2.53	0.89	0.033	0.85

Means with the same letters in same columns are not significantly different
N= Nitrogen, P =Phosphorus, S=Sulfur, B =Boron, %=Percentage, kg=kilogram
CV=Coefficient of Variations, LSD= Least Significance Difference, SG=Specific Gravity,
gcm^{-3} = gram cubic centimeter.

Crude fiber content was significantly highest different in variety Kulfo without fertilizer (8.98%), however, it did not significantly different from Kulfo with 239 kg ha^{-1} (8.29%). In this treatment, application of NPSB fertilizer reduced the fiber content from 0 to 214kg ha^{-1} with Kulfo and Guntutie (8.98 % to 5.82 % and 7.55% to 5.66%) respectively (Table 3). Inversely to this, NPSB from 0 to 159 kg ha^{-1} with Tulla resulted in increased crude fiber from 5.26% to 7.82% in respective order. Even though, fertilizer rate had an influence, variety had determinant effect in response to fiber content.

In line with this, Emmanuel *et al.* (2010) reported that, 4% in OFSP and 5% in YFSP flours. Afuape (2014) reported that, sweet potato is a good source of dietary fiber (2.5-3.3 g/100 gm) having with important vitamins like vitamin A, C and B6, as well as potassium and iron. He further reported that, variety King-J which is light OFSP scored average crude fibre of 1.47%, variety Mother's Delight (UMUSPO/3) which deep OFSP had crude fibre of 2.0% and variety UM USP/2 which is pure WFSP scored mean crude fibre of 1 .04% in Nigeria.

Ash content is the best reflection of the mineral content of the food material. Ash content was significantly highest in Kulfo with 239 kg ha^{-1} (5.11%) NPSB fertilizers. Following this, Kulfo with 159 kg ha^{-1} (4.68%), 214 kg ha^{-1} (4.64%) and Guntutie with 214 kg ha^{-1}(4.70%) resulted in highest scores; however, they did not significantly differed from each other (Table 4). Ash content in Kulfo increased from 4.47 to 5.11% as NPSB increased from 0 to 239 kg ha^{-1}, which was inversely to crude fiber in same treatment. In line with this experiment, Emmanuel *et al.* (2010) reported that, 4% ash in OFSP and 3% ash in YFSP. Closer to this experiment, Afuape (2014) reported that, variety King-J which is light orange-fleshed sweet potato scored average Ash content of 1.3%, variety Mother's Delight (UMUSPO/3) which deep orange-fleshed sweet potato had Ash content of 1.5% and variety UM USP/2 which is pure white-fleshed sweet potato mean Ash content of 1.5% in Nigeria.

Flour moisture content was significantly highest different in variety Guntutie with 214 kg ha^{-1} (7.79%). This did not significant different from 100 kg ha^{-1}(6.96%), 239 kg ha^{-1} (7.43%) and kg ha^{-1}; Tulla without NPSB (7.28%), 159 kg ha^{-1} (7.44) and Kulfo with 100 kg ha^{-1} (7.63%) (Table.4). Emmanuel *et al.* (2010) reported that, 17% flour moisture in OFSP and 15% in YFSP. Therefore, agronomic practices and variety have an effect on moisture content of sweet potato.

Correlations of Yield and Quality Variables

β-carotene was highly significant positively correlated with MY ton ha^{-1}(r=0.49),TY ton ha^{-1}(r= 0.501) and high significant negatively correlated to crude fiber (r=-0.475) (Table 4). Starch was highly positively significant to RDM(r=0.99), SG(r=0.989) (Table 4). An agreement to this result, Namo and Babalola (2016) reported that, a linear positive correlation was observed between dry matter and Starch content during the two seasons. Crude fiber was significant negatively correlated to β-Carotene(r=-0.475), MY ton ha^{-1} (r=-0.384), TY ton ha^{-1}(r = -0.386). NPSB blended fertilizer mostly contain p in proportion and plays appositive role in yield attributed parameters around storage root and quality of storage root of orange fleshed sweet potato.

Table 2. Correlations of yield and quality variables in interaction of OFSP varieties and NPSB blended fertilizer.

SRDM	β-car	MY t ha^{-1}	TY tha^{-1}	SG mm	Starch %	Fiber%	Ash%	
1	-0.11^{ns}	0.19^{ns}	0.17^{ns}	0.989**	0.999**	-0.11^{ns}	-0.11^{ns}	SRDM
	1	0.50**	0.50**	-0.129ns	-0.107ns	-0.475**	-0.10^{ns}	β-car
		1	0.99**	0.192^{ns}	0.195^{ns}	-0.384**	0.023^{ns}	MYtha^{-1}
			1	0.187^{ns}	0.19 ^{ns}	-0.39**	0.03^{ns}	TYtha^{-1}
				1	0.99**	-0.12^{ns}	-0.09^{ns}	SG
					1	-0.116^{ns}	-105^{ns}	Starch
						1	0.162^{ns}	Fiber
							1	Ash

SUMMARY AND CONCLUSIONS

Orange fleshed sweet potato is rich in β-carotenes which is a proven cost effective strategy for providing vitamin A. Result of this experiment revealed that, means of MSRY ton ha^{-1} and TSRY ton ha^{-1} were highly significant ($p<0.01$) in the interaction of OFSP varieties with NPSB fertilizer. Marketable storage root yield ton ha^{-1} was significantly highest different in Guntutie X 159 kg ha^{-1}, 214 kg ha^{-1}and 239 kg ha^{-1} NPSB with score 63.33 ton ha^{-1}, 60.16 ton ha^{-1} and 63.44 ton ha^{-1} respectively. Significantly highest different means of β-carotene content was recorded by Guntutie X 100 kg ha^{-1} NPSB which scored 1.4298mg/100g fwb. Guntutie X 159 kg ha^{-1} and 214 kg ha^{-1} scored 1.098mg/100g fwb and 1.065 mg/100g fwb β-carotene content respectively. High yield of RAE was recorded in Guntutie X 159 kg ha^{-1} that scored 46.4 g ha^{-1} RAE, which was found to be enough for house hold of 84.5 (507 peoples) for six months. Storage root dry matter was highest in Tulla X 159 kg ha^{-1} (35.4%). The dry matter increased from 24.23 to 33.48%; 25 to 35% as NPSB increased from 0 to159 kg ha^{-1} with Kulfo and Tulla variety respectively and from 22.07 to 30.52% in Guntutie, as NPSB increased from 0 to 214 kg ha^{-1} which implies the same flow in starch content. In correlation analysis, β-carotene was highly significantly and positively correlated with MY ton ha^{-1} (r=0.495) and highly significantly and negatively correlated to crude fiber (r=-0.475). Storage root dry matter was highly significantly and positively correlated to SG(r=0.759) and Starch(r = 0.771).

Fertilizer containing S and B are important for improvement of yield and quality of sweet potato. Over all 159 kg ha^{-1} NPSP was recommended with Guntutie in terms of yield, β–carotene quality and with Tulla for high yield of starch and dry matter.

Therefore, application of 159 kg ha^{-1} NPSB fertilizer rate is economical and recommended for sweet potato varieties production under Jimma and its vicinity of Southwest Ethiopia. Further research will be conducted with other OFSP varieties having low dry matter and β-carotene for their best response to NPSB fertilizer. Being Guntutie, our country collection resulted in high yield and β-carotene, further indigenous collection and evolution should be done for yield and quality.

ABBREVIATIONS USED

CSA DAP	Central Statistics Authority Days After Planting(Di-ammonium phosphate)
DRA	Daily Recommended Allowance
FAO	Food and Agricultural Organization
MARC	Melkassa Agricultural Research Center
MoARD	Ministry of Agriculture and Rural Development
MSRN	Marketable Storage Root Number
MSRWP	Marketable Storage Root Weight Per plant
MSRY	Marketable Storage Root Yield
OFSP	Orange Fleshed Sweet Potato
RAE	Retinol Activity Equivalent
SRDM	Storage Root Dry matter
SRG	Storage Root Girth
SRL	Storage Root Length
TSRN	Total Storage Root Number
TSRY	Total Storage Root Yield
WAP	Weeks After Planting
WFO	World Food Program
YFSP	Yellow Fleshed Sweet Potato

REFERENCES

Abdissa, T., Chali, A., Tolessa, K., Tadesse, F. and Awas, G. (2011). Yield and Yield Components of Sweet Potato as Influenced by Plant Density: In Adami Tulu Jido Kombolcha District, Central Rift Valley of Ethiopia. *American Journal of Experimental Agriculture.*1 (2): 40-48.

Afuape, O.A. (2014). Information Book on Sweet potato root Quality requirements for enterprise utilization. In: AGRA project for the selection and release of pro-vitamin a Sweet potato at the national root crops research institute, Umudike, Nigeria.

Afuape, S.O., Nwankwo, I.I.M., Omodamiro, R.M., Echendu, T.N.C. and Toure, A. (2014). Studies on some important consumer and processing traits for breeding Sweet potato for varied end-uses. *American Journal of Experimental Agriculture*, 4(1):114.

Alam, M.K., Rana, Z.H. and Islam, S.N. (2016). Comparison of the Proximate Composition, Total Carotenoids and Total Polyphenol Content of Nine Orange-Fleshed Sweet Potato Varieties Grown in Bangladesh. *Foods*, 5(3): 64.

Alemayehu, M. and Jemberie, M. (2018). Optimum rates of NPS fertilizer application for economically profitable production of potato varieties at Koga Irrigation Scheme, Northwestern Ethiopia. *Cogent Food & Agriculture*, *4*(1): 1-17.

Ambecha, O.G. (2001). Influence of nitrogen and phosphorus on yield and yield components and some quality traits of two Sweet potatoes (*Ipomoea batatas* (L.) Lam) cultivars (M. Sc Thesis, Alemaya University).

AOAC (Association Official Analytical Chemists) (2005). Manual of Food Analysis, USA.

Bellete, T. (2016). Soil Fertility Mapping and Fertilizer Recommendation in Ethiopia: Update of Ethio SIS project and status of fertilizer blending plants.

Beyene, T.M. (2013). Morpho-agronomical characterization of taro (*Colocasia esculenta*) accessions in Ethiopia. *Plant science publishing group*, 1(1):1-9.

Boru, M., Tsadik, W.K and Tana, T. (2017). Effects of Application of Farmyard Manure and Inorganic Phosphorus on Tuberous Root Yield and Yield Related Traits of Sweet Potato (*Ipomoea batatas* (L.) Lam) at Assosa, Western Ethiopia. *Advances in Crop Sci and Tech*, 5(4):1-8.

Busha, A. (2006). Effect of N and P Application and Seedbed Types on Growth, Yield and Nutrient Content of Sweet Potato (*Ipomoea batatas* (L.) Lam) Grown in West Wollega (Doctoral dissertation, Haramaya University).

Byju, G., Nedunchezhiyan, M. and Naskar, S.K. (2007). Sweet potato response to boron application on an alfisols in the sub humid tropical climate of India. *Communications in soil science and plant analysis*, 38(17-18): 2347-2356.

Connell, O.F., Ryan, L. and O'Brien, N.M. (2007). Xanthophyll carotenoids are more bioaccessible from fruits than dark green vegetables. *Nutrition Research*, 27(5): 258-264.

CSA (2016). Crop and livestock product utilization. Agricultural sample survey (private peasant holdings, meher season). The federal democratic republic of Ethiopia.

Dantata, I.J., Babatunde, F.E., Mustapha, S. and Fagam, A.S. (2010). Influence of variety and plant spacing on tuber size, tuber shape and fresh marketable yield of Sweetpotato in Bauchi Nigeria. *Biological and Environmental Science Journal for the Tropics,* 7: 140-144.

Degras, L. (2003). Sweetpotato: The tropical Agriculturalist. Macmillan publishers Ltd. Lima, Peru.

Demissie, T., Ali, A., Mekonen, Y., Haider, J. and Umeta, M. (2010). Magnitude and distribution of vitamin A deficiency in Ethiopia. *Food and Nutrition Bulletin*, 31(2): 234-241.

Dumbuya, G., Sarkodie-Addo, J., Daramy, M.A. and Jalloh, M. (2016). Growth and yield response of Sweet potato to different tillage methods and phosphorus fertilizer rates in Ghana. *Journal of Experimental Biology*, 4:5.

El-Sayed, H.E.A., Saif-el-Dean, A., Ezzat, S. and El-Morsy, A.H.A. (2011). Responses of productivity and quality of Sweet potato to phosphorus fertilizer rates and application methods of the humic acid. *International Research Journal of Agricultural Science and Soil Science*, 1(9):383-393.

Emmanuel, H., Vasanthakaalam, H., Ndirigwe, J. and Mukwantali, Ch. (2010). A comparative study on the β-carotene content and its retention in yellow and orange fleshed Sweet potato flours.

Essilfie, M.E. (2015). Yield and storability of Sweetpotato (*Ipomoea batatas* (L.) Lam) as influenced by chicken manure and inorganic fertilizer (Doctoral dissertation, Univ of Ghana).

Ethio SIS (2014). Tentative list of fertilizers required in Oromia Region for 124 surveyed woredas by Ethiopian Soil Information System. MoA, ATA. Addis Ababa, Ethiopia.

FAO (2014). Production year book 2012: Food and Agricultural Organization. Rome.

Fite, T., Getu, E., Sori, W., Hassanali, A., Herren, H., Khan, Z.R., Pickett, J.A., Woodcock, C.M., Alexander, Y., Belay, A. and Christerson, M. (2008). Proceeding of the 25th anniversary of Nazareth agricultural research center: 25 years of experience in lowland crops research, September 20-23, 1995. *Journal of Entomology,* 11(4): 611-621.

Gurmu, F. and Mekonen, S. (2017). Registration of a Newly Released Sweet Potato Variety ''Hawassa-09''for Production in Ethiopia. *J. Agro technology,* 6(2): 1-3.

Gurmu, F., Hussein, S. and Laing, M. (2015b). Diagnostic assessment of Sweetpotato production in Ethiopia: Constraints, post harvest handling and farmers' preferences. *Research on Crops*, 16(1):56-57.

Hassan, M.A., El-Seifi, S.K., Omar, F.A. and El-Deen, U.M. (2005). Effect of mineral and bisphosphate fertilization and foliar application of micronutrient on growth, yield and quality of Sweet potato (*Ipomoea batatas* (L.) Lam). *J. Agric. Sci. Mansoura Univ*, 30(10): 6149-6166.

Ji, H., Zhang, Ji, H., Li, H. and Li, Y. (2015). Analysis on the nutrition composition and antioxidant activity of different types of Sweet potato cultivars. *Food and Nutrition Sciences*, 6(01): 161.

Kaguongo, W., Ortmann, G., Wale, E., Darroch, M. and Low, J.W. (2012). Factors influencing adoption and intensity of adoption of orange flesh Sweet potato varieties: Evidence from an extension intervention in Nyanza and Western provinces, Kenya.

Kareem, I. (2013). Growth, yield and phosphorus uptake of Sweet potato (*Ipomoea batatas* (L.) Lam) under the influence phosphorus fertilizers. *Research Journal of Chemical and Environmental Sciences*, 1(3):50-55.

Karltun, E., Lemenih, M. and Tolera, M. (2013). Comparing farmers' perception of soil fertility change with soil properties and crop performance in Beseku, Ethiopia. *Land Degradation & Development*, 24(3): 228-235.

Kassaye, T., Receveur, O., Johns, T. and Becklake, M.R. (2001). Prevalence of vitamin A deficiency in children aged 6-9 years in Wukro, Northern Ethiopia. *Bulletin of the World Health Organization*, 79: 415-422.

Kidane, G., Abegaz, K., Mulugeta, A. and Singh, P. (2013). Nutritional analysis of vitamin A enriched bread from orange flesh Sweet potato and locally available wheat flours at Samre Woreda, Northern Ethiopia. *Current Research in Nutrition and Food Science Journal,* 1(1): 49-57.

Kurabachew, H. (2015). The role of orange fleshed Sweet potato (*Ipomea batatas*) for combating vitamin A deficiency in Ethiopia: A review. *International Journal of Food Science and Nutrition Engineering*, 5(3): 141-146.

Landon, J.R. (2014). Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics. *Routledge*.

Laurie, S.M., Faber, M., Van Jaarsveld, P.J., Laurie, R.N., Du Plooy, C.P. and Modisane, P.C. (2012). β-Carotene yield and productivity of orange-fleshed Sweet potato (*Ipomoea batatas* (L.) Lam) as influenced by irrigation and fertilizer application treatments. *Scientia Horticulturae*, 142: 180-184.

Low, J.W., Kapinga, R., Cole, D., Loechl, C., Lynam, J. and Andrade, M.I. (2009). Challenge theme paper 3: nutritional impact with orange-fleshed Sweetpotato. *Unleashing the potential of Sweetpotato in sub-Saharan Africa: current challenges and way forward. Lima: International Potato Center (CIP),* p.73.

Mbah, E.U. and Eke-Okoro, O. (2015). Relationship between some growth parameters, dry matter content and yield of some Sweet potato genotypes grown under rain fed weathered Ultisols in the humid tropics. *Journal of Agronomy*, 14(3): 121.

Mbwaga, Z., Mataa, M. and Msabaha, M. (2007). Quality and yield stability of orange fleshed Sweet potato (*Ipomoea batatas* (L.) Lam) varieties grown in different agro-ecologies. In 8th *African Crop Science Society Conference, El-Minia, Egypt, 27-31 October 2007* .Pp:339-345).

McLean, E.O. (1982). Soil pH and lime requirement. In: Page, A.L., Ed., Methods of Soil Analysis. Part 2. Chemical and Microbiological Properties, American Society of Agronomy, Soil Science Society of America, Madison, 199-224.

Mebratu, M. (2014). Sweet potato (*Ipomoea batatas* (L.) Lam) Growth and yield as affected by planting density and cultivar in Wolaita Soddy, Southern Ethiopia (M.Sc. Thesis).

MOARD (2009). Animal and Plant health regulatory directorate. *Crop variety register. Issue No.12*

Mulokozi, G.I. (2003). Content and In vitro accessibility of Provitamin A carotenoids in some Tanzanian Vegetables and fruits (Doctoral dissertation).

Mwanga, R.O., Odongo, B., Niringiye, C., Alajo, A., Kigozi, B., Makumbi, R., Lugwana, E., Namukula, J., Mpembe, I., Kapinga, R. and Lemaga, B. (2009). 'NASPOT7, 'NASPOT 8', 'NASPOT9 O', 'NASPOT 10 O' and 'Dimbuka Bukulula' Sweet potato. *Hort. Science,* 44 (3): 828-832.

Namo, O.A.T. and Babalola, O.M. (2016). Season and Tuber Size Affect Dry Matter, Specific Gravity and Starch Content of Sweet potato (*Ipomoea batatas* (L.) Lam). In Jos Plateau, North-Central Nigeria. *Int. Inv. J. Agric. Soil Sci,* 4(3): 27-36.

Ndunguru, J., Kapinga, R., Sseruwagi, P., Sayi, B., Mwanga, R., Tumwegamire, S. and Rugutu, C. (2009). Assessing the Sweetpotato virus disease and its associated vectors in northwestern Tanzania and central Uganda. *African Journal of Agricultural Research*, 4(4): 334-343.

Netherlands Commissioned by Ministry of Agriculture and Fisheries (1985). Agricultural Compendium for Rural Development in Tropics and Sub-tropics, Netherlands Ministry of Agriculture and Fisheries, Amsterdam, the Netherlands.

Norton, B.R., Mikkelsen, R. and Jensen, T. (2013). Sulfur for plant nutrition. *Better crops with plant Food*, 97(2): 10-12.

Nyarko, A. (2015). Growth, yield and root qualities of two Sweet potatoes (*Ipomoea batatas* (L.) Lam) Varieties as influenced by organic and inorganic fertilizer application (Doctoral dissertation, kwame Nkrumah University).

Olsen, S.R. and Sommers, L.E. (1982). Phosphorus. In: Page, A.L., R.H. Miller, and D.R. Keeney (eds.). Methods of Soil Analysis part 2. ASA and SSSA Madison, WI, USA. pp. 403-430.

O'Sullivan, J.N., Asher, C.J. and Blamey, F.P.C. (1997). Nutrient disorders of Sweet potato. Australian Centre for International Agricultural Research.

Page, A.L., Miller, R.H., Keeney, D.R., Baker, D.E., Ellis, R. and Rhoades, J.D. (1982). Methods of soil analysis. (*eds)* CIMMYT.

Sadler, G., Davis, J. and Dezman, D. (1990). Rapid extraction of lycopene and β- carotene from reconstituted tomato paste and pink grapefruit homogenates. *Journal of food science*, 55(5): 1460-1461.

Saif El Deen, U.M. (2005). Effect of phosphate fertilization and foliar application of some micronutrients on growth, yield and quality of Sweet potato (*Ipomoea batatas* (L.) Lam) (Doctoral Thesis, Suez Canal Univ, Egypt).

SAS Institute, 2011. SAS/IML 9.3 user's guide.

Scianna, J., Logar, R. and Pick, T. (2007). Testing and interpreting salt-affected soil for tree and shrub plantings. *In: plant materials technical note No.MT-60*, USDANRCS

Swamy, T.M.S., Sriram, S., Byju, G. and Misra, R.S. (2002). Tropical tuber crops production in Northeastern India: pests, diseases and soil fertility constraints. *Journal of Root Crops*, 28(62): 64-68.

Tanumihardjo, S.A., Bouis, H., Hotz, C., Meenakshi, J.V. and Mc-Clafferty, B. (2008). Bio fortification of staple crops: an emerging strategy to combat hidden hunger. *Comp Rev Food Sci Food Safety*, 7: 329-34.

Tesfaye, T., Feyissa, T. and Abraham, A. (2011). Survey and serological detection of Sweet potato (*Ipomoea batatas* (L.)Lam) viruses in Ethiopia. *Jor. of Applied Biosciences*, 41: 2746-2756.

Tofu, A., Anshebo, T., Tsegaye, E. and Tadesse, T. (2007). November. Summary of progress on orange-fleshed Sweetpotato research and development in Ethiopia. In *Proceedings of the 13th ISTRC Symposium*, Pp:728-731.

Trumbo, P., Yates, A.A., Schlicker, S. and Poos, M. (2001). Dietary reference intakes: vitamin A, vitamin K, arsenic, boron, chromium, copper, iodine, iron, manganese, molybdenum, nickel, silicon, vanadium, and zinc. *J. the Academy of Nutri and Dietetics*, 101(3): 294.

Van Jaarsveld, P.J., Harmse, E., Nestel, P. and Rodriguez-Amaya, D.B. (2006). Retention of β-carotene in boiled, mashed orange-fleshed Sweet potato. *Journal of Food Composition and Analysis*, 19(4):321-329.
Van Reeuwijk, L.P. (1992). Procedures for Soil Analysis. 3rd Edition International Soil Reference and information entre Wageningen (ISRIC). The Netherlands, AJ Wageningen.
Veda, S., Klamath, A., Platel, K., Begum, K. and Srinivasan, K. (2006). Determination of bioaccessi-bility of β- carotene in vegetables by in vitro methods. *Molecular nutrition & food research*, 50(11): 1047-1052.
Yeng, S.B., Agyarko, K., Dapaah, H.K., Adomako, W.J. and Asare, E. (2012). Growth and yield of Sweet potato (*Ipomoea batatas* (L.) Lam) as influenced by integrated application of chicken manure and inorganic fertilizer. *African Journal of Agricultural Research*, 7(39): 5387-5395.

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