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Influence of Blended Npsb Fertilizer Rates on Growth of Sweet Potato (*Ipomoea batatas* (L.) Lam) Varieties in Bako District, West Shewa Zone

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Abstract: Sweet potato (*Ipomoea batatas* (L) Lam) is one of the most important root crops. It is used as food and economically important crop in Ethiopia. However, its production and productivity is very low due to several factors: lack of information on the type and appropriate rate of fertilizers supplying major plant nutrients, which have been recognized to be deficient in Ethiopian soil and shortage of planting materials supplying system, Hence, a field experiment was conducted at Bako Agricultural Research Center in 2019/2020, to investigate the effect of blended NPSB fertilizer rates and sweet potato varieties on growth, components of sweet potato. Five different rates (0, 50, 100, 150 and 200 kg ha^{-1}) of blended NPSB fertilizer and two sweet potato varieties (Dimtu and Tola) were combined in a 5 X 2 factorial arrangement in a randomized complete block design with three replications. Data on growth components were collected and subjected to analyses of variance using SAS, version 9.3. The results of this experiment indicated that varieties and NPSB fertilizer rates highly significantly ($p<0.01$), and their interaction significantly ($p<0.05$) affected most of the growth parameters including: shoot fresh weight; shoot dry weight, vine length, days to bud sprout and days to physiological maturity. Tola at 100 kg ha^{-1}, 150 kg ha^{-1} and 200kg ha^{-1} NPSB fertilizer rates resulted in significantly ($p<0.01$) highest days to physiological maturity (136.69, 139.9 and 143.1) and the highest shoot fresh weight (653.3g, 668.3g and 690g), respectively. Dimtu at 0 kg ha^{-1} fertilizer rates resulted in significantly ($p<0.01$) highest days to bud sprouting (14.0). In conclusion, the above findings indicated that the growth and productivity of sweet potato at the study area can be improved by the combined use of appropriate variety and application of optimum rate of blended NPSB fertilizer. However, as the results are limited to one season and location, further research needs to be conducted over more seasons and locations by considering also using the more than 200 kg ha^{-1} of blended NPSB fertilizer rates and additional varieties to generate more reliable information.

Keywords: Dimtu, Tola, Tuberous Root Yield, Vitamin A

1. Introduction

Sweet potato *(Ipomoea batatas* (L.) Lam) is a dicotyledonous plant belonging to the family Convolvulaceae [46]. It has a chromosome number of 2n = 90. Since the basic chromosome number for the genus *Ipomoea* is 15, sweet potato is considered to be a hexaploidy. It is highly heterozygous cross-pollinated crop in which many of the traits show continuous variations.

Central American countries are considered as the center of Sweet Potato origin, but in recent times it is extensively cultivated with divergent agro climatic conditions and it was domesticated more than 5000 years ago [13]. Currently, it is widely grown throughout the tropics and temperate regions of the world between latitude of 40^0 North and South of the equator and 2300 meters above sea level. It is a root crop that provides food to a large segment of the world population, especially in countries like China, Uganda, Nigeria, Indonesia, Tanzania, Vietnam and India where the bulk of the crops are cultivated and consumed [37].

It is mainly grown for human food and animal feed. It produces storage roots which are rich in carbohydrate, vitamins such as A, B complex, C, E and minerals such as potassium, calcium and iron [24]. It is an important crop for food security and cultivated in over 100 developing countries. Sweet potato is globally the 7th most important crop after wheat, rice, maize, potato, barley and cassava [20]. Over 95% of the global sweet potato production is in developing countries. More than 140 million tons have been produced globally per year [20].

The world average storage root yield had been estimated to be 14.8 ton ha^{-1} [20]. Asia is the world's largest producing continent (129 M ton/annum) and China is the leading sweet potato producing country with production of 70,963,630 metric tons (MT), followed by Nigeria (3,478,270 MT), Tanzania (3,345,170 MT) and Ethiopia (2,701,599 MT) [24]. In Africa, sweet potato is the 2nd most important root crop after cassava [15]. African farmers produce only about 9 million tons per annum which is mostly used for human consumption to ensure food security.

Most varieties in sub-Saharan Africa are white-fleshed, low yielding and lacking β-carotene [48]. Ethiopia is one of the largest sweet potato producing countries in the world. It is widely grown in southern, southwestern and eastern parts of the country by small-scale farmers with limited land, labor and capital [7; 12]. In Ethiopia sweet potato is cultivated as most important root crop mostly for human consumption, which ranks the 3rd most important root crop next to Enset and Potato in the country. It is the most important sources of carbohydrates for small holder farmers in Ethiopia [4].

It is one of the major horticultural crops used as a source of food and income to the poor farmers and it is a major subsistence crop in the periods of drought [45; 22]. In Ethiopia sweet potato occupied about 53,449 hectares of land with a total annual production of 1.85 million tons during the main growing season and 1stposition in root and tuber crops. It yields 3.46 ton ha^{-1}, 2nd place next to sugar cane [14].

In Oromia, it was cultivated at about 16, 795.75 hectares and takes 2nd place next to Irish potato, among root and tuber crops grown in the region. About 10,355,295.09 ton was produced per year, making it 1st among root and tuber crops with 6.165 ton ha^{-1}, ranking 1st among all crops yield in the region [14]. However, the productivity of the crop remained low at national level (8 t ha^{-1}) for a long time [21]. The major causes of the low yields are, use of poor agronomic practices and extension system, lack of information on the appropriate rates of fertilizers recommendations, low soil fertility, shortage of improved varieties, shortage of planting materials and most varieties are white fleshed which lacks β-carotene [29]. Also, the production of sweet potato is constrained by the biotic factors (diseases, insect pests and weeds) and abiotic factors (drought, heat and low soil fertility) [33].

According to [50], the potential yield of sweet potato reached up to 50 ton ha^{-1} on research station and 17.5-30.50 ton ha^{-1} on farms with improved agronomic practices. [2] reported that, sweet potato yield under research field ranged from 30-35 ton ha^{-1} with improved cultivars. According to [44], average yield of 37.1 ton ha^{-1} was obtained from Bellala variety in Adami Tulu area with application of different fertilizers. [1] reported that, sweet potato yields up to 64.4 ton ha^{-1} from Bellala variety using appropriate agronomic practices. Dimtu and Tola varieties are more resistance to major disease and insects than standard check (Ballo).

The standard check was released for Bako and similar ecologies based on its adaptability and yield performance. But Dimtu and Tola gave significantly higher tuber yield than the standard check across locations and years. The newly released variety showed yield advantage of 83% over the standard check (Ballo) [49].

Inorganic fertilizers have been the important tools to overcome soil fertility problems and they are also responsible for a large part of the food production increases. The drive for higher agricultural production without balanced use of fertilizers created problems of soil fertility exhaustion and plant nutrient imbalances not only of major but also of secondary macronutrient and micronutrients. The deficiencies of secondary macronutrient and micronutrient will arise since they are not replenished timely under intensive agriculture [43].

In the years past, MoANRD recommended 175 kg ha^{-1} DAP and 80 - 100 kg ha^{-1} Urea in blanket [28]. Currently, the ammonium fertilizer representatives, Sulfur and Boron containing fertilizers has been availed in Ethiopia [8].

Following the soil fertility map of Ethiopia soil analysis data, revealed the deficiencies of most nutrients such as, nitrogen (86%), phosphorus (99%), sulfur (92%), born (65%), zinc (53%), potassium (7%), copper, manganese, and iron in Ethiopian soils. Consequently, to overcome this problem of nutrient deficiency using those multi-nutrient balanced fertilizers containing N, P, K, S, B and Zn in blend form have been issued to ameliorate site specific nutrient deficiencies and thereby increase crop production and productivity in the areas [18].

According to soil fertility maps [19], the deficiency of nitrogen, phosphorous, sulfur, and boron were widely spread in Bako areas. A number of experiments had been conducted on variety evaluation of sweet potato in different areas of Ethiopia, mainly on yield improvement. Also, a number of experiments were conducted to determine the response of sweet potato to NP, P, N and NPK fertilizer rates in different parts of the country. However, no research undertakings were reported on the effects of rate of inorganic fertilizers such as NPSB fertilizer on growth of sweet potato in Bako area, to date. Therefore the objectives of this study were to investigate the effects of blended NPSB fertilizer rates and on growth, sweet potato varieties under Bako area.

2. Materials and Methods

2.1. Description of the Study Area

The study was conducted at Bako Agricultural Research Center in Bako Tibe District of West Shewa Zone, Oromia Regional State during the 2019/2020 by irrigation system. Bako is located at 260 km in the western direction from Addis Ababa on the main road to Nekemte. Bako Agricultural Research Center lies between $9^0$6'N latitude and $37^0$9'E longitude at an altitude of 1650 m.a.s.l. Agro-ecology is mid-altitude with high rainfall of 1035-1290 mm $year^{-1}$ and hot humid weather with minimum of 13.3°C and maximum of 28°C temperature [47]. The soil of the site was characteristically Nitisols [49] which is slightly acidic with pH of 5.8 and Sandy loam in texture with sand, silt and clay in proportions of 52%, 33% and 13% contents (Table 4).

2.2. Description of Experimental Materials

Two sweet potato varieties (Dimtu and Tola) were used for the experiment. Both varieties were released form Bako Agricultural Research Center. The description of these varieties is presented in Table 1. Varieties Dimtu and Tola were selected based on their high root yields, good agronomic performance, high test quality, disease resistance and adaptability to the study area [31; 49]. Five levels of blended NPSB fertilizer: 0, 50, 100, 150 and 200 kg ha^{-1}. Blended fertilizers of NPSB which constitutes 18.9% N, 37.7% P_2O_5, 6.95% S and 0.1% B were used as sources of inorganic fertilizers [8]. Fertilizer NPSB had been recommended in blanket recommendation for West Shewa zone, including experimental site [19].

Table 1. *Description of the varieties used for the study.*

Variety	Year of released	Research station	Altitude m.a.s.l	Rain fall Mm	Maturity Days	Reference
Dimtu	2005	BARC	1500-2200	1120-1500	120	MoA, 2006
Tola	2012	BARC	1500-2010	1035-1290	120	Wandimu *et al*., 2015

Key: m.a.s.l Meter above sea level, BARC= Bako Agricultural Research Center

2.3. Treatments and Experimental Design

The treatments were factorial combinations of five levels of blended NPSB fertilizer rate (0, 50, 100, 150 and 200 kg ha^{-1}) and two sweet potato varieties (Dimtu and Tola). The 100 kg NPSB ha^{-1} was taken as a substitute of blanket fertilizer recommendation and used as a base to set the fertilizer levels. The nutrients amount in each fertilizer treatment is presented in Table 2.

Table 2. *Nutrient composition of the fertilizer treatments.*

NPSB Treatments	Rate NPSBha^{-1}	Element content N	P_2O_5	S	B
Control	0	0	0	0	0
NPSB1	50	9.45	18.85	3.475	0.05
NPSB2	100	18.9	37.7	6.95	0.1
NPSB3	150	28.35	56.55	10.425	0.15
NPSB4	200	37.8	75.4	13.9	0.2

Table 3. *Description of treatment combinations used for the experiment.*

Treatment	Description
T1	Dimtu + 0 kg ha^{-1} blended NPSB fertilizers
T2	Dimtu + 50 kg ha^{-1} blended NPSB fertilizers
T3	Dimtu + 100 kg ha^{-1} blended NPSB fertilizers
T4	Dimtu +150 kg ha^{-1} blended NPSB fertilizers
T5	Dimtu + 200 kg ha^{-1} blended NPSB fertilizers
T6	Tola + 0 kg ha^{-1} blended NPSB fertilizers
T7	Tola + 50 kg ha^{-1} blended NPSB fertilizers
T8	Tola + 100 kg ha^{-1} blended NPSB fertilizers
T9	Tola+ 150 kg ha^{-1} blended NPSB fertilizers
T10	Tola + 200 kg ha^{-1} blended NPSB fertilizers

The experiment was laid out in Randomized Complete Block Design (RCBD) in a 5 x 2 factorial arrangement, replicated three times. The 10 treatments were assigned to each plot randomly by using SAS. The treatment combinations were described in Table 3.

2.4. Soil Sampling and Analysis

Before planting, physicochemical properties of the experimental field of soil were determined. Therefore, representative soil samples were collected from the experimental field randomly in a zigzag pattern at depth of 0-20 cm before planting using an auger. The soil samples were composited and a one kg sample was taken as a working sample. Crumbs of soil were broken into pieces and sieved. The collected composite samples were air-dried on paper trays, ground and sieved to pass through a 2 mm sieve for chemical analysis. All samples were analyzed following standard laboratory procedures as outlined by [40]. Soil laboratory analyses were made at Bako Agricultural Research.

The soil analysis included determination of total nitrogen, available phosphorus, textural analysis (sand, silt and clay), soil pH, Cation exchangeable capacity and organic carbon (Table 4). Soil texture analysis was performed by Bouyoucous hydrometer method [16]. Total nitrogen was determined using the [30]. The pH of the soil was measured in water at soil to water ratio of 1:2.5 potentiometric pH meters with glass electrode [42]. The determination of organic matters and cation exchange capacity (CEC) was described by [30]. The available phosphorus content of the soil was determined by [26].

The organic carbon was determined according to the [34]. Thus, according to the soil laboratory results, soil of the study area is suitable for the production of sweet potatoes and other crops, but may not be sufficient for optimum production of sweet potato, as sweet potato required high level of soil nutrients due to relatively heavy feeders and shallow root system. Therefore, the analyzed soil results of the experimental area were fall in class of low soil fertility and the fertilizer use can be the right way to enhancing the growth of sweet potato varieties.

Table 4. *Some physical and chemical properties of soil before planting.*

soil particle in%			Soil type	Texture class	Soil chemical properties					
Sand	Silt	clay			pH	N%	A. P (ppm)	OC	OM	CEC (cmol)
52	33	13	Nitisols	Sandy loam	5.8^{sa}	0.26^{m}	10.1^{l}	2.03^{m}	3.5^{m}	9.11^{l}

Key: OC- organic carbon; OM- Organic matter; pH- hydrogen power, ppm- parts per million. Sa-slightly acidic, m-medium, l-low, pH-power of hydrogen, N-Nitrogen, P-Available phosphorus, Cmol- Cent mole

2.5. Experimental Procedures and Field Management

The experimental area was cleared, ploughed and harrowed, before planting. Lay out was done considering the slope gradients. The land was divided in three equal blocks each having 10 equal plots and received 10 treatment combinations. Plots were leveled and 25 cm height of ridges prepared using hand tools. Distance between block and plots were 1 m and 0.5 m respectively. The distance between rows and plants was 100 cm and 30cm [49] each plot containing 4 rows and 10 plants per row resulting in 40 plants per plot. Total experimental area was (483m^2) Length -34.5 m and width -14 m, the gross plot size for each treatment was 4m x 3m-12 m^2 and the net plot size was 2 m x 2.4 m – 4.8 m^2.

Blended NPSB fertilizers were used as a source of mineral nutrients and full doses which varied depending on treatments was applied as side banding at planting time. Vine cuttings of 30 cm length with six nodes were prepared from the healthy stem of each variety [35]. Planting was done on December, 6, 2019 at Bako Agriculture Research Center. Cuttings were planted on the ridges [6] with about three nodes buried in the soil uniformly for all treatments. The experiment was carried out using furrow irrigation starting from planting date to the harvesting date at seven-day irrigation intervals based on weather condition of the study area. Plots were irrigated until the soil was saturated. Other agronomic practices were kept uniform for all treatments. Weeding was done two times using manual method. Earthing up and other cultural practices were done according to the standard recommendation [25]. The data were subsequently taken from five randomly selected plants in the interior two rows.

2.6. Data Collection and Analysis

Five plants were tagged from each plot from two interior rows excluding the border rows. To evaluate the growth performance of sweet potato varieties all data on growth parameters were recorded. Data on Day to bud sprouting, Day to physiological maturity, Number of branches (Number plant^{-1}), Vine length (cm), Shoot fresh weight (g/plant), Shoot dry weight (g/plant). Finally data were subjected to analysis of variance using SAS statistical software (SAS Version 9.30) [41]. For treatment that was significant mean separation was done using the least significance difference (LSD) test at 5% probability level.

3. Results and Discussion

3.1. Influence of Blended NPSB Fertilizer on Phenology of Sweet Potato Variety

3.1.1. Days to Bud Sprouting

Days to bud sprout were highly significantly ($P < 0.01$) affected by the main effects and the interaction of blended NPSB fertilizer rates and Varieties. The highest days to bud sprouting (14.0) was recorded on Dimtu, which received 0kg ha^{-1} NPSB fertilizers, while the least number of days to bud sprouting (7.3) was recorded on Tola that received 200kg ha^{-1} NPSB fertilizers, however it was not significantly different from Tola variety treated with 150 kg ha^{-1} (8.3) of NPSB fertilizer (Table 5). Variety Tola showed a delayed bud sprouting by 1.3 days compared to variety Dimtu.

The differences in days to bud sprouting for varieties under different application rate of NPSB might be due to differences of the inherent genetic potential of varieties in response to nutrients. However, when NPSB applications were increased from 0 to 200kg ha^{-1} on both varieties there was slight decrease in days to bud sprouting. These is attributed to lack of essential nutrient for making metabolic process and differentiate buds at control treatments, so that days to bud sprout become increased.

This result is in line with the result of [51], who reported that the time taken for bud sprouting was significantly shorter by 1.25 and 1.78 days as N applications increased from 0 to 90 kg ha^{-1} and P applications increased from 0 to 75 kg ha^{-1}respectively. Similarly, [11] reported that when N and P applications were increased from 45 to 90 kg ha^{-1}and 25 to 75 kg ha^{-1} respectively, bud sprouting was uniform and early.

3.1.2. Days to Physiological Maturity

Days to physiological maturity was highly significantly ($P < 0.01$) affected by the main effect of blended NPSB fertilizer rates and variety, and their interaction ($p<0.05$). The highest days to physiological maturity (143.1) were obtained from the variety Tola with 200kg ha^{-1} blended NPSB fertilizer, which was not significantly different from Tola treated with 150 kg ha^{-1} (139.9) and 100 kg ha^{-1} NPSB fertilizer rate (136.69). However, the lowest days to physiological maturity (123) were obtained from Dimtu with control treatment (Table 5). In this experiment NPSB application at 200 kg ha^{-1} significantly reduced time to reach maturity by 20 and10 days over the control in Tola and

Dimtu sweet potato varieties respectively. The differences in days to physiological maturity of varieties may be attributed to genetic difference of varieties in response to nutrients.

The prolonged days to maturity may be attributed to the prolonged canopy growth in response to higher NPSB doses to maintain physiological activity for an extended period there by continuing photosynthesis. The use of inorganic fertilizer leads to increase the leaf area which increases the amount of solar radiation intercepted thereby increasing days to flowering, physiological maturity, plant height and dry matter accumulation.

The presence of N in excess promotes development of the above ground organs, synthesis of proteins and formation of new tissues are stimulated, resulting in vigorous vegetative growth and increases the days of physiological maturity. This is in agreement with the findings of [5] who reported that increasing the amount of N applied prolonged days to physiological maturity on sweet potato.

Table 5. *Interaction of sweet potato varieties and NPSB blended fertilizer on phenological data of days to bud sprout and physiological maturity.*

Treatment	NPSBkgha^{-1}	DBS	DPHM
Dimtu	0	14^{a}	123^{e}
	50	12.4^{ab}	130^{cde}
	100	10de	131.5^{cd}
	150	10.6^{cd}	133.2^{bc}
	200	8.6^{ef}	132.6^{bc}
Tola	0	12.6^{ab}	123.8^{de}
	50	11^{cd}	133.3^{bc}
	100	10de	136.6^{abc}
	150	8.3^{f}	139.9^{ab}
	200	7.3^{f}	143.1^{a}
CV (%)		4.54	1.76
LSD (0.05)		1.39	8.21

Means with the same letters in same column are not significantly different; N-Nitrogen, P-Phosphorus S-Sulfur, B-Boron, CV-Coefficient of Variation, LSD-Least Significance Difference, DBS-Day to bud sprout, PHM-Physiological maturity and kgha^{-1}-kilogram per hectare.

3.2. Influence of Blended NPSB Fertilizer on Growth Parameters

3.2.1. Vine Length

Vine length was significantly ($P < 0.01$) affected by the main effect and the interaction effect of blended NPSB fertilizer rates and varieties. The highest vine length was recorded by Tola variety that received 200 kg ha^{-1} NPSB fertilizer rate that scored 177.2cm. However, the lowest mean value of vine length (112.6 cm and 116.2 cm) was recorded from Dimtu and Tola variety at unfertilized plot, respectively (Table 6).

The possible reasons for the highest vine length observed from the higher combined application of NPSB blended fertilizer and varieties could be due to the presence of adequate amount of nitrogen and phosphorous which resulted in better vegetative growth, greater photo assimilate, activation of photosynthesis and metabolic processes of organic compounds in plants for the production of increasing vine length. The differences in vine length for varieties under different application rate of NPSB might be due to differences of the inherent genetic potential of varieties in response to nutrients.

In line with this, [3] reported that, the longest plant (122.4 cm) was recorded from BARI SP-5 sweet potato variety in combination with highest mineral fertilizer dose based on average yield goal. While the shortest plant (64.8 cm) was recorded from BARI SP-7 sweet potato variety in combination with control treatment. Similar to the result of the current research, highly significant differences were obtained in vine length among the sweet potato varieties evaluated [27; 39].

Boru, M. reported that, vine length showed increase with applied P up to the rate of 46 kg ha^{-1} P_2O_5 and further increase of P reduced vine length of Awassa-83 sweet potato [10].

3.2.2. Number of Branches Per Plant

Number of branches per plant was highly significantly ($P < 0.01$) affected by the main effect and the interaction of blended NPSB fertilizer rates and variety. The highest number of branches per plant (9.8 and 9.1) was recorded by Tola variety that received 200 kg ha^{-1} and 150 kg ha^{-1} NPSB fertilizer rate, respectively. However, the lowest number of branches per plant (3) was recorded from Dimtu and Tola variety at unfertilized plot (Table 6).

The increased numbers of branches in response to the increased rate of NPSB application might be attributed to increased concentration of nitrogen fertilizer in the soil that may have enhanced root uptake of the nutrient possibly resulting in increased concentration of chlorophyll in the leaves, heightened rate of photosynthesis, high rate of leaf expansion, increased leaf number, increased number of branches and dry matter accumulation in the aboveground biomass.

The differences in number of branches for varieties under different application rate of NPSB might be due to differences of the inherent genetic potential of varieties. The previous past history of planting material used those varieties are may be different, that means the plant which is prepared from good planting material are more vigorous, branched and good performance.

The current result is in conformity with the finding of [9] who reported significantly higher number (41.41) of branches per plant was recorded in Variety Tulla, while the lowest mean value (29.29) was recorded in the local variety compared to the remaining OFSP varieties. In line with the result of the current study, [17] concluded that sweet potato variety, SPK004 gave significantly higher number (4.83) of branches per plant while sweet potato varieties, NASPOT 2 and NASPOT 4 gave the least number (3.83) of branches per plant. The result is in agreement with [36] who reported that plant height and branching were cultivar dependent.

3.2.3. Shoot Fresh Weight

Shoot fresh weight was highly significantly ($P < 0.01$) affected by the main effect and their interaction of blended NPSB fertilizer rates and variety. The highest shoot fresh weight per plant (690g) was recorded from variety Tola that received 200 kg ha^{-1} NPSB fertilizer rate; it did not significantly differ Tola that received 150kgha^{-1} (668.3) and 100kgha^{-1} NPSB fertilizer rates. However, the lowest shoot fresh weight per plant (390g) was recorded from the variety Dimtu at unfertilized plot. However, it did not significantly differ from variety Tola at unfertilized plot (393.3g) (Table 6).

Table 6. *Interaction effects of sweet potato varieties and NPSB blended fertilizer on vine length, number of branches per plant, shoot fresh weight and shoot dry weight.*

Treatment	NPSB kgha^{-1}	VL (cm)	NBPP	SHFW (gplant^{-1})	SHDW (gplant^{-1})
Dimtu	0	112.6^{f}	3^{f}	390^{f}	123.6^{g}
	50	127.6^{e}	4.8^{e}	421.6^{ef}	132^{ef}
	100	132.3^{e}	5.8^{d}	456.6^{de}	136^{e}
	150	140.3^{d}	6.6^{cb}	500^{cd}	138.8^{de}
	200	144^{d}	7.5^{bc}	530^{c}	161.1^{c}
Tola	0	116.2^{f}	3^{f}	393.3^{f}	125.1^{fg}
	50	158^{c}	6.3^{d}	621.3^{b}	138.2^{e}
	100	161.4^{c}	7.9^{b}	653.3^{ab}	147^{d}
	150	166.7^{b}	9.1^{a}	668.3^{ab}	173.1^{b}
	200	177.2^{a}	9.8^{a}	690^{a}	187.4^{a}
CV (%)		1.95	6.85	3.64	2.41
LSD (0.05)		5.12	0.98	47.71	8.27

Means with the same letters in same column are not significantly different. N-Nitrogen, P-Phosphorus S-Sulfur, B-Boron, CV-Coefficient of Variations, LSD-Least Significance Difference, plant^{-1}- per plant, VL-Vine length, NBPP-Number of branches per plant, SHFW-Shoot fresh weight, SHDW-Shoot dry weight, gplant^{-1} -gram per plant, cm-Cent meter, kgha^{-1} -kilogram per hectare.

The increased shoot fresh weight in response to the increased rate of NPSB application might be attributed to increased concentration of nitrogen fertilizer in the soil that may have enhanced root uptake of the nutrient possibly resulting in increased concentration of chlorophyll in the leaves, heightened rate of photosynthesis, high rate of leaf expansion and increased leaf number in the aboveground biomass [38].

The observed differences of above ground fresh biomass among varieties may be mainly attributed to their inherent genetic constitution of difference of varieties. This is in agreement with [32] who reported that above ground fresh biomass yield is genetically controlled trait in sweet potato. The present result is in conformity with the findings of [23] who found that the application of 138 kg N ha^{-1}significantly increased shoot fresh weight of potato. The result is in agreement with [11] who found that as N levels increased from 0 to 90 kg N ha^{-1} on ridge seedbed, the highest shoot fresh weight of sweet potato (504 g hill^{-1}) was recorded at highest levels of N application (90 kg N ha^{-1}).

3.2.4. Shoot Dry Weight

Shoot dry weight was highly significantly ($P < 0.01$) affected by the main effect and their interaction of blended NPSB fertilizer rates and variety. The highest shoot dry weight per plant was recorded from variety Tola that received 200 kg ha^{-1} NPSB fertilizer rate and scored 187.4g plant^{-1}. The lowest shoot dry weight per plant (125.6g) was recorded from the variety Dimtu at unfertilized plot (Table 6). The differences in shoot dry weight of varieties under different application rate of NPSB might be due to differences of the inherent genetic response of varieties to nutrients.

The increased shoot dry weight in response to the increased rate of NPSB application might be attributed to increased concentration of nitrogen fertilizer in the soil that may have enhanced root uptake of the nutrient possibly resulting in increased concentration of chlorophyll, photosynthesis and dry matter accumulation in the aboveground biomass. This result is in line with the finding of [11] who reported highest shoot dry weight at 90kgha^{-1}N and 25kgha^{-1} of P (207g). The current result is in conformity with [5] who found that application of 92 kg N ha^{-1}and 23 kg P ha^{-1}increased significantly above ground dry biomass production in sweet potato.

4. Summary and Conclusions

Sweet potato (*Ipomoea batatas* (L.) Lam) is one of the most important root crops. It is an important crop and plays a major role in food security, poverty alleviation, and income generation. However, the production and productivity of the crop is constrained by various factors. The major causes of low yield include low soil fertility, use of poor agronomic practices, scarcity of information on the appropriate type and rates of fertilizers recommendations and shortage of improved varieties. Fertilizer containing S and B are important for improvement of yield of sweet potato.

Field experiment was conducted on blended NPSB fertilizer rate and sweet potato variety at Bako Agricultural Research Center during 2019/2020 using furrow irrigation. The results showed that interaction effect of varieties and NPSB rates highly significantly influenced fresh shoot and dry shoot weight and vine length. Physiological maturity was significantly influenced by the interaction effect of varieties and NPSB fertilizer rates.

The results of this experiment indicated that varieties and NPSB fertilizer rates highly significantly ($p<0.01$) and their interaction significantly ($p<0.05$) affected most of the growth parameters including: shoot fresh weight; shoot dry weight, vine length, days to bud sprout and days to physiological maturity. Tola at 100 kg ha^{-1}, 150 kg ha^{-1} and 200kg ha^{-1} NPSB fertilizer rates resulted in significantly ($p<0.01$) highest days to physiological maturity (136.69, 139.9 and 143.1) and the highest shoot fresh weight (653.3g, 668.3g and 690g), respectively. Dimtu at 0 kg ha-1 fertilizer rates resulted in significantly ($p<0.01$) highest days to bud sprouting (14.0). This result showed that application of blended NPSB fertilizer on the variety Tola produced better growth performance than Dimtu variety.

In conclusion, the above findings indicated that the growth and productivity of sweet potato at study area can be improved by the combined application of variety and blended NPSB fertilizer rate. However, as the results are limited to one season and location, further research needs to be conducted over more seasons and locations by considering also using the more than 200 kg ha^{-1} of blended NPSB fertilizer rates and additional varieties to generate more reliable information.

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