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Effect of NPSB Blended Fertilizer and Cattle Manure Rates on Growth, of Sweet Potato (*Ipomoea batatas* (L.) (LAM) at Bako, West Shewa Zone of Ethiopia

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Abstract: Sweet potato (Ipomoea batatas (L.) Lam) is an economically important and a food security root crop produced in Ethiopia. However, the production and productivity of the crop is low at national as well as regional level which is constrained mainly by low soil fertility. Lack of recommendation on appropriate rates of blended fertilizers and cattle manure is one of the problems limiting the production of sweet potato. A study was conducted to determine the combined effect of blended NPSB fertilizer and cattle manure rates on growth, yield and yield components of sweet potato at Bako Agricultural Research Center from December to April 2019/2020 using furrow irrigation. The treatment consisted four levels of blended NPSB fertilizer, (0, 50, 100 and 150 kg ha^{-1}) and three levels of cattle manure (0, 5 and 10 t ha^{-1}). The experiment was laid out in a Randomized Complete Block Design (RCBD) in a factorial arrangement and replicated three times. Data were collected on phenological, parameters growth of sweet potato. These data were subjected ANOVA using SAS (version 9.3) software. The results of analysis of variance showed that main effect of blended NPSB fertilizer and cattle manure rate were significantly ($P < 0.01$) affected and their interaction ($p>0.05$) affected. The number of branches per plants (NBPP), vein length (VL), total number of tuberes per plant (TNTPP) shoot fresh weight (SHFW), shoot dry weight (SHDW), The highest vine length (149.6cm), was recorded at 10 t ha^{-1}cattle manure +150 kg NPSB ha^{-1}, while the lowest vine length (108.10 cm), was recorded at control. In conclusion the result indicated that the growth, of sweet potato at study area can be improved by combined application of 150kg ha^{-1} NPSB blended fertilizers and 10 tone ha^{-1} cattle manure rates. As recommendation, further study needs to be conducted by considering higher combined application of blended NPSB fertilizer and cattle manure rates to find optimum growth of sweet potato that enables to obtain better result and to generate more reliable information.

Keywords: Mineral Fertilizer, Net Benefit, Organic Fertilizer, Soil Fertility, Tuberous Root Yield

1. Introduction

Sweet potato (*Ipomoea batatas* (L.) Lam) is a dicotyledonous plant belonging to the family Convolvulaceae [100]. 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 and it has a predominately prostrate growth habit typically with 1–5 m vines that grow horizontally on the ground [36].

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 [18].

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. Sweet potatoes are grown both in the short rainy season (February - April) and the long rainy season (July -

September), where the climate is warm and humid and an average temperature is approximately 24°C [9].

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 (Opeke, 2006). 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 [47].

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. Over 95% of the global sweet potato production is in developing countries. More than 140 million tons have been produced globally per year. The world average storage root yield had been estimated to be 14.8ton ha^{-1} [38].

Asia is the world's largest producing continent, followed by Africa. In Africa, the production of sweet potato is too low about 20.8, as compared to Asia which is about 75.1 [39]. In Africa, sweet potato is the 2nd most important root crop after cassava [24]. African farmers produce only about 9 million tons per annum which is mostly used for human consumption and to ensure food security [86].

Most varieties in sub-Saharan Africa are white-fleshed, low yielding and lacking β-carotene (Wariboko and Ogidi, 2014). 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 [9].

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 [5]. 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 [99].

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 1st position in root and tuber crops. It yields 3.46 ton ha^{-1}, 2nd place next to sugar cane [22].

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 yields were 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 [22].

However, the productivity of the crop remained low at national level (8 t ha^{-1}) for a long time [40]. 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 [61].

The potential yield of sweet potato reached up to 50 ton ha^{-1} on research station and 1.75-30.50 ton ha^{-1} on farms with improved agronomic practices [106]. The average yield of 37.1 ton ha^{-1} was obtained from Bellala variety in Adami Tulu area with application of different fertilizers [96]. The newly released Tola variety showed yield advantage of 83% over the standard check (Balo) [104].

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 if they are not replenished timely under intensive agriculture. In the years past, MoANRD recommended 175 kg ha^{-1} DAP and 80 - 100 kg ha^{-1} Urea in blanket for sweet potato root crop [56]. Currently, the ammonium fertilizer representatives, Sulfur and Boron containing fertilizers had been availed in Ethiopia [33; 10].

Cattle manure, contains large amount of nutrients and influences plant growth and production through improving chemical, physical and biological fertility. 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 were widespread in Ethiopian soils [33].

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 [34].

According to soil fertility maps [33], 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. Yield responses vary from variety to variety and from place to place [45].

However, little research undertakings were reported on the effects of rate of fertilizers such as blended NPSB fertilizer rate and Cattle manure on growth, yield and yield components of sweet potato on the study area. To address these gaps, the present work was initiated with the following objectives.

1.1. General Objective

To evaluate the effect of NPSB blended fertilizer and cattle manure rates on growth, of sweet potato around Bako District.

1.2. Specific Objectives

1. To determine the optimum rate of NPSB blended fertilizer and cattle manure rates on growth of sweet potato.
2. To assess the interaction effect of NPSB blended fertilizer and cattle manure rates on growth of sweet potato.

2. Literature Review

2.1. Origin and Botanical Description of Sweet Potato

Sweet potato originated from tropical Central America. Botanically, the underground part is classified as a storage root, rather than a tuber. Sweet potato is a perennial, although it is grown as an annual which belongs to the family of Convolvulaceae [35]. Christopher Columbus brought sweet potatoes to Europe after his first visit to the New World in 1492. The Spanish brought the crop to the Philippines and the Portuguese brought it to Africa, India, Indonesia and Southern Asia [37].

It has chromosome number of 2n = 90 and since the basic chromosome number for the genus *Ipomoea* is 15, it is hexaploidy and highly heterozygous cross-pollinated crop. Most varieties are self-incompatible and they cannot produce viable seed. It is also a branching, creeping vine with spirally arranged lobed, heart shaped leaves and white or lavender flowers depending on varieties. Enlarged roots called tuberous roots which stored energy for the plant and an economic part of the plant [28].

Vines can reach 4 m to 6 m in length depending on varieties, environmental conditions and agronomic practices. The skin and flesh colour may vary from variety to variety and the colours white, cream, yellow, orange, pink, or deep purple. White/cream and yellow/orange flesh colours are most common. Tuberous root can be shaped like a potato, being short and blocky with rounded ends, while other times it can be longer with tapered ends depending on varieties and sandy soil on which grown. Intensity of the tuberous root flesh color like yellow or orange flesh is directly correlated with its beta-carotene content [28].

2.2. Sweet Potato Improved Varieties Released in Ethiopia

Sweet potato is a co-staple crop in East Africa's mid-elevation farming areas. In Ethiopia, the number of sweet potato producers has increased recently and the crop is now considered as a major food crop, with 1.6 million producers [22]. It is mainly used for household consumption (82%), with only a small portion of the crop being sold (12%). Sweet potato seed system is almost entirely informal, with only occasional formal distributions of new varieties by agricultural research centers or non-governmental organizations [72]. The crop is generally propagated from farmer to farmer by vine cuttings obtained from mature crops. The crop requires low levels of inputs, can grow on degraded soils and is easily propagated from vines. Sweet potato is often regarded as a food security crop, having a flexible growing season over a 3-to 10-month period. The crop is also good to cope with slack season because it is possible to harvest sweet potato before the harvest season for other crops, at times when food shortages are common. Finally, sweet potato is a candidate of choice for biofortification the breeding of micronutrients into crops to control vitamin A, iron and zinc deficiencies [15].

Indeed, different varieties of sweet potatoes have different nutritional value. Orange-fleshed sweet potato varieties have high beta-carotene content and represent a promising and cost-effective way to combat micronutrient deficiencies, which are prevalent through the developing world. There is mounting evidence that the introduction of orange-fleshed sweet potato can increase vitamin A intakes among children and women [52] and reduce children's diarrhea prevalence and duration.

With the objective of spreading an 'orange revolution', several projects have been implemented to promote and disseminate orange-fleshed varieties [66]. In Ethiopia, the term 'improved variety' is used to designate a variety that has been tested by breeders and evaluated for its superiority over existing (traditional or local) varieties (Ethiopian Ministry of Agriculture, 2013).

The list of improved sweet potato varieties released in Ethiopia is provided in Table 1. Since 1990, a total of 25 improved sweet potato varieties have been released. Breeding and germplasm maintenance activities have been concentrated in the Southern Nations, Nationalities and Peoples' Region (SNNPRS) and Oromia [66]. Five orange fleshed varieties have been released and promoted for their higher nutritional content: Koka-12, Guntutie, Kero, Kulfo and Tulla.

2.3. Status of Sweet Potato Production in Ethiopia

Sweet potato is cultivated in Ethiopia mostly for human consumption and animal feed. It is manly grown by small scale, resource poor farmers. Even though, there are favorable agro ecological conditions, like good climatic sweet potato yields in Ethiopia are low. Sweet potato is adapted to tropical zone and subtropical zone of Eastern, Southern, and South-western parts of the country [93]. Since the establishment of agricultural research, a number of varieties have been releasing by Federal, regional and higher learning institute research system. Even though many of the varieties are WFSP which are low in vitamin A, some orange fleshed are released in Ethiopia. They were released under mandate of Hawasa, Sirinka, Bako, Werer and Haremaya University [93].

***Table 1**. Released Sweet potato varieties in Ethiopia.*

No	variety	Year release	Altitude	Maturity date	Flesh colour	Yield/Quintal	Center released
1	Kulfo	2005	1200-2200	150	Orange	127	Hawasa

No	variety	Year release	Altitude	Maturity date	Flesh colour	Yield/Quintal	Center released
2	Tulla	2005	1200-2200	150	Orange	285	Hawasa
3	Kero	2005	1200-2200	150	Orange	354	Hawasa
4	Kudade	1997	1200-2200	90-120	Cream	241	Hawasa
5	Falaha	1997	1200-2200	90-120	White	167	Hawasa
6	Dubo	1997	1200-2200	90-120	White	217	Hawasa
7	Guntutie	1997	Mid-altitude	120-150	Orange	354	Hawasa
8	Bareda	1997	1200-2200	120-150	White	296	Hawasa
9	Damota	1997	1200-2200	120-150	Cream	307	Hawasa
10	Awasa	1998	1200-2200	150-180	White	366	Hawasa
11	Koka-12	1987	1200-2200	120-150	Pale orange	177	Hawasa
12	Koka-6	1987	1200-2200	120-150	Cream	269	Hawasa
13	Belella	2002	1200-2200	90-120	Cream	183	Hawasa
14	Temesgen	2002	1200-2200	90-120	White	176	Hawasa
15	Ordollo	2005	1200-2200	150	White	173	Hawasa
16	Jari	2008	1650-1850	133	Yellow	192	Sirinka
17	Birtukane	2008	1650-1850	150	Orange	199	Sirinka
18	Berkume	2007	1650-2000	188-195	White	195	Har Uni.
19	Adu	2007	1650-2000	150-180	Cream	160	Har Uni.
20	Ballo	2006	1400-1800	120	White	294	Bako
21	Beletecch	2004	1200-2200	150	White	184	Hawasa
22	Dimtu	2005	1200-2200	120	White	NA	Hawasa
23	Ogansenga	-	1200-2200	-	White	NA	MoA
24	Mae	2010	300-980	-	White	NA	Werer
25	Tola	2012	1500-2010	120	White	NA	Bako

Source: Ethiopian Ministry of Agriculture, 2013. NA = Not available

2.4. Sweet Potato Production Constraints in Ethiopia

Production of sweet potato is constrained by biotic and abiotic factors. The biotic factors include diseases, insect pests and weeds; whereas abiotic factors are drought, heat [73]. Constraints related to socio-economic and quality attributes are: lack of improved varieties, lack of planting materials, low storage root yield, low or zero beta carotene content in white fleshed sweet potato and low storage root dry matter content of Orange flesh Sweet potato which are available currently [23].

Sweet potato production is constrained by the lack of clean planting materials, lack of high yielding cultivars, low soil fertility [73]. Similarly, the unavailability of high-quality planting material of improved varieties is another major limitation in increasing sweet potato production.

Inadequate supply of improved varieties among the farmers, less adoption rate of improved agronomic practices and insect pest damage causes low productivity in sweet potatoes production.

Due to the low level of agricultural input requirement, high productivity per unit area, good nutritional value and increasing food demand owing to high population growth of the country, sweet potato is one of the ideal starch staple for food security of the country. The major postharvest constraints among farmers were: poor prices, low yields, low dry matter content of tuberous roots, lack of knowledge about tuberous roots processing and preservation [40].

2.5. Economic Importance of Sweet Potato

Sweet potato tuberous root is high in food value, fiber and energy; it is rich in sugar and vitamin C. It also contains good quantities of vitamin A, vitamin B, calcium and iron [51]. It provides a healthy diet for millions of people across the country [48]. Moreover, it is commonly cultivated as an integrated crop, along with livestock, in the crop livestock farming systems [9].

South Nation, Nationalities and Peoples' Region (SNNPRS) and Oromia are the main regions that produce sweet potato in Ethiopia [51]. Sweet potato is an important crop in many parts of the world. The storage roots of sweet potato serve as staple food, animal feed and to a limited extent as raw material for industrial purposes as a starch source and for alcohol productions. The crop is one of the root and tuber crops grown in Ethiopia, and it is the third important root crop next to Enset and Potato [32].

The area covered and production of sweet potato in Ethiopia is increasing from time to time. However, its production is very limited to specific regions, like that of South Nation, Nationalities and Peoples, Oromia, and Amhara regions. Roots and tubers, most notably potato, cassava, sweet potato and yam are some of the most important primary crops ranking 4^{th}, 5th, 7^{th} and 9^{th}, respectively in the world. They play a critical role in the global food system, particularly in the developing world, like Africa and Asia, [83].

Globally sweet potato is the seventh rank (Birhanu *et al.,* 2014). Most important food crop in terms of production. It is grown on about 8.2 million hectares producing about 102 million tons with an average yield of 12.1 tons ha^{-1}. Sweet potato is one of the most widely grown root crops in sub-Saharan Africa [64] and it is particularly important in countries surrounding the Great Lakes in Eastern and Central Africa such as Malawi, Angola and Mozambique, and Madagascar in Southern Africa and Nigeria in West Africa [89]. Sweet potato is a major crop in most eastern and southern African countries such as Uganda, Rwanda, Kenya, Tanzania, Ethiopia, Zambia, Mozambique and South Africa [89].

In Ethiopia sweet potato is one of the most important horticultural crops widely grown in the eastern and southern regions. It grown in the low land and mid altitude areas of the country and occupies more than 52,000 ha^{-1}. Over 80% of the sweet potato produced in Sub Saharan Africa (SSA) is consumed fresh by human beings. The remainder is used for animal feed. Awareness of sweet potato as a healthy food crop is increasing, especially the orange fleshed sweet potato which is rich in pro-vitamin A carotenoids [45].

The roots of sweet potato are mainly starch and soluble carbohydrates, but the leaves and vines are high in amino acids, essential minerals and vitamins [2].

Sweet potato is a tuber root-bearing vegetable species grown in tropical areas for either domestic or industrial uses [57]. Root of sweet potato is rich in vitamin A, B6, C, riboflavin, copper, pantothenic and folic acid. These tubers have great food quality and an excellent source of anti-oxidants and carotenes [105].

The crop has several industrial uses, including medicinal purposes; use for treating diabetes, hookworms, ulcer and internal bleeding. [11],

2.6. Effects of Mineral Fertilizers on Growth of Sweet Potato

Growth parameters are the main important yield determining factors in sweet potato and they are highly influenced by soil fertility and soil amendments [45]. Yield of sweet potatoes crops are significantly affected by adding inorganic fertilizers [4]. The vegetative growth of “Beaure Gard” cultivar of sweet potato plants were significantly increased with increasing P rate from 35.71 kg ha^{-1} P_2O_5 up to 107.14 kg ha^{-1} P_2O_5 [87],. Plants which received the later rate had showed significant increases in main stem length, canopy dry weight, leaf area, total chlorophyll, carotenoids, marketable yield, total yield, dry matter percentage of tuber root, tuber root weight and diameter compared to the other rates [31].

Vine length was highly influenced by the interaction effect of FYM with P. As application of 0 ton FYM ha^{-1} + 0 P_2O_5 increased to 15 ton FYM+90 kg ha^{-1} P_2O_5, average vine length increased by about 51.86% [3]. Applications of N and P (46 N kg ha^{-1}, 23P kg ha^{-1}) significantly increased tuber number and vine length [6].

On most soils, tuber yield is increased by the application of nitrogen fertilizer. However, an excess of Nitrogen can stimulate increased foliage production at the expense of tubers and may also lead to tuber cracking [56].

Stated that the use fertilizer varies from region to region and the experience of some African country may apply in our country and indicate that use of Nitrogen beyond 45N kg ha^{-1} enhance vegetative growth rather than root growth [6].

Increasing the amount of N application significantly promoted shoots growth at the expense of tuber growth on ridge seed bed [6]. Adequate supply of N and P promotes higher photosynthetic activity and vigorous vegetative growth and promotes the chance for emergence of new vines.

Increasing N levels from 0 to 45N kg ha^{-1} significantly increased the internodes length of Sweet potato. Commonly adequate supply of N is associated with high photosynthetic activity and vigorous vegetative growth thereby increasing internodes lengths [16].

Stated that, even though shoot fresh weight Sweet potato (Bellala) of is benefited at the highest level of farmyard manure, shoot dry weight was increased as the proportion of farmyard manure to phosphorus decreased [3]. Days to maturity obtained at 15 ton FYM ha^{-1} + 180 $kgha^{-1}$ P_2O_5 was 22.76 % earlier than the one obtained at combined application of 10t FYM ha^{-1}+ 90kg FYM ha^{-1} [3]. Applications of N and P (46 kg ha^{-1}N, 23 kg ha^{-1} P) significantly influenced days to maturity [6]. Shoot dry weight of sweet potato was also highly responsive and significantly affected by the combined application of farmyard manure and phosphorus. Nitrogen affects the distribution of dry matter within the plant, particularly affecting root growth relative to top growth, delay tuber bulking and maturation (Bradbury and Holloway, 1988).

The rate of FYM decreased from 20 ton ha^{-1} to 0 ton ha^{-1} and concurrently as the rate of P increased from 0 kg ha^{-1} P_2O_5 to 180 kg ha^{-1} P_2O_5, shoot dry weight of Sweet potato (Bellala) increased by 215.8% and was statistically significant [3]. This indicates that even though shoot fresh weight is benefited at the highest level of farmyard manure, shoot dry weight was increased as the proportion of farmyard manure to phosphorus decreased [6, 3]. Total dry matter production and efficiency of dry matter allocation to storage roots are important factors determining storage root yield. Some reports indicate a linear increase in total yield and storage root dry matter in phosphorus application [70]. Applications of N and P (46 kg ha^{-1} N, 23 kg ha^{-1} P) significantly increase dry matter content [6].

All dry matter content of “Beaure Gard” cultivar of sweet potato were significantly increased with increasing P rate from 15 kg /fed P_2O_5 (35.71 kg ha^{-1} P_2O_5 or 15.7 P kg ha^{-1}) up to 45 kg /fed P_2O_5 (107.14 kg ha^{-1} P_2O_5 or 47.1 kg ha^{-1}p), [31]. Dry matter is one of the most important quality aspects in Sweet potato and most of the OFSP genotypes evaluated ranged between 25 and 30% at Malawi. Further indicated that, dry matter content in the boiled or roasted Sweet potato meal was a property that most preferred by consumers [55].

2.7. Effect of Cattle Manure on Growth of Sweet Potato

Organic manures and their extracts have been used to improve soil fertility and in combating pests and diseases [58]. Use of animal manure such as cattle manure has positively beneficial effects on vegetative growth, yield and tuber quality [8, 71].

Nutrients contained in organic manures are released more slowly and are stored for a longer time in the soil, thereby ensuring a long residual effect [88], supporting better root development, leading to higher crop yields [65].

Cattle manure is the main source of nutrients for the maintenance of soil fertility in settled agriculture until the advent of mineral fertilizers. The advantage of cattle manure application depends on application methods, which increase the value, reduce cost and effectiveness.

Increased plant height, shoot number, leaves area, and total dry matter accumulation were obtained by the application of appropriate amount of animal manure [1]. The increase in yield is due to more availability of essential nutrients to plants and improvement in physico- chemical properties of soil, resulting in better tuberization [59].

All these might have accelerated metabolic activities leading to better photo syntheses and efficient translocation of photosynthesis from sink to sources resulting in improvement of leaf yield and its related attributes. Regular application of organic amendments can sustain soil N fertility and increase marketable potato yields by 2.5 to 16.4 t $ha^{-1,}$ compared to the un amended and unfertilized soil.

The application of FYM substantially increased the total sweet potato yield by 25% as compared to control [17]. High ware potato yield was obtained with, 20 t FYM ha^{-1} [85].

2.8. Effect of Combined Use of Inorganic Fertilizers and Cattle Manure Rates on Growth of Sweet Potato

Inorganic fertilizers are considered to be an important source of major elements in crop production. Continuous use of inorganic fertilizer resulted in deficiency of micro nutrients, imbalance in soil physicochemical properties and unsustainable crop production [53].

Nutrients in manure and balanced supplement of nitrogen and phosphorus through mineral fertilizers might have contributed to increased cell division, expansion of cell wall, meristemtic activity, photosynthetic efficiency and regulation of water intake into the cells, resulting in the enhancement of yield parameters [67]. The maximum tuber yield (36.8 t ha^{-1}) was obtained by using 150 kg N ha^{-1} + 20 t CM ha^{-1}. For instance, in Kenya, reported that a combination of P at 100.4 kg ha^{-1} and FYM at 20t ha^{-1} resulted in an increase of 62% of fresh tuber yield compared to the control [85].

Soil amended with 45 t ha^{-1} FYM increased in potato yield by 23% compared to the yields from non-amended soils [84]. Higher tuber yield of potato when mineral NPK fertilizers were applied at the rate of 95.2, 66.7, and 145.2 kg ha^{-1}, respectively along with 10t ha^{-1} cow dung compared to that of without cow dung application [90].

To ensure soil productivity, plants must have an adequate and balanced supply of nutrients that can be realized through integrated nutrient management where both natural and man-made sources of plant nutrients are used [46].

Combining inorganic and organic fertilizers result in greater benefits than either in put alone through positive interactions on soil biological, chemical and physical properties. The applications of recommended mineral fertilizers do not improve the negative nutrient balance due to the higher nutrient removal from the soils. Many researches recommend integrated soil amendment practices because single application or practices could not reverse the existing problem. It is crucial to note that greater crop productivity induced by the use of mineral fertilizers does not translate into better soil fertility in the long term when large amounts of carbon and nutrients are removed every season from the fields with the crop harvests residue. Therefore, the use of integrated nutrient management is very important and best approach to maintain and improve soil fertility there by to increase crop productivity in an efficient and environmentally friendly manner without sacrificing soil productivity of future generations [27].

Integration of inorganic NPS and cattle manure exhibited an increase in tuber yield of sweet potato. This could be due to balanced C/N ratio; more organic matter builds up, enhanced microbial activity, improvement in soil properties, better root proliferation, sustainable availability and accelerated transport and higher concentration of plant nutrients. All these might have accelerated metabolically activities, leading to better photosynthesis and efficient translocation of photosynthesis from sink to sources [80].

Under Ethiopian condition particularly in the highlands, integrated soil fertility management can give better yields as high as balanced application of fertilizer and significantly higher yields than the traditional cultivation method. To recovering the soil to its productive state it was not enough to apply mineral fertilizer alone, therefore integrated nutrient management was considered for the area.

The combined use of organic manure and inorganic fertilizers helps to maintain soil health and sustain productivity especially in heavy feeder crop like potato, sweet potato [69].

Organic manure significantly enhances growth and yield of crops [92]. The use of organic manure enhances fertilizer use efficiency of crops [68]. Growth promoting substances like enzymes and hormones present in organic manures make them useful for improvement of soil fertility and productivity [87]. Application of organic manure produced high and sustainable crop yield, also asserted that organic manures increase can enhance the nutrient status of fruits.

Integrated with inorganic fertilizers, the use of farmyard manure alone may not fully satisfy crop nutrient demand, especially in the first year of application [82]. However, it was revealed that animal manure is useful in improving the efficiency of fertilizer recovery thereby resulting in higher crop yield [43].

The possibility of saving up to 50% of the recommended NP fertilizers due to amendment with 5-15 t ha^{-1} of farmyard manure to sorghum crop without significantly affecting the optimum possible yield that can be obtained with the application of full dose of inorganic NP fertilizers alone [101]. The results of an experiment conducted by showed that sweet potato fresh weight is highly responsive to increased levels of farmyard manure [6]. The rate of farmyard manure increased, the development of green top at the expense of production of tuberous root yields was promoted.

Also observed that if sweet potato is produced for livestock feed, application of high rate of farmyard manure helps for better fresh foliage production since increasing farmyard manure application and foliage development are positively correlated [95]. The effect of farmyard manure on average vine length is particularly high [98].

Tuberous root yield components of sweet potato was significantly enhanced in response to the application of farmyard manure, indicating that enriching the soil of the area with organic matter through the use of organic fertilizers holds the key for maximizing the yield of the sweet potato crop in the Central Rift Valley of Ethiopia [97].

Vine development of potato in response to application of cattle manure [71].

Increase in vine length of sweet potato in response to increased rate of farmyard manure and ascribed it to increase in availability of nutrients in the soil for uptake by plant roots that may have enhanced vegetative growth through increasing cell division and elongation [50]. Integrated use of organic waste and N fertilizers significantly increase the uptake of the N. The combination of organic fertilizer and inorganic fertilizers promote plant growth the most [21].

Combination of organic and inorganic sources of nutrients might be helpful to obtain a good economic return with good soil health for subsequent crop yield [27]. Also, it was reported in an experiment that the integrated use of farmyard manure and commercial N, P fertilizers significantly enhanced potato tuber yield as compared to the use of each fertilizer source separately, thus potentially reducing the cost of production [94].

3. Materials and Methods

3.1. Description of the Study Area

The study was conducted at Bako Agricultural Research Center, in Bako Tibe District of West Shewa Zone, Oromia National Regional State during the 2019/2020 using irrigation system. Bako was located at 260 km at the western direction from Addis Ababa on the main road to Nekemte. Bako Agricultural Research Center (BARC) 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 average rain rainfall of 1035-1290 mm year^{-1} and hot humid weather 13.3°C minimum and 28°C maximum annum^{-1} [102]. The soil of the site was characteristically Nitisol [104] which is slightly acidic with pH of 5.80 and sandy loam in texture with sand 52%, silt 33% and clay 13% in content (Table 2).

Table 2. *Some Physico-chemical properties of soil before planting.*

Parameter	Result	Rating	Reference
pH	5.8	Slightly acid	(Hazelton and Murphy, 2007),
OC %	2.03	Medium	Nethelands MoA (1985)
OM%	3.50	Medium	Ladon, (2014)
Total N%	0.26	Medium	Ladon, (2014)
Available P	10.1 (ppm)	Low	Karltun *et al.,* (2013)
CEC	9.11 (meq/100g soil	Low	Ladon, (2014)
Textural class:	Sandy loam	-	DAY, (1965)
Sand	52	-	-
Silty	33	-	-
Clay	13	-	-

Key: OC=Organic Carbon; OM=Organic Matter; TN=Total Nitrogen; AP=Available Phosphorous; CEC=Cation exchange capacity.

Furthermore, the results obtained showed a total nitrogen content of 0.26 %, which is medium 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 of 10.1 ppm which is low according to the rating by who described soils with available P content of less than < 10ppm as low [54]. Thus, soil of the experimental site is very low in available P content. The Netherlands commissioned study by also 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 [75].

Therefore, the organic carbon content of the soil (2.03%) of the experimental site is medium. This shows that the soil needs additional external organic matter supply to nourish the plant. Soils having CEC greater than 40 Cmol (+)/kg are rated as very high and 25-40 Cmol (+)/kg as high, 15-25, 5-15 and < 5 Cmol (+)/kg of soil are classified as medium, low and very low, respectively, in CEC [62]. Thus, the soil of the study site with the CEC of 9.11 Cmol (+)/ kg is rated as low.

3.2. Description of Experimental Materials

Tola sweet potato variety was used for the experimental material. This variety was released from Bako Agricultural Research Center (BARC). The description of Tola variety presented in Table 3. The cultivar this variety was selected because of its adaptability, high tuber yield and diseases resistance in the study area [19].

The released variety, *Tola* has lobed leaf shape, creamy skin color of root, white flesh color and with axial leaf vein of purple spot in several veins. This variety has high in energy, dietary fiber, potassium and vitamin C, low in fat and is important sources of the dietary antioxidant *β*-carotene [104].

Tola variety of sweet potato was tested for its adaptation in Bako Tibe Woreda and under distribution to farmers by Bako Agricultural Research Center (BARC) for cultivation [104].

Table 3. *Some characteristics of sweet potato variety Tola.*

Year of Release variety	Research Station place	Altitude	Rain fall	Maturity	Reference
		m. a. s. l	(mm) year[1]	Day of maturity	
2012	Bako	1500-2010	1035-1290	100-120	(Wendimu *et al*., 2015).

Source: BARC (Bako Agricultural Research Center)

3.3. Treatments and Experimental Design

The treatments were two factors namely four level of blended NPSB fertilizer application rates (0, 50, 100 and 150kg ha^{-1}) based on agricultural transformation agency tentative fertilizer recommendation rate on the study area 100kg ha^{-1} blended NPSB fertilizer was tentative recommendation [33].

Cattle manure was used as organic fertilizer. The three levels of cattle manure rates (0, 5 and 10t on ha^{-1}). It was collected from the dairy farm of Bako Agricultural Research Center and well decomposed before application and applied to soil at one month before planting [44].

The experimental designs were laid out as a randomized complete block design (RCBD) in a factorial arrangement and replicated three times [103].

There were twelve treatment combinations, which were assigned to each plot randomly. They are indicated in Table 4.

Table 4. *Description of treatment combination CM and blended NPSB fertilizers rate.*

Treatment	Description
T1	Control (0 NPSB + 0 CM) kg/t ha^{-1}
T2	50 kg ha^{-1} blended NPSB fertilizers +0 ton ha^{-1} cattle manure
T3	100 kg ha^{-1} blended NPSB fertilizers +0 ton ha^{-1} cattle manure
T4	150 kg ha^{-1} blended NPSB fertilizers +0 ton ha^{-1} cattle manure
T5	(0 + 5 tha^{-1} Cattle manure)
T6	50 kg ha^{-1} blended NPSB fertilizers+5 ton ha^{-1} cattle manure
T7	100 kg ha^{-1} blended NPSB fertilizers+5 ton ha^{-1} cattle manure
T8	150 kg ha^{-1} blended NPSB fertilizers+5 ton ha^{-1} cattle manure
T9	(0+ 10 tha^{-1} Cattle manure)
T10	50 kg ha^{-1} blended NPSB fertilizers+10 ton ha^{-1} cattle manure
T11	100 kg ha^{-1} blended NPSB fertilizers +10 ton ha^{-1} cattle manure
T12	150 kg ha^{-1} blended NPSB fertilizers +10 ton ha^{-1} cattle manure

Key: NPSB= Blended Nitrogen (N), Phosphorus (P), Sulfer (S) and Boron (B), CM= cattle manure, T= Treatment

The elemental content of 100, kg NPSB is N= 18.9% Nitrogen, Phosphorus P_2O_5= 37.7%, Sulfur S=6.95% and Boron B= 0.1% [10]. Fertilizer NPSB at the rate of 100 kg /ha^{-1} had been recommended in Bako Agricultural Research Center (BARC) including experimental site [34]. The content and formulated of NPSB Blended fertilizers were, indicated in table below.

Table 5. *Rate of NPSB formulated and tested of fertilizers.*

NPSB	Rate	Element content			
Treatments	NPSB kg ha^{-1}	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

Key: NPSB= Blended Nitrogen (N), Phosperus (P), Sulfur (S) and Boron (B) fertilizer

3.4. Experimental Procedure and Crop Management

The experimental area was cleared, ploughed, harrowed, ridged and well decomposed cattle manure was incorporated into the soil at before planting. Lay out was done considering the slope gradients and Plots were leveled and ridges prepared using hand tools. The land was divided in three equal blocks each having 12 equal plots and received 12 treatment combinations. Distance between block and plots were 1 m and 0.5 m between plots respectively. The distance between rows and plants was100 cm and 30cm [104] on plots with the size of 3×4 m containing 4 rows and 10 plants per row resulting in 40 plants per plot.

Total experimental area was ($581m^2$) Length =41.5 m and width = 14 m, there were the gross plot size for each treatment was 4m x 3m= 12 m^2 and the net plot size was 2 m x 2.7 m = 5.4 m^2. The height of ridge was 25 cm. Blended NPSB fertilizers were used as a source of mineral nutrients and full doses which varied depending on treatments were applied as side banding at planting time and well decomposed cattle manure also used as sources of nutrients and full doses which varied depending on treatments was applied at one month before planting the Sweet potato vines and homogeneously applied and distributed into desired the plots, then incorporated into the soil at the depth of 20 cm

[44].

Vine cuttings of 30 cm length with six nodes were prepared from the healthy stem of each variety [77]. Vines planted at 45^0slant on the prepared ridge and Planting was done on December, 6, 2019 at Bako Agriculture Research Center.

Cuttings were planted on the ridges [7] 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 Bako area. Plots were irrigated until the soil was saturated. Other agronomic practices were kept uniform for all treatments as recommended. Weeding was done two times after planting using manual method. Earthing up and other cultural practices were done according to the standard recommendation [48]. The data were subsequently taken from five randomly selected plants in the interior two rows.

3.5. Data Collected Procedures

Five plants were tagged from each plot from two interior rows excluding the border rows [78]. All yield and yield components of data were collected from sample plants. All data collections were done in the morning. Data on different growth and yield and yield components were recorded on sample plants and plot basis. The detailed methodologies adopted for collection of different data are described below [19].

3.5.1. Phenological Data Parameters

Days to bud sprouting: It was recorded by counting the number of days from date of planting to when 50% of the vine cutting produced sprout in each plot.

Days to physiological maturity: It was recorded as the number of days from planting to the day on which about 90% of the plants in each plot turned leaves to yellowish.

3.5.2. Growth Parameters

Number of branches per plant (NBPP): The number of primary and seconder branches was determined by counting from each of the five tagged plants on every plot. The mean value was estimated and express as number of branches per plants for each plot.

Vine length (cm): It was determined as average vine length of five randomly selected plants by measuring the vine length from the base of the plant to terminal tip at physiological maturity.

Shoot fresh weight (SFW) (g/plant): Includes fresh mass of vines and leaves. It was recorded by taking random samples of five plants per plot at harvesting stage and express in gram per plant.

Shoot dry weight (SDW) (g/plant): Includes dry mass of vine and leaves. It was recorded at physiological maturity. The above ground biomass was harvested by cutting vines close to the soil surface from five plants per plot and express in gram. Putting them in a forced air circulation oven at 80°C for 24 hours until a constant weight is attained.

3.6. Data Collection and Analysis

Data collected were subjected to analysis of variance (ANOVA) using the general linear model (GLM) SAS statistical software package (SAS, Version 9.3). Data were checked for normality and homogeneity, residuals. For treatments that were significant, mean separation was done using the Least Significant Difference (LSD) test at 5% probability level. Treatment means were compared using LSD test at 5% probability level.

4. Results and Discussion

4.1. Effect of Blended NPSB Fertilizer and CM Rates on Phenological Parameters

4.1.1. Days to Bud Sprouting

Days to bud sprouting was significantly ($P < 0.01$) influenced by the main effects of blended NPSB fertilizer and cattle manure rates their interaction also significantly ($p<0.05$) affected days to bud sprouting. The fastest days to 50% bud sprouting (7.34 days) was recorded at combination of 10 t ha^{-1} Cattle manure and 150 kg blended NPSB. This was followed by the combined application of 5t ha^{-1}CM and 150 kg ha^{-1} of blended NPSB fertilizer faster 7.8 days (Table 6), which may be due to better water holding capacity of the applied CM around root zone of the cuttings which enables initiation of roots and make the buds to sprout early.

Days to budding was delayed at treatments with no fertilizer which indicated that application of organic manure is very important for root initiation and prolification which speeds up budding of plants. Days to budding was faster at treatments with number fertilizer which indicated that application of CM/compost is very important for root initiation and which speeds up budding of plants [14]. This finding is similar with the result of that the main effects of P and farm yard manure and its interaction significantly influenced days to bud sprouting of sweet potato [97].

Organic fertilizers like phosphorus enhance the establishment of crops while those from mineralization of organic manure promoted and prolonged vegetative growth and yield when both fertilizers were combined [41, 88]. This result was in line with the findings of who reported that stimulation of root growth (initiation and proliferation of root hair), increased root biomass, enhanced plant growth and development with the application of vermicompost/ farmyard manure, because of the presence of humic acids due to water retention around root area of sweet potato plants which helped the cuttings to bud earlier [97]. This may be due to better water holding capacity of the applied cattle manure around root zone of the cuttings which enables initiation of roots and make the buds to sprout early.

Similarly, indicated that even though most of the yield and yield components of sweet potato were responsive to combined application of the two fertilizers, the crop benefited much from combined application of P and FYM to produce buds at earlier time [97]. As the combined application of the two levels increased, the crop required fewer days to produce sprout.

4.1.2. Days to Physiological Maturity

Days to physiological maturity was significantly (P<0.01) affected by the main effects of cattle manure and blended NPSB fertilizers rates and their interaction was also significantly (P<0.05). The highest days to physiological maturity (149.8) was observed as a result of interaction of 10 t cattle manure ha^{-1}, and 150 kg ha^{-1} of blended NPSB fertilizers followed by the value (140.3) obtained due to combined application of 5 t cattle manure ha^{-1} and 150 kg ha^{-1} NPSB of blended fertilizer but the lowest day (122) was observed at 0t ha^{-1}CM and 0 kg NPSB, ha^{-1} (Table 6), the result indicated that increasing rate of CM delayed time of maturity of sweet potato which may be attributed to the role that manure plays significant role in promoting vegetative growth before the start of tuberous root development as nitrogen promotes vegetative. Days to maturity was decreased by 18% lower than at application of 10 t cattle manure ha^{-1} + 0 t cattle manure ha^{-1} as compared to the control. The findings of this study are in agreement with the work of who reported that the application of N and P fertilizers delayed flowering and prolonged days required to attain physiological maturity of potato [107].

According to increasing rate of FMY delayed time of maturity of sweet potato which may be attributed to the role that manure plays significant role in promoting vegetative growth before the start of tuberous root development as nitrogen promotes vegetative and lush growth thereby delaying plant maturity [14]. According to the application of N resulted in significantly delayed physiological maturity [74]. Days to maturity of potato varieties varied from 90 to 120 days and the variation is accounted for by variety, growing environment and cultural practices [30]. 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. This increases the days of physiological maturity [63].

Table 6. *Interaction effect of Cattle manure and blended NPSB fertilizer on days to bud sprouting (DBS), and days to Physiological maturity (DPhM) of sweet potato at Bako during the 2019/2020 under irrigation.*

Treatment		**Phenological variables**	
Cattle manure + t/ha^{-1} (cm)	**Blended NPSB fertilizers kg/ha-^{1}**	**Days to 50% bud Sprouting**	**Days to Physiological Maturity**
0	0	14.23^{a}	122^{g}
	50	12.94^{b}	128.3^{ef}
	100	10.47^{cd}	135.8^{c}
	150	8.38^{ef}	138.3^{bc}
5	0	13.47^{b}	126^{f}
	50	11.18^{c}	130.6^{de}
	100	10.26^{d}	136.5^{c}
	150	7.88^{fg}	140.3^{b}
10	0	13.17^{b}	129.1^{def}
	50	11.01^{cd}	132.3^{d}
	100	8.75^{e}	135.8^{c}
	150	7.34^{g}	149.8^{a}
LSD (0.05)		0.75	3.45
CV (%)		4.18	1.33

Key: Means with the same letter(s) in same column are not significantly different at 5% level of significance. NPSB=Blended, N=Nitrogen, P=Phosphorus, S=Sulfur, B=Boron, CM=Cattle manure, CV =Coefficient of Variations, LSD= Least Significance Difference

4.2. Effect of Blended NPSB Fertilizer and CM Rates on Growth Parameters

4.2.1. Number of Primary Branches Plant^{-1}

Number of primary Branches per plant was significantly (P < 0.01) affected by the main effects and the interaction of blended NPSB fertilizer rates and cattle manure. The highest value of number of primary branches per plant (7.70) was obtained due to combined application of 10t ha^{-1} of CM and 150 kg ha^{-1} of blended NPSB fertilizer, followed by the value (7.08) obtained due to combined application of 5t ha^{-1} cattle manure and 150kg ha^{-1} NPSB of blended fertilizer and the value (6.63) obtained 150k gha^{-1} blended NPSB fertilizer alone and the value (6.52) obtained due to combined application of 100 kg ha^{-1} blended NPSB fertilizer +10t ha^{-1}cattle manure and the value (6.38) obtained due to combined application of 100 $kgha^{-1}$ NPSB blended+5t ha^{-1}cattle manure. But the lowest number of primary branches per plant (4.18) was observed at 0t ha^{-1}CM and 0 kg NPSB, ha^{-1} (Table 7). The increment in number of branches as affected by cattle manure and NPSB blended fertilizers supply could be attributed to the increase in number of vines length due to the presence of nitrogen fertilization. In the presence of cattle manure, however, vine growth showed increasing trend with increasing rate of cattle manure.

Farmyard manure combined with inorganic fertilizers play an important role in better penetrations and establishment of crop roots and the better roots help the plant to utilize water from deeper layers [49] that may have enhanced vegetative growth through increasing cell division and elongation [50, 76].

Similarly, many researchers have indicated that combined application of organic and inorganic (like phosphorus) amendments significantly increased the vegetative growth of plants [81, 21].

4.2.2. Vine Length

Vine length was significantly ($p<0.01$) affected by the main effects of cattle manure and blended NPSB fertilizer rates and their interaction was also significantly ($p<0.05$). The highest vine length (162.93 cm) was obtained as a result of combined application of 150 kg ha^{-1} of blended NPSB fertilizer and 10 t ha^{-1} of cattle manure fertilizer, followed by the value (155.73cm) obtained due to combined application of 150 kg ha^{-1} of blended NPSB + 5 t ha^{-1} cattle manure. Whereas, the lowest value (108.10 cm) was scored at control level (Table 7). Application of organic manures would have helped in enhancing the metabolic activities in the plant system through the supply of such important micronutrients in the early growth phase which in turn must have encouraged the overall growth of the vines per plant. In line with this, 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 vine length [14].

Confirmed the same result and reported that sweet potato benefited little from P to increase its canopy [97]. Applications of N and P (46 kg ha^{-1} N, 23 kg ha^{-1} P) significantly increased dry matter content [6]. All dry matter content of 'Beaure Gard' cultivar of sweet potato were significantly increased with increasing P rate from 15 kg /fed P_2O_5 (15.7 P kg ha^{-1}) up to 45 kg /fed P_2O_5 (47.1 kg ha^{-1}p). The apomuden grown on 15-30- 30 kg ha^{-1} NPK+ 5 ton ha^{-1}Cattle manure plot had resulted in the highest vine length and significantly different from other amended and the control plots. Okumkom variety of sweet potato grown on 30-30-30 kg ha^{-1}NPK rate had resulted in the highest vine length and significantly different from the other amended and the control plots [31].

According to the vine elongation rate during the linear growth phase and node addition rate during the whole season increased linearly with temperature [47]. This is in close conformity with the findings of who have also reported highest plant growth due to the combined application of organic manures and chemical fertilizers increase wheat yield [60].

4.2.3. Shoot Fresh Weight g Plant^{-1}

Shoot fresh weight was significantly ($P < 0.01$) affected by the main effects of blended NPSB fertilizer rates and cattle manure, and their interaction. At initial blended NPSB fertilizers levels from 0 to 150 kg ha^{-1} and cattle manure levels from 0 to 10 t ha^{-1}, there was much variation in shoot fresh weight. The highest shoot fresh weight (1010.64 g $hill^{-1}$) was recorded at 150 NPSB kg ha^{-1} blended fertilizers and10t ha^{-1} cattle manure organic fertilizers and the lowest fresh shoot weight (571.6g $hill^{-1}$) was recorded at the control treatment (Table 7). This result is consistent with that reported by at initial P level from 0 to 50 kg P $ha^{-1}$and N beyond 45 kg N ha^{-1}, there was a significant variation in shoot fresh weight [16].

This indicates that even though shoot fresh weight is benefited at the highest level of farmyard manure, shoot dry weight was increased as the proportion of farmyard manure to phosphorus decreased [3, 6]. Reported that sweet potato fresh weight is highly responsive to increased levels of farmyard manure [6]. Similarly, increasing N levels from 0 to 90 kg N $ha^{-1}$and at level of 0 kg P ha^{-1}on flat seedbed, there was a significant increase in shoot fresh weight (g $hill^{-1}$). Maximum shoot fresh weight was recorded on ridge seedbed (578 g $hill^{-1}$) at 90 kg N ha^{-1} and at 25 kg P ha^{-1}, and on flat seedbed (545 g $hill^{-1}$) at 90 kg N $ha^{-1}$and 0 kg P ha^{-1}.

4.2.4. Shoot Dry Weight g Plant^{-1}

Shoot dry weight was significantly ($P<0.01$) affected by the main effects of cattle manure and blended NPSB fertilizer rates, and their interaction was also significant ($P<0.05$). When cattle manure and NPSB blended fertilizers combination levels increased from 0 to 10 t cattle manure $ha^{-1}$and 0 to 150 kg NPSB ha^{-1}, there was significant increase in shoot dry weight (g $hill^{-1}$). However the highest shoot dry weight was recorded on the blended NPSB fertilizer 150 kg ha^{-1} and cattle manure 10 t $ha^{-1}$was (137.8, g $hill^{-1}$), the follows parameter 150 NPSB kg ha^{-1} was (134.1), 100 NPSB kgha^{-1} and 10 t ha^{-1} CM was 132gm/plant and the lowest was recorded (57.6, g $hill^{-1}$) at the control treatment (Table 7).

This result is consistent with who reported that at initial P level from 0 to 50 kg P $ha^{-1}$and N beyond 45 kg N ha^{-1}, there was significantly variation in shoot dry weight [16]. These results are in agreement with those reported by 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 [6]. The response of increase in above ground dry biomass with increasing levels of N and P could be attributed to the enhancing effect of Nitrogen on vegetative growth attributes.

Table 7. *The interaction effect of applied Cattle manure (t ha-1) and blended NPSB fertilizers (kg-1) on Number of branches per plant (NBPP), Vein length (VL), Shoot Fresh Weight (SHFW) and Shoot Dry Weight (SHDW), of sweet potato at Bako during the 2019/2020 u.*

Treatments		**Growth parameters**			
CM t ha^{-1}	**+ NPSB kg ha^{-1}**	**NBPP**	**VL Cm**	**SHFWg $plant^{-1}$**	**SHDW g $plant^{-1}$**
0	0	4.18^{i}	108.10^{i}	107.8^{e}	57.6^{g}
	50	5.46^{g}	132.25^{f}	620^{efg}	118^{cde}
	100	6.18^{de}	140.34^{e}	733.3^{cd}	125.7^{abc}
	150	6.63^{c}	151.27^{bc}	753.3^{cd}	134.1^{ab}

Treatments		Growth parameters			
CM t ha^{-1}	+ NPSB kg ha^{-1}	NBPP	VL Cm	SHFWg $plant^{-1}$	SHDW g $plant^{-1}$
5	0	5.07^{h}	115.87^{h}	611^{fg}	110.6^{ed}
	50	5.78^{f}	134.41^{f}	613.3^{fg}	117.5^{cde}
	100	6.38^{cd}	145.30^{de}	706.6^{cdef}	122.6^{bcd}
	150	7.08^{b}	155.73^{b}	860^{b}	136.8a
10	0	5.36^{g}	123.45^{g}	659.3^{defg}	108.3^{e}
	50	5.98^{ef}	134.33^{f}	715^{cde}	122.6^{bcd}
	100	6.52^{c}	150.00^{cd}	770.0^{bc}	132.0^{ab}
	150	7.70^{a}	162.93^{a}	1010.6^{a}	137.8^{a}
LSD (0.05)	-	0.29	5.07	13.2	12.9
CV %	-	2.84	2.18	6.78.	3.88

Key: Means with the same letter(s) in same column are not significantly different at 5% level of significance CM = Cattle manure, NPSB=Nitrogen, Phosphorus, Sulfur, Boron, VL=Vein length, LA= Leaf Area, SHFW=Shoot Fresh Weight, SHDW= Shoot Dry Weight, NBPP= Number of branches per plant, CV =Coefficient of Variations, LSD= Least Significance Difference

5. Summary and Conclusions

Sweet potato, (*Ipomoea batatas* (L) Lam) is economically important and food security root crop in Ethiopia. Production of sweet potato is constrained by biotic and abiotic factors. The biotic factors include diseases, insect pests and weeds; whereas abiotic factors are drought, heat, lack of planting materials and low soil fertility. Field experiment was conducted on the effect of blended NPSB fertilizer rate and cattle manure on sweet potato at Bako Agricultural Research Center site in 2019/2020 in the furrow irrigation. The experiment was laid out in a Randomized Complete Block Design (RCBD) in a factorial arrangement with four levels of blended NPSB fertilizers, (0, 50, 100 and 150 kg ha^{-1}) and three levels of cattle manure (0, 5 and 10 t ha^{-1}) and replicated three times.

The results of this experiment showed that growth of sweet potato such as days to 50% bud sprout, days to 90% of physiological maturity, vein length of tuber root, number of branch per plants, shoot fresh weight, shoot dry weight of sweet potato increased as a result of the application of blended NPSB fertilizer and cattle manure rate.

The results revealed combined application of blended NPSB fertilizer rate and cattle manure fertilizers were significantly ($P < 0.01$) affected most of the growth of sweet potato studied. The interaction of the two fertilizers also significantly ($p<0.05$) affected most of the growth of parameters considered. Application of combinations of 10t ha^{-1}cattle manure and the highest rate of NPSB resulted in faster in bud sprouting. The interaction effects of cattle manure and blended NPSB fertilizers affected length of tubers (18.8cm). The highest vine length (149.6cm), was recorded at 10 t ha^{-1}cattle manure +150, kg NPSB ha^{-1}, whereas the lowest vine length (108.10 cm) was recorded at the control treatment.

However the highest days to maturity (149.8), days to budding sprout (7.34) was obtained from the highest fertilizers rate. Though most of the sweet potato growth parameters showed good response to cattle manure, Thus, unless it is integrated with inorganic fertilizers, the use of cattle manure alone may not fully satisfy crop nutrient demand, especially in the year of application.

Generally, the present study indicated that the combined application of blended NPSB fertilizer rate and cattle manure improved growth of sweet potato. The combined application of mineral NPSB and cattle manure gave a better result than the application of sole, which indicates that integrated nutrient management is the best method for soil fertility management. In terms of economic point of view, combined application of 150 kg NPSB kg ha^{-1} blended fertilizers and 10t ha^{-1} cattle manure found high net benefit with high marginal rate of return and economically feasible and recommended for sweet potato growing areas of Bako agricultural Research centers and the same agro ecological area.

Therefore, as a recommendation, cash incomes of sweet potato, farmers of the study area could benefit if doses of 10t cattle manure ha^{-1} and 150 kg ha^{-1}NPSB blended fertilizers are combined and applied to sweet potato crop. Moreover, farmers in the study area need to be encouraged to use a combined application of inorganic fertilizer and organic manures as this improves physicochemical properties of the soil, thereby significantly enhance growth of sweet potato. However, as the results are limited to one season and location. Hence, further research need to be conducted over more seasons, locations and additional research area should be the use of more rate of cattle manure and blended NPSB fertilizers recommendations for maximum net benefit to farmers in the study area.

Conflicts of Interest

The authors declare no conflicts of interest.

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