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Response of Sweet Basil (*Ocimum basilicum* L.) to blended NPS and potassium fertilizers on growth and yield, in case of Wolaita zone, Southern Ethiopia

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ABSTRACT

Background: *Sweet basil (Ocimum basilicum L.) is one of the most economically important aromatic herbs of the Lamiaceae family. The plant is used in complementary and alternative medicine in different cultures worldwide. However, its productivity is generally low due to low soil fertility as an important constrain and there poor information on the type and rates of fertilizers applied.*

Objective: *Therefore, the present study was carried out in experimental gardens at Waja Kero Kebele, Sodo Zuria district, Wolaita Zone, southern Ethiopia to evaluate the effect of blended NPS and potassium fertilizer rates, and to assess their cost and benefit at different application rates.*

Methods: *The treatments were composed of four rates of blended NPS (0.50, 100 and 150 kg NPS ha^{-1}) and four rates of potassium (0, 35.5, 71, and 106.5 kg K ha^{-1}) fertilizers, plus 100 kg Urea ha^{-1} applied to all plots equally. The experiment was laid out as a Randomized Complete Block Design (RCBD) in a 4 x 5 factorial arrangement repeated three times. Widely used sweet basil variety Nantes was used as a test crop.*

Result: *The Analysis of Variance (ANOVA) revealed that the main effects of blended NPS and potassium fertilizers influenced significantly ($P<0.05$) plant height, number of leaves, shoot fresh and dry weight, root length, diameter, fresh weight, dry matter, total root yield, and marketable root yield. The highest marketable root yields were obtained in response to the application of 100 kg blended NPS ha^{-1} and 106.5 kg K ha^{-1} provided 21.46 t/ha. On the other hand, the lowest marketable yield of 12.82t ha^{-1} was obtained in response to an unfertilized plant. The partial budget analysis revealed that the application of 100 kg ha^{-1} blended NPS and 106.5 kg K ha^{-1} resulted in the net benefits of 115485.2 ETB ha^{-1} with 59% net income over control treatment. This treatment was initiated to optimum sweet basil root production and economic returns in the study area.*

Conclusion: *Furthermore, the yield of sweet basil at sodo zuria can be increased by combined application of 100 kg NPS with 106.5 kg K/ha. Whereas the highest net return however was obtained from sweet basil plants supplied above mentioned treatment when compared with all other treatments. To formulate sounded recommendation however, it is advised to repeat the same experiment on other areas of the woreda.*

Keywords: Blended NPS; Potassium fertilizer; Sweet basil; Fertilizer level; Randomized Complete Block Design (RCBD)

Introduction

Medicinal and aromatic plants are used by 80% of the global population for their therapeutic effects. Many of these medicinal and aromatic plants give off substances that are useful to the maintenance of health in humans and animals [1]. Some of the aromatic substances are phenols and their oxygen substituted derivatives, alkaloids, glycosides, saponins, and many active secondary metabolites. Sweet basil (*Ocimum basilicum* L.) is one of the most important aromatic herbs of the Lamiaceae family. It probably originated from southern Asia. Currently, it is cultivated mainly through the Mediterranean regions of Europe as well as in Asia and Africa. However, it is also grown in temperate zones. The commercial products obtained from basil are fresh and dry herbs used as a seasoning while its extracts and essential oil are exploited in the food and perfume industries. Worldwide production of sweet basil is estimated to 42.7 million tons, with China covering the highest production rate 48%, which is 20.5 million tons [2]. Also, it was grown in African countries like South Africa, Zambia, Zimbabwe, Botswana, and the average yield of sweet basil estimated at 8-12 t/ha for the tropics, is far below the world average estimated at 21 t/ha. In Ethiopia, sweet basil occupied 4,902.90 hectares of land with a total production of 173,334.27 quintals with 3.53 t/ha.

Organic fertilizer obtained from animal sources such as animal dung or plant sources like green manure serves as an alternative to synthetic mineral fertilizers to improve soil. Application of organic fertilizers to agricultural soils has beneficial effects on crop yields components by improving soil physical and biological properties. In comparison to chemical fertilizers, they have lower nutrient content and are slow-release but they are as effective as chemical fertilizers over longer periods of use as they take long time to decompose [3]. According to Mady and Youssef, the benefits of supplementing organic and bio fertilizers with chemical fertilizer found to enhance growth and essential oil productivity of sweet basil together with other vegetative growth parameters. Sweet basil requires optimum nutrients in a blended or single form for the best quality and high yield. However, according Shiferaw Ethiopian soils lack most of the macro and micronutrients that are required to capture optimal growth of the crops. Some of the deficient vital nutrients are N,P,K,S,B,Cu,Fe,Zn.

Ethiopian fertilizer application rates are below international and regional optimum standards. The Ministry of Agriculture of Ethiopia has been recently introduced new blended fertilizers like NPSB, NPSB, Cu, NPSB, Cu, Zn, and others especially NPS to surmount the existing situation [4]. Hordofa Sigaye, et al. recommended major mineral nutrients like Nitrogen, Phosphorus, and Potassium to their important role in the vegetative and reproductive phase of crop and the same is true for sweet basil. Even though, vegetable crops including sweet basil offer high yield per unit area, the case in Ethiopian is antagonistic at smallholder farmers. This may be due to the fact that, unmodernised systems of production and other cultural practices which incline the yield of crops creating demand and supply chain imbalance. Soil erosion, intensive crop cultivation, complete crop residue removal and high nutrient depletion may be the causes, with poor soil fertility and imbalance levels of blended NPS and potassium fertilizer application on sweet basil production takes lion’s share. These have been filtered as pressing challenges, and thereby low crop productivity in the study area [5].

To mitigate the problems, many studies have been made. According to Kafani the highest total root yield was obtained from 138 kg ha^{-1} N and 46 kg ha^{-1} of P fertilizer applications but 92 kgN/ha and 23 kg P/ha were an economically feasible combination [6]. Lefamo, et al., also reported sweet basil highest seed yield per hectare recording the application of 150 kg blended NPS fertilizer. The highest yield was from a treatment combination of 75-100 kg K ha^{-1} and 15 kg B ha^{-1} was reported to 70 kg K/ha increased yield of sweet basil. However, still there is a gap and very little information on levels of combined application of newly introduced blended NPS and potassium fertilizer in sweet basil production under densely populated parts of the country like the present study area to optimize the yield of the crop. With this in consideration, this study was carried out to determine the response of sweet basil to blended NPS and potassium fertilizer, to identify optimum levels of blended NPS and potassium fertilizer to sweet basil production and recommend an economically feasible rate of fertilizer combination [7].

Materials and Methods

Study site

The experiment was conducted under normal field condition in Waja Kero Kebele (small administrative unit separated from district), Sodo Zuria district in the year 2019/20 under supplementary irrigation fed agricultural setting. Waja Kero Kebele is located in 6o 88' N and 37°C 72' E longitude and latitude respectively, with 1920 m.a.s.l.

Materials

Experimental crop variety: The seed of the sweet basil, variety local 45 is a European cultivar that can be grown in different parts of the country including study area only for root production [8]. The roots are half long, slim, well-shaped, cylindrical with stumped and forming a small thin tail, deep orange-red cortex. It ranks first in quality and matures in 90-120 days, was selected for experimentation. The seeds were obtained from Damota Wolaita Farmer's Cooperative Union (DWFCoU). Blended NPS; Potassium Chloride Fertilizer as a source of K, and urea as a source of Nitrogen were obtained from the Sodo Zuria district agriculture Bureau [9].

Materials used: Instruments assisted to carry out the work successfully includes hoe, measuring tape, pegs, string, sensitive balance, caliper, cultivator, water pump, sharp pointed shovel, notebook and pen, sack, and computer.

Treatments and experimental design

The design used during experimentation was Randomized Complete Block Design (RCBD) with three replications, set up in a 4 x 4=16, factorial arranged four levels of blended NPS fertilizer NPS0 (0 kg NPS ha^{-1}), NPS1 (50 kg NPS ha^{-1}), NPS2 (100 kg NPS ha^{-1}), and NPS3 (150 kg NPS ha^{-1}) and four levels of potassium, K0 (0 kg K ha^{-1}), K1 (35.5 kg K ha^{-1}), K2 (71 kg K ha^{-1}), and K3 (106.5 kg K ha^{-1}) (Table 1).

Trt. No	Blended NPS rates Kg/ha	Potassium (KCl) rates kg/ha	Urea (46%N) rates kg/ha	Total chemical composition combinations (kg ha^{-1})			
				P_2O_5	K	N	S
1	0	0	100	0	0	46	0
2	0	71	100	0	35.5	46	0
3	0	142	100	0	71	46	0
4	0	213	100	0	106.5	46	0
5	50	0	100	19	0	55.5	3.5
6	50	71	100	19	35.5	55.5	3.5
7	50	142	100	19	71	55.5	3.5
8	50	213	100	19	106.5	55.5	3.5
9	100	0	100	38	0	65	7
10	100	71	100	38	35.5	65	7
11	100	142	100	38	71	65	7
12	100	213	100	38	106.5	65	7
13	150	0	100	57	0	74.5	10.5
14	150	71	100	57	35.5	74.5	10.5
15	150	142	100	57	71	74.5	10.5
16	150	213	100	57	106.5	74.5	10.5

Table 1: Treatments and their clarification.

Each experimental plot and whole treatments were assigned to the experimental plot completely at random and the randomization was selected by using lottery methods. The length and width of each plot were 1 m × 2 m=2 m^2 respectively [10]. The space between each plot and block was 0.5 and 1 meter respectively. The total experimental area coverage was 188 m^2. It was divided into 3 blocks, each subdivided into 16 plots and hence there were a total of 48 unit plots.

Field management

The experimental land was ploughed, leveled, disked, harrowed, and smoothly prepared manually with traditional hoes, next to that at planting the design, marking (with pegs). A seed rate of sweet basils ranges from 4 to 5 kg/ha in most parts of the country including the study area. The method of planting was dropping or drilling the seeds after mixing with sand at a 3:1 ratio on the rows of 30 cm apart [11]. The seeds were mixed with sand (1:1) and directly drilled by hand on to the rows at a depth of not more than 2 cm. Seeds were sown directly on the prepared land on November 12, 2019. Fertilizer applied during sowing, method of application was row placement in which fertilizer applied in bands a little below and 5 cm away from the plant during sowing except for nitrogen which was split into half applied at and 35 days after sowing approximately 75% of seeds were germinated at up to ten days of sowing.

The seedlings were thinned out 2 weeks after germination and intra row spacing of 5 cm between plants was done. Water was supplied with small scale irrigation systems when needed to keep the soil moist. After sprouting, the crop is weeded manually by handpicking every 2-4 days to prevent competition beneath the soil [12]. In crop weed management in organic production systems was primarily achieved by physical methods, which in row crops such as sweet basil done by inter-row hoeing. Earthing up was done every 15 days to cover and protect roots from sunlight were successfully prevented by pre disease occurrence. All management practices except the treatments were done equally to all plots during the overall period of plant growth and sweet basil roots were then harvested in February 2020.

Data collection

Soil sampling and analysis: Just before planting, for analysis of selected physical and chemical properties of experimental soil samples was taken from ten spots of the experimental site at 0 to 30 cm depth by using the zigzag method and one composite sample was taken. The composite soil sample was air dried and grinded to pass a 2 mm sieve and 0.5 mm sieve. Physical and chemical properties of soil were analyzed at Wolaita Sodo soil testing laboratory for determination of pH, % of Organic Carbon (OC), % of total N, available P (AP) (ppm), available K (mg/kg), % of available Sulfur (S), Cation Exchange Capacity (CEC) (meq/100 g), and texture [13].

Soil pH was measured potentiometrically in 1:2.5 soils to water ratio with standard glass electrode pH meter. Walkley and black method was used to determine the organic carbon content of the soil, and total nitrogen in the soil was determined by the Kjeldahl method [14]. Available soil phosphorus was determined following the Olsen method exchangeable potassum by neutral ammonium acetate method. Available sulfur was determined by the turbid metrically method. Soil Cation Exchange Capacity (CEC) was determined by the ammonium acetate method and Soil texture was analyzed by Bouyoucos hydrometer method.

Plant data (parameters): Data collection was classified into two parts; the first one was non-destructive data collection which included data of plant height and leaf number, and the next one was destructive data type which contains above ground biomass of crop; shoot dry weight, length of root, diameter of the root, fresh weight of root, dry matter content of root, marketable yield, unmarketable yield, and total root yield.

Plant Height (PH) (cm): Plant height was measured in centimeter from the ground level to the top up to the tip of the longest leaf at 70 and 100 DAS from ten randomly selected plants from each experimental plot.

The Number of Leaves per plant (LN): The number of leaves per plant was counted from ten randomly selected and tagged plants per each experimental plot at 70 and 100 DAS.

Shoot Fresh Weight (SFW) (g): The shoot fresh weights of 10 randomly selected plants were separated from the root (the root crown) and its weight was measured in grams [15].

Shoot Dry Weight (SDW) (%): Hundred grams of chopped sweet basil shoot was taken and oven dried (at 70°C for 72 hours) from each treatment and dry matter was calculated by the following formula.

Shoot dry weight=Dried weight of sample/Fresh weight of sample × 100

Length of Root (RL) (cm): Ten plants were selected randomly from the plot and the root length was measured with the help of a meter scale from the proximal end of the conical root to the last point of the tapered end of the root (distal end), and expressed in centimeter.

The Diameter of the Root (RD) (cm): To measure the diameter of the root a slide caliper was used. The diameter of the roots was measured in cm after harvest at the thickened portion of the root.

Fresh Weight of Root per plant (RFW) (g): Underground modified sweet basil roots of ten selected plants were made detached by a knife from the attachment of the stem and after cleaning the soil and fibrous root fresh weight was taken by the triple beam balance in gram and then the average value was calculated.

Dry Matter Content of Root per plant (DMCR) (%): Immediately after harvest, the roots were cleaned thoroughly by washing with water. Then from the roots, a sample of 100 g was taken randomly and cut into small pieces [16]. The small pieces were sun dried for 3 days, and then oven dried for 72 hours at 70℃. Immediately after oven drying, the dried root pieces were weighed and expressed by percentage. The percentage dry matter content of the roots was calculated by dividing dried weight of the sample by the fresh weight of the sample multiplied by a hundred.

Total Yield (TY) (t/ha^{-1}): A balance was used to record the gross weight of the harvested roots. All leaves were removed from the plant and the weight of the roots was taken in kilogram (kg) from each unit plot and expressed by converting in to yield in tone per hectare.

Percentage of cracked roots: At harvest, from the sweet basil roots the number of cracked roots was counted and expressed by percentage. Then the percentage of crack roots was calculated according to the following formula. The number of cracked roots divided by the total number of sampled roots multiplied by a hundred.

Percentage of branched roots: At harvest, the number of branched roots was counted and the result was calculated on a percentage basis by dividing the number of branched roots by the total number of sampled roots multiplied by a hundred.

Un Marketable root Yield (UMY) (t/ha^{-1}): Was calculated as the weight of diseased roots, insect attacked, deformed roots under or over weighted.

Marketable root Yield (MY) (t/ha^{-1}): Marketable root yield was calculated as the weight of all harvested roots which are free from cracking, branching, disease, insect attack, under or overweight, and deformed roots and converting plot yield into a hectare.

Data analysis

The data recorded from the experimental plots were statistically analyzed using SAS statistical package version 9.3. The mean value for all the treatments was calculated by Analysis of Variance (ANOVA. Least Significant Difference (fishery LSD) test was done to separate significant differences between treatments at 5% probability level.

Results and Discussion

Effects of blended NPS and potassium on growth and yield of sweet basil

Plant height (cm) at different days after sowing: The plant heights were varied significantly in all experimental plots treated with different levels of blended NPS and potassium fertilizers. The higher plant height was observed in (NPS3 which was followed by (NPS2 and (NPS1 and height was increased significantly (P<0.01 in comparison to treatments under control. During 70 days of sowing the longest plant height (43.24 cm) was recorded in NPS3 and the shortest record (30.62 cm) in control treatment (NPS0). The plant height at 100 DAS (43.21 cm) was found less than that of 70 DAS probably due to the starting senescence of the plant [17]. The plant height was increased gradually in the early stages of sowing and decreased at the later stage of plant development (Table 2).

S.V	Df	PH 70	PH 100	LN 70	LN 100	SFW	SD mC	RL	DR	RFW	RDM	TY	CR	BR	UMY	MY
NPS	3	398**	360.7**	261.8**	81**	798**	18.24*	32.9*	2.96*	1816**	13**	81**	8**	5.6**	6.9**	42*
K	3	172**	156**	17*	60**	489**	43**	39.**	6.26*	1302**	7**	36^{ns}	4**	2.7**	2.8**	42**
NPS*K	9	73**	87.8**	1.36^{ns}	4.71*	51^{ns}	4.47^{ns}	0.46^{ns}	0.59**	204*	1.74*	8.59^{ns}	5**	3.2**	4**	6*
Error	30	7.05	5.5	4.09	3.23	25.9	5.46	1.65	0.17	69	0.73	14	0.14	0.32	0.35	2.4

CV (5%)		7.15	6.34	19.35	20.17	12.33	19.21	9.69	12.05	9.63	11.5	16.31	10.28	17.9	17.29	7.83
Where: **highly significant; *significant; NS: Non-Significant; DF: Degree of Freedom, PH (70): Plant Height at 70 days after sowing; PH (100): Plant Height at 100 days after sowing; LN (70): Leave Number at 70 days after sowing; LN (100): Leave Number at 100 days after sowing ; SFW: Shoot Fresh Weight; SDmC: Shoot Dry matter Content; RL: Root Length; DM: Diameter of the root; RFW: Fresh Weight of Root; RDM: Root Dry Matter content; TY: Total Yield; CR: Cracked Root; BR: Branched Root; UMY: Unmarketable Yield; MY: Marketable Yield. meq/100g)																

Table 2: Summary of Mean Square for plant height and leaf number at 70 and 100 DAS, shoot fresh weight, shoot dry matter content, root length, root diameter, root fresh weight, root dry matter content, total root yield, marketable root, unmarketable root, branched root, cracked root of sweet basil for blended NPS versus Potassium rates evaluated for their response for sweet basil influenced by NPS rate and irrigation methods.

Similar trend was observed in treatment of different levels of potassium fertilizer. At 70 DAS, the highest plant height (41.56 cm) was seen from plot treated K_3, following K_2 (38.70 cm) and K_1 (35.45 cm) treatments. The height was significantly increased (P<0.05) in comparison to control treatment (K_0) that gave the shortest height (32.88 m). At 100 DAS also, the maximum plant height (40.98 cm) was recorded from K_3 and the shortest (32.52 cm) was in K_0. This finding agrees with the findings of Hossain, et al., Matsumoto, et al. also reported the application of phosphorus and potassium fertilizers at varied levels increasing the height adjustment of sweet basil. After a certain period of time the plants became short due to senescence of the longest leaves.

As indicated in Table 3, the combined effect of blended NPS and potassium fertilizer shown to have the best response for induced plant growth with the longest height (54.41 cm) in the treatment combination of NPS3K3 and was significantly (P<0.01) increased in comparison to the shortest height (27.9 cm) in control treatment both at 70 and 100 DAS.

Plant height (cm) at different days after sowing		
Treatments combination	**70 DAS**	**100 DAS**
NPS_0K_0	27.900^h	28.333^g
NPS_0K_1	32.567^{efg}	36.067^{cd}
NPS_0K_2	30.433^{gh}	29.267^{fg}
NPS_0K_3	31.600^{fgh}	31.367^{efg}
NPS_1K_0	31.667^{fgh}	31.067^{efg}
NPS_1K_1`	38.067^d	37.367^c
NPS_1K_2	33.000^{efg}	32.333^{def}
NPS_1K_3	34.200^{defg}	33.667^{cde}
NPS_2K_0	36.167^{de}	35.367^{cd}
NPS_2K_1	36.967^{de}	36.633^c
NPS_2K_2	42.867^c	42.633^b
NPS_2K_3	46.067^{bc}	45.700^b
NPS_3K_0	35.800^{def}	35.333^{cd}
NPS_3K_1	34.233^{defg}	33.900^{cde}
NPS_3K_2	48.533^b	49.633^a
NPS_3K_3	54.400^a	53.200^a
CV (%)	7.15	6.34
LSD (0.05)	4.4283	3.91
Similar letters indicate significance (P<0.05).		

Table 3: Interaction effect of blended NPS and potassium fertilizer rates on plant height at different days of sowing at sodo zuria.

Number of leaves per plant at different days of sowing: Both at blended NPS and potassium fertilizer, the higher leaf number per plant was obtained. At 70 DAS, blended NPS and potassium produced the maximum number of leaves (15) and was increased significantly in comparison to the leaf number under control treatments (4.2) in individual plants in all experimental plots. Such a response may be accounted for the physiochemical and biological improvement that occurred in the soil including favorable temperature and moisture regimes, nutrient availability, and microbial activities. But at 100 DAS, the highest number of leaves (12.16) was recorded in the experimental plots treated with NPS level (150 kgNPS/ha) which was the highest concentration and the response was decreased in comparison to 70 DAS which accounted. The decrement may be occurred due to a leaf falling by senescence of plant. Moreover, continuous increase of potassium from nil to 106.5 kg K/ha significantly increased leaf number from 9.2 and 6.26 to 11.16 and 11.42 at 70 and 100 DAS respectively.

The numbers of leaves per plant were significantly influenced by the combined effect of blended NPS and potassium fertilizer. The highest number (15.66) of leaves per plant were recorded from the treatment combination of NPS3K3 and was significantly increased ($P<0.05$) in comparison to the lowest number of leaves (4/plant) observed in control plots (NPS0K0) both at both 70 and 100 DAS. This finding is in-line with the results of Ypsilanti's, et al. in which the number of leaves at 100 days after sowing showed up significant differences in the application of different levels of the blended NPS and potassium and their interaction.

The leaf numbers per plant increased at an active vegetative stage and gradually declined at the maturity phase due to a leaf falling. In agreement with this result, Yermiyahu, et al., reported that the highest leaf number of sweet basil plants were observed in response to increasing the rate of P and K at the first vegetative growth stage and decreased during the maturity of the crop due to senescence of crop (Table 4).

Blended NPS	plant height	plant height	Leaf number	leaf number
(kg/ha)	at 70 DAS	at 100 DAS	at 70 DAS	at 100 DAS
0	30.62^{d}	31.24^{d}	4.250^{d}	5.683^{c}
50	34.23^{c}	33.60^{c}	8.583^{c}	8.417^{b}
100	40.52^{b}	40.08^{b}	13.000^{b}	9.675^{b}
150	43.24^{a}	43.01^{a}	15.000^{a}	11.917^{a}
LSD (0.05)	2.21	1.95	1.43	1.5
K levels (kg/ha)				
0	32.88^{d}	32.52^{d}	9.250^{c}	6.267^{d}
35.5	35.45^{c}	35.99^{c}	9.583^{bc}	8.083^{c}
71	38.70^{b}	38.46^{b}	10.833^{ab}	9.917^{b}
106.5	41.56^{a}	40.98^{a}	11.167^{a}	11.425^{a}
LSD (0.05)	2.21	1.95	1.43	1.5
CV (0.05)	7.15	6.34	16.83	20.17
LSD: Least Significant Difference; CV: Coefficient of Variation; Means bearing the same letter (s) in a column is/are statistically significant at 95% level of confidence.				

Table 4: Effect of blended NPS and potassium fertilizer rates on plant height and leaf numbers at 70 and 100 DAS.

Shoot fresh weight (g): The recorded highest weight for fresh shoot (51.95 g) was obtained at the application of 150 kg NPS ha^{-1} (NPS3) and was significantly increased ($P<0.05$) in comparison to the fresh shoot weight (32.8 g) at the control plots (NPS0). The application of NPS fertilizer which contains nitrogen, phosphorous, and sulfur promoted the growth and development of garlic and gave highest shoot fresh weight.

The rates of potassium fertilizers increased plant shoot fresh weight. Increasing the rate of the potassium from nil to 106.5 kg K ha^{-1} increased the fresh weight up to 48.77 g. These results may be due to the role of potassium element in metabolism and many processes needed to promote plant vegetative growth and development. The obtained results were in agreement with the work of Ali, et al., and Rani, et al., reported the effects of potassium fertilization having to increase the shoot height, number of leaves per plant, and shoot fresh weight.

The combined effect of blended NPS and Potassium at the level of 150 kgNPS/ha and 106.5 kg/ha increased the average shoot fresh weight of sweet basil at about 50 % but the difference was statistically non-significant. The maximum shoot fresh weight (59.83 g) was observed from the plot treated the highest concentration levels (NPS3*K3). The output of this finding agrees with the reports of Bufalo, et al. attained overall increment in shoot fresh weight with the application of NPKS on sweet basil.

Percent dry matter content of shoot: The highest shoot dry matter (13.97%) was obtained in the application of

150 kg NPS ha^{-1} (NPS3) and the difference was statistically insignificant (P>0.05) when compared to the shoot dry weight (11.45%) recoded in control plots (NPS0). The reason behind this was blended NPS which is the main source of phosphorus (38%) contributing to dry matter accumulation as described in Nigussie, et al., and in agreement with the present study.

The dry matter of shoot was significantly (P<0.01) influenced by application of different concentration levels of potassium fertilizer. The highest shoot dry matter content (13.75) was recorded in treatment K2 (71 kgK/ha) and 13.64 in treatment with K3 (106.5 kgK/ha). Increasing the rate of application of potassium could increase dry matter per plant from nil up to 71 kg K ha^{-1}. However, the rate beyond 71 kg ha^{-1} had shown no significant effect in shoot dry matter contents.

The combined effect of different levels of blended NPS and potassium on percentage dry matter of the shoot shown the highest content (16.44%) in the combination of NPS3K3. However, Yesmin found the highest dry matter (7.91%) from the treatment combination of P3*K3 (Table 5).

Blended NPS (kg/ha)	Shoot fresh weight/plant (g)	Shoot dry weight/plant (%)
0	32.800^{d}	11.459^{b}
50	42.61^{b}	11.213^{b}
100	37.80^{c}	12.073^{ab}
150	51.95^{a}	13.94^{a}
LSD (0.05)	4.24	1.95
K levels (kg/ha)		
0	34.00^{d}	9.76^{b}
35.5	38.59^{c}	11.52^{b}
71	43.84^{b}	13.75^{a}
106.5	48.73^{a}	13.64^{a}
CV (0.05)	12.33	19.25
LSD: Least Significant Difference; CV: Coefficient of Variation; Means bearing the same letter (s) in a column is/are statistically significant at 95% level of confidence.		

Table 5: Effect of blended NPS and potassium fertilizer rates on shoot fresh and dry weight of sweet basil at waja kero during 2019.

Root length: Increasing the rate of the blended NPS application from nil to 150 kg ha^{-1} significantly (P<0.01) increased the average root length of sweet basil. The maximum root length (15.17 cm) was recorded in treatment received highest (150 kg) NPS/ha in treatment K_3 (106.5 kg K/ha) and the minimum (11.38 cm) was recorded in a non-potassium treatment plot. Similar findings from Shikha, et al., shown the sweet basil yielding highest root length, root diameter, and root weight by using K fertilizer (Table 6).

Blended NPS (kg/ha)	Root length (cm)	Root diameter (cm)
0	11.31^{d}	2.89^{d}
50	12.66^{c}	3.27^{c}
100	13.93^{b}	3.64^{b}
150	15.17^{a}	4^{a}
LSD (0.05)	1.07	0.34
K levels (kg/ha)		
0	11.38^{c}	2.72^{d}
35.5	12.37^{c}	3.13^{c}
71	13.79^{b}	3.61^{b}
106.5	15.53^{a}	4.40^{a}
CV (0.05)	9.69	12.05
LSD: Least Significant Difference; CV: Coefficient of Variation; Means bearing the same letter (s) in a column is/are statistically significant at 95% level of confidence.		

Table 6: Effect of blended NPS and potassium fertilizer rates on root length and diameter of sweet basil at waja kero during 2019.

Blended NPS(kg/ha)	Root fresh weight/plant (g)	ROOT dry matter (%)
0	72.78^{d}	6.62^{c}
50	81.32^{c}	6.99^{c}
100	89.21^{b}	7.71^{b}
150	101.73^{a}	8.98^{a}
LSD (0.05)	6.92	0.69
K levels (kg/ha)		
0	74.05^{d}	6.75^{b}
35.5	82.16^{c}	7.10^{b}
71	90.67^{b}	7.97^{a}
106.5	98.12^{a}	8.47^{a}
CV (0.05)	9.63	11.04

LSD: Least Significant Difference; CV: Coefficient of Variation; Means bearing the same letter (s) in a column is/are statistically significant at 95% level of confidence.

Table 7: Effect of blended NPS and potassium fertilizer rates on root fresh and dry weight of sweet basil at waja kero during 2019.

The highest root length (17.70 cm) was obtained at a combination of 150 kg NPS ha^{-1}*106.5 kg of K and was significantly higher ($P<0.05$) in comparison to the lowest root length (9.26 cm) recorded in control treatment. Inorganic fertilizers play an important role in better penetrations and establishment of crop roots assisting the plant to utilize water from deeper layers that may have enhanced vegetative growth through increasing cell division and elongation increasing the root length.

Root diameter: The widest root diameter (4 cm) was recorded from the plot treated with NPS3 (150 kg NPS/ha) and the effects of the supplemental blended NPS rate were significantly ($P<0.01$) affected the diameter of sweet basil root in comparison to non-fertilizer treated (control) plots having the narrowest (2.89 cm) diameter of the root. Other similar findings by Shege, et al., shown that the widest bulb diameter of garlic was obtained from those garlic plants supplied with the highest combination of phosphorous and sulfur. This was probably due to the combined positive effects of phosphorous and sulfur that existed in NPS fertilizer.

In the potassium fertilizer treatment, the highest root diameters (4.40 cm) was recorded in experimental plot treated with K_3 (106.5 kg K/ha). There was a significant difference ($P<0.01$) among plots treated with various concentration levels of potassium in comparison to the lowest (2.7 cm) recorded diameter in control plots. This may be due to the significant role of potassium on photosynthesis, favors high energy status which helps the crop for timely and appropriate nutrients translocation and water absorption by roots in agreement with the finding of Arega Amdie.

The widest root diameter (4.86 cm) was obtained at a combination of 150 kg NPS ha^{-1}*106.5 kg of K and interaction effects for two fertilizers were significantly higher ($P<0.01$) than the narrowest root diameter (2.36 cm) recorded at 0 kg NPS*0 kg K ha^{-1} in control treatment. Increasing levels of blended NPS and potassium fertilizers were increased root size and diameter of sweet basil. The results of the present experiment agrees with the finding of Niguse, et al., reported significant effects of P and K fertilizer application on the size and number of tubers produced per plant on the potato.

Root fresh weight per plant: The highest fresh weight (98.12 g) was obtained in the plot treated with K_3 (106.5 kg K ha^{-1}) followed by K_2 (90.675 g), and K_1 (82.167 g). The root fresh weight in treatment plots were significantly ($P<0.01$) influenced by application of different levels of potassium in comparison to control treatment (K_0) giving the lowest root fresh weight (74.075 g) (Table 7). In agreement to the present study, Kumar, et al. stated that continuous increasing of potassium would enhance the root fresh weight due to the prominent role of potassium in translocation of photo assimilates sugars, and other soluble solids to the root.

The highest sweet basil root fresh weight (101.73 g) was recorded from the plot treated with the highest level of concentration (NPS3) which was followed by (NPS2), and (NPS1). The root fresh weight varied significantly high ($P<0.05$) due to the application of different levels of blended NPS and potassium fertilizers in comparison to the lowest weight (72.78 g) recorded in control (NPS0) treatment [18]. This is maybe due to the combined positive effects of nitrogen, phosphorous, and sulfur existed in NPS fertilizer that activated metabolic processes of sweet basil and similar output was obtained on garlic plants as a report by Assefa, et al., Furthermore sulfur and nitrogen in NPS fertilizer stimulate the enzymatic actions and chlorophyll formation which contributes to an increase in bulb sizes which resulted from the plot received high NPS produced maximum root fresh weight of garlic.

The maximum root fresh weight (121.70 g) was obtained in the treatment with blended NPS and potassium combination (NPS3*K3) and the root fresh weight was significantly higher in comparison to the recorded root fresh weight (58 g) in control treatment (NPS0*K0).

Root dry matter content (%): The highest percentage of root dry matter content (8.98%) was recorded in the plot received NPS3 (150 Kkg NPS/ha). Significant differences (P<0.01) were observed in between experimental plots treated with blended NPS fertilizer and control treatments having the lowest root dry matter contents (6.25%). The increase in root dry matter with the increment of NPS application rates observed in the present study was probably due to the accumulation and partitioning of more assimilates in root and agrees with the findings of Minwyelet.

The highest root dry matter content (8.47%) was obtained in K_3 (106.5 Kg K/ha) and application of different levels of potassium pose shoot up effect on the percent dry matter of sweet basil root. The effect was higher significantly (P<0.01) in comparison to the lowest record (6.75%) in control treatment (K_0) (Table 5). A result contradicts the findings of Nesa obtained the highest dry matter content in untreated plot and plot provided lowest root dry matter was treatment received maximum fertilizers (N98P72 K87 S14).

The highest dry matter content of root (10.4%) was observed in the treatment combination of NPS3*K3 (150 Kg NPS/ha with 106.5 kg k/ha) and was significantly (P<0.05) higher than the dry matter percentage of roots in control treatment (5.86%) NPS0*K0. Agreeing with this, Olorunmaiye, et al., reported the highest yield components including dry matter in the experimental unit treated with the highest OM (poultry manure) and inorganic NPK.

Total root yield per hectare: The higher root yield (25.15 t/ha) was obtained from plot treated with NPS2 (100 kg NPS/ha) followed by NPS3 and NPS1 and was significantly (P<0.01) higher than the root yield recorded in control plot (19.4 t/ha). Increase in NPS fertilizer rates increased sweet basil root yields. In other similar report supporting the present study it was reiterated that the potato tuber yield per hill was increased with increasing blended NPS rates.

Because of varied levels of fertilizer application, there was no significant differences (P<0.05) observed among treatment plots with potassium fertilizer, and the highest root yield (25.03 t/ha) was obtained from the experimental unit treated with K_3 (106.5 kg K/ha). In comparison to the yield obtained from control treatment (21 t/ha) the treatment plots with potassium had significantly (P<0.05) higher produce. This may be due to the significant role of potassium on sink source relation and provided a higher yield of sweet basil. The finding is in line with the findings of Hossain, et al., obtained the higher root produce in the application of increased rate of K fertilizer [19].

The highest root yield (28.25 t/ha) was obtained at the integration of 150 kg NPS ha^{-1}*106.5 kg of K. The root produce in combined effect of fertilizers was not significantly (P>0.05) different in all treatment plots, however, in comparison to the control plots (16.25 t/ha) the produce in treatment plots were significantly higher than the produce in control plots. Increasing the rate of blended NPS and potassium fertilizers increased root production. According to Yesmin and Dinato, et al., P and K fertilizer application significantly increased root yield of sweet basil in agreement to the present study.

Percentage of a branched root: A combination of two fertilizers showed a significant variation in the percentage of branched roots. The highest branched root (5.7 t/ha) was observed in the treatment combination of NPS3*K3 (150 Kg NPS/ha with 106.5 kg k/ha) and was significantly higher than recorded in control treatment (32 t/ha). In line with the present finding, Dinato, et al., reported highest branched roots in experimental unit treated with maximum NPKS and the lowest in plot treated with minimum NPKS fertilizer.

Unmarketable Root Yield per hectare: The highest unmarketable root (5.9t/ha) was observed in the treatment combination of NPS3*K3. This may be due to higher root cracking and branching. According to Dagne maximum and minimum unmarketable yields 9.62 and 1.53 t ha^{-1} were obtained in the combined treatments of 138 kg N and 46 kg P ha^{-1} and 46 kg N and 23 kg P ha^{-1}, respectively (Table 8).

Treatments combinations		Yields		
NPS (kg ha^{-1})	Potassium (kg ha^{-1})	Total Yield (tha^{-1})	Yield (tha^{-1}) Marketable	Unmarketable Yield (t ha^{-1})
0	0	16.250^{e}	11.70^{ef}	2.90^{efg}
	35.5	19.500^{de}	12.10^{def}	5.32^{bc}
	71	20.500^{de}	14.86^{abcde}	3.90^{cdef}
	106.5	21.400^{bcde}	13.03^{cdef}	3.90^{cdef}
50	0	22.200^{abcde}	14.37^{abcdef}	4.27^{cde}
	35.5	23.600^{abcd}	16.10^{abc}	1.53^{gh}
	71	23.150^{abcd}	10.80^{f}	6.43^{b}
	106.5	23.500^{abcd}	14.46^{abcdef}	4.06^{cdef}
100	0	24.600^{abcd}	14.46^{abcdef}	6.23^{b}
	35.5	24.700^{abcd}	17.07^{ab}	2.65^{fg}
	71	24.300^{abcd}	15.24^{abcde}	1.63^{gh}
	106.5	27.000^{abc}	17.20^{a}	2.65^{fg}
150	0	21.000^{cde}	15.57^{abcd}	3.73^{def}
	35.5	22.050^{abcde}	15.18^{abcde}	2.80^{cde}
	71	27.500^{ab}	10.68^{f}	9.62^{a}
	106.5	28.250^{a}	13.34^{bcdef}	5.21^{bcd}
	LSD (0.05)	6.25	3.842	1.49
	CV (%)	16.31	16.5	22.3
Means bearing the same letter (s) in a column is/are statistically significant at 95% level of confidence.				

Table 8: Interaction effect of blended NPS and potassium fertilizer rates on total, marketable and unmarketable root yield at sodo zuria during 2019.

Marketable root yield per hectare: The highest marketable root produce (23.86 t/ha) was obtained in the plots treated with 100 kg NPS/ha with 106.5 kg K/ha followed by 23.65 t/ha (150 kg NPS/ha with 71 kg K/ha). The interaction of fertilizers afford significantly ($P<0.05$) higher marketable root yield in treatment plots than the root produce in control treatments (14.25 t/ha). The lowest marketable root yield of sweet basil may be due to the absence of adequate nutrient needed for proper growth and development. According to Amin increased marketable tuber was obtained from potato (9.59 to 39.79 t/ha) by the combined supplementation of blended NPS and cattle manure up to 150 kg NPS/ha with 30 t/ha.

Conclusion

Sweet basils (*Ocimum basilicum* L.) among the most important root vegetables in the Apiaceae family, are cultivated worldwide. Even though, it serve as a major food source, as well as an inexpensive source of carotenoids, flavonoids, polyacetylenes, vitamins, and minerals, all of which possess numerous nutritional and health benefits.

Most of Ethiopian soil including in wolaita have limited potential of giving high crop yields due to the diverse and complex factors but declining soil fertility stand first. Moreover, low soil fertility is one of the factors limiting the productivity of crops, including sweet basil.

This might rose by low inherited soil fertility, limited use of chemical fertilizers are some major negative interventions slow agricultural productivity in Ethiopia including study area.

This finding out puts clearly indicated that sweet basil crop has clear requirement for a blended NPS and potassium fertilizers, without which the crop are poor yield and quality related parameters. Applying the right fertilizer at the “right nutrient source, right rate, right time, and right place” is a crucial issue takes into account to maximized production, productivity of this important crop.

The experiment was conducted under the field condition of Waja kero Kebele of Sodo Zuria Woreda in the year of 2019/20 under supplementary irrigation, The experiment was set up in a 4 x 4=16, factorial arranged four levels of blended NPS fertilizer NPS (0,50,100 and 150 kg NPS ha^{-1}) and four levels of potassium, K (0,35.5,71 and 106.5 kg K ha^{-1}) were arranged in Randomized Complete Block Design (RCBD) with three replications. Furthermore, the yield of sweet basil at sodo zuria can be increased by combined application of 100 kg NPS with 106.5 kg K/ha. Whereas the highest net return however was obtained from sweet basil plants supplied above mentioned treatment when compared with all other treatments. To formulate sounded recommendation however, it is advised to repeat the same experiment on other areas of the woreda.

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