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RESEARCH ARTICLE

Effect of NPSZnB fertilizer on yield and horticultural traits of tomato (*Solanum lycopersicum* L.) varieties in Tanqua Milash District of Tigray, Ethiopia

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Abstract
Tomato is the most significant vegetable for domestic use and commercialization, as well as income generation. However, its production is low due to various constraints like poor soil fertility, pests, abiotic factors and lack of knowledge on agronomic management. Hence, the study was implemented with the objectives of assessing the impact of NPSZnB fertilizer application rates on tomato and ascertaining the economic feasibility in the Gereb-giba small-scale irrigation scheme. Twelve treatments were comprised with diverse fertilizer application rates (150, 200 and 250 kg/ha) in combination with varieties of tomatoes (Melkasholla, Melkasalsa and Roma–VF) using Randomized Complete Block Design with three replications in factorial arrangement. The soil texture of the experimental field was classified as clay loam. The results of the analysis of variance indicate that there is a significant difference in the interaction effects of blended fertilizer with tomato varieties based on their agronomic characters. In terms of maturity, when compared to the other treatments, the contribution of NPSZnB to Melkasholla shows a major function for earliness. The highest total fruit yield production (64.11 t/ha) was found from the combination of the Melkasholla variety with the blended fertilizers of 150 kg/ha, followed by 250 kg/ha (58.73 t/ha). According to the cost-benefit analysis, the treatment applied 200 kg/ha blended fertilizer with the variety Roma-VF is generally the most recommended and economically viable for farmers situated in the Gereb Giba area and other similar agroecologies.
Keywords: Blended fertilizer rates, Economic feasibility, Soil characteristics, Tomato, Yield.

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Introduction

Tomato (*Solanum lycopersicum* L.) is the most widely grown vegetable in the world and popular as a home garden (Ebert and Chau, 2015). It is a recurrent rising plant of the family Solanaceae and is most extensively cultivated for fresh consumption and processing (FAOSTAT, 2018). It is an important source of vitamin A (30%), vitamin C (38%), calcium (2%), iron (3%) and an important cash crop for smallholders and medium-scale commercial farmers (Naika et al., 2005).

In Ethiopia, tomatoes are one of the most significant and extensively farmed vegetables. Fresh market tomatoes are mostly produced by small-scale producers. The majority of processing kinds are made on huge horticultural farms. Small-scale farmers rely on it as a major source of income and it also creates jobs in the manufacturing and processing sectors. There are favorable growing compartments in different parts of the country; the bulk of tomato production in Ethiopia is concentrated in the Central Rift Valleys (MoARD, 2009). The ideal elevation for tomato cultivation is less than 2000 m above sea level, and loamy sand and silt loam soil types are available. Although there isn't a high demand for the soil's organic matter content, soils with a medium level of OM provide higher yields than those with a low level and have good soil drainage. The ideal pH range is between 5.5 and 7.0. The entire area under production during the 2021–2022 Meher cropping season is 7710.14 hectares, and the production is estimated to be over 332,850.14 quintals (Ethiopian Agricultural Authority, 2022).

According to ATA (2014), the Tanqua Milash district of Tigray regional state has a mild salinity concern with its soil fertility status. In addition to this, the area is determined to be lacking in seven nutrients. These are total nitrogen, available phosphorus, exchangeable potassium, available sulfur and extractable iron, Zinc and boron. Crop production and quality can be improved by using effective soil fertility management techniques to reduce diminishing soil fertility and increase crop tolerance to salinity (Ouedrago et al., 2001). This shows that applying NPK fertilizer sensibly and steadily in combination with organic fertilizer can result in high and long-lasting crop yields (Makinde et al., 2001). The Gereb-giba small-scale irrigation scheme benefits a large number of households, mostly growing onions, followed by tomatoes and peppers. However, there is a low production of tomatoes mainly due to scarce environmental conditions, primarily salinity, low soil fertility, late blight and inadequate understanding of agronomic management. Therefore, the study was conducted with the aim of determining the impact of NPSZnB fertilizer application rates on tomato varieties, as well as determining the economic viability.

Materials and Methods

Description of the experimental field

The study was conducted in the Tanqua Milash districts of the Gereb-giba small-scale irrigation scheme. It is located $13^0 14'06''$ N Latitude and $38^0 58'50''$ E longitudes (CSA, 2002). It is characterized as hot, warm, sub-moist lowland (SMl-4b) below 1500 m above sea level. The mean annual rainfall is 350 to 700 mm with minimum and maximum temperatures of 24 and 41°C, respectively (Legesse, 1999)

Treatments and experimental design

The experiment involved two factorial combinations of NPSZnB and tomato varieties. The open-pollinated tomato varieties such as Melkasholla, Melkasalsa and Roma–VF; and three different dosages of NPSZnB fertilizers (150 kg/ha, 200 kg/ha, 250 kg/ha) were used. The trial was laid out in a factorial experiment arranged by a Randomized Complete Block Design with three replications. The seedlings of tomato were raised in well prepared seed bed. Watering was applied with a watering cane in the morning and afternoon. The compost was applied a month before transplanting to the prepared plots so as to incorporate in to the soil before transplanting. Healthy, vigorous and succulent seedlings were selected and transplanted in 80cm inter and 40cm intra-row spacing. All of the NPS source fertilizers and half of the UREA source fertilizers were applied during transplanting and half of the UREA source fertilizer was applied after 30 to 40 days of transplanting. The outermost rows at both sides of the plots were considered as borders. A 1m wide open strip separated the blocks, whereas the plots within a block were 0.5m apart from each other. In accordance with the specifications of the design, each treatment was assigned randomly to experimental units within a block. The transplanted tomato seedlings were irrigated with border irrigation to prevent the mixing of fertilizers. Stalking was done during fruit setting and tomato branches were tied with the stalk. Any diseases, insects and pests were managed as per the recommendation equally to all treatments.

Soil sample

Soil sample was collected randomly in a diagonal pattern from the experimental site at a depth of 0 to 30 cm before treatment application and at the end of harvest. These samples were composited and prepared for the determination of soil physicochemical properties involving soil texture, organic matter, bulk density, organic carbon, electrical conductivity, pH and amounts of phosphorus (P), nitrogen (N), potassium (K), calcium (Ca), magnesium (Mg), sodium (Na) and cation exchange capacity. The soil samples were cleaned of root and other dust, air dried thoroughly, mixed and ground to pass a 2 mm sieve before laboratory analysis. The sample soil was analyzed in the Mekelle Soil Laboratory. For soil texture, the hydrometer method (Gee and Or, 2002) was applied. OC was estimated by the Walkley and Black method (Nelson and Summers, 1996) and with a factor of 1.724 as suggested by (Ryan et al., 2001), OM percentage was estimated by multiplying OC by this factor. EC was determined by a conductivity meter in a 1:5 soil-to-water ratio, pH by using a pH meter; amounts of available phosphorus (P) were estimated by using the Olsen

Table 1: List of different fertilizer application rates in combination with varieties of tomatoes

No	*Treatment combinations NPSZnB + Tomato varieties*
1	250 kg/ha NPSZnB+Melkasholla
2	250 kg/ha NPSZnB+Melkasalsa
3	250 kg/ha NPSZnB+Roma-VF
4	200 kg/ha NPSZnB+Melkasholla
5	200 kg/ha NPSZnB+Melkasalsa
6	200 kg/ha NPSZnB+Roma-VF
7	150 kg/ha NPSZnB+Melkasholla
8	150 kg/ha NPSZnB+Melkasalsa
9	150 kg/ha NPSZnB+Roma-VF
10	Control (unfertilized plot) + each variety

procedure as described by Olsen et al. (1954). Nitrogen by micro- Kjeldahl digestion procedure (Bremmer, 1996), Ca and Mg were also analyzed by AAS (Thomas, 1982), K and Na were determined by flame photometer and cation exchange capacity (CEC) was determined by using ammonium saturation method (Jackson, 1968).

Phenological parameters

Days to 50% flowering were taken from the entire plot observation of each plot and days to 50% maturity were recorded in plot basis when half of the plant population in a plot reached the appropriate physiological maturity.

Growth parameters

Plant height (cm) was taken from eight randomly selected and pre-tagged plants when 50% of the plants in a plot reached maturity stage by using a tape meter from the collar region to the apex and the mean value was determined as the mean plant height. The number of primary branches was taken from the same eight randomly selected and pre-tagged plants when 50% the plants in a plot reach maturity.

Yield components and fruit yield

The number of plants per plot was counted total number of plants obtained in a plot at the maturity stage. The number of fruits per plant was recorded. The total number of fruits harvested from eight plants was counted individually and the mean values were expressed as the total number of fruits per plant. Fruit which are cracked, damaged by insects, diseases, birds, or those with sun burn was considered unmarketable, while those that are free of any feasible defect and damage were considered marketable fruits. The summation of marketable and unmarketable fruit yield per hectare was taken as the total fruit yield per hectare.

Partial budget analysis

A simple partial budget analysis was done for the economic analysis of fertilizer application and it was carried out for combined marketable bulb yield data. The potential response of the crop towards the added fertilizer and price of fertilizers during planting and cost of production (Labour and material cost) ultimately determine the economic feasibility of fertilizer application (CIMMYT, 1988). The economic analysis was calculated based on the formula developed by CIMMYT (1988) and given as follows:

Gross average fruit yield (kg ha^{-1}) (AvY) is the average yield of each treatment.

Adjusted yield (AjY) is the average yield adjusted downward by a 10% to reflect the difference between the experimental yield and the yield of farmers.

AjY = AvY*(1-0.1)

Gross field benefit (GFB) was computed by multiplying the field/farm gate price that farmers receive for the crop when they sale it as adjusted yield.

GFB = AjY*field/farm gate price for the crop

Total cost is the cost of fertilizers and seed used for the experiment. The costs of other inputs and production practices, such as labor cost for land preparation, planting, weeding, crop protection, and harvesting was considered insignificant among treatments.

Net benefit (NB) was calculated by subtracting the total costs from gross field benefits for each treatment.

NB = GFB – total cost

Marginal return (MR) is the measure of increasing in return by increasing input.

Marginal rate of return (MRR%) was calculated by dividing the change in net benefit by the change in cost.

$$M\ RR = \frac{\Delta NB}{\Delta \mathrm{TC}}$$

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using the appropriate SAS software program version 9.2 (SAS Institute, 2008). Duncan's multiple range tests were used for mean separation at 5% level of significance.

Results and Discussion

Soil characteristics of the experimental site

Soil tests are used to measure soil nutrients that are expected to become plant available. The study aimed to determine the composition of sand, clay and silt and to know the soil physicochemical properties of the site for improving the production and productivity of tomatoes in the target areas. The result of the physicochemical properties of the soil sample for the study area is presented in Table 2.

Organic carbon, electrical conductivity, cation exchange capacity and total nitrogen

The soil of the field mainly contained low rates of organic carbon (1.2%) with high electrical conductivity (0.86 ms/cm) and cation exchange capacity (32.2 Meq/100 g) and low rate of total nitrogen (0.097%) as presented in Table 2. According to Tekalign (1991), the organic carbon ranges between 0.5 to 1.5% and total nitrogen ranges between 0.05 to 0.12%. CEC is a measure of a soil's capacity to retain and release elements such as potassium, calcium, magnesium, and sodium. Soils with high clay and/or organic matter content have high CEC. Sandy, low organic matter soils have low CEC. Accordingly, the soil of the field experiment was obtained high in magnesium (2.83 Meq of Ca/L), phosphorus (25.17 ppm), calcium (17.08 Meq of Ca/L), potassium (378.08 ppm) and low in sodium (18.5 ppm).

Soil pH

The expression of soil acidity and most crops grown under a range between 6 and 8.2. The soil pH of the field was

Table 2: Soil physicochemical properties of the experimental site for tomato varieties and different application rates of NPSZnB fertilizer before transplanting

Properties	*Values*	*Rating*	*Range*
Soil physical properties			
Sand (%)	36.5		<50 (USAD, 1987)
Clay (%)	34.8		7–27 (USAD, 1987)
Silt (%)	28.67		28–50 (USAD, 1987)
Soil texture		Clay loam	
Soil chemical properties			
Organic carbon (%)	1.2	Low	0.5–1.5 (Tekalign, 1991)
Electrical conductivity (ms/cm)	0.86	High	>0.45 (Shaw, 1999)
Total nitrogen (%)	0.097	Low	0.05–0.12 (Tekalign, 1991)
pH	7.8	Mod. alkaline	7.4–8.4 (Horneck et al., 2011)
Cation exchange capacity (Meq/100g soil)	32.2	High	>25 (Hazalton & Murphy, 2007)
Available phosphorus (ppm)	25.17	High	25–50 (Horneck et al., 2011)
Potassium (ppm)	378.08	High	>161 (Daniel, 2018)
Sodium (ppm)	18.5	Low	< 150 (Horneck et al., 2011)
Calcium (Meq of Ca/L)	17.08	High	>2.0 (Horneck et al., 2011)
Magnesium (Meq of Mg/L)	2.83	High	>2.5 (Horneck et al., 2011)

Source: Mekelle Soil Laboratory

classified as moderately alkaline (7.8). The availability of soil pH for good tomato production was from 5.5 to 7.5. However, the experimental site was mostly covered by moderately alkaline soil. Therefore, the reduction in productivity of tomato due to alkalinity was improved by applying inorganic fertilizer to minimize the salt effect in the soil or through irrigation water.

Soil texture

The study site was important to know or create good environmental conditions for crop cultivation. The tested soil sample shows that sand (36.5%), clay (34.5%) and silt (28.67%). According to the USDA (1987) soil classification, the soil class of the experimental field was categorized as clay loam.

Phenological and growth parameters

Based on their agronomic characteristics, the results of the analysis of variance reveal a significant difference between the interaction effects of blended fertilizer with tomato varieties at the p <0.05 probability level (Table 3).

Days to flowering and maturity

The days to flowering trait showed a substantial difference between the treatments. The treatments of 250 kg/ha blended NPSZnB fertilizer with the Melkasholla variety had the shortest flowering times (44 days), followed by 200 kg/ha NPSZnB fertilizer with Melkasholla (44.5 days). This implies that Melkasholla is used more frequently than other tomato varieties in blended fertilizer applications, maybe due to the variety, in contrast to Tsedu *et al. (*2021, who reported that the combination of the Melkashola variety with 150, 200 and 250 kg/ha NPSBZn fertilizer had significantly longer days to flowering than other treatment combinations. This outcome demonstrates that the comparable varieties differed from the varieties employed in this investigation and the experimental field's environment also had an impact.

On the other hand, the longest flowering days were recorded in Roma-VF with unfertilized application (51.8 days), followed by 250 and 150 kg/ha blended fertilizer application with Melkasalsa variety. The unfertilized plot with Roma-VF shows delaying in flowering, but the applied fertilizer at different rates revealed earliness next to the variety Melkasholla. This reveals that the blended fertilizer has a significant influence on Roma-VF's early blossoming. On the other hand, in both fertilized and unfertilized plots, the variety Melkasalsa bloomed later than expected. In the variety Melkasalsa, the interaction effect of NPSZnB did not contribute to either early or late flowering, indicating that the variety is delaying blooming on its own.

Like days to flowering, maturity also showed a significant difference among the treatments. Days to maturity were delayed in both treatments of 150 kg/ha NPSZnB with Melkasalsa and the unfertilized plot with Roma-VF (78.5 days in each). Moreover, the variety Melkasalsa was late in maturity both in the unfertilized plot and the applied blended fertilizer rate of 250 kg/ha. This revealed that without any assistance of blended fertilizer for earliness, Melkasala was late in maturity by its nature. While the responses of different rates of NPSZnB for relatively early stages of Roma-VF displayed important contributions in maturity. In contrast, nitrogen has been demonstrated to enhance leaf size and chlorophyll content, postpone maturity, and expand the vegetative development stage (Haruna *et al*., 2011).

On the other hand, the treatments of Melkasholla with application rates of 250 and 200 kg/ha (70.8 days) blended fertilizer exhibited earliness in maturity. In most applied blended fertilizer and controlled plot, Melkasholla was early mature. This indicates that the contribution of NPSZnB on Melkasholla displays a significant role for earliness as compared to the other varieties.

Plant height and number of primary branches

Analysis of variance shows a significantly different between the treatments in plant height. The tallest plant was found in the application of 200 kg/ha (75.9 cm), followed by 250 kg/ha (73.4 cm) NPSZnB fertilizers with the variety of Melkasholla, which might be due to the availability of more nutrients. Contrarily, Melkashola was the shortest in their growth both in the unfertilized plot and 150 kg/ha application of blended fertilizer as compared with the high rate of fertilizers. In contrast, the shortest in height was registered in both unfertilized plots with Roma-VF (52.1 cm) and Melkasalsa (56.1 cm), followed by 250 and 200 kg/ha NPSZnB fertilizer with the variety of Melkasalsa. Roma-VF with different rates of fertilizers showed an increase in growth. The result shows that mostly Melkasalsa was the shortest in height among other varieties, but as blended fertilizer was applied, the growth might increase in proportioned.

None of the means of treatment in the primary branches was observed. The maximum number of primary branches was shown in the unfertilized plot with Melkasalsa (13.7), followed by application of 150 kg/ha blended fertilizer with Roma-VF. In contrary, the minimum number was exhibited in the unfertilized plot with the variety of Roma-VF (11.57). This shows that the response of tomato varieties to the application of different rates of NPSZnB fertilizer did not significantly change in the growth of primary branches.

Yield and Related Traits

Number of fruits per plant and number of plants per plot

The maximum and significantly different number of fruits per plant was obtained from the interaction of 250 and 150 kg/ha blended fertilizer with Melkasalsa, which shows 52 and 50.17, respectively. On the contrary, the unfertilized plot of Melkasalsa was low in fruit per plant than the applied fertilizer rates. This indicates that the contribution of nutrients for a large number of fruits was significantly important. On the other hand, the minimum in fruit number was exhibited in the interactions of the unfertilized plot with the varieties of Melkasholla, Melkasalsa, and Roma-VF, respectively. The result shows that most of the varieties applied with variable rates of NPSZnB were higher in fruit number than the unfertilized plot, which might be due to the necessity of more nutrients availability in the study area.

Significantly different and a high number of plants per plot were involved in the interaction of 250 kg/ha with Melkasholla (43.83), followed by 150 kg/ha application of NPSZnB fertilizer with the variety of Roma-VF. Contrarily, the minimum number of plants per plot was counted in the applied blended fertilizers of 250 kg/ha, with the varieties of Roma-VF and Melkasalsa showing 34.17 and 34.83, respectively. This revealed that the response of those varieties to the highest rate of NPSZnB fertilizers in the number of plants per plot was minimized, which might be due to the overdose application and/or toxicity formation.

Marketable and unmarketable fruit yields

The highest and significantly different marketable yield was obtained in the application of 150 kg/ha NPSZnB fertilizer with the variety of Melkasholla (50.85 t/ha). Even in the unfertilized plot, Melkasholla was best in its production than the other varieties. Moreover, in the application of different rates of blended fertilizers, the productivity of Melkasholla showed an increment as compared with the controlled plot (Table 3).

In contrast, the lowest in marketable yield was obtained from the unfertilized plot with the varieties of Melkasalsa (30.57 t/ha), followed by Roma-VF (31.18 t/ha). However, Roma-VF was linearly increased in marketable yield as the application of blended fertilizers rose. This indicates that the addition of fertilizers for potentially high-yielding of the Roma-VF variety in the target area was needed. Like the variety of Roma-VF, Melkasalsa also showed a relatively increment with the supplementation of optimum rates of NPSZnB fertilizers.

The unmarketable fruit yield was significantly and maximum in the interaction of Roma-VF with the applied fertilizer of 150 kg/ha (18.21 t/ha), followed by Melkasholla with 250 kg/ha NPSZnB fertilizer. This reveals that the management of pre- and post-harvest handling might be limited due to a lack of stalking, susceptibility to insects and pests, storage system and overall influenced by environmental factors. On the other hand, the minimum unmarketable yield was taken from the unfertilized plot with the varieties of Melkasalsa next to Roma-VF. This result indicates that those varieties are mostly due to low productivity, as well as reducing the unmarketable yield and vice versa.

The total fruit yield is obtained from the summation of both marketable and unmarketable yields. The highest yield production and significantly different among the treatments was obtained from the variety of Melkasholla with different rates of blended fertilizers, which are 150 kg/ha (64.11 t/ha), followed by 250 kg/ha (58.73 t/ha). In most cases, Melkasholla had the highest yield production than other varieties, both

Table 3: Mean values of yield and yield-related components of tomato varieties in response to different application rates of NPSZnB fertilizer

Fertilizer (Kg/ha) +Varieties	*DF 50%*	*DM 50%*	*PH (cm)*	*NFP*	*NPP*	*NPB*	*MKY (t/ha)*	*UNMY (t/ha)*	*TY (t/ha)*
250+Melkasholla	44[d]	70.8[d]	73.4[ab]	41.78[bcd]	43.83[a]	13.1[a]	42.07[ab]	16.66[ab]	58.73[ab]
250+Melkasalsa	50.5[ab]	78[ab]	58[cd]	52.00[a]	34.83[de]	13.4[a]	40.56[ab]	13.68[bcd]	54.24[abcd]
250+Roma-VF	48.5[bc]	76.7[ab]	65.1[abc]	41.67[bcd]	34.17[e]	11.9[a]	42.51[ab]	10.94[cd]	53.45[abcd]
200+Melkasholla	44.5[d]	70.8[d]	75.9[a]	48.00[abc]	41.5[abc]	13.13[a]	39.9[ab]	14.3[abc]	54.20[abcd]
200+Melkasalsa	50.3[ab]	77.7[ab]	58[cd]	48.50[abc]	38.17[abcde]	12.27[a]	42.17[ab]	13.77[bcd]	55.94[abc]
200+Roma-vf	47.5[c]	76[bc]	65[abc]	46.83[abc]	41[abcd]	11.97[a]	39.59[ab]	16.36[ab]	55.95[abc]
150+Melkasholla	47.7[c]	76.5[abc]	60[cd]	47.33[abc]	37[bcde]	11.9[a]	50.85[a]	13.26[bcd]	64.11[a]
150+Melkasalsa	50.5[ab]	78.5[a]	63.1[bcd]	50.17[ab]	36.17[cde]	14.7[a]	42.47[ab]	12.12[cd]	54.59[abcd]
150+Roma-VF	45.3[d]	71[d]	68.2[abc]	41.50[bcd]	42.67[ab]	13.45[a]	36.22[b]	18.2[a]	54.42[abcd]
Con+Melkasholla	47.7[c]	74.2[c]	61.9[bcd]	37.17[d]	41.83[abc]	12.7[a]	34.57[b]	12.78[bcd]	47.35[bcd]
Con+Melkasalsa	49.2[bc]	78.2[ab]	56.1[cd]	39.00[cd]	39[abcde]	13.7[a]	30.57[b]	10.19[d]	40.76[d]
Con+Roma-VF	51.8[a]	78.5[a]	52.1[d]	39.17[cd]	37.2[bcd]	11.57[a]	31.18[b]	10.94[cd]	42.12[cd]
LSD (5%)	2.1	2.4	12.4	9.5	6.18	3.23	136.04	40.29	148.03
CV (%)	2.62	1.87	11.64	12.66	9.38	14.9	20.4	17.5	16.5
SED	1.03	1.15	5.9	4.59	2.98	1.56	65.59	19.4	71.37

DM= days to flowering, DM= days to maturity, PH= plant height, NFP= number of fruits per plant, NPP= number of plants per plot, NPB= number of primary branches, MKY= marketable yield, UNMY= unmarketable yield, TY= total yield

at the unfertilized plot and in some of the applied blended fertilizer rates. This reveals that the variety was best performed and suitable for the environmental conditions of the study area.

Partial budget analysis

The partial budget analysis was important to determine the net benefit and marginal rate of return that could be confirmed from variable alternatives of treatments, CIMMYT (1988). The maximum and minimum application rates of fertilizers in response to varieties of tomato productivity were employed to evaluate the preference of farmers based on estimated cost benefits, as presented in Table 4. Moreover, the study was taken into consideration all the inputs used for the experiment, including labor costs. The highest net benefit was shown in the interactions of 150 kg/ha blended fertilizer with the varieties of Melkasholla and Melkasalsa, which are 449,085 ETB/ha and 373,665 ETB/ha, respectively. The result indicated that as fruit yield shows an increment, the net benefit also increases. On the contrary, the lowest in net benefit were obtained from the unfertilized plot with Melkasholla, Melkasalsa and Roma-VF, respectively (Table 4). This reveals that the smallest in net benefit might be due to the reduction in fruit yield as compared with the application of variable rates of fertilized plots.

Dominance analysis and net benefit curve

The dominance analysis was importantly needed to select potentially benefited treatments from the range that was tested, that serve to eliminate some of the treatments from further consideration and thereby clarify the analysis CIMMYT, 1998. Therefore, the farmer's interest was to get potentially high-yielding fruit yield varieties with low inputs for better benefits. Stephen and Nicky (2007) stated that a dominated treatment is any treatment that has net benefits that are less than those of a treatment with a lower cost that varies. Accordingly, ranking the treatments from minimum to maximum costs that vary was given in Table 5. The net benefit curve was used to determine the reason behind the calculation of marginal rates of return by comparing the increments in costs and benefits among paired of treatments. The result of the study shows that as the net benefit increases, the total cost also increases linearly, but in some treatments of 150 kg/ha fertilizer with Melkasholla, 200 and 250 kg/ha applications of fertilizer with the variety Melkasalsa were shown in proportioned.

Marginal rate of return

The net benefit-cost ratio shows a range from 35.45 in the treatments of 250 kg/ha blended fertilizer with Melkasalsa to 63.82 in the unfertilized plot with Melkasholla. The marginal rate of return among any couple of dominant treatments denotes the return per unit of investment in fertilizer, described as a percentage (Table 5). Accordingly, the dominant analysis of treatments shows that as one birr invested in purchasing of inputs, the probability to recover with the profitability of 27.4, 37.9, 25.9, 11.04, 40.8 and 35.24 birr/ha from the lowest application of blended fertilizers

Table 4: Net benefit estimates for response of tomato varieties to application of different rates of NPSZnB fertilizer

Fertilizer rates (kg/ha) + Varieties	*AvY (t/ha)*	*AjY (t/ha)*	*FP/qt (ETB)*	*GFB (ETB/ha)*	*TVC (ETB/ha)*	*NB (ETB/ha)*	*B:C ratio*
250+Melkasholla	42.07	37.86	1000	378630	10015	368615	36.8
250+Melkasalsa	40.56	36.51	1000	365040	10015	355025	35.45
250+Roma- VF	42.51	38.26	1000	382590	10015	372575	37.2
200+Melkasholla	39.9	35.91	1000	359100	9290	349810	37.65
200+Melkasalsa	42.17	37.95	1000	379530	9290	370240	39.85
200+Roma- VF	39.59	35.63	1000	356310	9290	347020	37.35
150+Melkasholla	50.85	45.76	1000	457650	8565	449085	52.43
150+Melkasalsa	42.47	38.22	1000	382230	8565	373665	43.63
150+Roma- VF	36.22	32.59	1000	325980	8565	317415	37.1
Cont.+Melkasholla	34.57	31.11	1000	311130	4800	306330	63.82
Cont.+Melkasalsa	30.57	27.51	1000	275130	4800	270330	56.32
Cont.+Roma vf	31.18	28.06	1000	280620	4800	275820	57.46

AvY= average yield, AjY= adjusted yield, FP= field price, GFB= gross field benefit, TVC= total variable cost, NB= net benefit and B:C ratio= benefit cost ratio

Table 5: Dominance analysis and Marginal Rate of Return for the response of tomato varieties to application of different rates of NPSZnB fertilizer

Fertilizer rates (kg/ha)+ Varieties	*TVC (ETB/ha)*	*NB (ETB/ha)*	*Dominance*	*MC (ETB/ha)*	*MB (ETB/ha)*	*MRR (%)*
Cont.+ Melkasalsa	4800	270330				
150+ Melkasalsa	8565	373665		3765	103335	2744.62
200+ Melkasalsa	9290	370240	Dominated			
250+ Melkasalsa	10015	355025	Dominated			
Cont.+ Melkasholla	4800	306330				
150+ Melkasholla	8565	449085		3765	142755	3791.63
200+ Melkasholla	9290	349810	Dominated			
250+ Melkasholla	10015	368615		725	18805	2593.79
Cont.+Roma vf	4800	275820				
150+Roma vf	8565	317415		3765	41595	1104.78
200+Roma vf	9290	347020		725	29605	4083.45
250+Roma vf	10015	372575		725	25555	3524.83

TVC= total variable cost, NB= net benefit, MC= marginal cost, MB= marginal benefit, and MRR= marginal rate of return

up to the highest rate of NPSZnB interacted with varieties of tomato.

According to CIMMYT (1988), the minimum rate of return to farmers' recommendation is 50 to 100%. This investigation indicates that most of the treatments are above the minimum required for acceptance and not dominated except for the fertilizer rates of 200 and 250 kg/ha with Melkasalsa, and 200 kg/ha with Melkasholla. Generally, based on the cost-benefit analysis, the treatment applied 200 kg/ha blended fertilizer with the variety Roma-VF is best recommended and economically feasible for farmers who are located in the Gereb giba area and the same agroecologies. CIMMYT (1988) reported that the best recommendation for treatments subjected to a marginal rate of return is not based on the maximum return, but rather based on the minimum acceptance of the marginal rate of return and the treatments with the highest net benefit, together with an acceptable marginal rate of return, become the tentative recommendation.

Conclusion

The soil textural class of the experimental site is clay loam with low rates of total nitrogen and medium organic carbon. The result indicated that the treatments of NPSZnB fertilizer and varieties, which are 150 and 250 kg/ha, interacted with Melkasholla and were highest in their production, respectively, while the lowest was obtained from the varieties of Melkasalsa and Roma-VF with controls (unfertilized plot). The fertilizer rates of 200 and 250 kg/ha with Melkasalsa and 200 kg/ha with Melkasholla are the only treatments whose marginal rates of return are not dominated and are above the minimum required for acceptance. Therefore, based on the cost-benefit analysis, the treatment applied 200 kg/ha blended fertilizer with the variety Roma-VF is best recommended and economically feasible to the farmers who are located in Gereb giba area and similar agroecologies. Additionally, further exhaustive studies on diverse agroecology and climate settings are crucial to acquire a broad assessment of the soil fertility and optimize fertilizer management techniques.

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सारांश

टमाटर घरेलू उपयोग, व्यावसायीकरण और आय सृजन के लिए सबसे महत्वपूर्ण सब्जियों में से एक है। हालांकि मिट्टी की कम उर्वरता, कीटों, अजैविक कारकों और कृषि प्रबंधन के ज्ञान की कमी जैसी विभिन्न बाधाओं के कारण इसका उत्पादन कम है। इसलिए इस अध्ययन को टमाटर पर एनपीएसजेडएनबी उर्वरक के प्रयोग की दरों के प्रभाव का अध्ययन करने और लघु-स्तरीय सिंचाई योजना में आर्थिक व्यवहार्यता का पता लगाने के उद्देश्यों के साथ कार्यान्वित किया गया। बारह उपचारों में टमाटर की किस्मों (मेलकाशोल्ला, मेलकासाल्सा और रोमा-वीएफ) के संयोजन में विभिन्न उर्वरक अनुप्रयोग दरों (150 किलोग्राम/हेक्टेयर, 200 किलोग्राम/हेक्टेयर और 250 किलोग्राम/हेक्टेयर) को शामिल किया गया था, जिसमें फैक्टरियल व्यवस्था में तीन प्रतिकृतियों के साथ यादृच्छिक पूर्ण ब्लॉक डिजाइन का उपयोग किया गया था। प्रायोगिक खेत की मिट्टी की बनावट को चिकनी दोमट मिट्टी के रूप में वर्गीकृत किया गया। विचरण विश्लेषण के परिणामों से पता चलता है कि टमाटर की किस्मों के कृषि संबंधी लक्षणों के आधार पर मिश्रित उर्वरक और टमाटर की किस्मों के बीच परस्पर क्रियात्मक प्रभावों में महत्वपूर्ण अंतर है। परिपक्वता के संदर्भ में, अन्य उपचारों की तुलना में, मेलकाशोल्ला किस्म में एनपीएसजेडएनबी का योगदान शीघ्र पकने में प्रमुख भूमिका निभाता है। कुल फल उत्पादन में उच्चतम (64.11 टन/हेक्टेयर) परिणाम मेलकाशोल्ला किस्म और 150 किलोग्राम/हेक्टेयर मिश्रित उर्वरकों के संयोजन से प्राप्त हुआ, इसके बाद 250 किलोग्राम/हेक्टेयर मिश्रित उर्वरकों के संयोजन से 58.73 टन/हेक्टेयर का स्थान रहा। लागत-लाभ विश्लेषण के अनुसार, गेरेब गिबा क्षेत्र और इसी तरह की अन्य कृषि-पारिस्थितिकी में स्थित किसानों के लिए रोमा-वीएफ किस्म के साथ 200 किलोग्राम/हेक्टेयर मिश्रित उर्वरक का प्रयोग करना आम तौर पर सबसे अनुशंसित और आर्थिक रूप से व्यवहार्य है।