



RESEARCH ARTICLE

Maize (*Zea mays* L.) productivity as affected by different ratios of fertilizer (blended NPS) and inter row spacing at West Omo, South-West Ethiopia

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Abstract

One of the principal food crops in almost all of Ethiopia is maize (*Zea mays* L.). However, it has very low production when compared to that of Africa and the rest of the world. Because of poor agronomic practices, such as inappropriate row spacing and fertilizer management practice. Therefore, the experiment was conducted during the 2020 main cropping season at Maenit Goldia district in South-West Ethiopia to decide the response of maize yield by inter-row spacing and blended NPS fertilizer rates. A factorial combination of 4 levels of blended NPS fertilizer (0, 50, 100 and 150 kg) and 3 levels of between row spacing (70, 75 and 80 cm) were laid out in a randomized complete block design (RCBD) with 3 replications. Data on crop phenology, growth yield components and yield parameter were collected and analyzed using SAS version 9.3 (SAS Institute Inc., 2015). The result of this experiment shows that combined use of blended NPS fertilizer and row spacing significantly influence growth and yield and yield components parameters of maize. As the use of blended NPS fertilizer and row spacing increased the days to tasseling, plant height, ear length, ear diameter and leaf area increased whereas, decreased days to maturity and days to silking. And also use of 150 kg ha⁻¹ of NPS blended fertilizer and row spacing (80 cm) increased number of grain yield, 100 grain weight, above ground biomass and harvesting index by 39.85, 35.20, 32.93 and 35.02%, respectively. Accordingly, it should be noted that, based on an analysis of the partial budget, combinations of the widest row spacing (80 cm) and 150 kg ha⁻¹ of blended NPS fertilizer were promising for maize production in the main cropping season of the Chat Kebele Maenit Goldia district and other similar agro-ecologies.

Keywords: Inter-row spacing, Yield and yield components, Blended NPS fertilizer

INTRODUCTION

Maize (*Zea mays* L.) originated in Mexico and Central America and belongs to the family Poaceae (Gramineae) and production and area coverage of maize is third in rank among cereal crops next to wheat and rice (Kebede *et al.*, 2019). Maize is now commonly farmed in most regions

of the world due to its ability to adapt to a wide range of environmental conditions ranging from 50° latitude north to south of the equator (Esayas *et al.*, 2018). The total area covered by maize and grain production in the world stayed at 177,379,567.09 ha and 975,587,619 ton respectively with the productivity of 5.5 t ha⁻¹ (Belay *et al.*, 2021). Maize is sometimes referred to as the "King of Cereals" due to its high genetic yield potential in productivity when compared to other cereals. (Tolera *et al.*, 2021). Also known as the 'queen' of cereals due to its importance in human and animal diets, it is a very efficient solar energy user with a large potential for better production. (Ram *et al.*, 2022).

Ethiopia is the most frequently cultivated crop in terms of area coverage (16.08%) and output (25.81%, 649,154,029 tons). (CSA, 2020). Maize is currently the most prominent crop grown by smallholder farmers in Ethiopia's highlands and lowlands. (Balemi, *et al.*, 2019). However, the estimated average yield of maize for smallholder farmers in Ethiopia is below 3.2 t ha⁻¹ (CSA, 2020) which is much lower than productivity in industrialized countries such as the USA which is 8-9 t ha⁻¹ (FAO, 2020). This is because of both

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biotic and abiotic stresses (Tolera, *et al.*, 2017). Like disease and pests, lack of suitable variety, lack of soil fertility, shortage of capital to purchase farm input materials, lack of transportation during harvesting and improper spacing (Karaye, 2017). The yield gap is multi-faced but nearly always contains inappropriate spacing and poor soil fertility management is the most chronic issue (Balemi, *et al.* 2019). The severe deterioration in soil fertility in south-western Ethiopia is because of leaching of the presence of the high amount of rainfall (Orebo *et al.*, 2021).

Farmers were unable to reach the yield potential of maize due to improper cropping practices, such as the monocropping system, the use of crop residue as fuel, the unbalanced application of nutrients, and continuous cultivation (Wuletaw, 2018). Rising food consumption and population expansions continue to exceed production growth (Nure *et al.*, 2021). The production of maize is still greatly hampered by improper plant spacing, low intrinsic, soil degradation and fertility caused by nutrient and organic matter removal, which also adds to persistent poverty (Belay *et al.*, 2021). For a long time, declining soil fertility has been recognized as a major hindrance to agricultural intensification in Ethiopia. (Wudu, 2020). In the world, there are projects, that to meet the ever-growing demand caused by expanding human population, income, and consumption, the global food supply must be boosted to 70% by 2050. (Abera *et al.*, 2019). Several factors inhibit production performance under different environmental conditions, to solve the problem, effective and complementary use of all available technology tools and resources is required. (Sivakumar *et al.*, 2021).

NPS fertilizer and proper plant spacing are among the major alternative methods of increasing maize production (Gurmu *et al.*, 2020). Blende NPS fertilizer has meaningful importance for increasing the production and productivity of maize compared to only the application of blended NPS fertilizer (Abera, *et al.*, 2019). There is evidence that the application of blended NPS fertilizer potentially increased the production and productivity of maize in south western Ethiopia (Kebede *et al.*, 202). Tolossa *et al.* (2020) also specified that the maximum grain yield (1909 and 9618.9 kg ha⁻¹) was attained at 15cm intra-row spacing and 65cm inter-row spacing, respectively. In the study area, the production of maize is less due to many factors as mentioned earlier. Therefore, to reduce this problem and increase maize production and productivity, the study was run on the effects of inter-row spacing with NPS blended fertilizer rate on maize yield in West Omo Zone Meant Goldia District South West Ethiopia. With the specific objective:-

- To determine the impact of NPS blended fertilizer rates and between plant spacing on yield components and yield of maize in the study area.

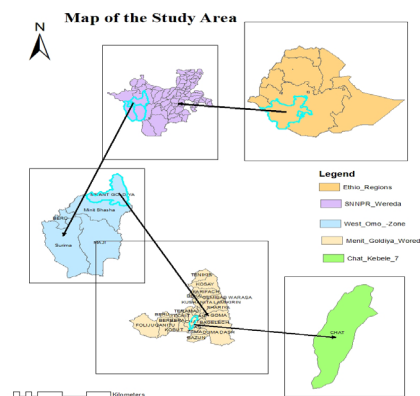


Figure 1: Map of study Area

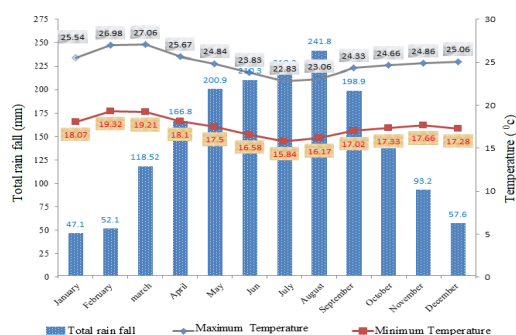


Figure 2: Monthly maximum and minimum temperature in (°C) and rain fall (mm) of experimental area (M.G Agri. office, 2020)

- To determine the best combination of blended NPS fertilizer rate and between plants spacing for optimum Maize yield in the study area
- To estimate the economic feasibility of the study.

MATERIAL AND METHOD

Description of the study area

The trial was run at "Chat" Kebele Mea'nit Goldia District, West Omo South-western Ethiopia during the 2020 cropping season. The district was located 615 km away from south-west Ethiopia of Addis Ababa (Figure 1). The district was located at 5°40'-7°40' latitude and 34°45'-36°10' longitudes and the elevation ranging from 1001–2500 m.a.s.l, with the mean minimum and maximum annual temperature of 15 and 27°C respectively. The average annual rainfall receives ranges from 1500–1800 mm per year (Agri. office, 2020) (Figure 2). The study area soil is sandy, silt and clay-loam soil. The pH of the soils ranges between 4 and 6. The main stable food crops in the district include maize, grain Amaranth, rice, groundnut, bean, pea, finger millet and Inset, while teff, sorghum, barley, and wheat are extensively cultivated. Cash crops comprise fruit (pineapple and banana) and spice (e. g. ginger and coriander). However, sesame and coffee are the principal cash crops.

Table 1: Improved seed maize varieties

Variety	Year of release	Breeding center	Maturity (days)	Rainfall (mm)	Altitude (m)	Yield (t ha ⁻¹)	
						farmer	Research
Pioneer (shone)	1926	Hi-Bred Corn Company	162	800 – 1200	1000-2000m	6 - 8	7-11

Source: MoARD, Crop Variety Register (2018)

Table 2: Blended NPS fertilizers and row spacing combinations

Treatments	Treatment Combination
T ₁	NPS 0 kg x 70 cm
T ₂	NPS 50 kg x 70 cm
T ₃	NPS 100kg x 70 cm
T ₄	NPS 150kg x 70 cm
T ₅	NPS 0 kg x 75 cm
T ₆	NPS 50 kg x 75cm
T ₇	NPS 100kg x 75 cm
T ₈	NPS 150kg x 75cm
T ₉	NPS 0 kg x 80 cm
T ₁₀	NPS 50 kg x 80 cm
T ₁₁	NPS 100 kg x 80 cm
T ₁₂	NPS 150 kg x 80 cm

Table 3: Population of maize with inter row spacing

Row Spacing per plot cm	Number of rows per plot	Number of plants per row	Net plot area (m ²)	population of maize per plot
70*25	7	8	4.9*2= 9.8	56
75*25	6	8	4.5*2= 9	48
80*25	5	8	4*2= 8	40

Experimental Materials

Pioneer (shone), an improved type of maize, was considered a test crop for NPS fertilizers. The nitrogen, sulfur, and phosphorus ratio in blended NPS fertilizer is 19 N, 7S, and 38% P2O5.

Soil Sampling and Analysis

Soil samples (0-20 cm depth) were collected before planting. Before planting, three subsamples were collected in a zigzag manner from the trial field using an auger. Then, one composite soil sample was prepared from the subsample. The soil samples were air drying and ground to pass through a 2.0 mm sieve before laboratory analysis. From the sample, the following parameter was analyzed. Soil texture (FAO (1990), Organic carbon Tekalign (1991), Cation exchange capacity Landon (1991), available nitrogen Murphy (1968), available phosphorus Olsen (1954), available sulfur Ethio SIS (2014) and pH Jones (2003) method by using standard laboratory procedures at Jemma soil and Plant Tissue Analysis laboratory.

Treatment and Experimental Design

The treatments were set in factorial combinations using a randomized complete block design (RCBD) with three levels

of between row spacing NPS (70*25, 75 *25 and 80*25 cm) and four levels of blended NPS fertilizer rates (0, 50, 100 and 150 kg ha⁻¹) (Table 2). The distance between the block and the plot is 1m and 0.5m, respectively. The plot width was 4.9 m and length of 2 m and the growth plot area was 9.8 m² (4.9 m X 2 m) the plot length and width respectively. The total trial area was 16.7 m x 30 m (501 m²). Description of blended NPS fertilizer treatment and their composition was (T1=0 NPS, 0-0-0), (T2=50 kg NPS, 55.5 - 19-3.5), (T3=100kg NPS, 65 -38- 7) and (T4=150 kg NPS, 74.5 -57- 10.5) (Table 3).

Experimental Procedures and Management

The field activity (land preparation, planting, fertilizer application and weeding) was done according to the recommended practice of the crop. The trial field was prepared following the convectional tillage practice of farmer' traditional farming system of plowing 4 times by using oxen before sowing all data on the crop phenology, growth, yield components and yield were measured from central rows of each plot to avoid border effect. Nitrogen was applied three split according to the treatments level (Golla *et al.*, 2018).

Data to be collected

Phenological data and Growth parameter

Days to 50% tasselling was recorded by calculating the number of days after sowing when 50% of the plants shed pollen from the tassel's primary branch and a few additional branches from each plot by visual observation (Gurmu *et al.*, 2020).

Days to 50% silking Visual observation was used to count the number of days from sowing when the silk will emerge on 50% of the plants in each plot. (Gurmu *et al.*, 2020).

Days to physiological maturity The days to physiological maturity were calculated as the time it took from the date of sowing until 90% of the plants established a black coating at the base of the kernel (at the point where the kernel attaches with the cob) and kernels were difficult to be broken by thumbnail.

Plant height (PH) was registered when the crop reaches maturity, 10 randomly selected plants from each plot are measured.

Leaf area index: the leaf area was determined initially from five randomly selected plants from the net plot at the 50% tasselling stage. The leaf area index was calculated by dividing a plant's total leaf area by the ground area covered by a single plant. (Nure *et al.*, 2021).

Yield and yield components

A number of ears per plant: It was determined by counting the number of ears in each plant by taking 5 randomly sampled plants' physiological maturity.

Ear length was measured between the two ends of the ear by taking 5 randomly selected ears at harvesting.

Ear diameter was measured from Varner calipers in the center of the ear by taking 5 randomly selected ears selected ears at harvesting.

A number of ears per row is taken from 5 randomly selected ears at harvesting by counting the number of rows in each ear.

A number of grains per row was recorded from 5 randomly selected ears at harvesting by counting the number of grains in each row on the ear.

A number of grains per ear was recorded from 5 randomly selected sampled ears by counting the grains in each ear.

Hundred-grain weight was calculated by counting the number of kernels in a sample shelled seed with an electronic seed counter and weighing it with a sensitive balance from a plot at harvest after correcting the grain to 12.5% moisture content.

Grain yield was calculated from the net harvestable area, adjusted to a moisture level of 12.5%, and converted to kg per hectare

Harvest index (HI) was computed as a percentage of the grain yield to the aboveground dry biomass yield. (Orebo *et al.*, 2021).

$$HI = \frac{GY}{BY} * 100$$

Where, HI=harvest index, GY=grain yield, BY=Biological Yield

Statistical Analysis

After checking for normality, the data were subjected to analysis of variance (ANOVA) using SAS version 9.3. (SAS Institute Inc., 2015). When ANOVA revealed a significant difference, mean separations were performed at a 5% probability level using the LSD test. Pearson's correlation analysis was used to investigate the link between various factors.

Partial Budget Analysis

Analysis of agricultural data to consolidate statistical analysis of partial budget was done for each treatment. For evaluation of economics, cost and return were calculated according to the procedure given by CIMMYT (1988). To estimate economic parameter maze was valued at an average open market price per kg during harvesting time. The mean straw and grain yield data were modified by 10% before being submitted to a partial budget and economic analysis using the CIMMYT methodology (CIMMYT, 1988). The total variable costs (cost of fertilizer, row making, and

planting cost) for each treatment were calculated, and treatments were ranked in order of ascending total variable cost (TVC), and dominance analysis was used to eliminate treatments that cost more but produced a lower net benefit than the next lowest cost treatment. The prices of the inputs that were in effect at the time of their use were used to calculate the cost of cultivation. Net returns per hectare were computed by subtracting production costs per hectare from gross income per hectare. (CIMMYT, 1988). The partial budget analysis was based on the formula developed by CIMMYT (1988) and given as follows:

Gross average yield (Av. Y kg ha⁻¹): was the treatment's average grain yield

Adjusted yield (Aj. Y): Was the average yield reduced by 10% to reflect the difference between the experimental yield and farmer yield?

$$AjY = AvY - (AvY \times 0.1)$$

Gross field benefit (GFB): Estimated by multiplying the adjusted yield by the field/farm gate price that farmers receive for the crop when they sell it (calculated both for grain and straw yield).

$$GFB = AjY \times \text{farm gate price for the crop}$$

Total variable cost (TVC) (ETB ha⁻¹): was computed by adding all the variable costs, including the cost of blended NPS (15.6 ETB kg⁻¹), Urea (13.55 ETB kg⁻¹) fertilizers and cost of seed (25 ETB Kg⁻¹) at the time of planting (September 2020) and according to Chat Kebele farm daily payment of labor cost for row making seed drilling and fertilizer application (12 person's ha⁻¹, each of 50.75, 61.50 and 70 ETB day⁻¹ ha⁻¹ for 80, 75 and 70-row spacing respectively).

The total cost was the cost of fertilizer row making and fertilizer application as part of the experiment Other inputs and production procedures, such as labor expenses for land preparation, planting, weeding, and harvesting, were thought to be the same or minor across treatments.

Net benefit (NB): The total expenses were subtracted from the gross field benefits for each treatment.

$$NB = GAY - TVC$$

Dominance analysis: was carried out by first listing all of the treatments in order of increasing costs that vary (TVC) and then setting aside their net benefits (NB). Any treatment with a higher TVC but net benefits less than or equal to the previous treatment (with a lower TVC but greater net benefits) is a dominated treatment (labeled "D").

Marginal rate of return (MRR) (%): was calculated by dividing the change in net benefit (ΔNB) by (ΔTVC) change in total variable cost times a hundred.

$$MRR = \frac{\text{Change in net benefits } (\Delta NB)}{\text{Change in cost } (\Delta TVC)} * 100$$

Table 4: Soil physical and chemical properties of the experimental site

Soil property (%)	Amount	Rating	References
Particle size distribution			
Sand	60		
Silt	8		
Clay	32		
Textural class	Sandy Clay loam		(FAO, 1990)
pH (soil: water in 1:2.5) (W/V)	5.22	strongly acidic	Murphy(1968) Jones 2003
TN (%)	0.11	low	Murphy (1968)
Available P (ppm)	7.08	medium	Jones (2003)
OC (%)	0.93	low	Tekalign (1991)
CEC (coml. (+) kg ⁻¹ soil)	18.34	Medium	Landon (1991).
Available S (ppm)	11.28	Low	Ethio SIS (2013)

Coml = cent mole, pH= hydrogen ion concentration, OC= organic carbon, TN= total nitrogen, Av. p (ppm) = available phosphorus in parts per million, CEC= Cation exchange capacity, Av. S = available sulfur in parts per million.

RESULT AND DISCUSSION

Soil physico-chemical properties of the experimental site before planting

The soil textural class of the trial site was found to be sandy clay loam with particle size distribution of sand 60, clay 32 and silt 8% (Table 4). Maize was best suited to well-drained sandy clay loam soil, and the trial location's soil texture is suitable for maize production. Based (FAO, 1990) the chemical analysis showed that the soil was strongly acidic with relatively medium phosphorus, low nitrogen, medium CEC and low organic carbon (Table 4). The amount of organic carbon (SOC) in the soil in the area of study was a value of 0.9% (Table 4). Giving to the OC rating by Tekalign (1991) the area of the district has little OC. This is due to continuous cultivation, use of only inorganic fertilizer or absence of use of organic fertilizer like, compost, farm yard manure, green manure and compost, and complete removal of crop residue from the field, as a result of organic matter degradation (Ejigu *et al.*, 2021). The result displayed that the trial soil CEC was 18.34 cmol (+) kg⁻¹ (Table 4) which is medium according to (Landon 1991).

The analysis outcomes displayed that the total nitrogen content in the soil was 0.11 % (Table 4). Murphy (1968) determined that the overall N concentration of soil is low. The nitrogen need of the maize crops is between (0.19–0.25%) (Balemi, *et al.*, 2019). Therefore, the total nitrogen of the experimental soil is rated as low. Therefore, there need to be the application of contented nitrogen fertilizer. The result of the analysis show that the available P level in the trial soil is 7.08 ppm (Table 4). According to Olsen *et al.*, (1954) soils having available P from 5 to 10 ppm are considered medium. Ethio SIS (2014) suggests optimum P content for most Ethiopian soil as 15 mg kg⁻¹. Therefore, the available phosphorus in the experimental soil is rated as medium. Available sulfur the value of the study area was 11.28 mg kg⁻¹ (Table 4). Based on Ethio SIS (2014) soil classification for S values lies in the low range. So the addition of fertilizer that contains S is relevant. The little content of sulfur in

the soil is because of lack of application of sulfur content organic fertilizer. Soil pH result were found to be highly acidic with pH value of 5.22 (Table 4) Murphy (1968) and Jones (2003) (Landon, 1991) found that the optimum soil pH values ranging from 5.0 - 78.0 were suggested for maize production. From the data, the presence of acidity is because of the generally high amount of rain falling in south-western Ethiopia and the leaching of basic cations that lead the soil to become dominated by Al³⁺, Fe^{+2/3}, Mn, intensive cultivation and continuous use of acid-forming inorganic fertilizers aggravated soil acidity in the study area (Zewide *et al.*, 2018).

Phonological and Growth Parameters

Days to 50% tasseling: The results of the analysis of variances revealed that blended NPS fertilizer application and between-row spacing are significantly influenced (p 0.01) days to 50% tasseling. The highest day (75.67) to reach 50% tasseling was recorded from a control plot with 70 cm between row spacing, while the shortest days (57.67) to reach 50% tasseling were recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between rows spacing (Table 5). The possible reason for the shortest days to attain 50% tasseling of maize was the accessibility of phosphorous in the soil, the application of 150 kg ha⁻¹ blended NPS fertilizer, good light penetration, and low competition for growth factors due to the wide space between rows (Table 5). These nutrients and wide row spacing promote good leaf development, increase sunlight interception, excessive vegetative growth, high photosynthesis, and the production of sufficient carbohydrates. As a result, 50% of tasseling achieved fasts. The result is similar to that reported by Gurmu *et al.* (2020), who reported that as the rate of blended fertilizer application increased, the number of days to tasseling in maize decreased. Priyavart *et al.* (2019) also observed that blended NPS fertilizer application significantly influenced days to maturity, silking, and tasseling.

Days to 50% silking: The results showed that the main effect of application of blended NPS fertilizer and between-row spacing had a highly significant influence (p 0.01) days

Table 5: Interaction effect of NPS and plant spacing on phenological data of maize

NPS	IRS	DT	DS	DPM
0	70	75.67 ^a	90 ^a	132.33 ^a
	75	71.67 ^b	84 ^b	125.33 ^b
	80	71.33 ^b	84 ^b	125.33 ^b
50	70	71.00 ^b	83.67 ^{bc}	124.67 ^{bc}
	75	69.67 ^{bc}	81.67 ^{bcd}	122 ^{bcd}
	80	69.33 ^{bcd}	81.33 ^{bcd}	121 ^{bcd}
100	70	68.00 ^{cd}	80.33 ^{bcd}	120 ^{cd}
	75	67.33 ^{cd}	79.67 ^{cd}	118.67 ^d
	80	66.67 ^{de}	78.67 ^{de}	117.33 ^{de}
150	70	64.3300 ^e	75.33 ^e	112.33 ^{ef}
	75	64.00 ^e	75 ^e	112 ^f
	80	57.67 ^f	64.33 ^f	101 ^g
LSD (0.05)		2.972	4.182	5.196
CV (%)		2.6	3.1	2.6
p-value		0.024*	0.006**	0.042*
SE ±		1.013	1.426	3.09 1.772

Where: IRS =inter row spacing, DT= Days to 50% tasseling, DS= Days to 50% silking, DPM=physiological maturity, LSD= list significant difference, CV= coefficient of variance, p-value= analysis of variances and standard error. The mean with the same letter indicates that the mean have statically no different.

to 50% silking. While the interaction had a significant (0.05) effect on days to 50% silking, The maximum days to 50% silking (90 days) were recorded from control plot with 70 cm row spacing, while the shortest days (64.33) were recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing (Table 5). Insufficient nutrient application results in slow development and delayed silking (Gurmu *et al.*, 2020). The result was in line with Balemi *et al.* (2019) and Bakala (2018), who reported that as the rate of application of blende NPS fertilizer increased, there was a reduction in the number of days to 50% in maize crops.

Days to 90% maturity: Days to 90% maturity was significantly (p 0.05) influenced by the interaction and the Main effects (p 0.01) of blended NPS fertilizer and between-row spacing. (Table 5). The longest days (132.33) were recorded in the control treatment with 70 cm between row spacing, whereas the shortest days (64.33) were recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing. This is due to the increased nutrient content of the soil from the applied NPS, which causes the crop to grow faster and produce more food; on the other hand, row spacing increases, and the vegetative growth of the crops becomes faster because there is less competition for nutrients, and the crop matures earlier. Whereas in control, there is no addition of nutrients, the crops go dormant and grow slowly; thus, a long period of time is required. A similar outcome was reported by Orebo

et al. (2021) early maturity was recorded with the application of fertilizer NPS. Yet late maturity was recorded in the control plot. Kinfe *et al.* (2019) also reported that early maturity was recorded with the application of blended NPS fertilizer, whereas the longest time to maturity was recorded from the control plot.

Plant height: The interaction (p 0.05) as well as the main effects (p 0.01) of blended NPS fertilizer and between row spacing affect plant height. The largest plant height (218.3 cm) was recorded from the application of 150kg ha⁻¹ blended NPS fertilizer with 70 cm row spacing, while the minimum plant height (165.2 cm) was recorded from the control plot with 70 cm row spacing (Table 3). The increase in plant height at the smallest between-row spacing and highest application of NPS blended fertilizer is because of the overcoming effect of the plant and the higher interspecific struggle for growth-limiting resources, particularly light. This competition is probably attributed to the relatively low solar radiation interception through the leaf canopy of plants, which might be responsible for the formation of longer internodes resulting in increased plant height. The idea is similar to that of Khan *et al.* (2017), who found that increasing plant population density increased plant height. Balemi *et al.* (2019) also found that increasing the application of blended fertilizers with smaller between-row spacing significantly increases plant height. While sparsely populated plants intercepted enough sunlight to promote lateral growth, the plant's height became medium.

Leaf area index: The result of the analysis of variance shows that the leaf area index was highly significantly (p 0.01) influenced by the main effects of blended NPS fertilizer rates, and the row spacing and the interaction effect were also significantly influenced (p 0.05) (Appendix Table 2). The highest leaf area index (5.98%) was recorded with the application of a 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing. The lowest leaf area index (3.68%) was recorded in the control plot with 70 cm between row spacing (Table 6). The reduced light struggle and overlapping from adjacent maize plants may have allowed the plants grown at the widest spacing to use their energy for more horizontal growth (Golla *et al.*, 2018). The leaf area index increased with the application of NPS fertilizer compared to the control plot. The above result indicates that achieving the maximum leaf area index requires a higher plant nutrient supply. These findings agree with Berdjour *et al.* (2020), who report increased leaf index by delaying leaf senescence, sustaining leaf photosynthesis, and maintaining leaf area duration as a result of nitrogen fertilizer application. Similar results were reported by Abera *et al.* (2017) the maize variety produces more leaf width and length, which attribute to producing more leaf area and leaf index. Belay *et al.* (2021) also reported that the application of blended fertilizer significantly increased leaf area, leaf area index, and the

Table 6: Interaction effects of NPS fertilizer rate and inter row spacing on growth parameters of maize

NPS	IRS	PLH	LAI	NEP	EL	ED
0	70	165.2 ^f	3.680 ^g	1.227 ^h	24.08 ^h	18.34 ^a
	75	168.8 ^f	4.353 ^f	1.45 ^g	28.12 ^g	22.25 ^b
	80	172.73 ^{ef}	4.73 ^e	1.58 ^f	30.38 ^f	24.43 ^{bc}
50	70	182.87 ^e	4.84 ^{de}	1.62 ^{ef}	31.08 ^{ef}	25.11 ^{cd}
	75	180 ^e	4.94 ^{de}	1.647 ^{ef}	31.64 ^{ef}	25.65 ^{de}
	80	182.87 ^e	5.027 ^{cde}	1.676 ^{def}	32.16 ^{def}	26.15 ^{def}
100	70	212.17 ^{ab}	5.15 ^{cd}	1.72 ^{ed}	32.92 ^{de}	26.89 ^{ef}
	75	197.47 ^d	5.307 ^{bc}	1.718 ^{de}	33.84 ^{cd}	27.78 ^{ef}
	80	199.2 ^{cd}	5.633 ^b	1.88 ^b	35.8 ^b	29.67 ^f
150	70	218.13 ^a	5.517 ^b	1.84 ^{bc}	35.1 ^{bc}	29 ^a
	75	209.07 ^{abc}	5.587 ^b	1.86 ^{bc}	35.52 ^{bc}	29.4 ^a
	80	202.4 ^{bcd}	5.987 ^a	2.04 ^a	38.72 ^a	32.5 ^h
LSD (0.05)		10.67	0.349	0.106	1.9081	1.84
CV (%)		3.3	4.1	3.7	3.5	4.1
p-value		0.047*	0.037*	0.014*	0.014*	0.014*
SE $\pm$		3.64	0.119	0.0361	0.651	0.63

Where: IRS=inter row spacing, PLH =plant height (cm), LAI =Leaf area index (%), NEP =Number of ear per plant ear⁻¹, EL= Ear length in cm, ED=Ear diameter in cm, LSD= list significant difference CV= coefficient of variance, p-value= analysis variance and SE =standard error. The mean with the same letter indicates that the mean has statically no different

number of leaves per plant for the maize crop. The leaf area index increased with increased NPS fertilizer rates because of vigorous crop growth and leaf expansion in length and width (Priyavart *et al.*, 2019).

The number of ears per plant: The analysis of variances showed that the number of ears per plant was extremely significantly (p 0.01) influenced by the main effects of blended NPS fertilizer rates and inter-row spacing, whereas the interaction was significantly (p 0.05) affected. The highest number of ears per plant (2.04) was recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, whereas the lowest number of ears per plant (1.24) was recorded from the control plot with 70 cm inter-row spacing (Table 6). The increase in the number of ears per plant with the increased spacing between rows is because of the availability of growth-limiting resources, higher net assimilation, and better partitioning of dry matter than with the narrow spacing. In addition, the reduced light competition and reduced overlapping from head-to-head maize plants could have enabled the plants grown at the widest spacing to utilize their energy for more horizontal growth (Golla *et al.*, 2018). The number of ears per plant increased with increased fertilizer NPS rates, and the vigorous growth of the crop and leaf was evident in their length and width (Abera *et al.*, 2017).

Ear Length: The analyses of variance revealed that ear length was highly significant (p 0.01) affected by the main

effects of blended NPS fertilizer rates, as well as that the interaction effect between row spacing and blended NPS fertilizer (p 0.01) also affected. The longest (38.72 cm) was recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, while the lowest ear length (24.08 cm) was recorded from the control plot with 70 cm between row spacing (Table 6). Because of the easy availability of growth-limiting factors both in the soil system and aboveground soil, this increased ear length was in response to the widest row spacing and a high fertilizer NPS rate. This could be responsible for maize plants expressing their full yield potential, and effective translocation of assimilates from the source to the sink may have further improved yield attributes resulting in the longest ear length under the widest inter-row spacing (Tamene *et al.*, 2018). Azam *et al.* (2017) found that row spacing had a significant effect on cob length due to intense competition for growth limiting factors such as nutrients, moisture, air, and light, and this finding is supported by Belay *et al.* (2021), who found a positive relationship between row spacing and NPS fertilizer in increasing cob length.

Ear diameter: The results of the analysis of variances showed that ear diameter was extremely significantly (p 0.01) and influenced by the main effects of blended NPS fertilizer rates and row spacing, while the interaction effects were a significant (p 0.05) affected (Appendix Table 2). The highest or thickest ear diameter (32.5 cm) was recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, while the smallest ear diameter (18.34 cm) was recorded from the control plot with 70 cm between row spacing (Table 6). This increase in ear diameter at the widest space between row spacing and more application of fertilizer NPS might be because of the reduction in the struggle among maize plants and efficient utilization of the growth resources, a high net assimilation rate, favorable assimilation portioning from the source to the sink, thick cobs, and high seed production. This outcome agrees with the finding of Priyavart *et al.* (2019), who reported that increasing row spacing positively affected ear diameter.

Yield Components and Yield of Maize

The number of grain rows per ear: The results of the analysis of variances revealed that the number of grain rows per ear was significantly (p 0.01) affected by the main effects of blended NPS fertilizer rates and row spacing, whereas the interaction result was significant (p 0.05) affected. The highest number of grain rows per ear (19.57 kernels) was recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, whereas the lowest number of grain rows per ear (14.77 kernels) was registered from control plots with 70 cm between row spacing (Table 7). The number of grain rows per ear increased as the between-row spacing increased from 70 cm to 80 cm. This increase in the number of grain rows per

ear in response to increasing row spacing and blended NPS fertilizer is due to increased availability of growth-limiting resources both in and outside the soil system, which may have allowed plants to grow vigorously and produce full, variable big ears that can carry a variety of grain rows. The number of grains per ear and the weight of grain can increase with increasing row spacing (Belay *et al.*, 2021). This outcome also aligns with the previous finding of Birhanu *et al.* (2018), who reported that increasing row spacing increased corn growth and development, increasing the number of grain rows per ear.

Number of Grains per row: the analysis of variances showed that the number of grains per row was extremely ($p < 0.01$) affected by the main effects of blended NPS fertilizer rates and row spacing, whereas the interaction effect was significantly ($p < 0.05$) affected. The highest number of grains per row (22.26 kernels) was recorded from the application of 150 NPS kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, while the lowest number of grains per row (12.56 kernels) was registered from control plots with 70 cm between row spacing (Table 7). The decrease in row spacing and blended NPS fertilizer reduces the number of grains per row. This is because of increased inter-plant completion and mutual shading of lower leaves, where light and air could not penetrate through and distribute to all leaves for efficiency. This increased number of grains per row with increasing row spacing and blended NPS fertilizer might be due to the availability of growth limiting factors that encouraged better plant growth and development. Resulting in more interception and conversion of light through leaves and setting an early sink for the accumulation of assimilates. The result is in line with the finding of Golla *et al.* (2018), who reported that increasing row spacing and fertilizer application increased cob length and the number of ears per row. Similarly, Esayas *et al.* (2018) reported that decreasing row spacing reduces the number of seeds per row due to increased inter-planting completion and mutual shading of lower leaves. Due to this, light could not penetrate throughout and distribute to all leaves for efficient photosynthesis.

Number of grains per ear: The analyses of variance showed that the number of grains per ear was highly significantly ($p < 0.01$) affected by the main effects of blended NPS fertilizer rates and inter-row spacing, while the interaction was also significantly ($p < 0.05$) affected. The highest number of grains per ear (734.67 kernels) was recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm row spacing, while the lowest number of grains per ear (441.33 kernels) was recorded from the control plot with 70 cm inter-row spacing (Table 7). With the widest spacing, there are enough resources in case there is no competition, so the amount of grain is high. This result is in agreement with the result of Nurse *et al.* (2021), who reported that row spacing of 30 cm

produced a greater grain yield per ear than that of 20 cm. This finding is consistent with the findings of Abera *et al.* (2017), who found that the highest grain number per ear in maize crop sown in 75 cm row space was higher than crop sown in 55 cm and 45 cm row space.

Hundred-grain weight (g): The analysis of variances showed that hundred-grain weight was highly significantly ($p < 0.01$) affected by the main influence of blended NPS fertilizer rates and row spacing, whereas the interaction effect was significant ($p < 0.05$). The highest hundred-grain weight (394.83 g) was recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, whereas the lowest hundred-grain weight (255.83 g) was recorded from a treatment control plot with 70 cm between rows spacing (Table 7). This is due to the fact that increasing row spacing and blended NPS fertilizer provide a better opportunity for a crop to utilize available resources with less completion, resulting in increased plant capacity for building large amounts of metabolites to be used in increasing this yield component. Furthermore, the widest row spacing, which improved the supply and portion of assimilating from source to sink to be stored the grains, could be the reason for producing a higher hundred seed weight. This result is in agreement with the findings of Azam *et al.* (2017), who observed that maximum 1000-seed weight (339 g) occurred at plant spacing of 30.5 cm and a minimum 1000-seed weight of 315.44 g occurred at 15.24 cm, and also agreed with the findings of Khan *et al.* (2017), who reported that the lowest plant population increased 1000-seed weight.

Aboveground dry biomass (kg): The result of the analysis of variance show that aboveground dry biomass was highly significantly ($p < 0.01$) influenced by the main effects of blended NPS fertilizer rates and row spacing, while the interaction effect was significantly ($p < 0.05$) affected. The highest aboveground biomass (15147.7 kg ha⁻¹) was recorded from the application of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, whereas the lowest aboveground biomass (10159 kg ha⁻¹) was recorded from a control plot with 70 cm between rows spacing (Table 7). As the NPS content of the soil and the row spacing increase, the above ground dry biomass also increases. This could be because increases in blended NPS fertilizer levels increase its availability in the soil, optimizing the nutrient requirements of dense and standing plants (Abera *et al.*, 2021). Mengistu (2022) reported that the application of blended NPS fertilizer meaningfully affected above ground biomass, and it was recorded as the highest (15147.7 kg ha⁻¹) at the application of 150 kg ha⁻¹ NPS blended fertilizer with 80 cm between row spacing and the lowest (10159 kg ha⁻¹) yield at the control plot with 70 cm between row spacing.

Harvesting index (%): The result of the analysis of variances indicated that the harvest index was extremely significantly

Table 7: Interaction effect of NPS and plant spacing on yield and yield component of maize

NPS	IRS	NRE	NGR	NGE	HGW (g)	AGB (kg)	HAI (%)	GYH (kg)
0	70	14.77 ^g	12.56 ^h	441.67 ^h	255.83 ^f	10159 ^f	44.81	4553.03 ^f
	75	14.93 ^g	15.24 ^g	522.67 ^g	257 ^f	10204.5 ^f	45.47	4640.15 ^f
	80	15.4 ^{fg}	16.74 ^f	567.67 ^f	260.5 ^f	10386.3 ^{ef}	46.67	4744.32 ^f
50	70	15.47 ^{efg}	17.2 ^{ef}	581.67 ^{ef}	295.33 ^e	10761.3 ^{dfe}	49.8	5360 ^e
	75	16.2 ^{ed}	17.57 ^{def}	593 ^{ef}	301.7 ^{de}	10761.3 ^{dfe}	52.9	5701 ^{de}
	80	16.27 ^d	17.91 ^{def}	603.33 ^{def}	311.7 ^{cde}	10840.9 ^{dfe}	54.41	5900 ^{cd}
100	70	16.13 ^{def}	18.41 ^{cde}	618.33 ^{de}	319.2 ^{cde}	10920.4 ^{cdef}	53.23	5814 ^{cd}
	75	16.67 ^{cd}	19.03 ^{bcd}	637 ^{cd}	327 ^{cd}	11443 ^{cde}	52.33	5989 ^{bcd}
	80	17.13 ^{bc}	20.32 ^b	676 ^b	357.5 ^b	11840.9 ^{bcd}	50.3	5956 ^{cd}
150	70	17.4 ^{bc}	19.86 ^{bc}	662 ^{bc}	394.8 ^a	13261.3 ^{bc}	45.9	6098 ^{bc}
	75	17.67 ^b	20.14 ^b	670.67 ^{bc}	336.7 ^{bc}	12784 ^b	49.5	6335 ^b
	80	19.57 ^a	22.26 ^a	734.33 ^a	394.83 ^a	15147.7 ^a	46.26	7007.58 ^a
LS(0.05)		0.7722	1.469	38.154	27.281	1.052	Ns	357.85
CV (%)		2.8	4.8	3.7	5.2	6.2	7.1	3.7
p-value		0.032*	0.047*	0.014*	0.034*	0.024*	ns	0.047*
SE ±		0.263	0.501	13.01	9.302	0.359	2.048	122.012

NRE: number of grain rows per ear, NGR: number of grains per row, NGE: number of grains per ear, HGW: Hundred-grain weight, AGB: Aboveground dry biomass (kg), HAI: Harvesting index (%), GYH: Grain yield per hectare (kg):

(p 0.01) and influenced by the main effects of blended NPS fertilizer rate and plant spacing, whereas the interaction effect was also significantly (p 0.05) affected. The highest mean harvest index (54.41%) was obtained by applying of 150 kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, whereas the lowest mean harvest index (44.81%) was obtained from control plots with 70 cm between row spacing (Table 7). The harvesting index increased as row spacing increased from 70 to 80 cm. This is due to the effective utilization of growth factors such as moisture, light, and nutrients, which results in high photosynthesis activity. Furthermore, the applied NPS blended fertilizer provides nutrients that allow crops to grow bigger, faster, and produce more food, resulting in a higher grain yield when compared to the control plot with 70 cm between row spacing. As a result, the widest spacing between rows and the highest application of NPS blended fertilizer resulted in a higher harvesting index. The outcome is consistent with Kebede (2019), which shows that wider between-row spacing generated a significantly larger maize harvest index than smaller between-row spacing. The result is also consistent with Tekle and Wassie (2018) research, which indicated that the treatment with blended fertilizer had the greatest teff harvesting index.

Grain yield per hectare (kg): The result of the analysis of variances showed that grain yield was highly significantly (p 0.01) affected by the main effects of blended NPS fertilizer rates and row spacing, and the interaction effect was also significant (p 0.05) affected. The highest mean grain yield (7007.58 kg ha⁻¹) was recorded from the application of 150

kg ha⁻¹ blended NPS fertilizer with 80 cm between row spacing, whereas the lowest mean grain yield (4553.03 kg ha⁻¹) was registered from the control treatment plots with 70 cm between row spacing (Table 7). Higher grain yield at an advanced NPS fertilizer level may be due to lower nutrient completion and the positive effect of fertilizer NPS on plant growth, leaf area expansion, and thus increased solar radiation use efficiency, which ultimately increases grain yield. A similar result was reported by Nure *et al.* (2021) highest grain yields were obtained from the application of 150 kg N/ha with a row spacing of 75 cm. Kinfe (2019) also found that the highest grain yield of maize was obtained from the application of blended NPS fertilizer as compared to the control plot. According to Tolossa and Gizawu (2020), grain and its component growth characteristics are increasing as the distance between rows increases from 60 to 70 cm.

Correlation analysis among phenology, growth parameters and yield components of maize

Grain yield is the end result of many complex morphological and physiological processes occurring during the growth and development of the crop. The relationship is used to describe and measure the strength and direction of the relationship between variables (Table 8). Plant height has a positive and highly significant relationship with leaf area index ($r = 0.74^{**}$), number of ears per plant ($r = 0.73^{**}$), ear length ($r = 0.73^{**}$), ear diameter ($r = 0.73^{**}$), number of rows per ear ($r = 0.65^{**}$), number of grains per row ($r = 0.73^{**}$), number of grains per ear ($r = 0.73^{**}$), hundred grain weight ($r = 0.70^{**}$), gain yield ($r = 0.74^{**}$), and plant height

Table 8: Correlation analysis for yield and yield components of maize during 2020/21 main cropping season

	PH	LAI	NEP	EL	ED	NRE	NGR	NGE	HGW	AGB	GYP
PLH	1	0.74**	0.73**	0.73**	0.73**	0.65**	0.73**	0.73**	0.70**	0.51*	0.74**
LAI		1	0.99**	0.99**	0.99**	0.83**	0.99**	0.99**	0.84**	0.67**	0.89**
NEP			1	0.99**	0.99**	0.85**	0.99**	0.99**	0.86**	0.70**	0.90**
EL				1	0.99**	0.85**	0.99**	0.99**	0.86**	0.70**	0.90**
ED					1	0.85**	0.99**	0.99**	0.86**	0.70**	0.90**
NRE						1	0.84**	0.85**	0.82**	0.78**	0.87**
NGR							1	0.99**	0.86**	0.69**	0.89**
NGE								1	0.86**	0.70**	0.90**
HGW									1	0.70**	0.89**
AGB										1	0.73**
GYP											1

Where: PLH = plant height, LAI = Leaf area index, NEP = Number of ear per plant, EL = Ear Length, ED = Ear Diameter, NRE = Number of rows per ear, NGR = Number of grains per row, NGE = Number of grains per ear, HGW = Hundred grain weight, AGB = Above ground biomass, GYP = Grain yield per hectare in kg. (**) = significant at 1%, (*) = significant at 5%.

The leaf area index has an absolutely and extremely meaningful relationship with the number of ears per plant ($r = 0.99^{**}$), ear length ($r = 0.99^{**}$), ear diameter ($r = 0.99^{**}$), number of rows per ear ($r = 0.83^{**}$), number of grains per row ($r = 0.99^{**}$), number of grains per ear ($r = 0.99^{**}$), hundred grain weight ($r = 0.84^{**}$), above-ground biomass yield ($r = 0.67^{**}$), and grain yield ($r = 0.89^{**}$). Ear length ($r = 0.99^{**}$), ear diameter ($r = 0.99^{**}$), number of rows per ear ($r = 0.85^{**}$), number of grains per row ($r = 0.99^{**}$), number of grains per ear ($r = 0.99^{**}$), hundred grain weight ($r = 0.86^{**}$), above-ground biomass yield ($r = 0.70^{**}$), and grain yield ($r = 0.90^{**}$) all have a positive and highly significant correlation. Ear length was positive and extremely meaningfully interrelated with ear diameter ($r = 0.99^{**}$), number of rows per ear ($r = 0.85^{**}$), number of grains per row ($r = 0.99^{**}$), number of grains per ear ($r = 0.99^{**}$), hundred grain weight ($r = 0.86^{**}$), above-ground biomass yield ($r = 0.70^{**}$), and grain yield ($r = 0.90^{**}$).

The ear diameter was positive and highly meaningfully interrelated with the number of rows per ear ($r = 0.85^{**}$), the number of grains per row ($r = 0.99^{**}$), the number of grains per ear ($r = 0.99^{**}$), the 100-grain weight ($r = 0.86^{**}$), the above-ground biomass yield ($r = 0.70^{**}$), and the grain yield ($r = 0.90^{**}$). Number of rows per ear was constructive and extremely meaningfully correlated with number of grains per row ($r = 0.84^{**}$), number of grains per ear ($r = 0.85^{**}$), 100-grain weight ($r = 0.82^{**}$), above-ground biomass yield ($r = 0.78^{**}$), and grain yield ($r = 0.87^{**}$).

The number of grains per ear was positive and extremely meaningfully interrelated with 100-grain weight ($r = 0.86^{**}$), aboveground biomass yield ($r = 0.70^{**}$), and grain yield ($r = 0.90^{**}$). The 100-grain weight was positive and extremely meaningfully interrelated with aboveground biomass yield ($r = 0.70^{**}$) and grain yield ($r = 0.90^{**}$). Above-ground

biomass yield was positive and significantly related to grain yield ($r = 0.73^{**}$). This relationship demonstrates that maize production is heavily influenced by growth parameters, which can be improved by optimizing the blended NPS fertilizer rate and plant spacing, resulting in increased maize grain yield.

Partial Budget Analysis

It was important to determine the profitability of the minimum rate of return acceptable to producers before recommending the results of the current study. The economic viability of fertilizer application is ultimately determined by the potential response of crops to applied fertilizers and the price of the fertilizers during the cropping season (CIMMYT, 1988). For a treatment to be considered a worthwhile option for farmers, the marginal rate of return must be 100%. It is the relationship between the costs and net benefits of non-dominant treatments. The net benefit was calculated by taking into account potential field variable costs, and all benefits indicated that combined application of a 150 kg ha⁻¹ NPS inorganic fertilizer with 80 between row spacing resulted in the highest net benefit/return of 90946.27 Ethiopian Birr per hectare (ETB) (1 USD = 51 Ethiopian Birr per Hectare (ETB)), followed by a net benefit of 8787.57 Ethiopian Birr per Hectare for a treatment consisting of a mixture application of 150 kg ha⁻¹ NPS. Thus, it can be inferred that the application of an appropriate rate of blended NPS fertilizer at proper between-row spacing is a means to increase the economic benefit of the application of NPS fertilizer (Table 9). The combined application of 150 NPS kg ha⁻¹ fertilizer and 80 cm between row spacing had an MRR of 1827%, which was above the acceptable minimum MRR of 100% (Table 10). It was discovered that the net benefit from using improved food maize at an application

Table 9: Partial budget analysis of the effect of NPS blended fertilizer and row spacing of maize crop

NPS (kg ha)	Row spacing (cm)	GAY(t ha ⁻¹)	ADY(t ha ⁻¹)	GFB (ETB)	CS (ETB)	CF (ETB)	CT (ETB)	CSFA(ETB)	TVC (ETB)	NB (ETB)	MRR (%)
0	80	4744.3	4269.9	64048.3	568	0	48	40	656	63392.3	ND
	75	4640.2	4176.1	62642.1	639	0	54	45	738	61904.1	D
	70	4553	4097.7	61465.9	710	0	60	50	820	60645.9	D
50	80	5899.6	5309.7	79644.9	568	780	168	140	1656	77988.9	ND
	75	5700.8	5130.7	76960.2	639	780	174	145	1738	75222.2	D
	70	5359.8	4823.9	72358	710	780	180	150	1820	70538.0	D
100	80	5956.4	5360.8	80411.9	568	1560	288	240	2656	77755.9	D
	75	5988.6	5389.8	80846.6	639	1560	294	245	2738	78108.6	ND
	70	5814.4	5233.0	78494.3	710	1560	300	250	2820	75674.3	D
150	80	7007.6	6306.8	94602.3	568	2340	408	340	3656	90946.3	ND
	75	6335.2	5701.7	85525.6	639	2340	414	345	3738	81787.6	D
	70	6098.5	5488.6	82329.6	710	2340	420	350	3820	78509.6	D

GAY= growth average yield, ADY= adjusted yield, GFB (ETB) = gross field benefits with Ethiopian Birr, TVC (ETB) = total variable cost with Ethiopian Birr, NB (ETB) = net benefits with Ethiopian Birr, CS = cost of seed (25 ETB Kg⁻¹) CF= cost of fertilizers (NPS and Urea 15.6 and 13.55 ETB Kg⁻¹) respectively CT = cost of transport, CSFA= cost of seed fertilizer application

Table 10: Marginal rate of return from NPS fertilizer and row spacing of maize crop

Treatments	NPS Rate (kg ha ⁻¹)	Row spacing (cm)	TVC (ETB)	MC	NB (ETB)	MNB	MRR (%)
T3	0	80	656		63392.3		
T6	50	80	1656	1000	77988.89	14597	1459.66
T8	100	75	2738	1082	78108.59	119.7	11.06
T12	150	80	3656	918	90946.3	12838	1398.44

Where: TVC (ETB) = Total variable cost with Ethiopian Birr, MC= Marginal cost, NB= NB (ETB) = Net benefits, MNB= Marginal net benefit, MRR= Marginal rate of returns, 1 Ethiopian Birr ≈ 0.027USD.

rate of 150 NPS kg ha⁻¹ blended fertilizer combined with an 80 cm row spacing was greater than the net benefit from applying blended NPS fertilizer at the rate, of 0, 50, and 100 kg ha⁻¹ application NPS fertilizer combined with 70 and 75 cm inter-row spacing. As a result, the suggested treatment was 150 kg ha⁻¹ NPS inorganic fertilizer blended with NPS fertilizer with 80 cm row spacing, and the profitability net benefit in this case was 150 kg ha⁻¹ NPS inorganic fertilizer with 80 cm between row spacing. However, the mixture of 100 kg ha⁻¹ of NPS fertilizer with 70, 75, and 80 mm between row spacing was taken as the gainful with the next highest net benefit, which can be taken as the second option.

Conclusions

the climate, soil fertility, and spacing requirements influence the growth, development, and yield of maize. Yield and soil analysis revealed that the soil fertility in Chat Kebele is low and that most farmers use improper spacing. As a result, all treatments that combined the use of proper spacing and blended NPS fertilizer produced higher maize yields than those that used either no fertilizer or blended NPS alone, which produced very low yields. The interaction effect of NPS and proper spacing gave a better result. This indicates

proper spacing and balanced use of NPS fertilizer is the best method for increasing Maize production and productivity. This is due to the application of NPS fertilizer increasing the nutrient content of soil and increasing the accessibility of macro and micronutrients also, using proper spacing reduces nutrient and light competition. Hence, the usage of a kilogram of one hundred fifty NPS inorganic fertilizer per hectare with 80cm between row spacing can be suggested for better maize production and productivity at Chat Kebele, West Omo, and South-West Ethiopia. This work concludes that the highest profitable rates and suggestible for similar agroecology and in the study area are the application of 150 kg NPS ha⁻¹ fertilizer with 80 cm between row spacing. This work concludes that the highest profitable rates and suggestible for similar agroecology and in the study area are the application of 150 kg NPS ha⁻¹ fertilizer with 80 cm between row spacing.

Conflict of Interest

Authors declare that they have no conflict of interest.

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