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The Effects of Fertilizer Rates on Growth, Yield and Yield Compononents of Maize [Zea Mays l.] at Taba Kebele, in Woliyta Zone, Southern Ethiopa

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***Abstract:** This study was determining an optimum rate of Nitrogen (N) and phosphorus (P) fertilizer rates for maximum maize production. The experiment had two factor: levels of N (0, 46, 92, and 138, kg/ ha-1) and levels of P (0, 23, 46, and 69kg ha-1) arranged in Randomized Complete Block Design (RCBD) with three replications. Agronomic traits siliking, tasseling, LA, LAI, Eear, length, plant height, above ground biomass, TSW, Grain yield highly significantly varied due to Nitrogen, phosphorous and their interaction. The highest grain yield (5840 kg/ ha-1) and highest harvest index (42.87%) were obtained from application of 138 kg Nitrogen ha^{-1} with 46 kg/ ha-1 phosphorous. The results of the economic analysis showed that the net benefit (211065 birr) and maximum net return (1886 %) was obtained due to the application of 138 kg Nitrogen ha-1with 46 kg phosphorous ha-1. The maximum grain yield (5840. 67 kg/ha-1) was obtained due to highest level of N (138 kg N/ha) and 46 kg P/ha. the performance of the study depicted that an application of 138 kg Nitrogen ha^{1} with 46 kg phosphorous ha^{-1} enhanced yield of maize with acceptable economic benefit. However, the experiment was carried out only in one location for one cropping season, so further studies at different locations for several seasons is needed to recommend agronomical optimum and economically feasible levels of Nitrogen and phosphorous fertilization study area.*

***Keywords:** Agronomic Parameter, Fertilization, Grain Yield, Treatments.*

Abbreviations:
ANOVA: Analysis of Variance
CV: Coefficient of Variance
ETB: Ethiopian Birr
FAO: Agriculture Organization of the United Nations
GLM: General Linear Model
LAI: Leaf Area Index
LSD: least Significant Difference
MRR: Marginal Rate of Return
N: Nitrogen
NP: Net Profit
P: Phosphorous
RCBD: Randomized Complete Block Design
SSA: Sub Saharan Africa
TR: Total Revenue
USA: Unite States of America

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I. INTRODUCTION

Maize (Zea mays L.) is a member of the grass family, Poaceae. It is believed that maize was originated in Mexico and introduced to West Africa in the early 1500s by the Portuguese traders [2]. Maize is widely grown in most parts of the world over a wide range of environmental conditions [26]. Currently, maize major role in the food security and livelihoods of millions of poor farmers in the worldwide [48]. Approximately 9.3 million smallholder farmers in Ethiopia grow maize, mainly for human consumption. These farmers rely heavily on it as a source of revenue [29]. Being a means of obtaining food as well as financial earnings, maize has remained a significant cereal crop in the southern region [32]. In the tropical environment like Ethiopia's crop production faces serious bottlenecks as a result of the periodic decline in soil fertility brought on by both natural and man-made factors [41]. Lack of high yielding varieties, biotic and a biotic stresses and the poor adoption of improved technologies by the predominantly small-scale maize farmers are the major reasons for low maize productivity [31]. This indicates the need to develop high yielding hybrid maize varieties that perform well under biotic and a biotic stress conditions [49]. In order to achieve this, potentially suitable parents and superior combinations must be identified [30]. Hybrid development in Ethiopia has been highly effective in increasing maize yields since the commercialization of the hybrids in the country. Increased yields are in part due to improved agronomic practices and increased inputs, but increased yields could not have been realized without genetic improvements [45]. The introduction of the hybrid seeds and the high yielding open pollinated varieties, and the increasing local demand, the importance of the crop may increase even further [32]. However, due to the widespread nutrient depletion in agricultural soils exacerbated by improper land use, yield and water productivity in the rain fed systems in many Sub Saharan Africa (SSA) countries is decreasing or stagnating [5]. Average grain yield of maize in Ethiopia is about 2 tons·ha-1, which is much lower than its productivity in industrialized countries such as USA which is 8 to 9 tons·ha-1 and that of the developing worlds' average 3 tons·ha-1 and the yield recorded under demonstration plots in Ethiopia is 5 to 6 tons ha-1 [10]. Soil fertility and agricultural water management for food and lively hood security is a major concern in the face of persistent poverty and rampant environmental degradation in the Sub Saharan Africa including Ethiopia. About 97 % of agricultural land in Sub Saharan Africa is under rain fed system [10]. This suboptimal performance is due to management problems rather than low potential of the agro-ecosystem that includes poor soil fertility management and crop management practices [25]. In the study area [18], maize accounts for about 30.5% of the area from cereal crops and about 7,368.1 ton of maize grain yield is produced on 2,532 ha with a productivity of 2.91 t ha-1 [6]. Maize is also the most widely cultivated cereal crop, covering 16.08% of the area and 25.81% of the production [9]. However, the national and average results of maize for smallholder farmers is 3 t ha-1 which is less than from world's average yield (5.6 t ha-1) [9]. Maize is heavy nutrient feeder and has high demand for N and P which are often the limiting nutrients for maize production [14]. Farmers are still very low. An important problem associated with phosphorus whether it is derived from the soil or applied as fertilizers is its fixation in the soil and the amount of inherent P is very low in the soils, most of which present in the soil in unavailable form, and added soluble forms of P are quickly fixed by many soils reported that in soils which are deficient or marginal in available P, application of higher dose of P enhances emergence of seedlings through its effect on development of root, and thereby enhances days to flowering and maturity and also increases the grain yield of maize[13]. Above ground biomass and grain yields of maize increased with application of increasing levels of P fertilizer [3]. According to the agricultural transformation agency of Ethiopia elements like N, P, K, S, Zn, B and Cu are deficient in major Ethiopia soils [1]. Besides this, recent studies conducted by indicated that OC, TN and available P and K were low in cropland in different areas of the Wolaita Zone [28]. They also reported that increased P application enhanced uptake of soil nitrate and K by maize plant [18]. It was also indicated that application of nitrogen fertilizer helps to increase phosphorus uptake from the soil [37]. Nitrogen can increase P concentrations in plants by increasing root growth, increasing the ability of roots to absorb and translocation of P, and by decreasing soil pH as a result of absorption of NH_4^+ and thus increasing solubility of fertilizer P [21]. The most limiting factors for sustainable maize production in smallholder farming systems of sub-Saharan Africa (SSA), especially the savanna agroecological zone, are unpredictable rains and low soil fertility [34]. The major causes of the low soil fertility are low levels of nutrient inputs, continuous cropping, overgrazing, deforestation, and poor soil and water conservation measures [44]. Many factors like soil fertility, imbalanced nutrition, disturbed soil properties, cultivars being grown weed infestation etc. limit maize yield worldwide. Different management practices are adopted to increase and optimize the maize yields [50]. For example, use of organic manures alongside inorganic fertilizers often lead to increased soil organic matter, water holding capacity and improved nutrient cycling and helps to maintain soil nutrient status, cation exchange capacity ,soil's biological activity and application of actual balanced recommended fertilizer rates based on soil and crop type [39]. Nitrogen and phosphorus are considered as the most deficient nutrients in soils of Ethiopia. This indicates that nitrogen and phosphorus are the most yield limiting factors of cereals including maize production in Ethiopia. To alleviate the soil fertility problem in the area, the office of agricultural and natural resources of the district has introduced chemical fertilizer such as Nitrogen Phosphorous fertilizer and urea fertilizer in each District. Therefore, further increases in production of maize must largely come from higher productivity per unit area per unit time which necessitates better management of scarce fertilizer nutrients at farmer's level. This experiment was initiated to determine the optimum levels of N and P fertilizer for maize production; and to see the interaction between different levels of N and P fertilizer on the growth and yield component.

II. MATERIALS AND METHODS

A. Experimental Site

A Field experiment was conducted during 2022/23 farmer's field the main crop growing season starting (January – July) at Taba of Damot Gale Woreda in southern region. Damot gale woreda is located at 515 km south Addis Ababa on the main road to Arbaminch. The study site is situated n approximate geographical coordinates of the site are 070 34'' N latitude and 360 34' ' E longitude and It has an altitude of 1750 meters above sea level. The mean maximum and minimum temperatures are 26 and 19ºC respectively. The experimental area receives mean annual rainfall of 755 mm where high amount of rainfall occurs during "Belg" from February to June cropping season whereas relatively low amount of rainfall received in "Meher" from July to October. Indeed, the area is characterized with bimodal pattern of rainfall of erratic type. Some physical and chemical properties of soil of experimental site is presented in (Table 1)**.**

B. Treatments and Experimental Design

The experiment consisted of a factorial combination of 4 levels of N (0, 46, 92, and 138 kg / ha-1) and 4 levels of P (0, 23, 46, and 69 kg / ha-1) arranged in Randomized Complete Block Design (RCBD) with three replications there is 4×4 = 16 treatment combination consisting 48 plots. The gross plot size was 4m×2.25 m (9 m2) while the net plot size was 3.5m × 2.m (7m2) plots and block were separated by 1 m and 1.5 m. The sources of N and P were urea (46% N) and triple super phosphate (TSP) (46% P_2O_5) respectively. Maize variety BH - 540 was used as a test crop. There were five rows for 75 cm row spacing and the spacing between plants was 25 cm and 8 plants were planted in one row. Half dose of N and full dose of P fertilizer, as per the treatments, were applied at planting and the remaining half dose of N was applied 45 days after sowing.

C. Agronomic Practice

The experimental field was ploughed, pulverized and leveled in order to get smooth seed bed. The field was oxen ploughed 3 times before sowing. The seed were sown directly in rows with spacing of 75 cm between rows and 25 cm between plants. Nitrogen was applied in two equal splits (half at sowing) and the other half at knee height as Urea (46 % N). Unlike nitrogen, the full rate of P was applied at sowing as TSP in different levels at different plot in order to determine the optimum level of Nitrogen and phosphorus for high yield of maize production .Weeds were manage by hand weeding after weed emergence. Late-emerging weeds were remove by hoeing to avoid interference with the maize plants and All other crop management practices (fertilizer, cultivation, harvesting, drying and threshing) was carried out uniformly for each plot as per the recommendation at the appropriate time [18].

D. Data Collection

Before initiation of the trial, soil samples were taken from entire experimental field to a depth of 0-30 cm using soil augur. The samples were air dried and ground to pass a 2 mm sieve and thoroughly mixed to get one composite sample. The representative soil sample was analyzed for organic carbon, total N, soil pH, available P, cation exchange capacity and textural analysis using standard laboratory procedures [15]. Organic carbon content was determined by the volumetric method as described in Food and Agriculture Organization of the United Nations (FAO) guide to laboratory establishment for plant nutrient analysis [46]. Total nitrogen was determined by Micro-Kjeldhal digestion method with sulphuric acid [22]. The pH of the soil was determined according to using 1:2.5 (weight/volume) soil samples to water ratio using a glass electrode attached to a digital pH meter [15]. Cat ion exchange capacity (CEC) was measured after saturating the soil with 1N ammonium acetate (NH4OAc) and displacing it with 1N NaOAc [7]. Available phosphorus was determined by the Olsen's method using a spectrophotometer [36]. Particle size distribution was done by hydrometer method (differential settling within a water column) according to [15].

E. Crop Data Collection Phonological Parameters

i. *Days to 50 % Tasseling:* It was record as number of days from planting to when 50 % of the plants in each net plot produced tassel.
ii. *Days to 50 % Silking:* Data was record as number of days from sowing to when 50 % of the plants in each net plot started shedding pollen.
iii. *Days to Maturity Stage:* It was record as number of days from sowing to when 90 % of the plants in each net plot formed black layer at the point where the kernel is attached to the cob.

F. Growth Parameters

i. *Plant Height (cm):* Plant height of maize was measured in centimeter as the distances from ground level to the point where the tassel starts to branch for five plants randomly selected from the net plot. The mean was recorded as plant height.
ii. *Ear Length:* Ear length was record from the measure of five randomly taken ears from net plot at harvest and then averaged on per plant basis.
iii. *Leaf Area Per Plant (cm2):-* All available leaves of five plants per net plot were collected at 50 % milking stage and leaf length and width was measured and the leaf area was calculated by using methods described as: Leaf area (LA) = Length x Maximum width of leaf (cm) x 0.733. Where W = leaf width, L = leaf length, and K = correction factor [27].
iv. *Leaf Area Index (LAI):* was calculated as the ratio of total leaf area per five plants (cm2) per area of land occupied by the plants [12].

G. Yield and Yield Component

i. *Thousand Seed Weight (g):* Thousand seed were count from a bulk of shelled grains from net plot and weighed using sensitive balance and the weight was adjust at 12.5% moisture level.
ii. *Aboveground Dry Biomass:* Aboveground dry biomass were determined by weighing the entire above-ground portion of the 3.5m×2.m (7m2) net plot during harvest from the center row with exclusion of the boundary rows, the biomass yield was calculated.
iii. *Grain Yield:* After correcting the moisture content to 12.5%, the grain produce has been manually gathered from a net plot size of 3.5 m×2 m (7m2) converted to kilograms/hectare.
iv. *Harvest Index (%):* Harvest index was calculate as the ratio of grain yield to above ground dry biomass per net plot and multiplied by 100.

H. Data Analysis

Data were was subjected to analysis of variance (ANOVA) as per the experimental designs for each experiment using General Linear Model (GLM) of Gen Stat15th edition [16]. The difference among significant treatment means was tested using least significant difference (LSD) at 5 % level of significance.

I. Economic Analysis

Economic analysis was made using the prevailing inputs at planting, outputs at the time of the crop was harvest and Labor costs involved for application of P and N fertilizer rates were recorded and used for analysis. Partial budget was estimate for average yield of the different treatment combinations. The prices of Maize, Tsp and Urea were used for the analysis. The fertilizer cost was calculated for the cost of each fertilizer of Nitrogen and phosphorous.

i. *Net Profit (NP):* was determined as the difference of gross income and variable cost [4].
ii. *Marginal Rate of Return (MRR):* In order to use the marginal rate of return (MRR) as a basis for fertilizer recommendation, the minimum acceptable rate of return was set at 100% [33]. Thus, marginal rate of return (MRR) calculated was the marginal net benefit (i.e., the change in net benefits) divided by the marginal cost (i.e., the change in costs), expressed as a percentage [8]. MRR= cange in net benefit change in Taotal variable cost x 100%.
iii. *Total Revenue (TR):* Estimated as TR = Adjusted Yield (AY) x Field price of the grain, the gross field benefits for each treatment is calculated by multiplying the field price by the adjusted yield.

III. RESULTS AND DISCUSSION

Based on the soil analysis made, the soil texture of the study site is sandy loam which is suitable for Maize production [42] (Table 1). The result of the physical and chemical analysis of experimental soil revealed that the textural class of the surface soil (0-30cm) was sandy clay loam with a particle size distribution of 52 % sand, 27 % silt and 11 % clay [23]. According to the chemical analysis showed that the soil was strongly acidic with relatively medium nitrogen, low organic matter, and low organic carbon [43]. The available P total N and organic carbon of the soil was 1.39 mg kg-1, 0.15 and 3.05 respectively. Such soil often responds to P and N application according to [2], respectively.

Table-I: Some Physical and Chemical Properties of Soils of Testing Field During 2022 to 2023 Cropping Seasons Before Sowing the Crop

Parameter	Value
Particle size distribution (%)	
▪ Sand	52
▪ Silt	27
▪ Clay	11
pH	6.1
Organic carbon (%)	1.15
Total N (%)	0.15
Available P (mg/kg)	1.39
CEC (cmolckg^{-1})	26.04

A. Phonological Parameters

Crop phonological events such as days to 50 % emergence, tasseling, silking, and 90 %physiological maturity were monitored and recorded. Percent seed emergence did not differ among all the treatments irrespective of the applied N and P. Fifty per cent of the seedlings from almost all plots emerged in 8 days. Germination may be inhibited if high rates of fertilizer were placed near maize seed. Low soil moisture enhances fertilizer injury because fertilizer granules imbibe moisture from the seed and make it unable to germinate. In this experiment, however, there was adequate soil moisture during germination and as result uniform germination was achieved without problem [33].

i. Days to 50 % Tasseling

The main effect of N and P as well as interaction had a highly significant the number of days to tasseling was influenced by various nitrogen and phosphorous levels. The effect of N and P on days to tasseling was significant ($p < 0.01$). Significantly shortest period to tasseling (76.05 d) and (76.07d) under 0 kg N/ha-1 and 46 kg N/ha-1 and the longest period to tasseling (77 d) under 138kg N/ha were recorded and shortest period of tasseling (75.82) and (76.37 d) under 69 kg p/ha and 0 kg p/ha respectively and the longest period to tasseling (77.62 d) under 23 kg p/ha (Table 2) . There was highly significant ($p < 0.05$)) interaction effects of various nitrogen and phosphorous levels on days to tasseling. That was lower day to tasseling on the interaction of control plot and the longest days to tasseling in the interaction effect were obtained 138kg N/ha with 23 kg p/ha (Table 2).

Table-II: Days to 50 % Tasseling as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate per kg/ha	N Rate kg/ha				
	0	46	92	138	Mean
0	75def	75.5cde	77bcd	78ab	76.37b
23	77.5bc	76cde	78ab	79a	77.62a
46	76bcd	77bc	77.5bcd	76cde	76.62ab
69	75.7cde	75.8cde	76cde	75.8cde	75.82c
Mean	76.05bc	76.07b	77.12ab	77.2a	
	CV = 1.65	LSD (5%) = 2.01			

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

ii. Days to 50 % Silking

The number of days to silking was influenced by various N and P levels as well as interaction effect (Table 3). The effect of N and P level on days to silking was significant ($p < 0.01$). The shortest period to silking (80.25 d) and (80.75 d) under 92 kg N/ha and 138 kg N/ha and the longest period to silking (85.25 d) under 0 kg N/ha were notable. The interaction between various N and P level on days to silking was significant ($p < 0.05$) short day to silking (76 d) was recorded under the interaction of 46 kg N/ha with 0 kg P/ha while the longest day to silking (88 d) under the interaction of 0 kg N/ha with 0 kg P /ha.

Table-III: Days to 50 % Siliking as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P rate per kg/ha	N rate kg/ha				
	0	46	92	138	Mean
0	88a	76f	78e	79de	80.25b
23	83bc	82c	81cd	85b	82.75a
46	84b	83bc	79de	80d	81.5ab
69	86a	85b	84b	79de	83.5a
Mean	85.25a	81.5b	80.5bc	80.75bc	
	CV = 0.78	LSD (5%) = 2.02			

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

iii. Days to 90 % Physiological Maturity

The result indicated that main effects of Nitrogen and Phosphorous also interaction having highly significant ($p < 0.01$) influence on days to physiological maturity. The maximum days to physiological maturity (158.) was recorded from plot received 138kg Nitrogen supplemented with 46 kg/ha phosphorous. However the lowest (141 d) were observed from control treatment (Table 4). Significantly longer days to physiological maturity (155.25 d) were recorded from 46 kg P/ha while significant shorter days to physiological maturity (144.25 d) was recorded from 0 kg P/ha (Table 4). Increased nitrogen application in combination with P increased days to 90 % physiological maturity in this study. highest days to 90 % physiological maturity (158 d) was recorded in the interaction of 138 kg N/ha with 46 kg P/ha while the lowest days to 90% physiological maturity (141 d) was recorded in the interaction of 0kg N/ha with
0 kg P/ha .

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Table-IV: Days to 90 % Physiological Maturity as Influenced by Applied the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/ha	N rate kg/ha				
	0	46	92	138	Mean
0	141m	143 l	145k	148h	144.25d
23	147i	150f	146j	150f	148.25c
46	152e	156ab	155abc	158a	155.25a
69	149fg	153de	154cde	155abc	152.75b
Mean	147.25c	150.5b	150b	152.75a	
	CV = 0.56	LSD (5%) = 1.39			

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

B. Crop Growth Parameters

i. Leaf Area Per Plant (cm2)

Maize leaf area was significantly affected ($p < 0.05$) main effect and interaction of Nitrogen and phosphorous fertilizer application. Even though the maximum leaf area (5856 cm2) were recorded from 138 Nitrogen and 69 phosphorous. In conversely, the minimum leaf area (3000 cm2) was recorded from control (Table 5).

Table-V: Leaf Area as Affected by the Interaction Effects of Different Levels of n and p Fertilizer Application on Maize Grown

P Rate kg/ha	N Rate kg/ha				
	0	46	92	138	Mean
0	3000ghi	3125fghi	3196fghi	3225efgh	3136.5d
23	3400efgh	3480efgh	3930bcde	4200bc	3752.5c
46	3600defg	3700cdef	4120bcd	4321b	3935.25b
69	3750cdef	4000bcde	4377b	5856a	4495.75a
Mean	3437.5cd	3576.25c	3905.75b	4400.5a	
	CV = 9.24	LSD (5%) = 512.5			

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

ii. Leaf Area Index (LAI):

Maize leaf area and leaf area index was significantly affected ($p < 0.05$) main effect and interaction of Nitrogen and phosphorous fertilizer application (Table 6). The maximum leaf area index (2.79) was recorded from 138 Nitrogen and 69 phosphorous. In conversely, the minimum leaf area index (1.2) was recorded from control.

Table-VI: Leaf Area Index as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/h	N Rate kg/ha				
	0	46	92	138	Mean
0	1.2ij	1.45hi	1.53ghi	1.72efgh	1.47d
23	1.34i	1.5ghi	1.68fghi	1.85defg	1.59c
46	1.44hi	1.92cdef	1.95bcd	2.58a	1.97b
69	1.52ghi	1.94bcde	2.25b	2.79a	2.12a
Mean	1.37d	1.70c	1.85b	2.23a	
	CV = 9	LSD (5%) = 0.38			

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

iii. Plant Height

The result also revealed that analysis of variance statistically significant ($p < 0.01$) difference in plant height due to main effects of Nitrogen and Phosphorous, supplemented the interaction of N and P applications (Table 7). Significantly the tallest (309 cm) and shortest (155.5 cm) plants were recorded supplemented 138 Nitrogen/h and 69 kg phosphorous /ha-1 and supplemented control treatment.

Table-VII: Plant Height as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/h	N Rate (kg/ha)				
	0	46	92	138	Mean
0	155.5fg	180cd	217cd	240bc	198.12d
23	167.8de	193cd	225bc	255b	210.2c
46	174de	199cd	238bc	269ab	220b
69	185cd	210cd	240bc	309a	236a
Mean	170.57d	195.5c	230b	268.25a	
	CV = 6.5	LSD (5 %) = 37.58			

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

iv. Ear Length

The result of this study indicated that there was highly significant variation ($p < 0.05$) main effects of Nitrogen and phosphorus., supplemented to response of Nitrogen to phosphorous and interaction in the study (Table 8). Thus the major changes on ear length were achieved as a result of interactions of nitrogen with Phosphorous fertilizer rates. With raising nitrogen and phosphorous fertilizer rates, length of ear increased. The longest ear length (18.75 cm) resulted from the combined application of Nitrogen 138 kilograms/hectare with 69 kilograms/ha phosphorous fertilizer rates followed by the application of 138 kilograms/hectare Nitrogen and 46 kilograms/hectare phosphorous fertilizer rates. The unfertilized plots had the smallest recorded ear length (11cm) (Table 8). An increase in ear length with increasing dosages of Nitrogen and phosphorous fertilizer rates could be attributed to a proportion of photosynthesis that were transported to the growing ear after fertilization which might have accounted for a positive influence on the proliferation of the ear. This showed that that ear length was longer at high rates of nitrogen and phosphorous fertilization and tended to decline with decreasing rates of Nitrogen and phosphorous fertilizers.

Table-VIII: Ear Length as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/ha	N Rate kg/ha				
	0	46	92	138	Mean
0	11ijk	10.8 jk	12hij	13fgh	11.7d
23	12hij	12.9ghi	13.75efg	14.6cde	13.31c
46	13fgh	14def	15bcd	16.5ab	14.62b
69	14 def	14.5cde	16abc	18.75a	15.81a
Mean	12.5d	13.05c	14.18b	15.71a	
CV = 3.05 LSD (5%) = 12.05					

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

C. Yield Components

i. Thousand Kernels Weight

The analysis of variance revealed a highly significant ($p < 0.01$) effect of nitrogen, phosphorus and their interaction on Thousand kernel seed weight (Table 9). The application of 138 nitrogen supplemented with 46 phosphorous thousand seed weight (405 g) was recorded plots supplied with138kg N ha^{-1} supplied 46 phosphorous fertilizer and where as the lowest (245.5g) thousand kernels weight value recorded in control treatment.

Table-IX: Thousand Kernel Weight as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/ha	N Rate kg/ha				
	0	46	92	138	Mean
0	245.5h	255h	270gh	295efgh	266.375d
23	253h	289efgh	300cde	315cdefg	289.25c
46	265gh	307.8cdefg	325cdef	405a	325.7a
69	260ghi	282fgh	313defg	385ab	310b
Mean	255.875d	283.45c	302b	350a	
CV = 5.85 LSD (5%) = 11.89					

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

ii. Above Ground dry Biomass Yield

The analysis of variance for biomass yield indicated significant ($P < 0.05$) biomass yield differences due to the interactions of Nitrogen, Phosphorous fertilizers and their main effects (Table 10). Similar to the results for grain yield, application of 138 kg /ha^{-1} Nitrogen 46 kg Phosphorous / ha fertilizers gave significantly the higher above ground biomass compared to rest of the treatment combinations. The maximum Above ground biomass (19145 kg/ ha^{-1}) was obtained from at combined application of 138 kg nitrogen and 46 kg phosphorous /ha fertilizer application while the minimum Above ground biomass (8010 kg/ha^{-1}) was obtained from control treatment.

Table-X: Above Ground dry Biomass Yield as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/ha	N Rate kg/ha				
	0	46	92	138	Mean
0	8010 k	8200 k	8900k	9567j	8669.25d
23	9239j	13244ghi	13040ghi	17320bcde	13210.75c
46	11675ij	15943cdef	18578ab	19145a	16335.25b
69	14210fgh	16413bcdef	17450abc	18105ab	16544.5a
Mean	10783.5d	13450 c	14492b	16034.25a	
CV = 6 LSD (5%) = 1210.5					

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

iii. Grain Yield

The means of maize grain yield was significantly ($p < 0.01$) affected by main effects of nitrogen and phosphorous fertilizer as well as their interaction in the study area (Table 11). The highest grain yield (5840 kg/ha$^{-1)}$ was obtained in application of 138kg Nitrogen with 46 kg phosphorous /ha^{-1}, where as the lowest (2010 kg/ha^{-1}) grain yield was obtained from control treatment.

Table-XI: Grain Yield as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/ha	N Rate kg/ha				
	0	46	92	138	Mean
0	2010i	2800h	3354fg	3400fg	2891c
23	2745hi	3244fgh	3967de	4300cde	3564b
46	3740ef	3854 de	4534bc	5840a	4492ab
69	3945de	4130de	4500bc	5560ab	4533.75a
Mean	3110d	3507c	4088.75b	4775a	
CV = 8.6 LSD (5%) = 708.5					

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance according to Turkey's Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

iv. Harvest Index

Harvest index (the partitioning efficiency of dry matter in to grain) was significantly ($p < 0.01$) affected by the application of nitrogen and phosphorus and their interaction. Increasing N from 0 to 138 kg N/ha increased the harvest index, similarly, increasing P from 0 to 23 kg P/ha also showed consistent harvest index increment was observed between 0 and 23 kg P/ha (Table 12). Application of 46 kg P ha^{-1} in combination with 138 kg N ha^{-1} gave significantly higher harvest index (42.87 g) than the rest of the fertilizer rates. On average harvest index consistently increased with an increase in N rate.

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Table-XII: Harvest Index as Affected by the Interaction Effects of Different Levels of N and P Fertilizer Application on Maize Grown

P Rate kg/ha	N Rate kg/ha				
	0	46	92	138	Mean
0	25f	33cdef	34cdef	36abcde	32c
23	30.5def	35abcdef	37abcde	38abcd	35.12bc
46	35abcdef	36.5abcde	39abc	42.87a	38.34a
69	31.6def	29.5ef	37.6abcde	40.62ab	34.83b
Mean	30.52d	33.5c	36.15b	39.37a	
	CV = 10.5	LSD (5%) = 5			

Parameter means followed by the same letter within columns are not significantly different at 5 % level of significance according to Turkey's Tests; CV = Coefficient of variance; LSD = Least Significant Difference at 5 % level.

D. Partial Budget Analysis

The results of partial budget analysis showed that the maximum net benefit (Birr 211065 ha^{-1}) with an acceptable marginal rate of return (MRR) was obtained from 138 kg Nitrogen and 46 kg Phosphorous /ha fertilizer application, whereas the lowest net benefit among the fertilized treatments was obtained from the 23 kg Phosphorous with 0 kg Nitrogen ha-1 (Birr 136970 ha^{-1}),but the net benefit of control treatment(Birr 71405 ha^{-1}) was the least (Table 13). This has resulted in a net benefit the application of 138kg nitrogen and 46 kg phosphorous kg resulted in above the maximum acceptable rate of return, i.e. 1886% marginal rate of return. This implies that for each ETB investment in maize production, the producer can get additional ETB 18.9 for treatment with 138 kg Nitrogen ha-1 + 46 kg phosphorous ha1. In conclusion, the net benefit obtained by the use of maize with rates of 138 Nitrogen kg / ha^{-1} + 46 kg of phosphorous ha^{-1}. Therefore, the net positive benefit obtained with application of 138 nitrogen and 46 kg phosphorous fertilizer ha^{-1} to maize are economically profitable application rates and can be recommended for farmers in study area and other areas with similar agro-ecological condition.

i. Economic Analysis of Maize

Price for fertilizer were listed as 1quntale of Tsp = 4680 birr, Urea = 4650 birr Maize grain price 1quntal = 4500 birr; which is 1kg = 45 birr Daily lab our worker person per day = 400 birr and if 25 person need the initial cost=10,000 birr

Table-XIII: Partial Budget analysis of Data of Fertilizer Treatments in Taba Kebele at Damot Gale During 2022 to 2023

N0	Treatment	Grain Yield	Adjusted Yield (10%kg/ ha^{-1})	Gross Benefit (Birr ha^{-1})	FC	LCH	TVC	Net Benefit	MRR (%)
1.	N_o x P_o	2010kg	1809kg	81405	0	10000	10000	71405	-
2.	N_oxP_1	2745	2471	111195	2340	11500	13840	97355	675
3.	N_oxP_2	3740	3366	151470	4680	12000	16680	136790	139
4.	N_0xP_3	3945	3550.5	159772.5	7020	11300	18320	141452.5	284
5.	.N_1xP_0	2800	2520	113400	2325	10300	12625	100775	D
6.	N_1 xP_1	3244	2919.6	131382	4665	10200	14865	116517	702
7.	N_1 x P_2	3854	3468.6	156087	7005	10400	17405	138682	872
8.	N_1 x P_3	4130	3717	167265	9345	11500	20845	146420	224
9.	N_2 x P_0	3354	3018.6	135837	4650	10000	14650	121187	D
10.	.$N_{2x}P_1$	3967	3570.3	160663.5	6990	12190	19180	141483.5	448
11.	. N_2 x P_2	4534	4080.6	183627	9330	12200	21530	162097	877
12.	$N_{2\,x}$ P_3	4500	4050	182250	11670	12700	24370	157880	D
13.	N_3 x P_o	3400	3060	137700	8975	10500	19475	118225	D
14.	.N_3 x P_1	4300	3870	174150	11315	11800	25455	151835	1183
15.	$N_{3\,x}$ P_2	5840	5256	236520	13655	11800	25455	211065	1886
16.	$N_{3\,x}$ P_3	55600	5040	226800	15995	12500	28495	198305	D

N = Nitrogen; P = Phosphorous; FC = Fertilizer cost; ETB = Ethiopian Birr; TVC = Total variable cost; MRR = Marginal rate of return; D: dominated treatment

IV. DISCUSSION

The result of present study indicated that the main effect of nitrogen and phosphorous fertilizer as well as interaction of phosphorous and nitrogen fertilizer to Maize as affected plant height. This might due to an application to different rates rate of Nitrogen and phosphorous fertilizer. Thus the increased plant height at the highest level of Nitrogen fertilizer supplemented with supplemented phosphorous rates could attributed to better vegetative development that resulted in increased mutual shading and inter nodal extension [47]. Thus, the enhanced vegetative development seen in this investigation could be linked to the soil's properly supplied nutrients. The investigation confirmed with the research for previous work in line with reported that there was more vegetative as well as reproductive growth with increase in the amount of N [19]. Similarly, increasing P rates from 0 to 69 kg P/ha also increased plant height. Relevant to this the result of the research revealed that, the application of Nitrogen and phosphorous as well as combined with the interaction effect of Nitrogen and phosphorous were highly significantly affected in all the agronomic traits studied. The difference days to 90% physiological maturity affected by different rates of N and P as well as interaction effect of N and P fertilizer Increasing N fertilization from 0 to 138 kg N/ha significantly was prolonged days to physiological maturity of maize [1]. As the nitrogen rates increased the days to physiological maturity was prolonged. This might be because application of N delayed leaf senescence, sustained leaf photosynthesis during active crop growth stage and extended the duration of vegetative growth and it clearly indicated that ever increasing nitrogen levels have vital effect on growth, development, and yield parameters. This result was in agreement with the findings of who reported that nitrogen rate significantly delayed days to maturity of maize by the application of maximum nitrogen dose of (200 kg N ha-1) with average of 151 days as compared to other treatments [11]. The application of N in combination with P reasonably hastened the days

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to physiological maturity. The highest grain yield (5840 kg/ha) was recorded at 138 kg N/ha and 46 kg P/ha Nitrogen from 0 to 138 kg N/ha consistently increased grain N concentration. This result supports the well-established idea that there is a tendency for N concentrations in maize grain to increase in response to additions of N that increase yields. Similarly, increased application of P from 0 to 46 kg P/ha also increased the P concentration in the grain of maize. Increasing rates of P steadily enhanced the N concentration in the grain while increasing rates of N brought inconsistent increment of P concentrations in maize grain [1]. This could be due to the fact that application of N and P increased the concentration of the elements in the soil solution, which in turn improved plant growth and development thereby increasing nutrient uptake by the plants, with subsequent increase in the amount of nutrient assimilated into grain tissue [31]. Generally, at the rate of nitrogen and phosphorous there is yield increase as the rate of Nitrogen , phosphorous increased might be because of the fact that phosphate application as being particularly useful in promoting good root system, which could favor the best utilization of mineral nutrients from the soil .Similarly in line with this previous research reported that confirmed that blended fertilizer application significantly increased maize grain yield compared to control [47]. Even if, maximum yield was obtained at 46 kg P/ha, no significant difference was observed between 23 and 69 kg P/ha when applied in combination with 69 and 92 kg N/ha [18]. Mean separations for the main effects of N and interaction effect indicated that still there exists a place for increasing maize grain yield through the application of N fertilizers beyond 92 kg N/ha while mean separation for the main effect of P and the interaction effect revealed that application of P beyond 23 kg P/ha did not significantly increase maize grain yield but the socio-economic conditions of the small scale farmers should be considered [38]. The mean separation for the main effect of N and interaction effect showed that still there exists a place for increasing maize dry biomass yield beyond the application of 138 kg N/ha while application of P beyond 46 kg P/ha did not significantly increase dry biomass yield [41]. Besides to this the response would be an adequate supply of Nitrogen and phosphorous application their assimilation in mersitemetic tissue which have been crucial role in tillering and plant growth [11]. The result of this study confirmed in Agreement with indicated that application of N had significantly increased the biomass yield of forage maize also similarly interaction of Nitrogen and phosphorous had a great role in increasing dry matter accumulation [20].

Difference in Thousand kernel weight showed there was considerable statically difference observed on thousand kernel main effect of Nitrogen and phosphorous fertilizer and interaction effect. Substantial out put on main and interaction effect of nitrogen and phosphorous fertilizer increased thousand kernels Weight of maize when N rates increasing from 0 to 138 increased thousand kernel similarly increasing p from 0 to 46 p rate per h-^{1} consistent increment on thousand kernel weight of maize. It ensures the utilization of applied nutrients and improves seed quality by activating the work of enzymes. This result confirmed in Agreement is similar to the findings of the highest (425.31 gm) thousand-grain weights was recorded from the application of 250 NPS + 150 urea+ 100 KCl kg ha-1 while the lower (300.78 gm) thousand-grain weights were recorded from the control treatment [35].

Difference in Harvest index at higher rates of Nitrogen combined with Phosphorous might be attributed to greater photo assimilates production and its ultimate partitioning into grain yield. This result is supported by reported that the harvest index in corn increases when N rates increase of nitrogen and phosphorus and their interaction [24]. Increasing N from 0 to 138 kg N/ha increased the harvest index. Similarly, increasing P from 0 to 46 kg P/ha also showed consistent harvest index increment while no significant difference was observed between 23 and 69 kg P/ha .in this study optimum level of N and P for Harvest index. The result of this study agrees with the previous finding that reported a significant increase of the harvest index of blended level of Nitrogen, phosphorous, sulfur rate increase maize production with increased level of added P [17]. Application of 46 kg ha^{-1} P in combination with 138 kg ha-1 N gave significantly higher harvest index than the rest of the fertilizer rates. On average harvest index consistently increased with an increase in N rate [40]. This result is in agreement with findings that reported higher harvest index under higher level of N and P than application of lower levels the fertilizers [41]. This could be due to an increase in grain yield more than the increase in biomass which resulted in higher harvest index. According to the analysis the highest economic benefit might be due to the highest Grain yield produced by Maize applying 138 kg N/ha^{-1} supplied with 46 kg p/ha^{-1} rate gave a net profit 211065 birr /ha with marginal rate of return (MRR) 1886% . So that, the best for effective choice for producing maize with application of 138 kg N supplied with 46 kg p/ha^{-1} was the most economically feasible treatment.

V. CONCLUSIONS

The present investigation revealed that Excessive use of fertilizers also affects farmers' economy as well as soil textural class. There for, identifying the appropriate levels of N and P fertilizers are the most important concern to maximize crop yields under the study. Significance of application of N and P highly significantly affected all the studied on yield and growth parameter. Application of 138 kg ha^{-1} N and 46 kg /ha^{-1} P gave the highest grain yield (5497. 5 kg/ ha^{-1}). This indicates that application of Nitrogen and phosphorous fertilizer above higher Nitrogen, phosphorous rates used in the current study does not have significant increase in the grain yield of maize in the study area. Similarly relevant wit grain yield the biomass showed the highest biomass yield (19145) kg/ ha-1) was supplied with at the highest rates of Nitrogen and phosphorous (138 kg/ ha Nitrogen and 46kg /ha phosphorous). The mean separation for the main and interaction effects showed the possibility for increasing maize biomass yield beyond the application of 46 kg ha^{-1} P while application of N beyond 138 kg ha^{-1} did not significantly increase biomass yield. There for experimental site from this the farmers around Taba area better use Nitrogen and Phosphorous fertilizers at the rate of 138and 46 to get highest significant yield. Even though the result obtained show good result with high amount of fertilizer rate gave high yield it is necessary to see the effect with soil acidity

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amendment as the area is seriously acidic.

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