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Effect of Inorganic N and P Fertilizers on Fruit Yield and Yield Components of Pineapple (*Annanas comosus* MERR L. Var. Smooth cayanne) at Jimma, Southwest Ethiopia

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Abstract

Field experiment was conducted at Jimma Agricultural Research Center (JARC) for two consecutive growing seasons (2012-2014 and 2015-2017 as a ratoon crop). The objective of the study was to evaluate the effect of different rates of inorganic N and P fertilizers on pineapple (variety Smooth cayenne) for yield and quality traits. Four levels of N (0, 93.6, 108 and 281 kg ha^{-1}) and four levels of P (0, 134.8, 269.6 and 404.4 kg P_2O_5 ha^{-1}) were arranged in RCBD with three replications. Data on yield and quality traits were collected and subjected to data analysis. Results of the study revealed that, the highest fruit yield was obtained by the rate of application of 281 kg N ha^{-1} and 134.8 kg P_2O_5 ha^{-1}. Application of nitrogen at a rate of 281 kg ha^{-1} significantly increased fruit yield of pineapple up to 20.19% than the control. Similarly, phosphorus application at a rate of 134.8 kg P_2O_5 ha^{-1} increased significantly fruit yield by 68.22%. For high yield and good quality of fruits, nitrogen should not be applied beyond 108 kg N ha^{-1} rate. Apply treatments beyond 108 kg N ha^{-1}, the TSS content declined by 1.95%. The economic analysis also revealed that the highest net benefit of 61,600.0 Ethiopian Birr/ha (ETB/ha) with marginal rate of return of 237.0% was obtained by the application of 281 kg N ha^{-1}. Likewise, the net benefit of 12,320 ETB/ha with marginal rate of return of 507.0% were obtained by the application of 134.8 kg P_2O_5 ha^{-1}. Based on the above results, a combined application of 281 kg N ha^{-1} and 134.8 kg P_2O_5 ha^{-1} are optimum and economically better for pineapple production at Jimma and its vicinity.

Keywords: Fertilizer rate; Nitrogen; Phosphorus; Pineapple; Quality

Introduction

Pineapple *Annanas comosus* (L.) is a perennial herb in the botanical family *Bromeliaceae*, native to the American tropics [1]. It is a hardy tropical fruit that grows well in frost-free area between 25° north and south of the equator [2,3]. It is the second most important fruit crop after bananas and contributing over 20% of the world tropical fruits. The remaining 30% used as chunks, slices, juices, syrups, jams, crushed pineapple, diced pineapple in major producing countries [4-6]. Besides, wastes from processing of pineapple fruit are now further processed into sugar, wines, vinegar, animal feed during the dry season [7]. The leaves of pineapple have high quality fiber, manufacture of luxury clothing, making rope, fishing nets and pulp in the paper industry. In addition, the fruit of pineapple rich in digestible carbohydrates, fat, vitamins A, C and essential minerals [8]. The suitability of pineapple as food stores on ships and medical ingredients greatly facilitated their distribution throughout the world. Currently, *Annanas* is a pan tropical genus and different species have been independently domesticated across continents.

In Ethiopia, pineapple successfully grows in South and Southwestern parts as small scale farming and the average yield of the crop is low about 45 tons/ha [9,10] as compared to global average fruit yield of 67.5 t/ha [11]. This low yield is partly due to: low fertility status of the soil when the pineapple was grown, resulting from depletion by proceeding crops [12], lack of improved pineapple technologies for diverse environmental conditions, longer maturity, poor marketing system, presence of diseases and insect pests, and lack of improved post harvest handling technologies are a few to mention [13]. Besides, lack of sufficient information on the nutritional requirement of pineapple, leads low productivity [14]. According to FAO 2000 [11], pineapple requires nutrients such as nitrogen (N), phosphorus (P) and potassium (K) for fertility maintenance and crop production. These nutrients are specific in function and must be supplied in sufficient quantity to plant at the right time [7]. According to the reported of Spironello et al. [8], fruit yield of pineapple is very responsive to NPK fertilization. In fruit crops, it is known that applications of NPK fertilizer are vital for fruit yield and quality [3]. Besides, NPK plays an important role in the growth and development of the plant [11]. Despite the importance of NPK, the nutrient requirement of pineapple in Ethiopia is poorly understood and leads severe yield losses. To increase the productivity, better understanding on the importance of pineapple in association with its appropriate fertilizer requirements and types are needed to boost pineapple production, which minimize the poverty and improve the livelihood security of rural households. Therefore, this study was designed to determine the effect of inorganic nitrogen and phosphorus fertilization on the yield and quality traits of pineapple in Southwest Ethiopia.

Materials and Methods

Description of the study area

Field experiment was conducted at Jimma Agricultural Research Center (JARC) for two consecutive growing seasons (2012-2014 and

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2015-2017 as a ratoon crop). The center is located at latitude 7° 40.00' N and longitude 36° 47'.00' E with an altitude of 1753 m.a.s.l. The area receives mean annual rainfall of 1432 mm with maximum and minimum temperature of 26.5°C and 12.0°C, respectively. The soil of the study area is characterized Eutric Nitosol (reddish brown) with pH of 5.3 [15].

Soil sampling and analysis

Fiften core soil samples randomly collected from 0-30 cm top soil and bulk to form a composite sample. The collected samples were air dried, crushed and allowed to pass through a 2 mm sieve. Particle size distribution was carried out by the hydrometer method, while soil pH in soil solution ratio 1:2 in 0.01M C_aCl_2. Soil organic carbon was determined by the Walkey and Black method and total N by the micro-kjeldahl digestion method [16]. Available P was determined by Bremer and Mulraney, [16] extraction method. Exchabgeble bases were extracted with neutral 1M NH_4OAC at soil solution ratio of 1:10 and measured by flame photometry. Exchabgeble acidity was determined by titration of 1M KCL extract against 0.05M NaOH to a pink end point using phenolphthalein as indicator [17] The soil sample analysis was conducted at JARC soil and plant tissue laboratory.

Experimental materials, design and management

For this study, the improved variety (*Smooth cayenne*) was planted in double row planting pattern of 90 x 60 x 30 cm between paired rows, between rows and plants, respectively during 2012-2014 and 2015-2017 as a ratoon crop. Treatment consisted on N applied at (0, 93.6, 108 and 281 kg ha^{-1} as urea (46% N) and P applied at (0, 134.8, 269.6 and 404.4 kg ha^{-1}) as DAP (46% P_2O_5 and 18% N).

The experiment was laid out in RCBD with three replications. The gross plot size for each treatment was 6 m x 4 m (24 m^2). Plants was field established using double spaced of 30 x 60 x 90 cm. Slips of the same size were used as planting material. Both fertilizers were applied near the rows. All DAP and 50% of urea was applied at planting. The remaining 50% of urea was applied as side banded after 60 days of planting. One month after planting, seedlings were earthed up, followed by frequent weeding. All other agronomic practices were followed according to the recommendations.

Data collection and analysis

Data were collected from ten plants from each plot and the average value was used for data analysis. The characters that manifested for data collection were: plant height (m), leaf length (cm), fruit length (cm), fruit diameter (cm), fruit fresh weight (kg fruit^{-1}) and TSS (%). Total soluble solid (TSS) in Brix was obtained by a temperature self compensating digital refractometer [18] at Jimma University, College of Agriculture and Veterinary Medicine (JUCAVM) food and nutrition laboratory. The collected data were subjected to analysis of variances and treatment means separated by Least Significant Difference (LSD) by using Statistical Analysis System (SAS) package [19].

Economic evaluation

Economic evaluation comprising partial budget with dominance and marginal rate of return was carried out. To estimate economic parameters, product (marketable fruit yield) was valued based on average market price collected from local markets during the two consecutive years of production when fresh pineapple fruits sold for 20 Ethiopian Birr per kg. Average price of urea, and DAP were 15.0 and 18.0 Birr per kg, respectively. Some of the concepts used in the partial budget analysis are gross field benefit (GFB), total variable cost (TVC) and the net benefit (NB). The GFB ha^{-1} was obtained as the product of the real price and the mean pineapple fruit yield for each treatment. TVC refers to the sum of cost of all variable inputs (fertilizers) were used according to CIMMYT [20].

Results and Discussion

Data on the soil physico-chemical properties of Jimma was presented in Table 1. The data indicated, the soil of study area is sandy clay with low N and available P, its characterization indicated soil pH 5.65 in water, 0.539 g kg^{-1} N, 3.27 g kg^{-1} organic C. 0.691 ppm available P, 1.969 meq/100 g K, 5.636% organic matter, 0.120 meq/100 g exchangeable acidity and 22.76 meq/100 g CEC. Particle size distributions were 52% sand, 36% clay and 12% silt.

The results of ANOVA indicated, plant height, leaf length, fruit length, fruit diameter, fruit fresh weight and TSS of pineapple plants had significant effect by the rates of nitrogen and phosphorus (Table 2). In both cropping seasons, plant height, fruit diameter, fruit fresh weight, and TSS of pineapple showed significant different at different level of fertilizer rates, while except fruit diameter, the rest of traits showed similar response in ratoon crop (Table 3). Application of 108 g Urea and 134.6 g DAP and 281.6 g Urea+134.8 g DAP produced the highest fruit yield of 1.35 kg/fruit and 1.31 kg/fruit from main and ratoon crop.

The effect of NP fertilization on yield and quality traits of pineapple

The effect of NP fertilizer on yield and quality traits of pineapple and ratoon crop at Jimma was presented in Table 4 and Table 5. The height of the plant is an important growth parameter directly linked with the fruit yield, which is positively correlated with plant productivity [21]. In this study, the effects of N fertilizer rates had significant effects on the height of pineapple plant (Tables 4 and 5). The tallest plant (58.81 cm) was obtained from 108 kg N ha^{-1} and 57.75 cm at rates of 269.6 kg P ha^{-1}. Pineapple treated at a control, the height became lowest (51.48 cm and 53.32 cm) N and P rates, respectively. The trends were N application at 108 kg N ha^{-1} gave 10.29% and 1.5% increases over the control in plant and ratoon crops (Tables 4 and 5). This result is consistent with the report of [22] who reported, increasing the level of N application was observed to increase the height and the yield of pineapple plants. The application of P was showed similar trends like as N application on plant height. The tallest plants were obtained at 269.6 kg P ha^{-1} rates. On contrary, the advanced rates of N and P from 93.6 kg N ha^{-1} to 108 kg N ha^{-1} and 269.6 kg P ha^{-1} to 404.4 Kg P ha^{-1} resulted

No	Physico-chemical composition	
1	% Sand	52
2	% Silt	12
3	% Clay	36
4	Textural class	Sandy clay
5	p^H (H_2O)(1:2:5)	5.65
6	Organic carbon	3.269
7	Available P (ppm)	0.691
8	Total N (g/kg)	0.539
9	Available K (meq/100 g)	1.969
10	%Organic matter	5.636
11	Exchangeable acidity (meq/100 g)	0.12
12	CEC (meq/100 g)	22.76
13	Exchangeable AL^{+++} (meq/100 g)	Trace

Table 1: Physico-chemical properties of top soil (0-30 cm) of experimental fields of Jimma.

Treatments	PH	LL	FL	FDi	FFW	Brix
0 N + 0 P_2O_5 kg/ha	57.0^{abcd}	58.21^{a}	12.61^{a}	7.85^{ab}	1.19^{ab}	14.83^{ab}
134.8 kg P_2O_5/ha	55.9^{bcd}	59.03^{a}	11.63^{a}	8.00^{a}	1.06^{ab}	14.17^{b}
269.6 kg P_2O_5/ha	61.87^{a}	57.01^{a}	11.81^{a}	7.39^{bc}	1.09^{ab}	15.23^{ab}
404.4 kg P_2O_5/ha	53.86^{cd}	56.11^{a}	12.03^{a}	7.70^{abc}	0.99^{b}	15.73^{ab}
93.6 kg N/ha	56.7^{abcd}	54.70^{a}	12.26^{a}	7.18^{c}	1.08^{ab}	14.43^{ab}
93.6 kg N+134.8 kg P_2O_5/ha	53.47^{cd}	55.78^{a}	12.37^{a}	7.28^{bc}	1.358^{a}	15.00^{ab}
93.6 kg N+269.6 kg P_2O_5/ha	58.5^{abc}	56.67^{a}	12.48^{a}	7.65^{abc}	1.40^{a}	15.16^{ab}
93.6 kg N +404.4 kg P_2O_5/ha	55.^{34bcd}	58.59^{a}	12.66^{a}	7.50^{abc}	1.09^{ab}	15.66^{ab}
108 kg N kg/ha	56.6^{abcd}	55.93^{a}	12.36^{a}	7.50^{abc}	1.15^{ab}	15.76^{ab}
108 kg N +134.8 kg P_2O_5/ha	54.5^{bcd}	57.02^{a}	12.60^{a}	7.51^{abc}	1.42^{a}	16.33^{a}
108 kg N +269.6 kg P_2O_5/ha	55.7^{bcd}	60.54^{a}	12.64^{a}	7.51^{abc}	1.22^{ab}	15.66^{ab}
108 kg N+404.4 kg P_2O_5/ha	56.5^{abcd}	58.25^{a}	12.13^{a}	7.60^{abc}	1.11^{ab}	15.33^{ab}
281.6 kg N kg/ha	55.5^{bcd}	57.54^{a}	12.62^{a}	7.64^{abc}	1.13^{ab}	15.83^{ab}
281.6 kg N +134.8 kg P_2O_5/ha	57.3^{abcd}	55.94^{a}	12.33^{a}	7.61^{abc}	1.35^{a}	15.73^{ab}
281.6 kg N +269.6 kg P_2O_5/ha	59.82^{ab}	55.69^{a}	12.40^{a}	7.58^{abc}	1.12^{ab}	15.56^{ab}
281.6 kg N +404.4 kg P_2O_5/ha	52.00^{d}	57.06^{a}	12.29^{a}	7.35^{bc}	1.15^{ab}	14.86^{ab}
Mean	56.28	57.13	12.33	7.55	1.18	15.33
LSD (<0.05) CV (%)	3.51 7.50	2.91 6.13	0.87 8.54	0.38 6.15	0.18 18.86	0.85 6.66

PH: Plant height (m); LL: Leaf length (cm); FL: Fruit length (cm); FDi: Fruit diameter (cm); FW: Fruit fresh weight (kg/fruit) and Brix: TSS (%)

Table 2: The analysis of variance of nitrogen and phosphorus on yield and yield related traits of pineapple 2012-2014 grown at Jimma.

Treatments	PH	LL	FL	FDi	FFW	Brix
0 N + 0 P_2O_5 kg/ha	58.20^{cd}	53.42^{ab}	11.40^{b}	10.0^{a}	1.11^{ab}	15.16^{a}
134.8 kg P_2O_5/ha	61.15^{abc}	54.57^{ab}	11.04^{ab}	10.0^{a}	0.88^{b}	14.83^{a}
269.6 kg P_2O_5/ha	60.3^{abcd}	54.44^{ab}	11.68^{ab}	10.0^{a}	1.07^{ab}	15.16^{a}
404.4 kg P_2O_5/ha	60.5^{abcd}	54.95^{ab}	12.01^{ab}	9.87^{a}	0.85^{ab}	15.00^{a}
93.6 kg N/ha	61.08^{abc}	57.69^{a}	11.80^{ab}	9.14^{a}	0.95^{ab}	14.76^{a}
93.6 kg N+134.8 kg P_2O_5/ha	62.84^{a}	56.28^{a}	11.86^{ab}	9.91^{a}	1.06^{ab}	15.16^{a}
93.6 kg N+269.6 kg P_2O_5/ha	60.9^{abcd}	57.18^{a}	12.28^{ab}	9.77^{a}	0.91^{b}	15.16^{a}
93.6 kg N +404.4 kg P_2O_5/ha	60.6^{abcd}	57.73^{a}	11.66^{ab}	10.2^{a}	0.95^{ab}	15.50^{a}
108 kg N kg/ha	61.98^{ab}	57.28^{a}	11.80^{ab}	9.71^{a}	1.06^{ab}	15.00^{a}
108 kg N +134.8 kg P_2O_5/ha	59.9^{abcd}	55.80^{ab}	12.11^{ab}	10.1^{a}	1.01^{ab}	15.33^{a}
108 kg N +269.6 kg P_2O_5/ha	60.4^{abcd}	50.63^{b}	12.50^{a}	10.1^{a}	0.94^{ab}	15.83^{a}
108 kg N+404.4 kg P_2O_5/ha	61.17^{abc}	53.51^{ab}	11.92^{ab}	9.27^{a}	0.94^{ab}	15.16^{a}
281.6 kg N kg/ha	59.93^{bcd}	54.50^{ab}	11.50^{ab}	10.1^{a}	0.90^{b}	14.66^{a}
281.6 kg N +134.8 kg P_2O_5/ha	61.35^{abc}	53.85^{ab}	11.63^{ab}	9.98^{a}	1.31^{a}	15.16^{a}
281.6 kg N +269.6 kg P_2O_5/ha	60.2^{abcd}	55.91^{ab}	11.95^{ab}	9.86^{a}	0.88^{b}	15.16^{a}
281.6 kg N +404.4 kg P_2O_5/ha	58.97^{cd}	55.89^{ab}	11.81^{ab}	9.89^{a}	0.90^{b}	15.16^{a}
Mean	60.60	55.23	11.81	9.87	0.98	15.15
LSD (<0.05) CV (%)	1.43 2.85	2.71 5.90	0.67 6.88	0.62 7.63	0.19 23.57	0.60 4.79

PH: Plant height (m); LL: Leaf length (cm); FL: Fruit length (cm); FDi: Fruit diameter (cm); FW: Fruit fresh weight (kg/fruit) and Brix: TSS (%)

Table 3: The analysis of variance of nitrogen and phosphorus on yield and yield related traits of ratoon pineapple grown at Jimma.

in a corresponding reduction in plant height, leaf length, fruit length and diameter, however, the opposite result was observed on fruit fresh weight and brix (TSS) contents, when the advanced rates of N and P [23]. Leaf length of a plant is an important growth character and directly linked with the yield potential of pineapple and positively correlated with plant productivity [7]. Pineapple tested with 281 kg N ha^{-1} and 134 kg P ha^{-1} had longest (59.44 cm and 59.01 cm) leaf length. The result obtained from this study was consistent with the report of [21] who reported, 58 cm and 52 cm of pineapple from application of 200 kg N ha^{-1} and 180 kg P ha^{-1}. The longest leaf as a result of N application is indicative of the role of N in promoting vigorous foliage growth and more intense physiological activities in the plant which favored the synthesis of more assimilates for fruit development. Similarly, nitrogen increases the chlorophyll contents of the leaves, thereby promote the photosynthetic capacity of the plant, plays a part in the manufacture of proteins and responsible for high fruit yield in pineapple [4]. On the other hand, phosphorous promotes CO_2 assimilation and energy for the translocation of carbohydrates from leaves to the fruits of crops, where carbohydrates are the main storage material [24].

Likewise, fruit length, fruit diameter and fresh fruit yield followed similar trends as plant height. The control plots (0 Kg N and 0 Kg P) showed the shortest plants with the lowest fruit length and fruit diameter. Fruit length and diameter had highest at application of 108 kg N/ha rates were statistically similar (Table 4). Fruit length and diameter/fruit were significantly increased by P application up to the 269.6 kg ha^{-1} rate and not beyond. Typically, the rate of application of N

Treatments	2012/2014					
	PH	LL	FL	FDi	FFW	Brix
Nitrogen (Kg/ha)						
0	51.48^{b}	54.54^{b}	12.24^{ab}	7.24^{b}	1.04^{b}	14.83^{ab}
93.6	54.45^{ab}	56.90^{ab}	12.32^{ab}	7.45^{ab}	1.07^{ab}	14.43^{ab}
108	56.30^{ab}	56.63^{ab}	12.44^{a}	7.61^{a}	1.18^{a}	15.49^{a}
281	58.81^{a}	59.44^{a}	12.31^{ab}	7.42^{ab}	1.25^{a}	15.83^{a}
SE±	**4.22**	**3.50**	**1.05**	**0.46**	**0.22**	**1.02**
Phosphorous (P_2O_5 Kg/ha)						
0	53.32^{b}	56.01^{b}	11.78^{b}	7.39^{ab}	1.07^{b}	14.83^{ab}
134.8	55.19^{ab}	59.01^{a}	12.62^{a}	7.58^{a}	1.19^{ab}	14.17^{b}
269.6	57.75^{a}	57.37^{ab}	12.49^{a}	7.56^{a}	1.28^{a}	15.23^{ab}
404.4	57.16^{a}	56.16^{ab}	12.28^{ab}	7.58^{a}	1.19^{ab}	15.73^{ab}
Interaction N x P	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV (%)	**7.50**	**6.13**	**8.54**	**6.15**	**18.86**	**6.66**

PH: Plant height (m); LL: Leaf length (cm); FL: Fruit length (cm); FDi: Fruit diameter (cm); FW: Fruit fresh weight (kg/fruit) and Brix: TSS (%).

Table 4: Effect of nitrogen and phosphorus on yield and yield related traits of pineapple crop grown at Jimma.

Treatments	Ratoon crop					
	PH	LL	FL	FDi	FFW	Brix
Nitrogen (Kg/ha)						
0	60.02^{b}	54.34^{ab}	11.43^{b}	9.65^{ab}	0.87^{ab}	15.14^{ab}
93.6	60.12^{b}	58.22^{a}	12.08^{a}	9.98^{a}	0.93^{ab}	14.76^{ab}
108	61.35^{ab}	54.30^{ab}	11.90^{ab}	9.75^{ab}	1.09^{a}	15.00^{a}
281	60.89^{a}	55.03^{ab}	11.72^{ab}	9.95^{a}	1.00^{a}	14.66^{ab}
SE±	**1.72**	**3.26**	**0.81**	**0.75**	**0.23**	**0.72**
Phosphorous (P_2O_5 Kg/ha)						
0	60.03^{b}	53.72^{ab}	11.62^{ab}	9.43^{b}	0.91^{ab}	14.81^{b}
134.8	61.33^{a}	57.13^{a}	11.66^{ab}	10.00^{a}	0.95^{ab}	14.83^{a}
269.6	60.46^{ab}	54.54^{ab}	12.19^{a}	9.95^{a}	1.03^{a}	15.16^{a}
404.4	60.30^{ab}	55.53^{ab}	11.85^{ab}	9.78^{ab}	1.16^{a}	15.00^{ab}
Interaction N x P	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**
CV%	**2.85**	**5.90**	**6.88**	**7.63**	**23.57**	**4.79**

PH: Plant height (m); LL: Leaf length (cm); FL: Fruit length (cm); FDi: Fruit diameter (cm); FW: Fruit fresh weight (kg/fruit) and Brix: TSS (%)

Table 5: Effect of nitrogen and phosphorus on yield and yield related traits of ratoon pineapple grown at Jimma.

from 0 up to 108 kg ha^{-1}, increased the length of fruit by 1.63%, whereas, the application of P up to 269.6 Kg ha^{-1}, gave the corresponding values of 6.02% than the control. Fruit length and diameter followed similar trends as increased the NP rates from 0 kg N ha^{-1} to 108 kg N ha^{-1} and 0 kg P ha^{-1} to 269.6 kg P ha^{-1}, respectively. The superior growth attributes was obtained at high rates of N and P in this study has been reported by other researchers [4,21]. The positive response of growth characters to the applied plant nutrients is attributable to their role in cell division, multiplication and photosynthesis which gave rise to increase in size and length of leaves, fruit and stems. Furthermore, the positive response shown by yield parameters to N and P could be directly linked to the well-developed photosynthetic surfaces and increased physiological activities leading to more assimilates being produced and subsequently translocation of assimilates and utilized for fast fruit development. In this regard, [25] reported, both N and P are necessary for root initiation, elongation, and increase in fruit length, diameter and fruit yield. Total fruit fresh weight obtained at 281 kg N ha^{-1} rates showed an increase of 20.19% over that of 0 kg N ha^{-1} rate, whereas, increasing P rates from 0 to 269.6 kg ha^{-1}, increase fresh fruit weight by 68.22%; a further increase P application up to 404.4 kg ha^{-1} decreased fruit fresh weight by 11.21 percent. On contrary, the results obtained from this study is higher than the reported value of 127.04 kg N ha^{-1} and 65 kg P ha^{-1} with fruit fresh weight of 16.72 t ha^{-1} [26]. The observed disparity between the results could be explained on the basis of the soil fertility difference and the environmental conditions upon which the plant was grown. Besides, [23], also reported significant differences on fruit yield of pineapple due to N, P and K application. This result was consistent with the report of and [27] who suggested that the maintenance dressing of 270 kg N ha^{-1} and 280 kg P ha^{-1} per cropping season may be adequate for continuous pineapple production in Nigeria.

The effect of N fertilizer rates on fruit juice quality of pineapple are presented in Tables 4 and 5. The TSS content increased significantly as N rates increased at ratoon, but no significant effect in the main plant. According to [7,28,29] reported, high N fertilizer application had significant positive effect on the TSS content. In this study, the highest TSS content (15.49%) and (15.33%) was obtained at N rates of 108 kg N ha^{-1} in plant and ratoon crops, respectively. Apply treatments beyond 108 kg N ha^{-1}, the TSS content declined by 1.95%. This result was consistent with the report of Ademar et al. [23] who reported, high N application had positive effect on fruit yield, but decreased quality (TSS) contents significantly. On contrary, adequate supply of P is important for energy synthesis and translocation, and it also increases yield and improves the fruit quality (brix contents). Hence, the positive

Sensitivity Analysis										
Fertilizer level	Mean Yield (Kg/ha)	Adjusted Yield (Kg/ha)	Gross Benefit (ETB/ha)	Cost of Urea (ETB/ha)	Cost Of DAP (ETB/ha)	Gross Cost (ETB/ha)	Net Benefit (ETB/ha)	Change gross cost	Change Net benefit	MRR (%)
N(kg/ha)										
0	50160.0	5016.0	100320.0	0	0	0	100320.0	-	-	-
93.6	51480.0	5148.0	102960.0	1404.0	0	1404.0	102960.0	1404.0	2640.0	188.0
108	51920.0	5192.0	103840.0	1620.0	0	1620.0	103840.0	216.0	880.0	407.0
281	55000.0	5500.0	110000.0	4215.0	0	4215.0	110000.0	2595.0	61600.0	237.0
P(P_2O_5 kg/ha)										
0	35640.0	3564.0	71280.0	0	0	0	71280.0	-	-	-
134.8	41800.0	4180.0	83600.0	0	2426.0	2426.0	83600.0	2426.0	12320.0	507.0
269.6	42680.0	4268.0	85360.0	0	4852.8	4852.8	85360.0	2426.0	1760.0	72.0
404.4	48400.0	4840.0	96800.0	0	7279.2	7279.2	96800.0	2426.0	11400.0	470.0
Fertilizer level	Mean Yield (Kg/ha)	Adjusted Yield (Kg/ha)	Gross Benefit (ETB/ha)	Cost of Urea (ETB/ha)	Cost Of DAP (ETB/ha)	Gross Cost (+10%)	Net Benefit (-10%)	Change gross cost	Change Net benefit	MRR (%)
N(Kg/ha)										
0	50160.0	5016.0	100320.0	0	0	-	90288.0	-	-	-
93.6	51480.0	5148.0	102960.0	1404.0	0	1544.00	92664.0	1544.0	2376.0	153.86
108	51920.0	5192.0	103840.0	1620.0	0	1782.00	93456.0	238.00	792.0	332.77
281	55000.0	5500.0	110000.0	4215.0	0	4636.00	99000.0	2854.0	5544.0	194.25
P(P_2O_5 Kg/ha)										
0	35640.0	3564.0	71280.0	0	0	0	64152.0	-	-	-
134.8	41800.0	4180.0	83600.0	0	2426.0	2668.0	75240.0	2668.0	11088.0	415.59
269.6	42680.0	4268.0	85360.0	0	4852.8	5338.0	76824.0	2670.0	1584.0	59.32
404.4	48400.0	4840.0	96800.0	0	7279.2	8006.2	87120.0	2668.2	10296.0	285.90

–MRR: Marginal Rate of Return; field price of pineapple: 20 ETB ha^{-1}; price of urea= 15ETB ha^{-1}; price of DAP: 18ETB/kg.

Table 6: Marginal rate of return and sensitivity analysis for NP fertilizer at Jimma stations.

response of fruit yield and yield components to increased rates of N and P could be adduced to high energy synthesis and translocation activities stimulated by N and P application. Moreover, the experimental soils were slightly low in nitrogen content, hence, the positive response observed. However, the pH of the experimental sites was slightly acidic (5.65), and had some fixation of P in the soil solution, as a result, some difficulty to absorb and utilize available nitrogen and other essential mineral nutrients from the soil by plants.

The results of economic analysis revealed that, the highest change net benefit of 61,600.0 ETB/ha with marginal rate of return (MMR) of 237.0% and 12,320.0 ETB ha^{-1} with marginal rate of return of 507.0% were obtained by application of 281 kg N and 134.8 kg P_2O_5 ha^{-1}, respectively. An increase in output will always raise profit as long as the marginal rate of return is higher than the minimum rate of return i.e. 50 to 100%. Data in Table 6 showed that, the marginal rate of return at the nitrogen application rate of 281 kg N ha^{-1} was greater than 50% marginal rate of return showed an economically feasible. The MRR decreased as the cost increased. Besides, the marginal rate of return due to phosphorus application is also more than 50%, application of phosphorus fertilizer is economically profitable up to the rate of 134.8 kg P_2O_5 ha^{-1}. Sensitivity analysis of profitability of fertilizer use relative to 10% increase in fertilizer price remained feasible (Table 6). Similarly, it remained profitable up on 10% yield decrease due to moisture loss during transportation and storage. In both cases MRR were above the acceptable range. This depicts relative advantage and stability of economic benefits due to NP fertilizer use in the production of pineapple in Jimma and other areas of similar soil and climatic conditions.

Conclusion and Recommendation

The present findings showed that nitrogen and phosphorus had positive effects on growth, yield and quality of pineapple. The application of 281 kg N ha^{-1} and 134.8 kg P_2O_5 ha^{-1} had significantly increased the fruit yield of pineapple. The economic analysis reveals that further application of NP fertilizer is not economical. Thus, application of 281 kg N ha^{-1} and 134.8 kg P_2O_5 kg ha^{-1} is economical and recommended for pineapple production under Jimma and its vicinity of Southwest Ethiopia.

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