Al-Qadisiyah Journal For Agriculture Sciences (QJAS)
ISSN : 2618-1479 Vol.12, Issue. 1 ,(2022), pp. 162-172
https://jouagr.qu.edu.iq/

Nitrogen Fertilizer Split Application Response on Late Maturing Maize ((Zea mays L.) at Banshure and Omonada Woredas, Sowthwest Ethiopia

Muhidin Biya[1], Sisay Gurmu[2] and Eshetu Yadete[3]

[1-3] Jimma Agricultural Research Center, P. O. Box 192, Jimma, Ethiopia.

[1]Corresponding author E-mail: muhibiya@gmail.com

Received : 20/5/2022
Acceptance : 30/5/2022
Available online: 1/6/2022

Abstract. The field experiments were carried out at Buno Bedele and Omonada Jimma Zones on farmers' fields for three consecutive main seasons and two sites each. The 10 treatments were laid down in a randomized complete block design (RCBD) with three replications using (BH661) hybrid maize variety. All across season and location data analysis of ANNOVA showed that all parameters were significantly affected by different time of nitrogen applications including plant height, grain yield, and harvest index, above ground biomass and logging percentage. The two highest grain yield 6.48 and 6.47 was recorded from applying 1/3 at planting + 2/3 at flag leaf appearance stage and applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) respectively again this treatment gave 13.08 and 12.62 t ha-1 above ground biomass yield respectively. The highest grain yield has 78.24 and 23.00 % yield advantage over negative control and applying all recommended N rate at planting respectively. Again in economic analysis, the above treatments gave the highest 111660 and 111840 net benefit respectively. Even though the applying 1/3 at planting + 2/3 at flag leaf appearance treatment MMR was not acceptable. Therefore, based on the highest net benefit applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) and applying 1/3 at planting + 2/3 at flag leaf appearance nitrogen fertilizer split application on late maturing (BH661) maize variety give an economic yield response and also acceptable for farmers of study areas and similar agro ecology.

Keywords. Grain, Biomass, Economic, Analysis.

1. Introduction

Maize (Zea mays L.) is the third most important cereal crop after wheat and rice and is known as the "King of grain crops". Ethiopia is partly because of its high value as a food crop as well as the growing demand for the Stover as animal fodder and source of fuel for rural families. [1]. Also approximately 88 % of maize produced in Ethiopia is consumed as food, both as green and dry grain [2]. In such a way maize plays an important role in the food security of the country. In Ethiopia, maize stands first of all other cereal crops in annual production and productivity, although it is leading all crops [3]. Currently in Ethiopia maize is cultivated by 5.62 million households on 3.41 million hectares and produced 11.73 million tones [3]. Maize contributes 54.91 % to the total national grain production as compared to other crops with 1.02 tone productivity but according to the GTP II, the productivity of maize will increase to 5.0 tones/ha with the total productivity of 10.9 million tones by the year 2020 according to the Ethiopian calendar. This high yield gap requires an intensive supply of inputs mainly in organic fertilizers like nitrogen with good management and improved superior hybrid varieties are the most important factors. Among the plant nutrients, primary nutrients such as nitrogen and phosphorus play a crucial role in determining the growth and yield [4].

Nitrogen has numerous functions in the plant. It is an essential element of amino acids, the building blocks of proteins and part of the nucleic acids; DNA and RNA [5]. Nitrogen is a constituent of plant compounds including nucleotides, amides and amines. Many enzymes are proteinaceous; hence, N plays a key role in many metabolic reactions. Because N is contained in the chlorophyll molecule, a

DOI: 10.33794/qjas.2022.133975.1044

deficiency of N will result in a chlorotic condition in the plant. Nitrogen is also a structural constituent of cell walls [6].

Nitrogen management is the main concern and factor that limit fertilizer N-uptake, uses efficiency and affects the yield in maize production. Due to the mobile nature of nitrogen in various soil types, particularly in areas where seasonal rains last for longer periods, its exposure to leaching and denitrification was found to be higher. Trials so far conducted in these agro-ecologies of Ethiopia indicate two split applications of nitrogen fertilizers that are 50% at sowing and the rest 50% top-dressed at knee-height. The works of some authors like [7] reported that in most humid areas of Ethiopia, the application of the total N requirement in three equal splits that is at sowing, knee-height and flag leaf emergence was recommended for maize production. A similar study conducted at Adet Agricultural Research Center on the split application of nitrogen fertilizer for two maize hybrid varieties was found variable by rate requirements. The total nitrogen rate requirement for BH-540 was applied in two splits where one-third at sowing and two-thirds at knee height and for BH-660 an application of one-fourth at sowing and three-fourth at knee height gave higher grain yield [8].

Therefore, it is becoming evident that variables such as maize variety, the total amount of nitrogen to be applied, soil type, climate, and crop rotation affect the optimum timing of nitrogen application. It is could be crucial for individual small holder farmers to manage their N fertilization schedules to best match with the peak demands of updated and recently released hybrid maize especially when increasing fertilizer cost by 170% in Ethiopia at 2022. The present investigation is, therefore, designed to determine the appropriate time of nitrogen fertiliser application for late-maturing hybrid BH-661 maize variety in potential maize agro-ecologies of southwest Ethiopia.

2. Materials and Methods

2.1. Description of The Experimental Site

The field experiments were conducted at Omonada, Jimma Zone and Banshure, Buno Bedele, Zone districts in the Oromia region in the southwestern part of Ethiopia. It was conducted for three consecutive years (2017-2019) main cropping seasons were planted from first May to mid-May. The Omonada is located 365 km southwest of Addis Ababa. The sites were located on 7º46' N and 36º 00'E and laid at an altitude of 1753 m.a.s.l. with soil type of the area is Upland: Chromic Nitosol and Combisol. The average maximum and minimum temperatures are 9ºC and 28ºC respectively and reliably receive good rains of 1561 mm per annum cropping season. While the Banshure site was located 493 km southwest of Addis Ababa with Eutric-nitisols (reddish brown) soil type. The farming system of both sites was coffee and cereal crops dominated with coffee, maize, tef, sorghum, rice and Niger also has a warm and cold climate. The soil type of the experimental sites was a warm and cold climate, also convenient topography which is very suitable for all agricultural practices.

The field experiments were arranged in a randomized complete block design (RCBD) with three replications. During site selection, soil samples were collected from three gradients at depth of 0-20 cm each gradient from one composite sample and put in a poly-bag. The application time and proportion of the recommended N rate (92 kg N /ha) from urea (46% N) are used as a source of nitrogen and Phosphorous fertilizer is also applied at a rate of 69 kg P2O5/ha (from TSP) (Table 1.) At all locations, nitrogen and phosphorous are applied at hills around each plant in micro-dose method at planting. A late maturing (BH661) hybrid maize variety was used for the study at both sites. Two maize seeds were planted per hill and thinned after establishment to maintain a single healthy plant per hill. A plot size of (0.75 m x 6 rows) 4.50 m x 5.10 m length. The net plot size was (0.75 m x 4 rows) 3 m x 5.10 m length, 75*25cm between row and plant respectively accommodates 53,3333 plant ha-1 which is recommended and spacing between plots and replications will be 0.5m and 1m, respectively. The experimental field was prepared following the conventional tillage practice and the furrow opened by using oxen. All other agronomic practices like three times hand weeding was applied uniformly to all experimental plots as per their respective recommendations for maize in the study area.

Table 1. Lists of treatments arranged.

Treatment No	Time of nitrogen split applications
1	No application of N (negative control)
2	Applying 1/2 at planting + 1/2 at 5 - 4 weeks after emergence (Positive control)
3	Applying all recommended N rate at planting
4	Applying all recommended N rate at 3 - 4 weeks after emergence
5	Applying 1/2 at planting + 1/2 at flag leaf appearance stage
6	Applying 1/3 at planting + 1/3 at 5 - 4 weeks after emergence + 1/3 at flag leaf appearance stage
7	Applying 1/3 at planting + 2/3 at 5 - 4 weeks after emergence
8	Applying 1/3 at planting + 2/3 at flag leaf appearance stage
9	Applying 2/3 at planting + 1/3 at 5 - 4 weeks after emergence
10	Applying 2/3 at planting + 1/3 at flag leaf appearance stage

2.2. Soil Chemical Properties

The experimental sites were blocked into three parts depending upon land uniformity. Plant residues on the sampling soil surface were removed. Finally a composite surface soil (0-20 cm depth) sample was collected from both sites using a gauge before planting. The soil samples were then analyzed at the Jimma Agricultural Research Center soil laboratory for chemical properties (Table2.).

Table 2. Soil chemical properties of the experimental sites before planting at Omonada and and Banshure sites.

Soil characters	Banshure site		Omonada site		
	Value	Rating	Value	Rating	Reference
pH(1:2.5)	5.055	Strongly acidic	5.11	Strongly acidic	[9]
Av P(mg kg-1)	14.86	High	1.91	Low	[10]
TN (%)	0.182	Medium	0.24	High	[11]
OC (%)	2.055	Low	2.62	High	[12]
SOM (%)	3.54	Medium	4.51	Medium	[11]
C: N ratio	11.32	Low	10.90	Low	[13]

Here pH= hydrogen power, TN=Total Nitrogen, Av P=Available Phosphorous, OC=Organic Carbon, SOM=Soil Organic Carbon. Values are the means of duplicated samples.

2.3. Data Collection and Measurement

All data were collected from ten plants based on guidelines for agronomy and soil fertility data collection in Ethiopia: National standard.

2.3.1. Plant Height (cm)

It was recorded from ten random plants at maturity by measuring the height from the ground to the tip of the plant.

2.3.2. Lodging Percent

It was obtained by counting the total number of the stalk and root lodging in each plot and dividing it by the total number of plants standing at harvesting.

2.3.3. Grain yield (t ha^{-1})

Grain yield (kg/ha) was recorded after harvesting from the harvestable rows. Seed yield was adjusted to 12.5% moisture using a moisture tester (Dickey-john) and converted to quintal ha-1 for statistical analysis. Adjusted yield=Actual yield × 100-M/100-D; where M is the measured moisture content in grain and D is the designated moisture content (12.5%). where D is the designated moisture.

DOI: 10.33794/qjas.2022.133975.1044

2.3.4. Biomass Yield (t ha^{-1})

Ten randomly selected plants were considered for the determination of above-ground dry biomass weight by drying in sunlight for ten days till a constant dry weight was attained

2.3.5. Harvest Index (%)

It was calculated as the ratio of grain yield to total above-ground dry biomass yield multiplied by 100 at harvest from the respective treatments [14].

$$\text{Harvest Index} = \text{Grain yield/ above-ground dry biomass yield} \times 100.$$

2.4. Statistical Analysis

Analysis of variance (ANOVA) for all collected data was computed using R software version 3.5.3 statistical software R Core Team (2019-03- 11). Whenever the ANOVA results showed significant differences between sources of variation, the means were separated using Fisher's least significant difference (LSD). The homogeneity test showed that all location-year variances were homogeneous. Therefore, all data were combined for analysis of the variance procedures.

2.5. Partial Budget Analysis

To assess the costs and benefits associated with different treatments, the partial budget technique as described by [15] was applied. Economic analysis was done using the prevailing market prices for inputs at planting and outputs, at the time the crop was harvested. All costs and benefits were calculated on a hectare basis of Ethiopian Birr (EtB). The inputs and/or concepts used in the partial budget analysis were the mean grain yield of each treatment in three years, the field price of maize grain sale price grain minus the costs of labor for land preparation, planting, seed), the gross field benefit (GFB)/ ha-1 (the product of field price of the mean yield for each treatment), the field price of Nitrogen (urea) kg ha-1 and wage rate of application, the total costs that varied (TCV) which included the sum labor for land preparation, of field cost of seed and its wage for application. The net benefit (NB) was calculated as the difference between the GFB and the TCV. The actual yield was adjusted downward by 10% to reflect the difference between the experimental yield and the yield farmers could expect from the same treatment. There were optimum plant population density, timely labor availability and better management (e.g. weed control, rainfall) under the experimental conditions.
The dominance analysis procedure as detailed in [16] was used to select potentially profitable treatments from the range that was tested. The discarded and selected treatments using this technique were referred to as dominated and un-dominated treatments, respectively. The un-dominated treatments were ranked from the lowest to the highest cost. For each pair of ranked treatments, the per cent marginal rate of return (MRR) was calculated. The MRR (%) between any pair of un-dominated treatments was the return per unit of investment in labour and urea. To obtain an estimate of these returns the MRR (%) was calculated as changes in NB divided by changes in cost. Thus, the MRR of 100% was used indicating for every one EtB expended there is a return of one EtB for a given variable input.
Sensitivity analysis for different interventions was also carried out to test the recommendation made for its ability to withstand price changes. Sensitivity analysis simply implied redoing the marginal analysis with the alternative prices. Through sensitivity analysis, the maximum acceptable field price of input was calculated with the minimum rate of return as described by [17].

3. Results and Discussion

3.1. Plant Height

The significant highest mean plant height of 263.86 and followed by 262.17 cm were recorded from Appling of 1/2 at planting + 1/2 at 4-5 weeks after emergence (Positive control) and Applying 1/3 at planting + 2/3 at flag leaf appearance stage respectively in contrast the lowest 238.42 m was recorded from No application of N (negative control) (Table 3). It's obvious that the difference in plant height was due to the effect of nitrogen application but the difference fewer 25.64 cm was due to soil nitrogen being from medium to high at both sites. Twice split application of recommended nitrogen

(Applying 1/2 at planting + 1/2 at 4-5 weeks after emergence) was given highest plant height than others than three and even amount difference in any two split applications. The result showed that split application of nitrogen improves plant height through physiological processes in cell division elongation resulting in increasing internode height. Similarly [18] reported that the increase in plant height with more N splits would be due to supply of proper amount of N at different growth stages of maize and N promotes plant growth, increases the number and length of the internodes which resulted in progressive increase in plant height. Also, The N promotes plant growth, increases the number and length of internodes which resulted in taller plants of maize crop [18].

3.2. Logging Percentage

The logging percentage of maize was significantly affected by the time of nitrogen application (Table 3). The highest Logging percentage of 37.90% was recorded from Applying 1/3 at planting + 1/3 at 4-5 weeks after emergence + 1/3 at flag leaf appearance stage. Which is the application of three times split it results in effective utilization of the plant without a loss for continuous growth that leads to excessive increase in height, weak stem results logging. In contrast, the lowest was recorded from applying 1/2 at planting + 1/2 at flag leaf appearance stage and applying 2/3 at planting + 1/3 at flag leaf and appearance stage 32.94 and 34.16 % respectively. Also similar results were observed with applying all recommended N rate at planting. The result showed that logging was mostly related to the time of application than amount because of the nature of nitrogen mobility and lost soon before the plant's active roots development to uptake results in deficient leads to stunted, weak stem and poor growth. The current result was similar with a sufficient quantity of N throughout the growing season is a must for optimum maize growth. It plays an important role in plant growth as an essential constituent of cell components and requires for the synthesis of chloroplast, amino acids, proteins and cell division [19] Further, N deficiency in maize may develop thin and spindly stems which could be prone to lodging by the wind. Moreover, maize plants deficient in N will develop a poor root system, which reduces their anchorage capacity [20].

Table 3. Across Season and location effect of time of nitrogen split applications on mean plant height and logging percentage during 2017-2019.

Treatments Number	Time of nitrogen split applications	Plant Height (cm)	Logging Percentage (%)
1	No application of N (negative control)	238.42	37.38
2	Applying 1/2 at planting + 1/2 at 4-5 weeks after emergence (Positive control)	263.86	35.41
3	Applying all recommended N rate at planting	258.63	34.51
4	Applying all recommended N rate at 3 - 4 weeks after emergence	251.42	36.88
5	Applying 1/2 at planting + 1/2 at flag leaf appearance stage	259.33	32.94
6	Applying 1/3 at planting + 1/3 at 4-5 weeks after emergence + 1/3 at flag leaf appearance stage	258.29	37.90
7	Applying 1/3 at planting + 2/3 at 4-5 weeks after emergence	257.00	34.72
8	Applying 1/3 at planting + 2/3 at flag leaf appearance stage	262.17	35.56
9	Applying 2/3 at planting + 1/3 at 4-5 weeks after emergence	258.88	35.08
10	Applying 2/3 at planting + 1/3 at flag leaf appearance stage	258.83	34.16
	Mean	256.68	35.45
	LSD	17.63	14.09
	Cv 5%	11.63	22.34

DOI: 10.33794/qjas.2022.133975.1044

Al-Qadisiyah Journal For Agriculture Sciences (QJAS)
ISSN : 2618-1479 Vol.12, Issue. 1 ,(2022), pp. 162-172
https://jouagr.qu.edu.iq/

3.3. Grain Yield

Significantly highest grain yield 6.48 and 6.47 was obtained from the applying 1/3 at planting + 2/3 at flag leaf appearance stage and applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) respectively (Table 4). The result implies that application at peak times like at 4-5 weeks after emerge and flag leaf appearance stage plating in addition to at plating gave high grain yield. It is obvious that, the lowest 3.63 t ha-1 grain yield was obtained from no application of N (negative control) and followed by 5.26 and 5.82 ha-1 was recorded from applying all recommended N rates at planting and applying all recommended N rate at 3 - 4 weeks after emergence respectively. The highest grain yield has a 78.24 and 23.00 % yield advantage over negative control and applying all recommended N rates at planting. The result showed that amount of nitrogen split and times of applications were not coinciding with plant's physiologically active to uptake and utilize. Any fertilizer applied at planting will, therefore, be subjected to leaching losses since absorption by the maize up to 10 - 15 days after sowing maize seed is rare [21]. [22] Reported that maize grain yield increased with the split application of fertilizer compared to one single application at planting. Also treatments like applying 2/3 at planting + 1/3 at flag leaf appearance stage was the time when rain offset moisture deficit and nitrogen was un available form or lost through mobile or volatile especially due to the nature of nitrogen unlike the others nutrients and not contribute to grain yield. The result was in agreement with the 120 kg N ha-1 applied once resulted in low nutrients because most of it would have been lost before the end of the gestation of the maize, whereas due to application some nutrients were still retained in the soil. It was reported [23] that greater than 50% of higher doses of applied N are unavailable in the soil to crop due to losses through leaching. Also, [24] reported that 58 - 70% of applied N may be secured in the soil due to the efficient time of N application. Further [25] found that maize yields declined when N applications were delayed.

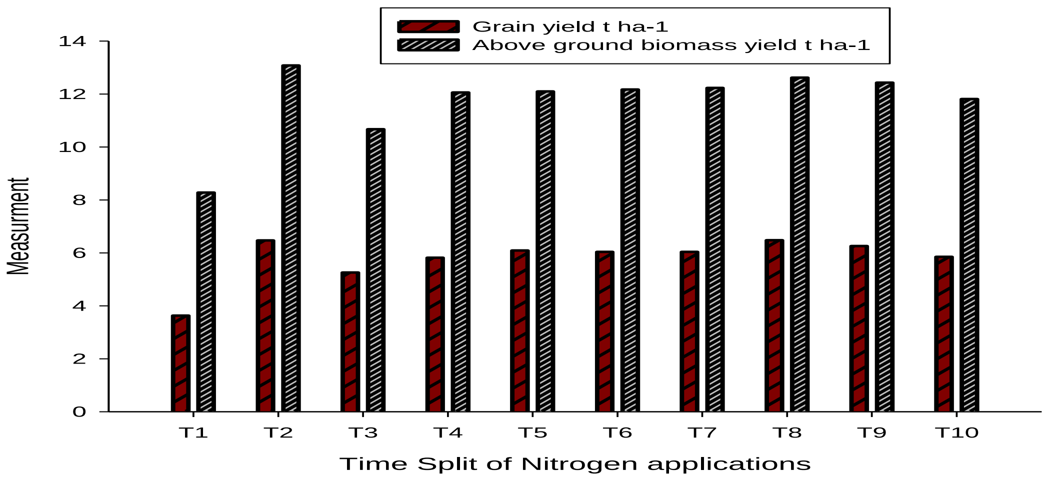

Figure 1. Graphs of grain and above ground biomass on split application of nitrogen.

3.4. Above-Ground Biomass Yield

The treatments applying 1/2 at planting + 1/2 at 4-5 weeks after emergence (Positive control) and Applying 1/3 at planting + 2/3 at flag leaf appearance stage gave significantly and the highest 13.08 and 12.62 t ha-1 above ground biomass yield respectively (fig 1). The results indicate that the both treatments amount and time of applications of nitrogen coincide with plant requirement for increased number of leaves, plant growth and plant height and this resulted in more nodes and internodes and subsequently attributes for more production in above-ground biomass yield. In contrast the lowest 8.28 and 10.67 t ha-1 above ground biomass yields were obtained from no application of N (negative control) and applying all recommended N rates at planting respectively. The highest above ground biomass yield has 57.97 and 22.59 % yield advantage over negative control and applying all recommended N rates at planting. These both treatments related with deficiency and high losses of nitrogen specially applying all recommended N rate at planting was result in leaching loss before roots not well developed. Also the same result reported by Excessive rainfall after planting often results in N loss through denitrification and leaching [26] Again, the [27] report shows that split application of fertilizer at different growth stages had significant effect on maize fodder yield.

3.5. Harvest Index

The applying 2/3 at planting + 1/3 at 4-5 weeks after emergence and applying 1/3 at planting + 2/3 at 4-5 weeks after emergence gave the 51.81 and 51.35% harvest index (Table 4). This implies that split application nitrogen at 4-5 weeks after emergence has positive effect on harvest index than amount of application. The least 42.87% harvest index was recorded from no application of N (negative control) and it shows that even though the amount of nitrogen vary the application at 4-5 weeks after emergence and flag leaf appearance stage gave higher harvest index than negative control. The result showed that split application has positive response on harvest index than applying at a time. A similar result was reported by [28] harvest index significantly influenced by time of nitrogen application. Further supported by the maximum HI (23.34%) was recorded when applying N in two splits (½ of nitrogen dose at 40 DAs +½ of nitrogen dose at tasseling) suggesting importance split application [29].

Table 4. Across Season and location effect of time of nitrogen split applications on mean grain yield, above ground biomass and harvest index of the common bean during 2017-2019.

Treatments Number	Time of Nitrogen split applications	Grain Yield (t/ha)	Above ground Biomass Yield (t/ha)	Harvest Index (%)
1	No application of N (negative control)	3.63	8.28	42.87
2	Applying 1/2 at planting + 1/2 at 4-5 weeks after emergence (Positive control)	6.47	13.08	49.76
3	Applying all recommended N rate at planting	5.26	10.67	49.76
4	Applying all recommended N rate at 3 - 4 weeks after emergence	5.82	12.06	49.29
5	Applying 1/2 at planting + 1/2 at flag leaf appearance stage	6.09	12.10	50.94
6	Applying 1/3 at planting + 1/3 at 4-5 weeks after emergence + 1/3 at flag leaf appearance stage	6.04	12.17	50.36
7	Applying 1/3 at planting + 2/3 at 4-5 weeks after emergence	6.04	12.23	51.35
8	Applying 1/3 at planting + 2/3 at flag leaf appearance stage	6.48	12.62	50.95
9	Applying 2/3 at planting + 1/3 at 4-5 weeks after emergence	6.26	12.43	51.81
10	Applying 2/3 at planting + 1/3 at flag leaf appearance stage	5.85	11.81	50.06
	Mean	**5.79**	**11.75**	**49.71**
	LSD	**1.08**	**2.43**	**4.92**
	Cv 5%	**20.34**	**25.05**	**13.29**

3.6. Economic Analysis

Analysis of variance showed that nitrogen split application had a significant (P = 0.001) effect on the grain yield. An economic analysis of the results using the partial budget technique was thus appropriate [15]. The result of the partial budget analysis and the data used in the development of the partial budget is given in (Table 5). It was performed by considering fertilizer, seed and labour costs for land preparation and application as the main input, mean grain yield obtained across the season. The total costs of fertilizers (NPS = 15.90 EtB/kg and urea = 12.65 EtB/kg and sale of maize grain at around Buno Bedele and Omonada an open market average price (20.00 EtB/kg). Grain yield was adjusted by 10% for management difference to reflect the difference between the experimental yield and the yield that farmers could expect from the same treatment [16].

Dominance analysis (Table 5) led to the selection of treatments after ranked in increasing order of total costs that vary. The applying 1/2 at planting + 1/2 at flag leaf appearance stage, applying 1/3 at planting + 2/3 at 4-5 weeks after emergence, applying 2/3 at planting + 1/3 at 4-5 weeks after emergence, applying 2/3 at planting + 1/3 at flag leaf appearance stage and applying 1/3 at planting + 1/3 at 4-5 weeks after emergence + 1/3 at flag leaf appearance stage treatments dominated and eliminated (Table 4).

Therefore, this investigation remained with no application of N (negative control), applying all recommended N rates at planting, applying all recommended N rate at 3 - 4 weeks after emergence, applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) and applying 1/3 at planting + 2/3 at flag leaf appearance stage were ranked in increasing order of total cost and promising new practices for farmers under the prevailing price structure. The gave below than 100% MRR was considered low and unacceptable to farmers; thus, applying all recommended N rate at planting, applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) and applying 1/3 at planting + 2/3 at flag leaf appearance. This was because such a return would not offset the cost of capital (interest) and other related deal costs while still giving an attractive profit margin to serve as an incentive (Table 6).

Market prices are ever-changing and as such a recalculation of the partial budget using a set of likely future prices i.e., sensitivity analysis, was essential to identify treatments that may likely remain stable and sustain satisfactory returns for farmers despite price fluctuations. The sensitivity analysis study indicates an increase in the field price of the total variable costs, and a fall in the price of maize grain, which represented a price variation of 15% (Table 7).

The price changes are sensitive under market conditions prevailing around Buno Bedele and Omonada. The new prices were thus used to obtain the sensitivity analysis (Table 5) Both treatments applying all recommended N rates at planting and applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) gave acceptable with MMR 1010 and 1656% respectively give an economic yield response and also sustained acceptable returns even under projected worsening trade conditions in both sites. But also applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) and applying 1/3 at planting + 2/3 at flag leaf appearance gave the highest 111660 and 111840 net benefits respectively (fig 2). Even though the applying 1/3 at planting + 2/3 at flag leaf appearance treatment MMR was not acceptable (Table 5). Therefore, applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) and applying 1/3 at planting + 2/3 at flag leaf appearance nitrogen fertilizer split application give an economic yield response and also sustained acceptable in the study area.

Table 5. Partial budget analysis with dominance to estimate net benefit for nitrogen split application at current prices.

Time of nitrogen split applications	Adjusted Grain (Yield t ha^{-1})	Gross Field Benefit	TCV (EtB ha^{-1})	Net Benefit (EtB ha^{-1})
No application of N (negative control)	3.27	65340	2300	63040 --
Applying all recommended N rate at planting	4.73	94680	4300	90380 Un
Applying all recommended N rate at 3 - 4 weeks after emergence	5.24	104760	4300	100460 Un
Applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control)	5.82	116460	4800	111660 Un
Applying 1/2 at planting + 1/2 at flag leaf appearance stage	5.48	109620	4800	104820 Do
Applying 1/3 at planting + 2/3 at 4-5 weeks after emergence	5.44	108720	4800	103920 Do

Applying 1/3 at planting + 2/3 at flag leaf appearance stage	5.83	116640	4800	111840	Un
Applying 2/3 at planting + 1/3 at 4-5 weeks after emergence	5.63	112680	4800	107880	Do
Applying 2/3 at planting + 1/3 at flag leaf appearance stage	5.27	105300	4800	100500	Do
Applying 1/3 at planting + 1/3 at 4-5 weeks after emergence + 1/3 at flag leaf appearance stage	5.44	108720	5300	103420	Do

Retail price of grain =Birr 20.00 per kg; Fertilizers urea = Cost of Birr 12.65, per kg; NPS =Cost Birr 15.90 per kg; TCV= total cost that varied, NB= Net benefit; MMR= Marginal Rate of Return; EtB = Ethiopian Birr.

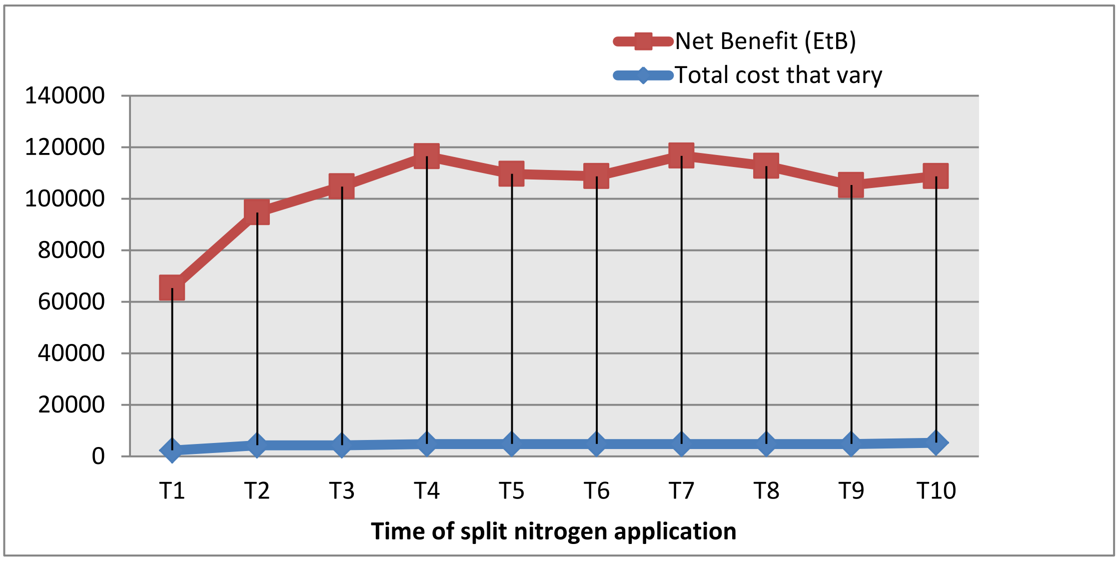

Figure 2. Graphs of the total cost that varied and net benefit on split application of nitrogen.

Table 6. Partial budget with estimated marginal rate of return (%) for nitrogen split application at current prices.

Split applications of Nitrogen	TCV (EtB/ha)	Net Benefit (EtB/ha	Raised Cost	Raised Benefit	MRR (%)
No application of N (negative control)	2300	63040	---	----	----
Applying all recommended N rate at planting	4300	90380	2000	27340	1367
Applying all recommended N rate at 3 - 4 weeks after emergence	4300	100460	0	10080	----
Applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control)	4800	111660	500	11200	2240
Applying 1/3 at planting + 2/3 at flag leaf appearance stage	4800	111840	0	180	----

Retail price of grain =Birr 20.00 per kg; Fertilizers urea = Cost of Birr 12.65, per kg; NPs =Cost Birr 15.90 per kg; TCV= total cost that varied, NB= Net benefit; MMR= Marginal Rate of Return; EtB = Ethiopian Birr.

DOI: 10.33794/qjas.2022.133975.1044

Table 7. Sensitivity analysis of maize production based on a 15% rise in the total cost and maize price of gross field benefit fall.

Time of Nitrogen applications	TVC (ETB ha^{-1})	NB (ETB ha^{-1})	Increment Cost	Increment Benefit	MRR (%)
No application of N (negative control)	2645	53584	---	---	---
Applying all recommended N rate at planting	4945	76823	2300	23239	1010
Applying all recommended N rate at 3 - 4 weeks after emergence	4945	85391	0	8568	---
Applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control)	5520	94911	575	9520	1656
Applying 1/3 at planting + 2/3 at flag leaf appearance stage	5520	95064	0	153	---

Retail price of grain =Birr 20.00 per kg; Fertilizers urea = Cost of Birr 12.65, per kg; NPs =Cost Birr 15.90 per kg; TCV= total cost that varied, NB= Net benefit; MMR= Marginal Rate of Return; EtB = Ethiopian Birr.

Conclusion

Maize has high nitrogen response especially those recently release high brides un like the normal maize varieties. Also the an optimum amount of nitrogen fertilizer application at a suitable application time when it is most efficiently, effectively utilized and with minimal losses was one of the most important yield determining factors. Because applied nitrogen N uptake rates are low or lost by many factors like; immobilization, clay fixation, denitrification, leaching and others at a time. There for, the split application of nitrogen experiment was conducted.

All across season and location data analysis of ANOVA showed that all parameters were significantly affected by different time of nitrogen applications including plant height, grain yield, harvest index, above ground biomass and logging percentage. Generally, applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) and applying 1/3 at planting + 2/3 at flag leaf appearance gave the highest 111660 and 111840 net benefit respectively. Even though applying 1/3 at planting + 2/3 at flag leaf appearance treatment MMR was not acceptable. Since the variety was late maturing, especially applying at flag leaf appearance was good during rain fall. Therefore, Based on high net benefit applying 1/2 at planting + 1/2 at 4-5 weeks after emerge (Positive control) and applying 1/3 at planting + 2/3 at flag leaf appearance nitrogen fertilizer split application for late maturing (BH661) maize variety gave an economic yield response and recommended for the study area and similar agro ecologies.

Acknowledgements

We would like to thank Almighty to Allaha (God), who gave us peace, health and strength that we required to complete this work. We would like to thank JARC in general specifically Sill laboratory team. Also the gratefully acknowledge Mr Kemerudin Aba Mecha and Zerihun Assefa who helped in overall trial management and support for collecting data from the field.

References

[1] Abdirazak A,Bereket T. Pre-Scaling up of Improved Maize Varieties in Essera and Boloso Sore Woreda of Southern Nation Nationalities and Peoples Regional State, Ethiopia. Agri Res & Tech :Open Access J. 2018; 17(2): 556019. DOI: 10.19080/ARTOAJ.2018.17.556019.

[2] T. Abate, B. Shiferaw, A. Menkir et al., "Factors that transformed maize productivity in Ethiopia," Food Security, vol. 7, no. 5, pp. 965–981, 2015.

[3] CSA. (2021). Ethiopian Agricultural Sample Enumeration, 2021/22 (2014 E.C). Central Statistics Authority, Addis Ababa, Ethiopia.

[4] Sirkanth M, Mohamed AM, Muthukrihan P (2009). Influence of plant density and fertilizer on yield attributes yield and grain uality of hybrid maize. Madras Agric. J. 96(1-6):139-143.

[5] Bould, C., E.J. Hewitt, and P. Needham, 1984. Diagnosis of Mineral Disorders in Plants. Vol. 1: Principles. Chemical Publishing, New York.
[6] Schrader LE (1984) Functions and transformation of nitrogen in higher plants. In: Hauck RD (Ed.) Nitrogen in Crop Production. pp. 55-60
[7] Tolessa D, Tesfa B, Wakene N, Tenaw W, Minale L, Tewodros M, Birtukan M , Waga M (2002). A review of fertilizer management research on maize in Ethiopia. Enhancing the Contribution of Maize to Food Security in Ethiopia:
[8] Tilahun Tadesse1* Alemayehu Assefa2 Minale Liben1 and Zelalem Tadesse1. (2013). Effects of nitrogen split-application on productivity, nitrogen use efficiency and economic benefits of maize production in Ethiopia
[9] Batjes, N. H., (1995). Aglobal data set of soil pH properties. Technical Paper 27, International Soil Reference and Information Centre (ISRIC), Wageningen.
[10] Olsen, S. R., Cole, C. V., Watanabe, F. S. and Dean, L. A. (1954). Estimation of available phosphorus in soilby extraction with sodium bicarbonate. USDA circular 939. 1-19p.
[11] Berhanu, D., (1980). A survey of studies conducted about soil resources appraisal and evaluation for rural development in Ethiopia, Addis Ababa. 70p.
[12] Tekalign M, and Haque I (1991). Phosphorus status of some Ethiopian soils, II. Forms and distribution of inorganic phosphates and their relation to available phosphorus. Tropical Agriculture, 68: 2-8.
[13] Donald CM (1962). "In search of yield." Journal of Australian Institute of Agricultural Science, vol. 28, pp. 171-178.
[14] CIMMYT (1988). From agronomic data to farmer recomendations: An economic training manual. Revised Edition. Mexico, D.F.
[15] Getachew, A., and Taye, B., (2005). On-farm integrated soil fertility management in wheat on nitisols of central Ethiopian highlands. Ethiopian Journal of Natural Resources, 7: 141-155.
[16] Shah H, Sharif M, Majid A, Hayat U, Munawar A. 2009. From experimental data to farmer recommendation: an economic analysis of onfarm trial of UMMB feed for milking animals in rain-fed Pothwar, Pakistan. Livestock Research for Rural Development, 21(117)
[17] Adhikari, P., Baral, B.R., & Shrestha, J. (2016). Maize response to time of
[18] nitrogen application and planting seasons. Journal of Maize Research and Development,2(1):83-93, doi: http://dx.doi.org/10.3126/jmrd.v2i1.16218
[19] Schrader LE (1984) Functions and transformation of nitrogen in higher plants. In: Hauck RD (Ed.) Nitrogen in Crop Production. pp. 55-60
[20] Brady, N., Weil R. R., (2008). Nature and Properties of Soils (14th edn.). Prentice Hall, Upper Saddle River. 992p.
[21] Abebe Z, Feyisa H. Effects of nitrogen rates and time of application on yield of maize: rainfall variability influenced time of N application. Int J Agron 2017; 2017: 1545280.CrossRef in wheat. J Agron 2006; 5(2): 251-6.
[22] Gehl RJ, Schmidt JP, Maddux LD, Gordon WB (2005). Corn yield response to nitrogen rate and timing in sandyirrigated soils. Agron. J.(97). Pp. 1230-1238
[23] Jamal Z, Hamayun M, Ahmad N, Chaudhary MF. Effects of soil and foliar application of different concentrations of NPK and foliar application of (NH4)2 SO4 on different yield parameters in wheat. J Agron 2006; 5(2): 251-6.
[24] Haile D, Nigussie D, Ayana A. Nitrogen use efficiency of bread wheat: effects of nitrogen rate and time of application. J Soil Sci Plant Nutr 2012; 12(3): 389-409
[25] Binder DL, Sander DH, Walters DT. Maize response to time of nitrogen application as affected by level of nitrogen deficiency. Agron. J. 2000; 92: 1228–1236. ttps://doi.org/10.2134/agronj2000.9261228x
[26] Thomison PR, Geyer AB, Bishop BL, Young JR, Lentz E (2004). Nitrogen fertility effects on grain yield, protein, and oil of corn hybrids with enhanced grain quality traits. Plant Management Network. Accepted for publication 15 October 2004. Published 24 November 2004
[27] Diekow J, Ceretta CA, Pavinato PE. Possible to anticipate the nitrogen dubbing of corn in the no-tillage system? In: South-brazilian soil science meeting 2. Santa Maria, DS/UFSM 1998; pp. 163-6.
[28] Megersa Debele, Tolera Abera and Tedesse. 2020. Debele Effect of Nitrogen Fertilizer Rates and Time of Applications on Phenology, Growth, Yield and Yield Components of Maize (Zea mays L.) Varieties at Bako, Western Oromia, Ethiopia
[29] Keyro Assefa* and Zenebe Mekonnen .2019. Effect of level and time of nitrogen fertilizer application on growth, yield and yield components of maize (Zea mays L.) at Arba Minch, Southern Ethiopia.