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Research Article

Urea Split Application to Maize (*Zea mays L.*) Growth Stages of Medium Maturities, Influenced on Grain Yield and Parameter for Yield at Bako, East Wollega, Ethiopia

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Appropriate timing of application can improve crop nutrient consumption efficiency. Maize production is still significantly below than its potential output, even though it is comparatively better than other main cereal crops. One of the main abiotic variables affecting crop growth is the timing of urea split application. Due to these gaps, an experiment was carried out at the Bako Agricultural Research Center during the 2019 and 2020 cropping seasons in order to ascertain the best time to apply urea split in order to maximize the yield and yield attributes of the maize varieties BH-546 and BH-547 in a study area and in countries with comparable agroecologies. Six levels of urea split application time (T1, T2, T3, T4, T5, and T6) were arranged in factorial combinations with two levels of maize varieties. In addition, a randomized complete block design with three replications was used for the previously advised urea split application. The harvest index of maize, grain yield, number of kernels per ear, ear dimension, and number of ears per plant all significantly differed depending on when nitrogen split administration occurred. Mean dry biomass, cob diameter, cob length, cob weight, and thousands seed weight of maize were all highly impacted by the interaction varietals and split time of nitrogen treatment. Compared to the previously recommended (1/2 dose at planting and 1/2 dose at knee height stage of maize), the time of N split application resulted in a significantly higher grain yield (9003.88 kg·ha^{-1}): 1/4 dose at planting + 1/2 dose of N at knee height + 1/4 dose at tasseling of maize. However, three urea application regimes 1/4 dosage at planting time, 1/2 dose at knee height, and 1/4 dose of split application should be utilized in the event of irregular and intensely rainy seasons in order to maximize grain output and yield attributable.

1. Introduction

One of the most important and well-liked cereal crops is maize (*Zea mays*), which has a high nutritional value and is also widely used for building, fuel, and animal feed [1]. Maize is also the most important and consistent crop for rural Ethiopian households in terms of calories consumed. Almost 88% of the maize grown in Ethiopia is used for grain and green cobs [2]. It is one of the most important crops to feed Ethiopia's expanding population because of its many advantages. It ranks first in productivity among major cereal crops [3], second only to tef in terms of production area.

Its yield productivity is below potential, even if its current productivity is better than that of other main cereal crops. Medium-maturing hybrid maize varieties have the ability to yield up to 8.5–11.5 tha^{-1} in research fields and 6.5–8.5 t·ha^{-1} in on-farm fields, which is significantly higher than the national average productivity of 3.2 tha^{-1} [4]. Depletion of soil fertility and inadequate nutrient management are two of the main causes of low productivity, although a variety of biotic and abiotic variables can also contribute to these large yield gaps [5].

As the most crucial and fundamental nutrient for crop growth and development, managing the timing of nitrogen application in the maize production system is one of the biggest concerns [6]. Therefore, it is normal to increase the use of fertilizer N to get higher biomass. When applied at the right time, split urea application can reduce environmental pollution and improve yield production and nutrient usage efficiency [7, 8].

Applying urea later than the recommended time for maize will not boost yield and could increase soil NO_3 levels and make the soil more vulnerable to leaching of NO_3 [9]. According to a different study, an abundance of N promotes NH_3 losses, particularly when the supply exceeds plant needs [10]. However, effective N management, which includes the suggestion of applying urea at the proper time, can reduce the adverse environmental effects linked to the production of maize [10]. To improve N use efficiency and raise maize yield, another key focus is applying urea at the right time throughout the crop growth stage.

The crop does not absorb all of the urea that is applied since leaching is a major factor in urea loss in regions with significant rainfall. Studies have indicated that urea loss through leaching causes roughly 50%, and even more at higher doses, of applied urea to remain unavailable to a crop [11]. On the other hand, urea administered at the right time can boost the crop's production and grain quality by up to 58–70% and increase the recovery of applied N [11, 12]. Half of the recommended urea at planting and half at the knee height stage was the previous advice for maize production in Western Ethiopia [2]. Numerous studies have, nevertheless, confirmed that urea applied at the time of maize planting does not effectively recover because the growth and development phase from planting to tasseling is a stage of N need [8]. Niaz et al. [13] discovered that nitrogen application postponed till after crop establishment significantly increased harvest index as compared to nitrogen application at planting.

When the crop has a good base, providing nitrogen in two separate applications considerably reduces nitrogen losses [14]. Nitrogen is applied twice by farmers in the study area: once at planting and once at knee height. On the other hand, additional research indicates that applying nitrogen usage efficiency two or three times enhances nitrogen absorption in favorable wet seasons [15].

Applying half of the appropriate amount of nitrogen at planting and the remaining amount at knee height is standard practice in the western Ethiopian research area. Urea can be applied on time and is good to boost maize output. Thus, the purpose of this experiment is to assess whether nitrogen split treatments on improved varieties of maize (BH-546 and BH-547) in the research region should be applied. This study set out to determine when split treatments of nitrogen should be applied in connection to the yield and yield parameters of the studied varieties of maize in the study area.

2. Materials and Methods

2.1. Experimental Site. The experiment was conducted at the Bako Agricultural Research Center in 2019 and 2020 during the main cropping season in the East Wollega Zone of the western Oromia Regional National State. Nekemte town is located in the Gobu Sayo district, approximately 8 kilometers from Bako town and is approximately 250 kilometers from the capital Addis Ababa. Bako is located at an elevation of 1650 meters above sea level. The study area was located at latitude 09° 6′ North and longitude 37° 02′ East (Figure 1). The area has a warm, humid environment, with average annual temperatures of 23.7 and 13.5°C (Figure 2). The region experiences an average annual rainfall of 1237 mm, mostly from May to October, with the wettest months being June and August (Figure 3). According to a grading by [16], the area's principal soil type is nitisol, which has a characteristic reddish brown color and a pH that ranges from very strongly acidic to very acidic.

The average annual temperatures were 23.7 and 13.5°C, and an average annual rainfall was 1237 mm, mostly from May to October, with the wettest months being June and August (Figure 2). According to a grading by [16], the area's principal soil type is nitisol, which has a characteristic reddish brown color and a pH that ranges from very strongly acidic to very acidic.

2.2. Materials for Experiments. The medium-maturing hybrid maize varieties (BH-546 and BH-547) were used for the treatments. The new varieties, which may be planted anywhere between 1000 and 2000 meters above sea level and need an even distribution of 1000 to 1500 millimeters of annual rainfall during their growing seasons, were recently unveiled by the Bako National Maize Research Center. Each variety's potential output on the farmer fields and research station was 65–75 $kg{\cdot}ha^{-1}$ and 85–115 $kg{\cdot}ha^{-1}$, respectively. 92 $kg{\cdot}N{\cdot}ha^{-1}$ of nitrogen fertilizers were employed, and they were applied in accordance with the treatment plans.

2.3. Treatments and Experimental Design. Two types of maize cultivars (BH-547 and BH-546) and six distinct nitrogen application periods comprised the treatments. T1 (half at planting plus half at knee height plus 0 at tasseling), T2 (half at planting plus 0 at knee height plus 1/2 at tasseling time), T3 (one-third at planting plus one-third at knee height plus one-third at tasseling), T4 (zero at sowing plus two-thirds at knee height plus one-third at tasseling), T5 (zero at sowing plus half at knee height plus half at tasseling), and T6 (1/4 at sowing + 1/2 at knee height + 1/4 at tasseling). The treatments were arranged as 2 × 6 factorial combinations in RCBD with three replications. Total treatments were twelve (12). The gross plot comprised of 7 rows of 3 m in length and 5.25 m in widths and on row each from both sides of the plot was left as a border. Thus, the central 5 rows were used for data collection, and the net plot size was $3\,m \times 3.75\,m = 11.25\,m^2$.

2.4. Experimental Procedures and Field Management. With a cutlass, the foliage was removed from the area, and then stumps were removed after that. Tractors were used to plow discs and harrow the ground. All cultural customs were followed in accordance with the suggestions. The experiment made use of 92 $N{\cdot}kg{\cdot}ha^{-1}$ of the same suggested N rate. The nitrogen came via the usage of urea. All plots received a 69 $kg{\cdot}ha^{-1}$ application of phosphorus at the time of Sowing. At the study region, two split nitrogen application times

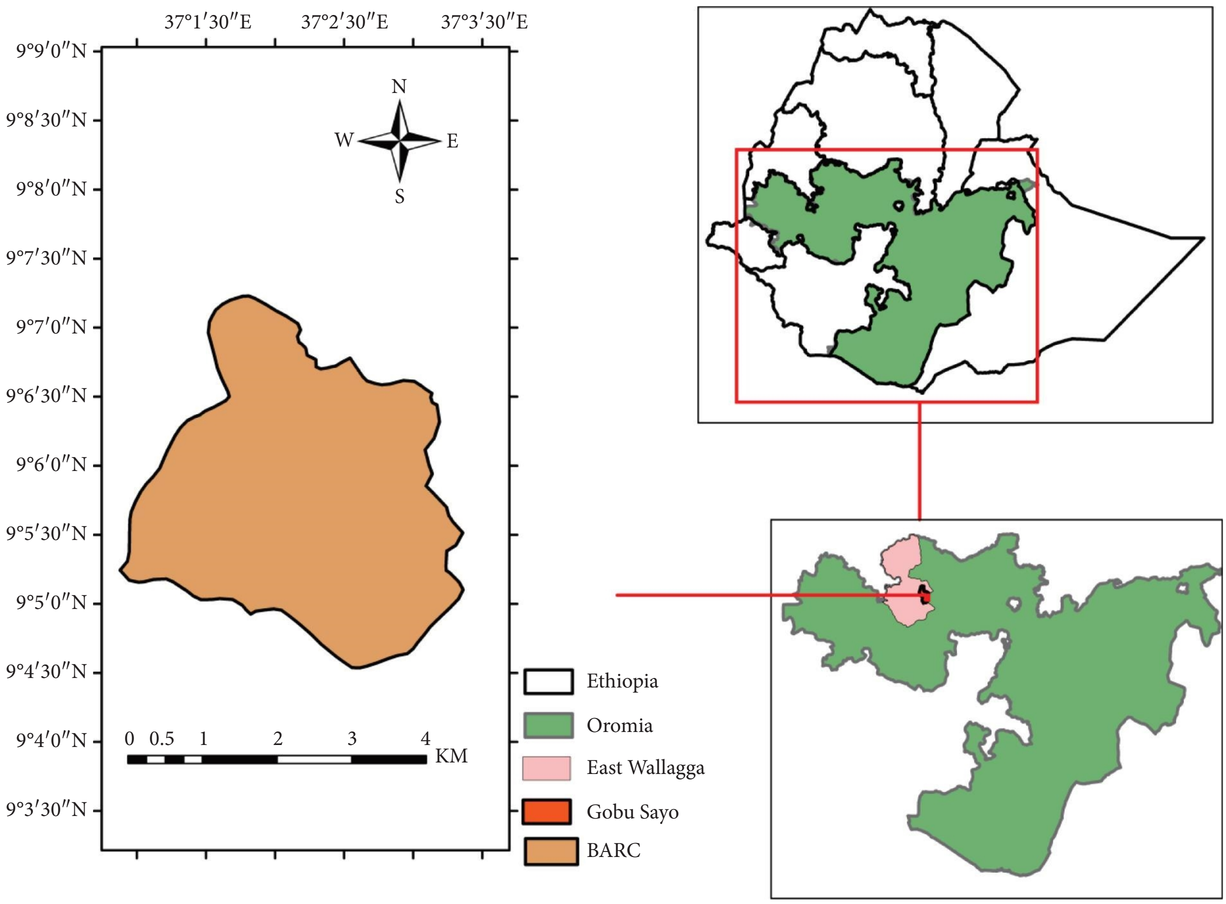

Figure 1: Geographic location of the experimental site.

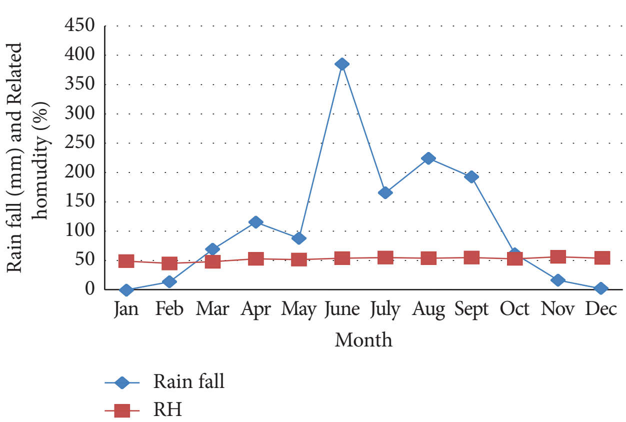

Figure 2: Mean of monthly rain fall (mm) and related humidity (%) at Bako during 2019 and 2020 cropping season.

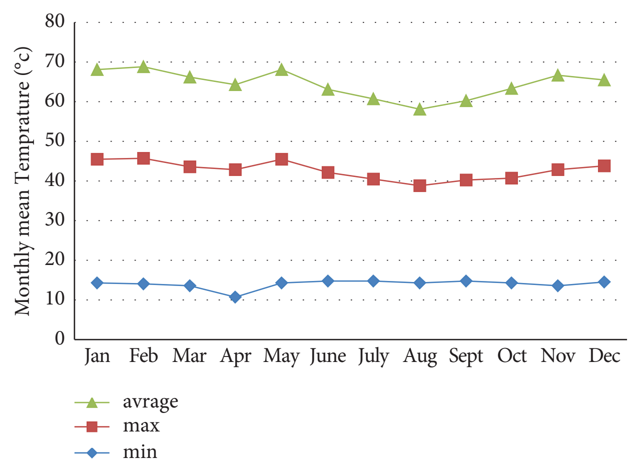

Figure 3: Mean of monthly maximum, minimum, and average temperatures (°c) at Bako during 2019 and 2020 cropping season. Source: Bako agricultural research center weather data, Bako, West Shewa, Ethiopia.

(half at planting + half at knee height and null at tasseling) were recommended. NPSB fertilizer was applied in the row on all treatments and mixed with soil just at the time of planting. 18% of the nitrogen used at planting that in NPSB for all treatment. Split application time of urea was done within the stated time ranges, but at the same date as per treatment arrangements. The crop was sowed at spacing of 75 cm between row 25 cm between plants, respectively. The spacing between blocks and plots is 1.5 m and 1 m, respectively. Two seeds were sown per hill, and then it was thinned to one plant after seedling emergence. The trial was planted in early June for both cropping season of 2019 and 2020. All other management practices were given as per the recommendations.

2.5. Data to Be Collected. During harvest, information on yield metrics was gathered. Five plants from each plot were sampled, and the seed yield from a 9 m^2 area was calculated as $kg{\cdot}ha^{-1}$ for each plot's yield component.

2.5.1. Number of Cobs per Plant. After counting the number of cobs or ears on the five selected plants in each plot, the average number of harvested cobs was calculated by dividing the total number of cobs by five.

2.5.2. Ear Diameter. Using calipers, the diameters of the cobs from each of the five plants that were sampled were measured. The mean of the diameters was then determined by adding up each cob's individual measurements and dividing the result by the total number of cobs from the five plants.

2.5.3. Ear Length. The length of each dehusked cob from the five plants that were sampled was measured using a measuring tape. The total lengths were divided by the total number of cobs from the five plants to determine the mean cob length.

2.5.4. Number of Grains per Ear. After drying and shelling, the seeds in five cobs from each plot were counted. To find the average, divide the total number of grains by the number of cobs.

2.5.5. Ear Weight. Five harvested cobs were dehusked and weighed using an electric balance. The total weight was then divided by the total number of plants that were sampled.

2.5.6. Weight of One Thousand Seeds. One hundred seeds were weighed and counted from each plot.

2.5.7. Number of Rows of Grains per Cob. For each plot, the five plants that were chosen had their number of rows of grains per cob visually counted and recorded. The average was then calculated after that. Each plot's five cobs were counted and averaged for the number of grains per row.

2.5.8. Harvest Index. This was calculated as a percentage of the economic and biological yields.

(1) Crop Yield. Following three days of oven drying at 60°C, data were translated into kg/ha and collected in each plot.

(2) Dry Biomass Yield. After chopping the plant parts above ground into small pieces and placing them in an envelope, the sections were oven-dried for three days at 72°C until a consistent weight was reached.

2.5.9. Statistical Analysis. SAS GLM version 9.1 (SAS, 2004) was used to do an analysis of variance on all parameters of the collected data. The means were compared using the least significance difference (LSD) test at the 5% level of significance when the effects of the treatments were found to be significant (Steel et al. [17]).

3. Results

3.1. Yield Component Parameter

3.1.1. Dry Biomass. The results of the dry biomass yield are displayed in Tables 1 and 2. The results for dry biomass production showed that there were no significant differences in the major influence of varieties, but there was a significant difference in the timing of split applications of nitrogen (Table 2). It was discovered that maize mean dry biomass was significantly impacted by the interaction between the varieties and timing of N split application (Table 1). Among the several treatment combinations, the nitrogen time application (quarter dosage at planting, half dosage at knee height, and quarter dosage at tasseling) yielded the highest mean dry biomass (21535.50 $kg{\cdot}ha^{-1}$). Table 3 shows that the lowest dry biomass was produced by a 1/2 N dose during sowing and a 1/2 N dose during tasseling during the nitrogen treatment period. In a similar vein, [18] found that maize biomass output was significantly impacted by the timing of N application. Belete et al. [12] found that at different growth phases, increasing the N rate significantly increased biomass yield. The larger than lower N rate-related increases in mean single leaf area, leaf area per plant, and plant heights may be the cause of the increased biomass yield. Applying N during the later stages of the vegetative phase of maize prolonged the growth phase (Belete et al. [12]), and the longer growth period caused the maize crop to assimilate more nutrients. This resulted in an increase in plant height, mean single leaf area, and leaf area per plant, which may have contributed to the higher biomass yield of maize while increasing the number of N split applications. According to Mariga et al. [19], applying N to maize until the tassel initiation stage significantly enhanced the crop's biomass production. Applying N in splits significantly increased maize production (Scharf et al. [20]).

3.1.2. Ear Diameter. Maize ear diameter was considerably impacted by varieties and year of growth, while cob diameter was not significantly impacted by the major effect of nitrogen time application (Table 4). Table 3 shows that there was a substantial ($P < 0.05$) impact on cob diameter from the interaction between variety and timing of nitrogen (N) delivery. The generation of the biggest cob diameters resulted from the interaction between BH-547 and 1/2 dose at knee height and 1/2 dose at tasseling of nitrogen application. The highest ear diameter (5.36 cm) was recorded from interaction BH-547 varieties with 1/4 N dose at planting, 1/2 N dose at knee height, and 1/4 N dose at tasseling; however, the interaction of BH-546 varieties with 2/3 dose at knee height and 1/3 N dose at tasseling of maize resulted in the lowest ear diameter (4.13) Table 5. Similarly, the authors in [21] indicated that ear width was significant difference between two varieties of maize. The

Table 1: Interaction effect of varieties and nitrogen application on dry biomass in 2019 and 2020.

Treatment	Varieties	
Time of nitrogen split application	BH-547	BH-546
1/2 sowing + 1/2 knee height + 0 at tasseling	18932.17	18598.83
1/2 sowing + 0 at knee height + 1/2 at tasseling	18265.50	15932.17
1/3 sowing + 1/3 knee height 1/3 tasseling	19932.17	21098.83
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	20598.83	21265.50
0 at sowing + 1/2 knee height + 1/2 tasseling	19635.60	18634.92
1/4 at planting + 1/2 at knee height + 1/4 at tasseling	21535.50	21298.50
LSD	1421.830	
CV	6.2	

Table 2: Main effects of varieties and time of urea split application on ear weight, dry biomass, and number of kernel per ear of maize at BARC in 2019 and 2020 cropping season.

Treatment	Cob weight per plant	Dry biomass	Number of kernel pre ear
Year			
2019	0.2764	19378.54	563.1
2020	0.2464	20209.54	544.9
LSD (5%)	0.01937	2010.772	Ns
Varieties			
BH-546	0.2406	19621.46	567.9
BH-547	0.2822	19966.63	540.1
LSD (5%)	0.00791	Ns	21.16
Level of significant			*
1/2 sowing + 1/2 knee height + 0 at tasseling	0.2500	18915.50	547.2
1/2 sowing + 0 at knee height + 1/2 at tasseling	0.2583	17248.83	565.5
1/3 sowing + 1/3 knee height 1/3 tasseling	0.2633	20665.50	515.9
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	0.2650	21082.17	544.2
0 at sowing + 1/2 knee height + 1/2 tasseling	0.2650	19285.26	552.6
1/4 at planting + 1/2 at knee height + 1/4 at tasseling	0.2667	21567.00	598.6
LSD (5%)	0.01370	1421.830	51.83
Level of significance		**	**
CV (%)		6.2	8.0

* Significant and ** highly significant at $P< 0.05$ and $P< 0.01$, respectively, and; ns = not significant.

Table 3: Interaction effects of varieties and nitrogen applications timing on mean cob diameter of maize in BARC 2019 and 2020 cropping season.

Treatment	Varieties	
Time of nitrogen split application	BH-547	BH-546
1/2 sowing + 1/2 knee height + 0 at tasseling	5.100	4.493
1/2 sowing + 0 at knee height + 1/2 at tasseling	4.900	4.387
1/3 sowing + 1/3 knee height 1/3 tasseling	4.940	4.507
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	4.967	4.413
0 at sowing + 1/2 knee height + 1/2 tasseling	5.337	4.133
1/4 at planting + 1/2 at knee height + 1/4 at tasseling	5.36	4.167
LSD (5%)	0.2722	
CV %	3.3	

authors in [22] found that varieties of maize were significantly produced different ear height and ear diameter between two varieties of maize [23] revealed that the Gibe 2 variety produced the thicker ear diameter measurements, whereas the local maize variety produced the thinner ear diameter measurements. In addition, it was shown by Mosisa et al. [24] that the nitrogen split administration had a substantial impact on the cob diameter of the maize variety.

3.1.3. Ear Length. The results of the analysis of variance showed that the primary influences on maize variety ear length were the year of growth, variety, and timing of N application, as well as the interaction of these factors (Tables 4 and 5). The interaction between the BH-546 variety and N split application 2/3 dose at knee height + 1/3 dose at the tasseling stage resulted in the longest maize ear length (17.23 cm), while the interaction between the BH-547 variety and N split application 1/2 dose at sowing + 1/2 dose at knee

Table 4: In the 2019 and 2020 cropping seasons at BARC, the main effects of cultivars and the time of urea split application on cob diameter, cob length, and number of ears per plant of maize.

Treatment	Ear diameter	Ear length	Ear number per plant
Year			
2019	5.026	16.408	1.1000
2020	4.426	15.608	1.0389
LSD (5%)		0.2203	
Level of significance	**	**	
Varieties			
BH-546	4.350	16.839	1.0250
BH-547	5.101	15.178	1.1139
LSD (5%)		0.2203	
Level of significance	Ns	*	*
1/2 sowing + 1/2 knee height + 0 at tasseling	4.797	15.700	1.0833
1/2 sowing + 0 at knee height + 1/2 at tasseling	4.643	16.067	1.0667
1/3 sowing + 1/3 knee height 1/3 tasseling	4.723	16.400	1.0667
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	4.690	15.767	1.0667
0 at sowing + 1/2 knee height + 1/2 tasseling	4.750	15.967	1.0833
1/4 at planting + 1/2 at knee height + 1/4 at tasseling	4.750	16.150	1.0500
LSD (5%)	Ns	0.3816	
CV (%)	3.3	2.9	

* Significant and ** highly significant at $P< 0.05$ and $P< 0.01$, respectively, and ns: not significant.

Table 5: Interaction effects of varieties and nitrogen split application on cob length in 2019 and 2020.

Treatment	Varieties	
Time of nitrogen application	BH-547	BH-546
1/2 sowing + 1/2 knee height + 0 at tasseling	14.933	16.467
1/2 sowing + 0 at knee height + 1/2 at tasseling	15.333	16.800
1/3 sowing + 1/3 knee height 1/3 tasseling	15.933	16.867
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	14.867	16.667
0 at sowing + 1/2 knee height + 1/2 tasseling	14.933	17.000
1/4 at planting + 1/2 at knee height + 1/4 at tasseling	15.067	17.233
LSD	0.5397	
CV	2.9	

**Significant at $P < 0.05$ and ns = not significant.

height resulted in the shortest ear length (14.867 cm) (Table 5). The least amount of variation was observed in plots fertilized with nitrogen 1/2 at sowing + 1/2 at knee height stage when it came to the interaction between variety and nitrogen treatment timings.

Consistent with the findings of this investigation, Negash et al. [25] observed that the combination of variety and split application time had a substantial impact on maize ear length. Similarly, the authors in [23] discovered that there was a considerable difference in ear length between the primary effects of different maize cultivars. According to Yusuf et al. [26], different maize cultivars have dramatically varying cob lengths. Varieties varied in ear length (Tolessa et al. [27]). As a result, Anus et al. [28] found that there were notable differences in cob length throughout maize cultivars.

3.1.4. Ear Number per Plant. The number of cobs per plant was largely determined by the growth year and variety (Table 4). Table 4 shows that the BH-547 varieties of maize had the highest ear count (1.15), while the BH-546 varieties had the lowest ear length (1.04). There was no discernible effect of the timing of nitrogen treatment or variety on the number of corn cobs per plant. This outcome similar to Mosisa et al. [24], it was shown that the cultivar of maize had a substantial impact on the number of ears per plant.

3.1.5. Ear Weight per Plant. Table 6 shows that cob weight per plant of maize was strongly influenced by the interaction between varieties and the timing of nitrogen treatment. The combination of BH-546 varieties and 1/4 dose of N split application at sowing + 1/2 dose of N split application at knee height + 1/4 N at tasseling stage resulted in the greatest ear weight per plant (0.295) of maize. The combination of BH-546 varieties and 1/2 dose of N split application at the sowing stage + 1/2 dose of N split application at the knee height stage of maize produced the lowest ear weight per plant (0.235) (Table 6). This outcome similar to Mosisa et al. [24], who found that maize cultivar significantly influenced ear weight per plant.

3.1.6. Number of Grain Rows per Ear. Table 2 shows that there was a significant difference ($P < 0.01$) in the number of rows per cob between the two types of maize, but there was no significant effect on grain row per cob from nitrogen time

Table 6: Interaction between nitrogen application and variety on cob weight in 2019 and 2020.

Treatment	Varieties	
Time of nitrogen split application	BH-547	BH-546
1/2 sowing + 1/2 knee height + 0 at tasseling	0.2650	0.2350
1/2 sowing + 0 at knee height + 1/2 at tasseling	0.2650	0.2517
1/3 sowing + 1/3 knee height 1/3 tasseling	0.2850	0.2417
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	0.2917	0.2383
0 at sowing + 1/2 knee height + 1/2 tasseling	0.2917	0.2383
1/4 at planting + 1/2 at knee height + 1/4 at tasseling	0.2950	0.2383
LSD	0.0137	
CV	4.5	

application or their interaction. The maize variety BH-546 yielded the maximum number of rows per ear, while BH-547 produced the lowest number of rows per ear [29] reported that the number of grain rows ear^{-1} was not significantly affected by the nitrogen application period (31) reported that the number of rows per plant was not significantly affected by the amount of nitrogen applied.

3.1.7. Number of Kernel per Ear. The main effect of varieties and growing year was not significantly affected on number of kernel per ear, but the number of grain kernels ear-1 was considerably impacted by the time of N split application, but the number of kernels ear-1 was not significantly impacted by the interaction between varieties and the time of nitrogen delivery (Table 2). While lower grain per ear (515.9 ear^{-1}) was recorded from 1/3 dose of N at sowing, 1/3 at knee height, and 1/3 dose of N at tasseling stage of maize, significantly higher grain yield (598.9 ear-1) was obtained from time nitrogen split application of 1/4 N dose at planting, 1/2 dose at knee height stage, and 1/4 N dose at tasseling stage (Table 2).

3.1.8. Grain Yield. The main effects of varieties and growing year did not significantly affect grain yield, but the main effects of N time of application significantly affects ($P < 0.001$) on mean grain yield, while the interaction effects of varieties and time of nitrogen application has no significant on grain yield (Table 7). Significantly higher grain yield (9127.68 kg·ha^{-1}) of maize was obtained with nitrogen application time of 1/4 dose at planting stage, 1/2 N dose at knee height stage and1/4 N dose at tasseling stage. While lower grain yield (7598.39 kg·ha^{-1}) was recorded from 1/2 N dose at sowing 1/2 dose of N at the tasseling stage of maize (Table 8). In comparison to the recommended nitrogen application time (1/2 at planting + 1/2 at knee height), the nitrogen split application time of 1/4 at planting, 1/2 at knee height, and 1/4 at the tasseling stage produced a 20.0% yield advantage. This indicates that maize needs more nitrogen to be applied at the knee height stage than at planting and tasseling. This conclusion was consistent with [18], which discovered that the timing of the nitrogen delivery stage had a considerable impact on grain production. Similarly, Negash et al. [25] showed that the timing of the nitrogen application stage had a substantial impact on grain production, and the author in [22] reported that the split application of N time application had a large impact on grain yield as well.

3.1.9. Harvest Index. The harvest index measures a crop's physiological productivity and ability to turn all dry matter into marketable products. The harvest index shows how a plant can physiologically transform some photosynthesis into final yield. A higher harvest index indicates a greater conversion of total dry matter into final kernel yield. Table 7 indicates that the harvest index of maize was significantly impacted ($P < 0.05$) by the main impacts of urea split application time, but not significantly by the interaction between urea split application and variety. The highest harvest index (43.45%) was obtained from nitrogen split application at 1/2 dose at sowing and 1/2 dose at knee, while the lowest harvest index (40.42%) was recorded from time of nitrogen split application at 1/2 dose at knee height + 1/2 dose at tasseling (Table 7). This result implies that grain formation was highly and strongly affected by nitrogen split application, and since harvest index is the balance between the productive parts of the plant and the reserves which form the economic yield, greater improvement in grain yield compared to the corresponding increase in stover yield might have contributed to the increase in harvest index across the increasing levels of N. In conformity, the authors in [30] found that time of nitrogen fertilizer application also significantly affected harvest index of maize. The maximum HI (23.34%) was recorded when applying N in two splits (1/2 of the nitrogen dose at 40 DAs + 1/2 of nitrogen dose at tasseling) suggesting the importance split application [18]. Accordingly, the authors in [31] indicated that time of nitrogen application influenced on harvest index of maize.

3.1.10. Thousand Seed Weight. It is a crucial determinant in determining yield and is a hereditary feature that is reportedly least affected by environmental influences. The mean thousand seed weight of maize was significantly ($P < 0.01$) affected by the varieties (Table 7). The interaction between varieties and time of N application was significantly affected on thousand seed weight (Table 8). The highest thousand kernels weight 390 g was recorded from the interaction of the BH-547 variety and 1/4 dose N at planting, 1/2 dose at knee height, and 1/4 dose at the tasseling stage of nitrogen time application. While the lowest 290 g was recorded from the interaction of the BH-546 variety with 1/2

Table 7: Main effect of growing year, varieties, and nitrogen split application on grain yield, harvest index, and thousand seed weight of maize in 2029 and 2020 cropping season.

Treatment	Grain yield	Harvest index	Thousand seed weight (mg)
Year			
2019	8205.32	42.48	330
2020	8637.32	42.00	360
LSD (5%)	244.241	Ns	0.013
Varieties			
BH-546	8400.46	42.54	330
BH-547	8442.19	41.94	360
LSD (5%)	244.241	Ns	0.013
Time of urea split application			
1/2 sowing + 1/2 knee height + 0 at tasseling	8196.3387	43.45	330
1/2 sowing + 0 at knee height + 1/2 at tasseling	7598.349	43.06	340
1/3 sowing + 1/3 knee height 1/3 tasseling	8327.3157	40.42	340
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	8803.6443	41.78	350
0 at sowing + 1/2 knee height + 1/2 tasseling	7969.3317	41.36	340
1/4 at sowing + 1/2 at knee height + 1/4 at tasseling	9127.6812	42.36	390
LSD (5%)	423.038	1.796	0.022
CV (%)	6.1	5.2	

Table 8: Interaction effect of varieties and nitrogen split application on thousand seed weight (g) in 2019 and 2020.

	Varieties	
Time of nitrogen split application	BH-547	BH-546
1/2 sowing + 1/2 knee height + 0 at tasseling	360	290
1/2 sowing + 0 at knee height + 1/2 at tasseling	380	300
1/3 sowing + 1/3 knee height 1/3 tasseling	360	330
0 at sowing + 2/3 dose at knee height + 1/3 dose at tasseling	370	330
0 at sowing + 1/2 knee height + 1/2 tasseling	330	350
1/4 at planting + 1/2 at knee height + 1/4 at tasseling	390	390
LSD	0.031	
CV	7.8	

dose N at planting and 1/2 dose of N at knee height (Table 8). Likewise, Ahmad et al. [32] indicated that thousand grain weights were significantly affected by cultivars, their interaction between cultivars, and nitrogen time application [23]. It was established that the thousand-kernel weight showed significant difference at $P < 0.05$ among the main effect of maize varieties and their interaction between varsities and nitrogen time application. Yusuf et al. [26] found that the hundred seed weight significant different due to maize varieties. The mean thousand seed weight of maize was significantly affected by the varieties [31].

4. Conclusion

Though maize production is greater than that of other major cereal crops, it is still far short of its potential. The timing of urea treatment is the primary abiotic factor limiting crop productivity and yield. One of the most important abiotic factors limiting crop yield and productivity is the timing of nitrogen split application. The amount and distribution of rainfall during the seasons had a significant impact on how maize responded to the timing of N split treatment. In comparison to alternative treatment methods, the timing of the nitrogen split application 1/4 at planting, 1/2 at knee height, and 1/4 at tasseling provided a comparable optimum grain production in the cropping seasons of 2019 and 2020. Therefore, in both the 2019 and 2020 cropping seasons, the timing of the nitrogen split application 1/4 at planting, 1/2 at knee height, and 1/4 at tasseling provided the best dry biomass. The best timing for three separate nitrogen split applications was 1/4 at planting, 1/2 at knee height, and 1/4 at tasseling. In conclusion, it is advised for end users to apply nitrogen split time: 1/4 at planting + 1/2 at knee height + 1/4 at tasseling. This will yield the highest net benefit and an acceptable MRR during favorable rainy seasons. However, in cases of erratic and heavy rainy seasons that may lead to N losses through runoff and leaching during the time of N application, three times of nitrogen split application (1/4 N at planting, 1/2 N at knee height, and 1/4 at tasseling) should be used to get maximum profit.

Data Availability

The access to data is restricted.

Disclosure

The Oromia Agricultural Research Institute of Bako Agricultural Research Center coordinates this work as part of its regular research activities.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

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