

## **Use of Biofertilizer and Different Timings of Nitrogen Application: A Scheme for Improving Performance of Corn**

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### **Abstract**

Biofertilizer inoculation and timings of nitrogen fertilizer application are two important factors for better nutrient use efficiency. A field experiment was conducted to determine the effect of bio-fertilizer inoculation and timing of two-split nitrogen (N) application on the growth and yield performance of *Zea mays*. A 3x4 factorial experiment in split-plot design with three replications was conducted. The main plot factor is the application of bioinoculant: BF1 – without bioinoculant and BF2 – with Bio-fertilizer Nutrio and BF3 – with Bio-fertilizer Mykoplus. The subplot factor is the timing of two-split nitrogen application. At a rate of 174kg/ kg<sup>-ha</sup>, the first application of half of the amount (87 kg/ kg<sup>-ha</sup>) was done basally. The other 87kg/ kg<sup>-ha</sup> was applied at different timings based on the phenological stages of corn, namely, at V3 (3 leaf collar), at V5 (5 leaf collar) and V7 (7 leaf collar). No nitrogen application served as control. Data obtained was analyzed using STAR. Significant results were subjected to further analysis using Least Significant Differences (LSD). The results showed that the application of inoculants significantly shortened the number of days from seeding to emergence and significantly increased the biological yield of the plants. Plants with second application of N at 5-leaf collar stage were tallest, had highest number of leaves and highest corn biomass. Second application of N at 7-collar stage gave the highest number of corn ears, the greatest number of corn kernels, largest cob diameter and highest biological and economical yield. Bio-fertilizer inoculation treatments had significant effect on the number of days from seeding to emergence and the biological yield of corn plants. It was also concluded that the timing of Nitrogen fertilizer application had significant effects on the growth and yield performance of corn.

**Keywords:** Bio-fertilizer, Corn, Nitrogen, Timing of N applicatio

## INTRODUCTION

Corn is one of the most important cereal grown all over the world with an estimated demand of 852 million MT in 2020, 72% of which is coming from developing countries and greater bulk is utilized for food (70%) among South east Asian countries where the country belongs [1]. In the Philippines corn is the second popular cereal crop grown next to rice. White corn is preferred by about 14 million Filipinos from the southern portion of the country as their main staple, while yellow corn accounts for about 50% of livestock mixed feeds [2]. Corn is also a good choice for snacks for all ages. Today, the demand for corn is continuously increasing because of its nutritional content and good palatability. Also, corn's contribution to the nation's Agriculture's sector is remarkable at 45.19 percent of the total agricultural output in the last quarter of 2019 [3]. These facts prompted farmers to intensify production at a shorter time thus increasing profitability [4]. While most of the farmers are aiming for an abundant harvest every cropping season, higher production inputs are needed for plant growth and development. However, continuous cultivation and improper fertilizer application resulted in soil degradation. Consequently, use of more inorganic fertilizers became necessary which tend to lower soil pH if applied for long period since they are acidic in nature [5].

Nitrogen is considered to be a vitally important plant nutrient, it plays an important role for protein formation, photosynthesis and vegetative growth of plant. Nitrogen management is considered one of the vital factors affecting maize growth [6], phenology and grain yield [7]. It also strongly stimulates growth, expansion of the crop canopy and interception of solar radiation [8]. Study conducted by [9], found that timing of nitrogen application based on the requirement of plants is important to increase the N use efficiency and growth regulators improve the effective partitioning and translocation of accumulates from source to sink in the field crops. This was supported by the study of [10] that N fertilization needs to be adjusted because excessive and improper timing of fertilization causes economical loss and leads to negative environmental consequences.

The definition of time of N application and the dose that coincides with the needs of corn in different environmental conditions and soil types are very important since these factors improve nutrients absorption and decrease N losses [11]. Utilization of nutrients by the plants to an adequate level largely depends upon the N quantity and time of its application and applying nitrogen according to the crop requirement at different growth stages needs to be taken into consideration [12]. Splitting the application of nitrogen fertilizers at more than one occasion can be good for both the environment and economy. Adjusting nitrogen supply according to the demand of a growing crop in turn improves nitrogen use efficiency [13], [14]. But this method must be taken with caution because Improper application of the synthetic fertilizers is found to be the main cause of low yield of corn [15]. This was addressed by Implementation and adoption of the new production technologies on corn production such as balanced use of agriculture inputs and new methodologies and practices [16].

The productive potential of corn cultivation is defined around the phenological stages

V4 and V5, of four and five expanded leaves, respectively, due to the floral differentiation. In this period the plant originates the primordia of the banner and the spike, and differentiation of all leaves also occurs [17]. In state V3, the apex of the stem (point of growth) is still below the surface of the soil. In state V5, the apical meristem is still below the surface of the soil, which allows the plant to recover from the damage caused in the aerial part [17], [18]. However, these practices are not particularly being adopted by the farmers instead, majority of conventional corn farmers fertilized their corn plant at knee high stage or about 4 – 5 weeks after planting.

Application of inoculants such as bio-fertilizers is one of the favorable approaches to restore the rejuvenated soil to its healthy form, hence it lessens the use of chemical fertilizers and maximize the utilization of available nutrients present in the soil. With this, it is necessary to address how to increase the yield rate of the crop while reducing the cost of production by using eco-friendly strategies and practices.

## OBJECTIVES OF THE STUDY

The general objective of this study is to determine the effect of bio-fertilizer inoculation and timings of two-split nitrogen (N) application on the growth and yield performance of corn in terms of growth characteristics, yield components, economic components used in corn production.

## MATERIALS AND METHODS

Field experiment was carried out at Brgy. Matikiw, Pakil Laguna in December 2019 to March 2020. The area was an open-field surrounded with trees such as Ipil-Ipil, acasia, mango and madre cacao. Leafy vegetables such as pechay and mustard were last crop planted in the experimental area. The experiments were designed to study the effects of bio-fertilizers and timings of two-split nitrogen (N) application on the growth and yield performance of corn.

**Land Preparation.** The experimental area was prepared two weeks prior to planting to allow the crop residues to be incorporated in the soil. Plowing was done to break the soil clods and remove the weeds and stone present in the experimental area. Land preparation was done to create a suitable environment for the plants enable them to germinate and grow well. The operations include clearing of the surrounding and application of mulching materials to the ground to minimize the growth of weeds in the experimental area.

**Bio-fertilizer inoculation.** MykoPlus<sup>®</sup> and Nutrio<sup>®</sup> biofertilizers were procured from UPLB-Biotech. *Nutrio or Enterobacter sacchari sp. nitrogen-fixing bacterium associated with sugar cane (Saccharum officinarum L.)* refers to microorganisms found in the soil and in plant roots which can fix nitrogen gases from the atmosphere into solid nitrogen compounds usable by plants. On the other hand, *MykoPlus* is a biological fertilizer (Biofertilizer) that contains multi-species of microorganisms that help plant roots obtain more nutrients and water from the soil, thereby enhancing crop growth,

yield and income. MykoPlus was applied at 2.1 kg per hectare while Nutrio was applied at rate of 2kg per hectare, both applied on slurry or slightly moistened seeds.

**Planting.** Seeds of Sweet Pearl F1 EW variety were used. The seeds used in Factor A (BF1 – without inoculant and BF2 – with Nutrio and BF3 – with Mykoplus). Inoculation was done by placing the seeds in a container large enough to facilitate mixing. The seeds were moistened before adding the required amount of inoculants. Mixing was done until the seeds were evenly coated. Then seeds were planted, at a rate of 2 seeds/hill, immediately after inoculation at a spacing of 25 cm between hills and 75 cm between rows. Replanting of missing hills was done one week after planting.

**Fertilizer application.** The amount of fertilizer materials applied per treatment was based on the result of the soil chemical analysis. The full amounts of phosphorus (P) and potassium (K) were applied basally. Two-split (50-50%) application of N was done- the first application of N was basal at 87kg<sup>-ha</sup> together with organic fertilizer (20 bags<sup>-ha</sup>). The second application, which is also at 87kg<sup>-ha</sup>, was based on the plants' leaf collar number- at V3 (3 leaf collar or 8 DAP), V5 (5 leaf collar or 14 DAP) and V7 (7 leaf collar or 21 DAP). No application of N served as Control.

Schedule of Fertilization		
	1st application	2nd application
Control	0 kg	0 kg
V3	87kg <sup>-ha</sup> at Basal	87kg <sup>-ha</sup> at 3 leaf collar (8 DAP)
V5	87kg <sup>-ha</sup> at Basal	87kg <sup>-ha</sup> at 5 leaf collar(14 DAP)
V7	87kg <sup>-ha</sup> at Basal	87kg <sup>-ha</sup> at 7 leaf collar (21 DAP)

### Sampling Procedure

Each of the experimental plot was composed of 94 plants. A 4.5 m<sup>2</sup> at the center of the plot was reserved as the harvest area for gathering of yield components of harvested corn plants per treatment. Ten (10) representative samples were randomly selected outside the harvest area excluding border plants.

### Data Gathering Procedure

The bio-fertilizers and the timings of two-split nitrogen application on corn (*Zea mays l.*), were evaluated by the quantifiable measurement of the different growth characteristic and yield components of corn. Data gathered includes average plant height, average number of leaves, average length and diameter corn ear (husked and unhusked), average biological and economical yield (husked and unhusked), average number of kernels/corn ear, weight of corn/4.5 m<sup>2</sup> harvest area, average plant biomass, computed yield of corn in kg/ha, production income and average pest and disease incidence in corn.

### Research Design

A 3x4 factorial experiment in Split-plot design was conducted to determine the effects of Biofertilizer inoculation and application of Nitrogen on different phenological stages

of corn. Distance of 2 meters was allocated as pathways between blocks and 1 meter between main plots and meter distance on sub plots. Thus, each plot has 96 corn plants. Each block was divided into three main plots where two inoculated and non-inoculated corn seeds were planted. The main plot factor, Factor A - application of Biofertilizer and the Factor B or subplot factor is the timings of two-split nitrogen application. Treatments were randomly selected and assigned to plots in each block.

### **Subject of the Study**

Corn (*Zea mays* L) applied with different bio-fertilizers and timing of two-split nitrogen application was the subject of this study. The first subject of the study was the different bio-fertilizer inoculants used in the study and the second subject of the study are the split nitrogen application. The effects of these treatments were measure based on the growth characteristic, yield component, pest and disease incidence and production income of the study were collected through quantitative observation.

### **Data Analysis**

Data gathered were organized and presented in textual and tabular forms and analyzed using the Analysis of Variance (ANOVA) in factorial Split-plot design to determine significant differences among treatment means. Significant results were subjected to further statistical analysis using Least Significant Differences (LSD). To facilitate easy computations, the collected data were analyzed with the use of STAR.

## **RESULTS AND DISCUSSION**

### **Number of Days from Seeding to Emergence**

The number of days from sowing to emergence of corn plant is presented in Table 1. The analysis of variance showed that that bioinoculant significantly ( $P=0.0003$ ) affected the number of days from seeding to emergence with the timing of fertilizer application ( $P=0.15013$ ) and interaction between bioinoculant and timing of N application ( $P=0.4384$ ) did not significantly affect the number of days from seeding to emergence.

Based from the findings, Bio-fertilizer inoculation significantly affects the number of days from seeding to emergence. Statistical analysis of data showed that the earliest emergence was on corn plants applied with inoculant both BF2 and with second application of N at 5-collar stage had the same mean of 2.82 days while the latest emergence was in plots without bioinoculants with the mean of 3.13 days.

The result of the study conforms with the findings of [19] that bio-fertilizers inoculation influences the number of days from seeding to germination. This was supported by the findings in the study of [20] that seed inoculation can speed up growth of seedlings in different cotton plants races.

Table 1. Average number of days from sowing to emergence

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	3.07	3.10	3.17	3.20	3.13 <sup>a</sup>
BF2	2.83	2.80	2.83	2.83	2.82 <sup>b</sup>
BF3	2.80	2.83	2.83	2.83	2.82 <sup>b</sup>
Timing of N Application	2.9	2.91	2.94	2.95	

Note: Inoculant means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	0.31	0.7511 <sup>ns</sup>
Factor A	105.31	0.0003 <sup>*</sup>
Factor B	2.00	0.1501 <sup>ns</sup>
Factor A x Factor B	1.03	0.4384 <sup>ns</sup>
CV(a)= 2.05%	CV(b)= 1.92%	
<sup>*</sup> significant	ns – not significant	

### Number of Days from Seeding to 50% Silking

The number of days from seeding to 50% silking of corn plant is presented in Table 2. Data showed that the earliest number of days from seeding to silking was observed on corn plants applied with *Mykoplus* and at V5 second application of N with a mean of 46.13 days while the latest number of days was observed on control plants with the mean of 47.37 days. However, analysis of variance showed that application of inoculant (P=0.4233), timing of fertilizer application (P=0.8894), and their interaction effect (P=0.7476), failed to show significant effects on the number of days from seeding to 50% silking. The finding implies that application of inoculant and timing of split application of Nitrogen used in this study did not significantly shorten the number of days from seeding to 50% silking of corn plants.

Table 2. Average number of days from seeding to 50% silking of corn plants

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	47.37	46.97	47.30	47.13	47.19
BF2	46.80	47.20	46.83	47.13	46.99
BF3	46.87	46.47	47.13	46.77	46.81
Timing of N Application	47.01	46.88	47.09	47.01	

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Analysis of Variance		
Sources of Variance	F value	P value
Block	0.63	0.5784 <sup>ns</sup>
Factor A	1.07	0.4233 <sup>ns</sup>
Factor B	0.21	0.8894 <sup>ns</sup>
Factor A x Factor B	0.57	0.7476 <sup>ns</sup>
CV(a)= 1.36%	CV(b)= 1.23%	
<sup>*</sup> significant	ns – not significant	

### Number of Days from Silking to Harvesting

The number of days from silking to harvesting of corn plant was presented in Table 3. Analysis of variance showed that that application of inoculant (P=0.0778), Timing of fertilizer application (P=0.1745), and their interaction (P=0.2989), did not significantly affect the number of days from silking to harvesting. Results show that application of

inoculant and timing of split application of Nitrogen used in this study did not significantly shorten the number of days from silking to harvesting of corn plants.

Table 3. Average number of days from silking to harvesting

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	22.63	22.60	22.50	22.70	22.61
BF2	23.87	22.47	22.80	23.10	23.06
BF3	23.10	23.17	23.17	23.70	23.29
Timing of N Application	23.20	22.75	22.82	23.17	

Analysis of Variance		
Sources of Variance	F value	P value
Block	0.38	0.7063 <sup>ns</sup>
Factor A	1.195	0.0778 <sup>ns</sup>
Factor B	1.85	0.1745 <sup>ns</sup>
Factor A x Factor B	1.32	0.2989 <sup>ns</sup>
CV(a)= 2.09%	CV(b)= 2.47%	
*significant	ns – not significant	

### Plant height

Data on plant height at maturity (week 6 or 42 DAE) showed that the tallest was noted on corn plants with second application of Nitrogen at 5-collar stage with a mean of 168.50 cm. Moreover, plants with second applications of N at 3-collar age, at 5-collar and at 7-collar stages have heights of 160.80 cm and 163.99 cm respectively, while the shortest corn plants (127.79 cm) were observed when no N fertilizer (Control) was applied. The results showed that application of inoculant did not significantly affect the height of corn plants at maturity, while the timing of split application of Nitrogen used in this study had significant effects.

The results conform with the findings of [21] that split application of N fertilizer may substantially improve N use efficiency, thus improving the growth of the plants, and supported by the findings of [22] that times of Nitrogen application affects the heights of corn plants.

Table 4. Average Plant height of corn plants (at Maturity)

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	126.50	126.23	169.37	163.43	146.38
BF2	127.87	160.63	170.30	165.23	154.01
BF3	129.00	159.53	165.83	163.30	154.42
Timing of N Application	127.79 <sup>c</sup>	160.80 <sup>b</sup>	168.50 <sup>a</sup>	163.99 <sup>b</sup>	

Analysis of Variance		
Sources of Variance	F value	P value
Block	2.07	0.2418 <sup>ns</sup>
Factor A	0.38	0.7082 <sup>ns</sup>
Factor B	190.33	0.0000 <sup>**</sup>
Factor A x Factor B	0.46	0.8270 <sup>ns</sup>
CV(a)= 2.92%	CV(b)= 2.64%	
*significant	ns – not significant	

### Number of Leaves

The findings revealed that the mean comparison of number of leaves at maturity (42 DAE), showed that the most number of leaves was when the second N application was

at 5-collar stage with a mean of 10.24 pcs, which is statistically similar to mean heights when second N application was at 3-collar and at 7-collar stages. Moreover, Control plants had a least number of leaves with a mean of 12.09 pcs. The findings further showed that the application of inoculants ( $P=0.3625$ ) did not significantly affect the number of leaves of corn plant, while the timing of split application of Nitrogen significantly increased the number of corn leaves ( $P=0.0313$ ).

The result of this study was supported of by the findings of [6] which reported significant influence of the times of Nitrogen application on the number of corn leaves.

Table 5. Average number of leaves of corn plants (at Maturity)

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	12.03	12.17	12.3	12.3	12.20
BF2	12.1	12.3	12.23	12.27	12.23
BF3	12.13	12.23	12.5	12.33	12.32
Timing of N Application	12.09 <sup>b</sup>	12.23 <sup>ab</sup>	12.34 <sup>a</sup>	12.30 <sup>a</sup>	

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#### Analysis of Variance

Sources of Variance	F value	P value
Block	1.66	0.2984 <sup>ns</sup>
Factor A	1.32	0.3625 <sup>ns</sup>
Factor B	3.36	0.0313 <sup>*</sup>
Factor A x Factor B	0.55	0.7669 <sup>ns</sup>
CV(a)= 1.28%	CV(b)= 1.42%	
*significant	ns – not significant	

### Number of corn ears per plant

Data on the number of corn ears per plant (Table 5) showed that the highest was with second application of N at 7-collar stage with a mean of 1.19 pieces while the lowest number of corn ears was observed when no N was applied (control plants) with mean of 1.02 leaves. Analysis of variance showed that the timing of fertilizer application ( $P=0.0000$ ) significantly influenced the number of corn ear per plant. On the other hand, the application of inoculant ( $P=0.1451$ ), and their interaction effect ( $P=0.8298$ ), did not significantly affect the number of corn ears per plant.

This finding indicate that optimum fertilizers and plant populations provide better crop growth and yield as observed by [22]. Similar results, that split nitrogen application has ensured high yield performance in maize crop, were also observed by [23].

Table 6. Average Ear of Corn plants

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	1.00	1.10	1.17	1.20	1.12
BF2	1.03	1.13	1.17	1.17	1.13
BF3	1.03	1.16	1.20	1.20	1.15
Timing of N Application	1.02 <sup>c</sup>	1.13 <sup>b</sup>	1.18 <sup>ab</sup>	1.19 <sup>a</sup>	

#### Analysis of Variance

Sources of Variance	F value	P value
Block	1.00	0.4444 <sup>ns</sup>
Factor A	3.25	0.1451 <sup>ns</sup>
Factor B	23.46	0.0000 <sup>**</sup>
Factor A x Factor B	0.46	0.8298 <sup>ns</sup>
CV(a)= 3.83%	CV(b)= 4.20%	
*significant	ns – not significant	

### Biological Yield

The biological yields of corn plant per 4.5m<sup>2</sup> harvest area are presented in Table 7. Analysis of variance showed that the biological yield of corn was significantly affected by bioinoculant ( $P=0.0182$ ) as well as by the timing of N application ( $P=0.0000$ ). However, interaction effect was not significant ( $P=0.8558$ ).

Comparison of treatment means showed that the plants with inoculant (BF2& BF3) have higher yield (4.91kg, 4.71kg) compared with plants without inoculants BF1 (4.36 kg).

Among the fertilizer treatments, second application of N at 7-collage stage) with a mean of 5.42 had statistically higher biological yield compared with (Control plants) with mean of 3.37. All fertilizer-treated plants had significantly higher biological weight of corn compared to control plants.

The findings were similarly on the study of [24] which found out that inoculation of seeds with biofertilizers in the presence of chemical fertilizers have a positive response in improving plant growth, thus increases the productivity of the plant. Meanwhile, [23] reported that split nitrogen application has ensured high yield performance in maize crop. It was supported by the study of [6] that application of nitrogen in split doses can increase the biological yield of the corn plants, hence, nitrogen was efficiently utilized.

Table 7. Average Biological Yield

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	3.07	4.57	4.73	5.08	4.36 <sup>b</sup>
BF2	3.71	5.08	5.27	5.58	4.91 <sup>a</sup>
BF3	3.33	4.61	5.31	5.58	4.71 <sup>a</sup>
Timing of N Application	3.37 <sup>c</sup>	4.76 <sup>b</sup>	5.11 <sup>ab</sup>	5.42 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test  
Inoculant means with the same letter are not significantly different by LSD Test

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#### Analysis of Variance

Sources of Variance	F value	P value
Block	1.15	0.4040 <sup>ns</sup>
Factor A	12.83	0.0182 <sup>*</sup>
Factor B	46.72	0.0000 <sup>**</sup>
Factor A x Factor B	0.42	0.8558 <sup>ns</sup>
CV(a)= 5.77%	CV(b)= 8.49%	
*significant	ns – not significant	

### Economical yield of corn (with husk)

The economical yield of corn is presented in Table 8. Analysis of variance showed that there is significant effect on the timing of N application ( $P=0.0000$ ), but there is no significant effect on the inoculants ( $P=0.0645$ ) and no bio-inoculant timing interaction effect on the economical yield (with husk) of corn( $P=0.9608$ ).

Based on the findings, the timing of fertilizer application significantly affected the economic yield of corn with husk. All of the fertilizer-treated plants have higher economical yield compared to (Control plants). Statistical analysis showed that the plants with second N fertilizer application at 7-collar stage had higher economical yield (4.92 kg) compared with the control plants with mean of 2.91 kg.

Results of this study conform with the findings of [25] that applied N tend to improve plant growth and increasing the yield of corn plants, which also supported by the study of [6] that application of nitrogen in splits doses can increase the biological yield of the corn plants hence nitrogen was efficiently utilized.

Table 8. Average economical yield (with husk)

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	2.67	4.00	4.32	4.42	3.85
BF2	3.13	4.42	4.80	5.17	4.38
BF3	2.92	4.23	4.91	5.17	4.31
Timing of N Application	2.91 <sup>c</sup>	4.22 <sup>b</sup>	4.68 <sup>ab</sup>	4.92 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	1.40	0.3462 <sup>ns</sup>
Factor A	5.88	0.0645 <sup>ns</sup>
Factor B	29.54	0.0000 <sup>**</sup>
Factor A x Factor B	0.23	0.9608 <sup>ns</sup>
CV(a)= 9.82%	CV(b)= 11.85%	
*significant	ns – not significant	

### Diameter of corn ear (with husk)

The average diameter of corn ear (with husk) per plant is presented in Table 10. Analysis showed that there is significant effect of the timing of N application ( $P=0.0000$ ), but there is no significant effect on the inoculants ( $P=0.2040$ ) and no interaction effect between the inoculant and timing of fertilizer application on the diameter of corn (without husk) ( $P=0.9214$ ).

Mean comparison showed that the plants with second Nitrogen fertilizer at 7-collar stage had a larger diameter (with husk) of 46.40 mm compared with the (control plants) with mean of 38.83 mm. All fertilizer-treated plants had significantly larger corn ear (with husk) compared with control plants.

The findings of this study complements the statement of [6] that application of nitrogen in splits doses can increase the yield of the corn plants hence nitrogen was efficiently utilized.

Table 9. Average diameter of corn ear (with husk)

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	38.05	44.18	44.39	45.66	31.96
BF2	39.68	45.13	45.37	46.11	32.87
BF3	38.76	46.14	46.22	47.42	33.01
Timing of N Application	38.83 <sup>b</sup>	45.15 <sup>a</sup>	45.33 <sup>a</sup>	46.40 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	6.22	0.0592 <sup>ns</sup>
Factor A	2.43	0.2040 <sup>ns</sup>
Factor B	42.94	0.0000 <sup>**</sup>
Factor A x Factor B	0.31	0.9214 <sup>ns</sup>
CV(a)= 4.01%	CV(b)= 4.20%	
*significant	ns – not significant	

### Length of corn ear (with husk)

The mean lengths of corn ears with husk are presented in Table 12. Analysis of variance showed that there is significant effect of the timing of N application ( $P=0.0000$ ) on the length of corn with husk, but there is no significant effect of the inoculants ( $P=0.1729$ ) and no interaction effect between the inoculant and timing of fertilizer application on the length (without husk) of corn ( $P=0.8649$ ).

Based on the findings, the timing of fertilizer application significantly affects the length of corn with husk. Statistical analysis showed that the plants with second in the split application of N at 7-collar stage 25.06 cm had a greater length compared with the ears of corn in control with mean of 22.29 cm. All fertilizer-treated plants had significantly longer corn ears (with husk) compared with those of the control plants.

Table 10. Average length of corn ear (with husk)

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	21.57	23.90	24.60	24.63	23.68
BF2	22.70	24.87	24.87	25.07	24.38
BF3	22.60	24.90	24.70	25.47	24.41
Timing of N Application	22.29 <sup>b</sup>	24.56 <sup>a</sup>	24.72 <sup>a</sup>	25.06 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	0.74	0.5320 <sup>ns</sup>
Factor A	2.81	0.1729 <sup>ns</sup>
Factor B	27.28	0.0000 <sup>**</sup>
Factor A x Factor B	0.41	0.8649 <sup>ns</sup>
CV(a)= 3.56%	CV(b)= 3.00%	
*significant	ns – not significant	

### Number of corn kernels

The average numbers of corn kernels are presented in Table 14. Analysis of variance showed that there is significant effect of the timing of N application ( $P=0.0000$ ) on the number of corn kernels, but there is no significant effect of the inoculants ( $P=0.1945$ ) and no interaction effect between the inoculant and timing of fertilizer application on the length (without husk) of corn ( $P=0.6836$ ).

Statistical analysis showed that the plants that received the second those of N at 7-collar stage had a most number of corn kernels compared with the control plant with a treatment mean of 184.64. All fertilizer-treated plants had significantly higher number of corn kernels compared with those in control

It is evident that findings are supported by the study conducted by [25] which reported that application of Nitrogen can improve plant growth and development and yield attributes which in turn results in increasing the corn kernels. [26] found that yield was still responsive to N application until silking, but full yield was not achieved when applications were delayed till then. This was supported by the study of [27] that found

that grain yield was increased with N application as late as R3 (milk) stage for extremely N-deficient maize.

Table 11. Average number of corn kernels

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	176.60	248.63	285.76	310.83	255.46
BF2	190.57	270.50	299.43	312.73	268.31
BF3	186.76	281.80	324.33	331.20	281.02
Timing of N Application	184.64 <sup>c</sup>	266.98 <sup>b</sup>	303.18 <sup>a</sup>	318.26 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	1.03	0.4354 <sup>ns</sup>
Factor A	2.54	0.1945 <sup>ns</sup>
Factor B	110.36	0.0000 <sup>**</sup>
Factor A x Factor B	0.66	0.6836 <sup>ns</sup>
CV(a)= 18.77%	CV(b)= 13.31%	
*significant	ns – not significant	

### Weight of corn stalk

The average weights of corn stalk are presented in Table 15. Analysis of variance showed that there is significant effect on the timing of N application ( $P=0.0000$ ) on the average weight of corn stalk, but there is no significant effect on the inoculants ( $P=0.6053$ ) and no interaction effect between the inoculant and timing of fertilizer application on the length (without husk) of corn ( $P=0.9443$ ).

All fertilizer-treated plants had significantly higher weight of corn stalk compared to control plants. Statistical analysis showed that the plants split application of Nitrogen fertilizer at 5-collar stage had mean of 5.28 kg which is significantly higher than the mean of control plants (3.38 kg). This result is in agreement with the findings of study conducted by [28] who reported that corn biomass increased with application of Nitrogen in corn plants.

Table 12. Average weight of corn stalk

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	3.30	5.10	5.40	4.97	4.69
BF2	3.57	4.67	5.52	4.88	4.66
BF3	3.27	4.58	4.90	4.67	4.36
Timing of N Application	3.38 <sup>b</sup>	4.78 <sup>a</sup>	5.28 <sup>a</sup>	4.84 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	4.38	0.0982 <sup>ns</sup>
Factor A	0.57	0.6053 <sup>ns</sup>
Factor B	16.54	0.0000 <sup>**</sup>
Factor A x Factor B	0.27	0.9443 <sup>ns</sup>
CV(a)= 18.77%	CV(b)= 13.31%	
*significant	ns – not significant	

### Computed Biological Yield per Hectare

The computed biological yield of corn plant per hectare was presented in Table 16. Analysis of variance showed that there is significant effect of applying inoculant ( $P=0.0182$ ) as well as the timing of N application ( $P=0.0000$ ), but there is no significant effect of the inoculant and timing of fertilizer interaction on the biological yield of corn ( $P=0.8558$ ).

Based on the findings, the application of inoculants and timing of fertilizer application significantly affect the biological yield of corn. Statistical analysis showed that the plants with inoculant (BF2 – with Nutrio & BF3 – with Mykoplus) gave higher yield means per hectare of 10,916.67 kg and 10,472.22 kg respectively, compared to plants BF1 - without inoculants with a yield means of 9694.44 kg. The result shows that the Factor A – inoculants significantly affect the computed yield of corn plants per hectare.

All of the fertilized plants have higher biological weight of corn compared to Control plants. Statistical analysis showed that the plants applied with the second dose of Nitrogen fertilizer at 7-collar stage had mean of 12037.04 kg which is higher compared with Control plant treatment mean of 7493.83 kg. Data shows that the timing of split application of Nitrogen significantly affects the computed biological yield per hectare of corn plants.

The result of this study is supported by the findings of [24] who found that inoculation of seeds with biofertilizers in the presence of chemical fertilizers have a positive response in improving increase in plant growth, thus increases the productivity of the plant. [23] reported that split nitrogen application has ensured high yield performance in maize crop. However, delaying N application may lead to irreversible yield loss [29]. which supported by the study of [30] found that nearly 12% decrease in maximum grain yield when application N was delayed until V6 growth stage.

Table 13. Computed Biological Yield per Hectare

Inoculant	Timing of Fertilizer Application				Inoculant Means
	TA1	TA2	TA3	TA4	
BF1	6814.815	10148.148	10518.519	11296.269	9694.438 <sup>b</sup>
BF2	8259.259	11296.296	11703.704	12407.407	10916.67 <sup>a</sup>
BF3	7407.407	10259.259	11814.815	12407.407	10472.22 <sup>a</sup>
Timing of Fertilizer Application	7493.83 <sup>c</sup>	10567.90 <sup>b</sup>	11345.68 <sup>ab</sup>	12037.04 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test  
Inoculant means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	1.15	0.4040 <sup>ns</sup>
Factor A	12.83	0.0182*
Factor B	46.72	0.0000**
Factor A x Factor B	0.42	0.8558 <sup>ns</sup>
CV(a)= 5.77%	CV(b)= 8.49%	
*significant	ns – not significant	

### Computed Economical Yield with Husk

The economical yield of corn is presented in Table 17. Analysis of variance showed that there is significant effect on the timing of N application ( $P=0.0000$ ), but there is no significant effect on the inoculants ( $P=0.0645$ ) and no interaction effect between the inoculant and timing of fertilizer application on the economical yield (with husk) of corn ( $P=0.9608$ ).

Based on the findings, the timing of fertilizer application significantly affects the computed economic yield of corn with husk per hectare. All of the fertilized-treated plants have higher economical yield compared to Control plants. Statistical analysis showed that the plants applied the second amount of N at 7-collar stage had a higher computed economical yield per hectare (10,925.93 kg) compared to the Control (6,456.79 kg).

It is evidently based on the results of this study that follows the findings of [25] that applied N tended to improve plant growth and increasing the yield of corn plants which supported by the study of [6] that application of nitrogen in splits doses can increase the biological yield of the corn plants hence nitrogen was efficiently utilized.

Table 14. Computed Economical Yield with Husk

Inoculant	Timing of N Application				Inoculant Means
	TA1	TA2	TA3	TA4	
A1	5925.93	8888.89	9592.59	9814.82	8555.56
A2	6962.96	9814.82	10666.67	11481.48	9731.48
A3	6481.48	9407.41	10925.93	11481.48	9574.08
Timing of N Application	6456.79 <sup>c</sup>	9370.37 <sup>b</sup>	10395.06 <sup>ab</sup>	10925.93 <sup>a</sup>	

Note: Fertilizer means with the same letter are not significantly different by LSD Test

Analysis of Variance		
Sources of Variance	F value	P value
Block	1.40	0.3462 <sup>ns</sup>
Factor A	5.88	0.0645 <sup>ns</sup>
Factor B	29.54	0.0000 <sup>**</sup>
Factor A x Factor B	0.23	0.9608 <sup>ns</sup>
CV(a)= 9.82%	CV(b)= 11.85%	
*significant	ns – not significant	

## CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

### Conclusions

Based on the foregoing findings and the hypotheses in this study, it was concluded that:

1. Inoculation with biofertilizer had significant effect on the growth particularly on the days from seeding to emergence and yield components specifically on the biological yield of corn plants.
2. The timing of Nitrogen fertilizer application had significant effects on the growth and yield performance of green corn plants, specifically on plant height, number

of leaves, number of corn ears per plant, length and diameter of husked and unhusked corn ear, yield of husked and unhusked corn ear per 4.5 m<sup>2</sup> harvest area in kilograms, number of corn kernels, weight of corn stalk and computed yield of unhusked corn ears per hectare in tons and cost and returns per hectare.

3. There was no significant interaction effect between bio-fertilizers inoculation and timing of nitrogen application on different Phenological stage of corn.

### Recommendations

1. Since the performance of inoculated corn was only significantly different on the number of days from seeding to emergence and average biological yield of corn. Application of Inoculant with the same study may be evaluated.
2. Performance of corn on the timing of nitrogen fertilizer application growth and yield performance of green corn plants, specifically with on plant height, number of leaves, number of corn ears per plant, length and diameter of husked and unhusked corn ear, yield of husked and unhusked corn ear per 4.5 square meter harvest area in kilograms, number of corn kernels, weight of corn stalk and computed yield of unhusked corn ears fertilizer with different levels and timing of splits of fertilization is highly recommended.
3. Replication of the same study on other environmental condition, location and utilization of different inoculants and timing of split application of Nitrogen is recommended.

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