

REDUCTION OF WHITE CORN (*Zea mays* IPB Var. 6) DEPENDENCY ON INORGANIC FERTILIZER THROUGH VAMRI AND BIO-N INOCULATION

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ABSTRACT

Farmer's dependency on inorganic fertilizer to increase farm productivity makes maintaining soil health a big challenge. One possible solution to improve farm productivity and soil health is through the use of bio-inoculants. Vesicular Arbuscular Mycorrhiza Root Inoculant (VAMRI) and Bio-N are available to help attain such goal by improving the physical, chemical, and biological properties of the soil. Thus, a single factor experiment using VAMRI and Bio-N singly and in combination together with reduced amount of inorganic fertilizer arranged in Randomized Complete Block Design (RCBD) was conducted for two cropping seasons. Agronomic parameters such as germination (%), plant height (cm), days to silking and tasselling were comparable. For yield and yield components, inoculation of VAMRI and the combination of VAMRI and Bio-N at half the amount of the recommended rate was comparable to using full recommended rate of fertilization during the first cropping and had significantly heavier dry kernels in the second cropping and thereby greater yield. Moreover, the use of VAMRI and BIO-N combination at half the amount of the recommended rate of fertilizer resulted to more than 100 percent increase in aboveground biomass (g), fresh and dry ear weight (g), average ear length (cm), average ear diameter (cm) and weight of kernels (g) than those not applied with fertilizer. Soil analysis further reveals more efficient utilization of P (ppm) and K (ppm) nutrient by corn with bio-inoculants. Considering the data on weight of kernels and number of ears, the said practice will yield to approximately 2.03 t/ha on dry season and 4.00 t/ha on wet season. This is above the current target of the province at 1.5 to 2 t/ha. Therefore, the need for inorganic fertilization can be reduced while still producing comparable yield to those applied with the full rate of fertilizer.

Keywords: bio-inoculation, fertilization rate, bio-fertilizer, white corn, sustainable production

INTRODUCTION

Corn is an important crop in the Philippines. The introduction of high yielding hybrids to enhance production in the Masagana Program in 1980 recommended the use of fertilizer and pesticides. This was to ensure high profits since it was thought that an increase in fertilization rate would be the first step to face the challenges of food production. Eventually, this resulted to total dependency in inorganic fertilizer and pesticide that leads to soil contamination and corn borer outbreaks. This also includes disruption of soil texture and physico-chemical properties. Moreover microorganisms, insects and worms in the soil are destroyed. Furthermore, the hiking price of inorganic fertilizer is unaffordable to ordinary farmers. Hence, farmers usually

cut down on their fertilizer usage which often results in lower grain yield.

Microbial inoculants are agricultural improvements that use beneficial microorganisms to promote plant and soil health. These are applied to enrich plant nutrition and can also be used to promote plant growth by stimulating plant hormone production (Bashan and Holguin, 1997). BIO-N is a microbial-based fertilizer that makes use of nitrogen fixing microbial inoculants which has been proven effective for enhancing root development resulting to an increase in crop yield. On the other hand, VAMRI (Vesicular Arbuscular Mycorrhizal Root Inoculant) is another microbial inoculant or bio-fertilizer that assists the plant roots in absorbing water and nutrients thus reduces the chemical fertilizer requirements of crops. It also protects the plants from root pathogens, secretes growth-promoting substances and improves soil structure and soil aggregation. These inoculants were found to be efficient for numerous agricultural and plantation crops in greenhouse (BIOTECH Terminal Reports, 1984 and 1989; Luis and Brown, 1986; Brown *et. al.*, 2005).

However under field conditions studies are still very limited, thus a study on determining the comparative performance of BIO-N and VAMRI in terms of agronomic characteristics and yield and its components, and evaluating the potential of combined inoculation of VAMRI and BIO-N as an alternative microbial fertilizer is deemed necessary.

METHODOLOGY

Same methods were applied for both dry and wet season planting.

Experimental Design and Treatments

A single factor experiment having five treatments replicated four times arranged in Randomized Complete Block Design (RCBD) was used in the study. Since both BIO-N and VAMRI does not provide nutrients to plants but instead allow more efficient utilization of available nutrient, single application of both bio-inoculants was not considered. The following were the treatments of the study

T0 - Control

T1 - Full Recommended Rate Inorganic Fertilizer (112 N – 62 P₂O₅ – 62 K₂O)

T2 - VAMRI + ½ Recommended Rate Inorganic Fertilizer

T3 - Bio-N + ½ Recommended Rate Inorganic Fertilizer

T4 - VAMRI + Bio-N + ½ Recommended Rate Inorganic Fertilizer

Land Preparation

The experiment was set-up in 517.5 m² land which was divided into four major blocks. The area was plowed twice and harrowed once before furrowing. Rock and plant residues were removed. Each major block/replication has a dimension of 22.5 m X 5 m with 1 meter between replications serving as pathway. These four blocks were further subdivided into smaller blocks for the treatments having 4.5 m X 5 m area. This contained six rows with a maximum of 20 plants per row.

Fertilization

Fertilization rate was based on soil analysis. This was also taken after one cropping year. Walkey-Black Method for OM, Vanadomolybdate Method for P and Flame Photometer Method for K.

The complete fertilizer was basally applied to the area to answer the total phosphorus and potassium requirements of the corn plants and approximately half of its nitrogen requirements. The remaining nitrogen requirements of the plants were applied 30 days after planting, immediately after thinning. Fertilization was based on the treatment requirements of the study.

Seed Inoculation and Sowing

The inoculant used in the study was of high quality. For BIO-N, at least 10^7 CFU /mL⁻¹ population of the biofertilizer strains in the product was determined before use. For VAMRI, microscopic analysis of the VAM root fragments should yield intact healthy spores.

The inoculants were coated to 3 kg corn seeds using 200 gram-pack of BIO-N or 30 gram-pack VAMRI. For the combination of BIO-N and VAMRI, only half the amount of each inoculant was used for 3 kg seeds. After which, the corn seeds were immediately sown. To ensure the survival of the microbial inoculant, the area was watered daily until germination was evident. The planting distance used was 75 cm between rows and 50 cm between hills based on farmers practice in Barili, Cebu. Each treatment in a replication contained six rows with each row planted using a seeding rate of 3 seeds per hill. Thinning to two seedlings per hill was done 20 days after emergence.

Care and Maintenance of Experimental Plants

Watering was done at three days interval one week after germination. Weeding was done just before thinning and fertilizer application. Constant check-up and regular monitoring was made to monitor pest and disease infestation.

Parameters Gathered

Agronomic Characteristics

Agronomic characteristics of corn were taken only from the four inner rows of each treatment for two cropping seasons.

The following data were gathered:

Germination (%) – this was computed by dividing the total number of seeds that germinated by the number of seeds sown multiplied by 100.

Plant Height (cm) – this was measured from the base of the plant to the point of the base of tassel.

Days to Tasseling – this was measured by counting the number of days from sowing until 50% of the plants have tasseled.

Days to Silking – this was measured by counting the number of days from sowing until 50% of the plants have silked.

Yield and Yield Components

Plant Stand – this was done by counting the number of live plants in a 3m x 3m crop-cut area.

Number of Ears – this was the total number of the ears of the plants within the 3m x 3m crop-cut area.

Fresh Weight of Ears with Husk (g) – this was the weight of the ears taken from the plants within the 3m x 3m crop-cut area.

Fresh Weight of Ears without Husk (g) – this was taken from ten sample ears randomly selected from the ears of the plants within the 3m x 3m crop cut area.

Dry Weight of Ears (g) – this was taken three days after sun drying the ten sample ears of the plants within the 3m x 3m crop-cut area.

Average Diameter of Ears (cm) – this was taken from the ten sample ears of the plants within the 3m x 3m crop-cut area. This was computed by getting the total diameter of ears divided by ten.

Average Length of Ears (cm) – this was taken from the ten sample ears of the plants within the 3m x 3m crop-cut area. This was computed by getting the total length of ears divided by ten.

Dry Weight of Kernels (g) - this was taken from the sun-dried ten sample ears.

Data Analysis

Analysis of variance (ANOVA) for a randomized complete block design (RCBD) was used in analyzing any significant difference on all the parameters gathered. Comparisons among means were done using Duncan Multiple Range Test (DMRT) to determine the specific significant differences among treatments.

RESULTS AND DISCUSSION

Effects of the Biofertilizer on agronomic characteristics of corn.

The agronomic characteristics of corn such as germination percentage, plant height, days to tasseling and days to silking as affected by BIO-N and VAMRI Biofertilizers for two croppings are shown in Table 1a and 1b. No significant differences among all treatments were observed on all agronomic parameters considered in the first cropping. Ammonia volatilized from soils treated with nitrogenous fertilizer is known to inhibit germination of seeds (Bremner and Krogmeier, 1989). On the second cropping where adequate moisture was available, higher percentage germination was observed. On the other hand, it can also be noted that plant height increased with the presence of fertilizer (organic or inorganic). This may be due to better utilization of nutrients in the soil. According to Migahed *et al.*, (2004), biofertilizers have positive effect on plant height and other agronomic characteristics. Furthermore, in the wet season planting, it is note-worthy that all treatments applied with fertilizer is not significantly different from each other.

Yield and Yield Components

Table 2a presents the yield and yield components of corn as affected by the application of different biofertilizers. All treatments were composed of approximately the same amount of plants in a 3m x 3m crop-cut area which produced approximately the same number of ears during dry season planting. While more number of plants resulted to more number of ears on fertilized treatments during wet season planting (Table 2c) However, in terms of the weight of these ears and its subsequent kernels, results from among the

different treatments significantly varied in both dry and wet season (Table 2b and Table 2d).

For the fresh weight of corn ears with husk taken from 3m x 3m area, fresh weight of ears without husk from ten sample ears, dry weight of ears from ten sample ears, average diameter of ten sample ears, average length of ten sample ears and dry weight of kernels from ten sample ears. Table 2a the amount of the recommended rate of fertilization resulted to increase by 155.38%, 104.88%, 108.11%, 16.02%, 38.86% and 114.54%, respectively as compared to those not applied with fertilizers during dry season. On wet season planting, application of BIO-N and VAMRI with half the amount of recommended rate of fertilization consistently produced the best results on the parameters considered (Table 2d). Furthermore, the application of VAMRI alone or in combination with BIO-N using half the recommended rate of fertilization yielded results comparable to using full amount of the recommended rate of fertilization majority of the time. It is also note worthy that the fresh weight of corn ears with husk taken from 3m x 3m area, fresh weight of ears without husk from ten sample ears, dry weight of ears from ten sample ears and dry weight of kernels from ten sample ears was significantly lower when not applied with fertilizers compared to those with VAMRI or applied with full recommended rate of fertilization. This means that BIO-N application resulted to lighter cobs with lighter kernels. On the contrary, the size of cobs (diameter and length) was comparable among all treatments, except for those not fertilized at all (Figure 1) the wet season planting.

On wet season planting, both length and width of corn ears were narrower and shorter, respectively. But both application of full rate of fertilizer and BIO-N and VAMRI application with half the amount of recommended rate of fertilizer still resulted to heavier dry weight of corn kernels.

Table 1a. Agronomic characteristics of corn as affected by biofertilizer application on the 1st cropping (July – October: dry season planting).

Treatments	Germination (%)	Plant height (cm)	Days to Taselling	Days to Silking
No Fertilizer	73.61 ± 0.74	139.05 ± 10.73	63.92 ± 0.53	80.83 ± 0.58
Full RR for Inorganic Fertilizer	52.54 ± 0.41	140.30 ± 14.12	66.96 ± 1.39	80.42 ± 0.41
VAMRI + ½ Recommended Rate	62.51 ± 0.86	161.65 ± 5.75	63.34 ± 0.19	80.00 ± 0.00
BIO-N + ½ Recommended Rate	63.43 ± 1.60	132.02 ± 9.62	65.46 ± 1.06	80.62 ± 0.39
BIO-N + VAMRI + ½ RR	66.90 ± 1.53	159.42 ± 1.74	64.00 ± 0.79	80.21 ± 0.20
C.V. (%)	21.00	12.85	0.73	2.22

Table 1b. Agronomic characteristics of corn as affected by biofertilizer application on the 2nd cropping (December – March: wet season planting).

Treatments	Germination (%)	Plant height (cm)	Days to Tasselling	Days to Silking
No Fertilizer	96.25±0.47a	80.02±9.30b	62.46±1.15b	71.75±1.35b
Full RR for Inorganic Fertilizer	95.00±0.14a	134.41±10.14a	60.29±0.47ab	66.83±1.94a
VAMRI + ½ Recommended Rate	96.46±0.06a	129.40±8.51a	60.25±0.19ab	66.87±1.41a
BIO-N + ½ Recommended Rate	88.33±0.60b	122.74±6.35a	62.21±0.89ab	69.50±2.06ab
BIO-N + VAMRI + ½ RR	98.34±0.53a	133.69± 2.42a	59.25±1.01a	65.96±1.27a
C.V. (%)	4.16	8.45	3.04	3.65

Table 2a. Yield and yield components of corn as affected by biofertilizer application on the 1st cropping (July –October: dry season planting).

Treatments	Plant Stand	Number of Ears	Fresh Weight of Ears with Husk (g)	Fresh Weight of Ears without Husk (g)
No Fertilizer	32.75 ± 2.28	23.75 ± 1.79	812.50 ± 112.5 ^c	512.50 ± 42.69 ^c
Full RR for Inorganic Fertilizer	26.50 ± 2.53	24.25 ± 1.25	1,843.75 ± 58.07 ^a	900.00 ± 70.71 ^a
VAMRI + ½ Recommended Rate	32.00 ± 1.68	27.50 ± 2.06	1,912.50 ± 51.53 ^a	1,025.00 ± 62.91 ^a
BIO-N + ½ Recommended Rate	27.75 ± 3.44	25.50 ± 1.55	1,325.00 ±126.65 ^b	700.00 ± 40.82 ^b
BIO-N + VAMRI + ½ RR	34.25 ± 2.64	24.75 ± 1.25	2,075.00 ± 116.36 ^a	1,050.00 ± 35.35 ^a
C.V. (%)	16.15	13.29	13.24	12.89

Considering the weight of dried corn kernels and the number of corn ears produced, inoculation of VAMRI combined with BIO-N at half the amount of inorganic fertilizer will yield to 2.03 t/ha. This yield is 154% more than the current yield for Central Visayas which is less than a ton per hectare (approximately 800 kg/ha) and achieves the current target of 1.5 to 2 t/ha (Cebu Provincial News, 2014).

Table 2b. Yield and yield components of corn as affected by biofertilizer application on the 1st cropping (July –October: dry season planting).

Treatments	Dry Weight of Ears without Husk (g)	Ave. Diameter of Ears (cm)	Ave. Length of Ears (cm)	Dry Weight of Kernels (g)
No Fertilizer	462.50 ± 62.5 ^c	3.62 ± 1.31 ^b	9.65 ± 7.26 ^b	343.75 ± 47.18 ^c
Full RR for Inorganic Fertilizer	837.50 ± 74.65 ^a	4.08 ± 1.88 ^{ab}	11.58 ± 9.34 ^{ab}	612.50 ± 78.06 ^{ab}
VAMRI + ½ Recommended Rate	850.00 ± 35.35 ^a	4.20 ± 1.35 ^a	12.40 ± 2.48 ^a	637.50 ± 59.94 ^{ab}
BIO-N + ½ Recommended Rate	650.00 ± 40.82 ^b	3.85 ± 1.32 ^{ab}	11.62 ± 5.08 ^{ab}	493.75 ± 27.71 ^{bc}
BIO-N + VAMRI + ½ RR	962.50 ± 37.5 ^a	4.20 ± 0.70 ^a	13.40 ± 3.80 ^a	737.50 ± 33.07 ^a
C.V. (%)	13.95	7.19	11.25	18.53

Table 2c. Yield and yield components of corn as affected by biofertilizer application on the 2nd cropping (December – March: wet season planting).

Treatments	Plant Stand	Number of Ears	Fresh Weight of Ears with Husk (g)	Fresh Weight of Ears without Husk (g)
No Fertilizer	38.25±1.68 ^b	33.50±1.58 ^b	888.75±115.02 ^c	200.00±42.90 ^d
Full RR for Inorganic Fertilizer	44.25±2.44 ^{ab}	44.50±1.05 ^a	3,962.50±78.70 ^a	987.50±71.01 ^b
VAMRI + ½ Recommended Rate	46.00±1.28 ^a	47.00±1.86 ^a	3,577.50±71.43 ^a	828.00 ±56.91 ^b
BIO-N + ½ Recommended Rate	43.25±3.64 ^{ab}	41.50±1.335 ^a	1,990.00±130.15 ^b	600.00 ±43.02 ^c
BIO-N + VAMRI + ½ RR	48.25±3.44 ^a	48.00 ±1.20 ^a	4,138.75±136.78 ^a	1,162 ±33.38 ^a
C.V. (%)	8.63	11.21	22.17	14.29

Yield and yield component increase of the plants applied with biofertilizer may be due to the growth hormone that stimulates growth and production of organic acids compounds such as IAA which are enhanced with biofertilizer application (Wibowo, 2007). Matiru and Dakora, (2004) reported that auxin, cytokines, abscisic acid, lumikrom, riboflavin, oligosaccharide and vitamins which can improve plant growth are produced by microbial rhizosphere. Also, in the study of Ratti *et al.*, (2001) on hyssop, its increased growth parameters was

associated to the production of growth hormones by the bacteria which led to conclude that a combination of the arbuscular mycorrhizal fungi and other microorganism maximized biomass and phosphorus content of the plants. Furthermore, Han and Lee, (2005) reported that the use of bacteria such as *Bacillus megaterium* was able to increase the dry weight of on *Solanum torvum*. In addition, higher dry matter production by the inoculated plant might be because of the augmented uptake of N and P, which in turn was a consequence of the root proliferation. The microorganism present in biofertilizer develops good root system which increases nutrient absorption capacity of plant (Javier and Brown, 2009), therefore will improved plant growth and increase biomass production.

Table 2d. Yield and yield components of corn as affected by biofertilizer application on the 2nd cropping (December – March: wet season planting).

Treatments	Dry Weight of Ears without Husk (g)	Ave. Diameter of Ears (cm)	Ave. Length of Ears (cm)	Dry Weight of Kernels (g)
No Fertilizer	162.50±62.39c	3.12±1.02c	5.96±3.56c	120.75±40.18e
Full RR for Inorganic Fertilizer	775.00±74.66a	4.38±1.80ab	12.22±4.54a	615.75±68.01b
VAMRI + ½ Recommended Rate	562.50±34.35b	4.05±2.00b	10.85±1.08b	454.00±42.94c
BIO-N + ½ Recommended Rate	450.00±41.80b	4.02±0.76b	10.03±2.68b	347.25±25.01d
BIO-N + VAMRI + ½ RR	876.25±38.01a	4.55±0.57a	12.55±1.80a	752.50±29.98a
C.V. (%)	14.10	6.07	6.35	13.09

Table 3. Nutrient analysis of soil after two cropping seasons as affected by different fertilization schemes.

Treatments	Results of Analysis			
	pH	OM (%)	P (ppm)	K (ppm)
Uncropped Land	7.29	1.93	14.2	35
T0 - Control (no fertilizer)	7.26	2.15	12.9	34
T1 - Full Recommended Rate for Inorganic Fertilizer	6.87	2.51	93.30	82
T2 - VAMRI + ½ Recommended Rate	7.12	2.31	29.0	41
T3 - Bio-N + ½ Recommended Rate	7.12	2.45	19.0	36
T4 - Bio-N + VAMRI + ½ Recommended Rate	7.11	2.03	18.6	41

CONCLUSION

Under CTU-Barili Cebu condition, the application of VAMRI singly or in combination with BIO-N together with inorganic fertilizer is generally more effective than the use of BIO-N with inorganic fertilizer for both dry and wet seasons. Such effectiveness can be observed through the increased yield and yield performance of corn. This also shows that VAMRI application alone or in combination with BIO-N as applied with inorganic fertilizer has greater potential of reducing inorganic fertilizer usage up to 50% of the recommended amount compared to using BIO-N as an inoculant.

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Rate	Recommended Rate	Rate	Recommended Rate
14	11.7	2.03	1.7
36	2.97	0.45	0.37