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Response of corn to chicken dung and rice hull ash application and mycorrhizal fungi inoculation

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ABSTRACT

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This study evaluated the growth and yield responses of corn to chicken dung and rice hull ash application as well as to mycorrhizal fungi inoculation. The experiment was laid out in a split-plot in Randomized Complete Block Design consisting of three replications. Vesicular-arbuscular mycorrhizal (VAM) inoculation served as the main plot while application of fertilizer was designated as the sub-plot. The fertilizer treatments included the following: T_0- control, T_1- inorganic fertilizer (60-60-60 kg ha $^{-1}$ N, P_2O_5, K_2O), T_2- chicken dung alone (60 kg ha $^{-1}$N) and T^3- chicken dung (as in T_2) + 30 kg ha^{-1} rice hull ash. The experimental area had an alluvial clay loam soil.

Results showed that VAM inoculation significantly increased the total N but not the total P, K, and Ca contents of the tissue of corn plant. However, VAM inoculation did not significanlty affect the grain yield and the agronomic characteristics of corn. In contrast, fertilization using either inorganic fertilizer, chicken dung or chicken dung plus rice hull ash enhanced the early tasseling and silking but not emergence and maturity of corn. The application of fertilizers significantly increased plant height as well as the fresh stover yield compared to the control.

The inorganic fertilizer, chicken dung, and chicken dung plus ricehull ash, significantly increased the number of ears per plant, ear length, number of grains per ear, weight of 1000 seeds, grain yield and harvest index. The use of chicken dung combined with rice hull ash for corn production is a good substitute for the inorganic fertilizer in increasing grain yield.

Keywords: chicken dung, rice hull ash, corn, nutrient uptake, mycorrhizae

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INTRODUCTION

The worldwide demand for corn as food and feed is projected to greatly increase in the coming decades (Paliwal, 2000).This necessitates an increase in grain production per unit area planted to corn. Both options are, however, faced with declining soil fertility status and the high cost of inputs particularly chemical fertilizers.

The use of locally available and cheap organic fertilizers like chicken dung and rice hull ash which have the ability to improve soil quality is becoming a popular solution to the above-mentioned problems among farmers in many places in the Philippines.

Previous studies on the use of chicken dung as organic fertilizer revealed that it can be a cheap substitute to the costly chemical fertilizer for corn (Javier, 2000) and rice (Gato, 2000) production. Likewise,the limited research on the use of rice hull ash as a soil amendment indicated that it can be a good ameliorant for acid soils (Cabulong and Duque, 1984). Daftardar and Savant (1995) have also shown that rice hull ash is a good source of silica for rice. Flinn and Marciano (1984) likewise reported that Tarlac farmers in Central Luzon incorporate rice hull ash into the soil to improve fertility status.

Mycorrhizae are the most widespread symbiotic association between the roots of higher plants and soil fungi. The most commonly occurring forms are the vesicular-arbuscular mycorrhizae or VAM. Mycorrhizae is known to increase the P uptake of many plants in P-deficient soils (Marschner, 1995). Bowen (1980) also revealed that mycorrhizal fungi can enhance the plant uptake of Zn, Mo, and Cu which promotes biological N fixation.

Although corn is generally believed to be mycorrhizal (Marschner, 1995), very little research has been done on the effect of this root-fungus association on corn performance especially when applied with organic fertilizer. Thus, this study was conducted to evaluate the growth and yield response of corn to the application of chicken dung and rice hull and mycorrhizal fungi inoculation.

MATERIALS AND METHODS

Experimental design and field layout

The experiment was laid out in a split-plot arranged in Randomized Complete Block Design (RCBD) consisting of three replicaitons. Mycorrhizal fungi inoculation (2) served as the main plot while fertilizer application (4) was designated as the sub-plot. The treatments were as follows:

Treatments:

A. Main plot (Mycorrhiza Inoculation)

M_0 - without mycorrhiza
M_1 - with mycorrhiza

B.Sub-plot (Fertilizer Application)

T_0 - control (no fertilizer application)
T_1 - inorganic fertilizer
T_2 - chicken dung alone (60 kg ha^{-1} N)
T_3 - chicken dung (as in T_2) + 30 kg ha^{-1} rice hull ash

Chicken dung and rice hull ash collection, preparation and application

Chicken dung was collected from the Ramoneda poultry farm in Kilim, Baybay, Leyte. It was sun-dried for three days before it was applied in the field. The amounts applied were computed on the rate indicated in each treatment and incorporated into the soil in the furrows two weeks before planting. A representative sample of chicken dung was collected for the analysis of N, P, K, Ca, Mg and Na contents. Laboratory analysis of a representative sample of the chicken dung revealed the following elemental composition: 1.7% N, 0.659% P, 0.596 K, 0.202% Ca, 0.028% Mg and 0.0254% Na.

Rice hull ash was collected from Candadam, Baybay, Leyte. It was mixed manually with the chicken dung according to the rate specified in each treatment prior to its application. Laboratory analysis of a representative sample of the rice hull ash used showed the following nutrient contents: 0.145% N, 0.541% P, 0.659% K, 0.018% Ca, 0.0113% Mg and 0.0020% Na.

Inorganic fertilizer application

For the inorganic fertilizer treatment (T_1), single fertilizers like urea (46-0-0), solophos (0-18-0), and muriate of potash (0-0-60) were used. Half of the required amount of urea and the whole amount of solophos and muriate of potash were applied by basal method at planting. The remaining amount of urea was side-dressed before tasseling (about six weeks from planting).

VAM quantification and inoculation

Vesicular-arbuscular mycorrhiza (VAM) inoculum was obtained from Biotech, Los Baños, Laguna. VAM spores were quantified through wet sieving and decanting procedures of Phillips and Hayman (1970) and by counting under the stereoscope to determine the number of spores per gram. Three grams of VAM inoculum, which contained 35-50 spores, was applied to each plant after emergence.

Planting, thinning, care and maintenance of plants

Three corn seeds (VM var.2) were sown per hill at a distance of 75 cm between rows and 25 cm between hills. Thinning to one plant per hill was done one week after emergence. Replanting was also done in plots where some of the seeds were eaten by ants.

Hilling-up operation was manually done one month after planting. Handweeding was employed whenever necessary to keep the area weed-free throughout the growing period of the crop. Plants were sprayed with Cymbush at the rate of 4 tbs/gallon water at two weeks after planting and before tasseling stage to control the infestation by leaf hopper and corn borer.

Harvesting

Corn was harvested when 80% of the plants in each treatment plot (harvestable area of 9 m^2) had matured as indicated by the browning of husk and a black closing layer that developed in the placental region of the kernel (Daynard and Duncan, 1969 as cited by Escasinas, 1984).

Soil and tissue sampling and analysis

Before treatment application, 6 soil samples were randomly collected from every treatment plot per replicate, which were then mixed into one composite sample per plot for a total of 24 samples. All soil samples were air-dried, sieved to pass a 2 mm mesh,and analyzed at the Soil Laboratory of the National Abaca Research Center and at the Central Diagnostic Laboratory of the PhilRootcrops, LSU, Baybay, Leyte for soil pH in water by potentiometric method (ISRIC, 1995), total N by modified Kjedahl method of ISRIC (1986), organic matter by modified Walkley-Black method (Nelson and Sommers, 1982), available P by extraction using 0.03 M NH_4F in 0.1 M HCl (Bray and Kurtz No.2) and quantified using spectrophotometer following the method of Murphy and Riley (1962) for color development, and exchangeable K and Ca by extraction with 1N NH_4OAc at pH 7.0. The extract was then added with 1 ml of 10,000 ppm cesium chloride and 5 ml of 10,000 ppm strontium chloride, respectively, and the K and Ca concentrations quantified by atomic absorption spectrophotometry.

Tissue samples were also collected at tasseling stage from 6 randomly selected plants in every treatment plot per replicate.They were oven-dried at 70^{0}C for 3 days ground,and sieved using a Wiley mill and later ashed at 550^{0}C in a furnace for one day. The ash was dissolved in 3 ml concentrated HCl and evaporated to dryness in a hotplate after which, it was volumed to 100 ml using 0.1 N HCl. Quantification of total K and Ca was done by atomic absorption spectrophotometry.

Agronomic and yield data gathered

The following agronomic characteristics were evaluated:number of days from seedling to emergence, tasseling and silking, and maturity; plant height at flowering; leaf area index (LAI), fresh and stover yield. For the yield and yield characteristics, the following were measured: number of ears per plant, average ear length, average ear diameter, number of grains per ear, weight of 1000 seeds and grain yield. Harvest index was also calculated as the ratio of the economic yield and biological yield.

Mycorrhizal infection was determined following the procedure of Phillips and Hayman (1970) and Kormanik *et al.*, (1980).

RESULTS AND DISCUSSION

Nutrient concentration in corn leaf tissue

Table 1 shows the total concentrations of the mineral nutrients N, P, K, and Ca in the leaf tissue of corn as affected by the various treatments. VAM inoculation significantly increased the total N but not the total P, K,and Ca concentrations in the tissue of the experimental corn plants.Among the fertilizer treatments used, chicken dung and rice hull ash application significantly increased the total N and P contents but not total K and Ca.

The significant increase in the total N contents of corn tissue with VAM inoculation could be attributed to the probable increase in the absorbing surface area of the root system considering the fact that N was deficient in the soil (Table 2). VAM hyphae are known to be effective in enhancing the uptake of N when this nutrient is low in the soil (Ames *et al.*, 1983). Infection evaluation revealed 6-15% infection of the roots of VAM inoculated corn plants (Fig. 1). However,despite the increased N uptake, the amount of this nutrient in the corn tissue was still below the optimum level of 2 to 5% (Marschner, 1995) regardless of treatments. Statistical analysis also revealed no significant interaction effects between mycorrhizal fungi inoculation and fertilizer application on the N concentrations in the leaves of corn.

VAM inoculation did not significantly affect the uptake of P by the corn plants. The total P levels in the tissue of both the inoculated and uninoculated plants were above the critical levels of 0.18 to 0.25% (Forde, 1976 as cited by Gardner *et al.*, 1985) which can be attributed to the high levels of this nutrient in the soil (Table 2). VAM is known to enhance P uptake of plants (Rhodes and Gerdemann, 1975; Li and Barber, 1991) when this nutrient is lacking in the silo. However, an interaction effect between inoculation and application of fertilizer was observed (Table 3). Application of chicken dung

Table 1.Plant tissue analysis of corn as influenced by fertilizer application with or without VAM inoculation

Treatments	Total N (%)	Total P (%)	Total K (%)	Total Ca (%)
Inoculation				
M_0	1.101 b	0.246	0.65	0.32
M_1	1.303 a	0.277	0.65	0.35
Fertilizer Treatment				
T_0	0.962 c	0.193 b	0.64	0.29
T_1	1.470 a	0.247 ab	0.65	0.36
T_2	1.230 ab	0.302 a	0.64	0.37
T_3	1.147 bc	0.305 a	0.65	0.32
CV (a)	3.73	12.16	2.29	20.1
CV (b)	16.73	17.20	1.69	21.85

Treatment means followed by common letters are not significantly different at 5% level of significance based on Duncan's Multiple Range Test (DMRT)

Legend:

M_0 - without VAM inoculation
M_1 - with VAM inoculation
T_0 - no fertilizer application
T_1 - 60-60-60 kg ha $^{-1}$ N, P_2O_5, K_2O
T_2 - chicken dung alone (60 kg ha $^{-1}$ N)
T_3 - chicken dung (as in T_1) + 30 kg ha $^{-1}$ rice hull ash

Table 2. Some chemical properties of the soil before planting corn as influenced by fertilizer application with or without VAM inoculation

Treatments	pH-H_2O (1:2.5)	OM (%)	Total N (%)	Available P (mg/kg)	Exch. K (me/100g)
Inoculation					
M0	5.79	1.45	0.117	34.25	0.783
M1	5.79	1.52	0.114	34.87	0.802
Fertilizer Treatment					
T0	5.82	1.42	0.125	31.74	0.72
T1	5.78	1.59	0.106	36.65	0.787
T2	5.76	1.49	0.124	35.06	0.797
T3	5.80	1.53	0.108	34.78	0.815

Legend:

M_0 - without VAM inoculation
M_1 - with VAM inoculation
T_0 - no fertilizer application
T_1 - 60-60-60 kg ha $^{-1}$ N, P_2O_5, K_2O
T_2 - chicken dung alone (60 kg ha $^{-1}$ N)
T_3 - chicken dung (as in T_1) + 30 kg ha $^{-1}$ rice hull ash

Table 3. Interaction effects between VAM inoculation and fertilizer application on the concentration of phosphorus (%) in the tissues of corn

Treatments	VAM Inoculation	
	With VAM	Without VAM
T0	0.230 bc	0.157 c
T1	0.213 bc	0.280 ab
T2	0.327 a	0.277 ab
T3	0.340 a	0.270 ab

Treatment means followed by common letters are not significantly different at 5% level of significance based on Duncan's Multiple Range Test

Legend:

M_0 - without VAM inoculation
M_1 - with VAM inoculation
T_0 - no fertilizer application
T_1 - 60-60-60 kg ha^{-1} N, P_2O_5, K_2O
T_2 - chicken dung alone (60 kg ha^{-1} N)
T_3 - chicken dung (as in T_1) + 30 kg ha^{-1} rice hull ash

alone (T_2) or in combination with rice hull ash (T_3) significantly increased the concentration of P in the tissue of corn inoculated with VAM. This can be attributed to the possible improvement of the soil conditions wich could have favored the activity of the mycorrhizal fungus (Muler-Samann and Kotschi, 1994).

Agronomic characteristics of corn

Table 4 presents the agronomic characteristics of corn as influenced by chicken dung and rice hull ash as well as inorganic fertilizer with or without VAM inoculation. Inoculation did not significatly affect the agronomic characteristics of corn. However, application of inorganic fertilizer (T_1), chicken dung (T_2), and chicken dung in combination with rice hull ash (T_3) markedly enhanced earlier tasseling and silking but not emergence and maturity, and significantly increased plant height at flowering stage as well as the fresh stover yield but not leaf area index compared to the control.

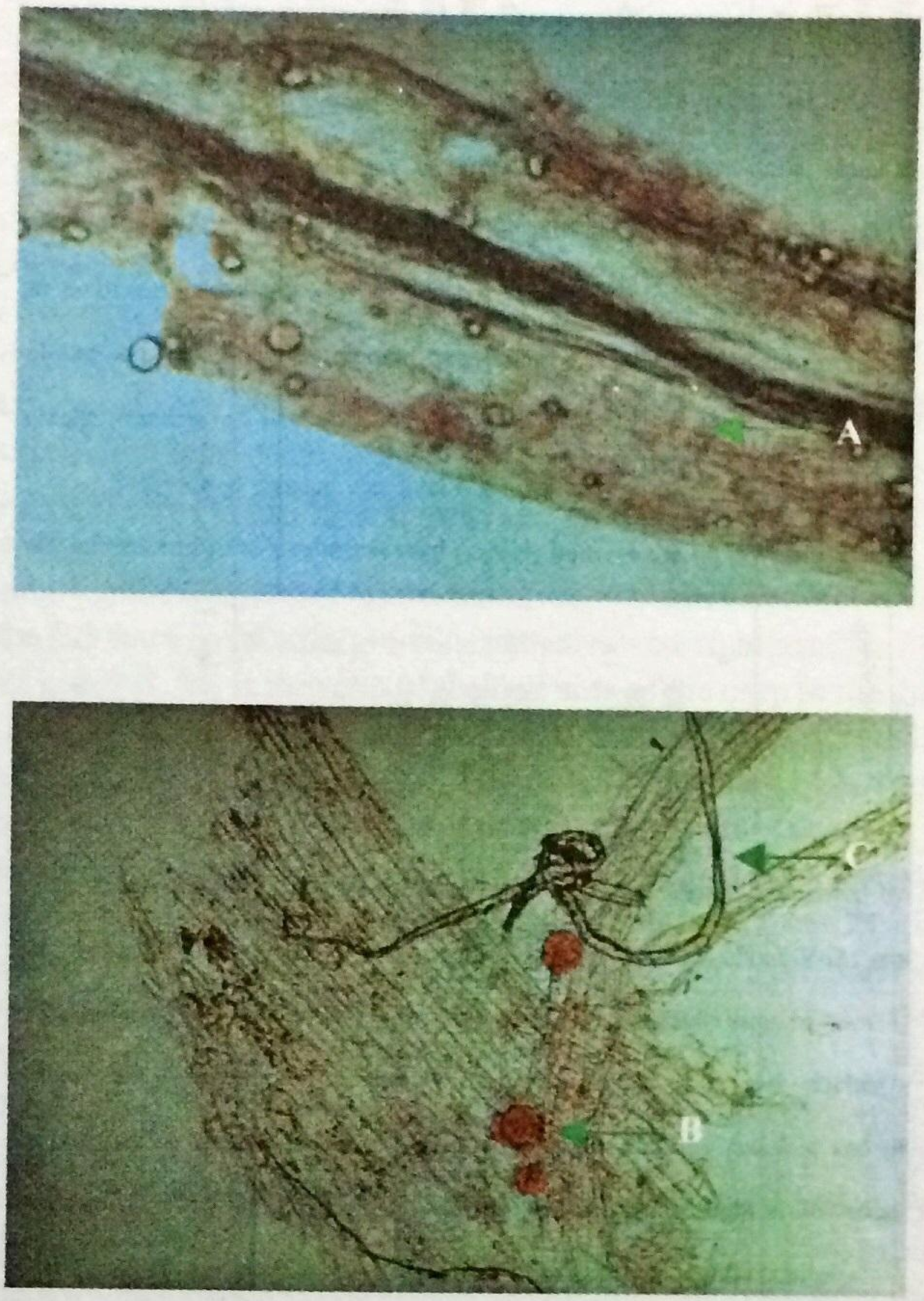

Figure 1. Photomicrograph of VAM infection (magnified 40x) of root of corn showing micorrhizal arbuscules (A), vesicles (B) and hypha (C) in chicken dung and rice hull ash treated plants

Table 4. Agronomic characteristics of corn as influenced by fertilizer application with or without VAM inoculation

Treatments	Days from Planting to				Plant Height (cm)	Leaf Area Index (LAI)	Fresh Stover Yield (t ha $^{-1}$)
	Emergence	Tasseling	Silking	Harvesting			
Inoculation							
M_0	4.00	55.67	61.25	101.40	244.99	2.81	9.89
M_1	4.00	54.25	60.03	101.18	251.63	3.01	10.56
Fertilizer Treatment							
T_0	4.00	57.17a	64.67a	102.00	231.10b	2.66	8.62b
T_1	4.00	53.67b	57.00c	100.30	259.55a	2.81	11.00a
T_2	4.00	54.50b	60.33b	101.80	251.05a	3.03	10.17a
T_3	4.00	54.50b	59.67b	100.85	251.55a	3.17	11.11a
CV (a)	0.00	1.97	2.05	0.73	4.22	7.84	5.73
CV (b)	0.00	1.55	2.83	1.05	4.22	7.84	10.27

Treatment means followed by common letters are notsignificantly different at 5% level of significance based on Duncan's Multiple Range Test (DMRT)

Legend:

M_0 - without VAM inoculation
M_1 - with VAM inoculation
T_0 - no fertilizer application
T_1 - 60-60-60 kg ha $^{-1}$ N, P_2O_5, K_2O
T_2 - chicken dung alone (60 kg ha $^{-1}$ N)
T_3 - chicken dung (as in T_2) + 30 kg ha $^{-1}$ rice hull ash

The non-significant effect of VAM inoculation, despite the presence of root infection (Fig. 1), may be explained by the fact that the soil already contained high levels of vailable P hence, the contribution of mycorrhizae in enhancing P absorption by the plant was not expressed. On the other hand, the significant reduction in the number of days to tasseling and silking with application of fertilizer is probably attributable to the enhancing effect particularly of the nitrogen added through the fertilizer. Gardner *et al.* (1985) reported that fertilizer application increases the growth rate and photosynthetic efficiency of leaf surfaces and thus, of the plant. This positive effect is also clearly reflected by the significant increase in plant height and fresh stover yield with the application of inorganic fertilizer,chicken dung, and chicken dung in combination with rice hull ash.

A non-significant effect of the treatments on leaf area index was observed despite the fact that several other growth parameters were significantly affected. Leaf area index (LAI) is the ratio of the leaf area of the corp to the ground area. It is a rough measure of leaf area per unit available solar radiation (Gardner *et al.*, 1985). Although the differences in LAI among treatments were not significant, there was a general tendency for this parameter to be lower in the control plots.This implies that the nutrients (particularly N) supply was not enough to cause significant increase in leaf area which was confirmed by the tissue analysis (Table 1). Nitrogen is vital for the development of leaves (Marschner, 1995) hence, its sufficient supply most likely slowed down the production of larger leaves.

Comparing the effects of inorganic fertilizer (T_1), chicken dung (T_2), and chicken dung plus rice hull ash (T_3) revealed generally no considerable differences in their effects on most of the agronomic characteristics of corn. This suggests that the amounts of nutrients they supplied were probably comparable within the short duration of the experiment. Although as mentioned in an earlier section, the chicken dung-treated plants were more vigorous in the early weeks of growth, the second dose of inorganic fertilizer enabled the plants in this treatment to recover and be comparable to the chicken dung treated plants.

Yield and yield components of corn

Results showed that among the yield parameters of corn measured, only the number of grains per ear was affected by VAM inoculation (Table 5). Results further showed, however,that the fertilizer treatments using inorganic fertilizer (T_1), chicken dung (T_2), and chicken dung plus rice hull ash (T_3) significantly increased the number of ears per plant, ear length, number of grains per ear, weight of 1000 seeds, grain yield, and harvest index.

The significant effects of fertilizer treatments on most yield parameters of corn suggest that the crop is responsive to nutrient addition especially since the variety used was VM-2, a new high yielding variety aside from the fact that the soil contained insufficient nitrogen. Gardner *et al*. (1985) reported that as much as 50% of the high yields of maize is attributed to fertilizers. This positive response of corn to fertilizer treatments is the common effectparticularly of increased nitrogen and phosphorus supply during the vegetative growth as well as during the development of the grains (Marschner, 1995). This was in fact confirmed by the results of the tissue analysis (Table 1).

As can be seen from the data, plants in fertilized plots (T_1, T_2 and T_3) developed more ears per plant, which no longer, and with more grains than those plants in the unfertilized plots. The results also suggest that plants that received fertilizer were more effective in photosynthates partitioning as indicated by their significantly higher harvest index than the unfertilized plants. McMillan *et al*. (1988), as cited by Escasinas (1988), found that as nitrogen was increased, there was also an increase in the proportion of the total dry matter which was distributed to the grains thus, increasing the harvest index of corn.

Comparing the effects of inorganic fertilizer (T_1),chicken dung (T_2) and chicken dung plus rice hull ash (T_3), there were slight differences observed among the three fertilizer treatments on the number of ears per plant, length of ears, number of grains per ear, and weight of 1000 seeds. Chicken dung plus rice hull ash (T_3) and inorganic fertilizer (T_1) appeared comparable in their effects on grain yield corn.

The generally low yield of corn obtained in this experiment, regardless of treatments, can be attributed to the low nitrogen supply from the soil and fertilizer as shown by the low levels of N in the plant tissue. Escasinas (1998)

Table 5. Yield and yield components of corn as influenced by fertilizer applcation with or without VAM inoculation

Treatments	Number of ears per plant	Ear Diameter (cm)	Ear Length (cm)	Number of grains per ear	Weight of 1000 seeds (g)	Grain Yield (t ha^{-1})	Harvest Index
Inoculation							
M_0	0.825	3.941	11.06	233.13a	184.27	0.82	0.32
M_1	0.925	3.972	12.18	286.15b	186.71	1.07	0.41
Fertilizer Treatment							
T_0	0.667b	3.760	10.30c	137.98b	171.85b	0.52c	0.26c
T_1	0.950a	4.083	13.04a	297.13a	193.50a	1.32a	0.45a
T_2	0.883a	3.951	10.92bc	308.33a	185.78ab	0.83bc	0.36b
T_3	1.000a	4.032	12.20ab	295.82a	190.82a	1.10ab	0.38ab
CV(a)	14.37	4.45	15.63	9.82	11.20	43.61	26.35
CV (b)	10.78	5.11	10.20	17.62	6.32	28.28	17.57

Treatment means followed by common letters are not significantly different at 5% level of significance based on Duncan's Mulitple Range Test (DMRT)

Legend:

M_0 - without VAM inoculation
M_1 - with VAM inoculation
T_0 - no fertilizer application
T_1 - 60-60-60 kg ha^{-1} N, P_2O_5, K_2O
T_2 - chicken dung alone (60 kg ha^{-1} N)
T_3 - chicken dung (as in T_1) + 30 kg ha^{-1} rice hull ash

stressed the importance of nitrogen for high corn yield when he mentioned that the dominant nutrient causing yield increase in corn is nitrogen. Another reason was the damage (about 15-20%) caused by stalk rot (*Pectobacterium chrysanthemum* pv. Zeae) infestation before maturity of the plants.

CONCLUSIONS

Based on the results of the study, the following conclusions maybe drawn:

1. Application of chicken dung alone or in combination with rice hull ash hastens the flowering and increases the height and stover yield of corn. In addition, it increases the number of ears per plant, ear length, number of grains per ear, weight of 1000 seeds, grain yield and harvet index of corn. The effects of chicken dung alone or in combination with rice hull ash on the agronomic characteristics and yield components of corn are generally comparable to that of the inorganic fertilizer.

2. Mycorrhizal (VAM) fungi inoculation does not significantly affect the agronomic characteristics of corn. Moreover, among the yield parameters studied, only the number of grains per ear is significantly increased. However, it significantly increased the N uptake of corn although it is still below the critical level required for optimum growth. Hence, it could have indirectly enhanced the growth and yield of the plant.In addition, VAM inoculation significantly increases the tisssue concentration of P in corn plants treated with chicken dung and rice hull ash.

3. Chicken dung and rice hull ash incombination improve the pH and OM, N, P, and K contents of the soil relative to the initial analysis. However, no considerable differences were noted on the above-mentioned soil parameters among plots treated with chicken dung alone, chicken dung plus rice hull ash, and inorganic fertilizer after the short duration of the experiment.

4. The use of chicken dung combined with rice hull ash for corn production is a good substitute for inorganic fertilizer in increasing grain yield.

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