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Growth Performance and Yield of Sweet Corn Grown on Rasau Series Soil Under Organic Amendments

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ABSTRACT

Soil health and food safety are giving more reasons to researchers in the field of organic farming to study the alternative means of soil amendments in place of chemical farm inputs. A 4x2 factorial field experiment in Randomized Complete Block Design (RCBD) replicated four times was carried out at Universiti Malaysia Terengganu, Bukit Kor campus to determine the impact of different chicken manure rates and Arbuscular Mycorrhizal Fungi (AMF) inoculation on growth performance and yield of sweet corn. The factors used for this study are chicken manure rates (CM) at four levels CM_1 (control), CM_2 (25t/ha), CM_3 (50t/ha) and CM_4 (75t/ha). While the 2nd-factor Arbuscular Mycorrhizal Fungi (AMF) at two levels M_1 (with AMF inoculation) and M_2 (without AMF inoculation). Growth parameters (plant height, stem girth and leaf number) were measured at 4, 6 and 8 weeks after planting (WAP) and cob yield parameters (length, girth, and weight) were recorded after harvest. Data collected were statistically ($p<0.05$) analysed using analysis of variance (ANOVA) with Statistical Analysis System (SAS) software version 9.4. Means separated using Duncan's Multiple Range Test (DMRT), chicken manure at the rate of 50t/ha was statistically superior to the control (CM_1) treatment and 25t/ha (CM_2) in both growth and yield of sweet corn. Single sole application of chicken manure at the rate of 50t/ha can significantly improve the growth performance and yield of sweet corn.

Keywords: Chicken Manure, Arbuscular Mycorrhiza Fungi, Inoculation And Sweet Corn.

I. INTRODUCTION

The need for more sweet corn cultivation is increasing by the day across Malaysia for its nutritive and economic value (Salleh et al., 2001). The less the starch and the more the sugar content of fresh sweet corn coupled with good sweet corn taste and aroma will give consumers more preference of the crop (Azanza et al., 1996). Base on its kernel sugar content, sweet corn is grouped into three viz; sugary (su), sugary enhanced (se) and super sweet also known as shrunken (sh2) as classified by Hale et al. (2005).

The use of organic manure is on the rise across the globe most especially for better soil and crop improvement (Ceglie et al., 2015), they are eco-friendly, conforms to the vegetation and other environmental features need (Bautista et al., 2008). Organic manure amendments benefit the tropical regions more than temperate due to the high rate of nutrient washing and breakdown of soil structure, which in-turns lead to the reduced fertility of the soil in such areas. As such, it becomes vital to appropriately and adequately manure the land with organic materials for better soil health, crop production and consumer health (Audi et al., 2013). Some research has established that organic manure has a positive impact on growth performance and yield of crops, as it contains nutrients which are beneficial in a gradual process of mineralization and humification which make the essential nutrients available to plants (Chiezey and Odunze, 2009).

Ewulo et al. (2008) reported an improvement of soil physical properties by amendment of 50t/ha of poultry manure, which in-turns resulted in improved growth and yield of tomato. The soil is said to be fertile when it contains an organic matter of 3% and above (Shaheen et al., 2015), materials made from plant and animal added

to soil for better soil health and crop performance are said to be organic manures (Aniekwe and Nwokwu, 2015).

Arbuscular Mycorrhizal Fungi (AMF) exist as part of the ecosystem for the fact that they can symbiotically associate with about 90% of plant species. With the primary role of aiding the uptake of phosphorus and other nutrient elements via its extra-radical hyphae which leads them to the plant root tissues (Giri and Mukerji, 2004; Wu et al., 2010) and it gets fixed carbon from the plant host in return.

II. MATERIALS AND METHODS

A. Field Experiment

The experiment was conducted at the Universiti Malaysia Terengganu, at Bukit Kor, Marang, Terengganu. Located at latitude 5^o 21' North and longitude 103^o 2' East, with an altitude of about 32m above sea level (asl). Tropical rainforest being its climate with mean annual rainfall of 2911mm (114.6in) and an average temperature of 26.7^oC (min 22^oC and max 32^oC), 77.7% as the relative humidity which ranges from 68% in May/June to 79% in December.

The study was a 4x2 Randomized Complete Block Design (RCBD) replicated four times. The factors include chicken manure rates; CM_1 (control), CM_2 (25t/ha), CM_3 (50t/ha) and CM_4 (75t/ha) and Arbuscular Mycorrhiza Fungi (AMF); M_1 (with AMF inoculation) and M_2 (without AMF inoculation). That gives a total of 8 treatments replicated four times and made it to 32 experimental units (plots) of $4.725m^2$ each in a total field area of $322.4m^2$, and the area contains rasau series soil.

The growth parameters were recorded at 4,6 and 8 WAP while that of cob yield at harvest, which were analysed using Analysis of Variance (ANOVA) using SAS 9.4 ($p<0.05$) and means separated using Duncan's Multiple Range Test (DRMT).

The soil was amended with chicken manure according to the treatments two weeks before planting, to allow proper mineralization of nutrients and AMF was inoculated at planting (10g/hole).

Sweet corn (*Zea mays* saccharata L.) Var Thai Super sweet was procured from Bumi Agro, Kuala Terengganu, and planted three seeds/hole later thinned to 1stand/hole after germination.

III. RESULTS AND DISCUSSIONS

The soil under study was analysed before amendment with the treatments, and found to be sandy loam with sand, silt, and clay separates (%) as 56.28, 29.91, and 13.81 respectively. It has a pH (H_2O) of 4.36, organic C (1.69%), total N (0.105%), available P (7.52ppm), and exchangeable bases (cmol/kg) K (0.026), Ca (0.222) and Mg (0.046) as presented in Table 1.

Table 1: Initial soil properties from the experimental location

Parameters	Value
pH (H_2O)	4.36
Organic C (%)	1.69
Total N (%)	0.105
Av P (ppm)	7.52
Exchangeable Bases (cmol/kg)	
K	0.026
Ca	0.222
Mg	0.046
Mechanical Composition (%)	
Sand	56.28
Silt	29.91
Clay	13.81
Textural Class (USDA)	Sandy Loam

Source: Field Experiment

A. EFFECTS OF DIFFERENT CHICKEN MANURE RATES AND AMF ON GROWTH PERFORMANCE OF SWEET CORN

1) Plant Height: There was significant main effect of chicken manure rate and AMF inoculation statistically ($p<0.05$) at 4, 6 and 8 weeks after planting (WAP), but interaction exist at 6 and 8 WAP as presented in the ANOVA table (Table 2). At 4 WAP CM_3 (50t/ha) and CM_4 (75t/ha) did significantly better than CM_2 (25t/ha) and the control (0t/ha), though, the highest mean value

of 128.19 was for CM_4, still not significantly better than CM_3 which has a mean value of 125.64, this indicates that optimum sweet corn height can be achieved with 50t/ha chicken manure taken into consideration the lowest mean value 84.92 cm of the control as shown in Table 3.

As stated by Gasim (2001), corn plant height increases with increase in manure rate, because Nitrogen improves plant growth rate by the frequency and length of internodes which leads to total improvement of the plant height.

This agrees with the findings of of Enujeke (2013) who conducted a study on the effect of chicken manure on corn growth performance and yield, and reported increase in plant height with increase in chicken manure dosage, also similar results were reported by Fagimi and Odebode (2007) on pepper and Izonobi (2002), they all recorded an increase in plant height with higher rate of chicken manure.

AMF inoculation was also promising to the increase in plant as seen from the ANOVA Table (Table 2), at 4 WAP the highest mean value was recorded for M_1 (with inoculation) 113.13, while the treatment without AMF inoculation (M_2) recorded the lowest mean values of 108.98 as presented in Table 3. AMF is known to improve nutrition by tapping the labile P through its hyphae which might have been unavailable to plant roots (Talbot et al., 2008).

The interaction effect of poultry manure rate and AMF inoculation was significant for plant height at 6 and 8 WAP as seen in the ANOVA table (Table 2), the interactions is presented in Table 4, this means that the plant height increase was based on the combination of the two factors (CM and AMF), at 6 WAP the highest mean value was 221.93 for CM_4M_1 where as the lowest was 134.66 for CM_1M_2, similar trend was observed at 8 WAP with CM_4M_2 having the higest mean value of 299.332 and lowest mean value was recorded for CM_1M_2 of 189.12. This shows that CM_1 (0t/ha) can as well be improved with the inoculation of AMF only as seen from their significant difference between the control CM treatment with inoculation and that without inoculation.

This was also reported by Enujeke (2013) and Galbiatti et al. (2011), who stated that combination of poultry manure with AMF is proved to be superior than sole amendment with only the PM, similar result was also reported by Abdullahi et al. (2015a) from their study of AMF and PM on corn in Eastern Malaysian region of Sarawak.

2) Stem Girth: This study reveals that, the higher the chicken manure rate, the larger the diameter of corn plant as analysed, this can be due to more essential nutrients as the rate increases as narrated by Elmar (2001).

From the ANOVA table (Table 2), it can be observe that there was significant main effect of PM rate at 4, 6 and 8 WAP, while neither significant main effect of AMF no interaction (CM*AMF) was observed.

The treatments with 50t/ha (CM_3) and 75t/ha (CM_4) were not significantly different ($p<0.05$) from one another, though the former has slightly higher mean value than the latter. But both performed significantly different from the control (CM_1) and CM_2 (25t/ha) at all the 3 measured and analysed growth periods (4, 6 and 8 WAP). The highest stem girth mean value observed are 22.59, 27.70 and 30.04 at 4, 6 and 8 WAP respectively for CM_4 (75t/ha), but CM_3 also performed well and closely as shown in Table 3 with a mean value of 21.78, 26.99 and 29.50 at 4, 6 and 8 WAP in that order, CM_1 (control) has the lowest mean value of 12.82, 17.18, and 18.43 for 4, 6, and 8 WAP respectively and significantly ($p<0.05$) inferior to all the the treatments as presented in Table 3.

The result is in accordance with the outcome of a study by Ali et al. (2006) on their work on poultry manure rate effect on Irish potato, Fagbola and Ogungbe (2007) on corn cultivars and with the work of Agbede and Ojeniyi (2009) on sorghum plant.

3) Leaf Number: Rate of CM have significant effect on corn number of leaves, as there was significant main effect ($p<0.05$) of CM for corn leaf number from this study as shown on Table 2. CM_3 and CM_4 (50t/ha and 75t/ha) did significantly better than CM_1 and CM_2 (control and 25t/ha), the highest mean value recorded were 9.63, 12.63 and 13.75 at 4, 6 and 8 WAP respectively, and the lowest mean value were recorded for the control treatment CM_1 (0t/ha) of 7.50, 10.00 and 11.13 at 4, 6 and 8 WAP in that order as presented in Table 3.

CM_3 and CM_4 were not statistically ($p<0.05$) different from one another. The more the number of leaves on a plant, the higher the photosynthesis rate due to the presence of more chlorophyll content (Karanatsidis and Bravo, 2014).

This result agrees with the outcome of the study conducted by Mubondeni et al. (1999) and the findings of Enujeke (2013b) that recommended an application of manure at a rate that meets the nutritional requirement of the growing crop for better growth and yield enhancement. Also a study on corn plant using different CM rate by Enujeke (2013a) recommended CM application at the rate of 30t/ha.

There was a significant main effect of AMF inoculation for corn number of leaves at 4, 6 and 8 WAP as shown on Table 2, with inoculated treatment (M_1) being significantly better than the non-inoculated treatment (M_2), this can be attributed to the symbiotic relationship between AMF and its host (corn root). Studies suggests that AMF do benefit plant performance by making P from non-labile origin to be available to the plant root, and consequently aids plant growth (Cardoso et al., 2006). As presented in Table 5, the AMF inoculated treatment (M_1) has higher mean value of 8.94, 12.00, and 13.13 at 4, 6 and 8 WAP respectively, while the AMF control treatment (M_2) which is significantly inferior than the inoculated treatment has a mean value of 8.56, 11.13 and 12.38 at 4, 6 and 8 WAP in that order. There was no significant interaction present.

The result is in accordance with the findings of Abdullahi et al. (2015b) and a study by Galbiatti et al. (2011).

Table 2: Mean square of plant height (cm), stem girth (mm), and leaf number at 4, 6, and 8 weeks after planting

Treatments	Plant Height			Stem Girth			Leaf Number		
	4	6	8	4	6	8	4	6	8
CM	**	**	**	**	**	**	**	**	**
AMF	**	**	**	ns	ns	ns	*	**	**
Interactions									
CM*AMF	ns	**	**	ns	ns	ns	ns	ns	ns
CV	2.95	2.16	3.02	9.73	5.35	3.91	4.04	5.86	4.13

NB: CM= Chicken Manure; AMF=Arbuscular Mycorrhizal Fungi; CV= Coefficient of Variation; ns= not significant, *=significant at 0.05 level; **= significant at 0.01 level

Table 3: Main effect of chicken manure rate and AM inoculation on plant height (cm), stem girth (mm) and leaf number at 4, 6, and 8 Weeks After Planting (WAP)

Treatments	Plant Height	Stem Girth		
	4	4	6	8
CM (LSD)	5.11	2.85	1.96	1.54
CM1 (0t/ha)	84.92c	12.82c	17.18c	18.43c
CM2 (25t/ha)	105.47b	17.73b	21.95b	23.74b
CM3 (50t/ha)	125.64a	21.78a	26.99a	29.50a
CM4 (75t/ha)	128.19a	22.59a	27.70a	30.04a
AMF (LSD)	2.62	1.46	1.00	0.79
M1 (with)	113.13a	18.75a	23.82a	25.57a
M2 (without)	108.98b	18.71a	23.10a	24.83a

NB: Means with the same letter within the same column of either of the treatments are not significantly different

Table 4: Effects of interaction between chicken manure rates and AMF inoculation on sweet corn plant height (cm) at 6 and 8 WAP

Treatments	6	8
CM1M1	157.58c	221.89c
CM1M2	134.66d	189.12d
CM2M1	182.86b	249.11b
CM2M2	167.56c	233.93bc
CM3M1	218.47a	289.39a
CM3M2	212.33a	286.42a
CM4M1	221.93a	294.67a
CM4M2	220.23a	299.32a

NB: Means with the same letter within the same column of either of the treatments are not significantly different

Table 5: Main effect of chicken manure rate and AM inoculation on sweet corn leaf number at 4, 6 and 8 WAP

Treatments	4	6	8
CM (LSD)	0.55	1.06	0.82
CM1 (0t/ha)	7.50c	10.00c	11.13c
CM2 (25t/ha)	8.38b	11.13b	12.38b
CM3 (50t/ha)	9.50a	12.50a	13.75a
CM4 (75t/ha)	9.63a	12.63a	13.75a
AMF (LSD)	0.28	0.54	0.42
M1 (with)	8.94a	12.00a	13.13a
M2 (without)	8.56b	11.13b	12.38b

NB: Means with the same letter within the same column of either of the treatments are not significantly different

B. EFFECTS OF CHICKEN MANURE RATE AND AMF ON COB YIELD OF SWEET CORN

Three different cob parameters were measured and analysed statistically ($p<0.05$), namely; cob length (cm), cob girth (mm) and cob weight (t/ha) and they all show significant interaction effect of CM rate and AM inoculation (CM*AM) as shown in Table 6. Though there was significant main effect of CM rate and AM inoculation, the presence of interaction of the two factors have suppress their impact.

The highest mean value of cob length for the interaction effect is 20.77 for CM_4M_1, while the lowest mean value of cob length was recorded for CM_1M_2 (0t/ha and non-inoculated) with a mean value of 11.15 as presented in Table 7.

Same goes for the cob girth (diameter) with the highest mean value of 51.12 for CM_4M_1 which is significantly different from the lowest mean value observed 36.76 for CM_1M_2.

Finally the cob weight of sweet corn, also displays similar trend with other cob parameters mentioned above, with the highest recorded for CM_4M_1 (12.00) and significantly different from the lowest CM_1M_2 (5.02) as presented in Table 7.

The presence of interaction on cob parameters means that the CM rate depends on AM inoculation for the significant difference to manifest, for instance, CM_1 (control 0t/ha) did significantly better with AM inoculation than CM_1 without AM inoculation for corn cob length and girth with a mean value of 14.67 and 43.44 respectively compared to same treatment of CM rate (control) with no AM inoculation with a mean value of 11.15 and 36.76 for cob length and girth respectively as presented in Table 7.

The results is in accordance with several research with the combination of organic manure and AM inoculation viz; Omar and Bela (2007) on mango, Maksoud et al. (2012) on pomegranate fruit, and Abdullahi et al. (2015b) using corn and finally the findings of Torshiz et al. (2017) also on pomegranate fruit.

Table 6 : Main effects of chicken manure rates and AM inoculation on sweet corn cob parameters

Treatments	Length (cm)	Girth (mm)	Weight (t/ha)
CM	**	**	**
AMF	**	**	*

Interactions			
CM*AMF	**	**	*
CV	3.77	2.47	9.23

NB: CM= Chicken Manure; AMF=Arbuscular Mycorrhizal Fungi; CV= Coefficient of Variation; ns= not significant, *=significant at 0.05 level; **= significant at 0.01 level

Table 7: Effects of interaction between chicken manure rates and AM inoculation on sweet corn cob parameters

Treatments	Length (cm)	Girth (mm)	Weight (t/ha)
CM1M1	14.67c	43.44bc	6.20bc
CM1M2	11.15d	36.76d	5.02c
CM2M1	17.40b	46.33b	7.99b
CM2M2	14.89c	42.34c	6.19bc
CM3M1	20.63a	49.68a	11.07a
CM3M2	20.10a	51.10a	11.96a
CM4M1	20.77a	51.12a	12.00a
CM4M2	20.52a	50.46a	10.95a

NB: Means with the same letter within the same column of either of the treatments are not significantly different

IV. CONCLUSION

The growth performance of Thai super sweet corn was significantly ($p<0.05$) affected by the main effect of chicken manure rate across all the parameters measured (viz; plant height, leaf length, leaf width, leaf area, stem girth and leaf number), the highest mean value for these parameters were obtained for CM_4 (75t/ha) treatment, though not significantly different from CM_3 (50t/ha) but both were significantly different from the control treatment 0t/ha) and CM_2 (25t/ha). As such, the 50t/ha can be of preference in Bukit Kor area of Terengganu that has rasau series soil. AM inoculation was statistically significant and being superior over the non-inoculated treatment, the study also revealed that mycorrhiza can benefit sweet corn growth performance and yield if the soil fertility of the field is low. In the case of CM_3 and CM_4 (50 and 75t/ha) treatment of chicken manure, the AM inoculation shows no significance ($p<0.05$), that brings about the interaction present in some of the parameters measured.

Same trend was observed for cob yield parameters (cob length, cob girth and cob weight), there was significant interaction ($p<0.05$) effect in all the 3 parameters, and it was the control treatment and CM_2 (25t/ha) that were affected by the interaction effect, as there was no significant interaction between CM_3 and CM_4 both with and without AM inoculation, this indicates that AM inoculation benefits sweet corn in low CM rate.

From the findings of this study, it can be concluded that rasau series soil is good for sweet corn production with a chicken manure of single sole application of 50t/ha.

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