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Genotypic Variation in Yield and Yield Components of Plantain (*Musa* spp.) in Response to Containerized Planting Material and Mulching

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Abstract

The study was conducted to evaluate the field performance of local plantain genotypes; Apem, Oniaba, Apantu (AAB) and FHIA 21 (AAAB) suckers that were raised in containers (polybags) and their corresponding conventional suckers. Half of the containerized and conventional suckers in each plot were mulched with empty fruit bunch (EFB). Survival rate three months after transplanting was higher in containerized (100%) than conventional materials (60%) with or without mulching. Mulching increased the girth at flowering and total leaf area by 8% and 28% respectively, and reduced the number of days to flowering. Mulching also increased yield of plantain and the highest was recorded in FHIA 21. Bunch yield of container raised suckers per hectare was 19% greater than conventional suckers, due to higher survival rate after transplanting. Bunch yield among the genotypes in decreasing order was as follows, FHIA21 (20.7), Oniaba (16.9), Apem (15.9) and Apantu (13.2) tons/ha. Mulching increased the yield components such as, pulp weight, peel weight, finger weight and number of fingers. Genotypic variation in pulp yield was in the following decreasing order Apantu > FHIA 21 > Oniaba > Apem fresh weight. The pulp to peel ratio was in the following decreasing order Apantu > FHIA 21 > Apem > Oniaba. It is concluded that raising plantain suckers in polybags and applying EFB mulch is an improved production technique.

Keywords

Containerized Planting Material, Conventional Planting Material, Plantain Genotypes, Mulching

1. Introduction

Plantain (*Musa* AAB) is a major starchy staple in Ghana. In West and Central Africa, it is estimated that about 70 million people derive 25% of their food energy requirement from plantain [1]. They are staple foods for rural and urban consumers in the humid tropics and an important source of rural income particularly in some locations where small holders produce them in some compound or home gardens [2]. Three major local cultivar groups namely Apantu (False Horn), Apem (French plantain), and Asamienu (False Horn) have been identified and classified [3] in Ghana, and differ in maturity periods, bunch yields, nutrient requirement, draught tolerance and suckering. In spite of the high demand for plantain, demand far exceeds supply in several parts of the country, especially the urban centres. The present low production level is due to several constraints including disease and pest problems, poor soil fertility management, soil moisture stress and high mortality rate after transplanting into the field. Raising seedlings in containers and organic mulching can address these agronomic constraints.

Container raised seedlings has many advantages over bared-root plants production. These include less damage occurring to the root system and better establishment resulting in higher survival rate after transplanting, easier to handle and transport, and promotes fertilizer and water use efficiency [4] [5].

Mulching is a means to conserve soil moisture. Besides, mulch keeps the soil moist [6], protects the soil from erosion and suppresses weeds [7], serves as nutrient sources when they decay [8], and improves soil fertility as well as other soil physical properties such that plantain yield increases [9] [10] [11]. Plantains require high amount of organic mulch for high yielding. This will include the use of organic residues such as oil palm empty fruit bunch (EFB), poultry droppings, sawdust, and cocoa pod husk. These materials are affordable, and release their nutrient to the plant over a longer period compared to the inorganic fertilizers. Field research has shown positive plantain response to organic mulch such as elephant grass [9] [12], wood chips, sawdust and cassava peels [9] [13]. However, there is limited information on the effects of EFB mulch on the maturity period and yield of potted split corm derived plantain suckers. The beneficial effects of EFB mulching on oil palm growth and yield have been known since 1934 [14]. The need to conserve soil moisture in plantain cultivation cannot be overemphasized. The crop experiences soil moisture stress during the dry season and this affects growth and yield, especially when the plant is approaching or has reached the flowering stage. This situation is more pronounced if the crop is grown under rain-fed conditions, which is prevalent in Ghana. The study was conducted to determine how plantain genotypes raised in polybags and mulched with EFB will perform in the field.

2. Materials and Methods

The experiment was conducted at Forest and Horticultural Crops Research Centre, Kade (Lat. 6˚09′and 6˚06 N and Long. 0˚55′and 0˚49 W) from December, 2014 to August, 2016. The experiment was performed in a split–split plot laid out in a randomized complete block design. Experimental treatments consisted of three local plantain genotypes Apem, Oniaba (both French plantains, AAB), Apantu (False Horn Plantain, AAB) and FHIA 21 (Hybrid plantain, AAAB), two types of planting materials; container raised suckers and conventional (pared and hot water-treated) suckers and two rates mulching types (no mulch and 90 tonnes per hectare EFB mulch). Maiden suckers of the four plantain genotypes were obtained from mother plants and corms were pared and split into mini-setts of 300 g.

The mini-setts were treated with Bendazim (carbendazim fungicide) at the rate of 2 g per litre of water to prevent fungal infection and rot. The mini-setts were then planted in sterilized sawdust in nursery boxes to sprout. Watering was done immediately the mini-setts were planted in the sawdust and afterwards whenever necessary.

One month after nursing the split corms, the sprouted mini-setts were planted into polybags filled with a mixture of sawdust and carbonated rice husk (CRH) at a ratio of 1:1 (v/v) and grew under irrigated condition at the nursery. Watering was done immediately after planting and whenever needed afterwards. Each potted plant was supplied with 500 ml of 10 g NPK (15-15-15 compound fertilizer) plus 10 g Urea per week.

The container-raised split corm-derived suckers were transplanted into field three months after planting into the polybags at a spacing of 3 m × 3 m. Conventional suckers of the different genotypes were included. Each plot consisted of 16 plants and replicated three times in a randomized complete block design. Half of each plot was mulched with 90 tonnes per hectare of EFB. 400 g NPK (15-15-15 compound fertilizer) was applied to each plant six weeks after transplanting.

Data was collected on the following: percent plant survival, days to flowering, plant height and girth at flowering, number of leaves and total leaf area at flowering, number of suckers at flowering, bunch weight, number of hands per bunch, peduncle weight, number of fingers, length of fingers, circumference of fingers, weight of fingers, peel and pulp weight and pulp: peel ratio.

Data were analyzed using analysis of variance procedure with Genstat 5.0 Release 4.23DE, Discovery Edition 1 (GENSTAT, 2003). Duncan Multiple Range Test was employed for means separation.

3. Results

The results in Table 1 show the survival rate of the different plantain genotypes three months after transplanting into field. The survival rate was higher in containerized (100%) than conventional (farmer practice) materials which was about 60% with or without mulch.

Mulching significantly reduced the number of days to flowering and the reduction was much higher under containerized condition as presented in

Table 1. Effect of plantain genotype, containerized and mulching conditions on survival rate (%) after transplanting in the field.

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	100a	100a	100a	100a
	Mulch	100a	100a	100a	100a
Conventional sucker	No-mulch	60b	60b	60b	60b
	Mulch	60b	60b	65b	60b

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 2. The highest reduction was observed in Apem (88 days) and lowest in Oniaba (26 days).

Plant height, girth and total leaf area were significantly improved due to mulching for Apem, Apantu and Oniaba (Tables 3-5 respectively). The highest plant height, girth and total leaf area were observed with mulched Apem (Tables 3-5 respectively). However, for FHIA 21, the highest plant height was observed with the no-mulched plants (Tables 3) whilst the highest plant girth and total leaf area were obtained with the mulched plants (Table 4 and Table 5). Mulching increased the girth at flowering and total leaf area by 8% and 28% respectively over no-mulched plants.

The bunch yield for all the genotypes under mulched condition was significantly higher than without mulch and the difference were much higher for the containerized planting materials (Table 6). The bunch yield of container raised suckers per hectare was 19% greater than conventional suckers. Bunch yield among the genotypes in decreasing order was as follows, FHIA21 (20.7), Oniaba (16.9), Apem (15.9) and Apantu (13.2) tons/ha.

Mulching increased the yield components such as finger weight, pulp weight, peel weight, and number of fingers. Number of hands (Table 7) and fingers (Table 8) for all the genotypes under containerized with mulched conditions was higher than all other treatments. Genotypic variation in number of fingers was in the following decreasing order Oniaba > FHIA 21 > Apem > Apantu.

Finger weight (Table 9) and pulp weight (Table 10) were significantly (P = 0.05) increased by mulching for both container raised and the conventional planting materials but was higher under the former. Genotypic variation in pulp yield was in the following decreasing order Apantu > FHIA 21 > Oniaba > Apem fresh weight. Mulching increased peel weight over non mulched treatments and was higher for the conventional suckers (Table 11). Containerized suckers generally produced higher pulp: peel ratio than the conventional suckers with or without mulch (Table 12). Pulp to peel ratio was in the following decreasing order Apantu > FHIA 21 > Apem > Oniaba (Table 12).

Number of suckers produced at flowering was significantly increased by mulching treatments over non-mulched and the increase was much higher for

Table 2. Effect of plantain genotype, containerized and mulching conditions on number of days to flowering.

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	356d	339c	350c	311d
	Mulch	320b	313b	323b	306b
Conventional sucker	No-mulch	414a	394a	389a	352a
	Mulch	362c	343c	358c	331c

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 3. Effect of plantain genotype, containerized and mulching conditions on plant height at flowering (cm).

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	327.9ab	266.8c	302.0b	312.3b
	Mulch	338.7a	255.8c	318.3a	323.8a
Conventional sucker	No-mulch	320.0b	275.0a	306.1b	310.2b
	Mulch	321.0b	235.4b	314.3a	328.2a

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 4. Effect of plantain genotype, containerized and mulching conditions on plant girth at flowering (cm).

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	59.1d	58.9d	61.3c	62.1c
	Mulch	65.4a	63.9a	64.2a	65.0a
Conventional sucker	No-mulch	55.2b	56.4b	58.1b	59.2b
	Mulch	63.2c	62.1c	62.3c	63.9c

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 5. Effect of plantain genotype, containerized and mulching conditions on total leaf area at flowering (m^2).

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	5.2b	5.2b	6.0ab	5.6b
	Mulch	6.7a	6.5a	6.5a	7.4a
Conventional sucker	No-mulch	4.7b	4.4b	5.1b	5.2b
	Mulch	6.3a	6.3a	6.5a	6.6c

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 6. Effect of plantain genotype, containerized and mulching conditions on bunch yield (kg).

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	10.3b	12.6b	8.4b	11.0c
	Mulch	12.5a	15.9a	9.9a	13.7a
Conventional sucker	No-mulch	10.0b	11.5b	8.0b	10.2b
	Mulch	11.9a	14.2a	9.4a	11.9c

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 7. Effect of plantain genotype, containerized and mulching conditions on number of hands.

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	6.6b	6.4b	6.3b	6.6b
	Mulch	7.3a	7.3a	6.6a	7.6a
Conventional sucker	No-mulch	6.3b	6.2b	6.2b	6.4b
	Mulch	7.0a	7.0a	6.2b	7.0a

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 8. Effect of plantain genotype, containerized and mulching conditions on number of fingers.

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	59.7ab	70.2a	28.7b	75.3b
	Mulch	69.8a	72.0a	30.1a	82.7a
Conventional sucker	No-mulch	52.4b	72.1a	27.2b	72.8b
	Mulch	60.2ab	71.3a	28.7b	80.3ab

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 9. Effect of plantain genotype, containerized and mulching conditions on finger weight (g).

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	110.0c	168.1b	226.5c	139.2b
	Mulch	125.6a	207.0a	285.7a	168.6a
Conventional sucker	No-mulch	104.2b	160.2b	201.1b	141.8c
	Mulch	119.6ab	208.3a	288.8a	165.2a

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 10. Effect of plantain genotype, containerized and mulching conditions on pulp weight (g).

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	64.0c	103.5b	143.0d	78.4b
	Mulch	72.4a	134.3a	181.3a	90.5a
Conventional sucker	No-mulch	61.2b	102.3b	124.6b	73.4b
	Mulch	67.4c	120.2c	171.2c	83.6c

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 11. Effect of plantain genotype, containerized and mulching conditions on peel weight (g).

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	42.8b	68.8b	86.5b	61.8b
	Mulch	49.1a	81.7c	109.8c	72.3c
Conventional sucker	No-mulch	43.2b	68.3b	83.8b	65.4b
	Mulch	52.4a	88.0a	116.8a	80.4a

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

Table 12. Effect of plantain genotype, containerized and mulching conditions on pulp to peel ratio.

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	1.50a	1.50b	1.65a	1.27a
	Mulch	1.47a	1.64a	1.62a	1.25a
Conventional sucker	No-mulch	1.42a	1.50b	1.49b	1.12b
	Mulch	1.29b	1.37c	1.47b	1.04c

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

the containerized planting materials (**Table 13**). FHIA 21 produced the highest number of suckers whilst Oniaba had the lowest number of suckers with or without mulch.

4. Discussion

The increased yield per hectare observed for all the genotypes with the containerized materials over the conventional materials was due to the higher plant survival rate after transplanting. The greatest advantage of container production over field production may be seen in establishment success after transplanting or in transplant quality [15] [16].

Table 13. Effect of plantain genotype, containerized and mulching conditions on number of suckers at flowering.

Type of planting material	Mulching	Cultivar			
		Apem	FHIA 21	Apantu	Oniaba
Containerized sucker	No-mulch	6.5d	7.1b	7.3c	5.5b
	Mulch	8.2a	10.0a	8.4a	7.3a
Conventional sucker	No -mulch	5.5b	6.5b	6.4b	4.6b
	Mulch	7.1c	9.1a	7.4c	6.8c

Values with the same letters in the same column are not significantly different (P = 0.05) by DMRT.

The larger bunch yield observed in FHIA 21 may be a function of its genetic make-up and could be attributed to a stronger competitive sink. Variability in efficiency of resource conversion to dry matter has been observed in *Musa* species and may be related to differences in genomes [17] [18].

The results of the study showed that EFB mulch treatments significantly improved plant growth, bunch yield and yield components of plantain. Growth and yield increases as a result of mulching were due to the fact that water conservation improved physical and chemical properties of soil and enhanced biological activities [19] [20]. Surface mulching reduces evaporation and increases infiltration which result into more water availability for crop growth. The positive responses of plant growth to EFB mulch are attributed to improvement in the soil moisture regime, soil structure, organic matter content and microbial activity, and reduction in soil erosion and nutrient losses and soil surface temperature [21] [22]. The benefits of organic mulch in plantain production are well known by farmers and have been documented [23]. Field research has shown positive plantain response to organic mulch such as elephant grass [9] [12] wood chips, sawdust and cassava peels [9] [13].

Reduction in the number of days to flowering was attributed to the combined effects of containerized condition and mulching. This is as a result of improvement in early establishment and growth of the transplanted suckers. [5] reported that container production has many advantages over traditional in-ground (field) production due to less damage occurring to the root system when transplanted and better establishment after transplanting.

The observation that mulching significantly increased the number of suckers produced is as a result of positive plantain response to organic mulch as has been reported [9] [12] [13].

5. Conclusions

Plantains require high amount of organic mulch for high yielding. From the results of this study, it was found that EFB mulch is effective in enhancing the plantain yield, and yield components and water use efficiency by the crop. Therefore EFB mulch bears a significant beneficial impact on the soil water conservation and nutrient supply for plantain production.

Raising plantain suckers in containers and mulching them with EFB after transplanting significantly reduced the mortality rate, maturity period and increased yield per hectare of plantain genotypes.

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