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Plantain Ratooning Pattern and Associated Plant Parasitic Nematode Densities As Influenced by Paring and Organic Mulch Types

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Abstract--The study assessed the effects of paring, oil palm bunch refuse and sawdust mulches on growth performance of the first three suckers following plantain mother plant. A 2 x 3 factorial experiment was laid out in a randomized complete block design on the field in Akure, Nigeria. At flowering of each mother plant, growth parameters of each of the three suckers were measured and population densities of plant parasitic nematode in the rhizosphere of the flowered plants were assessed. Results showed that mulching and paring impacted positively on suckering pattern. The better growth performance was obtained on mats mulched with oil palm bunch refuse and this is related to the higher nutrient level obtained in the rhizosphere compared with that of the sawdust mulch and the control. Therefore, the result of this study placed emphasis on the importance of the quality of the selected mulch materials. Generally, paring enhanced the benefit derived from mulch but the level or extent of the benefit is accentuated by the quality of the mulch material used. This signified that cycling rate is enhanced when planting materials are "cleaned" by physical disinfecting before planting. This is expected to reflect positively on cumulative annual yield. *Helicotylenchus dihystera*, *H. multicinctus*, *Meoidogyne* spp., Pratylenchus coffeae and Radopholus similis were recovered from the rhizosphere of the flowered mother plant. Higher densities of the nematodes were observed in the non-pared treatments compared with the pared and this established paring as an effective pre-plant cultural practice aimed at cleaning plantain sucker planting materials. Additionally, mulch depressed the densities of P. coffeae but not that of *R. similis* implying that organic input may effectively control the former and not the latter. This underscored the complexity of managing plant parasitic nematodes as a result of concomitant parasitism.

Keywords: follower, mother plant, oil palm bunch refuse, plant parasitic nematodes, plantain, ratoon, root health, sawdust, sucker

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INTRODUCTION

Plantain is a large herbaceous perennial with a short underground stem or corm which bears an erect, leafy pseudostem from which bunches eventually emerge, and an adventitious root system (Blake, 1969; Gowen and Quenehervé, 1990). New roots are continuously being produced on plantain until flowering when the plant ceases to produce roots (Beugnos and Champion, 1996., Blomme *et al.,* 1999). Hence after flowering, the development of the inflorescence is sustained by a declining root system.

The disintegration of the root systems at this stage would impair the absorption efficiency of the roots system resulting in increased sensitivity of the plant to water stress (Rotimi *et al*., 2004a) and other constraints such as nutrient deficiency. Negative influence on growth, size of leaves (Blomme, 2000), bunch weight and rate of sucker production would also be expected. Reduction of the root system would also result in poor plant anchorage. Under the weight of a maturing bunch such a plant readily topples over, especially during wet or windy weather (Blake, 1969; Robinson, 1996b; Rotimi *et al*., 2004b).

Other resultant symptoms include stunted growth, chlorosis, lengthening of the crop cycle, reduction in size and number of leaves, reduction in bunch weight and reduction in the production life of the plantain (Sarah, 1989; Gowen and Quenehervé, 1990). It is at this critical stage that the increasing growth of the suckers may be beneficial as they provide additional anchorage to the mother plant and a supplementary source of nutrients for the maturing fruit (Lavigne, 1987).

Moreover, natural senescence of the root system is hastened by the activities of root pathogens (Gowen and Quenehervé, 1990) such as plant parasitic nematodes. Although naturally plantain yield in Nigeria declines heavily after the first crop cycle (Swennen and De Langhe, 1985), plant parasitic nematodes greatly contribute to declining plantation longevity and yield decline (Coyne *et al.,* 2005).

Mulching has been established to substantially reduce the massive yield losses to plant parasitic nematodes on plantain, improve above ground growth and bunch yield per plant while extending plantation longevity (Coyne *et al*., 2005). Since nematodes are readily introduced into clean soil through infested rhizomes and suckers, all planting material should be produced in nematode free soils. This is not often the case though, therefore, infested rhizomes or suckers must be treated to remove nematodes. The simplest method consists of paring the rhizomes superficially to remove lesioned tissues.

Paring has also been reported to improve the hardiness of plantain as Olaniyi (2006) reported that it helped planted suckers withstand the stress of the short period of drought of the dry season in Nigeria and also enhanced plant establishment. However, the effect of paring on plantain cycling is not known. This study investigated the effect oil palm bunch refuse and sawdust mulches on vegetative growth response of three subsequent suckers following the flowering of the mother plant.

MATERIALS AND METHOD

Experimental Site

The experiment was carried out at the Crop Section of the Teaching and Research Farm (Crop Section) of the Federal University of Technology, Akure. Akure lies between latitude 5^{o}N of the equator and is within the tropical rain forest belt, with an average annual rainfall of about 1613mm per annum and an annual mean temperature of about 27^{o}C.

The experiment had been laid out six (6) months before the observations made in this study commenced. Therefore, details on experimental design and layout are provided elsewhere (Olaniyi, 2006). The experiment was multifactorial with six treatment combinations arranged in a randomized complete block design (RCBD) in three replicates. Factors investigated were two (2) levels of paring (i.e. pared and not pared) and three (3) levels of mulching (oil palm bunch refuse, sawdust and no mulch). This gave a total of six treatment combinations. Each treatment was assigned to a plot making a total of six plots (representing the treatments) per block. Plants were arranged within plots at 2 m x 3 m spacing between and within rows respectively. Each plot was separated from the next by a 3 m alley while blocks were separated by 4 m alleys. Each plot had six plants.

The soil at the experimental site is sandy, have high clay content, prone to compaction, and low fertility and organic matter content (Ewulo, 2004). Pre-plant soil examination revealed *Helicotylenchus multicinctus, Helicotylenchus dihystera, Meloidogyne spp*, *Radopholus similis,* and *Pratylenchus coffeae* are the predominant plant parasitic nematodes in the field (Olaniyi, 2007).

Treatments and Field Establishment

Before the observation reported in this study began, mulch had been applied at the base of each plant six months after field establishment to plants that received the mulch treatments (Olaniyi, 2006). Five months after, mulches were renewed at the rate of $4.1cm^3$ per plant after the previously applied mulch had decayed. This represented 9.7kg per plant for the oil palm bunch refuse and 3.75kg per plant for the sawdust. Earlier, chemical analysis of the mulch materials showed that oil palm bunch refuse had 7.71% N, 928.3 ppm P and 0.43 Cmol/kg; while sawdust had 2.63% N, 361.9 ppm P and 0.13 Cmol/kg K (Olaniyi, 2008).

History of the field revealed that weeds were controlled in the field by manually slashing at 4 weeks interval until January 2006, and between March and July, 2006. When manual weeding could not be sustained due to high rate of weed growth and cost, chemical control was then employed with glyphosate at the rate of 3.5kg a. i. per hectare. Herbicide was applied three (3) times between August 2006 and May 2007. Application of NPK 12-12-17-MgO fertilizer was done a couple of times (8 and 14 MAP) at the rate of 60g and 30g respectively, in band per plant. No fungicide was applied throughout the duration of the experiment (Olaniyi, 2007). The experiment was rain-fed and no additional irrigation was provided.

Estimation of Plant Growth and Suckering

Successive emergence of the first three suckers was noted and at flowering of mother plant, above ground growth parameters of each sucker were measured. Parameters included: height of pseudostem from soil level to the point of intersection of the last furled and the unfurled leaves (HT), girth / circumference of pseudostem at soil level (GTH), number of green (functional) leaves (GLV), and dead (non-functional) leaves (DLV). A leaf is said to be green if at least 75% of the surface area was green. The area of the youngest leaf opened (YLA) was computed as length x width of the youngest leaf opened x 0.83 (Obiefuna and Ndubizu, 1983).

Estimation of nematode population densities from the rhizosphere of the flowered mother plants

At flower initiation of the mother plant, soil samples were taken from a 20 x 20 x 20cm^3 excavations was dug at the base of each mother plant. The soil samples removed where pulverized gently with hand and pebbles removed. Nematodes were extracted from 100g of each sample while the remaining portion was used for soil mineral analysis. Nematodes were extracted with the modified Baermann funnel method (Hopper, 1990). The setup was left to rest for 18 hours during which active nematodes migrated from the sieve into the dish. The filtrate (nematode suspension) was collected, left to stand for 8 hours before reducing to 30ml with a siphon. Three 2 ml aliquots of each suspension were separately taken for nematode identification and population density counts. The plant parasitic nematodes were identified to species level under a light microscope and their population densities extrapolated accordingly. Except for *Meloidogyne* spp., population density of each species was calculated as the sum of all developmental stages (juveniles, females and males). For *Meloidogyne* spp, only the vermiform juveniles and the males could be recovered by the extraction method used, and their sum thus constituted the population. Densities were estimated per litre of soil.

Data analysis

The nematode population densities were log(x+1) transformed (Gomez and Gomez, 1984), while other count data were square root transformed prior to using the General Linear Model (GLM) in Statistical Package for Social Science (SPSS) software. Where statistical differences were observed, means were separated using the Duncan Multiple Range Test (DMRT).

RESULTS

Effect of paring and mulch types on some selected growth parameters of the first ratoon suckers at the inception of flowering of mother plants

The first sucker that emerged after the mother plant is subsequently referred to as the first follower sucker on the mat, the next referred to as the second follower and the sucker emerging third as the third follower suckers. These suckers generally constitute the first second and third ratoon crops of the mats respectively.

The pared treatment that received oil palm bunch refuse had the tallest plant although generally, whether pared or not, plants mulched with oil palm bunch refuse had significantly ($P\leq0.05$) taller suckers than other treatments (Table 1).

Pared plants that were mulched with oil palm bunch refuse also had first follower sucker with thicker pseudostems, more functional leaves with larger areas. Generally, the non-pared plants that were not mulched had the poorest performing first ratoon suckers.

TABLE 1:

EFFECTS OF PARING AND MULCH TYPES ON SELECTED GROWTH PARAMETERS OF THE FIRST RATOON SUCKERS AT FLOWERING OF MOTHER PLANTS.

Treatments	HT(cm)	GTH(cm)	GLV	LA(cm2)
PMO	110.9a	21.98a	5.2a	8990.3a
NPMO	92.67b	18.66b	4.0b	5800.6b
PMS	88.5bc	17.55b	3.75b	4725.4b
NPMS	79.65c	17.11bc	3.70b	4830.4b
PMN	78.56c	17.50b	3.50b	1650.0c
NPMN	78.86c	15.89c	3.15c	924.8d
N	52	52	52	52

HT: height of pseudostem; GTH: girth of pseudostem; GLV: number of green or functional leaves; LA: area of the youngest leaf opened; PMO: pared &mulched with oil palm bunch refuse; NPMO: not pared but mulched with oilpalm bunch refuse; PMS: pared and mulched with sawdust; PMN: pared but not mulched; NPMN: not pared but mulched with sawdust.

Effect of paring and mulch types on some selected growth parameters of the second ratoon suckers at the inception of flowering of mother plants

The result as shown on Table 2 revealed a significantly taller rations produced in mats mulched with oil palm bunch refuse and pared (PMO) with an average height of 95.6cm when compared to other treatments. This was closely followed by NPMO which was significantly different from PMN and NPMN but not from NPMS. The PMS and NPMS were both significantly taller than NPMN but not from PMN. Moreover, PMN and NPMN were found not to be significantly taller than each other.

The PMO suckers were significantly thicker than those in NPMO which in turn was significantly thicker than the sawdust mulched and not mulched ones (pared or not pared). The sawdust mulched ones were also significantly thicker than the not pared and not mulched ones (NPMN) but not than the PMN. However, the PMN and the NPMN were found not to be significantly thicker than each other.

The functional leaves in PMO were significantly higher than the other treatments. Meanwhile, NPMO, PMS, NPMS and PMN were significantly higher than that o NPMN, NPMS and PMN were not considering the leaf area (cm^2), PMO was significantly larger than PMS and NPMS. These, in turn were larger significantly than NPMO; which in turn was larger than PMN and NPMN significantly ($P\leq0.05$).

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TABLE 2

EFFECTS OF PARING AND MULCH TYPES ON SELECTED GROWTH PARAMETERS OF THE SECOND RATOON SUCKERS AT FLOWERING OF MOTHER PLANTS

Treatments	HT(cm)	GTH(cm)	GLV	LA(cm2)
PMO	95.6a	17.23a	3.75a	4074.2a
NPMO	55.67b	14.54b	3.25b	2343.6c
PMS	50.75bc	9.75c	2.85b	3444.1b
NPMS	50.10bc	9.75c	2.50bc	3360.6b
PMN	48.95cd	8.90cd	2.25bc	448.78d
NPMN	43.95d	8.50d	2.0c	468.1d

HT: height of pseudostem; GTH: girth of pseudostem; GLV: number of green or functional leaves; LA: area of the youngest leaf opened. PMO: pared &mulched with oil palm bunch refuse; NPMO: not pared but mulched with oil palm bunch refuse; PMS: pared and mulched with sawdust; PMN: pared but not mulched; NPMN: not pared but mulched with sawdust.

Effect of paring and mulch types on some selected growth parameters of the third ratoon suckers at the inception of flowering of mother plants

The result shown on table 6 revealed that the oil palm bunch refuse mulched mats produced the tallest suckers. These were significantly taller than the sawdust mulched ones and the not mulched. Meanwhile, the sawdust mulched ones pared or not was not different from the pared but not mulched (PMN) plants but differed from the not pared and not mulched (NPMN) plants. Moreover, the PMN and NPMN plants were statistically not significantly different from each other (P≤0.05).

The PMO ratoons were also the thickest and significantly different from the NPMO ratoons, which in turn was thicker than the ones found under all the remaining treatments. All the remaining treatments though were not significantly different from each other. The result also shows that mulching improved the production of more functional and larger leaves than the not mulched treatments. The pared plants that were mulched with oil palm bunch refuse outperformed other treatments, while the not mulched plants had the least performance.

TABLE 3

EFFECTS OF PARING AND MULCH TYPES ON SELECTED GROWTH PARAMETERS OF THE THIRD RATOON SUCKERS AT FLOWERING OF MOTHER PLANTS.

Treatment	HT(cm)	GTH(cm)	GLV	LA(cm2)
PMO	47.8a	15.27a	2.75a	3200.1a
NPMO	37.25a	12.45b	2.50b	672.8c
PMS	12.25b	9.00c	2.55b	846.4b
NPMS	13.55b	9.25c	2.65b	816.56b
PMN	9.85bc	8.90c	2.00c	341.7d
NPMN	8.88c	8.75c	2.25c	288.6d
N	52	52	52	52

HT: height of pseudostem; GTH: girth of pseudostem; GLV: number of green or functional leaves; LA: area of the youngest leaf opened; PMO: pared &mulched with oil palm bunch refuse; NPMO: not pared but mulched with oil palm bunch refuse; PMS: pared and mulched with sawdust; PMN: pared but not mulched; NPMN: not pared but mulched with sawdust.

Effect of paring and mulch types on plant parasitic nematodes extracted from the rhizosphere of flowered mother plants

Five plant parasitic nematode species namely *Helicotylenchus dihystera*, *H. multicinctus*, *Meoidogyne* spp., *Pratylenchus coffeae* and *Radopholus similis* were recovered from the rhizosphere of the flowered mother plant (Fig 1). Composition of the species differed under the different treatments. Higher densities of nematodes were recovered from the non-pared, non-mulched treatment while the density of *P. coffeae* in this environment was the highest in all the environments. *Helicotylenchus dihystera* was detected in only the non-pared non-mulched treatments while *H. multicinctus* was present in all the treatments. *Meloidogyne* spp. density was higher in the non-pared compared with pared treatments irrespective of mulch type. Higher densities of *R. similis* were generally obtained in mulched treatments with higher values when not pared compared with pared.

Apart from *R. similis*, plant parasitic nematode population densities were lower in the mulched treatments than in the not mulched (Fig 1).

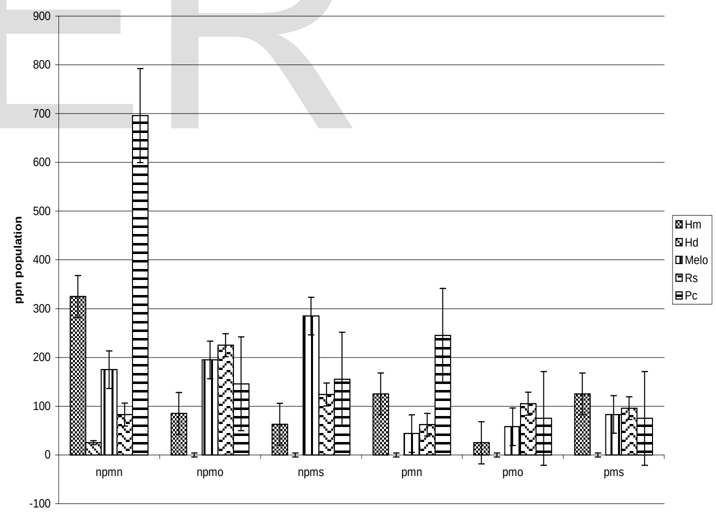

Fig1. Nematode densities extracted from rhizosphere of mother plant at flowering.
Hm: *Helicotylenchus multicinctus*; Hd: *H. dihystera*; Melo: *Meloidogyne* spp; Rs: *Radopholus similis*; Pc: *Pratylenchus coffeae;* NPMN: not pared and not mulched; NPMO: not pared but mulched with oilpalm bunch refuse; NPMS: not pared but mulched with sawdust; PMN: pared but not mulched; PMO: pared &mulched with oil palm bunch refuse; PMS: pared & mulched with sawdust;.

Effect of paring and mulch types on chemical properties of the soil at flowering of mother plants

The mulch materials did have obvious effects on the chemical properties of the rhizosphere of the mats at flowering of the mother plants. The mulched rhizospheres had higher nitrogen, potassium, phosphorus, and magnesium contents. They also had higher organic matter content; 10.23% and 9.89% for MO and MS respectively as against 8.7% for MN. The pH increased to a slightly acidic level; 6.52 and 6.38 for MO and MS respectively when compared to 6.04 for MN. The phosphorus level for MO (9.93cmpl/kg) was particularly higher as compared to its level in MS (4.12cmol/kg) and MN (1.68cmol/kg). The same trend, as observed with phosphorus levels, was also observed for potassium; 6.82ppm for MO, 2.43ppm for MS and 1.37ppm for plots that were not mulched. Nitrogen was 1.22% for oil palm bunch refuse-mulched treatments, 1.08% for saw dust-mulched and 0.66% for the non-mulched treatment. However, the reverse was the case in calcium content level with the non-mulched having the highest level of 5.11cmol/kg, 3.95cmol/kg for sawdust mulched and oil palm bunch refuse mulch having 4.13cmol/kg (Table 4).

TABLE 4

CHEMICAL PROPERTIES OF THE SOIL AT FLOWERING OF MOTHER PLANTS

TRT	N (%)	OM (%)	K (PPM)	P (CMOL/KG)	MG (CMOL/KG)	CA (CMOL/KG)	PH
MO	1.2	10.2	6.8	9.9	2.2	4.1	6.5
MS	1.08	9.89	2.4	4.1	1.0	4.0	6.4
MN	0.66	8.7	1.4	1.7	0.8	5.1	6.0

TRT: treatment; N: Nitrogen; OM: organic matter; K: potassium; P: Phosphorous; Mg: Magnesium; Ca: Calcium; MO: soil under Oil palm bunch refuse mulch; MS: sawdust mulch; MN: Not mulched soil.

DISCUSSION

The result of this study showed that mulching and paring impacted positively on sucker production and growth parameter. Mulch is reputed to improve plantain root production and growth (Salau *et al.*, 1992; Olaniyi and Opadare, 2006). Hence, the roots and rhizomes of the mulched plants would have become more active. Such increased activity could have resulted into an increased cytokinin /auxin ratio in the root tips. Once cytokinin production is increased, the lateral buds on the corms would become more active and the apical dominance suppressed for a while; thus resulting into better growth performance of suckers produced in the mulched treatments.

Meanwhile, Swennen and De Langhe (1985) had earlier confirmed that fast growing mother plants would be accompanied by fast growing ratoons. Hence, suckers with better growth at flowering of mother plant would not be a burden on the main plants. The expanded leaves of the fast growing ratoons would have ceased to be a sink and become source of production of photosynthate. In accord, Teisson (1970) demonstrated that suckers could contribute to the nutrition of the mother plant and Shammugavelu *et al.* (1992) proved the interdependence of suckers with expanded leaves for photosynthate production. Therefore, it is logical to conclude that the high pre-flowering sucker production of mulched plants could be a factor that contributed to the improved growth of the main plants (Olaniyi, 2014 in press).The better performance of followers on mats that were established with pared suckers that received mulch then means that the mother plant benefited from this and the impact is expected to be reflected on the yield. Consequently, yield performance of these treatments should be compared

The better grown suckers of mulched plants at flowering of mother plants observed in this study implied that cumulative photosynthate production on the mat would have been enhanced. Hence the mother plant, which is the preferred sink in this phase, would have benefited more from the partitioning of the cumulative photosynthate produced on the mat. More so at flowering, when root development ceases and deterioration progresses at a very fast rate (Beugnon and Champion, 1996), the connection of the mother plant to the suckers would have beneficial effects on growth and further development of the filling fruits. This assumption needs to be further verified.

The chemical analysis of the soil samples taken at flowering showed that the oil palm bunch refuse mulch enhanced soil nutrients in the rhizosphere of the plants. It had a statistically higher content of Nitrogen (N), Phosphorus (P), Potassium (K), organic matter (OM) and other secondary elements analyzed compared to the sawdust mulched and the non-mulched rhizospheres respectively. It also improved the pH of the soil. Since the soil nutrient status is a major factor affecting the above-ground growth of plantain (*Musa* spp. cvr. Agbagba), then the better performance of the mats mulched with oil palm bunch refuse would be related to their higher nutrient status compared to that of the sawdust mulch and also the control. For instance, Purseglove (1972) confirmed the importance of Potassium to plantain production as being responsible for stimulation of good vegetative growth. Therefore, the result of this study placed emphasis on the importance of the quality of the selected mulch materials, as it primarily dictated the level of beneficial minerals available to the plants and the effect on plantain growth.

Generally, paring enhanced the benefit derived from mulch but the level or extent of the benefit is determined by the quality of the material used. This signified that when planting materials are “cleaned” by physical disinfecting before planting, cycling rate is enhanced and this is expected to be reflected positively on cumulative annual yield.

The effect of mulch on the densities of *Helicotylenchus dihystera* observed in the rhizosphere of the mother plantain plants in this study did not seem to be clear as it remained at an undetectable level in most of the treatments. Even in the root where it was detected in most of the treatments, it was at a generally low level (Olaniyi, 2014 in press). The presence of *H. multicinctus* in all the treatments in this study is in accord with the report of Speijer *et al*. (2001) who observed that the species was ubiquitous on plantain in Nigeria. Population densities of juveniles of *Meloidogyne* spp were generally lower under mulch than non-mulched and it is likely that natural enemies predominant in the mulch environment (Riegel *et al.*, 1996; Atungwu *et al.*, 2012) helped to keep its density at low levels in the mulch environment.

Contrary to earlier reports (Speijer *et al*., 2001; Rotimi *et al.,* 2004 a & b), densities of *H. multicintus* were not always higher than other species in this study. Populations of *R. similis* were higher in organic soil, being statistically higher in mulched treatments when the planting materials were not pared prior to planting. The opposite was the case for *P. coffeae* whose densities declined in mulched treatments and was further depressed when planting materials were pared prior to planting. This indicated that organic mulch may not depress *R. similis'* population. Therefore, in an organic environment where *P. coffeae* that is considered as the primary species most damaging on plantain in Nigeria (Speijer *et al.,* 2001) might have been effectively controlled, *R. similis* density may surge to become a primary spp. (Rotimi and Speijer, 2004). This underscores the big challenge often encountered in the management of plant parasitic nematodes because of concomitant parasitism.

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