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Influence of planting dates and mulch application on the productivity of late season banana in Owerri, Southeastern Nigeria

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ABSTRACT: A study to determine the influence of planting dates and mulch application on the productivity of late season banana in Owerri, Southeastern Nigeria, was carried out at the teaching and research farm of Federal University of Technology, Owerri Research Farm. A split plot design was used for the experiment, with the main plots comprised of three planting dates of 1st of September, October and November in each case and the sub-plot treatments comprised of six mulch types, namely: black polyethene, wood shavings, sawdust, palm bunch refuse, trash and the unmulched plots (control plots). The three main plot treatments were randomised within each main block, and the sub-plot treatments were randomised within each main plot. The land was cleared and prepared manually, using a planting depth of 60 x 60 x 60 cm in a planting distance of 2 x 3 m. Growth and yield data of banana were collected and analysed using Genstat, while mean separation was done using the least significant differences (LSD) at 5% level of probability. The results obtained revealed that planting dates and mulch materials significantly ($p<0.05$) improved the late season banana productivity. Bananas in plots planted in September and mulched with palm bunch refuse recorded the earliest days to 50% flowering in the plant crop (268.90 days), while the bananas planted in September and mulched with sawdust flowered earliest (263.50 days) in the first ratoon crops. Bananas planted in September showed significant improvement in all the reproductive and yield characters, and heavier bunches were recorded in (9.97 t ha^{-1}), number of hands per bunch (8.67), number of fingers per bunch (95.67) and the heaviest individual finger (94.67g/finger) was obtained from the bananas planted in September and mulched palm bunch refuse. Furthermore, the bananas planted in September and mulched with sawdust produced the longest and largest individual 12. 2MAP. The bananas planted in September and treated with sawdust produced the heaviest bunches (7.23 t ha^{-1}), the highest number of hands per bunch (6.67), total number of fingers per bunch (74.00), heaviest finger (40.43 g/finger), longest finger (7.90 cm) and largest finger (5.90 cm) at harvest of the first ratoon crop. Main plant crops recorded a higher yield than the first ratoon crop production. Bananas mulched with palm bunch refuse produced the highest crop yield in the main plant crop, while those mulched with sawdust and wood shavings recorded the highest in the ratoon crop yield. Late season bananas should be mulched with palm bunch refuse, sawdust and wood shavings for increased productivity.

Keywords: Banana, late season, mulch materials, planting dates, productivity.

INTRODUCTION

Banana is a crop found in the humid tropics and sub-Saharan Africa, including high rainfall areas of southern Nigeria, which include Akwa-Ibom, Cross-River, Imo, Enugu, Rivers, Edo, Delta, Ogun, Osun and Oyo States (Salau *et al*., 2016; Ayanwale *et al*., 2016). It is among the most important staple food crops in the humid forest zone

of West and Central Africa. It has the potential to contribute to strengthening the nation's food security and reducing poverty (Odemero, 2013). It is an important part of the diet of Nigerians and in most West African countries. The possibility of maintaining continuity of supply throughout the year makes it a basic component of the farming system in many areas of Sub-Saharan Africa (Faturoti *et al*., 2019). Malnutrition rarely occurs in areas where bananas and plantains are widely grown, since they are rich in many essential nutrients such as iron, zinc and beta-carotene; they can also be processed to substitute many staple crops such as yams (*Discorea* sp.) and cassava (*Manihot* sp.) (Faturoti *et al*., 2019). Food security is the access by all people at all times to have enough food for active and healthy lives (FAO, 2001). Banana, a key food security cash crop, has been feeding millions of people worldwide (FAO, 2021). It has become a key source of revenue as they are not only traded within countries but also exported for foreign exchange. The status change from food to food/cash crop has enhanced its importance (Odemero, 2018). Banana is of high commercial interest as it is an important source of income and employment for many households, as well as a source of income, nutrition and food security. Banana is the second most important fruit in the world after tomatoes, with 115.74 million metric tons in a year (FAO, 2006; FAO, 2005). It is an important fruit in tropical and subtropical regions and an essential staple food for many developing countries. Banana is among the world's most popular fruit and food crop cultivated after rice, wheat and maize (Aurore *et al*., 2009; Woldu *et al*., 2015). Bananas are very convenient for snacks on the go, coming with their protective case and easy peel with no washing required, providing a fifth of the recommended daily B6 vitamins. They help metabolise proteins, fats and carbohydrates. They are a good source of vitamin C for immunity 10%, fibre for digestion (2.6 grams) (Britannica, 2024). The use of proper mulch materials during dry seasons will help to conserve the moisture content of the soil and make water available for the banana plants. The use of organic mulches has been a common practice in the production system in southeastern Nigeria because their agroecology is characterised by high annual rainfall (2500 mm) and temperature (20-32°C) (Emma-Okafor *et al*., 2019), which encourages fast weed development, excessive evaporation, and consequently wilting of the Musa species. Mulching with organic mulch lowers soil temperature at the root zones, smoothes weeds and improves the soil's physical, chemical and biological properties and crop productivity (Okoli *et al*., 2020; Ibeawuchi *et al.,* 2008). The seasonal fruiting habit of the banana placed the crop in a superior position in bridging the hunger gap between crop harvests. In Africa, banana production and supply are highly seasonal. Early season banana planting results in an abundance of banana fruits between July and December, which results in fruit scarcity from January to June, making the banana fruit very costly and scarce (Alagba *et al*., 2017). To secure better prices during the off-season, it is therefore required that dry season banana production is encouraged to reduce the scarcity of banana during these periods of scarcity and to directly increase the farmers' income (Ara *et al*., 2011).

MATERIALS AND METHODS

The experiment was conducted at the Teaching and Research Farm of the School of Agriculture and Agricultural Technology, Federal University of Technology Owerri, located 5°20 N -5°27 N and longitude 7°02E-7°07E at an elevation of 55 m above sea level in the rainforest zone of southern Nigeria (Onweremadu and Peter, 2016). The area has a bimodal rainfall pattern with peaks in July and September, a minimum and maximum annual temperature of 20°C and 32°C respectively, mean annual rainfall of 2316 mm and relative humidity of 85 - 89% (Adegun and Balogun, 2015). The soils are deep, porous and derived from sand deposits of the coastal plains, which are highly weathered, low in mineral reserve and natural fertility (Onweremadu *et al.,* 2007; Ononiwu, 1990). Soil samples were collected from the field of the experiment at 0-30 cm depth randomly using a soil auger after clearing the experimental site for soil physicochemical characterisation. The collected soil samples were air dried in the laboratory, ground and sieved using a sieve pan of 2 mm and were analysed for physicochemical properties as described by Ojo *et al*. (2015).

Experimental design

Allocations of various treatments were done using Gomez and Gomez (1984), Table of random numbers. A split-plot design was used in the study. The whole plot or main plot comprised the three planting dates, September 1st, October 1st, and November 1st, while the sub-plot treatment comprised six mulch types, namely: black polyethene, wood shavings, sawdust, palm bunch refuse, trash and the unmulched plots (control plots). The three whole treatments were randomised within each main plot, and the sub-plot treatments were randomised within each main plot. The experimental plot contains four (4) stands per plot, that is, seventy-two (72) stands of banana suckers per replication, with a total of 216 stands of banana suckers. All the 4 stands of banana suckers were used as sample plants for data collection.

Land preparation and planting

A two-year fallow farm was selected as the experimental site. This was mapped out using measuring tapes, ranging poles, pegs, ropes and was later cleared manually,

stumped and packed with the aid of machetes, hoes, spades and axes. An experimental plot size of 60 x 30 meters (m) was used (1800 m^2) with a 1 m alley at the boundaries of the experimental plot. A hole with a depth of 60 x 60 x 60 cm was dug, separating the topsoil from the subsoil according to CTA (1987). Uniform sword suckers (1 m) height were planted at the planting spaces of 3.0 x 2.0 meters on the 1st day of each of September, October and November (2021), which continued into 2022 to 2024 for the ratoon crop. The suckers with a height of 1 m were sourced from a healthy banana plantation from the FUTO Research Farm. The suckers were allowed to dry in the shade overnight before planting. Each sword sucker was put in each hole and was covered with topsoil, and then trampled upon to firm the stand and then covered with the subsoil.

Poultry manure application

The cured poultry manure was procured from the Livestock Farm of the Federal University of Technology, Owerri. It was weighed using a weighing balance (50 kg Salter Scale) and was applied at the rate of 10 t ha^{-1} in one dose. Each plant received a total of 6 kg of poultry manure, which was incorporated in each depth and was spread in a circumference around the base of the pseudostem after covering the pseudostem with topsoil that was dug out from the planting holes. The manure was spread in such a way as to cover the base of the planting hole.

Mulching

After planting the sucker, 2 kg of each mulch material, apart from the black polythene, was weighed out on the weighing balance of a 50 kg salter scale and was spread around each depth of banana holes respectively. The mulch was spread around the base of the banana pseudostem above the poultry manure layer. The back polyethene was perforated and was spread at the base of the banana sucker above the poultry manure layer. The control plot received the same quantity of manure but was not mulched.

Data collection

Days to 50% flowering

Days to 50% flowering were taken by counting the number of days within which 50% of the banana flowered in each treatment. It is determined by counting the number of days it took for 50% of the sampled plants to flower, and the values were averaged per plot for plant and for ratoon crops.

Harvest of banana

The banana bunches were harvested when they were fully mature in each plot and were weighed with a 50 kg salter scale. The bunch weight was converted to tons per hectare, while the number of hands and fingers was determined by taking a physical count of the hands in each bunch and fingers in each hand. The values were averaged per plot for plant and first ratoon crops.

RESULTS

Days to 50% flowering for the plant crop and first ratoon crops

The number of days to 50% flowering in the late season banana plant crop (Table 1) showed a highly significant ($p<0.05$) influence of planting dates, mulch materials ($p<0.05$) and their interactions ($p< 0.05$). The longest days to 50% flowering were recorded in the bananas planted in the unmulched plots of November (314.20 days), followed by those planted in the control plots of October (304.27 days), while the earliest days to 50% flowering were obtained from the bananas in plots planted in September and mulched with palm bunch refuse (268.90 days). The results (Table 1) highlighted the effects of planting dates, mulch materials and their interactions on days to 50% flowering of the first ratoon of late season banana, which showed that only the application of mulches significantly ($p<0.05$) influenced days to 50% flowering. The bananas planted in the control plots and established in October flowered the latest (309.30days), while the closest days to 50% flowering were obtained from the bananas in plots planted in September and mulched with sawdust, which flowered earliest (263.50days), and this was followed by those in plots planted in September and mulched with wood shavings (272.20 days).

Bunch weight (t ha^{-1}), number of hands per bunch and total number of fingers per bunch in late season banana at harvest of plant crops

The results in Table 2 showed the effect of planting dates, mulch materials and their interaction on bunch weight, number of hands per bunch and number of fingers per bunch at harvest of the plant crop of late season banana**.** Results indicate that there was a significant ($p<0.05$) effect of planting dates, mulch materials and their interactions on bunch weight, while planting dates and mulch materials significantly ($p<0.05$) improved the number of hands per bunch and number of fingers per bunch in late season banana at harvest of the plant crop. The interaction of planting dates and mulch materials showed no significant effect on the number of hands per bunch and the number

Table 1. Effects of planting dates and mulch materials on days to 50% flowering of the plant crop and the first ratoon crop of late season banana.

Mulch materials	Harvest periods/Planting dates							
	Plant crop				First ratoon crop			
	Sept1	Oct1	Nov1	Mean	Sept1	Oct1	Nov1	Mean
Blackpolyethene	283.07	284.27	290.80	286.05	277.30	280.90	285.30	281.2
Woodshavings	279.90	282.70	283.70	281.90	272.20	284.20	286.20	280.9
Palm bunch refuse	268.90	271.60	280.87	273.79	274.70	275.70	277.90	281.2
Sawdust	270.60	277.73	279.23	277.85	263.50	273.60	275.70	270.9
Trash	282.47	284.57	292.07	286.37	295.60	298.60	304.00	299.4
No mulch	283.10	304.27	314.20	300.52	299.20	309.30	305.30	304.6
Mean	279.01	284.19	290.05	284.41	280.42	287.05	289.06	285.5
LSD (0.05) planting dates				2.52				7.16(ns)
LSD (0.05) Mulch materials				4.97				8.39
LSD (0.05) Mulch x planting dates				8.05				14.20(ns)

Table 2. Effect of planting dates and mulch materials on bunch weight (t ha^{-1}), number of hands per bunch and number of fingers per bunch of the late season banana at harvest of the plant crop.

Mulch materials	Yield data/Planting dates											
	bunch weight (t ha^{-1})				number of hands per bunch				total number of fingers per bunch			
	Sept1	Oct1	Nov1	Mean	Sept1	Oct1	Nov1	Mean	Sept1	Oct1	Nov1	Mean
Blackpolyethene	8.07	5.93	5.37	6.46	7.33	7.00	6.67	7.00	84.33	84.33	78.67	82.44
Woodshavings	8.57	6.70	6.00	7.09	8.00	7.50	7.00	7.50	85.00	86.67	80.67	84.11
Palm bunch refuse	9.97	9.53	7.57	9.02	8.67	8.00	8.00	8.22	95.67	89.00	88.78	91.15
Sawdust	9.00	7.50	6.43	7.64	8.33	8.25	8.00	8.19	88.00	84.00	85.67	85.89
Trash	8.20	6.90	6.43	7.18	7.00	6.90	6.33	6.74	78.67	75.67	70.00	74.78
No mulch	6.53	5.20	4.27	5.33	6.33	5.67	5.55	5.85	51.33	41.67	41.00	44.67
Mean	8.39	6.96	6.01	7.12	7.61	7.22	6.93	7.25	80.50	76.89	74.13	77.17
LSD $_{(0.05)}$ Planting dates				0.33				0.78				3.20
LSD $_{(0.05)}$ Mulch materials				0.55				0.46				4.52
LSD $_{(0.05)}$ Mulch x planting dates				0.89				1.66(ns)				7.31(ns)

of fingers per bunch. The heaviest bunch weight (t ha^{-1}) was recorded in the banana plots planted in September and mulched with palm bunch refuse (9.97 t ha^{-1}), followed by those planted in October and mulched with the same (9.53 t ha^{-1}). The lightest bunch (t ha^{-1}) was recorded in the banana plots of the control planted in November (4.27 t ha^{-1}). Bananas planted in September and mulched with palm bunch refuse recorded the highest

Table 3. Effects of planting dates and mulch materials on bunch weight (t ha^{-1}), number of hands per bunch and total number of fingers per bunch in the first ratoon crops of the late season banana.

Mulch materials	Yield Parameters/Planting dates											
	Bunch weight (t ha^{-1})				Number of hands per bunch				Total number of fingers per bunch			
	Sept1	Oct1	Nov1	Means	Sept1	Oct1	Nov1	Means	Sept1	Oct1	Nov1	Means
Blackpolyethene	4.57	4.23	3.80	4.20	5.00	4.67	3.67	4.44	45.00	48.33	46.67	49.22
Woodshavings	6.80	6.20	6.03	6.34	6.33	6.33	5.33	6.00	71.33	68.67	67.00	69.00
Palm bunch refuse	5.10	4.70	3.93	4.58	5.00	4.67	5.00	4.89	61.00	63.33	57.33	60.56
Sawdust	7.23	6.30	5.67	6.40	6.67	6.33	6.00	6.33	74.00	69.33	65.00	69.44
Trash	4.93	4.23	3.93	4.37	5.00	4.33	5.00	4.78	47.00	44.67	42.00	44.56
No mulch	3.33	3.03	2.10	2.82	4.33	4.00	3.67	4.00	45.00	45.67	43.33	44.67
Mean	5.33	4.78	4.24	4.79	5.39	5.06	4.78	5.07	58.50	56.67	53.56	56.24
LSD $_{(0.05)}$ Planting dates				0.40				0.48(ns)				2..65
LSD $_{(0.05)}$ Mulch materials				0.39				0.59				4.39
LSD $_{(0.05)}$ Mulch x planting dates				0.69(ns)				1.00(ns)				7.19(ns)

number of hands per bunch (8.67) at harvest of plant crop of the late season banana (Table 2), this was followed by those planted in September and mulched with sawdust (8.33). The least number of hands per bunch was recorded in the bananas in the control plots established in November (5.55). The highest number of fingers per bunch was obtained from the bananas in plots planted in September and mulched with palm bunch refuse (95.67), followed by bananas in plots planted in the same month and mulched with sawdust (88.00). The least total number of fingers per bunch was recorded in the bananas in the control plots planted in November (41.00).

Bunch weight (t ha^{-1}), number of hands per bunch and total number of fingers per hand at harvest of the first ratoon crops of late season banana.

The results in Table 3 indicate that the application of mulches significantly ($p<0.05$) improved all the parameters measured, while planting dates significantly ($p<0.05$) favoured the bunch weight (t ha^{-1}) and total number of fingers per bunch in first ratoon crops of late season banana. However, the interaction of planting dates and mulch materials showed no significant difference in all the parameters measured (Table 3). The heaviest late season banana bunches were obtained from the bananas in plots planted in September and mulched with sawdust (7.23 t ha^{-1}), followed by those planted in the same month and treated with wood shavings mulch (6.80 t ha^{-1}). On the other hand, the lowest late season banana bunch yield was recorded from the control plot of November (2.10 t ha^{-1}). The largest hands per bunch was obtained from the bananas in plots established in September and treated with sawdust (6.67), this was followed by those planted in September and October and mulched with wood shavings, and those planted in October and mulched with sawdust, respectively (6.33). The least number of hands per bunch was recorded from the bananas in plots planted in November and mulched with black polyethene (3.67), and the banana plots planted in the unmulched plots of November (3.67), respectively. Banana plots planted in September and mulched with sawdust recorded the highest total number of fingers per bunch (74.00), followed by those planted in the same month that received wood shavings mulch (71.33), while the least total number of fingers per bunch was obtained from the bananas planted in November and mulched with trash (42.00).

Finger weight (g), finger length (cm) and finger girth (cm) in late season bananas at the harvest of the plant crop

The effect of planting dates, mulch materials and their interactions on finger weight (g), finger length (cm) and finger girth (cm) in late season bananas at the harvest of the plant crop. Results in Table 4

Table 4. Effect of planting dates and mulch materials on finger weight, finger length and finger girth of the late season banana at harvest plant crop.

Mulch materials	Planting dates											
	finger weight (g)				finger length (cm)				finger girth (cm)			
	Sept1	Oct1	Nov1	Means	Sept1	Oct1	Nov1	Means	Sept1	Oct1	Nov1	Means
Blackpolyethene	72.33	67.67	52.33	64.11	10.63	10.57	10.10	10.43	8.57	8.30	8.27	8.38
Woodshavings	90.33	83.67	75.67	83.22	11.57	11.53	11.20	11.43	8.92	8.53	8.73	8.73
Palm bunch refuse	94.67	90.33	86.67	90.56	11.87	11.83	11.47	11.72	11.20	10.10	9.53	10.28
Sawdust	93.33	91.67	88.67	91.22	12.10	12.07	11.93	12.03	11.27	10.20	9.57	10.34
Trash	74.00	71.00	54.00	66.33	11.20	10.77	10.53	10.83	8.53	8.73	8.63	8.63
No mulch	58.00	44.33	48.00	50.11	10.73	10.17	9.50	10.13	7.60	6.53	6.47	6.87
Means	80.44	74.78	67.56	74.26	11.35	11.16	10.79	11.10	9.35	8.73	8.53	8.87
LSD (0.05) Planting Dates				3.83				0.36(ns)				0.65(ns)
LSD (0.05) Mulch Mat				4.38				0.72				0.44
LSD (0.05) Mulch Mat x Pdate				7.44				1.16(ns)				0.86

indicate that the planting dates, mulch materials and their interaction significantly ($p<0.05$) favoured the finger weight (g), finger length (cm) and finger girth (cm) of the plant crop in late season bananas. The bananas planted in September and treated with palm bunch refuse produced the heaviest finger (94.67g/finger), which was followed by those planted in the same month and mulched with sawdust (93.33g/finger), while the lightest finger was recorded in bananas of the control plots planted in November (48.00g/finger). The finger length was significantly ($p<0.05$) influenced by the mulch materials, while the planting dates and the interactions of planting dates and mulch materials showed no significant difference in the finger length of late season banana. The longest fingers were recorded from the bananas in plots planted in September and treated with sawdust mulch (12.10). This was followed by those planted in October and treated with the same (12.07), while the shortest fingers were obtained from the bananas in the control plots planted in November (9.50). Mulch materials and the interaction of planting dates and mulch materials significantly ($p<0.05$) increased finger girth; however, the finger girth was not significantly influenced by planting dates. Results (Table 4) showed that bananas planted in September and mulched with sawdust recorded the largest fingers (11.27), while the least fingers were obtained from bananas in the control plots planted in November (6.47).

Finger weight (g), finger length (cm) and finger girth (cm) of the first ratoon crop of late season banana

The effect of planting dates, mulch materials and their interactions on finger weight (g), finger length (cm) and finger girth (cm) of the first ratoon crop of the late season banana at harvest was presented in Table 5. There was a highly significant ($p<0.05$) effect due to the application of mulches on the finger weight (g), finger length (cm) and finger girth (cm), respectively. Planting dates significantly ($p<0.05$) increased finger weight (g) and finger girth (cm), while there was no significant effect of the interaction of planting dates and mulch materials on finger weight (g), finger length (cm), and finger girth (cm), respectively. However, planting dates had no significant effect on the finger length of late season banana at the harvest of the plant crop. Bananas in plots planted in September that received sawdust mulch recorded the heaviest finger weight (40.43g), followed by the bananas in plots planted in the same month and mulched with wood shavings (39.35g), while the least finger weight was recorded in the bananas in the control plots planted in November (35.02g).

Bananas in plots planted in September and mulched with sawdust had the longest fingers (7.90cm), followed by those in plots planted in the same month and mulched with wood shavings (7.83cm), while the shortest fingers were produced in the banana plots planted in the control plots of November (5.00cm). Bananas in plots planted in

Table 5. Effects of planting dates and mulch materials on finger weight (g), finger length (cm) and finger girth (cm) of the first ratoon crop of the late season banana at harvest.

Mulch materials	Yield data/Planting dates											
	Finger weight (g)				Finger length (cm)				Finger girth (cm)			
	Sept1	Oct1	Nov1	Mean	Sept1	Oct1	Nov1	Mean	Sept1	Oct1	Nov1	Mean
Blackpolyethene	37.27	36.12	36.00	37.46.	6.73	6.50	6.33	6.52	4.90	4.57	4.50	4.66
Woodshavings	39.35	38.00	37.68	38.34	7.83	7.33	7.30	7.49	5.83	5.63	5.33	5.60
Palm bunch refuse	39.15	38.00	37.78	38.31	7.47	7.03	7.00	7.17	5.33	4.90	4.56	4.93
Sawdust	40.43	39.00	35.67	38.37	7.90	7.23	6.17	7.10	5.90	5.73	5.33	5.65
Trash	36.12	35.98	35.50	35.87	7.00	6.83	6.55	6.79	5.30	4.67	4.30	4.76
No mulch	35.06	35.12	35.02	35.07	5.49	5.30	5.00	5.26	5.00	4.33	4.00	4.44
Mean	37.87	37.04	36.28	37.06	7.07	6.70	6.39	6.72	5.38	4.97	4.67	5.01
LSD $_{(0.05)}$ Planting dates				1.76				0.31				0.32
LSD $_{(0.05)}$ Mulch materials				3.09				0.31				0.28
LSD $_{(0.05)}$ Mulch x planting dates				5.03(ns)				0.59 (ns)				0.49 (ns)

Table 6. Effects of planting dates and mulch materials on the total yield (t ha^{-1}) at harvest of plant crops and first ratoon crop of the late season banana.

Mulch materials	Yield parameters/Planting dates			
	Sept1	Oct1	Nov1	Mean
Blackpolyethene	12.64	10.15	9.17	10.65
Woodshavings	15.37	12.83	12.03	13.41
Palm bunch refuse	15.07	14.23	11.47	13.59
Sawdust	12.89	13.77	12.10	12.92
Trash	13.13	11.13	8.27	10.84
No mulch	9.86	8.23	6.37	8.15
Mean	13.16	11.72	9.90	11.59
LSD $_{(0.05)}$ Planting dates				1.27
LSD $_{(0.05)}$ Mulch materials				1.31
LSD $_{(0.05)}$ Mulch materials x planting date				2.26(ns)

September and treated with sawdust recorded the highest finger girth (5.90cm), followed by those in plots planted in the same month and treated with the mulch of wood shavings (5.83 cm). The bananas in plots planted in control plots established in November recorded the least finger girth (4.00 cm).

The total yield (t ha^{-1}) at harvest of plant crops and the first ratoon crop of the late season banana.

The total yield (t ha^{-1}) of late season plant crop and first ratoon crop of banana (Table 6) indicated a highly significant ($p<0.05$) effect of planting dates and mulch materials, but the interaction of planting dates and mulch materials was not significant. The highest total yield of plant crop and first ratoon crop of banana was obtained in plots planted in September and mulched with wood shavings (15.37 t ha^{-1}), followed by the bananas in plots planted in the same month and treated with palm

bunch refuse (15.07t ha^{-1}), while the lowest total crop yield was obtained in the control plot of November (6.37t ha^{-1}).

DISCUSSION

Reproductive and yield parameters of the plant crop of late season bananas

Planting dates, mulch materials and their interaction had a significant effect on bunch weight (t ha^{-1}) and finger weight (g), while mulch materials significantly influenced all the reproductive and yield parameters of late season banana at plant crop. This may be attributed to the time of planting, quality of suckers and the positive influence of different mulches used on soil, crop growth and yield and the favourable influence of planting in the dry season. Emma-Okafor *et al*. (2017) confirmed this report that dry season planting of banana is done around September to December to make banana fruits and suckers available all year round to reduce the surplus that occurs from July to December which is caused by March and May plantings and to take advantage of higher prices in the dry seasons (January - June). Alagba *et al*. (2017) reported that dry season cultivation of plantain/banana is done around September, October, November, and December, since banana requires 10 to 12 months from planting to harvest. Furthermore, Alagba *et al*. (2018) and Obiefuna and Oti (2009) reported that the highest total plantain yields were obtained when the suckers were planted in August to December. Bananas planted in mulched plots flowered earlier than those in the control plots at all the stages of planting. This could be due to the availability of more nutrients as a result of mineralisation of organic mulches used, as well as moisture conserving benefits of mulches on the soil. Banana planted in September and mulched with palm bunch refuse were the earliest to flower (268.90 days), closely followed by the bananas in plots planted in the same month and mulched with sawdust (270.60 days). This is in contrast with the report of Ravi and Vaganan (2016), who reported that the banana inflorescence (flowering stalk) is produced 10 to 15 months after planting. The early flowering observed in the bananas with these mulches could be due to the high nutrient content and moisture conserving effects of palm bunch refuse and sawdust mulches, the type of planting materials used and the favourable environment, even though late season bananas are usually affected by water stress during the flowering stages. This confirms the study of Kader *et al*. (2019) who noted that mulching is the most effective at water conservation when rainfall events are less frequent in banana production El-Beltagi *et al*. (2022); Ahmad *et al*. (2020); Kader *et al*. (2019) and Iqbal *et al*. (2019) all corroborated this report and noted that mulching improves water supply capacity and can reduce irrigation requirements of crops and sometimes they can finish the need of irrigation.

The bananas planted in November delayed flowering in all the treatments, while the bananas in plots planted in September flowered earliest in all the treatments. Salau *et al*. (2016) explained that planting in September is characterized with consistent rainfall pattern that is good for the vegetative growth of banana. Kubiriba *et al*. (2016) were in contrast with the study that planting of banana is best done towards the end of the dry season and the beginning of the wet season for adequate initial moisture and to avoid waterlogging of young plants. However, Salau *et al*. (2016) agreed with the report that planting in May/June is associated with excessive rainfall, with extremely high temperatures that can reduce banana production. Furthermore, Robinson and Sauco (2010) supported the statement that it is good to plan planting dates and harvest in accordance with market demands. In their views, Joshi *et al*. (2023) and De Holanda *et al*. (2022) supported the report that the optimal temperature for the development of banana ranges from 28°C to 32°C, and these are climatic conditions that are associated with September. Temperatures below 15°C can stunt growth and negatively impact fruit development (Joshi *et al*., 2023).

The bananas in plots planted in September and mulched with palm bunch refuse had the heaviest bunch (9.97 t ha^{-1}), highest number of hands per bunch (8.67), highest number of fingers per bunch (95.67), and the heaviest fingers (94.67g/finger) while the longest and largest fingers were recorded from the bananas in plot planted in September and mulched with sawdust (12.10 cm) and (11.27 cm). This result may be attributed to the fact that palm bunch refuse is rich in the nutrient potassium. Caliman *et al*. (2001) opined that potassium is the primary content of palm bunch refuse, and it is released into the soil within 3 MAP. Kumar and Kumar (2008) agreed that potassium is another element of high importance for the growth of banana. Senthilkumar *et al*. (2017) agreed that the concentration of potassium in the plant system is much higher than all other nutrients, or even all the mineral nutrients combined. Mustaffan and Kumar (2012) corroborated the report and agreed that the supply of potassium (K) fertilisers in adequate quantity not only increases growth and yield in banana, but also in the physiology of the plant and offers resistance against biotic and abiotic stresses. Potassium (K) is also known for stimulating early shooting, increasing the number of hands, and finger size, according to Radha and Mathew (2007).

Reproductive and yield parameters of the first ratoon crops of the late season banana

Time to 50 % flowering and subsequent harvest was significantly influenced by mulch materials. The variation may be due to the moisture conservative effect of different mulches on banana phenology. Earlier sucker proliferation

in response to good nutrition may have been as a result of the nutrient turnover from the plant crop. The first ratoon bananas planted in September and mulched with sawdust recorded the earliest days to 5 0% flowering (263.50 days) compared to the plant crop that recorded its earliest days to 50 % flowering (268.90 days) from the bananas in plots that were mulched with palm bunch refuse. Okoli *et al*. (2020) explained that plots mulched with sawdust in late season plantain significantly gave higher yield than those mulched with other organic mulches in the first ratoon crops. Ashiono *et al*. (2017) agreed that a higher carbon-to-nitrogen ratio in sawdust can potentially shorten the time it takes for ratoon crops to reach 50 % flowering compared to the initial plant crop. This is likely due to the fact that sawdust and wood shavings, with their high C: N ratios, can initially bind nitrogen, which is essential for plant growth, making it less readily available for plant uptake. But over time, these mulches will degrade to release carbon and nitrogen, which help to improve growth, and therefore the ratoon crops receive the mulch benefit from the organic matter turnover from the plant crop.

The longest days to 50% flowering were obtained from the bananas in the control plot planted in November. This may be due to the fact that the control plots received no mulch, although poultry manure was applied. Emma-Okafor *et al*. (2019) reported that days to 50% flowering were influenced by manure rate and time of planting, where mulched plots were earlier in flowering compared to the unmulched plots (control plots). Shiyam *et al*. (2010) reported that mulched and manured plots had better yield in the ratoon than in the plantain in control plots.

The bananas in plots planted in September and mulched with sawdust recorded the heaviest bunch (7.23 tha^{-1}), the highest number of hands per bunch (6.67), the highest total number of fingers per bunch (74.00), the heaviest finger (40.43 g/finger), the longest finger (7.90 cm) and the largest finger (5.90 cm) in the first ratoon banana. The results obtained in the total yield (t ha^{-1}) at harvest of the plant crop and in the first ratoon crop indicated that the banana plots planted in September and mulched with wood shavings recorded the highest yield (15.37 t ha^{-1}). Although the first ratoon crops recorded a decline in yield compared to the plant crops. The findings of Nwauzoma and Shauibu (2008) reported that yield characteristics like bunch weight, number of hands and fingers show a steady decrease with increasing cycle. However, Ndukwe *et al*. (2009), Baiyeri *et al*. (2005), and Oluma *et al*. (2004) contrasted the report that ratoon crop plants yield was higher than the plant crop at harvest. Furthermore, the reports of Tosi *et al*. (2022), Xiao *et al*. (2022), Chen *et al*. (2022), Hou *et al*. (2021), and Rubio *et al*. (2021) all reported that under normal ratoon cultivation practices, crop ratoons often experience reduced stress tolerance, compromised growth conditions, and decreased yield and quality. Wang *et al*. (2024) in their report pointed out that the ecological factors of untilled rhizospheric crop ratoon soil undergo long-term evolution that leads to deficiencies in essential nutrients and accumulation of allelopathic substances released through root exudation and organic matter decomposition. This influence could be the reason for the reduced performance of the ratoon crop compared to the main plant crop.

Conclusion

The results show that mulch materials significantly improved the productivity of late season banana in Owerri, Southeastern Nigeria, with the bananas planted in September producing the best yield characters in all the mulches used in both plant crop and in the first ratoon production, followed by the bananas planted in October. The application of sawdust and wood shavings mulches in the banana plots planted in September recorded the heaviest banana bunch in the first ratoon crops (7.23 t ha^{-1}), while the bananas planted in the same month and mulched with palm bunch refuse produced the highest bunch (9.97 t ha^{-1}) at plant crop. First ratoon banana flowered earlier than the plant crop, while the plant crop produced a higher yield than the first ratoon crop. The research showed that mulching in dry season banana is a key player in the late season banana production, and such mulches can decay over time and become important sources of nutrients later in the production cycle, especially for the first retoon crops. It is therefore recommended that banana farmers should make good use of palm bunch refuse mulches for better banana yield in plant crop and then use sawdust and woodshavings for better first ratoon banana production, while late season banana production should be done in September.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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