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EFFECT OF NUTRIENT SUPPLEMENTATION AND SUCCESSIVE PLANTINGS IN OIL-POLLUTED SOIL ON THE PERFORMANCE OF *CARICA PAPAYA L.*

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ABSTRACT

The effect of 6 % oil in soil, soil amendment with NPK fertilizer (204 kg/ha) and poultry manure (278 kg/ha) and five successive plantings at 6 – week intervals in the same soil, on seedling emergence and growth of *Carica papaya* was investigated under humid tropical conditions. Without soil amendment, very good plant growth was observed in soil receiving only 6% oil, at the 5th planting or 24 weeks after oil application (waoa). However, treatments receiving 6% oil, amended with fertilizer or fertilizer plus p ultry manure, sustained very good plant growth at the 4th planting, 18 waoa. Poultry manure alone, added to 6% oil-polluted soil, failed to improve on the soil recovery period of 24 waoa. Treatments (T_6 and T_8) receiving fertilizer application appeared to be most effective in soil amelioration.

KEYWORDS: Oil Pollution, Nutrient Supplementation, Papaya

INTRODUCTION

Awobajo (1981) stated that from 1976 to 1986, about 1337 million barrels of crude oil was reported spilled into the Niger Delta ecosystem; 4.5% of this volume was spilled onto dry ground and 47% into offshore environments. The main occupations of the inhabitants in this area are fishing, farming and trading, and often their livelihood is jeopardized from oil spillages arising from equipment failures, oil well blowouts and sabotage. Scientific investigation into the effect of oil pollution in Nigeria began after the Shell-BP Bomu II blowout of 1970 (Odu, 1981). Since then a number of studies have been carried out, but the issue of restoring oil polluted land back to normal crop production still poses a major problem. In 1970, the Agbada-Bomu trunk pipeline situated in the farmland of Ejamah-Ebubu community burst and a large quantity of crude oil spilled into the farms and fresh water swamps. Polluted soil in the area contained 17.2% to 85.2% oil and grease, but no cleaning was carried out (Amajor, 1985). Similar cases have been reported (Odu, 1981; IPS, 1990, cited by Amadi et al; 1996). There have been recommendations in growing of crops in oil-polluted soils of the Niger Delta, but these recommendations only had to do with light oil pollution levels. Zuofa et al; (1988), Isirimah et al; (1989), Amadi and Bari, (1992) and Amadi et al; (1993) made recommendations for pollution levels of less than 4%. However, these recommendations are inadequate to take care of higher pollution levels often encountered in real situations. According to Schwendinger (1968), cited by Udo and Fayemi (1975), plants could tolerate up to 3% oil pollution of the soil. In this study, we report on the effect of nutrient amendment to 6% oil in soil and successive plantings in the same soil on the growth of pawpaw (*Carica papaya L.*). Since high levels of oil pollution occur in the field (Odu, 1972; Amakiri and Onofeghara, 1983; Orubima, 1983; Amajor, 1985) there is still a great need to study more of remediation of heavily polluted soils. The objective of this study was therefore to determine the length of time (weeks) taken to ameliorate heavily polluted soil (6% oil pollution) under the influence of different nutrient supplementations. It is hoped that studies of this nature will help us to understand the role of nutrient addition to soils in expediting the recovery of oil polluted soils

MATERIALS AND METHODS

The topsoil used in this study (acidic sandy loam soil, classified as Typic Paleudult) was obtained from an area near the experimental site of the Department of Biological Sciences, RSUST, Port Harcourt. Weeds growing in the area were first cleared and soil was collected to a depth of about 20 cm, mixed and sieved to remove coarse particles. Fresh Bonny Medium Crude (BMC) oil (specific weight 0.886 kg/l) was obtained from the Shell Petroleum Development Company of Nigeria, Port Harcourt. Mature and fully ripe fruits of *Carica papaya* L. cv. Yellow pawpaw, were purchased as a single batch from a local market in Port Harcourt. The larger dark – coloured seeds (more than 98% viable) were extracted from the fruits and air-dried for two days before use. The fertilizer used was N:P:K–Ca (20:10:5–10). Poultry manure, obtained from the University Teaching and Research Farm, was also used for the experiment. The poultry manure was not of very good quality because it contained litter from decaying wood shavings used as beddings for the poultry birds. Twenty four black nursery bags, having drainage holes and each bag measuring 36 cm high, 13 cm radius (= 531 cm^2 surface area) served as an experimental unit (plot) for a trial having eight treatments and three replications. The treatments were derived from a $2 \times 2 \times 2$ factorial set: factor A is crude oil applied at 0% and 6% w/w levels (6% oil application is equivalent to about 135,000 l/ha); factor B is poultry manure (applied at 0 and 1.5g/bag ≡ 278 kg/ha, levels); factor C is NPK -Ca 20:10:5 – 10 fertilizer (at 0 and 1.1g/bag ≡ 204 kg/ha, levels). First, homogenized topsoil was put into each of the 24 nursery bags (plots) to a depth of 15 cm. Then for each treatment, 12 kg of the topsoil was taken and the appropriate treatment was applied to the soil, mixed thoroughly and then transferred to its experimental unit. The treatment with no oil, no poultry manure and no fertilizer served as control. Treatments were assigned to plots at random, as for a completely randomized design.

The experiment was conducted in a plant house. Fifty seeds were sown in each experimental unit to a depth of 3 cm. The plants were watered to about field capacity as and when

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necessary. Seedling emergence was recorded 3 weeks after planting (wap). Only healthy plants were scored for emergence. Seedlings that failed to emerge or showed severe disease symptoms (e.g chlorosis, wilting and death) were discarded. Plant height, measured from soil level to the terminal bud, was taken at 6 wap. Dry matter weight was determined at 6 wap, after oven-drying each plot harvest for 36 hours at 65^{0}C. Five crops were raised in succession at 6-week intervals in the same soil of an experimental unit. For successive plantings at 6-week intervals, weeks to soil amelioration, as ascertained by good crop growth, was determined using the formula :
6 (c – 1) where c = the crop number in which the growth observation was made. Statistical analysis, including arcsin data transformation of % seedling emergence, was as described by Gomez and Gomez (1984). Duncan's Multiple Range Test (DMRT) was used to compare treatment means.

RESULTS

Seedling Emergence

Results on % seedling emergence are presented in Table 1.

Data presented in Table 1 show that for the 1st and 2nd crops, there was no seedling emergency (SE) in the treatments receiving 6% oil. The difference between those receiving oil and those without oil was significant at the 5% level. In the 3rd crop, there were reductions in % SE in the four treatments (T_5 – T_8) receiving oil, as compared to their counterpart no–oil treatments. In the 4th crop, % SE in T_6 (= 97%) and T_8 (=96%) was higher than % SE in T_2 (= 75%) and T_4 (88%), though not significantly different at the 5 % level. This trend was repeated in the 5th crop. Additionally, % SE in T_6 and T_8 was higher than that of T_5 (= 83%), which was higher than that of T_1 or control (= 56%). The results showed that soil recovery from 6% oil pollution, sufficient enough to allow for comparable mean % seedling emergence, occurred in the 4th crop, about 18 waoa. Treatments receiving fertilizer (T_6 and T_8) were most effective.

TABLE 1: The effect of oil pollution in soil, nutrient supplementation and successive plantings at 6 weeks interval on % seedling emergence of pawpaw.

Treatment	% Seedling Emergence Weighted Means* at Different Successive Croppings				
	1st Crop	2nd Crop	3rd Crop	4th Crop	5th Crop
T_1 = Control	61.5 ^{a}	84.0 ^{a}	81.5 ^{ab}	58.0 ^{ab}	56.6 ^{b}
T_2 = Fertilizer (204kg/ha)	34.0 ^{a}	35.5 ^{a}	65.0 ^{ab}	75.0 ^{ab}	59.0 ^{b}
T_3 = Poultry manure (278kg/ha)	74.5 ^{a}	82.0 ^{a}	66.5 ^{ab}	69.0 ^{ab}	59.0 ^{b}
T_4 = P-Manure + Fertilizer	75.5 ^{a}	47.0 ^{a}	90.0 ^{a}	88.0 ^{ab}	92.0 ^{ab}
T_5 = 6% Oil	0 ^{b}	0 ^{b}	31.5 ^{bc}	56.0 ^{ab}	83.5 ^{ab}
T_6 = 6% Oil + Fertilizer	0 ^{b}	0 ^{b}	35.5 ^{bc}	97.0 ^{a}	91.5 ^{ab}
T_7 = 6% Oil + P-Manure	0 ^{b}	0 ^{b}	12.5 ^{c}	45.0 ^{b}	53.5 ^{b}
T_8 = 6% Oil + P-Manure + Fertilizer	0 ^{b}	0 ^{b}	26.0 ^{bc}	96.0 ^{a}	100.0 ^{a}

PLANT HEIGHT

Results on mean plant height (cm) are presented in Table 2.

Data in Table 2 show that during the 1st and 2nd crops, there was no plant growth in the treatments receiving 6% oil. In the 3rd crop, there was significant (P = .05) reductions in the four treatments (T_5 – T_8) receiving oil, as compared to their counterpart no-oil treatments. In the 4th crop, there were no significant differences between treatment means at the 5% P-level. However, T_6 (=17cm) was higher than T_2 (=11.7cm) and, T_8 (=15.3cm) was close to T_4 (=17cm). In the 5th crop, T_6 (=28 cm) and T_8 (=31.7cm) were higher than T_5 (=18 cm), which in turn, was higher than T_1 or control (= 12.7cm). The results showed that soil restoration from 6% oil pollution, sufficient enough to allow for comparable mean plant height, occurred in the 4th crop, about 18 waoa. Treatments with fertilizer application (T_6 and T_8) were most effective.

DRY MATTER YIELD

Results on mean dry matter weight (g) are presented in Table 3.

Data in Table 3 show that during the 1st and 2nd crops, there was no plant growth in the treatments receiving 6% oil. In crop 1, dry matter yields in the no-oil treatments were low. In crop 2, their yields increased significantly (P = 0.05). In the 3rd crop, dry matter weight in T_6 (= 2.9g) and T_8 (= 3.0g) were higher than those in counterpart no-oil treatments T_2 (=1.5g) and T_4 (=2.3g). This trend was again seen in crop 5. Here, both T_6 (=3.7g) and T_8 (=4.1g) were greater than T_5 (=3.4g) which in turn, was greater than the control (T_1) = 2.0g. The results showed that soil amelioration from 6% oil pollution, sufficient enough to allow for comparable mean dry matter weight, occurred in the 5th crop, about 24 waoa. Treatments having fertilizer applications (T_6 and T_8) were most effective.

Average of 3 replications. Mean separation in a column by DMRT at 5% level. In a column, means followed by the same letter are not significantly different at the 5% level.

Least significant difference (Lsd) (0.05) for comparing means in a row is 30.2

TABLE 2: Mean plant height (cm) as affected by crude oil addition to soil, nutrient supplementation and successive plantings at 6 weeks interval.

Treatment	Mean Plant Heights (cm)* at Different Croppings.				
	1st Crop	2nd Crop	3rd Crop	4th Crop	5th Crop
T_1 = Control	22.7 ab	12.3 ab	21.0 abc	14.3 a	12.7 c
T_2 = Fertilizer (204kg/ha)	14.0 b	15.3 a	28.0 a	11.7 a	13.7 c
T_3 = Poultry manure (278kg/ha)	31.0 a	18.0 a	14.3 bcd	8.7 a	16.0 bc
T_4 = P-Manure + Fertilizer	17.3 b	19.0 a	23.3 ab	17.0 a	22.0 abc
T_5 = 6% Oil	0 c	0 b	3.0 de	10.7 a	18.0 bc
T_6 = 6% Oil + Fertilizer	0 c	0 b	12.0 bcde	17.0 a	28.0 ab
T_7 = 6% Oil + P-Manure	0 c	0 b	2.3 e	7.0 a	16.3 [illegible]
T_8 = 6% Oil + P-Manure + Fertilizer	0 c	0 b	8.7 cde	15.3 a	31.7 a

* Average of 3 replications. Mean separation in a column by DMRT at 5% level. In a column, means followed by the same letter are not significantly different at the 5% level. Lsd (0.05) for comparing means in a row is 11.2

TABLE 3: Effect of Crude Oil concentration in soil, nutrient supplementation and successive cropping at 6 weeks' interval on Dry Matter Weight (g) of pawpaw.

Treatment	Means Dry Matter Weight (g)* at Different Croppings				
	1st Crop	2nd Crop	3rd Crop	4th Crop	5th Crop
T_1 = Control	0.9 a	3.7 b	0.8 b	2.4 ab	2.0 bc
T_2 = Fertilizer (204kg/ha)	0.4 a	1.2 cd	1.5 ab	1.1 bc	1.7 c
T_3 = Poultry manure (278kg/ha)	0.6 a	6.2 a	1.1 b	2.8 a	1.7 c
T_4 = P-Manure + Fertilizer	1.0 a	1.8 c	2.3 ab	1.4 bc	3.2 abc
T_5 = 6% Oil	0 a	0 d	1.7 ab	1.0 bc	3.4 ab
T_6 = 6% Oil + Fertilizer	0 a	0 d	2.9 a	1.0 bc	3.7 a
T_7 = 6% Oil + P-Manure	0 a	0 d	0.9 b	0 c	2.0 bc
T_8 = 6% Oil + P-Manure + Fertilizer	0 a	0 d	3.0 a	0.9 bc	4.1 a

* Average of 3 replications. Mean separation in a column by DMRT at 5% level. In a column, means followed by the same letter are not significantly different at the 5% level. Lsd (0.05) for comparing means in a row is 1.44

DISCUSSION

The inferences that could be made from the results on % seedling emergence, plant height and dry matter weight are as follows: when acidic sandy loam soil is contaminated with BMC oil at a concentration of 6% and, planting in succession in the same soil is practiced, it takes natural rehabilitation proce (nrp) about 24 waoa to bring about soil amelioration and plant growth. The degree to which a given soil amend with nutrients aids nrp in bringing about restoration of s determined by the shortness of time it takes to have a crop growth before 24 waoa. The addition of NPK fertilizer (204 kg/ha) or fertilizer plus poultry manure (278 kg/ha) to 6% oil-polluted soil aided nrp and reduced the soil recovery period to 18 waoa. The combination of fertilizer and poultry manure was slightly better than that of adding fertilizer alone. Poultry manure alone added to 6% oil-polluted soil failed to reduce the recovery period of 24 waoa. The poultry manure used was not of a high grade. This explains why it was ineffective in aiding nrp. These results also point to the fact that for BMC oil pollution of 6% in acidic sandy loam soil, it may be quite possible to bring about soil recovery and good crop growth in less than 18 waoa, provided appropriate amounts of good quality fertilizer and animal manure are used, along with aerating the soil twice, through tillage, before planting. In treatments receiving 6% oil, there was no plant growth at the 1st and 2nd plantings. This observation agrees with those of Udo and Fayemi (1975), Zuofa et al; (1988), Isirimah et al., (1989) Amadi & Bari (1992) and Anoliefor and Vwioko (1995) who reported no plant growth in soils receiving more than 3% oil pollution. Oil persisted for a very long period of time under conditions of poor aeration (Odu, 1981). However, tillage helps to aerate the soil. According to Vasudevan and Rajaram (2001), several factors such as aeration, use of fertilizers and appropriate microbial species play a major rôle in the remediation of oil-contaminated sites. Our finding that fertilizer application (204 kg/ha) in 6% oil-polluted soil aided nrp and brought about good plant growth in 18 waoa confirms those of El-Nawawy et al; (1992), as cited by Vasudevan and Rajaram (2001), who indicated up to 71% removal from 5.8% oil-sludge amended with fertilizer in 16 weeks. We also found that addition of poultry manure alone in 6% oil-polluted soil failed to aid nrp in bringing about soil amelioration and good crop growth. This also confirms the observation of Amadi and Bari (1992) that increasing oil concentration (4.6 to 19%) generally depressed maize growth regardless of the amendment rate of poultry manure applied.

CONCLUSION

When acidic sandy loam soil is contaminated with Bonny medium crude oil at 6% concentration and planting in succession, at 6-week intervals, in the same experimental unit is practiced, there was no plant growth at the 1st and 2nd croppings. However, at the 5th planting (24 weeks after oil application), very good plant growth was observed. Apparently, without soil amendment, the polluted soil had been sufficiently weathered by natural rehabilitation processes 24 waoa. The addition of NPK fertilizer (204kg/ha) or fertilizer plus poultry manure (278 kg/ha) reduced the soil recovery period to 18 waoa and allowed good plant growth at the 4th planting. The combination of fertilizer and manure appeared to be slightly better than that of fertilizer alone. Poultry manure alone added to 6% oil-polluted soil failed to improve on the soil recovery period of 24 waoa, possibly because the manure used contained litter from decaying wood shavings. This report may be the first to show in the Niger Delta area that 6% oil-polluted soil could be brought into productive use 18 waoa, if appropriate soil aeration and fertilizer use are incorporated in the remediation measures.

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