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Transformation of Poultry Wastes and Oil Palm Residues into Liquid Fertilizers and its Use in the Fertilization of Oil Palm at the Juvenile Stage

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Authors' contributions:

This work was carried out in collaboration among all authors. The author ABYC designed the study and then wrote the protocol and the first draft of the manuscript. The authors YGF and LTT provided suggestions. The authors NKA and GDO have read and approved the final manuscript. All authors read and approved the final manuscript.

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ABSTRACT

The use of organic fertilizers is beneficial and less expensive if applied in adequate doses. This is how the present investigation aims to determine the optimal quantities of vermiwash based on poultry waste and oil palm residues to be applied to oil palms in prenurseries and in nurseries. To do this, different quantities of this locally manufactured vermiwash constituted the treatments applied to the oil palms at the juvenile stage. Growth parameters such as collar diameter, length of longest leaf, number of leaves emitted, and height of seedlings and plants were assessed. At the prenursery stage, the results obtained showed that, whatever the growth parameter, the maximum values were recorded at a dose of 30 ml of vermiwash per seedling. In the nursery, the maximum values were recorded, on the one hand, at the dose of 100 ml in foliar application and, on the other hand, at the dose of 150 ml in application on the substrate. These different doses therefore constitute the optimal doses for the development of the oil palm at the prenursery and nursery stages. Vermiwash from poultry waste and oil palm residues therefore contributes to the development of oil palm at the prenursery and nursery stages and, thus, can be an alternative to chemical fertilization of plants.

Keywords: Vermiwash; seedling; plant; fertilizer; stage of development; optimal dose; Côte d'Ivoire.

1. INTRODUCTION

The oil palm is the oilseed plant with the best yield of vegetable oil per hectare [1]. It accounts for 39% of global vegetable oil production, although it is grown on a smaller fraction of agricultural land than that devoted to other oilseed plants [1]. "To increase this production of palm oil, farming practices include fertilization. However, the massive use of chemical fertilizers at the expense of organic manure certainly increases the immediate yield, but gradually destructures and degrades the soil and the environment" [2]. "These chemical fertilizers are often the cause of the physico-chemical and microbiological imbalance of the soil and sometimes promote an increased susceptibility of plants to diseases" [2]. "In addition to their impact on the environment, these chemical fertilizers are very expensive for farmers" [3].

In view of the disadvantages of chemical fertilizers, the need to use organic fertilizers as an alternative to chemical fertilizers is essential in rural areas, especially among nurserymen and planters in the oil palm sector. This eco-biotechnological practice, respectful of the environment, constitutes a mode of management of organic waste, viable both technically and economically.

Vermiwash (a liquid obtained from a product resulting from the digestion of compost by earthworms) is used as a substitute or supplement for chemical fertilizers in organic farming in Asian countries. However, the constituents and levels of fertilizing elements from vermiwash depend on the nature of the organic material that contributed to the development of vermicesting [4]. Although this eco-biotechnology technology does not require special training or expensive infrastructure, it is little known in the West African sub-region, especially in Côte d'Ivoire.

The objective of this study is to valorize poultry waste and oil palm residues as a source of organic fertilization in the production of oil palm seedlings and plants through vermicomposting. Specifically, the aim is to study the effect of a vermiwash based on poultry waste and oil palm residues on the vegetative development of oil palm at the prenursery and nursery stages. To achieve this objective, it was hypothesized that the use of vermiwash could boost the vegetative development of oil palm at the prenursery and nursery stages.

2. MATERIALS AND METHODS

2.1Trial Site

The test was set up at the CNRA-IRHO-La Mé Research Station located in the south-east of Côte d'Ivoire, in the lagoon region, 24 km from Abidjan and 30 km set back from the Gulf of Guinea (Fig. 1). "Its geographical coordinates are 05°26' North latitude and 03°50' West longitude. The altitude of the various points of the station

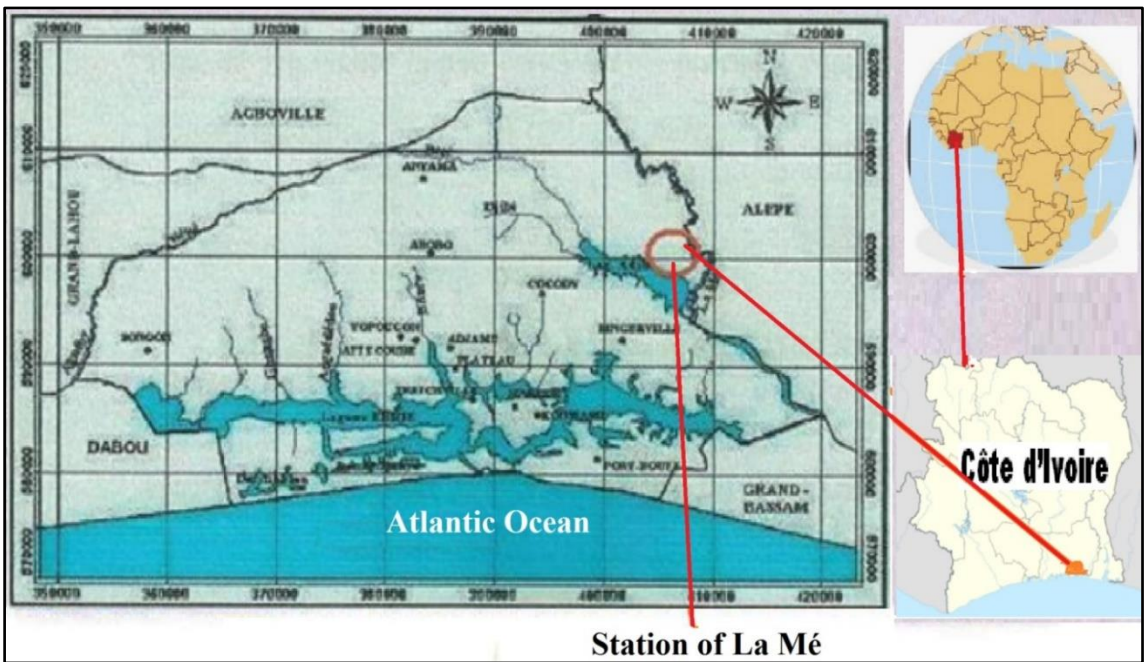

Fig. 1. Location of the CNRA IRHO-La Mé Research Station

varies from 10 to 100 m. The climate of La Mé is of the humid tropical type. This resort is bordered to the east by La Mé river and to the south by the Aghien lagoon. The soil of this station is of the desaturated ferrallitic type and is poor in potassium" [5].

2.2 Plant Material

The plant material consists of oil palms from the C1001F seed category selected and popularized by the Center for Agronomic Research of Côte d'Ivoire (CNRA). It was produced at the CNRA-IRHO-La Mé Research Station. "For the establishment of the trials, it was supplied in the form of germinated seeds. Three (3) months after the establishment of the prenursery, these seeds were transformed into seedlings for the rest of the experiment. This plant material has been used since 1995 and comes from the second round of reciprocal recurrent selection (SRR). This hybrid has a production potential of 25 tons of bunches/ha/year, an oil content of 26% and an industrial extraction rate of between 22 and 23%. It is also characterized by an early production of bunches, an economic exploitation of about 30 years and a strong resistance to Fusarium wilt. It is the one that is currently popularized in the Ivorian areas of oil palm cultivation, for the creation of oil palm plantations in Côte d'Ivoire" [6-9].

2.3 Choice and Extraction of Soil

Light and huminiferous ground from an apparently healthy forest was chosen to collect potting soil in order to fill the prenursery bags (size 10 by 20 cm) and those of the nursery (size 40 by 40 cm). This potting soil was taken from the first 10 centimeters of the ground using a hoe, pickaxe and shovels. It was then passed through a 1 to 2 cm mesh sieve in order to eliminate the coarse elements.

2.4 Vermiwash Production

A compost pit built of a concrete wall with dimensions of 2 x 1 x 1.5 m was filled with 50% manure from laying hens, 25% oil palm bunch roundups and 25% oil palm seed pulp, for their decomposition by microorganisms. After the establishment of this compost, a regular turning followed by a watering was carried out each month until the maturation of the compost characterized by the absence of neither odor nor heat release. This compost obtained was placed in 100-litre drums fitted with a tap at the base. These drums were filled in successive layers from the base to the opening as follows:

- a layer of gravel (15 cm thick);
- a layer of coarse sand (10 cm thick);
- a layer of compost from the decomposition of oil palm residues (palm

bunch roundups and oil palm seed pulp) and manure from laying hens (15 cm thick);
- introduction of 200 g of earthworms of the genus Eisenia into the drum.

The drums thus filled were then installed on racks. A perforated container at the base was permanently suspended from each barrel. This container allowed 2 liters of water to drip into the barrel. The layers of gravel and coarse sand made it possible to filter the liquid which passed through the barrel. For the first time, the collection of vermiwash began 15 days after the filling of the drum and the introduction of earthworms (just enough time for the multiplication of earthworms). After these first 15 days, vermiwash was collected every 3 days. Immediately after each collection, the taps were closed and 2 liters of water were immediately introduced into the permanently perforated containers at each barrel.

2.5 Experimental Details

Different amounts of vermiwash to apply to seedlings and plants produced on a substrate composed of 100% potting soil constituted the different treatments. These treatments were applied either to the leaves or to the substrates.

In the prenursery phase, only the foliar application was carried out on seedlings arranged in a tray, according to an experimental device in Randomized Fisher Block of six treatments (Table 1), repeated three times.

In the nursery phase, the foliar application and that on the substrate were carried out. Whatever the type of application of the vermiwash, the experimental device was in a Randomized Fisher Block of six treatments (Table 2), repeated three times.

2.6 Setting up of the Prenursery

On the eve of sowing or transplanting the germinated seeds, the bags filled with potting soil were watered abundantly. The transplanting of the germinated seeds was carried out by making in the center of each bag thus filled, using the finger (index), a hole 2 to 3 cm deep. In each hole was inserted a seed so that the radicle was oriented downwards. The seed was then covered with the substrate used to fill the sachets. This prenursery was set up for a period of three (3) months.

2.7 Setting up of the Nursery

Three (3) months after the prenursery phase, the best seedlings (seedlings resulting from the optimal dose of vermiwash) were selected for setting up the nursery. On the eve of planting these seedlings, the bags filled with potting soil were watered abundantly. The seedlings were transplanted by making a hole 10 to 15 cm deep in the center of each bag thus filled using a dibber. In each hole was planted a seedling with its clod of soil removed from its bag. The clod of soil was then covered with the soil taken out during the digging. This nursery was set up for a period of six (6) months.

2.8 Application of Vermiwash to Oil Palm Leaves

At the “one-leaf” stage of the seedling, precisely 1 month after sowing the germinated seeds in sachets filled with unfertilized soil, half a dose of each treatment was applied to the seedlings using a knapsack sprayer. One week later, this half dose was again applied to the seedlings. After this last stage, the application of the normal doses of vermiwash was carried out every two (2) weeks until the seedlings were 3 months old.

Two (2) weeks after the establishment of the nursery, the application of vermiwash to the leaves of the plants using a knapsack sprayer was carried out at the frequency of two (2) weeks throughout the duration of the nursery.

Irrespective of the stage of development of the oil palms, the application of the vermiwash to the leaves was carried out in the evenings, at sunset.

2.9 Application of Vermiwash to Oil Palm Substrates

One (1) month after sowing the germinated seeds, half a dose of each treatment was applied to the seedlings. One (1) week later, this half dose was again applied to the seedlings. After this last stage, the application of the normal doses of vermiwash was carried out every two weeks until the seedlings were 3 months old.

In the nursery phase, the normal doses were applied to the plants every two (2) weeks for six months, since one (1) month after establishment.

Table 1. Different doses of Vermiwash applied in the prenursery

Treatments	Designations
Tw0	Without fertilizer input (absolute control)
Tw1	Application of 20 ml of vermiwash per seedling
Tw2	Application of 25 ml of vermiwash per seedling
Tw3	Application of 30 ml of vermiwash per seedling
Tw4	Application of 35 ml of vermiwash per seedling
Tw5	Application of 40 ml of vermiwash per seedling

Table 2. Different doses of Vermiwash applied in the nursery

Treatments	Designations
Tws0	Without fertilizer input (absolute control)
Tws1	Application of 50 ml of vermiwash per plant
Tws2	Application of 100 ml of vermiwash per plant
Tws3	Application of 150 ml of vermiwash per plant
Tws4	Application of 200 ml of vermiwash per plant
Tws5	Application of 250 ml of vermiwash per plant
Tws6	Application of 300 ml of vermiwash per plant

2.10 Plant Care and Maintenance

Watering of seedlings and plants was carried out every morning between 6 and 7 a.m. using a watering can. In case of rain, watering was not practiced in order to avoid excess water. Manually, the weeds that appeared in the bags were uprooted. The weeding of the surroundings of the test space was carried out by spraying herbicide using a knapsack sprayer. On the other hand, the space housing of the trial was weeded using daba in order to avoid any inconvenience likely to be caused to the plants by the use of herbicides.

2.11 Collection of Data

The measurements were taken at 3 and 6 months, respectively after the establishment of the prenursery and that of the nursery. They were carried out on all the seedlings and plants. The agronomic parameters used to characterize the effects of the different doses of vermiwash on the growth of the seedlings and plants were the diameter at the collar (DC), the height of the seedlings (Hp) and plants (HP) and the length of the longest leaf (LgF). These agronomic parameters are expressed in centimeters (cm). To these three parameters was added the number of leaves emitted (NLE).

2.12 Statistical Analysis of Data

Statistical analyzes were performed with Statistica 7.1 software. Analyzes of variance with one classification criterion were carried out on the means of the various parameters. In the event of a significant difference between two means, the Turkey test at the 5% threshold was used to classify the means.

3. RESULTS

3.1 Effects of Different Vermiwash Doses on Prenursery Oil Palm Growth Parameters

The analysis of Table 3 shows that, whatever the treatment, the values expressed by each growth parameter were higher than those displayed by the control treatment (Tw0: potting soil without vermiwash input). These values progressed in the direction of the increasing gradient of the dose of vermiwash until reaching their peaks at the dose of 30 ml of vermiwash per seedling. Ranging from a dose of 30 to 40 ml of vermiwash per seedling, the values expressed did not show any significant difference, whatever the growth parameter.

3.2 Effects of Vermiwash Application on Oil Palm Growth Parameters in the Nursery

Whatever the dose and mode of application of the vermiwash to the plants, the values expressed by each growth parameter were higher than those displayed by the control treatment (Tw0: potting soil without vermiwash input). These values progressed in the direction

Table 3. Variation of oil palm growth parameters according to different doses of Vermiwash in the prenursery

Treatments	Vermiwash dose (ml/seedling)	NLE	Hp (cm)	DC (cm)	LgF (cm)
Tw0	0	3.45^{c}	15.02^{b}	0.60^{c}	12.00^{b}
Tw1	20	4.58^{b}	16.70^{a}	0.80^{b}	13.04^{a}
Tw2	25	4.96^{ab}	16.80^{a}	0.90^{ab}	13.46^{a}
Tw3	30	5.31^{a}	17.02^{a}	0.97^{a}	13.69^{a}
Tw4	35	5.31^{a}	16.92^{a}	0.95^{a}	13.65^{a}
Tw5	40	5.30^{a}	17.00^{a}	0.95^{a}	13.67^{a}

Values with the same letter in the same column are not significantly different according to Turkey's p<0.05 test. NLE: number of leaves emitted; Hp: seedling height; DC: diameter at the collar; LgF: longest leaf length

Table 4. Variation of oil palm growth parameters according to different doses of Vermiwash applied to nursery substrate

Treatments	Vermiwash dose (ml/plant)	NLE	HP (cm)	DC (cm)	LgF (cm)
Tw0	0	9.8^{c}	40.5^{c}	2.6^{c}	36.8^{c}
Tw1	50	11.2^{b}	70.8^{b}	4.12^{b}	52.2^{c}
Tw2	100	12.6^{a}	72.7^{ab}	5.04^{a}	62.2^{b}
Tw3	150	13.8^{a}	76.7^{a}	5.24^{a}	66.8^{a}
Tw4	200	13.7^{a}	76.7^{a}	5.20^{a}	66.5^{a}
Tw5	250	13.7^{a}	76.4^{a}	5.22^{a}	66.6^{a}
Tw6	300	13.5^{a}	75.8^{a}	5.14^{a}	65.9^{a}

Values with the same letter in the same column are not significantly different according to Turkey's p<0.05 test. NLE: number of leaves emitted; Hp: seedling height; DC: diameter at the collar; LgF: longest leaf length

Table 5. Variation of oil palm growth parameters according to different doses of vermiwash in foliar application in the nursery

Treatments	Vermiwash dose (ml/plant)	NLE	HP (cm)	DC (cm)	LgF (cm)
Tw0	0	9.84^{c}	40.50^{c}	2.55^{c}	36.8^{c}
Tw1	50	11.15^{b}	72.38^{b}	3.73^{b}	60.63^{b}
Tw2	100	14.75^{a}	78.13^{a}	5.85^{a}	67.00^{ab}
Tw3	150	14.73^{a}	77.89^{a}	5.82^{a}	66.90^{a}
Tw4	200	14.70^{a}	78.00^{a}	5.83^{a}	66.93^{a}
Tw5	250	14.55^{a}	77.85^{a}	5.77^{a}	66.88^{a}
Tw6	300	14.65^{a}	77.75^{a}	5.80^{a}	66.80^{a}

Values with the same letter in the same column are not significantly different according to Turkey's p<0.05 test. NLE: number of leaves emitted; Hp: seedling height; DC: diameter at the collar; LgF: longest leaf length

of the increasing gradient of the dose of vermiwash until reaching their peaks at the dose of 100 ml of vermiwash per plant in foliar application (Table 4) and at the dose of 150 ml of vermiwash per plant in substrate application (Table 5). From these doses of vermiwash to the higher doses, by mode of application, the values expressed did not show any significant difference whatever the growth parameter.

3.3 Comparative Study of the two Types of Vermiwash Application on the Growth Parameters of Oil Palm in the Nursery

The analysis of the results recorded in Table 6 shows that, overall, it was at the level of the dose of 100 ml of vermiwash per plant that there was a significant difference between the values. At this dose, regardless of the oil palm growth parameter, the foliar application of vermiwash generated values that were statistically higher than those displayed by the application on the substrate.

4. DISCUSSION

The vermiwash used as fertilization material in the present study was a product derived from a lombricoid digestion filtrate of compost produced from 50% manure from laying hens, 25% oil palm bunch roundups and 25% oil palm seed pulp. The growth parameters evaluated were the diameter at the collar, the length of the longest leaf, the number of leaves emitted and the height

Table 6. Comparative values of variations in oil palm growth parameters according to different doses and modes of application of Vermiwash in the nursery

Traitements	Vermiwash dose (ml/plant)	Methods of application	NLE	HP (cm)	DC (cm)	LgF (cm)
Tw1	50	On substrates	11.22^{a}	70.84^{a}	4.12^{a}	52.21^{b}
		On leaves	11.15^{a}	72.38^{a}	3.73^{a}	60.63^{a}
Tw2	100	On substrates	12.57^{b}	72.79^{b}	5.04^{b}	62.24^{b}
		On leaves	14.75^{a}	78.13^{a}	5.85^{a}	67.00^{a}
Tw3	150	On substrates	13.77^{a}	76.72^{a}	5.24^{a}	66.77^{a}
		On leaves	14.73^{a}	77.89^{a}	5.82^{a}	66.90^{a}
Tw4	200	On substrates	13.76^{a}	76.74^{a}	5.20^{a}	66.52^{a}
		On leaves	14.70^{a}	78.00^{a}	5.83^{a}	66.93^{a}
Tw5	250	On substrates	13.78^{a}	76.41^{a}	5.22^{a}	66.63^{a}
		On leaves	14.55^{a}	77.85^{a}	5.77^{a}	66.88^{a}
Tw6	300	On substrates	13.59^{a}	75.8^{a}	5.14^{a}	65.92^{a}
		On leaves	14.65^{a}	77.75^{a}	5.80^{a}	66.80^{a}

For each treatment and growth parameter, the values with the same letter in the same column are not significantly different according to Turkey's test p<0.05.
NLE: number of leaves emitted; Hp: seedling height; DC: diameter at the collar; LgF: longest leaf length

of seedlings and plants of oil palms. These oil palms, although they were identical according to their stages of development, reacted differently according to the different doses of vermiwash which were applied to them: hence the presence of the effect of variation in doses of the vermiwash on the parameters growth of the oil palm in the juvenile state. This effectiveness of vermiwash in plant fertilization has been proven by several studies in India, Morocco, Zimbabwe, etc. on market garden crops ([6]; [7]; [8]).

Considering the oil palms according to their stages of development, all the growth parameters of the seedlings (seedlings aged 3 months and originating from the prenursery) reached their peaks at the level of the dose of 30 ml of vermiwash per seedling. On the other hand, at the level of the plants from the nursery (plants aged 9 months), all the growth parameters reached their peaks with the dose of 100 ml of vermiwash per plant in foliar application and with the dose of 150 ml of vermiwash per plant in application on substrate. These findings suggest that the nutritional requirements of oil palm depend both on its stage of development and on the mode of application of fertilizer. Thus, different quantities of nutritional elements available in a culture medium therefore make it possible to define the one that is optimal for the development of the plant. This is why the peaks were obtained at a dose of 30 ml of vermiwash per seedling at the prenursery stage and at doses of 100 ml and 150 ml of vermiwash per plant at the nursery stage.

By mode of application of vermiwash, from these different doses up to higher doses, no significant difference was expressed in the values expressed, whatever the growth parameter. This reflects a saturation of all plant biosynthetic organs with nutrients provided by the vermiwash. This consistency of values expressed despite the increase in doses of vermiwash above those giving the maximum values could mean that the vermiwash is not offensive and that its overdose could not cause any harm to the plant. This assertion is justified by the statistically identical values expressed at doses of 150 and 300 ml of vermiwash per plant in the nursery phase.

Overall, the significant difference between the values was observed at the level of the dose of 100 ml of vermiwash per plant. At this dose, regardless of the oil palm growth parameter, the foliar application of vermiwash generated values that were statistically higher than those displayed by the application on the substrate. Beya [9] explains this situation by the fact that the effect of applying fertilizer to the soil is slower than that of foliar application. Or, according to the same author, this reflects the fact that leaf fertilization stimulates the plant by the fact that it is directly related to the enzymatic activity of plants. These values generated by the foliar application of vermiwash remained statistically stable regardless of the increase in the dose of vermiwash. Also, these same values were statistically identical to the maximum values displayed by the 150 ml dose of vermiwash applied to the substrate. These observations could mean that the plant, for its development, uses less fertilizer product in foliar application than in application on substrate. This is evident when Beya [9] argues that the positive effect of foliar fertilizer is based on better absorption of applied nutrients. This implies economical and efficient use of vermiwash in the production of oil palm plants in the nursery phase.

5. CONCLUSION

Under the terms of the present investigation, it should be noted that at the prenursery and nursery stages, oil palms reacted favorably whatever the dose of vermiwash from 50% laying hens manure, 25% oil palm bunch roundups and 25% oil palm seed pulp. At the prenursery stage, the optimal dose of vermiwash was 30 ml per seedling. In the nursery, the optimal doses of vermiwash were, on the one hand, 100 ml per plant in foliar application and, on the other hand, 150 ml in application on the substrate. Vermiwash from poultry waste and oil palm residues therefore contributes to the development of oil palm at the prenursery and nursery stages and, thus, can be an alternative to chemical fertilization of plants.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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