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*Research Article*

# Responses of leaf amaranth (*Amaranthus hybridus* L.) Amaranthaceae to composts enriched with organic nitrogen sources.

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## Abstract

The reportedly low nitrogen (N) contents of composts, widely used for sustainable soil improvement, management and maintenance, has engendered its fortification with other N-rich sources, especially inorganic fertilizers became a necessity. The adoption of chemical fertilizers is however constrained by scarcity, rising prices and the potential for environmental pollution, such that the potential of alternative N-rich organic materials for compost fortification/enrichment need to be exploited. The composts reportedly increased N concentrations in soils and simultaneously raised the phosphorus and potassium levels such that their impacts should be evaluated on crops. Two composts: cow dung + sawdust (CDS) and poultry dung + sawdust (PDS) were enriched with organic materials: abattoir wastes- bone (BN), hoof (HM), horn (HN) and blood (BM); tithonia (TM) and neem (NM) meals to 60 kg N levels as CDSBN, CDSBM, CDSHM, CDSHN, CDSNM and CDSTM; PDSBN, PDSBM, PDSHM, PDSHN, PDSNM and PDSTM. The growth and yield responses of leaf amaranth (*Amaranthus hybridus*) to the enriched composts at 30 t $ha^{-1}$ and 400 kg $ha^{-1}$ NPK 15-15-15 were assessed in a field experiment arranged in a randomized complete block design with three replicates. Growth data collection and harvesting of amaranth were done at 6, 7 and 8 weeks after sowing and data generated were subjected to analysis of variance and the means separated using DMRT at p=0.05. Various enriched composts are compared strongly with the inorganic fertilizer (NPK) and can effectively serve as alternatives, to the inorganic fertilizers, putting the cycles or life span of vegetables and crops in consideration.

## 1. Introduction

Livestock manure supplies all major nutrients (N, P, K, Ca, Mg, S) necessary for plant growth, as well as micronutrients [1]. The effects are long lasting as the application of manure improves the performance of the crops grown in a given year while the residual effects will continue to influence crops in the succeeding years [2]. This arises because the decomposition of the organic material is continuous and not completed within one year [3]. Thus, in the many experiments conducted to compare manure with an equivalent amount of NPK (chemical fertilizer) and most often, the results favoured manure [4-6]. The reasons for the superiority of manure include: low decomposition rate of organic matter resulting in a slow release of nutrients; increase in infiltration rate with more rain water and irrigation water entering the soil; and decrease soil bulk density resulting in a greater capacity for more air and water within the soil.

Compost is an organic fertilizer made from the regulated and monitored biological breakdown of organic materials that have been sterilized, stabilized, and cured to the point where they are useful to plant growth [7-8]. Its use alleviates the nutritional, physical and biological aspects of soils by increasing soil organic matter quality and quantity, as well as the number, diversity, and activity of soil organisms [9]. Therefore, compost has become a valuable ingredient in organic farming on account of several beneficial aspects: saves money that could have been used for buying fertilizers; improves the soil physical, chemical and biological properties; feeds the soil which feeds the plants that feed the animals and the whole world; increases the nutrition of growing plants which leads to good nutritional quality and increased human health [10].

The word amaranthus comes from the Greek word "*amarantos*" meaning the one that does not wither or never fading (flower). Amaranthus species are ancient cultivated crops that have long been neglected by Western agriculturists and gardeners. *Amaranthus* species were ranked major potential crops with the most promising economic values among the 36 underexploited tropical plants indicating that there are untapped prospects and potentials in their utilization [11]. Amaranthus (vegetable and grains) is one of the food plants to improve nutrition and the quality of life in developing countries. *Amaranthus hybridus* is an important vegetable crop in Nigeria and other parts of the world. In Nigeria, vegetable *amaranth* is planted all year round and harvested for food [12]. The local synonyms in Nigeria are *alayyafu* or *aleho* (Hausa), *ẹfọtẹtẹ* or *tẹtẹ* (Yoruba), and *inine* (Igbo). In the 70s, there was renewed interest in the cultivation of amaranth due to the discovery that the crop is a cheap and rich source of protein, vitamins and minerals [13]. *Amaranthus hybridus* is useful for livestock feed [14] and human consumption being a source of leaf protein concentrates, essential amino acids (Lysine and Methionine), minerals (especially calcium and iron), vitamins (carotene, riboflavin, niacin) and other essential nutrients needed for feeding young children and other persons with nutritional deficiencies or malnutrition [15-16].

*Amaranthus* plants thrive well on poultry and other farmyard manure-amended soils. It grows in full length and is most productive on soils with high organic matter and adequate nutrient reserves [5, 17]. This is on account of nitrogen (N) needed for luxuriant growth of crops, especially leaf vegetables, but only a small quantity, between 0.5 to 2.5 % (dry weight basis) exists in finished composts [18]. Thus, there is the need to identify the materials which will give higher N quantity when composted, or used to enrich the composted materials with N. Inorganic fertilizers had been used to fortify/amend organic fertilizers, to raise their N content; but these have recently been reported as scarce and expensive, and therefore unavoidable to most farmers apart from the fears that the use of synthetic products, including inorganic fertilizers is unhealthy for the contact environment. Therefore, the need has become urgent to evaluate the potential of organic materials as N-enriching substances in composts. The positive effects of composts enriched with organic N-rich substances on soil N, P and K have been reported [19-20]. In this study, the organic N-rich materials (common agricultural wastes and weeds) were added to the common compost materials in order to improve the N status. The materials were Mexican sunflower, neem, blood and bone meals, hoof and horn meals.

### *1.1 The organic wastes used in the study*

#### *1.1.1 Poultry manure*

Poultry manure is a valuable, concentrated and quick releasing organic fertilizer [21]. It contains all the basic nutrients necessary for crops but in much greater amounts; 3-5% N, 1.5-3.5 % P and 1.5-3.0% K [22], 3% N, 2.5% P and 1.8% K [23]. All nutrient contained in poultry manure takes the form of available compounds. Most of the nitrogen (N) in it is in the form of uric acid which turns in storage, first to urea and then to ammonium carbonate under unfavourable storage conditions [24]. Poultry manure is applied both before sowing and for dressing. Poultry manure enhances soil fertility by combating soil improvement, promoting soil structure, supplying and retaining water until decomposition is completed, this aids the breakdown of organic matter and also makes a living soil moister than soil with no organic matter. Poultry manure activates soil life: giving food to soil inhabitants that change them into organic matter, which decays and is in turn changed into humus releasing mineral nutrients.

#### *1.1.2 Cow dung*

Cow dung is the waste of bovine animal species. Cow dung is the undigested residue of herbivorous matter which has passed through the animal's guts. The resultant faecal matter is rich in minerals [25]. Cow manure contains 3% nitrogen, 2% phosphorus, and 1 % potassium—3-2-1 NPK [26]. Colour ranges from greenish to blackish, often darkening in colour soon after exposure to air. Cow dung (usually combined with soil bedding and urine) is often used as manure (agricultural fertilizer). If not recycled into the soil by species such as earthworms and dung beetles, it dries out and remains on the pasture, creating an area of grazing land which is unpalatable to livestock [27].

### *1.1.3 Sawdust*

This is composed of fine particles of wood. This is produced with the use of cutting wood with a saw. It has a variety of practical uses including serving as mulch, as a fuel or for the manufacture of particle board. Sawdust is high in carbonaceous compounds (lignin, cellulose and pectin) and low in useful plant nutrients such that for bacterial decay to occur, carbohydrates for energy and N to build new bodies as they grow and multiply are needed [28]. The N deficiency limits building of bacterial tissues and can deplete available nitrogen in soils and thereby hinder plant growth. The N consumed by microorganisms becomes available and utilizable to crops after the sawdust is degraded.

### *1.1.4 Bone meal*

From every cattle slaughtered, about 70-90 kg bones are obtained, which could thereafter be washed, dehydrated and burned-out so as to convert to bone meal which has a huge market in livestock feed and fertiliser industries [29]. Animal bones are cooked, ground, packed and then sold as a slow release fertiliser that adds a good amount of P to the soil [30]. It also contains Ca [30]; of about 12–13% [31] and NPK ratio of approximately 3:15:0, indicating that they are low in nitrogen (N) and potassium (K) but high in phosphorus (P) [32-33]. Bone meal is emphasized as an effective soil amendment especially on degraded soils where the physical properties of soil are unaffected by inorganic fertilisers [34].

### *1.1.5 Blood meal*

Slaughtered cattle give out 25 litres of blood which is rich in N as it contains 12% N [35] and so can be used as an enrichment material for a finished compost in order to increase its N content [29]. Blood meal is a high-nitrogen fertilizer created from a dry, inert powder made from blood. The release of N is rapid and it is suited to fast growing vegetables. Blood meal is water soluble and it can be used as a liquid fertiliser [30], which could balance the C: N ratios of composts.

### *1.1.6 Hoof and horn meal*

The cooked, ground and dehydrated hooves and horns obtained from cattle slaughter houses are good N sources (12%) and contain about 2% P which makes the meal a 12-2-0 NPK fertilizer. It is alkaline in nature and so a good choice for improving acidic soils [36]. The N is locked inside the horn and hoof meal is released slowly so that it does not burn the plants [37]. The N release starts at 4-6 weeks after application and can last for 12 months [38].

### *1.1.7 Tithonia diversifolia*

Mexican sunflower (*Tithonia diversifolia*) is a juicy soft shrub belonging to the Asteraceae family, which had its source in Mexico and Central America but has a practically pan-tropical distribution [39]. It is currently found in most parts of America, Asia, and Africa [40]. The leaves and succulent stems decompose readily when applied to the surface of the soil or integrated into it to release and make available nearly all the N in about 2 weeks [41]. As a result, it provides a vital source of biomass and nutrients for short term crops, supplying N, P and K in quantities comparable to or better than poultry, cattle and swine manure [42]. It has nutrients averaging 3.5% N, 0.37% P and 4.1% K on dry matter basis [43]. The best fertilizer is made when the plant is dark green and about 1 m tall. Once the plant has flowered it is no longer high in N as most of it has been used in producing the flowers and seeds [44].

### *1.1.8 Neem*

The tree called neem (*Azadirachta indica*) is a member of the family Meliaceae. It reportedly originated from India, Pakistan, and Bangladesh, but it can also be found in tropical regions [45]. Its leaf litter brings the surface pH of acid soils to neutral [46] and the leaves are valuable as mulch, amendments to neutralize soil acidity, as fertilisers, resulting in increased crop growth and output [47]. Neem by-products (the seedcake and leaves) can be used to enhance local soils and encourage long-term productivity. Neem fruits contain 3.3% N, 4.1% P and 3.8% K while neem leaves contain 2-3% N, 1% P and 1.4% K. [48-49].

Neem leaf mould applied to the soil along with sawdust was used in suppressing the populations of plant parasitic nematodes on tomato [50]. The azadirachtin repels and disrupts the growth and reproduction of insects; melantrior causes insects to cease feeding and sallanin inhibits feeding while nimbin and nimbidin have antiviral activities [51].

## 2. Materials and methods

### 2.1 Study site

The experiment was conducted at the Teaching and Research Farm of the Ekiti State University, Ado-Ekiti, Ekiti State, Nigeria. The soil was a slightly acidic (pH (H2O = 6.4) loamy sand, with moderate organic matter content (22.2 g/kg), total N (2.3 g/kg) and exchangeable K (0.3 cmol/kg) while the available P was low (4.47 mg/kg) [19-20].

### 2.2 The treatments

The two composts were alkaline with pH at 8.0 and 8.3 for PDS and CDS respectively. The CDS contained higher total N and K (6.4 and 6.1 g/kg) while PDS contained higher total P (23.0 g/kg) [19-20].

The Sixteen (16) treatments applied in three replicates are:

PDS=Poultry dung/ Sawdust
PDSBN= Poultry dung/Sawdust enriched with Bone meal at 60 g/kg N
PDSBM=Poultry dung/Sawdust enriched with Blood meal at 60 g/kg N
PDSTM=Poultry dung/Sawdust enriched with Tithonia at 60 g/kg N
PDSHN= Poultry dung/Sawdust enriched with Horn meal at 60 g/kg N
PDSHM=Poultry dung/Sawdust enriched with Hoof meal at 60 g/kg N
PDSNM=Poultry dung/Sawdust enriched with Neem at 60 g/kg N
CDS=Cow dung/Sawdust
CDSBN=Cow dung/Sawdust enriched with Bone meal at 60 g/kg N
CDSBM=Cow dung/Sawdust enriched with Blood meal at 60 g/kg N
CDSTM=Cow dung/Sawdust enriched with Tithonia at 60 g/kg N
CDSHN=Cow dung/Sawdust enriched with Horn meal at 60 g/kg N
CDSHM= Cow dung/Sawdust enriched with Hoof meal at 60 g/kg N
CDSNM=Cow dung/Sawdust enriched with Neem at 60 g/kg N
NPK, Soil Alone, there were a total of 48 plots.

### 2.3 Parameters measured

The parameters measured on the field are plants height, number of leaves, stem girth, leaf width, leaf area and total yield. The parameters were measured at 5$^{th}$, 6th, and 7$^{th}$ week after sowing.

### 2.4 Planting, Weeding and Harvesting

Compost treatments were randomly assigned to various plots, of 2 m × 4 m each using completely randomized design (CRD). The different treatments were weighed and mixed with soils of the assigned plots at the rate of 30 t/ha. Sowing of amaranth seeds, at 2.5 kg/ha was done by broadcasting, two weeks after composts' application. Application of NPK, to the designated plots, at 400 kg/ha was also done by broadcasting, two weeks after sowing. Weeding was done twice during the period of study, by uprooting at 3 and 6 weeks after sowing. Sample seedlings were taken for measurements of growth parameters: plant height, leaf area, stem girth, number of leaves and marketable yield (obtained by uprooting and rinsing of vegetables to remove the attached sands). Harvesting was done at 5, 6 and 7 weeks after sowing, by uprooting the vegetables.

### 2.5 Data analysis

Data collected were analyzed using the analysis of variance (ANOVA) and the means were separated using Duncan multiple range test at p=0.05.

## 3. Results and discussion

### 3.1 Performances of Amaranth treated with the organic N-enriched composts

Growth and yield performances of amaranth treated with composts enriched with organic N sources at 5 weeks (WAS) are as indicated in Table 1. CDSNM and PDSNM produced the tallest plants (29.7 cm), and highest number of leaves (PDSNM= 13.7 and CDSNM= 13.3 cm) which did not differ from more leaves (PDSNM= 13.7 and CDSNM= 13.3 cm) though not significantly different from NPK treatment. The thickest stems were obtained from the NPK treatment but which were not significantly different from all N-enriched CDS based composts but significantly differed from all PDS based composts except the PDSNM. The NPK treatment gave the highest leaf

**Table 1.** Responses of Amaranth to composts enriched with organic N sources at 5 WAS

| Treatments | Plant Height (cm) | Number of leaves | Stem Girth (cm) | Leaf Width (cm) | Leaf Area (cm²) | Marketable Yield (t/ha) |
|---|---|---|---|---|---|---|
| Control | 22.00def | 8.00d | 2.50abc | 20.00e | 29.26f | 8.00d |
| NPK | 27.30abc | 11.30abc | 2.80a | 43.33a | 53.83abc | 17.60a |
| PDS | 19.70f | 9.70cd | 2.10bc | 28.00cde | 46.15abcde | 11.20bcd |
| PDSBN | 24.70bcde | 11.30abc | 2.07cd | 25.00de | 44.20abcdef | 10.00cd |
| PDSBM | 26.00abc | 11.70abc | 2.03dc | 30.67bcd | 36.42def | 12.27bc |
| PDSTM | 21.00ef | 10.70abcd | 2.17bc | 35.00bc | 43.97abcde | 13.00bc |
| PDSHN | 22.00def | 10.00cd | 1.57d | 27.00cde | 32.80def | 10.80cd |
| PDSHM | 28.70ab | 12.70abc | 2.10c | 28.67cd | 37.87cdef | 11.37bcd |
| PDSNM | 29.70a | 13.70a | 2.67ab | 31.00bcd | 54.33ab | 12.40bc |
| CDS | 25.7abcde | 11.30abc | 2.03cd | 26.00de | 47.13abcd | 10.40cd |
| CDSBN | 22.70cdef | 10.30bcd | 2.30abc | 23.67de | 40.67bcdef | 9.47cd |
| CDSBM | 25.3abcde | 11.30abc | 2.37abc | 26.33de | 30.33ef | 10.53cd |
| CDSTM | 27.00abc | 11.70abc | 2.53abc | 29.67cd | 44.13abcdef | 11.87bcd |
| CDSHN | 24.3bcdef | 10.70abcd | 2.43abc | 27.33cde | 33.33def | 10.93cd |
| CDSHM | 25.0abcde | 10.00cd | 2.30abc | 27.33cde | 38.22bcdef | 10.93cd |
| CDSNM | 29.70a | 13.30ab | 2.57abc | 38.00ab | 57.83a | 15.20ab |

Means with the same letters in the same columns are not significantly different at $\alpha_{0.05}$

width (43.3 cm) which was not different significantly from only CDSNM while the leaf area (53.83 cm²) was significantly different from the control, PDSBM, PDSHN, CDSBM and CDSHN. The highest marketable yield of leaf amaranth (17.6 t/ha) was produced from the NPK treatment which was not significantly different from 15.2 t/ha obtained from (CDSNM) while the composts gave higher yields than the control. The CDSNM compared well with NPK as an indication of fast N-releasing ability of CDSNM. [19] reported a steady release of N, and probable reduction in fixation of available N in CDSNM.

At 6 WAS (Table 2), the NPK treatment produced the tallest plants (54.67 cm), which differed significantly from all treatments except CDS (51.00 cm) while PDS gave the shortest vegetables (29.00 cm). The values of the growth parameters for CDSNM were lower than those obtained at 5 WAS probably as it released the N faster than PDSNM and some of the other composts. [19] reported a lower C: N ratio of the CDS than PDS which is an indication that N would be released earlier and faster in CDS. The NPK treatment outperformed most of the enriched composts, including CDSDNM in most of the growth parameters measured and marketable yield (18.53 t/ha) which was not significantly different from PDSHM (16.40 t/ha), PDSNM (17.47 t/ha), CDS (17.47 t/ha) and CDSBM (16.00 t/ha). The thinnest vegetables (28.33 cm) with the smallest leaves (20.67 cm in width) and lowest yield (8.27 t/ha) were obtained from plots treated with CDSHN.

Table 3 shows that the NPK-treated plots at 7 WAS produced the highest marketable yield (22.67 t/ha) but was not significantly different from the control, PDSHM, CDSHM and CDSNM. The CDSBM gave the lowest vegetable yield of 8.93 t/ha at 7 WAS. The CDSBM gave the lowest vegetable yield of 8.93 t/ha at 7 WAS. Some of the composts decreased in yield and most of the growth parameters between the weeks PMSD, PDSTM, CDSTM, CDSHN and CDSNM gave lower yields at 6 WAS but increased at 7 WAS while PDSHN, PDSNM, CDS, CDSBN and CDSBM had yield increase at 6 WAS but reduced at 7 WAS. The yields of PDSBN, PDSHM and CDSHM treatments increased throughout the study period.

The enriched composts were comparable to NPK 15-15-15 and PMSD, PDSTM, CDSTM, CDSHN and CDSNM, which gave reduced yield values at 6 WAS could be recommended for short-season vegetables. [19] had noted the suitability of PDSTM for short-season vegetables and CDSNM for both short and long-season crops, including vegetables.

## 4. Conclusions

The composts: CDS and PDS did not differ from the control treatment in leaf amaranth growth and

**Table 2.** Responses of Amaranth to composts enriched with organic N sources at 6 WAS

| Treatments | Plant Height (cm) | Number of leaves | Stem Girth (cm) | Leaf Width (cm) | Leaf Area (cm²) | Marketable Yield (t/ha) |
|---|---|---|---|---|---|---|
| Control | 31.00efg | 11.00a | 2.90ab | 29.00fg | 32.00e | 11.60fg |
| NPK | 54.67a | 13.67a | 3.00a | 46.33a | 53.83bc | 18.53a |
| PMSD | 29.00fg | 11.00a | 2.90ab | 25.00gh | 48.15bcd | 10.00gh |
| PDSBN | 30.00efg | 13.67a | 2.60abcd | 26.00gh | 45.95cde | 10.40gh |
| PDSBM | 30.00efg | 12.67a | 2.43bcd | 23.00gh | 38.13de | 9.20gh |
| PDSTM | 34.00edf | 14.00a | 2.60abcd | 28.33fg | 47.17bcd | 11.33fg |
| PDSHN | 31.67ef | 13.00a | 2.63abcd | 33.33def | 35.02de | 13.33def |
| PDSHM | 36.00cde | 12.67a | 2.87ab | 41.00abc | 37.73de | 16.40abc |
| PDSNM | 41.33bc | 12.33a | 2.73abcd | 43.67ab | 110.30a | 17.47ab |
| CDS | 51.00a | 14.00a | 2.93ab | 43.67ab | 41.65de | 17.67ab |
| CDSBN | 33.33def | 12.67a | 2.83ab | 37.33bcde | 38.73de | 14.93bcde |
| CDSBM | 42.33b | 12.33a | 2.80abc | 40.00abcd | 31.73e | 16.00abcd |
| CDSTM | 24.67g | 10.67a | 2.63abcd | 24.33gh | 42.15de | 9.73gh |
| CDSHN | 28.33fg | 11.67a | 2.33cd | 20.67h | 37.07de | 8.27h |
| CDSHM | 31.67ef | 12.33a | 2.87ab | 30.33efg | 39.75de | 12.13efg |
| CDSNM | 38.33bcd | 14.00a | 2.90ab | 34.33cdef | 60.50b | 13.73cdef |

Means with the same letters in the same columns are not significantly different at $\alpha_{0.05}$

**Table 3.** Responses of Amaranth to composts enriched with organic N sources at 7 WAS

| Treatments | Plant Height (cm) | Number of leaves | Stem Girth (cm) | Leaf Width (cm) | Leaf Area (cm²) | Marketable Yield (t/ha) |
|---|---|---|---|---|---|---|
| Control | 38.00bcd | 15.00a | 2.700cd | 44.00ab | 39.25fg | 17.20ab |
| NPK | 52.00a | 13.00abc | 3.200a | 56.67a | 63.08b | 22.67a |
| PDS | 31.00cde | 11.33bc | 2.700cd | 31.00bc | 42.25fg | 12.27bc |
| PDSBN | 26.67de | 10.67c | 2.700cd | 30.33bc | 52.72cde | 12.00bc |
| PDSBM | 29.33cde | 13.00abc | 2.77abcd | 36.00bc | 43.33efg | 14.40bc |
| PDSTM | 37.33cde | 11.33bc | 2.73bcd | 31.33bc | 55.33bcd | 12.40bc |
| PDSHN | 30.67cde | 11.33bc | 2.50cd | 25.67bc | 37.82fg | 10.27bc |
| PDSHM | 40.00bc | 13.33abc | 2.97abc | 44.33ab | 39.40fg | 17.33ab |
| PDSNM | 32.00cde | 12.33abc | 2.83abc | 37.00bc | 112.00a | 14.67bc |
| CDS | 29.67cde | 10.67c | 2.63cd | 29.33bc | 47.83def | 11.73bc |
| CDSBN | 25.00e | 11.33bc | 2.73bcd | 36.33bc | 38.07fg | 14.40bc |
| CDSBM | 25.67e | 13.33abc | 2.30d | 22.33c | 33.33g | 8.93c |
| CDSTM | 29.67cde | 15.33a | 2.63cd | 29.33bc | 38.82fg | 11.60bc |
| CDSHN | 25.33e | 12.67abc | 2.60cd | 24.33bc | 37.33fg | 9.73bc |
| CDSHM | 44.00ab | 14.00ab | 2.17ab | 43.00ab | 40.67fg | 16.80abc |
| CDSNM | 37.00bcde | 14.00a | 2.83abc | 42.00abc | 62.32bc | 16.40abc |

Means with the same letters in the same columns are not significantly different at $\alpha_{0.05}$

marketable yields. This makes additional N input inevitable to ensure that the N level in composts would support crop performance. This was achieved with organic N materials as the ensuing enriched composts gave higher growth and yield parameters than the control and compared favourably with the quick nutrient-releasing NPK 15-15-15 fertilizer in the growth and yield measurements. The implication is that the enriched composts would effectively replace inorganic fertilizers for soil management and improvement, especially while putting the life cycle of crops into consideration. PMSD, PDSTM, CDSTM, CDSHN CDSNM PDSHN, PDSNM, CDS, CDSBN and CDSBM, are recommended for short-season crops and PMSD, PDSTM, CDSTM, CDSHN and CDSNM, whose yield values increased at 7 WAS could also be useful for long-season crops, while PDSBN, PDSHM and CDSHM with continuous yield increase should be adopted for both short and long-season crops.

## Authors' contributions

Conceptualization, A.F.O; Methodology, A. F. O.; Software, A.F.O. and O.S.O.; Validation, A.F.O. and O.S.O.; Formal Analysis, A.F.O.; Investigation, A.F.O.; Resources, A.F.O.; Data Curation, A.F.O.; Original Draft Preparation, A.F.O.; Review & Editing, O.S.O.; Supervision, A.F.O.; Project Administration, A.F.O; Funding Acquisition, A.F.O. and O. S. O.

## Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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## Conflicts of interest

The author declares that there is no conflict of interest regarding the publication of this paper

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