

Analysis Of Different Levels of Composted Poultry Litter on Growth and Yield of Amaranthus in Owo. Ondo State

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Abstract- *This study evaluated the effects of different levels of compost manure on the growth and yield of Amaranthus hybridus in Owo, Ondo State, Nigeria. The experiment was conducted in 2025 at the Teaching and Research Farm of Rufus Giwa Polytechnic, using a Randomised Complete Block Design (RCBD) with four treatments: 0, 5, 10, and 15 t/ha of compost manure, each replicated three times. Proper soil analysis before planting indicated sandy clay loam, slightly acidic and low in essential nutrients. Data were collected on soil physical properties, plant height, number of leaves, number of nodes, stem girth, and fresh and dry weights, and analysed using Analysis of Variance (ANOVA) with Duncan Multiple Range Test (DMRT) at 5% significance level. Results showed that compost manure significantly improved soil physical properties by reducing bulk density and temperature while increasing porosity and moisture content. Growth and leaf yield of Amaranthus hybridus were significantly enhanced with increasing compost levels. The highest values for plant height, leaf number, number of nodes, stem girth, and biomass yield were recorded at 10 and 15 t/ha, with no significant difference between these two rates in most cases. The poor performance observed in the control treatment was attributed to low soil fertility. The study concludes that composted poultry manure at 10–15 t/ha optimises the growth and yield of Amaranthus hybridus under the agroecological conditions of Owo. The use of compost manure is therefore recommended as a sustainable and environmentally friendly soil fertility management practice for vegetable production.*

Keywords: *Amaranthus hybridus, compost manure, poultry litter, soil fertility, growth performance, yield.*

I. INTRODUCTION

Amaranthus hybridus, commonly called green amaranth (Jimoh et al., 2018), belongs to the family Amaranthaceae, the subfamily Amaranthoideae, and

the genus Amaranthus, which are plants with broad leaves and nutritious grains (Christenhusz et al., 2016; Waselkov et al., 2018). Amaranthus is a leafy vegetable, widely cultivated in Nigeria, due to its high nutritional value, adaptability, short maturity period, and economic importance to smallholder farmers (Olawuyi et al., 2018). Amaranth is of great importance to humans because it is a rich source of essential vitamins, proteins, minerals, and bioactive compounds (Nyonje et al., 2014). It also contains vitamins such as thiamine, niacin, and riboflavin, and minerals like calcium, iron, potassium, zinc, copper, and manganese (Mathe, 2014). The Amaranthus leaves are an ideal source of antioxidant pigments, like betalain, β -xanthin, and β -cyanin, anthocyanins, carotenoids, and chlorophylls (Sarker et al., 2018b, 2018c) and natural antioxidant phytochemicals, like vitamin C, phenolic acids, and flavonoids (Sarker et al., 2018a). The high consumer demand makes it a choice among local farmers. The fibre content also prevents constipation when consumed (Noonan, 1999; Buragohain et al., 2013). However, low soil fertility and poor soil nutrient management remain key constraints to improved growth and productivity (Adeniyi & Ojeniyi, 2008). Organic amendments such as compost manure have shown positive effects on soil health and crop performance due to their mineral element and microbial enrichment (Bolandnazar et al., 2018).

Compost manure has been known to stabilise soil nutrients, reduce pathogens and create a valuable organic fertiliser (Al-Karaki et al., 2004). Yet, despite the agronomical and nutritional importance, the crop is most often produced below its biological and economic potential under smallholder conditions. There is, therefore, limited empirical data on the

optimal compost manure rates for Amaranthus production in the agroecological zone of Owo, Ondo State. There is a need to identify sustainable nutrient management strategies that maximise yield while maintaining soil health. This study aims to evaluate the effect of different levels of compost manure on the growth parameters of Amaranthus, determine the influence of compost manure on its yield components, and identify the best compost manure application rate for its production in Owo.

Compost manure is generally considered the most valuable for use as a fertiliser, due mainly to its buffering effect on soil and availability of large amounts of N, P and K.

Composting is an ecological and economical alternative for treating organic waste; it is the transformation of manure into an organic fertiliser (Huang et al., 2017). Composting is not a new technology; it is a waste management strategy, a suitable option for manure management due to its economic and environmental benefits (Bernal et al., 2009). The composting process, if carried out properly, converts wet, odorous organic waste into a dry, odourless, decomposed, and reusable product (Khater, 2015)

Therefore, the nutrient content of compost manure is closely related to the organic matter content of the materials used (Wells, 2007). As a result, compost manure provides nutrients available for plant use, increases soil organic matter, thereby improving soil structure, porosity, bulk density, and moisture content (Agbede 2008; Agbede et al., 2013).

Compost manure enhances soil characteristics, such as soil pH, soil aeration, microbial growth, and the cation exchange capacity. Agbede (2007) stated that to obtain a well-balanced fertility in any soil, the application of compost derived from poultry and other animal manures is necessary to improve the structure of the soil, existing nutrients and moisture content.

II. Materials and Methods

Site description

The field experiment was carried out at the Teaching and Research Farm of Rufus Giwa Polytechnic, Owo, Ondo State, Nigeria, in 2025. Owo is located at a latitude of 7° 12'N, longitude 5° 35' W, within the forest-savanna transition zone of southwest Nigeria. The soil at Owo is an Afisol classified as Oxic Tropudalf (Luvisol (FAD, year) (USDA year) or Luvisol (FAO). There are two rainy seasons, one from March to July and the other from mid-August to November. Annual rainfall ranges from 1,100 to 1,500mm, and temperatures range from 24°C to 30°C. The experimental site was previously used to cultivate a mixed crop patterned in subsistence agriculture and was later fallowed for two years. Before clearing, the predominant weeds at the site were siam weed (*Chromolaena odorata* L.), water leaf (*Talinum triangulare* L.) and haemorrhage plant (*Aspilia*) milk weed

Field Experiment, Treatment and Crop Establishment

The experiment was laid out using a Randomised Complete Block Design (RCBD) with three applications. The treatments consisted of four levels of compost manure (0, 5, 10, and 15kg/ha). Each plot was 2m x2m. The site was ploughed and harrowed before sowing. Amaranthus seeds obtained from the shelter agronomist supply, Owo, were sown by drilling at a depth of 1cm, at a spacing of 50cm x 30cm on 12 June 2025. One week after sowing, the seed emerged. Seedlings were thinned to two vigorous seedlings per stand. Compost manure (CM) was applied by mixing with cultivated soil two weeks before planting. Weeds were normally controlled by hoeing at 2, 4 and 6 weeks after sowing. Insect pests were controlled by spraying insecticide at 30ml per 10 litres of water, starting one week after seedling emergence, using the discharge spray.

Determination of Pre and Post Soil physical and chemical Properties

Before commencement of the experiment in 2025, (surface 0-15cm depth) soil samples from the experimental site were randomly collected from five different points in each plot and bulked. After air drying, it passes through a 2mm engineering (builder) sieve for analysis. A similar approach was used after harvest. Particle size analysis was by the hydrometer method, organic matter by the dichromate oxidation method, total N by the micro-Kjeldahl, and available

P by Bray-1 extraction followed by molybdenum blue colourimetry. Exchangeable K, Ca, and Mg were extracted using ammonium acetate. Thereafter, the K level was determined using a flame photometer, and the Ca and Mg levels by an atomic absorption spectrophotometer. Soil pH was evaluated using a (1:2) medium with a digital electronic pH meter.

Source and Preparation of Compost Manure

The poultry litter was obtained from the poultry unit, and cassava peels were collected from the garri processing shed, Rufus Giwa Polytechnic, Owo.

The compost site was well-shaded. The compost was prepared using three pits; two of the pits were filled with dry material (straw and leaves), followed by poultry manure and a thin layer of soil. This process was repeated until the pit was filled up. In the process, a little amount of water was sprinkled. The compost was then turned every two weeks into the third pit, and in the order until it was thoroughly mixed and decomposed. Compost samples were taken for laboratory analysis to determine their nutrient composition. As well as organic C, total N, P, Ca and Mg.

Determination of growth and yield parameters

Five plants were randomly selected from each plot at 15 and 20, 25, 30 days after planting, after compost manure application using a destructive method. For data analysis, Plant height, number of leaves, number of nodes, stem girth, fresh and dry weight were measured by a sensitive balance. The leaves' weight was evaluated on the cumulative quantity at harvests. After harvest, the plants were excavated to measure fresh and dry weight and stem girth.

Statistical Analysis

Data collected from the experiment were subjected to analysis of variance (ANOVA), and treatment means were compared using the Duncan Multiple Range Test (DMRT) at 5% probability level.

III. RESULTS

Initial soil properties and analysis of compost manure
 The physico-chemical properties of soil at the experimental site and the physico-chemical properties of compost manure are shown in Table 1.

The results show the soil type was sandy clay loam in texture, slightly acidic and low in nutrients before the experiment. The physicochemical properties of the soil and the compost are shown in Table 1. The soil type was sandy clay loam, slightly acidic and low in fertility as reflected by low organic matter (1.16%), total N (0.08%), available P (8.6mg/kg) and exchangeable Ca (1.20%). The exchangeable K and Mg were adequately recorded to the critical levels of 3% OM, 0.2%N, 10 mg/kg available P, 0.16-0.20cmol/kg exchangeable K, 2.0 cmol/kg exchangeable Ca and 0.40 cmol/kg exchangeable Mg recommended for crop production in ecological zones of Nigeria (Akinrinde and Obigbesan, 2000). The soil also had high bulk density. The compost manure used was rich in major nutrients needed for the growth of vegetable crops such as okra. The compost application is expected to improve soil fertility and amaranth's performance.

Table 1: Initial soil physical and chemical properties (0-15cm depth) of the experimental site before sowing amaranths in 2025, and the chemical composition of the compost manure used

Property	Value	Property	Value
Sand percentage	68.8	Compost Manure	
Silt percentage	6.0	Ph	6.8
Clay percentage	25.2	Organic C %	14.9
Textural class	sandy clay loam	Nitrogen %	2.23
PH (water)	5.3	C: N	6.7
Bulk density (Mg/m ³)	1.56	Phosphorus %	0.83
Total porosity (% v/v)	41.1	Potassium %	1.94
Organic matter percentage	1.16	Calcium %	1.42
Total Nitrogen percentage	0.08	Magnesium %	0.58
Available P (cmol/kg)	8.8		
Exchangeable K (cmol/kg)	0.26		
Exchangeable Ca (cmol/kg)	1.20		
Exchangeable Mg (cmol/kg)	0.60		

Effect of compost manure on soil physical properties
 Data on soil physical properties in response to compost manure are presented in Table 2. Compost manure significantly influences ($p \leq 0.05$) soil bulk density, total porosity, moisture content and temperature compared to the control. Compost manure at all levels reduced soil temperature and increased porosity and moisture content with application. There were no significant differences in bulk density, moisture content, total porosity, and temperature at 5, 10, and 15t/ha compost manure application.

Table 2: Effect of Compost manure on soil physical properties (0- 15cm depth) when average cross sampling periods (0 – 15cm depth) during the cropping season

Treatment	Bulk density (Mg/m ³)	Total porosity	Moisture content (%)	Temperature (°C)
0t/ha PM (control)	1.53a	42.3d	12.4d	34.6a
5t/ha PM	1.31b	50.6c	15.0c	31.3b
10t/ha PM	1.12c	57.7a	17.5b	29.2c
15t/ha PM	1.08cd	59.2ab	20.1a	28.7cd

Note; DAS- Days after sowing

Values are not significantly different at $p = 0.05$ according to Duncan's multiple range test (DMRT). PM = Compost Manure.

Table 3 – Analysis of variance for mean plant height of amaranthus (amaranthus hybridus) at different sampling dates showed that organic compost treatments had significant effects on plant height(cm). The mean plant height under control on different sampling dates showed the lowest values in relation to the highest values obtained at 5, 10, & 15 tons/ha compost. However, the highest value was obtained at 15 tons/ha application level. There was no significant difference between 10t/ ha and 15t/ha application rates across all sampling dates. At 20 days after sowing (DAS), the lowest height was obtained at the control, while other values, though varied, were not significantly different at ($p \leq 0.005$)

Table 3: Effect of compost manure treatment on the plant height of Amaranthus (Amaranthus hybridus) at different sampling dates

Organic manure level	15DAS	20DAS	25DAS	30DAS
0t/ha PM	10.52c	13.58b	14.96bc	17.50
5t/ha PM	12.66bc	15.33a	16.87b	20.20b
10t/ha PM	15.02ab	17.68a	19.36ab	25.25a
15t/ha PM	17.17a	18.17a	21.22a	27.14a

Note: DAS- Days after sowing

Values are not significantly different at $p = 0.05$ according to Duncan's multiple range test (DMRT). PM = Compost Manure.

Table 4- The number of leaves was influenced significantly by the application of compost at different sampling dates. The highest number of leaves was recorded at 15t/ha application rates, while the least was recorded at the control across all

sampling dates. Growth was linearly positioned with increasing order corresponding to days after sowing (DAS). Application of 10 and 15 t/ha compost produced high leaves that were not significantly different ($p \leq 0.05$). At 2 DAS, values of the number of leaves at 10t/ha and 15t/ha were not significantly different, but application of 15t/ha influenced the number of leaves of amaranth more.

Table 4: Effect of compost manure treatment on the number of leaves on Amaranthus (Amaranthus hybridus) at different sampling dates

Compost manure level	15DAS	20DAS	25DAS	30DAS
0t/ha PM	8.66cc	10.85c	16.00c	17.00c
5t/ha PM	10.16c	15.56b	29.19b	25.20b
10t/ha PM	14.39b	17.00b	22.18ab	28.00a
15t/ha PM	17.36a	19.86a	25.00a	30.33a

Note: DAS- Days after sowing

Values are not significantly different at $p = 0.05$ according to Duncan's multiple range test (DMRT). PM = Compost Manure.

Table 5: Number of nodes of amaranths showed a significant difference with the application of 15t/ha of compost across the treatment sampled. The number of nodes produced at 5t/ha and 10t/ha of compost across all sampling data was not significantly different ($p \leq 0.05$). The lowest node value was recorded in the control treatment.

Table 5: Effect of compost manure treatment on the number of nodes on Amaranthus (Amaranthus hybridus) at different sampling dates

Compost manure level	15DAS	20DAS	25DAS	30DAS
0t/ha PM	4.26b	5.66c	8.36c	12.36c
5t/ha PM	5.00b	7.11b	11.12b	13.17bc
10t/ha PM	5.25b	7.95b	11.69b	14.99b
15t/ha PM	8.31a	10.36a	14.13a	17.96a

Note: DAS- Days after sowing

Values are not significantly different at $p = 0.05$ according to Duncan's multiple range test (DMRT). PM = Compost Manure.

Table 6- Effect of compost manure treatment on the stem girth of Amaranthus (Amaranthus hybridus) at different sampling dates showed a significant difference ($p \leq 0.05$). The highest value was recorded at the highest compost level of 15 tons/ha, and the lowest value was obtained from the control treatment

at all sampling dates. There was no significant difference in the value of stem girth at 10t/ha and 15t/ha application rates across the sampling dates.

Table 6- Effect of compost manure treatment on the stem girth of *Amaranthus* (*Amaranthus hybridus*) at different sampling dates

Compost manure level	15DAS	20DAS	25DAS	30DAS
0t/ha PM	1.12b	1.20c	1.86b	2.36d
5t/ha PM	1.12b	1.25b	1.93ab	2.58c
10t/ha PM	1.53a	1.97a	2.28a	3.11b
15t/ha PM	1.55a	2.10a	2.50a	3.65a

Note: DAS- Days after sowing

Values are not significantly different at $p = 0.05$ according to Duncan's multiple range test (DMRT). PM = Compost Manure.

Table 7-The analysis of variance of means of fresh weight and dry weight of amaranths at different sampling dates revealed that the fresh weight of *Amaranthus* was significantly influenced by compost manure. The highest fresh weight was recorded at 10/15tons/ha of compost across all samples. The least value was recorded in the control treatment.

Similarly, the dry weight followed the pattern of the fresh weight. Dry weight of amaranths was influenced by the application of 10/15 tons/ha of compost. The dry weight was under control, and 5 tons/ha was the least in value. There was no significant difference between the treatments of control and 5ton/ha compost manure.

Table 7 - Effect of compost manure treatment on the fresh and dry weight of *Amaranthus* (*Amaranthus hybridus*) at different sampling dates

Organic manure level	15DAS		20DAS		25DAS		30DAS	
	DRY	FRS	DRY	FRS	DRY	FRS	DRY	FRS
0t/ha PM	0.30	15.11d	0.45c	18.13d	0.56d	20.10c	1.25c	19.69d
5t/ha PM	0.48b	32.34c	1.07b	50.00c	1.32c	54.13b	1.47b	55.0c
10t/ha PM	0.52b	37.16b	1.17b	55.14b	1.77b	58.41b	1.65b	55.63b
15t/ha PM	0.60a	50.18a	1.47a	74.28a	2.91a	70.33a	2.47a	72.11a

Note; DAS- Days after sowing

Values are not significantly different at $p = 0.05$ according to Duncan's multiple range test (DMRT). PM = Compost Manure.

IV. DISCUSSION

Amaranth is an important vegetable garden crop in both commercial and subsistence agriculture, particularly among women in agriculture. (Gelaye, 2023). Leafy production has been enhanced by inorganic fertilisers, which are becoming unpopular due to low nutrient content and poor taste. The use of organic manure had been advocated in place of chemical fertilisers.

The result of the soil test conducted before the research indicated a relatively low nutrient status. Probably as a result of fatigue from continuous cropping, the soil is exposed, which manifested in the poor vegetative growth of amaranths obtained from the control plots in all sampling dates of the experiment. This observation is consistent with the report by Akanbi and Toogun (2002) that poor nutrient status reduces leaf area index and overall performance of amaranths.

Application of compost manure at the rate of 10- 15 tons/ha influences the overall performance of amaranths in this study. Highest plant height, number of leaves, number of nodes, Fresh weight and dry weight were obtained with the application of 10-15 tons/ha of compost. This observation could be linked to the sufficiency of macro and micro nutrients for the plant. Supporting this result, Akanbi et al. (2010) and Babalola et al. (2010) in their various studies on okra, tomatoes, and roselle (*Hibiscus babdariffa*) reported the highest plant growth parameter. According to Adeyeye et al., (2025) shoot yield of amaranth vegetable was improved by the compost manure treatment, which may be due to the supply of organic nitrogen by the compost manure, stressing further, Daramola et al.,(2009) elaborated that nitrogen which is an important constituent of chlorophyll, protein, amino acid, nucleic acid, nucleotides, enzymes alkaloids, and vitamins which played a significant roles in the synthesis of carbohydrate and protein metabolism. The presence of nitrogen facilitated the growth and development of amaranths in the study.

Fresh and dry weights of amaranths increased significantly with the application of compost manure. The nitrogen load in the compost manure could be

responsible for the energy required for metabolic activities in the plant; therefore, cell division and subsequent provision of large biomass was recorded in this study. This agrees with Adeyeye et al. (2025) that poultry manure (organic) supply not only primary elements, but secondary and trace elements, which are released to plants in synchrony and also influence shoot increase and dry matter production throughout the growing phase.

V. CONCLUSION

This research study evaluates the effects of varying levels of compost manure in the cultivation of amaranths. The result showed that compost manure can largely improve poor soil that has been depleted of fertility.

Improving the vegetative yield of amaranthus was achieved with 10-15 tons/ha of compost manure. Organic manure composting is easy, less expensive and environmentally friendly in terms of toxicity to plants and consumers of the crops. Nutrient improvement on varied soil overcropped soil was accomplished with the application of compost manure, with assurances of lasting effect on soil fertility enhancement.

REFERENCES

- [1] Adeniyi, O. N., & Ojeniyi, S. O. (2008). Growth and yield response of Amaranthus hybridus to poultry manure. *African Journal of Agricultural Research*.
- [2] Adeyeye, A.S, Etukudo, O.O, Ahmadu, R, Balogun, K, Olalekan, K.K, Gadu, H.O, & Ishaku, M.A. (2025). Influence of Organic and Inorganic Nutrient Sources on the Growth and Shoot Yield of Amaranthus Variety (AMARANTHUS CRUENTHUS) in North East Nigeria. In *Global Journal of Research in Agriculture & Life Sciences* (Vol. 5, Number 3, pp. 24–31). <https://doi.org/10.5281/zenodo.15377640>
- [3] Akanbi, W.B, Togun, A.O., J.A. Adediran and E.A.O. Ilupeju; Growth, Dry Matter and Fruit Yields Components of Okra under Organic and Inorganic Sources of Nutrients, *Am. Eurasian J. Sustain. Agric.*,4(1): 1-13, 2010
- [4] Agbede, T.M. (2007) Response of soil properties and sorghum (*Sorghum bicolor* (L) Moench) to tillage and poultry manure in the Forest-savanna transition zone of Nigeria. Unpublished PhD thesis, the Federal University of Technology, Akure, 212pp.
- [5] Agbede, T.M. (2008), Agbede et al. (2013). Effect of poultry manure on soil characteristics
- [6] Such as soil pH, soil aeration, microbial growth and CEC and the buffering action of the soil. and the yield of white yams and yellow yams. *University of Khartoum Journal of Agricultural Sciences* 20(3), 286-303.
- [7] Akanbi, W.B, and Togun, A.O. (2002). The influence of maize stover compost and nitrogen fertiliser on growth, yield and nutrient uptake of amaranths. *Scientia Horticulture* 93(1), 1-8. [https://doi.org/10.1016/50304-4238\(01\)00305-3](https://doi.org/10.1016/50304-4238(01)00305-3)
- [8] Al-Karaki, G. N., et al. (2004). Composting poultry manure: Effects on nutrient content and maize yield. *Soil Science*
- [9] Babalola, D.A; Makinde, Y.O; Omonona, B.T; Oyekanmi, M.O. (2010). Determinants of Postharvest Losses in Tomato Production: Case Study of Imeko–Afon Local Government Area, Ogun State. *Acta SATECH*, 3,14-18
- [10] Bernal, M.P.; Albuquerque, J.A.; Moral, R. Composting of animal manures and chemical criteria for compost maturity assessment. A review. *Bioresour. Technol.* 2009, 100 5444–5453. [CrossRef]
- [11] Bolandnazar, S., et al. (2018). Organic amendments and vegetable crop performance. *Journal of Plant Nutrition*
- [12] Buragohain J, Singh VB, Deka BC, Jha AK, Wanshiong K and Angami T (2013). Collection and evaluation of some underutilized Leafy vegetables of Meghalaya.

- Indian Journal of Hill Farming, 26(2) (2013)pp 111-115.
- [14] Christenhusz, M.J.M.; Byng, J.W. The Number of Known Plant Species in the World and Its Annual Increase. *Phytotaxa* 2016, 261, 201. [Google Scholar]
- [15] Daramola B, Fasominu, O. A, Oje, O. J, Makanju, O.O (2009) Influence of dietary Supplementation on biotransformation of locust beans (*Parkia biglobosa*) to condiment *African Journal of Biotechnology*, 2009
- [16] Gelaye (2023). A review of the amaranth crop as a potential solution to Ethiopia's nutritional crisis. *Nutrition and Dietary Supplement*; 15 ;101-110 <https://doi.org/10.2147/NDS.S428058>
- [17] Huang, J.; Yu, Z.; Gao, H.; Yan, X.; Chang, J.; Wang, C.; Hu, J.; Zhang, L.(2017). Chemical structures and characteristics of animal manures and composts during composting and assessment of maturity indices. *PLoS ONE* 2017, 12, e0178110. [CrossRef]
- [18] Jimoh, M. O., Afolayan, A. J., & Lewu, F. B. (2018). Suitability of *Amaranthus* species for alleviating human dietary deficiencies. *South African Journal of Botany*, 115, 65–73. <https://doi.org/10.1016/j.sajb.2018.01.004>
- [19] Khater, E.S.G. Some Physical and Chemical Properties of Compost. *Int. J. Environ. Waste Manag.* 2015, 5, 172. [CrossRef]
- [20] Mathe, S. (2014). A comparative study of antioxidant potentials of some leafy vegetables, Emphasis on African leafy vegetables and exotic vegetables.
- [21] Nyonje, W.A.; Makokha, A.O.; Abukutsa-Onyango, M.O. (2014), Anti-Nutrient, Phytochemical and Antiradical Evaluation of 10 Amaranth (*Amaranthus* spp.) Varieties Before and After Flowering. *J. Agric. Sci.* 2014, 6, 68. [Google Scholar] [CrossRef]
- [22] Olawuyi, O. J., et al. (2018). Nutrient management strategies for leafy vegetables in Nigeria. *Journal of Horticultural Science*.
- [23] Sarker, U., Islam, M. T., Rabbani, M. G., & Oba, S. (2018a). Phenotypic divergence in vegetable amaranth for total antioxidant capacity, antioxidant profile, dietary fibre, nutritional and agronomic traits. *Acta Agriculturae Scandinavica. Section B—Soil & Plant Science*, 68, 67–76. <https://doi.org/10.1080/09064710.2017.1367029>
- [24] Sarker, U., Islam, M. T., Rabbani, M. G., & Oba, S. (2018b). Variability in total antioxidant capacity, antioxidant leaf pigments and foliage yield of vegetable amaranth. *Journal of Integrative Agriculture*, 17(5), 1145–1153. [https://doi.org/10.1016/S20953119\(17\)61778-7](https://doi.org/10.1016/S20953119(17)61778-7)
- [25] Sarker, U., Islam, T., Rabbani, G., & Oba, S. (2018c). Antioxidant leaf pigments and variability in vegetable amaranth. *Genetika*, 50(1), 209–220. GENS1801209S
- [26] Wells, M.L. 2007 Southeastern pecan grower's handbook. Univ. Georgia Coop. Ext. Pub. 1327
- [27] Waselkov, K.E.; Boleda, A.S.; Olsen, K.M. (2018) A Phylogeny of the Genus *Amaranthus* (Amaranthaceae) Based on Several Low-Copy Nuclear Loci and Chloroplast Regions. *Syst. Bot.* 2018, 43, 439–458. [Google Scholar] [CrossRef]