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Research Article

The Effects of Different Types of Soil on Germination and Early Seedling Development of *Annona muricata* Linn.

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Abstract: The germination and early seedling development of *Annona muricata* were examined in four different types of soil viz: loamy soil, sandy soil, clay soil and top soil (control). Percentage germination, seedling height, number of leaves per plant, stem girth and leaf area were determined for three months. The results obtained revealed that the highest mean germination of 100% was recorded in seeds sown in sandy soil while the least percentage germination was recorded in seeds sown in loamy soil (20%). The results of this study also showed that seedlings planted on top soil has the highest mean height (19.12cm), stem girth (1.51cm), leaf area (31.23cm^2) and lower number of leaves (11.34) compared to that of loamy soil. Seedlings on loamy soil have the highest number of leaves (12.50) when compared to seedlings planted on other types of soil. Seedlings on sandy soil had no appreciable performances with mean plant height, number of leaf, stem girth and leaf area of 11.42cm, 7.00, 0.9cm and 9.24cm^2 respectively. While the least seedling development was recorded in seedlings planted on clay soil which gave mean plant height, leaves production, stem girth and leaf area of 2.33cm, 1.33, 0.12cm and 4.38cm^2 respectively at three months after planting. It is therefore opined that sandy soil was the most effective soil type for enhancing best seed germination while top soil may be considered for enhancing best seedling development in *Annona muricata* Linn**.**
Keywords: Soil type, Germination, Seedling development, *Annona muricata*.

INTRODUCTION

Soils are heterogeneous composition of substances that constitute an important component of the earth's biosphere (Glanz 1995). Gopal (1990) defined soil as a thin layer of the earth's crust which serves as a natural medium for the growth of plants. Plant-soil relationships in the surface soil layer affect crop productivity, nitrate leaching and plant pest interactions (Wyland *et al.*, 1996). Soil is one of the most important natural resources and a major factor in global food production (Den Biggelaar *et al.*, 2003). There has been an innate interest in soil and land quality since the advent of agriculture (Carter et al, 2004). The soil characteristics below the grounds are recognized as possible key factors in affecting plant species coexistence and community organization (Bonanomi and Mazzoleni, 2005). Inappropriate land use and poor soil management adversely affect the environment and soil's productivity (Jagadamma *et al.*, 2008).

The characteristics of soil play a big part in the plant's ability to extract water and nutrients. If plants are to grow to their potential, the soil must provide a satisfactory environment for plant growth. Plants obtain oxygen and carbon from the air by photosynthesis. Soil provides the place for plants roots to anchor and grow. It holds the water in which the soil plant nutrients are changed into ions, which is the form that the plant can use. It holds the air space that prevents the plant from becoming water logged; it holds the chemicals that determine soils pH, salinity and dispersivity (CSIRO 1979). A soil favourable for plant growth consists of approximately one-half solid mineral particles and one-half pores, voids, and cracks between the particles. Pores, voids, and cracks are of irregular size and shape and are filled with air and water. A mixture of large and small pores is desirable (Gardner & Ross 1979). Nutrient availability varies and mostly depends on soil types. Nutrients content of the soil is an important soil chemical property and different soil has different properties (Brye *et al.*, 2004). Nitrogen deprivation in

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the soil reduces the leaf production, individual leaf area and total leaf area of plants (Vos *et al.*, 2005). High nitrogen (N) in the soil resulted in high shoot dry matter production per plant (Cechin & Fatima, 2004).

The names of soil texture classes are intended to give an idea of textural make-up and physical properties of soils. The three basic groups of texture classes are sands, clays and loams. A soil in the sand group contains at least 70% by weight of sand, a soil in the clay group contains at least 35% - 40% clay and, a loam soil is a mixture of sand, silt and clay particles that exhibit light and heavy properties in about equal proportions. The basic soil group name comes last in the class name, thus loam sand is in the sand group, and sandy loam is in the loam group (Buckman & Brady 1960).

Clay based soils tend to have a reddish or orange colour due to higher iron content. Clay soils have smaller soil particles and therefore do not drain well. Typically soils that are high in clay are considered a lower quality soil for growing plants (Wikipedia 2019). According to Komolafe & Joy (1981), clay soil is sticky, plastic and easily mouldable into shapes when wet. Clay particles tend to aggregate into lumps which get very hard as they dry out. Sandy soil is the opposite of clay soil in that the soil particle size is larger allowing for water and nutrients to flow through it quickly. Hence it is consider a lower quality soil (Wikipedia, 2019). Sandy soil has the disadvantages of being hungry soils, because nutrients are easily leached away by drainage. Water drains easily and very rapidly through sandy soils (Komolafe & Joy 1981).

The “gold standard” soil is called loamy soil and is comprised of 20% clay, 40% sand, and 40% silt (medium sized particles) (Wikipedia 2019). Loamy soils are 'all round' soils and may be used to grow most crops. They have the advantages of clay soils in that they retain plant nutrients and also the drainage of sandy soils. They are easy to cultivate, easy for root to penetrate and ideal for seed germination (Komolafe & Joy, 1981). Topsoil is the upper, outermost layer of soil, usually the top 5 inches (13 cm) to 10 inches (25 cm). It has the highest concentration of organic matter and microorganisms and is where most of the Earth’s biological soil activity occurs. Topsoil is composed of mineral particles, organic matter, water, and air. Organic matter varies in quantity on different soils. The strength of soil structure decreases with the presence of organic matter, creating weak bearing capacities. Organic matter condenses and settles in different ways under certain conditions, such as roadbeds and foundations (William 2010). Topsoil is the primary resource for plants to grow and crops to thrive and the main two parameters for this are Carbon and Nitrogen. The Carbon provides energy and Nitrogen is a tissue builder and plants require them in a range of ratios to enable suitable growth. Elsewhere in the UK, an optimum figure for topsoil is a ratio of less than 20:1. This ensures that the soil has a suitable energy reserve as well as tissue building material to enable the plants to thrive (Miller 2000). Plants generally concentrate their roots in and obtain most of their vital nutrients from this layer. Actual depth of the topsoil layer can be measured as the depth from the surface to the first densely packed soil layer known as subsoil (USDA 1993).

Annona muricata Linn is one of the highly valued medicinal plants in south west Nigeria. The name *Annona* is derived from the Latin word meaning “annual harvest”. It is a small tree with low-branching and bushy slender upturned branches and of about 5.0 to 9 m tall. The leaf is alternate, smooth, glossy, evergreen, dark green and lighter on the upper and lower surface respectively. It varies in shape from oblong to narrow obovate and pointed at both ends. The fruits could be oval, heart-shaped or curved in shape. The fruit is covered with a reticulated, leathery-appearing but tender, inedible, bitter skin from which protrude few or many stubby and curved, soft, pliable spines. Its inner surface is cream-coloured and granular and separates easily from the mass of snow-white, fibrous, juicy segments. The aroma is somewhat pineapple-like. Each fruits contains a single oval, smooth, hard black seed, 1.25-2cm with about 100-200 per fruit (SCUC 2006). Germination of its seed under sub-optimal condition has been found to be delayed for 2-3months but can occur in three weeks if condition is favourable and its seedlings are usually ready for field transplant in 6-9 months (Joseph 2014). *Annona muricata Linn* is a plant that is empirically trusted by societies to have anticancer properties in its leaves. In Nigeria, it is called *Sopsop or Shawa shawa* (Roesler 2007).

Recent initiative revealed that research interest on the type of soil and its effects on fruit tree species is scanty in the country. Therefore, the present study was carried out to determine the effects of different soil types on germination and seedling development of *Annona muricata*.

MATERIALS AND METHODS

Seed Source

Fresh fruits of *Annona muricata* were collected from the parent plant from its natural habitat in Ipoti-Ekiti located in Ijero Local Government Area of Ekiti State, Nigeria, and was taken to the herbarium of Plant Science and Biotechnology Department of Ekiti State University, Ado Ekiti for authentication. The seeds were subjected to viability test by using Tetrasolium chloride and the viable seeds were obtained and used for the study.

Location of Experiment:

This experiment was conducted at Experimental field of the Department of Plant Science and Biotechnology, Ekiti State University, Ado-Ekiti.

Procedure:

Four types of soil i.e. loamy soil, sandy soil, clay soil and top soil were collected and analysed at the soil laboratory of Faculty of Agricultural Science, Ekiti State University. Ado-Ekiti. Eighty (80) seeds of *Annona muricata* were divided into four (4) parts and sown into black polythene bags separately filled with the four types of soil viz; loamy soil, sandy soil clay soil with the top soil that served as the control. The experiment was subjected to natural condition favourable for germination. Germination initiation was observed for two (2) months when the total emergence were counted and recorded. Assessment of growth parameters commenced four (4) weeks after epicotyls emerged and was done fortnightly for three (3) months. The parameters assessed were seedling heights, stem girth, leaf production and leaf area.

Data Analysis:

The data collected were subjected to one-way analysis of variance (ANOVA) and the means were separated at $P \leq 0.05$ using Duncan's Multiple Range Test (DMRT). All statistical analyses were done using SAS software, 1999 version (SAS 1999).

RESULTS AND DISCUSSION

Table I shows the result of chemical analysis of different soil types used for this experiment. It was revealed that the sandy soil used was acidic with the highest pH of 6.91. Clay soil has the lowest pH, organic carbon, calcium, magnesium, potassium, available phosphorus, Nitrogen and percentage sand of 5.62, 2.55g/kg, 1.74cmol/kg, 0.84cmol/kg, 0.17cmol/kg, 2.05mg/kg, 0.89g/kg and 55.62% respectively. Also, clay soil used has the highest silt and clay percentage of 19.50% and 24.88% respectively. While the loamy soil used has the highest organic carbon (23.60g/kg), calcium (6.24cmol/kg), magnesium (1.87cmol/kg), potassium (0.36cmol/kg), available phosphorus (24.83mg/kg) and Nitrogen (5.73g/kg). The top soil used has the following organic materials: pH, organic carbon, Calcium, Magnesium, Potassium, available phosphorus, Nitrogen, sand (%), silt (%), clay (%) and textural class of 6.61, 20.30g/kg, 5.75cmol/kg, 1.24cmol/kg, 0.28cmol/kg, 18.53mg/kg, 3.75g/kg, 86.60%, 8.64%, 4.76% and loamy sand respectively.

The highest mean percentage germination of 100% was recorded in seeds sown in sandy soil (Table 2), seeds sown in clay soil and seeds sown in top soil had the same mean percentage.

Table 1: Physico-chemical properties of the soil types used in this study

Parameters	Top soil	Sandy soil	Clay soil	Loamy soil
PH (H_2O)	6.61	6.91	5.62	6.57
Organic Carbon (g/kg)	20.30	9.60	2.55	23.60
Ca (cmol/kg)	5.75	4.22	1.74	6.24
Mg (cmol/kg)	1.24	1.61	0.84	1.87
K (cmol/kg)	0.28	0.27	0.17	0.36
Available P (mg/kg)	18.53	8.33	2.05	24.83
N (g/kg)	3.75	1.86	0.89	5.73
Sand (%)	86.60	85.10	55.62	75.12
Silt (%)	8.64	5.18	19.50	12.50
Clay (%)	4.76	8.72	24.88	12.38
Textural class	Loamy sand	Loamy sand	Sandy clay loam	Sandy loam

Table 2: Effect of different type of soil on percentage germination of *A. muricata*

Treatments	Germination (%)
T_1-Loamy soil	20
T_2-Sandy soil	100
T_3-Clay soil	40
T_4-Top soil	40

Table 3: Effect of different type of soil on plant height of *A. muricata*

Treatments	Plant Height (cm) / Month after planting		
	One	Two	Three
T_1-Loamy soil	8.00^c	12.50^b	17.25^b
T_2-Sandy soil	10.55^b	11.98^c	11.42^c
T_3-Clay soil	6.87^d	5.00^d	2.33^d
T_4-Top soil	11.90^a	14.73^a	19.12^a

Values with the same letter(s) within the column are not significantly different at $P \leq 0.05$

Germination (40%) while seeds sown in loamy soil recorded the least mean percentage germination of 20%.

The effect of different types of soil on plant height of *Annona muricata* was presented in Table 3. Result obtained revealed that significant differences abound in plant heights between the varied treatments. Top soil produced significantly highest mean seedling height (19.12cm), this was followed by seedlings in loamy soil with mean height of 17.25cm, and seedlings on sandy soil had no appreciable value of 11.42cm. While the least mean seedling height (2.33cm) was recorded in clay soil treatment.

Significant differences abound in leaf production among the four treatment used in this study (Table 4). The highest number of leaves (12.50) was recorded in seedlings on loamy soil; seedlings on top soil had mean value of 11.34. This was followed by seedlings on sandy soil with mean value of 7.00, while seedlings on sandy soil had the least mean leaf production of 1.33.

Table 4: Effect of different type of soil on Number of leaf of *A. muricata*

Treatments	Number of Leaf / Month after planting		
	One	**Two**	**Three**
T_1-Loamy soil	4.00^b	8.00^a	12.50^a
T_2-Sandy soil	3.83^b	5.33^c	7.00^c
T_3-Clay soil	2.00^c	1.33^d	1.33^d
T_4-Top soil	5.16^a	7.49^b	11.34^b

Values with the same letter(s) within the column are not significantly different at $P \leq 0.05$

Table 5: Effect of different type of soil on Stem girth of *A. muricata*

Treatments	Stem Girth (cm) / Month after planting		
	One	**Two**	**Three**
T_1-Loamy soil	0.80^b	0.95^b	1.30^b
T_2-Sandy soil	0.80^b	0.91^c	0.90^c
T_3-Clay soil	0.40^c	0.34^d	0.12^d
T_4-Top soil	0.94^a	1.18^a	1.51^a

Values with the same letter(s) within the column are not significantly different at $P \leq 0.05$

Results in Table 5 shows that the control experiment had the highest mean stem girth of 1.51cm, seedlings on loamy soil had a mean stem girth of 1.30cm followed by those on sandy soil with 0.9cm stem girth. However, the least stem girth of 0.12cm was observed in those seedlings treated with clay soil. Table 6 shows the effect of soil types on leaf area of *A. muricata*. Seedlings leaf area was significantly affected ($P \leq 0.05$) by varied soil types over the period of assessment. Results obtained revealed that seedlings in the control experiment had the highest mean leaf area of 31.23cm^2. This was followed by seedlings treated with loamy soil (13.79cm^2), seedlings treated with sandy soil had poor mean leaf area of 9.24cm^2. The least mean leaf area was observed in clay soil with mean value of 4.38cm^2.

Table 6: Effect of different type of soil on Leaf area of *A. muricata*

Treatments	Leaf Area (cm^2) / Month after planting		
	One	**Two**	**Three**
T_1-Loamy soil	6.50^c	10.84^b	13.79^b
T_2-Sandy soil	8.63^b	8.63^c	9.24^c
T_3-Clay soil	6.22^d	5.66^d	4.38^d
T_4-Top soil	21.33^a	30.12^a	31.23^a

Values with the same letter(s) within the column are not significantly different at $P \leq 0.05$

The different soil types affected the germination of *A. muricata* seeds and significantly ($p<0.05$) affected seedling performance of this species. This agreed with the findings of Kundu *et al.*, (2011) asserted that the exposure of different types of abiotic and biotic stresses, such as drought, high temperature, salinity and pathogens adversely affected the growth and productivity of *Vigna mungo*. Also, Jawayria *et al.*, (2018) reported that Variation in seedling growth performance of pea (*Pisum sativum* L.) seedlings can be attributed to the treatment of different types of soil.

The results from this study revealed that sandy soil gave maximum support for the seed germination of *A. muricata* when compared to other treatments. This could be attributed to the fact that sandy soil is loose with large particle size thereby allows easy sprouting of *A. muricata* seeds. This finding agreed with the assertion of Komolafe & Joy (1981) who reported that sandy soils are well aerated, light and easy to work, allow viable seeds to germinate easily and permits easy penetration of roots.

This study also revealed that seedlings treated with top soil had better performance over seedlings treated with other soil types. This treatment produced the highest plant height, stem girth and leaf area. This result tends to suggest that top soil possesses the physio-chemical properties needed by *A. muricata*. This result tends to be similar to that of Aderounmu (2010) who reported that top soil + river sand medium consistently produced highest leaf production and leaf area as an indication that the media had physio-chemical properties needed by *V. paradoxa*.

The results obtained in this study shows that loamy soil has a positive effect on seedling development of *A.muricata.* Seedlings on this soil type had competitive values with seedlings on top soil where highest values were recorded. Seedlings treated with loamy soil not only competed with those of top soil treatment but also recorded the highest leaf production of *A. muricata.* This tends to confirm that loamy soil is good for plants because as it has the correct ratio of particle sizes that allow for the retention of water and nutrients, and enough spaces between the particles for roots to grow easily and obtain the required oxygen. Study on *Senna obtIusifolia* by Abdulazeez (2017) reported that loamy soil is an ideal soil for sufficient vegetative growth, root development, uniform seed germination, uniform seedlings and post seedlings management of the plant. Also, Ken (2014) reported that *Senna obtusifolia* prefers a deep, well-drained, moderately fertile sandy loam soils.

The results from this study shows that clay soil had a negative effect on the seedling development of *A. muricata* It was found that the seedling growth performance was very poor and recorded least values in all the parameters when compared to those seedlings treated with other soil types. The clay soil does not allow easy movement of air and water thereby deprived seedling roots of essential nutrients. The findings in this study agreed with Komolafe & Joy (1981) who observed that clay soils are heavy to work, drain poorly, very hard for root to penetrate and for seeds to germinate. It could be suggested that the poor drainage in clay soils might withhold the nutrients in them from the plants.

CONCLUSION

This study provides preliminary results concerning soil types that enhanced the best seeds germination and seedlings development of *A.muricata.* The results from this study revealed that sandy soil was the most effective soil type for enhancing best seed germination while top soil may be considered for enhancing best seedling development in *Annona muricata*. Thus while sandy soil might be utilized in the nursery for raising seedlings of this plant, transplantation to top soil rich sites should be ensured.

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