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Root Growth Potential of Antipolo (*Artocarpus blancoi*) in a Clay Soil of Arakan Cotabato Philippines

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ABSTRACT

Background: The study aimed to determine the relationship between root growth and morphological growth characteristics of one-year old Antipolo trees planted in the ecological garden of the Forestry Department, Cotabato Foundation College of Science and Technology, Doroluman Arakan Cotabato.

Methods: Ten trees were uprooted and gathered data on root growth potential such as number of first order lateral roots (FOLR), primary root diameter and length. Morphological growth characteristics such as stem diameter, stem height, number of leaves and basal area were also taken.

Result: Findings reveals that the size of primary roots significantly related to number of leaves, stem height, diameter and basal area. The root growth has significant influence on the number of leaves and plant height and found out the size of the primary roots to be the predictor of the morphological growth of the one-year Antipolo trees. On the root/shoot ratio, it reveals an average 0.16 root biomass per 1 unit shoot or aboveground biomass of the tree species and found stem diameter as significant predictor of aboveground biomass, indicating that the diameter of an stem can be used to estimate aboveground biomass. Manifesting also the importance of root size in judging the performance of the tree that can be seen through stem height and number of leaves of the specific trees.

Key words: Antipolo tree, Biomass, FOLR, Morphology, Performance, Root growth.

INTRODUCTION

Artocarpus blancoi, known locally as Antipolo, is a threatened Philippine tree species utilized in reforestation and urban greening, requiring effective seedling propagation to survive habitat loss. Initial survival of planted trees depends in large measure on their physiological readiness to rapidly produce new roots and thereby re-establish intimate contact with the soil (Smith, 1962). This ability is sometimes referred to as the “Root growth potential,” or RGP and many authors have stressed its importance as a critical ingredient of seedling quality and subsequent reforestation success (*e.g.*, Larson 1970; Larson and Whitmore, 1970; Carandang, 1994). While it has been difficult to establish a clear cause-effect relationship between RGP and seedling survival after planting, a compelling body of evidence indicates that the two are often very closely correlated. More than seventy years ago Wakeley (1948) emphasized that seedling morphological grades were inadequate indicators of seedling performance and that seedlings that survived and performed well apparently did so due to their superior physiological grade. He concluded, however, “How to recognize physiological grades before planting the seedlings and observing their success or failure remains to be discovered.” Several years later, E.C. Stone and co-workers demonstrated that a seedling’s ability to grow roots in a test environment could be used as a measure of seedling physiological grade or overall seedling vigour (Stone, 1955; Stone and Jenkinson, 1971). Furthermore, the period during which seedlings exhibit high RGP coincides very closely with the period during which they are most tolerant to desiccation and physical damage (Mullin, 1978) and therefore are more able to survive the rigors of lifting, handling, storing and outplanting. The RGP level can thus be used, in effect, as an index of seedling resilience (Stone, 1955; Stone and Jenkinson, 1971).

This study investigates the root growth potential (RGP) of one-year-old *A. blancoi* seedlings in Arakan, Cotabato, analyzing correlations between root development and physical traits such as height, diameter and root-shoot ratio. The research aims to establish reliable indicators for seedling selection to enhance field survival rates for this endemic species.

Objectives of the study

Generally, the study was conducted to determine the root growth potential of antipolo (*Artocarpus blancoi*). Specifically, this study sought to determine the following objectives:

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1. To evaluate the root growth potential of antipolo particularly the number of first order lateral roots develop and length of the primary roots.
2. To calculate the root volumes, basal area and biomass of the one year old antipolo.
3. To measure the plant height and stem diameter of the one year antipolo.
4. To determine the correlation between root growth and morphological characteristics such as plant height and stem diameter of the tested plant.
5. To determine the biomass weight percentage of the crown system, trunk and root system of the antipolo species.

Significance of the study

Root growth and seedling establishment are tied together whenever foresters talk about successful reforestation programs. Seedling establishment depends on site environmental conditions and seedling quality at time of planting (Rietveld, 1989; Burdett, 1990). These two factors come into play whenever a seedling is planted. How a seedling responds to the environment and starts to develop roots out into the surrounding soil determines whether a seedling survives the planting process.

A newly planted seedling can be coupled to the reforestation site only if it has access to available soil water to meet the atmospheric demand for water. This coupling is important because reforestation sites can present extreme environmental conditions that alter site heat exchange processes and soil water relations (Miller, 1983). The ability of a seedling to take up water is affected by its root system size and distribution, root-soil contact and root hydraulic conductivity. The seedling shoot system, which is exposed to the atmospheric demand for water, has transpirational water loss from needles which is determined by the degree of stomatal opening and needle area. Typically, newly planted seedlings have restricted root placement, low root system permeability and/or poor root-soil contact, which can limit water uptake from the soil (Kozlowski and Davies, 1975; Rietveld, 1989; Burdett, 1990). As a result, seedlings can be exposed to stress just after planting (*i.e*., planting stress) because they are not fully coupled into the hydrologic cycle whereby water flows from the soil to plant roots, through the plant and into the atmosphere. This planting stress can lead to root growth being limited by the lack of water and photosynthates and in turn photosynthesis being limited by water stress due to a lack of root growth (Burdett, 1990; Grossnickle, 2000). Seedlings that develop a root system after planting establish a proper water balance and respond to field site atmospheric conditions without limitations that occur when seedlings do not have access to soil water (Margolis and Brand, 1990). Thus, seedlings with a favorable water status can have a cycle of root growth supported by photosynthesis and photosynthesis supported by root growth (Burdett, 1990). Seedlings enter the establishment phase when they are fully coupled into the site hydrological cycle and begin to respond to silvicultural practices that have been used to create favorable site conditions (Rietveld, 1989; Grossnickle, 2000).

Conceptual framework

The RGP of Antipolo in terms of primary root length and diameter, number of lateral roots, soil pH, soil water and soil temperature will be correlated with its morphological characteristics such as stem diameter, plant height, number of leaves, basal area and biomass (Fig 1).

MATERIALS AND METHODS

The materials used in the study were one-year old Antipolo trees (Fig 2), tape measure, digital vernier caliper, thermometer, lagaraw and shovel in uprooting the plants.

Experimental design

Correlational research design was used in this study to evaluate the effect of the RGP on the morphological characteristics of one-year old Antipolo trees. Correlational research design had been used in determining the relationship between the RGP and morphological growth characteristics of the Antipolo trees. Influence statistics was used to determine the influence of RGP on the visible growth characteristics of Antipolo such as number of leaves, plant height and stem diameter.

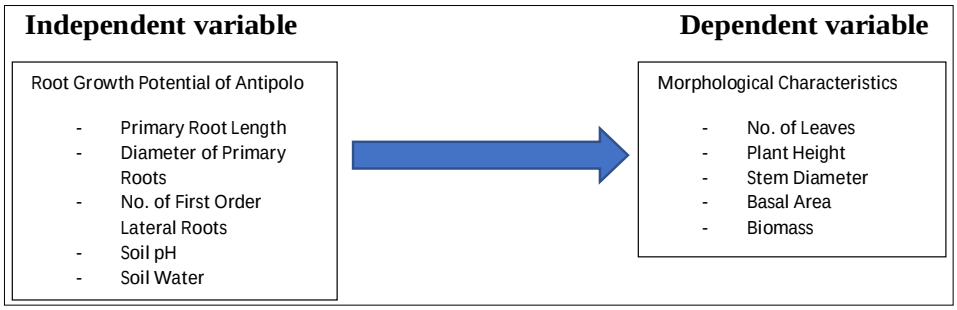


Fig 1: Conceptual framework of the study.

Time and location of the study

This study was conducted in the ecological garden of the cotabato foundation college of science and technology (Fig 3) manage by the office of the director for agro-eco-tourism in January to March 2023.

Data gathering procedure

The data were gathered though the use of tape measure for the plant height, digital vernier caliper for the stem diameter and actual counting of leaves. Soil water was determine through moisture content equation such as:

$$\% \text{ MC} = \frac{\text{FW} - \text{OW}}{\text{FW}} \times 100$$

Where,
MC= The moisture content of the soil.
FW= The fresh weight of the soil.
OW= The ovendry weight of the soil sample.

Data gathered

The plant height was gathered using tape measure, stem diameter was taken using digital vernier caliper and number of leaves through actual counting of leaf (Fig 4).

Destructive sampling was employed in gathering data on the root growth potential of the antipolo plants. The primary root length was measured by the used of tape measure, its diameter was measured through digital vernier caliper, number of lateral roots was counted.

Statistical analysis

Regression-correlation analysis was used in analyzing the relationship of the root growth potential and other factors on the morphological characteristics of the antipolo trees in the ecological garden of the cotabato foundation college of science and technology in March 2023.

RESULTS AND DISCUSSION

This section present the result of data measurement, analysis and interpretation of findings drawn from correlation and regression of the different data gathered.

Soil moisture, density and soil pH

The soil moisture was taken through soil sampling. The soil moisture in the immediately surrounding of the trees varies from 35.4% to 40.35%, soil density of 1.40 g/cu.cm with soil pH of 6.75.

Morphological growth characteristics

Table 1 present the morphological growth data of one-year old Antipolo such as number of leaves, plant height, diameter and basal area. It can be glance in the matrix that the mean number of leaves of the plant is ten, plant height is 162.8 cm, based diameter is 23.16 cm with computed basal area of 458.82 sq.cm.

Data on root growth potential

The matrix below presented the data on root growth potential of the one-year Antipolo (Table 2). The first order lateral roots (FOLR) has a mean number of 23 pcs,



Fig 2: The One-year antipolo plantation in the ecological garden of CFCS.

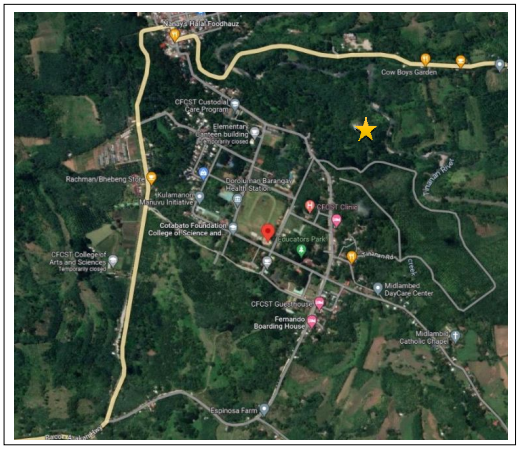


Fig 3: Google map showing the location of the study.



Fig 4: Stem diameter and height measurement.

primary root length of 70.8 cm and primary root diameter of 22.06 cm.

Relationship between morphological characteristics and root growth potential of the one-year antipolo trees

The result of correlation analysis between root growth and morphological characteristics of one-year old antipolo tree reveals that the diameter of primary roots has significant relationship on the morphological growth characteristics such as number of leaves, stem height, diameter and basal area (Table 3).

The correlation coefficient ranges from 0.904-0.989 is interpreted very strong linear relationship between primary root diameter and morphological growth characteristics. This positive linear relationship implies that an increased primary root will eventually results to increase number of leaves, stem height, diameter and basal area of Antipolo tree.

When seedlings were carefully lifted as what has been done in the study, number of leaves, plant height, diameter and basal area were very closely related with primary root diameter. At harvest, large diameter seedlings have more primary laterals (Rowan, 1986). While it is possible that large diameter seedlings inherently have a more fibrous root system, it is more likely that smaller seedlings have thinner primary lateral roots that are more easily stripped during lifting operations (Carandang, 1994). According to Gulaiya *et al*. (2026), seeds exhibited the largest positive association among the different yield attributing parameters of soybeans. The experiment conducted by Anita (2025) reveals that positive correlation and positive direct effect on seed yield of mungbean were observed for plant height, number of pods per plant, number of seeds per pod and 100 seed weight.

Table 1: Morphological growth data of the sampled one-year antipolo trees (*Artocarpus blancoi*).

Characteristics	Mean data
Number of leaves (pcs)	10.00
Plant height (cm)	162.80
Stem diameter (cm)	23.16
Basal area (sq.cm)	458.82

Table 2: Root growth potential data of the sampled one-year antipolo trees (*Artocarpus blancoi*).

RGP	Mean data
FOLR number (pcs)	22.80
Primary root length (cm)	70.80
Primary root diameter (cm)	22.06

Influence of root growth potential on the morphological growth characteristics

RGP on number of leaves

Table 4 presents the influence of root growth on the morphological characteristics of one-year old Antipolo tree in the clay soils of Arakan Cotabato Philippines. The matrix shows that root growth has significant influence on the number of leaves (F=166.631; prob= 0.050). Root growth accounted to have 99.8% effect on the morphological growth characteristics. However, among the root growth parameters, only the primary root diameter has significant influence on the number of leaves of one year old Antipolo tree.

This finding indicated that number of leaves of Antipolo can be an indicator of the size of the primary roots of the plant.

Operational experiences tended to indicate that, other factors being equal seedlings with large stem calipers or diameters outperform those with smaller ones (Chavasse, 1990; Cleary *et al*., 1979; Sutton, 1980). The environmental factors which contribute significantly to the overall make-up of the plant constitute major differences in RGP among seedlings even of the same species (Landis and Skakel, 1988). Seedlings with large robust root systems have the best opportunity to achieve early competitive position (Ruehle and Kormanik, 1986). Although a robust root system is normally associated with desirable stem characteristics, large stems themselves are not necessarily related to robust roots an d competitive ability after outplanting (Feret and Kreb, 1986).

RGP on plant height

The root growth has significant influenced on the plant heigh of Antipolo tree (F=501.205; prob= 0.033). This influence is 99.9% (R^2 = 0.999) emphasizing that RGP is a measures of stem height of Antipolo. The significant but negative

Table 3: Relationship between root growth and morphological characteristics of the one-year antipolo (*Artocarpus blancoi*).

		No. of FOLR	Length of primary root	Primary root diameter
Number of leaves	Pearson correlation	0.000	0.728	0.989**
	Sig. (2-tailed)	1.000	0.163	0.001
Plant height (cm)	Pearson correlation	-0.439	0.628	0.904*
	Sig. (2-tailed)	0.459	0.257	0.035
Stem diameter (cm)	Pearson correlation	-0.016	0.632	0.915*
	Sig. (2-tailed)	0.980	0.253	0.030
Basal area (cm^2)	Pearson correlation	.054	.658	0.893*
	Sig. (2-tailed)	.931	.227	0.041

Table 4: Influence of root growth on the morphological characteristics of one-year old antipolo (*Artocarpus blancoi*) in a clay soils of arakan cotabato philippines.

	Number of leaves	Plant height	Stem diameter	Basal area
Number of FOLR	1.250	-14.885*	0.139	0.250
Primary root lenght	-3.107	-4.330	-0.562	-0.318
Primary root diameter	15.251*	23.382*	1.951	1.478
R^2	0.998	0.999	0.876	0.822
F	166.630	501.205	2.355	1.540
Prob	0.050	0.033	0.439	0.521

Table 5: Weight percentage of tree parts with its total weight.

Tree parts	Biomass	Percentage
Crown system	79.72	33.36
Stem/trunk	126.67	53.00
Root system	32.60	13.64

t-value of the number of FOLR indicated that as the height of Antipolo increases, the number of FOLR will not go linearly or increase because its concentration is to increase its size. As evidence, the primary root diameter in this study has significant influence on stem height (t=23.382; p=0.027) explaining that primary root diameter can be an indicator of stem height in antipolo trees.

Stem diameter, shoot length and number of FOLR were correlated with second year height and diameter of Northern red oak 2 years after planting in Ontario, with initial stem diameter being the best predictor (Dey and Parker, 1997). Stem diameter was also a good predictor of many root system traits such as volume, area and dry mass. This is consistent with the study of Williams (1972) that showed stem diameter as better predictor of black walnut growth than root fibrosity. In the sweetgum research of Belanger and Mc Alpine (1975), stated that the growth response of various root Stem diameter, shoot length and number of FOLR were correlated with second year height and diameter of Northern red oak 2 years after planting in Ontario, with initial stem diameter being the best predictor (Dey and Parker, 1997). Stem diameter was also a good predictor of many root system traits such as volume, area and dry mass. This is consistent with the study of Williams (1972) that showed stem diameter as better predictor of black walnut growth than root fibrosity. In the sweetgum research of Belanger and Mc Alpine (1975), stated that height growth was 1.92 m taller at age 7 for the largest seedlings and Mc Nabb (2001) found that large seedling sizes increased plot volumes by up to 87% in age 2.

RGP on stem diameter

The result of analysis in Table 4 shows no significant influence of Root Growth on the stem diameter of Antipolo tree. The finding reported by Corpuz and Carandang (2012) indicated that the RGP in terms of root class and root biomass of Gmelina tree was positively associated with the other growth traits and characters. Thompson and Schultz (1995) found that the number of FOLR was positively and significantly correlated with diameter growth, heights and growth of trees such as basal area and volumes. It can be said therefore that the use of RGP as an expression of seedling quality finds merit in its positive correlations with the other growth traits considered in the study. All morphological features specifically height and stem diameter, currently provide the best estimate of seedling performance after outplanting (Mexal and Landis, 1990). Diameter is considered to be one of the best predictor of field survival while height seems to predict height growth in plantation (Ritchie, 1984). Root classes are highly correlated with biomass production as the findings of this study indicate support to Mexal and Landis (1990). Nevertheless, root morphology, specifically number of FOLR, finds much use with the trend towards the use of root growth potential as an indicator of early field performance and subsequent growth (Larsen *et al*., 1986; Ritchie and Dunlap, 1980).

RGP on basal area

It has been previously reported that the root growth potential of one-year old Antipolo did not significantly influence the primary root diameter, thus RGP also come up an insignificant influence on basal area since the latter is computed based on diameter. Stem diameter according to Dey and Parker (1997) is a best predictor of growth. Computation of the basal area considered the density of tree per hectare, does more density of tree means higher basal area.

Weight percentage of tree parts with its total weight

The biomass of the different parts of the antipolo tree (Crown, trunk and roots) is presented in Table 5. The crown system is reported to have 33.36% of its total biomass. The Stem/trunk is 53%. While the root system is 13.64%.

The study of Haozhi *et al*. (2021) reported that roots make up 22% of total biomass in the forest areas, 47% for shrubland and 67% in the grassland biomass. Globally, the belowground portion of plants is 24%, meaning nearly a quarter of the biomass stored by plants world-wide is in roots.

Root/shoot ratio

The root-shoot ratio analysis presented in Table 6 reveals that below ground biomass of one-year old Antipolo tree is only 15.8 per cent of its aboveground biomass. This implies that there is an average of 0.16 unit weight of roots per 1 unit weight of aboveground biomass.

Table 6: Ratio of the below ground biomass with the aboveground biomass of one-year old antipolo tree.

Components	Biomass	Ratio	R	Prob
Belowground biomass (Roots)	32.60	15.8	0.986	0.002
Above ground biomass (Trunk+crown)	206.39			

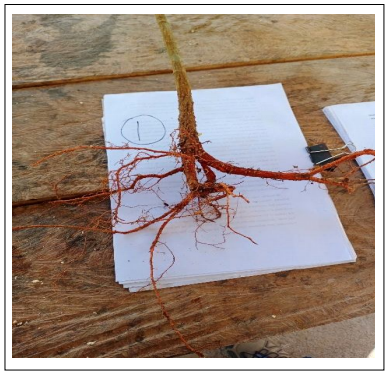


Fig 5: The root system of the one-year antipolo.

The study of Assma *et al*. (2024) states that mean root-shoot ratio of Young Mediterranean argan trees was 0.64. The root-shoot ratio indicates that there are on average 0.64 units of root per 1 unit of aboveground biomass across the plants in the study. The variation in the root-shoot ratio across diameter classes indicates that smaller plants allocate a larger proportion of their resources to belowground structures compared to larger plants. Fig 5 shows the complex root system of the one-year destructed sample of Antipolo. Under unfavorable conditions due to low light, the growth and development of the embryonic root and seedling formation was slow (Krylov *et al*., 2025).

Correlation between root biomass with aboveground biomass

The correlation analysis reveals that stem diameter had highly significant relationship with the aboveground biomass (R=0.986; prob= 0.002), this indicates that stem diameter of a one-year old Antipolo trees can be a basis in estimating aboveground biomass of the tree species in a plantation. This finding is supported by the plotting presentation which shows that stem diameter is linearly related with the aboveground biomass with r^2= 0.9714.

The study of Kormanik (1986) reported that while stem diameter is a better indicator of seedling vigor, it cannot fully explain the differences in seedling performance after outplanting. Webb (1969) earlier cautioned against using stem diameter when comparing early plantation performance of sweetgum seedlings from the same family when grown at varying seedling bed densities. This is because stem diameter represents a seedling's response to edaphic conditions.

According to Chung-Wang and Ceulemans (2004), the vertical distributions of biomass of branches, needles and of their total, were similar and skewed vertically downward. The stem diameter at breast height (DBH) and tree height were significant determinants of biomass of stems, coarse roots and small roots. Similarly, DBH, tree height and crown length were the predominant variables of biomass of branches and needles and of the entire tree biomass.

RECOMMENDATION

The author recommended to validate the findings of the study through the conduct of similar study with more trees/ seedling samples to lessen experimental errors and to come up a more precise result.

CONCLUSION

Based on the findings of this particular study, predictor of RGP in one-year old Antipolo trees/seedlings were number of leaves and plant height. These indicators can be used as measures of the sturdiness of a seedling for outplanting and tree performance in the field. However, Stem diameter shows linear relationship with aboveground biomass which indicates that Stem diameter can be used to estimate the aboveground biomass of one-year antipolo trees, thus predicting a carbon storage potential of said tree species.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

All procedures for experiments were approved by the Research Ethics Committee of the Cotabato Foundatiuon College of Science and Technology.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or sponsorship influenced the design of the study, data collection, analysis, decision to publish, or preparation of the manuscript.

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