RESEARCH ARTICLE

Morphological Traits and Nastism of Mango Ginger (Curcuma Amada Roxb.)

V. O. Ayodele[1*], O. M. Olowe [2]

10.18805/ag.D-140

Abstract

Necessity demands observation and assessment of growth development of Mango ginger plants (with a paucity of or no publication about its agronomy and pathology), as a prerequisite to understanding their nature and avoid incorrect plant disease diagnosis (by taking for an abnormal condition that which is normal). Hence, this study observed the morphological development of Mango ginger (*Curcuma amada* Roxb.) plants, a rare crop, and assessed for its plant height and number of leaves in the years 2016 and 2017. The rhizomes, the most economical part of the plant, was observed to emerge from a corm and appeared finger-like with dome ends. Mango ginger leaves averaged Nine per plant stand and showed curling nastic movement. Sunlight and temperature had a positive and significant effect on the daily curling and uncurling of leaves. Also, the height parameter of Mango ginger plants was inconsistent, when measured from soil level to tip of youngest leaf/apical bud. But when measured from soil level to peak/top (highest point attained at a natural position above soil level), irrespective of what leaf made the upper boundary, plants increased in height with time. A significant difference existed in 2016 between the two different upper boundaries of plant height. The study provides basic understanding of the morphology of Mango ginger plant; and gives original and significant insight on the nastic movement of its leaves, for better understanding of its fundamental botany, which may form bases for its disease identification and further investigation as an under-cultivated and underutilized crop (for colouring and flavouring drinks, and as: food preservative; medicine for cure of bacterial and fungal infection; anti-inflammatory and antipyretic; hypotriglyceridemic and hypoglycemic; anti-cancer with fertility potential).

Keywords: *Curcuma amada*, Mango ginger, Nastism/nastic movement, Number of leaves, Plant height.

Agricultural Science Digest (2019)

Introduction

Mango ginger (*Curcuma amada* Roxb.) is a perennial herb of asian origin (Chatterjee *et al*., 2012), and commonly cultivated for its mango-flavored rhizomes. It is used in the Ayurvedic medicines to cure ailments like jaundice, hemorrhage, colic; and its leaves are employed in orthodox medicine in the killing of some cancer cells (Vishnupriya *et al*., 2012). As a notable spice, it is used as a flavor, and its yellow color may be evident in drinks (Vishnupriya *et al*., 2012). Its rhizomes morphologically resemble ginger (*Zingiber officinale*), according to Vishnupriya *et al.* (2012). Samant (2012) described its leaves as long, oblong-lanceolate with petiole, and its aerial shoot to be up to 90cm above ground level.

Plant height, generally, is an important trait related to the potential of yield in plants (Wu *et al*., 2010). According to Heady (1957) ' the height of a plant is a perpendicular distance from the soil at its base to the highest point reached with all parts in their natural position.' Apart from the ability of plants to compete for light, plant height strongly correlates with their life span, seed mass and time to maturity (Moles *et al*., 2009).

In addition, plant organs may move in response to stimulus, in which the quality of the stimulus, rather than direction, triggers the response, and the movement is independent of the direction of the stimulus; as such is nastic response (Stiles, 2010). Ability to sense and respond to external stimuli at various timescales may be observed in some plants species including Mango ginger where it may be difficult to separate the stimuli: temperature and light.

Curcuma amada plants were assessed for growth and development, to understand their nature, and to avoid the incorrect diagnosis of diseases (through taking for abnormal condition a normal state). Riley *et al.* (2002) stated that it is meaningful to know the normal appearance of species of plant investigated so as to recognize when something is wrong, because each plant species has growth habits, colours and growth rates that are unique to self.

Furthermore, it may be acknowledged that there is a difficulty in measuring plant height in precise manner which include when plants trail or droop, when the top is the tip of

[1]Department of Pure and Applied Botany, College of Biosciences, Federal University of Agriculture Abeokuta, PMB 2240, Abeokuta, Nigeria

[2]Department of Crop Science, College of Agriculture, Animal Science and Veterinary Medicine, University of Rwanda, Rwanda

Corresponding Author: V. O. Ayodele, Department of Pure and Applied Botany, College of Biosciences, Federal University of Agriculture Abeokuta, PMB 2240, Abeokuta, Nigeria, Email: ayodele.victor@pg.funaab.edu.ng

How to cite this article: Ayodele, V. O. and Olowe, O. M.(2019). Morphological traits and Nastism of Mango ginger (Curcuma amada Roxb.). Agricultural Science Digest, 39(3): 177-183.

Source of support: Nil

Conflict of interest: None

Submitted:08-03-2019 **Accepted:**03-07-2019 **Published:** 01-10-2019

an awn, and when several parts are nearly the same height (Heady, 1957). This study was aimed to understand the morphology of Mango ginger plant, evaluate its height (from two different upper boundaries) and an average number of leaves, and observe likely response of the crop to field and greenhouse conditions and assess for observed nastism in its leaves.

Materials and methods

Two experiments, one field, and the other greenhouse were carried out within the premise of Federal University of Agriculture Abeokuta, Nigeria.

Planting Materials

Rhizomes for planting were sourced from the Department of Plant Physiology and Crop Production, College of Plant Science and Crop Production of the Federal University of Agriculture Abeokuta.

Experiment I

Experimental design

The design was a Quasi-experimental design (natural experiment) which is fulcrum as field observational study as described by Shadish *et al.* (2002) and Harris *et al.* (2004), to observe and measure variables without assigning treatment. An experiment was replicated twice. Two planting surveys were conducted in June 2016 and April 2017; with a duration of 6 and 7 months, respectively, at a maiden portion of the Teaching and Research Farm of Federal University of Agriculture Abeokuta. Plot sizes of 20m by 20m and 15m by 15m were used to carry out the two plantings. Intra- and inter-ridge spacings were 25cm and 45cm. Plants were subjected only to the prevalent natural condition, with no chemical and no fertilizer application. General weeding was done at three weeks interval, beginning from the seventh (7th) week of planting.

Trial plots

The first planting was located at latitude 7.216463, longitude 3.441747 and altitude 66m above sea level; the second planting at 7.215908 and 3.4238338 latitude and longitude, respectively and 66m above sea level.

The area is characterized by a tropical climate with relatively high temperature and distinct wet and dry seasons. According to Adeleke *et al.* (2015), the wet season is associated with the relative prevalence of the moist maritime southerly monsoon from the Atlantic Ocean, while the dry season is predicated by the continental north easterly harmattan winds from the Sahara desert, and the area is located within a region characterized by a bimodal rainfall pattern (commencing in March; plentiful in July and September, with a short dry spell in August): the dry season spans from November to March and annual rainfall ranges between 1400 and 1500mm with mean annual air temperature being about 30°C, and the greatest variation in temperature experienced in July (25.7°C) and in February (30.2 °C); Humidity is lowest (37%–54%) at the peak of dry season in February and highest at the peak of the rainy season between June and September (78%–85%).

The soil of the two planting sites was loamy; with initial vegetation cover of *Aspilia africana* (34%), *Tithonia diversifolia* (20%), *Euphorbia heterophylla* (16%), *Chromolaena odorata* (13%) *Setaria barbata* (10%), *Tridax procumbens* (6%) and *Leucaena leucocephala* (1%).

Cultural practice

The field was marked out and manually plowed into 15 and 10m parallel long ridges in 2016 and 2017, respectively, using hand hoe, after the removal of weed with a cutlass, for a mono-culture planting of Mango ginger. Planting of rhizomes was done 20th June 2016 and 11th April 2017.

Assessment of crop growth development:

Data of growth development of plants were taken during the growing seasons. It described development from the emergence of sprouts till harvest. Plants were randomly selected and tagged for record observations.

Plant height

This was done at 7 days interval, beginning from the emergence to determine morphological growth of Mango-ginger. Measurements were taken with meter rule from surface soil level to tip of youngest leaf/apical bud, and from surface soil level to peak/top (highest point attained at a natural position above soil level).

Leaf number per stand:

It was taken concurrently with plant height, beginning at emergence, to serve as a description of various stages of development. Every visible leaf on the plant was counted including emerging leaf.

Experiment II

Design

Forty Mango ginger rhizomes sowed in 5kg sterilized loamy soil in separate sterile bags with holes, were made to sprout and grow upon watering with tap water, from which three plants of three months old were selected, across a diagonal of the area ($4m^2$) occupied by the bags: two at both ends and one at middle. Tagged leaf from each selected plant was measured at a natural position. Plants were kept watered, to avoid the confounding factor of leaf curl due to water stress, which may also be observed with Mango ginger plants.

Evaluation of leaf curvature

Leaves curvature, due to light intensity and temperature variation, was measured, in millimeters, with a transparent rule (placing the zero mark on one end against the other end, across the width), and readings converted to degrees and subtracted from 180° (mature leaves of Mango ginger were naturally positioned at relative flat plane under no or insignificant external stimuli of light and temperature).

The angle of curvature away from the initial natural flat plane position of little or no stimuli =

$$180 - \left(\frac{180 \times \text{leaf width due to nastism}}{\text{leaf width before nastism}}\right)$$

Measurement was done at 7am, 10am, 11am, 12pm, 2pm, 3pm, 5pm and 7pm daily, for three consecutive days, beginning from 15th June, 2018. Light intensity and atmospheric temperature were concurrently measured using a light meter in lux (lx) and thermometer in Celcius (°C).

Analysis of data

Comparison of mean was done by t-test, to determine significant difference between the two upper reference points of plant height; correlation analysis done to determine the significance of evaluated factors of the stimulus (sunlight intensity and temperature), using SPSS version 20.

Results and discussion

Growth Development of Mango ginger Plant

Planted rhizome of mango ginger sprouted into shoot: the first leaf unfolded and enlarged, and erect non-woody pseudostem increased in height and girth (Figure 1). Subsequent leaves developed into older tuft with newer leaves emerging at a time as leaf bud, from within the pseudostem (Figure 1). Mango ginger leaves were green, smooth on both adaxial and abaxial surfaces and matured leaves were broad, in comparison to most herbs. Leaves were lance-shaped and elongated; tapering at heads and bases to form tips and petioles, respectively (Figure 1). The midrib, from which parallel network of veins emerged, originated from the petiole and cut across the blade; veins connected to rib with a presentation of 'V' anatomy on the blade. Leaves with petioles were alternately positioned on pseudostems by sheaths (Figure 1). The average size of the broadest leaves measured 40cm by length and 16cm by breadth. Also, new shoots sprouted from developing underground stems (rhizomes) of older shoots as number of leaves per plant averaged eight; while older leaves senescence, became yellow and wilted. Rhizomes and roots emanated from a corm. Rhizomes appeared finger-like with a relatively cylindrical shape, dome-like ends, and scaly surface, and turned from green to light brown at maturity (Figure 2).



Figure 1: A, B, C, D, E= 2nd day, 5th day, 6th day, 9th day and 90th day of emergence, respectively

Rhizomes survived the end of growing seasons, after the death of aerial shoots, to sprout anew at the onset of rain/spring. Roots were brown and fibrous, with some lengthening as the plant height and others interlocked or interwoven.

The average maximum height attained by Mango ginger plants relatively agrees within the plant height range of 60cm to 90cm as given by Samant (2012). This characteristic, together with its non-woody pseudostem, may be stated to qualify it as an herb. Again, the rhizomes of Mango ginger were observed to be finger-like with relative cylindrical shape and dome end and having scaly leaves. Unlike Vishnupriya *et al.* (2012), the rhizomes may not be said to morphologically resemble ginger (*Zingiber officinale*), as rhizomes of ginger may not be seen to be clearly separated into fingers. Further, the rhizomes having potential to survive in the soil at the end of a growing season, after the death of the aerial shoot, sprouts again at the beginning of rain or spring, making it a perennial herb. This observation agrees with Chatterjee *et al.* (2012), who qualified it as a perennial herb.

Plant height and number of leaves

Bud leaf which emerged from within the tuft of older leaves unfolded and grew to become the peak of plant in two to three weeks; however, newer bud leaf emerged, again, within tuft, shifting reference peak of measurement from the growing leaf to the newer leaf bud. The height of mango ginger plants, thus, were observed to be inconsistent with time when reference was from soil level to tip of youngest leaf/apical bud; but when measured from soil level to peak/top (highest attained point of plant), irrespective of what leaf made the point, plant height steadily increased; there was significant difference between the two different upper boundaries of plant height in 2016 (Figure 3). According to Heady (1957), the height of a plant is assessed by measuring the erect distance from the base of the plant, at the soil level, to the highest point reached while having all parts at a natural position. It is, also, the shortest distance between the upper boundary of the main photosynthetic tissues (excluding inflorescences) on a plant and the ground level, which is

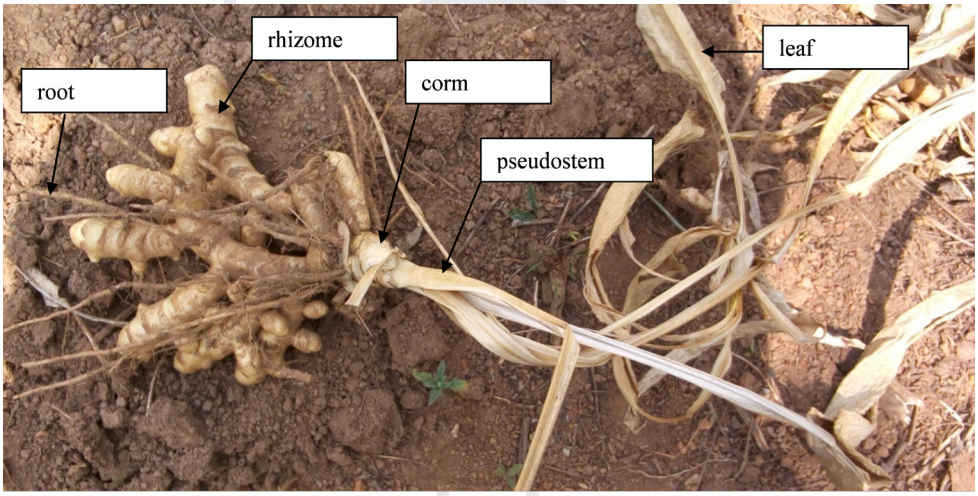

Figure 2: Mango ginger plant harvested 184th day of emergence, with already dried aerial parts

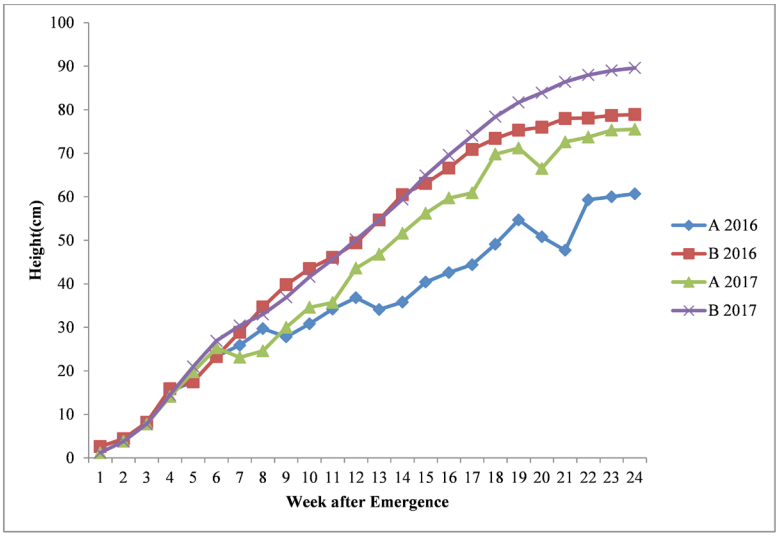

Figure 3: Plant height of mango ginger evaluated in 2016 and 2017. **A-**Mean height (Measured from Soil Level to Tip of Youngest Leaf/Apical Bud); **B-**Mean height (Measured from ground Level to top of the plant at natural standing). t(39.588) = -2.161, p = 0.037 for year 2016; t(46) = -1.003, p = 0.321 for 2017.

expressed in meters, according to Pérez-Harguindeguy *et al.* (2013). There was a difference in the aerial reference points or upper boundaries in the measurement of Mango ginger plants, as suggested by the result. Measurement of height of Mango ginger plants, done from soil level to peak (highest natural point above ground level attained), and which gave a consistent increase in height with growth development, differ from the measurement done from soil level to tip of youngest leaf/apical bud, which produced a rise and fall in height, due to constant emergence of new leaves from within tuft, over time. Apical buds/emerging leaves of Mango ginger plants, therefore, may not be appropriate as the upper boundary of the plants.

Again, some of the mango ginger plants attained a number of ten leaves per plant stand before the onset of senescence and depletion of leaf number, which marked the ending of a growth season. An average number of leaves attained per plant was nine, at 14th week of emergence and 12th and 13th week of emergence in 2016 and 2017, respectively (Figure 4).

Further, leaves indicated sensitivity to sunlight and temperature: there was downward curling of blades, obvious, at moderate to intense sunlight (≥ 10240lx) and temperature (28-35°C); and blades gradually unfolded back to relatively flat planes at mild temperatures (24-27°C) and sunlight (≤ 6000lx) in 30minutes (Figure 5). Sunlight had a significant effect on leaf curvature (Table 1 and 2), and Sunlight and Temperature were significant to leaf curvature (Table 3).

The result suggested that sunlight and temperature had a positive and significant effect on the observed daily curling and uncurling of Mango ginger leaves. As against the xerofotic movements (curling upward of the blades, due to drying effect by direct sunlight) in leaves described by Gates (1916), the gradual downward curling movement of the leaves to sunlight may be regarded as a type of photonastic response due to osmotic pressure, the direction of which does not depend on the stimulus. The result further suggested temperature as another factor responsible for the nastism, so the leaves' movement may also be thermonastic. Although, separating these causal factors as against their effect may be difficult (that is common experience of fall in temperature at mild sunlight, and rise in temperature at intense sunlight makes it difficult to separate causal factors of sunlight and temperature), Stiles (2010) opined that movement of plants

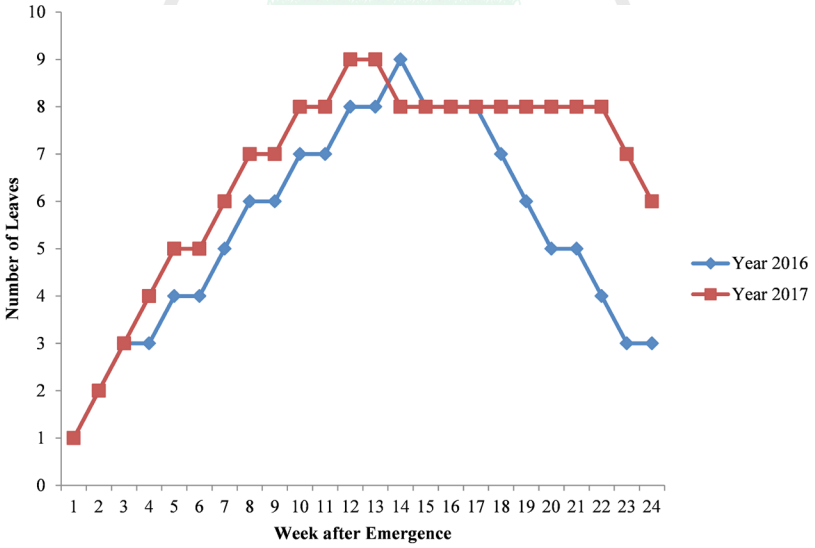

Figure 4: Mean Number of Leaves per Plant Stand, Evaluated in 2016 and 2017



Figure 5a: Population of mango ginger with unfolded leaves in morning (8:30am)



Figure 5b: Population of mango ginger fold leaves downward at noonday

Table 1: Correlation matrix of characters evaluated on leaves of Mango ginger on 15th June, 2018

	Time (hour)	*Sunlight (lx)*	*Temperature (^{0}C)*	*Curvature (^{0})*
Time (hour)	1	– 0.212	– 0.378	– 0.475
Sunlight (lx)		1	0.637	0.766*
Temperature (^{0}C)			1	0.619
Curvature (^{0})				1

*Correlation is significant at 0.05 level (2-tail)

Table 2: Correlation matrix of characters evaluated on leaves of Mango ginger on 16th June 2018

	Time (hour)	*Sunlight (lx)*	*Temperature (^{0}C)*	Curvature (^{0})
Time (hour)	1	0.409	– 0.206	0.124
Sunlight (lx)		1	0.448	0.768*
Temperature (^{0}C)			1	0.500
Curvature (^{0})				1

*Correlation is significant at 0.05 level (2-tail)

Table 3: Correlation matrix of characters evaluated on leaves of Mango ginger on 17th June, 2018

	Time (hour)	*Sunlight (lx)*	*Temperature (^{0}C)*	*Curvature (^{0})*
Time (hour)	1	0.411	– 0.277	– 0.145
Sunlight (lx)		1	0.623	0.829*
Temperature (^{0}C)			1	0.838**
Curvature (^{0})				1

*Correlation is significant at 0.05 level (2-tail)
** Correlation is significant at 0.05 level (2-tail)

in response to stimulus, in their natural habitat, could be as a result of combined nastic stimuli 'so that nyctinastic movement might be either photonastic or thermonastic or both'. The term for this curiosity, also, agrees with Stiles (2010) who defined nastic phenomena as 'response that has no relation to the direction of the stimulus and can be brought about generally by a change in a condition all round the organ, so that the stimulus can be described as diffuse.' Other plants noted for photonastic movements include sweet clover (*Melilotus indicus*) Schwartz *et al.* (1987) and busy lizzie (*Impatiens* spp.) Stiles (2010).

Conclusion

Mango ginger plant, with an average height of 84.3cm (from ground level to tip of the tallest leaf at the natural position), is a perennial herb, having aerial part composed of pseudostem and leaves, while underground part made of the corm, rhizomes, and roots. The leaves undergo daily nastic curling movement, concerning sunlight and temperature, which should not be misunderstood for symptoms of disorder or disease.

References

Adeleke O. O., Makinde V., Eruola A. O., Dada O. F., Ojo A. O. and Aluko T. J. (2015). Estimation of Groundwater Recharges in Odeda Local Government Area, Ogun State, Nigeria using Empirical Formulae. Challenges 6: 271-281.

Chatterjee R., Chattopadhyay P. K., Hnamte V., Chongtham T. and Datta Ray S. K. (2012). Assessment of Quality Characteristics of Mango Ginger (Curcuma amada Roxb.) Germplasm. International Journal of Bio-resource and Stress Management 3(3): 380-382.

Gates F. C. (1916). Xerofotic Movements in Leaves. Botanical Gazette 61(5): 399-407.

Harris A. D., Bradham D. D., Baumgarten M., Zuckerman I. H., Fink J. C. and Perencevich E. N. (2004). The Use and Interpretation of Quasi-Experimental Studies in Infectious Diseases. In: Clinical Infectious Diseases 38(11): 1586-1591.

Heady H. F. (1957). The Measurement and Value of Plant Height in the Study of Herbaceous Vegetation. Ecology 38(2): 313-320.

Moles A. T., Warton D. I., Warman L., Swenson N. G., Laffan S. W., Zanne A. E. *et al.* (2009). Global Patterns in Plant Height. Journal of Ecology 97(5): 923-932.

Pérez-Harguindeguy N., Díaz S., Garnier E., Lavorel S., Poorter H., Jaureguiberry P. *et al.* (2013). New Handbook for Standardised Measurement of Plant Functional Traits Worldwide. Australian Journal of Botany http://dx.doi.org/10.1071/BT12225

Riley M. B., Williamson M. R. and Maloy O. (2002). Plant Disease Diagnosis. The Plant Health Instructor DOI: 10.1094/PHI-I-2002-1021-01

Samant L. R. (2012). Curcuma amada Roxb.: A Phytopharmacological Review. Samant. / Journal of Pharmacy Research 5(4): 1992-1993.

Schwartz A., Gilboa S. and Koller D. (1987). Photonastic Control of Leaflet Orientation in Melilotus indicus (Fabaceae). Plant Physiology 84(2): 318-323.

Shadish W. R., Cook T. D. and Campbell D. T. (2002). Experimental and Quasi-Experimental Designs for Generalized Causal Inference. Houghton Mifflin Company, Boston. 14pp.

Stiles W. (2010). Principles of Plant Physiology. Discovery Publishing House Pvt. Ltd. New Delhi, pp520-521.

Vishnupriya M., Nishaa S., Sasikumar J. M., Teepica P. D. D., Hephzibah C. P. and Gopalakrishnan V. K. (2012). Chemical Composition and Antioxidant Activity of Essential Oil from Curcuma amada Roxb. International Research Journal of Pharmacy 3(6): 99.

Wu X., Wang Z., Chang X. and Jing R. (2010). Genetic Dissection of the Developmental Behaviours of Plant Height in Wheat under Diverse Water Regimes. Journal of Experimental Botany 61(11): 2923–2937.