# Flowering of taro germplasm (*Colocasia esculenta* (L.) Schott) in Cuba

Yadelys Figueroa Águila[1], Marilys D. Milián Jiménez[2], Yuniel Rodríguez García[3] & Manuel Lima Díaz[4]

Received: November18, 2015
Accepted: March 5, 2016

## ABSTRACT

Research was done at the Center for Tropical Crop Research (INIVIT), to evaluate inflorescence of taro germplasm (104 accessions) in Cuba´s climatic conditions. Sampling was made every 7 days in the 2013-2014 period to evaluate inflorescence; accessions were characterized according to flowering parameters. The results showed that natural flowering by the 26-accession sample (25%), was observed to early blossom from July to October in 18 accessions (69.2%). Increased temperature and relative humidity lasted until November, when inflorescence ends.

**KEY WORDS: Colocasia esculenta, breeding, flowering**

## INTRODUCTION

Taro (Colocasia esculenta (L.) Schott) is widely used in the world, including Cuba, as a highly convenient food for children and the elders. It also helps in the diet of people with digestive disorders, and it is a commonly used food in the Cuban cuisine. Taro tubers are an important source of carbohydrates when they are eaten along with meat and other vegetables (Agama et al., 2011). Humans may also eat the corms alternatively.

Genetic breeding research is limited due to the restricted number of genotypes available, but this issue may be properly addressed at the germplasm banks. Some cultivars are invaluable local ecotypes, thanks to their natural rusticity, which is an advantage over others from different locations (Gómez, 1983). Taro (Colocasia esculenta (L.) Schott) has a limited clonal composition due to defficient sources of variability, both natural and induced. Inflorescence is sporadic and not very productive, with few pollinating agents, and dependent on the environmental conditions. Consequently, the genetic breeding of the species is hampered.

[1]Agronomer Engineer, Associate Researcher, Center for Tropical Crop Research, INIVIT: geneticamc@inivit.cu
[2] Dr. in Biological Sciences, PhD., Full Researcher, Center for Tropical Crop Research, INIVIT: geneticamx@inivit.cu
[3] MSc. in Sustainable Agriculture, Associate Researcher, Center for Tropical Crop Research, INIVIT: geneticadioscorea@inivit.cu
[4] MSc. in Sustainable Agriculture, Specialist,Center for Tropical Crop Research,INIVIT: utilización@inivit.cu

On many occasions, flowering may be successively induced by dusting with Gibberellic Acid Powder (GA3) (Ivancic, 2011). It is a thermogenic species, since several studies have reported that thermogenic activity is significant to inflorescence. It is related to the species protogyny, and pollination by insects early in the morning (Ivancic et al., 2008).
The search for new sources of genetic variability that facilitated increase and clonal diversification for crop improvements in Cuba, is fundamental. Accordingly, the purpose of this paper is to evaluate flowering of taro germplasm (Colocasia esculenta (L.) Schott) for the Cuban climatic conditions.

## MATERIALS AND METHODS

This study was made at the Center for Tropical Crop Research (INIVIT), located on 22.35' of latitude; 80.18' of altitude, and 45.35 meters above sea level, in the municipality of Santo Domingo, province of Villa Clara, Cuba. A number of 104 accessions were planted in brown softened soil, partly washed (Hernández et al., 2015). The accessions were evaluated in the 2013-2014 period, in 60-plant plots at a distance of 0.30 x 0.90 m. Crop handling was made according to the current Technical Instructions for taro plantations (2010), sampling was made every seven days. The accessions with inflorescence, the month of occurrence, and the kind of flowers observed, were characterized according to IPGRI (1999) and Milian et al,. (2008).

## RESULTS AND DISCUSSION

Taro (Colocasia esculenta (L.) Schott) does not flower naturally in every environmental condition, or does it the same way every year. Inflorescence develops only when the environmental and physiological conditions satisfy the plant´s needs. Some taro accessions have been observed to blossom spontaneously and sporadically, under high humidity and temperature conditions. Taro flowering is produced when the plant is able to form flower primordium, besides internal and external factors that induce or stimulate flowering (Souza et al., 2002). Amadi et al., (2012) said that conventional breeding to produce new taro varieties in Nigeria, has failed, due to erratic flowering and poor seed production.
The onset of flowering is generally associated to a strong scent, coming mainly from the spathe to attract pollinizing insects (Ivanicic, 2011). A plant may have 2-4 flowers that sprout from the corm´s apical meristem. Between the petioles and leaves a wrapping leaf forms; the spathe surrounds the flowered column (the spadix that coils around a yellow sheet), forming an angle. In 21 of the accessions evaluated, the spadix remains inside the spathe, and in 5 cases, it grew upwards. The spadix is formed by sessile flowers, in the lower part of the female flowers (pistillate), that may be functional or sterile. The latter do not develop; instead, they dry and vanish. The fertile flowers have a stigma on the apex; inside they have six placentas with numerous ova each. The next section is made of sterile flowers of 1.5-2.5 cm long. The upper part of the spathe has staminate flowers, with six double-anther wings, that open through an apical pore that let pollen

**Agrisost|2016, Vol.22, No.1: pages 54-60 ISSN 1025-0247**
**Available at: http://www.agrisost.reduc.edu.cu**

spores; it is the first stage of inflorescence to dry out and detach. These results coincide with Ivancic (2011).

Inflorescence occurred in the fourth stage of accessions (Table 1), 69.2% of them (18 accessions) showed early flowering, and 30.76 (8 accessions) had late flowering. Studies of 2 298 clones in The Philippines, Viet Nam, Thailand, Malaysia, Indonesia, Papua New Guinea and Vanuatu concluded that only 38% of clones had inflorescence (Lebot et al., 2000).

**(Table 1) Accessions that favor inflorescence in taro (Colocasia esculenta (L.) Schott.) germplasm**

| No. | Accession | Inflorescence occurrence | Origin |
|---|---|---|---|
| 1. | 'Miyako' | Early | Japan |
| 2. | 'Klang' | Early | Malaysia |
| 3. | '2000-21' | Early | Hawaii |
| 4. | 'IND-231' | Early | Indonesia |
| 5. | 'IND-225' | Early | Indonesia |
| 6. | 'Lamputara' | Early | Indonesia |
| 7. | 'Pauli' | Late | Samoa |
| 8. | 'Manu' | Early | Samoa |
| 9. | 'INIVIT 97-3' | Late | Cuba |
| 10 | 'Samoana' | Early | Samoa |
| 11. | 'IND-178' | Early | Cuba |
| 12. | 'C2-E-11' | Early | Papua New Guinea |
| 13. | 'Pa´akala' | Late | Hawaii |
| 14. | 'Srisamrong' | Late | Thailand |
| 15. | 'Sapapalii' | Early | Samoa |
| 16. | 'Saleapaga' | Early | Samoa |
| 17. | 'Surin' | Early | Thailand |
| 18. | 'INIVIT 97-1' | Early | Cuba |
| 19. | 'Boklua' | Early | Thailand |
| 20. | 'Samoa 13' | Late | Samoa |
| 21. | 'Cameron 14' | Early | Cameron 14' |
| 22. | 'INIVIT MC 2005' | Early | Cuba |
| 23. | 'French' | Early | Viet Nam |
| 24. | 'Mexico 9' | Late | 'Mexico 9' |
| 25. | 'Isleña Rosada de Mayajigua' | Early | Cuba |
| 26. | 'Isleña Rosada de Santi Spiritus' | Late | Cuba |

The inflorescence clones are from the Pacific area, mostly. They are characterized by a strong scent, coinciding with Ivanicic´s (2011) remarks that flowering was often associated with a strong scent, mainly produced in the spathe, to attract pollinizing insects.
The accessions that produced inflorescence in more than 10% of the plants represented 68.4%.
Only 26 accessions were able to produce inflorescence naturally under the humidity and temperature conditions of Cuba, between July and up to November (Fig. 1). The rest failed to produce inflorescence along the evaluation period. Therefore, flowering may be induced in other months to make hybrids, due to flowering irregularities and floral structure disorders which are intensified after the application of hormones (GA3) that induce flowering (Ivancic, 1995).

The mean relative humidity values observed in the evaluation years (Fig. 1) increased between July and October. This period coincides with plant inflorescence, with a decrease in relative humidity in October-November when flowering ends. These results also mean gradual decrease of temperature; considerable fluctuation is observed in terms of rainfall, but its deficit is met with permanent irrigation along the crop cycle, for the two evaluation years.

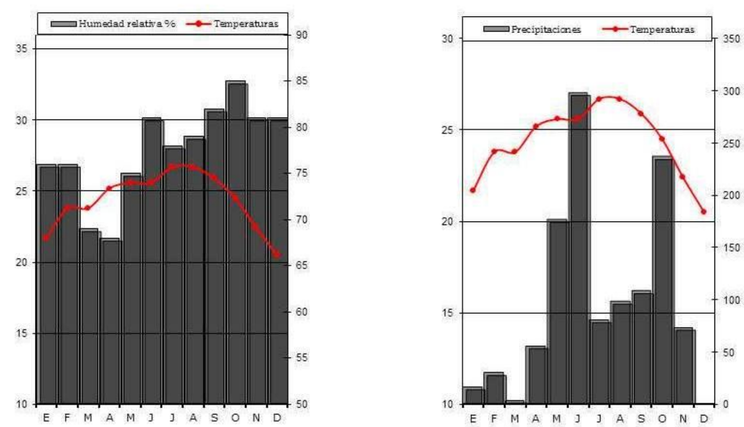


**Fig. 1 Weather variables. Mean values 2013-2014.**

According to Ivancic et al., (2008), Colocasia esculenta is a thermogenic species, since several studies have reported that thermogenic activity is significant to inflorescence. These results were achieved in a collection of the same genus in Vanuatu, where the highest average difference of mean air temperatures and inflorescence in the female stage, at 05: 00 h, was 6.8º C above the air temperature. Thermogenic activity is synchronized with the protogyny of this species.

## Morphological characterization

The morphological characterization of inflorescence concluded that green is the predominant color at the axis of inflorescence (68%); 78% of flowers have 2 and 3 flower bunches per plant, and 83% of inflorescence have a wrapped male part. The color of the flag leaf is orange-yellowish (81%), and differ from Rodríguez et al., (2002) in which all the accessions showed a green flag leaf, caused by amplification of the germplasm and ensuing variability increase. The shape of spathe at the masculine anthesis is indented (92%). 79.5% of accessions have yellow inflorescence limbus, and green inflorescence tube (42%). These characters are important to choose parents for genetic breeding by hybridization, because the success is in the frequency of inflorescence occurrence, and require optimum environmental conditions (Ivancic, 2011).

Most inflorescence had a green axis (57.9%), light green (31.6%), and green with purple spots (10.5%). Most accessions produced two inflorescences (68.4%), one (15.8%), and three inflorescences per leaf axis (15.8%).

The plants studied had 2-3 flower bunches (73.7%), one bunch (21.0%), and 4-6 bunches (5.3%). The masculine part of inflorescence wrapped 63.1% of accessions, and was exposed for 36.9%.

Pollen production is essential for breeding by hybridization. All the accessions evaluated produced light yellow pollen with low variability (19%) for most accessions (79.0%); 10.5% of accessions showed moderate variability (34%), and a similar percentage (10.5% of accessions), had high variability (82%), which is an encouraging result to perform breeding through hybridization. Pollen fertility was poor (0-40%); hence, breeders must perform a high number of hybridization to find the best heterotic combinations (Bradshaw, 2010) for the crop. 94% of flowers are fertile.

Scented inflorescence are often erectile, with a loose spathe.

All accessions with inflorescence are receptors for the feminine part, due to a marked presence of a jelly-like substance in the area.

The masculine part had no pigmentation, but the pollen was light yellow in the producing accessions (5), yellow limbus (79.0%), and orange-yellowish (21.1%). The inflorescence tube was more variable, with several shades of green (green, 36.9%; green with light yellow tips, 31.6; green with purple tips, 15.7; green on the upper part and light yellow with purple spots in the lower part, 10.5%; and green with light stripes or spots (yellow), 5.3%).

As to the flag leaf, 63.1% of the accessions evaluated were orange-yellowish, and 36.9% were yellow. Additionally, all accessions had indented spathe at the masculine anthesis (68.4% of accessions), flat (21.1%), and hooded (10.5%).

This variation in the evaluated characters may be associated to mutations (Rao et al., 1998). Furthermore, plant propagation continues, and natural and induced selection may have contributed to the phenotypical diversity observed (Okpul et al., 2004).

Not all the accessions preserved in the germplasm can flower, which is fundamental for hybridization programs, because they ensure the inclusion of desired traits that can meet the growing demands of farmers and consumers.

The data collected provide a starting point to set up further genetic breeding programs based on farmer and consumer demands, considering the traits observed in the accessions that flowered. Hence, clonal diversity of local production systems can be improved.

## CONCLUSIONS

1. Accessions that flowered at the Cuban *Colocasia esculenta* taro germplasm bank were characterized. The accessions with natural inflorescence accounted for 25% (26 accessions), of which 69.23% (18 accessions) showed early flowering, and 30.76 (8 accessions) had late flowering.
2. One out of four accessions of the germplasm studied were able to produce inflorescence between July and November. Increased relative humidity from July to October (78-85%) coincides with inflorescence occurrence; a decline (85-80%) was observed in October. November, when the crop´s flowering stage ends.

## REFERENCES


Agama, E., García, F., Gutiérrez, F., Sánchez, M., San Artin, E. and Bello, L. 2011. Isolation and Partial Characterization of Mexican Taro (*Colocasia esculenta* (L.) Schott. Starch/Stärke, 63(3):139-146

Amadi, C. O., E. N. A. Mbanaso, and G. O. Chukwu. (2012). A Review of Cocoyam Breeding in Nigeria: Achievements, Challenges and Prospects. Niger. Agric. J 43:72

Bradshaw, J. E. (ed.),( 2010). Root and Tuber Crops. Handbook of Plant Breeding, 295. Springer, London.

Hernández, J. A.; Pérez, J M.; Bosch, I. D. and Castro, S. N. 2015. Clasificación de los suelos de Cuba 2015. Ediciones INCA, Cuba, 93 p.

International Board for Plant Genetic Resources (IBPGR).Descriptors for *Colocasia.* Rome. 1999.

Ivancic, A. 2011. INEA Hybridization Protocols. www.ediblearoids.org/PROJECTS/WP3Breeding. Retrieved on 9/7/2011.

Ivancic, A (1995). Abnormal and Unusual Inflorescences of Taro, *Colocasia esculenta* (Araceae). Australian Journal Botany, v. 43, p. 475-489

Ivancic, A., Roupsard, O., Quero-García, J. (2008). Thermogenesis and Flowering Biology of *Colocasia gigantea* (Araceae). J Plant Res. 121: 73-82

Ivancic, A.; Lebot, V. 2000. The Gnetics and Breeding of Taro. Series Repères. Montpellier, France, Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), 194 p.

Libro "Instructivo Técnico del Cultivo de la Malanga", editora Agroecológica, Cuarta Edición, Junio – 2010, Cuba, Biblioteca ACTAF, Asociación Cubana de Técnicos Agricultores y Forestales, Instituto de Investigaciones de Viandas Tropicales.

Milián Jiménez, M., 2008. Caracterización de la variabilidad de los cultivares de la colección cubana de germoplasma del género *Xanthosoma* (Araceae). Tesis presentada en opción al grado científico de Doctor en Ciencias Biológicas. Fac. de Biología, Universidad de La Habana - Instituto de Investigaciones en Viandas Tropicales (INIVIT), Cuba, 122 p

Okpul, T., Gunua, T., Wagih, M.E. (2004). The Selection of a Core Sample of Papua New Guinean Taro (*Colocasia esculenta* (L.) Schott) Using Agro-Morphological Characteristics. Genetic Resources and Crop Evolution 51:671–678

Pereira, F.H.F.; Puiatti, M.; Miranda, G.V. 2003. Divergencia genética entre araceaes de taro utilizando caracteres morfo-cualitativos de inflorescencia. *Horticultura Brasileira*, Brasilia, 21(3): 520-524

Pedralli ,G., Carmo do Simões , C., Cereda , M & Puiatti, M. (2002). Uso de nomes populares para as especies de Araceae e Dioscoreaceae no Brasil. *Horticultura Brasileira*, Brasília, v. 20, n. 4, p. 530-532

Rao, M.B., Aparna, M,, Tanksale M,, Ghatge S. & Deshpande V.V. (1998). Molecular and Biotechnological Aspects of Microbial Proteases. Microbiol Mol Biol Rev.62: 597-635

Rodríguez Manzano, A., & Rodríguez Nodals, A.( 2002). Diversidad de la malanga isleña *Colocasia esculenta* (L.) Schott en Cuba. III Inflorescencias. Revista Jard. Bot. Univ. Habana. 23 , 119-126

Souza, M. M., De Pereira, T. N. S., & Martins, E. R. (2002). Microsporogênes e microgametogênese associadas ao tamanho do botáo floral e da antera e viabilidade polínica em maracujazeiro-amarelo (*Passiflora edulis* Sims f. flavicarpa Degener). Ciênc. Agrotec. 26(6): 1209