Research Note

PERFORMANCE OF BLIGHT-TOLERANT GENOTYPES OF TARO (COLOCASIA ESCULENTA) UNDER UPLAND CONDITIONS[1,2]

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Taro leaf blight caused by the fungus *Phytophthora colocasiae* currently limits worldwide production and trade of taro (*Colocasia esculenta*). In Puerto Rico taro is a minor crop more frequently grown on diversified small farms. Locally both wetland and upland production systems are used. Cultivar Lila is used under wetland conditions, whereas 'Blanca' is used for the upland system. These cultivars were described by Goenaga (1995). In 2004 there were field reports of a blight, later confirmed as the taro leaf blight, destroying the foliage, thus decreasing plant size and reducing yield (Rosa-Márquez et al., 2006). The disease devastated wetland taro production throughout southeastern Puerto Rico and was eventually found in the upland production system. Farmers with limited resources, who count upon taro as part of a group of crops they depend on, were negatively affected. In order to bring back production of this specialty crop under the pressure of this disease, and given the limited chances for registering fungicides for small acreage crops such as taro, strategies such as the use of blight-tolerant genotypes must be evaluated.

Ten taro genotypes with diverse genetic backgrounds, and identified as having tolerance to taro leaf blight in Hawaii, were imported into Puerto Rico for this study (Table 1). Field activities were conducted at the Gurabo Agricultural Substation located in the Turabo Valley in east-central Puerto Rico. This location is 80 m above sea level and is characterized by its humid climate.

After increasing planting material, we established non-replicated field observation plots in order to examine the relative susceptibility of the Hawaiian genotypes to leaf blight as compared to that of the local cultivars Lila and Blanca. Twenty plants for each of the Hawaiian genotypes and also for Lila and Blanca were planted under upland conditions 3 October 2007 in a single bed 0.61 m wide and 9.14 m long. In the area, the soil was an Inseptisols from the Coloso series (Vertic Endoaquepts) with a pH of 7.2, 3.1% organic matter, and 1% slope. Water was applied as needed with a drip irrigation

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TABLE 1.—*Genetic background of taro genotypes imported into Puerto Rico from Hawaii.*

Genotypes	Genetic background
MP2	Moi × Palau 20[1]
MP6	Moi × Palau 20
MS3	Maui Lehua × Sushi[1]
PN2	Genotype collected in Papua New Guinea
Shogatsu	Cultivated genotype from Japan
19F	(PH21[1] × [Red Moi × PH15[1]]) × Maui Lehua
30F	(Maui Lehua × 261[1]) × Maui Lehua
2000-101	(Red Moi × PH15-11[1]) × Sawahn Kurasai
2000-148	(Bun Long × PH21) × White Bun Long
2002-21F	India × (Pwetepwet[1] × Maui Lehua)

[1]Source of resistance to the leaf blight.

system. Each plant was side-dressed with 57 g of 12-5-10 fertilizer applied at two and at four months after planting. Weeds were controlled by a combination of herbicides and hoe weeding. No measures were taken to control the blight. At 120 days after planting, all plants within the row were evaluated for symptoms of leaf blight. For each genotype, the percentage of plants affected by the disease was calculated. Presence of the disease was recorded when there was at least a 1-cm diameter brown spot present on any of the leaves. For each genotype, five plants among those showing the disease were chosen at random, and the percentage of leaves showing symptoms was calculated.

On 1 July 2008, we established a field experiment to compare leaf area and dry matter among genotypes under natural infestation of the leaf blight. At the experimental site the soil was a Vertisols from the Mabí series (Aquic Hapluderts) with an average pH of 6.9, organic matter 2.6%, and 2% slope. Treatments were the Hawaiian genotypes plus Lila and Blanca. The experimental layout was a randomized block with four replications. Each plot consisted of a bed 0.61 m wide and 9.14 m long. Within the bed, 24 setts (also known as hulis) were planted in a zigzag pattern. Because sett size significantly influences both the size of the plant and the yield of taro (Ortiz and González-Vélez, 1999), only setts from 200 to 270 g in fresh weight were used for planting. Irrigation, fertilizer and weed control were the same as described for the previous planting. Symptoms of leaf blight were present on the plants throughout the crop cycle, and no control measures were taken. At 119 and 289 days after planting, two plants were randomly chosen from each plot, removed from the soil, cleaned with pressurized water and allowed to dry at room temperature for one day. Not all roots were obtained; thus roots still attached to the corm and to the cormels were discarded. Sampled plants were divided into the main plant and the suckers; then each part was further divided into leaf lamina, leaf petiole and corm or cormels. Before taking leaf area measurements, necrotic areas (brown spots) associated with symptoms of leaf blight were removed; thus the area measured[6] and reported herein is green-leaf area. For dry weight determinations all plant parts were dried to a constant weight in a forced-air oven. For the lamina and petiole the oven was set at 38° C, whereas 48° C was used for corm and cormels. Stand, the percentage of

[6]Leaf area was measured by using a LI-COR model 3100 area meter. Trade names are used only to provide specific information. Mention of a trade name does not constitute a warranty of materials or equipment by the University of Puerto Rico, nor is this mention a statement of preference over other materials or equipment.

TABLE 2.—*Percentage of plants showing symptoms of leaf blight in observation plots at 120 days after planting and percentage of leaves showing symptoms of leaf blight.*

Genotype / Cultivar	Plants showing symptoms of leaf blight	Leaves among infested plants with visible symptoms of leaf blight
	- - - - - - - - %	- - - - - - - -
19F	35	33
PN2	35	14
MP2	30	31
21F	10	28
Shogatsu	20	53
2000-101	25	14
2000-148	70	32
MP6	80	66
30F	30	60
MS3	55	54
Lila	35	33
Blanca	16	27

plants completing the crop cycle, was evaluated just before harvest. Plants were harvested at 289 days after planting. The average corm fresh weight was obtained by using all plants within the plot.

Under the conditions of this study, all the Hawaiian genotypes and cultivars Lila and Blanca showed symptoms of leaf blight (Table 2). Leaf blight symptoms appeared initially as small brown specks on the leaves which eventually enlarged into brown lesions. A detailed description of the symptoms for this blight has been given by Rosa-Márquez et al. (2006). At 120 days after planting, only 10% of the plants of the Hawaiian genotype 21F showed blight symptoms (Table 2). Among all genotypes, MP6 appeared to be the most susceptible, with 80% of plants affected by the blight and an average of 66% of the leaves showing symptoms. Cultivar Blanca was among the least affected, with 16% of the plants showing symptoms (Table 2). Cultivar Lila began showing advanced stages of the blight more than 120 days after planting, with a large number of leaves becoming necrotic and the eventual collapse of the petioles.

Results of the 1 July 2008 planting demonstrated significant varietal differences in combined green leaf area (Table 3). At 119 days after planting, leaf area (after removing necrotic areas) of genotypes 19F, 21F, and 2000-101 was significantly greater than that of Blanca, with 2000-101 having leaf area significantly greater than that of Lila (Table 3). The latter result is noteworthy because there is evidence that both Blanca and Lila express their maximum leaf area and leaf area index at approximately 117 days after planting (Goenaga, 1995). In the presence of the disease there were Hawaiian genotypes having significantly more photosynthetic leaf area than that of traditional cultivars Lila and Blanca. For taro, leaf area is distributed in the main plant leaf area and in the sucker's leaf area. Sucker leaf area for Lila represented more than half of the total leaf area for the plant. The same trend was observed for Hawaiian genotypes MP2, Shogatsu, 2000-101, 2000-148, and 30F (Table 3).

Dry matter production was significantly different among the genotypes (Table 4). At 119 days after planting, both Shogatsu and 2000-101 had more combined plant dry weight than that of the cultivar Lila (Table 4). However, only 46% of Shogatsu's dry weight was from the main plant, with a large percentage accumulated in the suckers (Table 4). Also at 119 days after planting, all genotypes and cultivars accumulated more dry weight in the petiole than in the leaf lamina (Table 4). Genotypes 19F, 21F, and Blanca had significantly more leaf lamina dry weight than Lila (Table 4). This result is

TABLE 3.—*Green leaf area at 119 days after planting after removing necrotic areas caused by taro leaf blight.*

Genotype / Cultivar	Leaf area		
	Combined[1]	Main plant	Suckers
	sq cm/plant		
19F	6,361	4,493	1,868
PN2	3,291	2,649	642
MP2	4,961	2,466	2,495
21F	6,339	3,442	2,896
Shogatsu	5,093	1,776	3,317
2000-101	7,278	3,457	3,821
2000-148	5,384	2,505	2,879
MP6	5,350	2,850	2,500
30F	4,123	1,967	2,155
MS3	1,863	1,273	590
Lila	4,607	2,131	2,475
Blanca	4,046	2,896	1,150
LSD (0.05)	2,164	1,046	1,439

[1]Leaf area combined for main plant and suckers.

relevant because in this study lamina dry weight represents that of photosynthetically active leaf area (area damaged by the blight was removed before measurements). Genotypes 19F, MP2, Shogatsu, 2000-101, and Blanca had significantly more dry weight in the corm than Lila (Table 4). Shogatsu also had more corm dry weight than Blanca. This result indicated that in the presence of leaf blight, and at 119 days after planting, some Hawaiian genotypes accumulated dry weight in the economic part of the plant more rapidly than Lila. Overall, the latter results indicate that in the presence of taro leaf blight and under upland conditions, some of the Hawaiian genotypes, among them 19F, 21F, Shogatsu, and 2000-101, were more efficient than the local cultivars in accumulating dry weight per unit of time.

At 289 days after planting, dry weight was concentrated in the corm and suckers (Table 4). Leaf dry weight represented 1 to 2% of the combined dry weight, whereas petiole dry weight was 1 to 6%. Corm dry weight of genotypes 19F and MP2 was significantly more than that of Blanca, whereas dry weight of 19F, PN2, MP2, and of Blanca itself, was more than that of Lila. The latter results were indicative that some of the Hawaiian genotypes have potential for being better yielders than the traditional cultivars for Puerto Rico. With the exception of MS3, dry weight of the suckers at 289 days was more than half of the combined dry weight (Table 4). As Goenaga (1996) noted, in taro the partitioning of a significant percentage of dry matter to suckers is of particular importance because corms of suckers seldom reach a marketable size.

At harvest, corm fresh weight varied from 171 to 539 g although most genotypes were statistically similar regarding this characteristic (Table 5). Corm fresh weight of 19F was more than that of both Blanca and Lila (Table 5). Five Hawaiian genotypes showed stands of 90% or more (Table 5). Seven of the 10 Hawaiian genotypes had significantly better stands than Blanca (51%), and genotypes PN2 and MP2 had significantly better stands than Lila (70%). Estimates of yield were based upon the stand and the corm fresh weight. Genotypes 19F, PN2 and MP2 had significantly higher estimated yield than Lila and Blanca.

Lila and Blanca had a ratio corm dry weight to combined plant dry weight of 0.38 and 0.37, respectively, surpassed significantly only by that of genotype MS3 (Table 5).

TABLE 4.—*Dry weight for taro plant parts at 119 and at 289 days after planting.*

Days after planting	Genotype/ Cultivar	Combined dry weight	Main plant				Suckers dry weight
			Lamina	Petiole	Corm	Combined	
		g/plant					
119	19F	87.9	16.7	30.8	23.9	71.3	16.6
	PN2	53.7	10.9	21.6	15.6	48.1	5.6
	MP2	76.6	6.1	21.9	20.9	48.9	27.7
	21F	80.0	13.1	24.0	19.0	56.0	24.0
	Shogatsu	128.7	5.7	15.0	38.9	59.6	69.1
	2000-101	104.0	12.6	22.5	27.2	62.4	41.6
	2000-148	61.6	8.8	14.7	7.9	31.4	30.2
	MP6	60.0	11.5	22.6	7.3	41.4	18.6
	30F	60.3	6.7	16.8	11.9	35.4	24.9
	MS3	41.9	3.9	10.0	18.7	32.6	9.3
	Lila	61.5	8.5	21.3	10.4	40.1	21.4
	Blanca	75.6	13.7	15.5	27.8	57.0	18.6
LSD (0.05)		31.8	4.2	10.6	10.2	17.6	19.4
289	19F	350.7	3.8	7.9	148.0	159.7	191.0
	PN2	413.6	4.4	11.3	121.2	136.9	276.7
	MP2	423.7	2.4	5.5	135.5	143.3	280.4
	21F	303.7	4.3	9.5	85.8	99.6	204.1
	Shogatsu	276.9	0.7	1.2	41.4	43.3	233.6
	2000-101	265.7	1.8	4.4	55.8	61.8	203.9
	2000-148	104.3	1.2	1.8	19.5	22.5	81.8
	MP6	216.9	4.1	7.6	39.4	51.0	165.9
	30F	149.9	2.6	9.1	49.5	61.2	88.7
	MS3	71.9	1.3	2.4	34.2	37.9	34.0
	Lila	165.9	2.9	5.7	61.8	70.4	95.5
	Blanca	280.6	3.3	5.5	98.3	106.9	173.7
LSD (0.05)		123.4	2.1	4.0	32.0	34.1	104.1

TABLE 5.—*Corm fresh weight, stand, estimated yield and ratio corm dry weight to combined plant dry weight for taro genotypes and cultivars.*

Genotype/Cultivar	Corm fresh weight	Stand	Estimated yield	Number of suckers	Ratio corm dry weight to combined plant dry weight
	g/corm	%	kg/ha	no.	%
19F	539	93	12,279	6.3	0.44
PN2	395	94	8,797	8.5	0.30
MP2	358	95	8,430	11.3	0.32
21F	348	85	6,903	6.3	0.28
Shogatsu	301	90	6,536	14.8	0.16
2000-101	264	90	5,803	10.5	0.24
2000-148	171	89	3,727	6.8	0.18
MP6	229	71	3,665	5.5	0.23
30F	193	75	3,299	5.0	0.33
MS3	205	56	2,749	2.5	0.50
Lila	303	70	4,826	7.3	0.38
Blanca	396	51	4,765	4.8	0.37
LSD (005)	126	24	2,565	3.3	0.11

However, MS3, was among the lowest yielders. These results showed that dry matter partitioning into the edible part of the plant (main corm) was relatively low for the Hawaiian genotypes included in this study. Along with the results of Goenaga (1995) and Ortiz and González-Vélez (1999), these findings further point out the desirability for improving taro for high dry matter partitioning to the main corm.

Several of the Hawaiian genotypes, among them 19F, PN2, MP2, 21F, and 2000-101, demonstrated good potential; thus these genotypes should be further evaluated under the conditions of the Caribbean Basin. In the Caribbean Basin taro is primarily grown for table use; thus varietal selection must consider consumers' preferences. Although this study did not include an organoleptic evaluation of the Hawaiian genotypes, access to these genotypes was important because they contain genes of tolerance to the blight that can be incorporated into cultivars adapted to the Caribbean production system and market demands.

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