Proceedings of the 13th ISTRC Symposium, 2007
pp. 284 - 291

Screening of cocoyam (*Xanthosoma Sagittifolium* (L) Schott) for disease resistance under two contrasting environments

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Abstract. Sixty-six (66) accessions of cocoyam germplasm collection held by the Plant Genetic Resources Center at Bunso, Ghana were screened for their reaction to the common cocoyam diseases under two different soil moisture conditions. One set was grown under rain fed conditions on the upper slope while the second set was grown at the bottom of the slope where the water table was high. The sites were otherwise similar in soil characteristics, such as pH, organic matter content, fertility and texture. The disease incidence and severity were different in the two environments. The percentages of germplasm attacked by various diseases under the upland conditions were: dasheen mosaic virus 18.2%, bacteria leaf necrosis 36.4%, Phytophthora leaf blight 84.9% and cocoyam root rot blight 77.2%. Under the valley conditions, the disease incidence was dasheen mosaic virus (84.9%), bacterial leaf necrosis (62.1%), Phytophthora leaf blight (9.10%), Cladosporium leaf spot (1.5%), Leptosphaerulina leaf spot 1.5% and Concentric leaf spot (51.5%). The devastating attacks of the Cocoyam root rot blight complex and Phytophthora leaf blight diseases under the upland conditions resulted in no economic yield. However, there was reasonable yield of cormels in the lowland conditions where soft rot complex was not detected and Phytophthora leaf blight was mild.

Introduction

Cocoyam (*Xanthosoma sagittifolium* (L) Schott), a native of the Americas, was introduced into Ghana by West Indian missionaries in 1843 (Wright, 1930). It thrives well in the humid tropics where rainfall is bimodal and exceeds 1000mm on a well-drained, deep and fertile soil, hence its distribution and cultivation are concentrated in the forest zone of Ghana (Afreh-Nuamah, 1991). Cocoyam is one of the important staple root and tuber crops in Ghana and serves as an important food security crop to most peasant farmers when the cereals and plantain fail or are scarce especially during the perennial “lean” season at the beginning of the rains and, before the harvest of the cereals.

Production levels in Ghana were relatively high in the early sixties, but have suffered considerable decline over the past three decades. According to Dorosh (1988), production levels and yield dropped from 7.6t/ha to 4.7t/ha. The decline is attributed to factors such as changing environmental conditions, deteriorating soil fertility status, inadequate planting materials but worst of all is attack by diseases. In Ghana, no major pest has been linked to the decline in production but diseases especially the cocoyam root rot blight complex (CRRBC or soft rot) and Phytophthora leaf blight cause considerable loss in yield of cocoyam.

Moisture influences the initiation and development of infectious plant diseases in many interrelated ways. It activates bacterial, fungal and nematode pathogens, which may infect the plant. According to Agrios (1988) the underground parts of plants such as roots tubers and young seedlings affected by fungi like Pythium show severity of disease incidence in proportion to the amount of soil moisture and are greatest near the saturation point. The objective of this study therefore, was to assess the extent of susceptibility of the germplasm to the common cocoyam diseases in two environments with differing soil moisture regimes.

Materials and Methods

Two field experiments, one at the upper slope and the other at the bottom of the slope where the water table was high, were established. The planting materials used were obtained from The Plant Genetic Resources Centre at Bunso, Ghana. All the 66 local accessions were used for the experiments. After clearing and removal of dried trash, the upland plot was ploughed, harrowed and ridges, spaced 1m apart, were prepared. Ten corm sets each weighing about 150g for each accession was planted at a spacing of 0.6m on the ridges. At the bottom slope, ridges were prepared without prior ploughing. Planting operations were the same as for the upper slope experiment. Both experiments were planted on 26th May 2001. Cultural practices undertaken at the two sites included weeding, earthening up ridges and raising of embankment to keep water within the valley bottom plots. The water level within the embankment was controlled such that it did not rise above the plants base. Harvesting was done 10 months after planting (10 MAP).

Data were collected on the following parameters starting from 10 weeks after planting (WAP) and regularly at monthly intervals: Number of leaves (both fresh and senesced), petiole length, leaf area, disease incidence and cormel yield. Other data collected included soil analysis and meteorological data of the two environments as shown in Table 1.

The rainfall pattern for the period was very typical of the forest belt with its two rainfall maxima showing a break in August. For the Upland site, which was rain fed, the total amount of rainfall received during the experimental period was 747.3mm in the major season and 168.3 in the minor season. The valley bottom site received the same amount of rain, in addition to the high moisture table.

Results and Discussions

Growth data. Leaf turnover was measured as the number of leaves appearing and dying. Data taken before the end of the rains (10 WAP), at the end of the rains (18 WAP) and during the dry season (30 WAP) are shown in Table 2. Plant growth in both environments was vigorous up to the end of October 2001, which marked the end of the rainy season (Figure 1a and 1b). Data show that before the end of the rains, the plants maintained an average of 6 leaves all of which remained green or photosynthetic. Toward the end of the rainy season (around 18 weeks) about half of the leaves had been lost due to disease or senescence. The rate of leaf loss increased and by the 30th week, only 2-3 leaves remained green. This was more serious with the upland site (Figure 2).

Up to the 10th week, it would appear that more accessions showed vigorous growth in the lowland environment than the upland one. By the 18th week, vigour of growth as judged by the length or size of petiole was higher under the upland environment than the

Table 1: Soil physical and chemical characteristics at the two sites.

Site	SoilTexture	PH1:25	Carbon (%)	Organic matter (%)	Nitrogen (%)	Available Phosphorus (Mg/kg))	Calcium (Cmol/kg)	Potassium (Cmol/kg)
Upland	Sandy-loam	5.7	0.91	1.57	0.08	11.25	2.20	0.06
Lowland	Sandy-clay loam	6.5	0.63	1.09	0.07	12.50	3.40	0.07

Table 2: Frequency distribution of leaf turnover in the Upland environment.

Leaf turnover at 10 weeks			Leaf turnover at 18 weeks			Leaf turnover at 30 weeks		
No. of leaves (No. dead)	Frequency or No. of accessions		No. of leaves (No. dead)	Frequency or No. of accessions		No. of leaves (No. dead)	Frequency or No. of accessions	
	U[1]	L[2]		U	L		U	L
5 (0)[3]	5	0	8 (4)	0	3	11 (9)	0	6
6 (0)	25	42	9 (4)	0	6	12 (10)	0	2
7 (0)	36	24	10 (5)	12	57	13 (12)	4	0
			11 (6)	38	0	14 (11)	0	38
			12 (6)	16	0	14 (12)	7	0
						15 (11)	0	19
						15 (14)	21	0
						16 (14)	2	0
						16 (15)	22	0
						17 (13)	0	1
						17 (15)	10	0

[1]U = Upland site. [2]L = Lowland site.
[3]Numbers in parenthesis indicate dead leaves due to disease or senescence.

Figure 1a: Growth of accessions 4-5 MAP at the Lowland site.

Figure 1b: Vigorous growth of accessions 4-5 MAP at the Upland site.

lowland one (Figure 3). However, by the 10th month, the top portion of the plants in the upland environment had virtually been lost while the plants in the lowland environment still retained some top growth (see Figure 4).

Leaf area by the 10th week had reached a maximum of 1000cm² in both environments. As occurred with the petiole, plants on the upper slope appeared more vigorous as the majority had reached maximum leaf area of 1700-1900 and some were in the 2300-2500cm² ranges by the 18th week. In the lowland environment, 42 accessions had maximum leaf area in the 600-800 range and only 4 had leaf area between 1100 and 1200 cm².

As happened with petiole length, by the 30th week, leaf area had been reduced in all environments but a few plants in the upland environment still had higher leaf area than the lowland environment. All these indicate that while cocoyam cannot resist drought very well, it does not grow as vigorously in very wet conditions.

Disease incidence. In general disease incidence was higher in the lowland conditions than the upland as shown in Table 3. Six different diseases were identified in contrast to the four under the upland conditions. Dasheen mosaic virus disease was more prevalent under the lowland conditions. The main symptom of this disease is wrinkled leaves, which become reduced in size. It would appear that high soil moisture condition promote the movement of the virus, and thus promote the development of the disease. Bacterial leaf necrosis caused by *Xanthomonas compestris* was the next important disease that affected mostly the plants in the high soil moisture environment. This is not surprising since high moisture or humid conditions usually promote bacterial diseases. Concentric leaf spot, which

Figure 2 a: Initiation of senescence of accessions at the upland site at the beginning of the dry season.

Figure 2 b: Initiation of senescence of accessions at the upland site at the beginning of the dry season.

Figure 3: omparison of growth of an accession under upland condition (left) and lowland environments (right) at 4.5 months (18 weeks).

Figure 4 a: Ten (10) month old materials under lowland conditions still retaining green top-growth.

Figure 4 b: Ten (10) month old materials under upland conditions with much top-growth lost.

Table 3: Percentage of germplasm attacked by various diseases.

Types of disease	% attack Upland	% attack Lowland
Dasheen mosaic virus	18.18	84.85
Bacterial leaf necrosis	36.36	62.12
Phytophthora leaf blight	84.85	9.10
Cladosporium leaf spot	-	1.52
Leptosphaerulina leaf spot	-	1.52
Concentric leaf spot	-	51.52
Cocoyam root rot blight complex	77.24	-

appeared mainly under the lowland conditions, is not an economically important disease (Théberge, 1985).

Cocoyam root rot blight complex. The two most serious diseases of cocoyam, CRRBC and leaf blight mostly occurred in plants grown at the upper slope site. Doku (1980) citing Viennot-Bourgin (1964) stated that the development of CRRBC caused by soil-borne fungi coincides with cormel formation. As a result, cormels of infected plants are no larger than palm nuts. In addition, corms get rotten, produce an offensive odour (Figure 5). Although a few accessions were moderately susceptible, majority were additively resistant to CRRBC (Table 5).

Cormel yield in lowland environment. Table 4 shows the yields for the germplasm in the lowland environment. The absence of the incidence of CRRBC and the mild leaf blight diseases attack and availability of moisture sustained the growth and productivity of the plants during the period of dry spells. This resulted in the appreciable economic cormel yield (Figure 6).

The main pathogen responsible for CRRBC is *Pythium myriotylum*. It grows best under temperatures of 25º-37ºC. Nzietchueng

Figure 5: Corm severely attacked by CRRBC under the Upland condition.

Figure 6: Cormel yield under the lowland conditions.

Table 4: Cormel yield in the lowland plot.

No. of accessions	Cormel yield per plant (kg)	Cormel yield per hectare (tonnes)
11	0.70-1.00	16-20
15	0.51-0.69	11-15
32	0.30-0.50	6-10
8	0.10-0.29	1-5

Table 5: Frequency distribution of percent attack and severity score for CRRBC.

% Attack	No of accessions	Severity score	No of accessions
0	14	1	17
10-30	5	2	12
31-50	13	3	21
51-70	6	4	16
71-90	17		
91-100	11		

(1985) observed that the mean temperature of 26ºC, relative humidity of 89% and rainfall of 400-700mm between July and September favour the development of the pathogen in Njambe ecological zone of Cameroon. These were the conditions in the study areas.

Phytophthora leaf blight. Erwin and Ribeiro (1996) citing Gregory (1983) stated that leaf blight caused by *Phytophthora colocasiae* is spread by water-splashed sporangia and zoospores onto nearby leaf surfaces. The fact that the incidence of this disease was also low under the lowland conditions supports the argument that moisture stress is an important factor, which predisposes cocoyam to attack by the pathogen. As shown in Table 6, most accessions were susceptible to Phytophthora leaf blight

Greehouse screening for CRRBC. The field screening of the accessions for resistance to

Table 6: Frequency distribution of severity score for Phytophthora leaf blight.

Severity (%)	No. of accessions
0-10	0
11-20	1
21-30	12
31-40	7
41-50	25
51-60	14
61-70	4
71-80	3

Table 7: Correlations between some vegetative and yield characters and disease score of the germplasm.

Character	1	2	3	4	5	6	7
1. Total Cormel yield	1	0.214	-0.048	0.084	0.042	0.156	0.866**
2. Total corm yield		1	-0.326**	0.288*	0.006	0.399*	0.184
3. Disease score			1	-0.480**	-0.166	-0.424**	-0.084
4. Plant vigor				1	0.133	0.340**	0.031
5. Mean base circumference					1	-0.065	0.067
6. Mean petiole length						1	0.340**
7. Mean number of cormels							1

*Significant at 0.05 ** Significant at 0.01

CRRBC was followed by screening in the greenhouse. Correlations were established between the various parameters as shown in Table 7. It is clearly shown that disease score was negatively correlated with both growth and yield parameters.

Conclusion

The soil moisture regimes do not only influence the growth and development of cocoyam but the development of diseases. High soil moisture under the lowland conditions (moisture stress) did not favour high vegetative development. However, the water stress was a very important factor that predisposed cocoyam to attack by CRRBC and Phytophthora leaf blight as occurred in the upland environment. This implies that treatments that will conserve soil moisture such as mulching are likely to reduce the attack of these two devastating diseases. Genetic variation observed in the response of the germplasm especially to CRRBC implies that selection for resistance may be successful.

Acknowledgement

The authors would like to give special thanks to MOFA/IFAD Root and Tuber Improvement Programme, Ghana for financially supporting the project.

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