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Reaction of abaca (*Musa textilis* Nee.) accessions and varieties to fusarium wilt caused by *Fusarium oxysporum f.sp. cubense* (E.F. Smith) Snyd. and Hans.

Lucia M. Borines, Elsie E. Salamat, and Rammel B. Cardines.

Department of Pest Management, College of Agriculture,
Leyte State University, Baybay, Leyte 6521-A, Philippines.

ABSTRACT

Fusarium wilt caused by *Fusarium oxysporum f.sp. cubense* (FOC) is one of the problem diseases attacking abaca. The most effective way of minimizing the damage is through the use of resistant varieties. The levels of resistance of different abaca varieties/accessions, however, have not been determined yet so this study was conducted to: 1) evaluate the reaction of eight recommended abaca varieties to fusarium wilt, 2) evaluate the reaction of abaca varieties/accessions and abaca relatives from the National Abaca Research Center (NARC) germplasm collection and production area to fusarium wilt, and 3) confirm the reaction of the identified resistant varieties/accessions in a naturally infested field.

Among the 8 recommended abaca varieties, Linino showed resistance to FOC having the lowest infection, foliage yellowing and internal vascular discoloration ratings in a pot experiment. This variety was also proven resistant in the field plot screening together with 6 other accessions, namely: Alman No. 2, Alman No. 4, Tinawagan Puti #. 2, Pakol, CES x Pacol and Pakil # 1. Of the six, Alman No. 4, Tinawagan Puti # 2, Linino and Pakil also showed resistance to FOC, when planted in a naturally infested field in Polahongon, Mahaplag, Leyte.

Keywords: abaca, germplasm, resistance, fusarium wilt

Correspondence: L. M. Borines *Address*: Department of Pest Management, College of Agriculture, Leyte State University, Baybay, Leyte, 6521-A, Philippines. *Tel. No*. (053) 335-2626
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INTRODUCTION

Abaca (*Musa textilis* Nee) or Manila hemp is a succulent annual plant similar to banana but it has a more slender stalk and pointed leaves than banana. It is primarily grown for its strong but flexible fiber. Commercially, abaca fiber is one of the important million-dollar earners of the country. About 85% of the total world fiber comes from the Philippines, while 23% was supplied by South America (PCARRD, 2007). The abaca industry generated an annual average income of US $ 82,329,941 and supports 68,492 abaca farmers (FIDA, 2007). It is exported raw, manufactured or as finished fiber craft. Abaca fiber is an excellent raw material for paper and for dissolving grade pulps due to its lignin, ash, silica and extractive contents as well as its high total cellulose content. It is three times stronger than cotton and twice as strong as sisal fibers and its fibers can also be used as meat casing, vacuum cleaner, brushes, currency papers and tea bags (Aldaba, 1982). Abaca is also made into cordage, ropes and twines, pulp and specialty papers, fibercrafts, textiles and fabrics (FIDA, 2007).

From 1991 to 2000, the Philippines had an average of 109,000 ha. of abaca plantation producing an average of 66,000 tons of fiber (PCARRD 2003). The major abaca-producing regions in the country were Eastern Visayas (~39%) and Bicol (~33%). The whole production contributed an average of 17,359 mt per annum or 27% of the total production (PCARRD, 2003; DA-AMAS, 2006).

Despite the high market potential of abaca, its production has been limited by among other factors the occurrence of insect pests and diseases. The industry is threatened especially by diseases which results in low productivity and inconsistent fiber quality. Bunchy top, bacterial wilt and fusarium wilt are considered economically important diseases of abaca (Bastasa and Baliad, 2005).

Abaca diseases have taken their toll on many abaca farms, particularly in Bicol Region. The uncontrollable devastation caused by virus diseases, bacterial and fusarium wilt in abaca further aggravates the farmers' abaca production problems (PCARRD, 2003). Since 1992, The Fiber Development Authority spent millions of pesos to help farmers rehabilitate their farms. The rehabilitation program covers the Bicol Region, Eastern Visayas and Caraga in Northeastern Mindanao (Bajet and Magnaye, 2002).

Fusarium wilt affects primarily banana, but other banana relatives are also susceptible. It caused commercial losses before banana production ceased

in Central America in 1956 (Ploetz, 2005). It is recognized as one of the most destructive diseases of banana worldwide (Moore *et al*., 2001) as well as a serious disease of abaca. The disease is thought to be endemic to Southeast Asia (Stover, 1962) and is becoming widely distributed throughout the country where abaca is extensively grown. It is one of the major diseases attacking abaca in Leyte (Borines, 1996) with ~ 5-65% disease severity in major abaca growing municipalities (Bastasa and Baliad, 2005). The disease is most devastating especially in areas of high elevation.

External symptom of the disease is yellowing of the leaves, usually the lower leaves then to the younger ones, followed by drying and finally wilting of the entire plant. Affected plants have discolored vascular bundles and most die before reaching maturity forcing the farmers to harvest the abaca plant prematurely. Fibers of affected plants are discolored and of low tensile strength and quality resulting in a much lower price.

The use of host plant resistance in disease control is very effective and economical in the long run (Moore *et al*. 1995). Resistance genes can be incorporated in an agronomically good cultivar; however, host genotypes that possess resistance to fusarium wilt must first be identified. In addition, the level of resistance of the recommended abaca varieties commonly grown by farmers needs to be measured before they are used for commercial production.

Abaca varieties/accessions with resistance to fusarium wilt have not been identified yet except for a few cultivars evaluated by Umali et al. (1956) and Magnaye (1975). The National Abaca Research Center (NARC) germplasm collection has a total of 522 accessions (Moreno, 1995). These consist of 425 cultivated species, 69 wild relatives and 28 hybrids, which is the largest in the country. The degree of resistance or susceptibility of these varieties/ accessions to fusarium wilt needs to be evaluated.

The study evaluated and compared the reaction of eight recommended abaca varieties to fusarium wilt; evaluated the reaction of abaca varieties/ accessions and relatives from the germplasm collection and production area of the National Abaca Research Center (NARC) to fusarium wilt; and confirmed the reaction of the identified resistant varieties/accessions in a naturally infested field.

MATERIALS AND METHODS

Collection and isolation of fusarium wilt fungus

Fusarium wilt diseased abaca plants were collected from Polahongon, Mahaplag, Leyte and brought to the laboratory at Leyte State University for isolation of the pathogen. Isolation process was done by obtaining 3-mm^2 sections from the infected pseudostem or corm in 1%NaOCl (sodium hypochlorite) for 2 minutes and 3 changes of sterile water and then blotted dry with sterile tissue paper. They were plated into PDA plates and incubated at room temperature. Small portions of fungal growth emerging from the plated tissue sections were aseptically cut and transferred into PDA slants for pure culture and maintained for future use.

Mass culture of Fusarium oxysporum f. sp. cubense (FOC)

FOC was mass cultured in corn meal-sand medium (CMS) which was used as inoculum. CMS was prepared by mixing 1 part ground corn for every 20 parts of fine sand. The mixture was placed in glass jars to a desired volume, moistened and covered with aluminum foil then bound with a rubber band at the rim. They were sterilized at 15 psi for 1 hour. Pure culture of the fungus from PDA slant was aseptically seeded into the prepared CMS medium and incubated at room temperature until completely colonized by the fungus.

Pathogenicity testing

CMS culture of the fungus was inoculated into the soil by mixing with the soil in 50 x 60 cm^2 seed box. After infesting the soil, abaca seedpieces (Inosa variety) were planted and given the necessary cultural care daily thereafter. Plants were observed daily until typical symptoms of fusarium wilt infection were noted.

Evaluation of the reaction of eight recommended abaca varieties to fusarium wilt

The reaction of 8 recommended abaca varieties to FOC was determined and compared in a pot experiment with treatments arranged in a randomized

complete block design. The 8 varieties were: Inosa, Lagwis, Laylay, Linawaan, Linino, Linlib, Minenonga and Putian. Sixteen seedpieces per variety were used in 3 replications, with 2 seedpieces planted in each 12 in. diameter clay pots (Fig. 1). One hundred fifty grams of CMS culture of the fungus was used as inoculum.

Two set ups were made. In one set up, the inoculum (FOC) was incorporated into the soil immediately prior to planting while in the other, the inoculum was introduced to the soil 2 months after planting. The plants in both set ups were observed for the development of typical symptoms. To gather data, 3 parameters were used in measuring the reaction of the varieties, namely: 1) percent infection, 2) foliage yellowing rating and 3) vascular discoloration. Percent infection was computed using the formula:

$$\% \text{ Infection} = \frac{\text{No. of plants showing foliage yellowing}}{\text{Total number of plants}} \times 100$$

Foliage yellowing rating was gathered using the scale below:

b Rating	Description
1-1.9	No yellowing
2-2.9	Slight yellowing
3	Extensive yellowing

For the third parameter, all plants were uprooted and the pseudostem sliced longitudinally. Disease scoring/rating used in banana fusarium wilt by Pedrosa in 1995 shown below was followed.

c Rating	Description	Reaction
0.1	No discoloration	Immune (Im)
1.1.2	Isolated points of vascular discoloration	Resistant (R)
2.1.3	Discoloration up to 1/3 of corm vascular tissue	Moderately Resistant(MR)

Figure 1. Pot screening of eight recommended abaca varieties against *Fusarium oxysporum f.sp. cubense*

Figure 2. Field plot screening of abaca lines/varieties from the NARC Germplasm against *Fusarium oxysporum f.sp. cubense.*

3.1.4	Discoloration between 1/3 -2/3 of corm vascular tissue	Moderately Susceptible (MS)
4.1-5	Discoloration greater than 2/3 of corm vascular tissue	Susceptible (S)
5.1.6	Total discoloration of corm vascular tissue	Highly Susceptible (HS)

Evaluation of the reaction of abaca germplasm to FOC

To evaluate the reaction of abaca germplasm to FOC, a macro plot (84 m^2) was constructed in the field with hollow blocks as borders (Fig. 2). Screening was done by batches due to planting material and space limitations. One kg CMS culture of the fungus was added per sq. m. of the plot at planting time. Seedpieces of abaca that were screened were gathered from the NARC genebank and pre-germinated in pots. They were transplanted into the macro plot when they were approximately at three-leaf stage. Each batch of screening was done in 3 replications. At least 10 plants per variety per replication were planted. Inosa variety was used as the susceptible check for each batch of screening.

Cultural care like weeding, watering, fertilization and insecticide spraying were provided to all test plants in the field plot in each batch of screening.

Four batches of screening were done for the abaca accessions from the NARC Germplasm due to the bulk of materials tested, space limitation, and availability of planting materials. In the first batch of varieties evaluated, 20 accessions were entered including Inosa variety as susceptible check. In this batch of screening, plenty of planting materials were available from the germplasm such that 30 sample plants were included per entry. Twenty-two accessions were included in the second batch of screening, and still with 30 plants per entry. Forty-eight accessions were entered into the third batch of screening since only few planting materials per entry were available from the germplasm, with only 10 entry plants per accession. During the fourth batch of screening, 41 accessions were included with ten entry plants per accession.

Observation was done within a 6-month period after planting. Disease scoring was done by measuring the percentage area of vascular discoloration

which was modified from the rating scale used by Pedrosa (1995) for bananas.

Percent area of vascular discoloration	Reaction
0	no infection/immune (I)
1-20	resistant (R)
21-40	moderately resistant (MR)
41-60	moderately susceptible (MS)
61-100	Susceptible (S)

Field evaluation of identified selected varieties

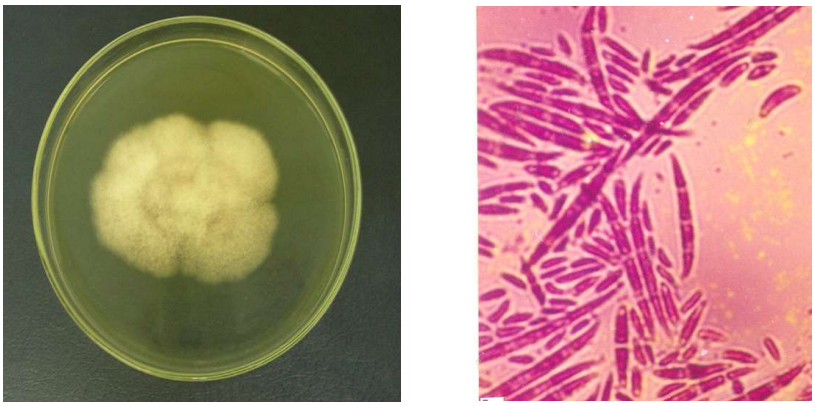
The identified resistant varieties during the macro plot screening were further tested with Inosa variety as the susceptible check under farmer's field condition in Polahongon, Mahaplag, Leyte where high natural incidence of fusarium wilt was observed. Three leaf-stage abaca seedlings were planted with 3 replications and 5 plants per replication. All necessary care such as weeding, fertilizing, watering and insect control was done whenever necessary.

RESULTS AND DISCUSSION

Collection and isolation of pathogen

Diseased specimens of abaca fusarium wilt that were collected from Polahongon, Mahaplag, Leyte that showed early stage of external foliage yellowing symptoms were used for pathogen isolation. Microscopic examination of the samples revealed the presence of FOC spores and mycelia on the affected tissues. Examination of the isolated pathogen confirmed the identity of the fungus based on cultural and morphological characters as described by Wardlaw (1972).

In PDA medium, mycelial growth of the fungus was extensive and cottony, whitish at first (Figure 3a) and often with tinge of pink or purple on the surface of the media, which became darker as the media aged. Conidia were hyaline and septated. Macro and micro conidia were both produced with the latter more numerous than the former (Figure 3b) .



A B

Figure 3. a) *Fusarium oxysporum f. sp. cubense* in culture plate showing whitish cottony mycelia and b) macroconidia and microconidia of the fungus

A B

Figure 4. a) *Fusarium oxysporum* f.sp. *cubense* inoculated plants showing the typical fusarium wilt external symptom, and b) internal vascular discoloration symptom.

Pathogenicity testing

Pathogenicity testing revealed an incubation period of 26-35 days before external manifestation of the disease was noticed. External symptom of fusarium wilt in abaca at its early stage showed a characteristic yellowing of the lower or outer leaf blades. This color develops along the margin and subsequently spread inward the midrib. Infected leaves wilts rapidly and the petiole buckles and breaks causing the leaf to hang down. The rapid buckling, withering and browning of the first affected leaf is followed by similar development in the remaining leaves (Fig. 4a). Similar observations were reported by Umali *et al*. (1956) and Roperos and Magnaye (1969). At the advanced stage of infection, the plant stands erect although already dead, eventually rots and topples down. Internal symptom consists of discoloration of the corm or vascular tissues, which appear as yellow, red or brownish streaks (Fig. 4b). The streak turns more reddish brown as infection advances. The red brownish streaks run through the vascular strands from the corm upward to the leaf sheaths and even to the petiole. When the infected plant is about to die, the corm and rhizome blackens and eventually decay.

Reaction of 8 recommended abaca varieties to fusarium wilt

The reaction of the 8 recommended abaca varieties to fusarium wilt is shown in Tables 1 and 2. When the FOC inoculum was applied prior to planting (Table 1), variety Linino showed a significantly lower percent infection (50%) compared to the rest of the varieties tested. In terms of foliage yellowing rating, Linino and Linawaan showed the least ratings which were significantly lower (rating of 2.0) than those of Inosa and Laylay (rating of 3.0), Linlib and Minenonga (rating of 2.67). In terms of vascular discoloration rating which is considered a more reliable parameter in measuring, Linawaan and Linino still showed the lowest rating (1.70) which were significantly lower than the rest of the varieties, indicating a resistant reaction of these two varieties to FOC. Lagwis and Putian showed moderately resistant reaction, Linlib and Inosa, a moderately susceptible reaction, and Laylay and Minenonga a susceptible reaction to FOC.

In the set up where the pathogen was applied 2 months after planting (Table 2), Linino consistently showed a resistant reaction in terms of percent infection and vascular discoloration rating. Linawaan and Putian were moderately resistant. Lagwis and Linlib were moderately susceptible, Laylay and Minenonga were still susceptible and Inosa was susceptible.

Table 1. Percent infection, foliage yellowing and internal vascular discoloration rating of 8 recommended abaca varieties inoculated with FOC prior to planting at four months after planting

Variety	% Infection[a]	Foliage Yellowing Rating [b]	Vascular Discoloration Rating [C]	Reaction
Inosa	83 ab	3.00 a	4.00 a	MS
Laylay	100 a	3.00 a	4.30 a	S
Linlib	100 a	2.67 ab	3.70 ab	MS
Minenonga	100 a	2.67 ab	4.70 a	S
Lagwis	83 ab	2.33 bc	3.00 ab	MR
Putian	83 ab	2.33 bc	3.00 ab	MR
Linawaan	83 ab	2.00 c	1.70 b	R
Linino	50 b	2.00 c	1.70 b	R
C.V.	23.90	16.62	29.4	

a Means followed by a common letter are not significantly different from each other at 5% level DMRT

Table 2. Percent infection, foliage yellowing and internal vascular discoloration rating of 8 recommended abaca varieties inoculated with FOC at two months after planting four months after planting

Variety	% Infection[a]	Foliage Yellowing Rating [b]	Vascular Discoloration Rating [C]	Reaction
Inosa	100 a	3.00 a	4.50 a	S
Laylay	100 a	3.00 a	4.17 ab	S
Linlib	50 b	2.33 ab	3.28 ab	MS
Minenonga	64 ab	1.67 b	4.33 a	S
Lagwis	100 a	2.33 ab	3.11 ab	MS
Putian	100 a	2.33 ab	2.28 ab	MR
Linawaan	100 a	2.00 b	2.28 ab	MR
Linino	50 b	2.33 ab	1.78 b	R
C.V.	17.3	16.62	29.40	

a Means followed by a common letter are not significantly different from each other at 5% level DMRT

Reaction of abaca germplasm to FOC

Four batches of screening were done for the abaca accessions from the NARC Germplasm due to the bulk of materials tested, space limitation, and availability of planting materials. The original rating scale used by Pedrosa (1995) was modified in that. Actual measurement of percentage area of vascular discoloration was the parameter used for evaluation and not visual

Table 3. Abaca cultivars included in the first batch of field plot screening listed according to their disease reaction to fusarium wilt [a]

Accession /Var No.	Common Name	Disease Rating (% area of Vascular Discoloration)	Reaction
M-139	Pakil No. 1	2.14	R
M-182	Canton Jamboree	31.34	MR
M-119	UP-USP-CAF No. 4	40.03	MR
M-238	Baguisan White	42.49	MS
M-126	Del MontePuti No. 2	44.22	MS
M-98	Bogtong	45.47	MS
M-281	Calbayognon	46.33	MS
M-114	Maguindanao White	49.81	MS
M-7	CES No. 3	50.11	MS
M-178	Lagwis No. 12	51.60	MS
M47	Laylay NO. 1	52.31	MS
M-125	Danganon	58.93	MS
M-40	Del Monte Pula	63.97	S
M372	Kiling (unknown)	65.81	S
M-117	(UP-USP-AF No. 1)	68.80	S
M-150	Laguis (Kilayan) No. 8	73.59	S
M-206	Davao	76.86	S
M-145	Cainti No. 1	78.44	S
M-374	Ihalas No. 2	84.79	S
VAR	Inosa (suceptible check)	64.36	S
C.V. (%)		21.30	

[a]Varietal Reaction Index

% Area of Vascular Discooloration	Reaction
0	Immune (I)
1-20	Resistant (R)
21-40	Moderately Resistant (MR)
41-60	Moderately Susceptible (MS)
61-100	Susceptible (S)

estimates as in the original Pedrosa's procedure. The modified procedure is thus more objective and easier to do.

In the first batch of varieties evaluated, 20 accessions were entered including Inosa variety as susceptible check. In this batch of screening, plenty of planting materials were available from the germplasm such that 30 sample plants were included per entry. The result is shown in Table 3. Accession NARC-M139 (Pakil # 1) showed the lowest area of vascular discoloration (2.14%) indicating a resistant (R) reaction to FOC. Two (2) accessions NARC-M182 (Canton Jamboree) and NARC-M119 (UP-USP-CAF # 4) were

Table 4. Abaca cultivars/accessions included in the second batch of field plot screening listed according to their disease reaction to fusarium wilt [a]

Accession /Var No.	Common Name	Disease Rating (% area of Vascular Discoloration)	Reaction
VAR	Lagwis	35.18	MR
NARC-M175	Inisarog	42.63	MS
NARC-M25	Binagakay	52.22	MS
VAR	Laylay	81.90	S
NARC-M16	Korokotohan	66.34	S
NARC-M58	Linino # 01	69.29	S
NARC-M361	Kadaohan	69.33	S
NARC-M43	Guinabaki	72.80	S
NARC-M56	Alman # 02	72.83	S
BARC-M312	Lagwis # 17	73.70	S
NARC-M209	Putian # 06	74.37	S
NARC-M284	Bool # 1	75.03	S
NARC-M199	Inosa # 11	75.93	S
NARC-M27	Bagakayon Kidit	76.16	S
NARC-M46	Baunan # 01	79.39	S
NARC-M35	Canarahon	81.71	S
NARC-M309	Libutanay # 11	81.77	S
NARC-M52	Minenonga # 2	82.68	S
NARC-M317	Inosa # 17	82.75	S
NARC-M79	Laylay # 2	82.98	S
NARC-M169	Inosa # 9	84.50	S
NARC-M374	Ihalas # 2	91.39	S
C.V.(%)		19.50	

[a] Varietal Reaction Index

% Area of Vascular Discoloration	Reaction
1	Immune (I)
1-21	Resistant (R)
21-41	Moderately Resistant (MR)
41-61	Moderately Susceptible (MS)
61-100	Susceptible (S)

moderately resistant. Eleven of the accessions were moderately susceptible while eight were susceptible.

Twenty-two accessions were included in the second batch of screening, and still with 30 plants per entry. None of the accessions showed a resistant reaction to FOC and only one (Lagwis) showed a moderately resistant reaction. Two were moderately susceptible namely: NARC-M175 (Inisarog) and NARC-M25 (Binagakay) while the majority were susceptible including three Inosa accessions (Table 4).

Table 5. Abaca cultivars/accessions included in the third batch of field plot screening listed according to their disease reaction to fusarium wilt [a]

Accession No.	Common Name	Disease Rating (% area of Vascular Discoloration)	Reaction
NARC-M129	Alman # 2	3.08	R
NARC-M215	Alman # 4	8.18	R
NARC-M131	Tinawagan Puti # 2	13.76	R
NARC-M51	Linawaan # 2	22.28	MR
NARC-M256	Musa Balbito x NARC-M110 Agutay # 2	27.57	MR
NARC-M241	Abuab # 2	28.16	MR
NARC-M234	Caraycayon	33.53	MR
NARC-M19	Bulao-luno	40.39	MR
NARC-M166	Itihenbalod	46.37	MS
NARC-M10	Binangongoran	47.95	MS
NARC-M332	Wild # 14	50.86	MS
NARC-M252	Tangongon x Linawaan x Maguindanao	51.53	MS
NARC-M60	Linlib # 2	53.35	MS
NARC-M235	Samoro	55.07	MS
NARC-M232	Guinabaki # 1	58.72	MS
NARC-M184	Minsog # 2	60.38	MS
NARC-M249	Balonan	60.89	S
NARC-M190	Laguis (Natural)	61.01	S
NARC-M220	Putian (Dagami)	61.10	S
NARC-M137	Soglin # 2	61.79	S
NARC-M187	Bulao # 3	67.45	S
NARC-M247	Hinagikhik	67.61	S
NARC-M146	Lagwis Pula # 2	76.10	S
NARC-M39	Amokid	76.56	S
NARC-M222	Libutanay	76.88	S
NARC-M197	Naglawaan	77.83	S
NARC-M317	Inosa # 15	79.51	S
NARC-M355	Wild # 16	80.06	S
NARC-M163	Luno-luno # 2	82.00	S
NARC-M307	Cambanog	85.43	S
NARC-M167	Inosa # 8	85.50	S
NARC-M236	Semelia	86.11	S
NARC-M224	Lawisig	86.81	S
NARC-M138	Itesog # 2	87.11	S
NARC-M158	Lagurhuan # 4	87.35	S

Continuation.....Table 5

NARC-M57	Layahon # 2	87.38	S
NARC-M303	Inosa # 13	89.58	S
NARC-M311	Bitanhuan	91.22	S
NARC-M8	San Bangui	92.22	S
NARC-M227	Putomag # 22	93.75	S
NARC-M237	Sabunaa (White)	96.53	S
NARC-M358	Napagasan	97.14	S
NARC-M297	Pulangbato	92.20	S
NARC-M144	Wild # 6	98.27	S
NARC-M359	Putian # 12	100.00	S
NARC-M34	Inosa # 01	100.00	S
NARC-M322	Wild # 13	100.00	S
NARC-M310	Wild # 11	100.00	S
C.V.(%)		28.50	

Forty-eight accessions were entered into the third batch of screening since only few planting materials per entry were available from the germplasm, with only 10 plants per accession. Three accessions showed resistance to fusarium wilt, namely NARC-M129 (Alman # 2), NARC-M215 (Alman # 4) and NARC-M131 (Tinawagan Puti # 2). Four accessions were moderately resistant, namely: NARC-M51 (Linawaan # 2), NARC-M241 (Abuab # 2) and NARC-M234 (Caraycayon). Nine were moderately susceptible and majority, (33 out of 49) were susceptible including four Inosa accessions (Table 5).

During the fourth batch of screening, 41 accessions were included with 10 plants per accession. Pacol and Linino and NARC-M3 (cross between CES and PACOL) showed resistance to fusarium wilt. No accession was moderately resistant, 18 were moderately susceptible and 21 were susceptible, including one Inosa accession (Table 6). Twenty-four accessions were included during the last batch of screening including NARC-M139 or Pakil.which was proven resistant during the first batch of screening. Still it showed resistance (Table 7). Ten more accessions showed resistance to FOC, which include:

NARC-M370 or Putian #. 13, NARC-M076 or Minsog # 1, NARC-M029 or Layahon #1, NARC-M023 or Agutayon, NARC-M053 or Putian # 1, NARC-M024 or Magsarapong, NARC-M037 or Linawaan x Tangongon, NARC-M071 or Minorado, NARC-M030 or Sairaya and NARC-M061 or Linawaan # 3. Three were moderately resistant, namely: NARC-M028 or Samina, NARC-M055 or Itesog # 1 and NARC-M258 or Senorita. The remaining 10 were all susceptible.

Table 6. Abaca cultivars/accessions included in the 4th batch of screening using the field plot screening technique against FOC according to varietal reaction to Fusarium wilt disease

Accession No.	Common Name	Disease Rating (% area of Vascular Discoloration)	Reaction
VAR	PACOL	15.11	R
VAR	LININO	17.49	R
NARC-M3	CES X PACOL	17.61	R
NARC-M75	WILD # 1	40.90	MS
NARC-M9	JAVAQUE # 1	42.73	MS
NARC-M161	LAGWIS # 5	44.21	MS
NARC-M216	MAG-ASO # 2	44.61	MS
NARC-M38	CASILIHON	46.01	MS
NARC-M211	LIBUTANAY	46.43	MS
NARC-M80	MALANICERON	47.53	MS
NARC-M132	BINONGONGORAN # 2	48.37	MS
NARC-M174	JAVAQUE # 2	48.86	MS
NARC-M148	BISAYA	51.22	MS
NARC-M128	CANTON FARM MACHINERY # 2	51.62	MS
NARC-M14	LAGWIS	52.12	MS
NARC-M4	UGARUM	52.53	MS
NARC-M151	LIBUTANAY # 2	54.08	MS
NARC-M78	SOGLIN # 1	58.06	MS
NARC-M53	PUTIAN # 1	58.32	MS
NARC-M186	LAUSMAG	59.25	MS
NARC-M130	PACOL X CES II-2	59.54	MS
NARC-M33	LUNHAN	60.77	S
NARC-M185	CANYON ECOGAR	61.85	S
NARC-M20	PUTI # 1	62.52	S
NARC-M36	SUGMAD PULA	63.32	S
NARC-M72	LAGWIS # 2	66.12	S
NARC-M253	TANGONGON X BONGOLANON # 22	67.64	S
NARC-M227	PUTOMAG # 22	68.64	S
NARC-M360		68.69	S
NARC-M12	DEL MONTE PUTI # 1	71.20	S
NARC-M164	LINAWAAN # 4	71.44	S
NARC-M1	TANGONGON # 1	75.19	S
NARC-M231	GOA-X	77.42	S
NARC-M168	BAUNAN #. 1	78.89	S
NARC-M6	GAES # 1	81.85	S

Continuation.....Table 6

NARC-M62	SINAMORO	81.87	S
NARC-M194	BANIAS	85.90	S
NARC-M226	PACOL X ABACA HYBRID	86.61	S
NARC-M77	LAGURSOG	87.94	S
NARC-M92	INOSA # 3	89.78	S
NARC-M93	LAYLAY #3	92.99	S
C.V.(%)		26.00	

Field evaluation of selected resistant varieties

Among the identified resistant accessions from the NARC Germplasm, only 4 were further evaluated in the field due to the unavailability of planting materials of the other resistant lines during the conduct of the study. The 4 resistant lines include NARC-M215 (Alman # 4), NARC-M131 (Tinawagan Puti # 2), NARC-M139 (Pakil # 1) and Linino. The 4 resistant lines plus Inosa (susceptible check) were planted at a naturally infested field at Polahongon, Mahaplag, Leyte. Results showed that all the 4 accessions/variety were proven resistant under field condition. Their disease ratings were 2.27%, 0.10%, 0.04% and 0.03% for Alman # 4, Tinawagan Puti # 2, Pakil # 1 and Linino, respectively which were significantly lower than that of Inosa which was 69.6% (Table 8).

The 4 varieties/accessions which were proven resistant to fusarium wilt both in an inoculated experiment and under a naturally infested farmer's field are therefore good to use especially in areas which are heavily infested with FOC. In banana for example, the widespread deployment of fusarium wilt-resistant clones in 1960s put to a stop the epidemics in Gros Michel (Stover and Buddenhagen, 1986). Banana cultivars such as FHIA 01 or "Gold finger" and FHIA 18 also controlled FOC in Australia (Moore *et al.* 2001).

CONCLUSION

Among the 8 recommended abaca varieties, Linino showed resistance to fusarium wilt caused by *Fusarium oxysporum f.sp. cubense* in the pot experiment, filed plot screening and field evaluation. Six other accessions from the NARC germplasm and production area namely: Alman # 2, Alman # 4, Tinawagan Puti # 2, Pacol CES x Pacol and Pakil # 1 also showed resistance

Table 7. Abaca cultivars/accessions included in the last batch of screening for resistance to fusarium wilt using the field plot screening technique according to varietal reaction to fusarium wilt[a]

Accession No.	Common Name	Disease Rating (% area of Vascular Discoloration)	Reaction
NARC-M139	Pakil (Resistant check)	0.50	R
NARC-M370	Putian # 13	0.60	R
NARC-M076	Minsog # 1	0.90	R
NARC-M029	Layahon # 1	1.00	R
NARC-M023	Agutayon	1.20	R
NARC-M053	Putian # 1	1.60	R
NARC-M024	Magsarapong	3.10	R
NARC-M037	Linawaan x Tangongon	8.90	R
NARC-M071	Minorado	9.40	R
NARC-M030	Sairaya	13.00	R
NARC-M061	Linawaan # 3	14.80	R
NARC-M028	Samina	20.20	MR
NARC-M055	Itesog #. 1	27.40	MR
NARC-M258	Señorita	37.10	MR
NARC-M054	Inosa # 2	73.50	S
NARC-M074	Tangongon # 2	74.80	S
NARC-M017	Bongotsanon	76.60	S
NARC-M237	Maguindanao x Inosa # 2	85.40	S
NARC-M069	Libutonay # 2	91.20	S
NARC-M159	Inosa # 6	93.90	S
NARC-M068	Bulao # 1	99.40	S
NARC-M070	Minenonga # 3	100.00	S
NARC-M144	Wild # 6	100.00	S
NARC-M317	Inosa # 15	100.00	S
C.V.		37.1%	

[a]Varietal Reaction Index

% Area of Vascular Discoloration	Reaction
0	Immune (I)
1.22	Resistant (R)
21.42	Moderately Resistant (MR)
41.62	Moderately Susceptible (MS)
61-100	Susceptible

Table 8. Farmer's field verification trial of four identified resistant abaca varieties conducted at Polahongon, Mahaplag Leyte

Common Name	Disease Rating	Reaction
Inosa (susceptible check)	69.60 a	S
Alman # 4	2.27 b	R
Tinawagan Puti # 2	0.03 b	R
Pakil # 1	0.04 b	R
Linino	0.03 b	R
C.V.	37.0%	

to fusarium wilt in the field plot screening. Of the 6 accessions, Alman # 4, Tinawagan Puti # 2, Linino and Pakil # 1 were proven resistant in the field evaluation.

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