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Development of a management strategy forBean root rot in southwestern Uganda

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Abstract

Bean root rot was first noted in Southwestern Uganda many years ago according to the people in the area but it wasn't until early 1990's when its destruction became apparent. The disease is now the most important disease affecting beans in this area. It has resulted in total destruction of the crop during favourable weather conditions for the disease. It was therefore important that a management strategy for the disease be developed so that the bean production in the area could be revitalized. Several management options were tested singly and in combination on farmers' fields to select that which could reduce the effect of this disease. Six varieties of beans were selected as best at tolerating the disease. However the disease was better controlled when tolerant varieties were combined with soil amendment methods such as applying farmyard manure, inorganic fertilizer and green manure. The combination that gave the lowest disease incidence and severity was that involving tolerant varieties, farm yard manure, intercropping (with maize and sorghum) and earthing up.

Introduction

Bean root rot is the most most important disease affecting beans in Southwestern Uganda (Opio et al 2000). The disease was first noted in the area many years ago according to the people in the area but is wasn't until early 1990's when its destruction became apparent. The severity increased until about 1994/1995 when it reached epidermic level. Production of beans in the area has declined from being 30% of the country's production in 1990 (MAAIF, 1992), to 25% in 1994 and less than 20% in 1995 (MAAIF, 1997). The production is still declining. This decline is mostly attributed to the root rot disease and yet beans is regarded as one of the most important crop in the area. This disease has been observed to be serious in Burundi, Central and Western Kenya and Rwanda in addition to Uganda. Conditions under which the disease is observed are similar. These are mainly highland areas with intensive bean cultivation and declining soil fertility (CIAT, 1992).

In South Western Uganda, root rot is primarily caused by mainly *Pythium spp, Fusarium solani* and *Rhizoctonia solani* (Opio et al 2000). The root rot pathogens attack the beans at all stages but the most serious attack is that by *Pythium spp* which occurs at seedling stage and results in dumping off. In such case there is total loss, of the crop. Other above ground symptoms of the disease are yellowing, stunted growth and wilting of the plant.

There are several control measures that have been suggested (Buruchara and Rusuku, 1992, CIAT 1992, 1993). It has been pointed out that the ability of the bean crop to tolerate root rots is related to the level of resistance of the variety the soil nutrient supply and the environmental conditions. With high soil fertility, bean grows vigorously and tolerates root rot infections (Otsyula and Ajanga, 1994). Application of fertilizers or readily decomposed organic manures have been shown to improve crop tolerance to root rots (CIAT, 1992, Mutitu et al 1985 and 1998). Addition of fertilizer or organic manures may affect the pathogens either directly or indirectly, e.g through attack of root rot pathogens by soil micro-organisms or competition for some essential substrate; (Mutitu et al 1995, Pyndji 1996). The effectiveness of cultural practices such as planting on ridges and hilling have been demonstrated in Rwanda (Buruchara 1991, Buruchara and Rusuku 1992). Proper use of fungicides results in effective control. Varietal tolerance, expressed as ability to produce adventitious roots and recover from attack, and resistance expressed as low levels of infection has been found in bean germplasm (CIAT, 1992 and 1993).

With the information available on root rot management and drawing on the experiences in Rwanda and Western Kenya an adaptive research programme was initiated in 1996 in South Western Uganda to develop an integrated management strategy for bean root rots in this area. The results obtained between 1996 to 1997 were reported earlier (Opio et al, 2001). This paper concentrates on the strategy developed keeping in mind the work reported earlier.

This work was carried out in Kisoro district on farmers fields. Before commencement of the study a survey was carried out to determine the incidence, severity and distribution of the disease. It was found that over 90% of the plants sampled were affected, by root rot and the disease occurred throughout the district. Therefore two subcounties (Nyondo and Busanza) were randomly selected for this work. Only fields which had previsouly had severe infection of root rots were used.

Objectives

The main objectives of this study were:

1. To identify resistant or tolerant varieties which are acceptable to farmers and consumers.
2. To evaluate the different inorganic and organic amendments (green and farm yard) in controlling bean root rots
3. To determine which cultural control measures can reduce the root rot.
4. To determine the combination of organic amendments, cultural practices and resistant varieties that are effective in controlling root rots and stem maggots.
5. At the end develop an integrated control strategy for controlling both the root rots and stem maggots in South Western Uganda.

Materials and methods

Evaluation of organic amendments and cultural practices

Evaluation of organic amendments and other cultural practices in controlling root rot was carried out in 1997 for two seasons (1997A & B). The trial was set up on ten and twelve farmers' fields in Kisoro district in 1997A and 1997B respectively.

In 1997A treatments included use of:

(a) *Calliandra/sesbania* as green manures (at a rate of 10 tons per hectare)
(b) *Acanthus sp* as green manure (10 tons per hactare)
(c) Inorganic fertilizer (NPK) (125 kg/hactare)
(d) Planting on ridges
(e) Earthing up
(f) Seed treatment with a combination of fungicide (Benlate) and insecticide (endosulfan) (Benlate at 28g per kg of seed)
(g) Application of farmyard manure (10 tons per ha)
(h) Control where no treatment was applied

In 1997B the treatments included those above (a-h) but in addition the following treatments were included:
(i) Treatment with fungicide (Benlate) alone
(ii) Treatment with insecticide (Endosulfan) alone

Data on root rot severity was assessed at 3 weeks after planting flowering and pod filling stage. The International Centre for Ttropical Agriculture based in Cali, Colombia (CIAT) 1-9 scale was used (where 1 indicates no visible symptoms and 9 represents 75% or more of the hypocotyl and root tissue with lesions and advanced decay). Five plants were used for assessment of severity at each time of assessment. The incidence was taken as percentage number of plants affected using a $1m^2$ quadrat. In each quadrat the total number of plants were counted and the number affected determined.

Genotype evaluation for resistance to root rots

In 1996B season one hundred locally grown bean cultivars in Uganda and twenty two introductions previsouly identified as resistant in Rwanda were evaluated on ten farmers fields in 1996. Single row plots, 3m in length were sown with one replicate per farm. K132, a well adapted but susceptible calima type variety was sown after every ten rows to account for variation in disease severity throughout the fields.

In 1997A and 1997B seasons only the twenty introductions were tested on eighteen farmers fields. All the 100 local cultivars were severely affected in 1996 and were therefore not included in 1997. The varieties were planted in a completely randomized design with two replicates on each farm. Double row plots each 2m in length were used. Records were taken as described for organic amendments.

Determination of a combination of variety and organic amendments that can control root rots

In 1998A season the most resistant varieties and the organic amendments that gave the lowest incidence were combined to determine the best control for root rots.

Two separate experiments were set up for bush and climbing beans. The bush beans selected included RWR 719, MLB 49/89A and RWR 1092. The climbing genotypes included Vuninkingi, Umubano and Flora. The soil amendments included farm yard manure, Calliandra, Acanthus, Inorganic fertilizer (NPK), dressing with both fungicide and insecticide and control. The design was a split plot design with varieties in main plots and soil amendments in sub-plots. The same experiment was repeated in 1998B except that RWR 1092 was replaced by MLB 40/89A in 1998B. This work was on 18 farmers' fields.

Combination of variety, organic/inorganic amendments and cultural practices that can control root

In 1999/2000 the combination of resistant varieties and soil amendments that gave the lowest incidence and severity of root rot and highest yield in 1998A and B were combined with known cultural practices in Kisoro. Two experiments were set up involving bush beans and climbing beans.

(i) The experiment involving climbing beans included a combination of one of the two resistant varieties (Vuninkingi or Umubano) and three soil amendments namely acanthus, farm yard manure and inorganic fertilizer (NPK and SSP). Each combination of the resistant variety and soil amendment was combined with earthing up. The treatments are shown in Table 1.

Table 1: Climbing bean root rot integrated trial using different management practices

VARIETY	REP I	REP II
VUNINKINGI	FYM	CONTROL
	ACATH	FYM + EU
	FERTZ	ACANTH + EU
	CONTROL	FERTZ + EU
	FYM + EU	ACANTH
	ACANTH + EU	FYM
	FERTZ + EU	FERTZ
UMUBANO	CONTROL	ACANTH + EU
	ACANTH + EU	FYM + EU
	FYM + EU	FERTZ + EU
	FERTZ + EU	CONTROL
	ACANTH	FYM
	FYM	FERTZ
	FERTZ	ACANTH

N.B: FERTZ = Fertilizer, FYM = Famyard manure, ACANTH = Acanthus; EU = earthing up

(ii) The experiment involving bush beans was slightly modified. In addition to earthing up, intercropping was also used. This is because in Kisoro bush beans are planted as an intercrop with maize and sorghum. The treatments are shown in Table 2.

A randomized complete block design in a split plot arrangement was used for both experiments. Bean varieties were in main plots and management practices in sub-plots. In total the two experiments were planted on 22 farmers' fields in two sub-counties of Kisoro (Busanza and Nyondo). Records were taken on disease (root rot) incidence and severity at V4 and R6. Incidence was taken as percentage number of plants affected per plot and severity assessed using a CIAT 1-9 scale of the three major root rot pathogens (*Pythium sp., Fusarium sp. And Rhizoctonia sp).*

Table 2: Bush bean integrated root rot/stem maggot management trials

VARIETY	REP I	REP II
RWR 719	FYM + IC + EU	ACANTH
	ACATH + IC + EU	FERTZ
	FERTZ + IC + EU	FYM
	CONTROL	FERTZ + EU
	ACANTH	ACANTH + EU
	FERTZ	FYM + EU
	FYM	CONTROL
	FERTZ + EU	ACANTH + IC + EU
	FYM + EU	FERTZ + IC + EU
	ACANTH + EU	FYM + IC + EU
MLB 49-89A	FYM	FERTZ + EU
	ACANTH	FYM + EU
	FERTZ	ACANTH + EU
	ACANTH + IC + EU	CONTROL
	FYM + IC + EU	FERTZ
	FERTZ + IC + EU	ACANTH
	CONTROL	FYM
	FYM + EU	FERTA + IC + EU
	ACANTH + E	FYM + IC + EU
	FERTZ + EU	ACANTH + IC + EU

FERTZ = Fertilizer, FYM = Farm yard Manure, ACANTH = Acanthus EU = earthing; IC = intercrop.

Results

Evaluation of soil amendments seed dressing and cultural practices

Root rot severity was high and similar for all treatments involving soil amendments when the disease inoculum was high and a susceptible variety was used. The incidence of the root rot was 100% for all the treatments except treatments that had fungicide (Benlate) applied. The root rot incidence for this treatment was 50-70% but the plants were not vigorous.

Application of farm yard manure (FYM) was the most effective in improving crop tolerance as indicated by plant survival and grain yield (Fig. 1). FYM was followed by inorganic fertilizer (NPK), a combination of fungicide and insecticide, Calliandra/sesbania and Acanthus respectively. The other management practices reduced the root rot but the number of plants that died at 3 weeks was more than 60%.

Application of farm yard manure and NPK were of similar effectiveness in improving crop yield. The fungicides reduced the disease attack but the surviving plants looked malnourished and the resulting yield was low compared to FYM and NPK. This indicates that in addition to the root rot, the soil nutrient problem enhanced the problem in this area. This called for more studies to understand the effect of different levels of nutrients on root rots which is now being carried out.

Genotype evaluation for root rot resistance

There were significant differences between varieties (Fig. 2) for number of plants dead at V4. The disease level was low in 1997A as compared to 1997B. The varieties with the least plant loss included RWR 719, Vuninkingi, G 2333, RWR 1092, Flora, MLB 49-89A. These were combined with the soil amendments that

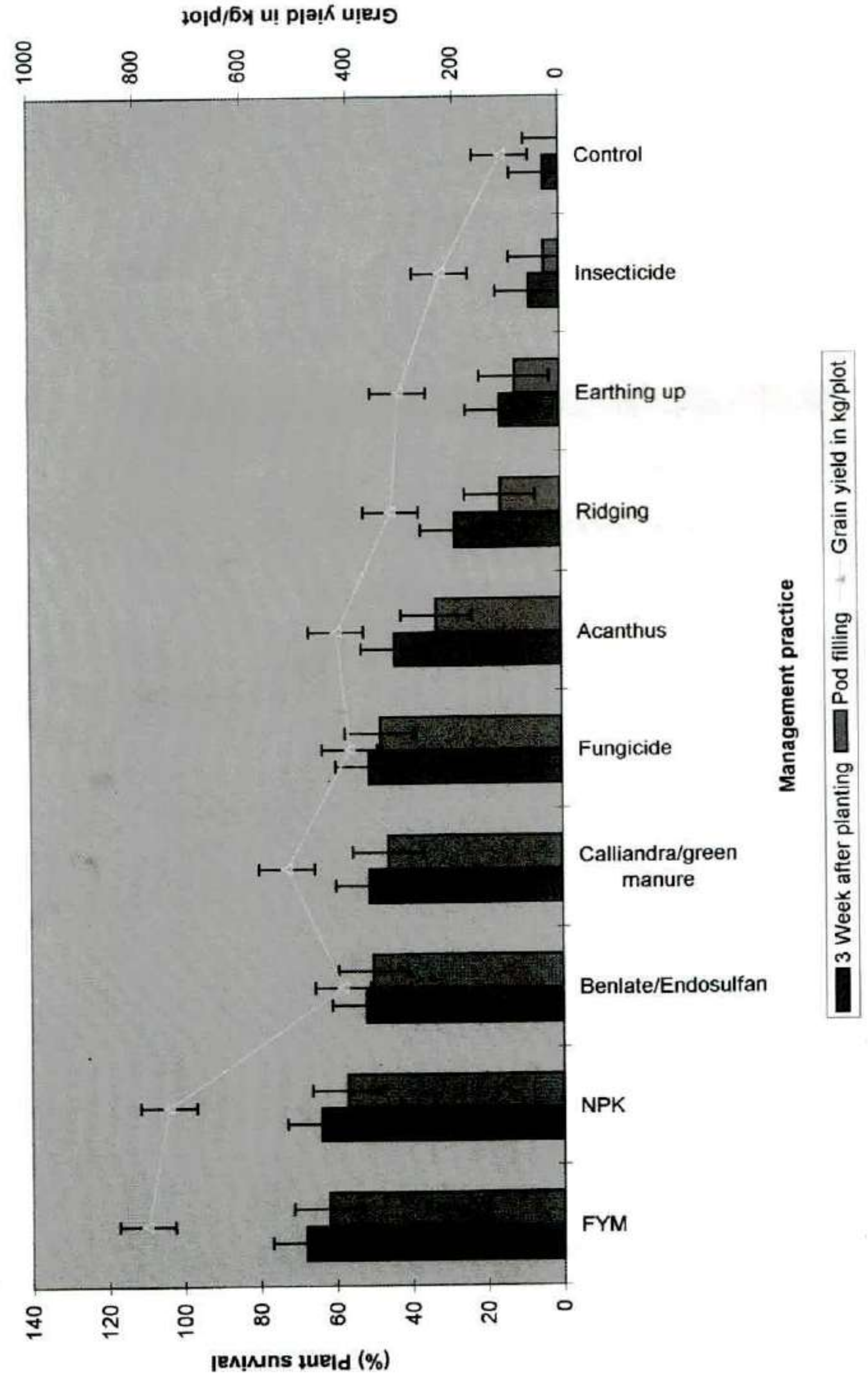
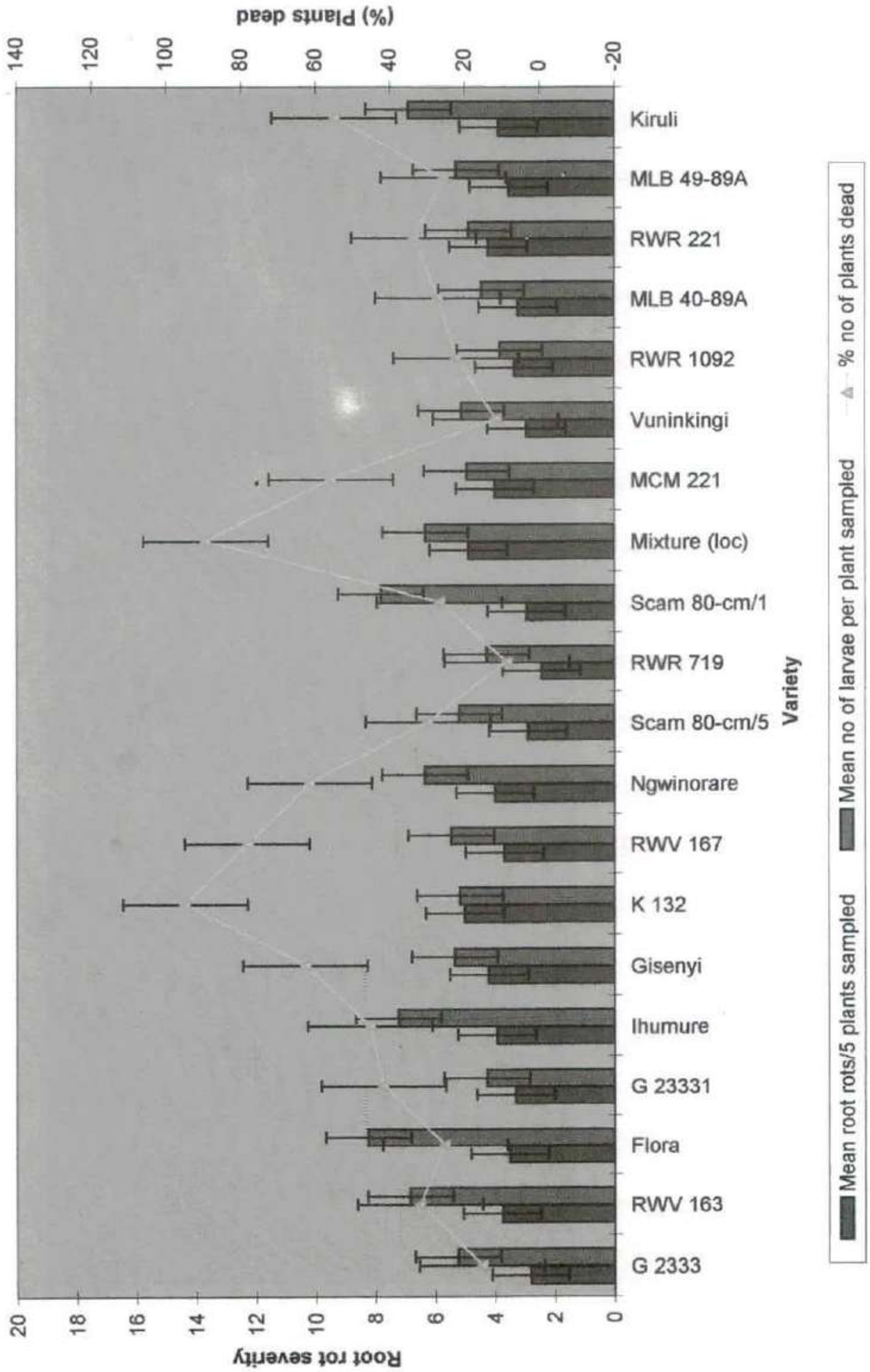


Fig. 1. The effect of different soil amendments and cultural practices on root rots in Kisoro district (mean of two seasons).

gave the highest yield in 1998 to determine the combination that gives the lowest incidence of root rot.

Combination of varieties and organic amendments
For both 1998A and 1998B the disease level was generally low for all treatments. This may have been due to the low rainfall and also tolerant varieties used. For both bush and climbing beans, a combination of farmyard manure and any of the varieties gave the best control of the disease in both seasons for that variety. Figures 3-5 summarises the results. The highest yield for climbing bean was with Vuninkingi (2.4 tons/ha)

Fig. 2. The incidence of root rot and stem maggot for different bean genotypes in 1997 B at V4.



followed by G 2333 (2.0 tons/ha) and Flora (1.8 tons/ha) when combined with farm yard manure. This was followed by inorganic fertilizer.

For bush beans RWR 719 gave the highest yield followed by MLB 49/89 and RWR 1092 respectively. There was no significant difference between FYM and inorganic fertilizer in yield. However these two were significantly different from Calliandra, Acanthus and control.

In 1998B still RWR 719 had the lowest disease severity and highest plant survival followed by MLB 49/89A and MLB 40/89A for the bush beans. For the climbers the results were similar to 1998A.

There was significant genotype by soil amendment interaction indicating that given tolerant varieties and improved soils, the root rot severity can be reduced. In addition where earthing up was applied there was increased adventious root development and better yield.

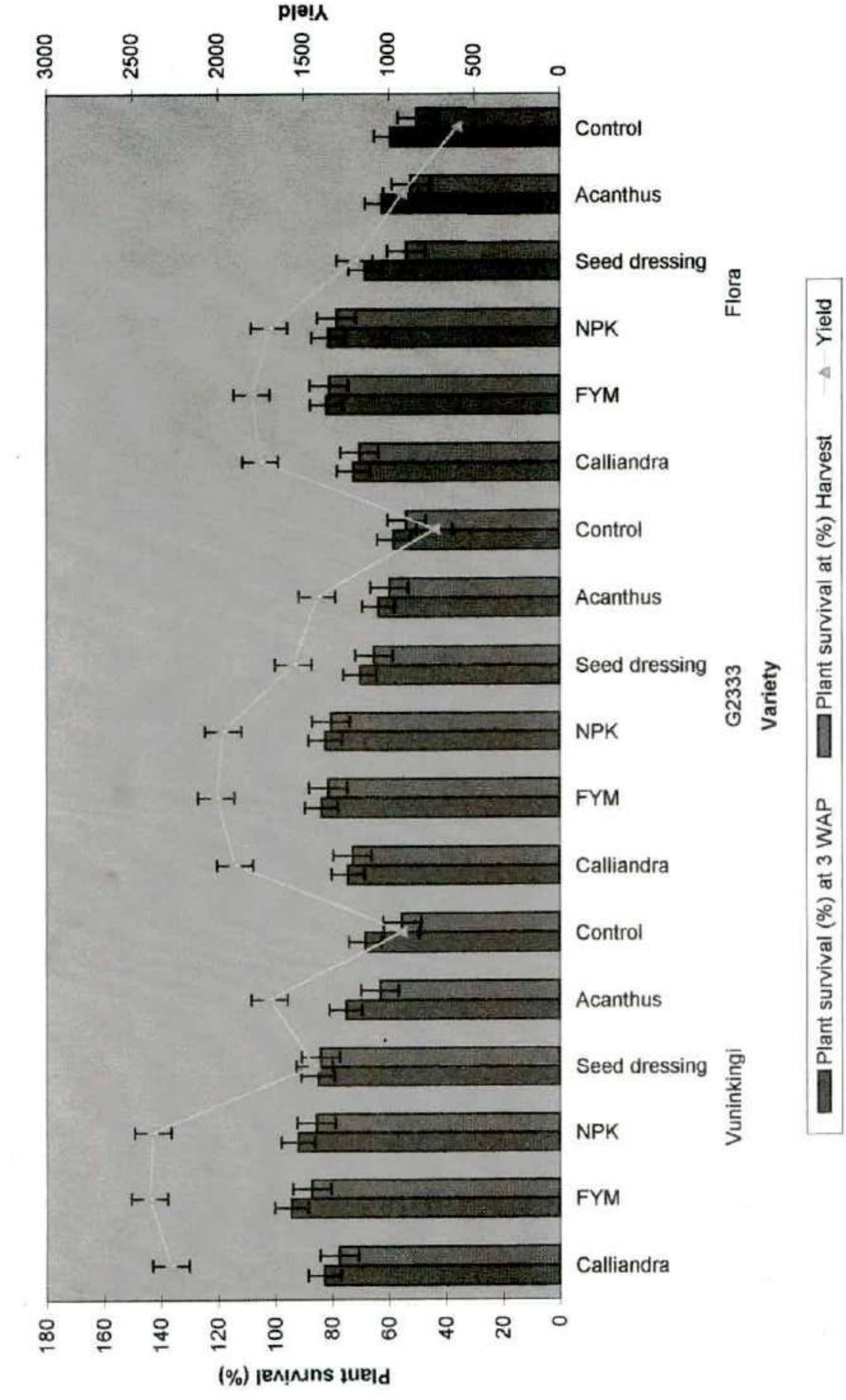
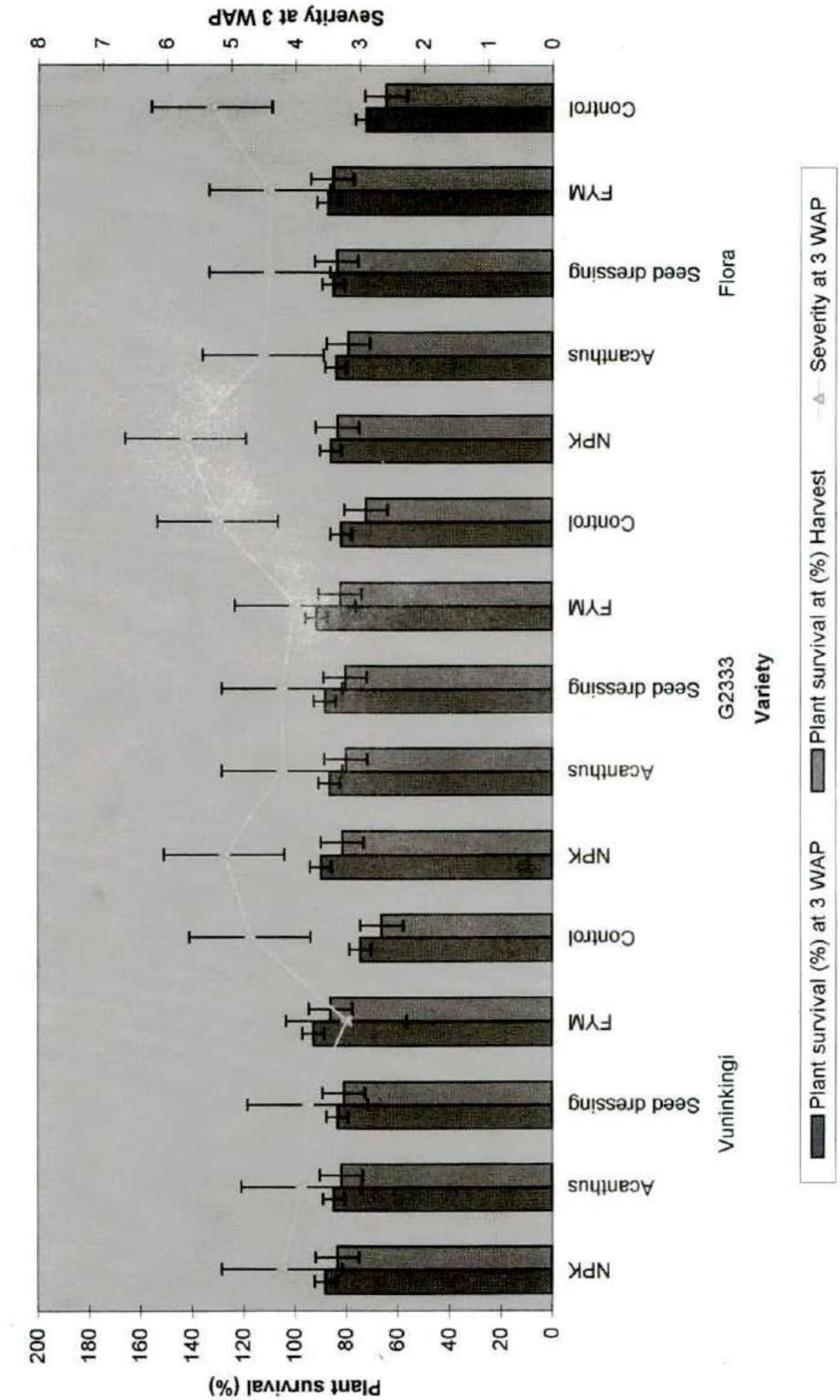


Fig. 3. Reaction of 3 climbing bean varieties (Vuninkingi, G 2333 and Flora when combined with different organic amendments in 1998A.

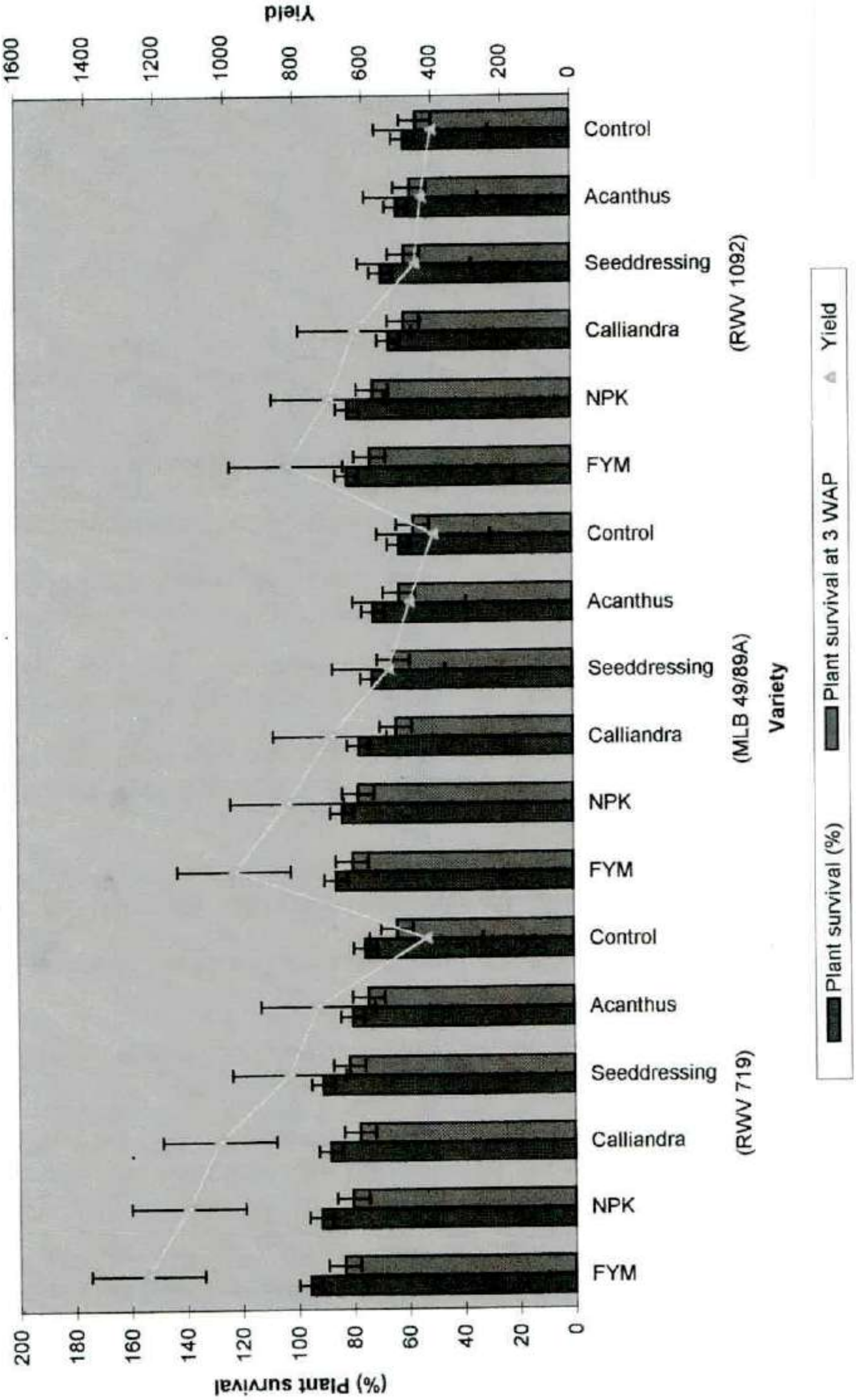
Fig. 4. Reaction of 3 climbing bean varieties (Vuninkingi, G 2333 and Flora when combined with different organic amendments in 1998B.



Combination of resistant/tolerant variety, organic/ inorganic amendements and cultural practices that can control root rot

Tables 3 and 4 shows the effect of the different treatments on the severity of the root rots caused by the different organisms for the three varieties (Vuninkingi and MLB 49-89A). For climbing beans treatments that had a combination of soil amendments and earthing up generally gave lower disease severity than those that had soil amendments alone. For bush beans it was found (during both seasons 1999B and 2000A) that combining soil amendments, earthing up and intercropping gave much lower disease severity than either a combination soil amendments and earthing up or soil amendments

Fig. 5. Reaction of 3 bush beans varieties when combined with different organic amendments.



alone. This was true for both RWR 719 and MLB 49-89A. There were significant difference between treatments with either a combination of farm yard manure, earthing up and intercropping or acanthus, earthing up and intercrop giving the lowest disease severity. However there was no significant difference between the two treatments indicating that any of the combination could be used for the control of the root rots.

Discussion and conclusion

Several genotype with resistance to the root rot complex in South Western Uganda were identified. Several management practices including combination of tolerant varieties, soil amendments and cultural practices were identified with the farmers. The genotypes identified are mainly small seeded genotypes and yet the farmers prefer large seeded types. The only medium seeded types amongst these are black seeded. There is therefore need to sensitize the farmers on advantages of these bean types of seed vis-a-vi the large seed types which are acceptable but susceptible to the root rot. Farmers who have participated in this research and those in surrounding areas have adopted these varieties but when it is not very wet, they revert back to the large seeded types. There is one sugar bean which is a climbing type which is acceptable in the area. This means that more work need to be done on incorporation of resistance in acceptable seed types.

Improving soil fertility through application of farm yard manure, green manure or fertilizer is acceptable but they also have problems. Given the hilly nature of the area, farmers find it difficult to carry manure up or down the hills. The inorganic fertilizer is too expensive and they can't afford. The comprise has been to use green manures where the legumenous trees e.g calliandra and or sesbania are grown along bands in

Table 3: The reaction of vuninkingi to root rot under different management practices on 10 farmers fields in 1999B

Treatment[2]	Mean severity[1]					
	Pythium		Fusarium		Rhizoctonia	
	R6	R8	R6	R8	R6	R8
1	3.37A	3.23BC	4.12AB	4.61AB	3.51A	2.57AB
2	3.40A	2.83C	4.44AB	4.03B	3.75A	2.25B
3	3.44A	3.23BC	4.86AB	4.38AB	3.76A	2.17A
4	3.48A	4.47A	5.87A	5.17A	3.90A	3.02B
5	3.64A	3.5BC	4.94AB	4.85AB	3.84A	2.45B
6	3.72A	3.18BC	4.99AB	4.68AB	3.80A	2.5B
7	3.40A	3.83AB	4.92AB	4.93AB	3.59A	2.3B
CV	21.88	26.5	17.51	21.6	25.3	24.2
LSD	0.51	0.75	0.55	0.82	0.62	0.49

Treatments:
1 – Fertilizer + Earthing up
2 – FYM + Eearthing up
3 – Acanthus + Earthing up
4 – Control
5 – Fertilizer
6 – Farmyard manure
7 – Acanthus

Table 4: The reaction of MLB 49-89A to root rot under different management practices on 10 farms in Kisoro District in 1999B

Treatment[2]	Mean severity[1] Pythium		Fusarium		Rhizoctonia	
	R6	R8	R6	R8	R6	R8
1	3.7B	2.467ABC	3.7B	1.47CD	3.95ABC	3.47ABCD
2	3.65B	2.60AB	3.55AB	2.00ABD	4.50ABC	3.86AB
3	3.65B	2.93AB	3.80A	1.80BD	4.20ABC	3.27ABCD
4	4.85A	3.00A	5.10AB	2.50A	4.85A	4..20A
5	3.95AB	2.13CB	3.75B	2.27AB	3.95ABC	3.46ABCD
6	4.0AB	1.93D	2.95B	1.67BCD	4.25ABC	3.33ABCD
7	3.70AB	1.90CD	3.70B	1.80BC	4.20ABC	3.60ABC
8	3.60B	2.75B	2.65B	1.67BC	3.7BC	2.93BCD
9	3.60B	2.2BCD	2.90B	1.40CD	3.7BC	2.53CD
10	3.65B	1.25BCD	3.70B	1.07D	3.60B	2.33D
LSD at 5%	0.97	0.98	1.39	0.62	0.97	1.23
CV (%)	17.03	20.63	25.35	20.54	16.8	21.86

Treatments:
1 - Fertilizer + EU
2 - FYM + EU
3 - Acanthus + EU
4 - Control
5 - Fertilizer
6 - FYM
7 - Acanthus
8 - Fertilizer + EU + IC
9 - FYM + EU + IC
10 – Acanthus + EU + IC

the field then they just cut the leaves from along the plots and incorporate in the soil.

Intercropping was acceptable when bush beans are grown but not with climbing beans. Hilling and earthing up is an acceptable cultural practice in Kisoro district. Crop rotation could not be used effectively because the farmers had their own set rotation which was difficult to interfere with at that time. They also complained about their small land holdings which did not allow effective rotation. Therefore from the present work the most effective control strategy for controlling bean root rots in South Western Uganda was found to be the use of a combination of tolerant/resistant varieties, soil fertility amendment and earthing up. Intercropping can be used where bush beans are grown. However the farmers have to be given the chance to select which option to use in the soil fertility amendments.

What remains of this work on management is to scale it up so that farmers in South Western can be sensitized on the management strategy.

Future work

The work presented here was carried out as a response to farmers outcry and the need to get an immediate control to the disease. There is however need to understand more the root rot disease and pathogen complex associated with it. To have a very intensive breeding work to incorporate resistance into acceptable seed types. Therefore the Beans Programme at NAARI in collaboration with CIAT, and Horticultural research institute (U.K) has embarked on a study to:

a) To determine the pathogen variability of *Pythium* spp and *Fusarium* spp associated with root rots in Uganda (ie race identified using both conventional and molecular means) (not only South Western but in the whole country)
b) Map out the distribution of the different species identified
c) Study the epidemiology of the disease
d) Determine the interaction of the pathogens causing root rot
e) Determine management options which are appropriate to the resource –poor farmers given the findings from the above study and if need be fine tune on the already developed
f) The CIAT breeder had in 1999/2000 made crosses between the acceptable seed types and resistant genotypes. Segregating population will also be evaluated on the farmers fields so that farmers can select those resistant types with qualities which they prefer. The breeder at NAARI to continue on the crosses to improve on acceptable varieties not only for seed types but for other market qualities.
g) Select varieties acceptable to farmers
h) Complete on the study on understanding the effect of different levels of nutrients on root rots which already commenced in 2000/2001
i) Scale out on disseminated on the strategy developed

There are 2 PhD students and one Masters student on this project.

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