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FOREWORD

This issue of CARDI Review (Issue 8) and the issue before this one (Issue 7) are somewhat different from earlier issues in that a considerable number of hard (paper) copies were printed. CARDI Review is primarily an electronic publication available through the CARDI website (www.cardi.org), but a few hard copies are made for distribution to our main stakeholders.

However, for Issues 7 and 8, funding was obtained from CTA (EU/ACP Technical Centre for Agricultural and Rural Cooperation) to print the extra hard copies; the object of this is to make CARDI Review available to more stakeholders and those who may not regularly visit CARDI's website. We are very pleased to acknowledge this support from CTA which is improving the availability of CARDI Review.

Besides increasing availability of CARDI Review, a decision has been taken to widen the contributor base. So in future issues we will be inviting submissions not only from CARDI staff, but also from any other authors who may have some completed research work, which will help to increase food and nutrition security in the CARICOM region.

Therefore, I am inviting submission of articles from any author who wishes to publish relevant work in CARDI Review. Articles submitted to CARDI Review are subject to a peer review as part of the publication process. The editorial guidelines on page 22 indicate the format to be followed when submitting an article.

F B Lauckner
Editor, CARDI Review

EVALUATING THE PERFORMANCE OF VARIOUS MANURES AND VERMI-COMPOST FOR VEGETABLE PRODUCTION

Leslie Anthony Simpson

Soil Scientist, Caribbean Agricultural Research and Development Institute
P.O. Box 113, UWI Campus, Mona, Kingston 7, Jamaica

ABSTRACT

Over a period of six years, five field studies were conducted by CARDI to evaluate the performance of various manures and vermi-compost on the production of callaloo (*Amaranthus* sp.). These manures were cow manure, goat manure, vermi-compost and a commercial organic fertiliser. In the first three studies significantly higher yields of callaloo were obtained from either cow or goat manure (P• 0.05) with vermi-compost providing the least yield in every season. In the fourth and fifth year a commercial organic fertiliser was evaluated against cow manure and vermi-compost and was found to produce significantly higher yields of callaloo than the vermi-compost in both years (P• 0.05). There were no significant differences of yield of callaloo between the commercial organic fertiliser and cow manure in the two trials.

INTRODUCTION

The use of organic manures in commercial agriculture production has declined considerably since the "green revolution" in the United States which signalled the widespread use of agrochemicals including synthetic fertilisers and high yielding crop varieties responsive to fertilisers to break the yield barrier. However, with the passage of time, the environmental demerits of synthetic fertiliser use including widespread N and P pollution of waterways, increasing cost of the commodity and the return to more natural and balanced crop production systems such as organic farming have led to a return to more recycling of the earth's elements and the use of various organic by-products and animal manures as possible alternatives to synthetic fertilisers in some production systems.

In this regard, one of the newer practices which have come into the Caribbean is vermiculture and the use of vermi-compost. In recent years, the use of earthworms in the breakdown of a wide range of organic residues, including sewage sludge, animal wastes, crop residues, and industrial refuse, to produce vermi-compost has increased tremendously (Mitchell et al. 1980; Reinecke and Venter 1987; Edwards and Neuhauser 1988; Chan and Griffiths 1988; Hartenstein and Bisesi 1989; Haimi 1990; van Gestel et al. 1992; Dominguez and Edwards 1997; Edwards 1998; Kale 1998). The earthworms fragment the organic waste substrates, greatly stimulate microbial activity and increase rates of mineralisation, rapidly converting the wastes into humus-like substances with a finer structure than thermophilic composts but possessing a greater and more diverse microbial activity (Elvira et al. 1996, 1998; Atiyeh et al. 2000b).

Keywords: vermi-compost, organic manure, organic agriculture, fertilization, callaloo production

The effects of vermi-compost on the growth of a variety of crops including cereals and legumes, vegetables, ornamental and flowering plants have been assessed in the greenhouse and to a lesser degree in field crops (Chan and Griffiths 1988; Edwards and Burrows 1988; Wilson and Carlile 1989; Mba 1996; Thankamani et al. 1996; Buckerfield and Webster 1998; Vadiraj et al. 1998; Buckerfield et al. 1999; Nethra et al. 1999; Atiyeh et al. 1999, 2000c, 2000d).

These investigations have demonstrated consistently that vermi-composted organic wastes have beneficial effects on plant growth independent of nutrient transformations and availability. The greatest plant growth responses and yields have occurred usually when vermi-compost constituted a relatively small proportion (10–40%) of the total volume of the plant growth medium in which they are incorporated. Usually, greater proportions of vermi-compost substituted in growth media have not increased plant growth as much as smaller proportions (Subler et al. 1998; Atiyeh et al. 1999, 2000a, 2000c, 2000d, 2001, 2002). The mechanisms by which vermi-compost produce these growth enhancement effects are not fully known but they are definitely related to the increased activities of microorganisms in the vermi-compost. This is so as any form of sterilising the vermi-compost results in a loss of the effects mentioned (Edwards, personal communication, 2004).

In this investigation, vermi-compost and three organic fertilisers were assessed for their effect on the production of callaloo, grown under organic conditions, in field studies. The three organic fertilisers were cow and goat manures and a commercial organic fertiliser.

MATERIALS AND METHODS

Field studies were carried out on the CARDI Jamaica Unit Demonstration and Training Centre (DTC) on the University of the West Indies (UWI) Campus, Mona. The study area was cleared, rotated and marked out into three plots, approximately 4m x 6m each. Planting holes were then dug in each plot according to the spacing for callaloo 30 cm within rows and 45 cm between rows. Organic nutrient treatments were then applied to the holes ensuring that it was thoroughly mixed with the soil. Six-week old callaloo seedlings were then transplanted into the plots. The production of the crop was done as described in the CARDI, Jamaica pamphlets for the production of callaloo, except that no chemical fertilisers or pesticides were applied. Seedlings were planted 30 cm within rows and 45 cm between rows. Sufficient moisture was provided for establishment and optimum growth through drip irrigation. Plots were kept weed free through timely manual weeding.

In the first three years, three types of organic nutrient sources were used on the plots. These were goat manure, cow manure and vermi-compost from coffee. In the first callaloo study, vermi-compost was applied at two levels making at total of four treatments as follows:

T1: Goat manure at 0.5 kg per plant hole (approx. 7500 kg/ha)
T2: Vermi-compost at 0.25 kg per plant hole (approx. 3750 kg/ha)
T3: Vermi-compost at 0.5 kg per plant hole (approx. 7500 kg/ha)
T4: Cow manure at 0.5 kg per plant hole (approx. 7500 kg/ha)

In the second and third studies the four treatments were as follows:

T1: Cow manure at 0.25 kg per plant hole (approx. 3,750 kg/ha)
T2: Cow manure at 0.5 kg per plant hole (approx. 7,500 kg/ha)
T3: Vermi-compost at 0.5 kg per plant hole (approx. 7,500 kg/ha)
T4: Goat manure at 0.5 kg per plant hole (approx. 7,500 kg/ha)

The treatments were arranged in a randomised complete block design (RCB) with 4 treatments and three replicates. Each treatment was applied to two rows of callaloo plants. Yield data was obtained as total harvested weights of callaloo, which was separated into what could be marketed and that which was thought to be unmarketable owing mainly to pest damage. This harvest was done weekly beginning four weeks after transplanting and continuing until the end of the crop.

In the fourth and fifth studies a commercial organic fertiliser (Trade name: Rescue) was added to the manures, the treatments assessed were as follows:

T1: Vermi-compost at 0.5 kg per plant hole (approx. 7500 kg/ha)
T2: Cow manure at 0.5 kg per plant hole (approx. 7500 kg/ha)
T3: Rescue at 0.5 kg per plant hole (approx. 7500 kg/ha)

The vermi-compost was made from coffee beans at the Mona DTC, while the cow and goat manures were obtained from the Bodles Research Station (BRS) and the Sam Motto Goat and Sheep Demonstration and Training Centre (SMGSDTC) of CARDI, Jamaica. The animal manures were not fresh but had been weathered for at least six weeks. Chemical analyses of the organic manures were done by the Sugar Industry Research Institute (SIRI) using the methods they employ for the various analyses. The data were subjected to statistical analysis applying the ProcGLM, in SAS, 1989.

RESULTS AND DISCUSSIONS

Chemical analysis of the vermi-compost and the cow and goat manures used in the studies are given below (Table 1). The composition of these manures vary from season to season and in the case of the vermi-compost is dependent on the composition of the material being utilised by the earthworms, while that of the goat and cow manures depend on the diet of the animals.

Table 1 Chemical composition of cow and goat manures and vermi-compost produced from dry coffee beans

Sample	**%**						
	Organic Carbon	**Total N**	**C/N ratio**	**P_20_5**	**K_20**	**Ca**	**Mg**
Cow manure	21.7	1.2	18.0	0.98	1.80	0.09	0.32
Goat manure	21.4	2.3	9.0	1.42	2.75	0.19	0.50
Vermi-compost	32.2	3.4	9.5	0.28	1.74	0.46	0.54

	%			**mg/L**		
	N	**P**	**K**	**Zn**	**Fe**	**Cu**
Commercial organic fertilizer	4	11	3	2.5	12	3

Initial callaloo studies

Table 2 gives the results of the first callaloo study. Callaloo was harvested four times during a six week period. The data are given in terms of total, marketable and unmarketable yields for each of these harvests as well as for the total harvest.

Table 2 Yields of callaloo grown under four organic manure treatment levels in the first trial

Time	**Treatments**				**LSD (P=0.05) (6df)**
	T1	**T2**	**T3**	**T4**	
	Total Yields (kg)				
First harvest	6.40	7.40	5.40	8.40	3.77
Second harvest	4.50	3.32	3.97	5.00	2.20
Third harvest	3.30	4.38	4.46	5.37	3.26
Fourth harvest	7.68	9.82	8.70	12.62	8.73
Total harvest	***21.85***	***24.89***	***22.52***	***31.40***	***13.53***
	Marketable yields (kg)				
First harvest	2.60ab	2.17b	1.95b	3.63a	1.38
Second harvest	2.23	1.55	2.28	2.55	2.75
Third harvest	1.77	3.02	3.40	4.08	3.09
Fourth harvest	4.38	5.18	3.77	7.43	5.64
Total harvest	***10.98***	***11.92***	***11.40***	***17.70***	***10.23***
	Unmarketable yields (kg)				
First harvest	3.75	5.20	3.43	4.80	2.97
Second harvest	2.28	1.77	1.68	2.45	1.76
Third harvest	1.53	1.37	1.07	1.28	0.94
Fourth harvest	3.30	4.63	4.93	5.18	4.25
Total harvest	***10.87***	***12.97***	***11.12***	***13.68***	***5.20***

Values in the same row followed by the same letters are not significantly different (P>0.05)
T1: Goat manure at 0.5 kg per plant hole (approx. 7,500 kg/ha)
T2: Vermi-compost at 0.25 kg per plant hole (approx. 3,750 kg/ha)
T3: Vermi-compost at 0.5 kg per plant hole (approx. 7,500 kg/ha)
T4: Cow manure at 0.5 kg per plant hole (approx. 7,500 kg/ha)

The results indicate that the plots treated with cow manure had consistently higher marketable and total yields than plots treated with the other soil ameliorants. This difference was, however, not statistically significant (P>0.05) except for marketable yields in the first harvest. Unmarketable yields also followed this trend but were not totally consistent. There was very little difference in the performance of the other three treatments for the parameters measured. This means that the two levels of vermi-compost had no effect on yields although one level was twice that of the other. In fact average yield appear to be higher at the lower treatment.

The level of unmarketable yield is related to insect damage to the callaloo leaves. This was relatively high compared to traditionally grown callaloo. In fact it was so high that it affected the length of the callaloo harvesting cycle which is normally weekly harvests for about 3 months. These plots had a total of 4 harvests in 6 weeks.

The results of the second organic callaloo study are given in Table 3. Callaloo was harvested five times during a six week period before it was overtaken by leaf eating caterpillars which drastically reduced marketable yields. As in the first trial, the data are given in terms of total, marketable and unmarketable yields for each of these harvests as well as for the total harvest.

Plate 1 Organic nutrient treatment being applied to plant holes before transplanting of callaloo

Plate 2 Callaloo growing in experimental plot

Table 3 Yields of callaloo grown under four organic manure treatment levels in the second trial

Time	Treatments				LSD
	T1	**T2**	**T3**	**T4**	**(P=0.05)**
	Total Yields (kg)				**(6df)**
First harvest	1.92	1.44	1.23	1.33	0.98
Second harvest	5.46	4.27	4.01	5.21	2.58
Third harvest	5.77ab	4.86ab	3.63b	6.53a	2.53
Fourth harvest	3.01	3.11	2.40	3.65	2.06
Fifth harvest	9.63ab	10.37ab	6.97b	12.11a	4.91
Total harvest	***25.8***	***24.0***	***18.2***	***28.8***	***11.1***
	Marketable yields (kg)				
First harvest	1.92	1.44	1.23	1.33	0.98
Second harvest	5.08	4.10	3.80	4.93	2.05
Third harvest	2.93a	3.16a	1.74b	3.13a	1.14
Fourth harvest	1.73	2.18	1.18	1.61	1.21
Fifth harvest	1.95	1.97	1.20	2.25	1.75
Total harvest	***13.61***	***12.85***	***9.16***	***13.25***	***5.29***
	Unmarketable yields (kg)				
First harvest	-	-	-	-	-
Second harvest	0.38	0.17	0.21	0.28	0.60
Third harvest	2.83	1.70	1.88	3.40	1.83
Fourth harvest	1.28ab	0.93b	1.22ab	2.03a	1.05
Fifth harvest	7.68ab	8.40ab	5.77b	9.87a	3.81
Total harvest	***12.18***	***11.19***	***9.08***	***15.58***	***6.74***

Values in the same row followed by the same letters are not significantly different (P>0.05)
T1: Cow manure at 3,750 kg/ha
T2: Cow manure at 7,500 kg/ha
T3: Vermi-compost at 7,500 kg/ha
T4: Goat manure at 7,500 kg/ha

Generally, the data indicate that cow manure at both levels and goat manure had a more beneficial effect on the yield of callaloo than did vermi-compost. This is indicated in the total yield, marketable and unmarketable yields for the overall harvest of the plot.

For specific weekly harvests, at the third harvest, for marketable callaloo yields plots treated with cow manure at 7,500 kg/ha showed significantly higher yield than plots treated with vermi-compost, there was no significant differences among the other treatments.

The unmarketable callaloo yield data indicated that plots treated with goat manure were significantly higher than plots treated with cow manure at 7,500 kg/ha and plots treated with vermi-compost at the fourth and fifth harvests respectively. But the more important factor pertaining to unmarketable yields is the fact that this component of yield steadily increased from zero in the first harvest to being the major part of the yield component in the fifth week. This is a direct indication of the pest infestation of the crop by the fifth harvest.

The total yield of the third and fifth harvests showed that the goat manure treated plots had significantly higher yields than the vermi-compost treated plots. There was no significant difference between the goat and cow manure treatments at these harvests.

This data is quite similar to that obtained in the first study when cow manure was found to be superior to vermi-compost in the production of organic callaloo.

The results of the third organic callaloo study are given in Table 4. Callaloo was harvested three times during a six week period. As in the previous trials, the data are given in terms of total, marketable and unmarketable yields for each of these harvests as well as for the total harvest.

Table 4 Yields of callaloo grown under four organic manure treatment levels in the third trial

Time	**Treatments**				**LSD (P=0.05) (6df)**
	T1	**T2**	**T3**	**T4**	
	Total Yields (kg)				
First harvest	4.11ab	3.91b	3.97b	5.33a	1.23
Second harvest	4.68	4.43	4.30	5.88	2.21
Third harvest	3.73b	3.23b	3.13b	5.15a	0.87
Total harvest	***12.52b***	***11.57b***	***11.40b***	***16.36a***	***2.95***
	Marketable yields (kg)				
First harvest	0.81	0.61	0.66	1.29	0.93
Second harvest	2.25b	2.03b	2.28b	3.43a	0.83
Third harvest	0.00	0.03	0.00	0.00	Na
Total harvest	***3.06b***	***2.67b***	***2.94a***	***4.72a***	***1.48***
	Unmarketable yields (kg)				
First harvest	3.30	3.30	3.32	4.03	1.36
Second harvest	2.43	2.40	2.03	2.45	2.43
Third harvest	3.73	3.20	3.13	5.15	0.33
Total harvest	***9.46***	***8.90***	***8.48***	***11.63***	***3.56***

Values in the same row followed by the same letter are not significantly different (P>0.05)
T1: Cow manure at 3,750 kg/ha
T2: Cow manure at 7,500 kg/ha
T3: Vermi-compost at 7,500 kg/ha
T4: Goat manure at 7,500 kg/ha

Generally, the data indicate that goat manure had a more beneficial effect on both the total and marketable yields of callaloo than did vermi-compost and cow manure.

For specific biweekly harvests, the total yield of the first and third harvests showed that the goat manure had significantly (P•0.05) higher yields than vermi -compost. Goat manure also had significantly (P• 0.05) higher yield than cow manure at the third harvest. There was no significant (P• 0.05) difference between the goat manure and the lower cow manure treatments at the first harvest.

For the marketable yields, significant differences were detected only during the second harvest. Goat manure showed significantly (P• 0.05) higher yield than vermi-compost and cow manure.

An important observation from these results is the low ratio of marketable yield to total yield; about 1:4, on average. This was a result of the pest infestation of the crop from the very beginning of harvest. This was quite different from the previous year when the pest infestation slowly built up as the crop moved from the first to fifth harvest. The reason for this difference may be in the type of irrigation practiced during this trial. While in previous trials drip irrigation was used, in this trial, sprinkle irrigation was employed. This caused quite a difference in the micro-climate around the crop and may have precipitated the high pest incidence.

In the three studies total yield of callaloo per harvest in the period of optimum growth ranged from 25.2 kg in the three plots in the first study to 17.3 kg in the third. This corresponds to 25,000 kg to 37,500 kg/ha of callaloo per harvest. This yield is considered acceptable for this crop.

Studies with a commercial organic fertiliser

In the final two studies vermi-compost and cow manure were assessed against a commercial organic fertiliser (Trade name: Rescue). Table 5 gives the total fresh weight yield of callaloo obtained from the plots in relation to the three manure treatments. This yield is broken down into that which was marketable and that which was unmarketable due to pest damage. The first study data indicated that the plots treated with Rescue and cow manure produced significant (P• 0.05) total and marketable fresh weight of callaloo compared to plots treated with vermi-compost. There was no difference in yields between plots treated with Rescue and cow manure. Also there were no differences of unmarketable fresh weight yield amount treatments. In this study callaloo was harvested over a10 week period which is the longest time organic callaloo has been harvested on the station. In previous years the crop was quickly overcome by pest infestations. In this study, pest infestation was reduced by the use of the “exclusion cage technology.”

The second study data indicated that the plots treated with Rescue and cow manure produced significantly more (P• 0.05) total fresh weight of callaloo compared to plots treated with vermi-compost. There was no difference in total yields between plots treated with Rescue and cow manure. Also there were no significant differences of marketable and unmarketable fresh weight yield amount treatments, although the difference in marketable yield between bioorganic treated plots and vermi-compost plots was quite substantial. In this study, callaloo plots were surrounded by mesh to exclude pests. The top was however not covered and this procedure appeared to be ineffectual against caterpillars (*Lepidoptera* spp.). Plots were severely affected by caterpillars and had to be abandoned after four weeks of harvest.

Table 5 Total fresh weight of callaloo harvested in relation to three manure treatments

First Study			
	Callaloo harvest (kg)		
Treatment	**Marketable**	**Unmarketable**	**Total**
T1	5.75b	4.32	10.07b
T2	12.87a	4.87	17.74a
T3	15.82a	4.47	20.29a
LSD (18df)	3.37	1.35	2.98

Second Study			
	Callaloo harvest (kg)		
Treatment	**Marketable**	**Unmarketable**	**Total**
T1	1.03a	4.57a	5.60b
T2	5.43a	5.03a	10.46ab
T3	9.74a	10.18a	19.92a
LSD (8df)	11.09	6.00	11.08

Values in the same column followed by the same letter are not significantly different ($P > 0.05$)
T1: Vermi-compost at 0.5 kg per plant hole (approx. 7,500 kg/ha);
T2: Cow manure at 0.5 kg per plant hole (approx. 7,500 kg/ha);
T3: Rescue at 0.5 kg per plant hole (approx. 7500 kg/ha)

CONCLUSION

The use of organic manure/fertilisers is now the subject of much discussion as the price of its synthetic counterpart rises out of the reach of poor farmers. This study has indicated that acceptable yields of callaloo can be obtained using organic manures. In the study, cow manure, goat manure and the commercial organic fertiliser (Rescue) treated plots all produced superior yields of callaloo to plots treated with vermi-compost. This was somewhat surprising as vermi-compost was thought to have the potential to provide even more than its mineral content indicates to the growth and well-being of crops. The study indicates that growing callaloo with organic soil amendments is commercial viable. This organic amendment could be bought as the commercial fertiliser gave consistently higher yields than the traditional cow and goat manure and significantly higher yields than vermi-compost. A closer look at the performance of vermi-compost may also be necessary.

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EVALUATION OF FUNGICIDES FOR THE MANAGEMENT OF ASIAN SOYBEAN RUST

Anil Sinha and Hector Reyes

Caribbean Agricultural Research and Development Institute
Central Farm, P.O. Box 2, Belmopan, Belize

ABSTRACT

Asian soybean rust, caused by *Phakopsora pachyrhizi* Sydow, is a devastating foliar disease of soybean that may cause significant yield losses if not managed by well-timed fungicide applications. The rust was first recorded in Belize in January 2006 and at that time some of soybean fields had up to 100% yield loss. To determine the effect of fungicide timing on soybean rust severity and soybean yields, field trials were conducted in Belize in 2006-2007 and 2007-2008. All fungicides evaluated reduced rust severity and produced higher yields compared to untreated. Based on the results over two years (2007 and 2008) of trials it would be recommended that fungicides containing protective and curative properties like Silvacur Combi 30 SC® and other triazole classes of fungicides could be applied at the first detection of soybean rust symptoms on lower trifoliate leaves. The disease seems to affect soybean after flowering, about 55 days after planting and mainly during January to March when the weather is cool and moist.

INTRODUCTION

Asian soybean rust, caused by *Phakopsora pachyrhizi* Sydow, is a devastating foliar disease of soybean that may cause significant yield losses if not managed by well-timed fungicide applications as currently there are no known commercial cultivars available that are resistant to the rust. The pathogen is readily disseminated by wind-borne urediniospores and can drastically reduce yields. Yield losses ranging from 10% to 100% have been reported for individual fields and in experimental plots (Hartman et al. 1991; Wang and Hartman 1992; Hartman 1996; Levy et al. 2002; Morel and Yorinori 2002; Caldwell and McLaren 2004; Yorinori et al. 2005; Delancy et al. 2007). In Belize yield losses up to 100% were recorded in 2007. The disease had been limited to the eastern hemisphere, until it was found in Hawaii in 1994 (Killgore and Heu 1994).

Currently, the distribution of *P. pachyrhizi* includes Africa, Asia, Australia, South America, Hawaii, Mexico and Belize (Miles et al. 2003; CARDI 2006). Most recently it was reported from Hawaii in 1994, eastern and southern Africa from 1996-1998, Nigeria in 2001, Brazil and Paraguay in 2002, USA in September 2004 (Schneider et al. 2005) and Mexico in October 2005. It was recorded for the first time in

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Keywords: Soybean, Soybean var. *Huasteca 200*, Soybean var. *CARDI S-89*, Asian soybean rust

Belize in January 2006. Symptoms of the disease were first observed on soybean in a field at Central Farm, Cayo District. Later it was confirmed by the Belize Agricultural Health Authority (BAHA) as the Asian soybean rust.

The most common symptoms are grey green, tan to dark brown or reddish brown lesions with one or many erumpent, globose uredia, particularly on the underside of the leaflets. The lesions tend to be angular, are restricted by leaf veins, and reach 2 to 5 mm in diameter. Lesions may also appear on petioles, pods, and stems (Sinclair and Hartman 1999). Severely infected plants show early defoliation, compromising pod formation and filling and final grain weight (Yang et al. 1991).

In Belize Asian soybean rust seems to affect soybean crops planted in November/December and the disease is detected in January and February. At this time, the only effective means of management is immediate fungicide application when the disease is detected. Many fungicides have been evaluated to control soybean rust. Early research from Asia indicated that mancozeb was effective (Hartman et al. 1992). Other fungicides available at the time were compared to mancozeb and were effective, but results varied by test (Miles et al. 2003a). Fungicide trials in India (Patil and Anahosur 1998), South Africa (Levy 2005), South America (Mueller et al. 2009), United States (Delancy et al. 2007) identified several triazole compounds and triazole mixes (Miles et al. 2003b). To determine the effect of fungicides timing on soybean rust severity and soybean yield, field trials were completed in 2007 and 2008.

MATERIALS AND METHODS

Fungicides were evaluated in soybean fields at Central Farm, Cayo District in Belize during 2006-07 and 2007-08 growing seasons. A list of fungicides with trade name, chemical name and their mode of action is presented in Table 1. During 2006-07, Soybean var. *Huasteca 200* was machine planted on 24 November 2007 in 75 cm row width at Central Farm. The experimental design was a split-plot with three replications. The main effect was fungicides and the subplot treatments were one or two applications of the main effect treatments. Plots were 18 rows wide with 15 rows receiving the fungicide applications. Ten rows of each plot were harvested, with a harvest length of 10 m. The first application of each subplot treatment was made at the first detection of rust symptoms on the lower trifoliate of leaves which appeared at 70 days after planting (DAP) and second application was made at 10 days after first application. During 2007-08, Soybean var. *CARDI S-89* was planted on 14 December 2007 in 75 cm row width at Central Farm. The soybean crop was machine planted using the 4-row Baldan planter. The experimental design was randomised block with three replications containing 10 treatments of four fungicides applied once or twice and two untreated plots of water applied once or twice. Plots were 10 rows and 10 m long. Six rows of each plot were harvested, with a harvest length of 8 m. The first application was made at the first detection of rust spores on lower canopy of soybean plants which was at 55 DAP and the second application was made at 20 days after first application. Fungicides were applied using a rate of 300 L water/ha with a motorized mist blower. The fields were managed using recommended agronomic practices for soybean production.

Table 1 List of fungicides evaluated in the efficacy trials

Product/formulation	Chemical name	Mode of action
Amistar 50 WG	azoxystrobin	Systemic (protectant and curative)
Bravo 50 SC	chlorothalonil	Protectant
Duett 25 SC	carbendazim, epoxiconazole	Systemic (protectant and curative)
Score 25 EC	difenconazole	Systemic (protectant and curative)
Silvacur Combi 30 SC	tebuconazole, triadimenol	Systemic (protectant and curative)
Tilt 25 EC	propiconazole	Systemic (protectant and curative)

Ten leaves from each plot at random were collected each from lower third, middle and upper third canopy level of plant. Soybean rust severity was rated, using percentage of leaf infected leaf areas affected in the lower, mid and upper canopy and recorded as density of lesions using 1-9 scale (developed by Miles et al. 2005) at 90 DAP.

All plots were hand harvested and mechanically threshed, and seed weights and moisture content were recorded. Yields were calculated as kilograms per hectare at 13% moisture. Analysis of variance was performed using GenStat statistical software (VSN International, 2008).

RESULTS AND DISCUSSION

Soybean rust was first recorded in the lower canopy in both years of trials. All fungicides treatments had significantly lower disease severity and greater 100 seed mass weight (Tables 2 and 3). There were no differences between the means of 1-application and 2-applications for rust severity except Silvacur Combi®. Overall all treatments except Amistar® and Bravo® provided higher yield than the untreated. Overall all treatments produced larger seed size as compared to untreated.

In general, soybean planted in December 2007 had low infection with Asian soybean rust as compared to 2006-2007 plantings. All fungicide treatments had significantly lower disease severity as compared to the untreated plot (Table 4). There were no differences between the means of 1-application and 2-applications for rust. Overall all treatments had significantly higher yields than the untreated (Table 5). There was no significant difference in the seed size.

In two years' studies, fungicide applications made immediately after first observation of symptoms of rust resulted in higher yields and low level of severity especially on top canopy of soybean plants.

A single, properly timed application can effectively protect yields with little added benefit from a second application and also for resistance management with fungicide use. Similar results have been reported by Levy (2004). Mueller et al. (2009) reported results conducted from 2005-2006 in Paraguay (four locations), the United States (two locations) and Zimbabwe (one location) on the effects of fungicide timing on soybean rust severity and soybean yields. The effectiveness of any given treatment (timing of application and product applied) was often dependent on when rust was first detected and intensity of development.

Table 2 Effect of fungicide treatments on the Asian Rust on various canopy of soybean var. *Huasteca 200* planted on 24 November 2006 at Central Farm, Cayo District, Belize

Fungicide treatment and rate/ha	**1 application**				**2 applications**			
	Rust severity score*				**Rust severity score***			
	Bottom	**Middle**	**Top**	**Overall**	**Bottom**	**Middle**	**Top**	**Overall**
Duett 25 SC, 0.8 L	5.7	4.2	2.4	4.1	5.7	4.0	2.7	4.1
Score 25 EC, 0.4 L	7.3	3.6	2.7	4.5	6.6	4.2	2.9	4.6
Tilt 25 EC, 0.4 L	6.4	4.2	2.6	4.4	6.4	3.6	2.6	4.2
Amistar 50 WG, 200 g	7.7	4.9	3.0	5.2	6.4	5.0	2.8	4.7
Silvacur Combi 30 SC, 0.5 L	6.7	3.7	2.5	4.3	5.6	3.8	2.3	3.9
Bravo 50 SC, 2.5 L	7.7	5.1	3.3	5.4	7.6	4.9	3.5	5.3
Untreated Control - water	8.4	7.0	6.1	7.2	7.4	5.9	4.6	6.0

SEM (Bottom, Middle, Top means) 0.48 (45df), LSD at 5%: 1.09 (means in same column), 1.37 (means in different column)

*Rust severity was scored on a scale of 1 to 9, where 1 was 0% coverage with rust lesion while 9 was more than 20% coverage (Miles et al. 2005)

Table 3 Effect of fungicide treatments on the yield of soybean var. *Huasteca* 200 planted on 24 November 2006 at Central Farm, Cayo District, Belize

Fungicide treatments and rate/ha	1 application			2 applications		
	Yield/plot* (kg)	Yield/ha (kg)	100 seed mass wt (g)	Yield/plot* (kg)	Yield/ha (kg)	100 seed mass wt (g)
Duett 25 SC, 0.8 L	18.89	2,519	20.10	15.78	2,104	19.27
Score 25 EC, 0.4 L	18.75	2,500	18.47	18.45	2,460	17.70
Tilt 25 EC, 0.4 L	17.10	2,280	17.97	16.38	2,184	19.40
Amistar 50 WG, 200 g	17.66	2,355	19.80	15.18	2,024	18.50
Silvacur Combi 30 SC, 0.5L	17.39	2,319	20.13	18.66	2,488	19.40
Bravo 50 SC, 2.5 L	14.93	1,991	16.30	15.58	2,077	19.17
Untreated control - water	14.34	1,912	15.13	13.46	1,795	14.63
SEM 12 df	0.82		0.92	0.82		0.92
LSD at 5%	2.82		2.40	2.82		2.40

* Plot size = 75 m^2

Table 4 Effect of fungicide treatments on the Asian Rust on various canopy of soybean var. *CARDI S-89* planted on 14 December 2007 at Central Farm, Cayo District, Belize

Fungicide treatment and rate/ha	1 application				2 applications			
	Rust severity score*				Rust severity score*			
	Bottom	Middle	Top	Overall	Bottom	Middle	Top	Overall
Silvacur Combi 30 SC, 0.5 L	1.1	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Duett 25 SC, 0.8 L	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Tilt 25 EC, 0.4 L	1.2	1.1	1.0	1.1	1.0	1.0	1.0	1.0
Amistar 50 WG, 200 g	1.4	1.1	1.0	1.2	1.3	1.3	1.1	1.2
Untreated control - water	5.0	5.0	2.7	4.2	6.5	6.3	3.7	5.5
SEM 27 df	0.36	0.34	0.45	0.27	0.36	0.34	0.45	0.27
LSD 5%	1.05	0.99	1.30	0.79	1.05	0.99	1.30	0.79

*Rust severity was scored in the scale of 1 to 9, where 1 was 0% coverage with rust lesion while 9 was more than 20% coverage (Miles et al. 2005)

Table 5 Effect of fungicide treatments on the yield of soybean var. *CARDI S-89* planted on 14 December 2007 at Central Farm, Cayo District, Belize

Fungicide treatments and rate/ha	1 application			2 applications		
	Yield/plot* (kg)	Yield/ha (kg)	100 seed mass wt (g)	Yield/plot* (kg)	Yield/ha (kg)	100 seed mass wt (g)
Silvacur Combi 30 SC, 0.5 L	11.14	3,094	20.2	11.73	3,258	20.8
Duett 25 SC, 0.8 L	10.94	3,038	20.5	9.67	2,685	20.8
Tilt 25 EC, 0.4 L	10.68	2,967	19.2	11.28	3,133	19.1
Amistar 50 WG, 200 g	10.85	3,013	18.6	11.74	3,261	19.4
Untreated control - water	7.04	1,954	19.5	7.63	2,119	18.8
SEM 27 df	0.565	222.1	0.616	0.565	222.1	0.616
LSD 5%	1.640	455.7	1.788	1.640	455.7	1.788

* Plot size = 36 m^2

CONCLUSION

One of the strategies for managing Asian soybean rust is to scout and initiate fungicide application at the first detection of rust symptoms to reduce the number of fungicide applications and ensure that applications are made when needed. The limiting factor to applying fungicides at first detection is the need for intensive scouting systems that detect the disease soon after initial symptoms development. Sometimes it may become difficult to make applications due to adverse weather conditions (precipitation) soon after the detection of initial symptoms. It is recommended to scout for the early symptoms of disease at the lower canopy and apply fungicide almost immediately upon detection. Since the yields tend to decrease as the time between first detection on lower trifoliate and first application increased, it is recommended to apply fungicides as a preventive, or within a week after the first symptoms are confirmed (Levy 2005).

Based on the results of two years (2007 and 2008) trials it is recommended that fungicides containing protective and curative properties like Silvacur Combi 30 SC® should be applied between 55 to 60 days after planting. The disease seems to affect soybean after flowering, about 55 days after planting.

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