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Evaluation of ecofriendly management practices of french bean rust (*Uromyces appendiculatus)* in organic farming system.

G.K.N.Chhetry and H.C.Mangang

Department of Life Sciences, Manipur University, Canchipur, Imphal, India,795003
Email: huidromc@gmail.com

ABSTRACT

Organic farming system emphasises on sustainable development of agriculture. The traditional agriculture system was much akin to the organic system but modernization of agriculture made a shift to this trend. The north east region of India is potential organic farming sites. Most of the farming systems are traditional and are organic by default; however crops in organic farming are prone to many fungal diseases. Hence for validation of the impact of organic practices on the disease development of plants, a study has been conducted for three years under natural environmental conditions on bean rust (*Uromyces appendiculatus*). Study includes ecofriendly practices like: plant extract treatment, intercropping of beans with maize, organic manure application, influence of cropping season and Trichoderma treatment. Rust is a major prevalent disease in the cultivation of beans as in other parts of the world. Detailed study of the disease in the organic environment and the impact of various treatments and agricultural agronomic practices would help in validation of the practices for the management of the disease in the organic farming system. In our study for three consecutive years it has been revealed that the practices of the traditional farmers like plant extract application, intercropping, and manure application were found to have significant positive effects in reducing rust development in the bean fields. The treatment of farm yard manure resulted in development of lesser area under disease progress curve. The plant extract of *Artemisia vulgaris* has marked positive impact on reducing rust disease parameters. Foliar application of *Trichoderma* reduces the disease parameters of rust. This study would enhance information in understanding the impact of organic farming system on bean rust and would help in validitation of sustainable agricultural practices for use in organic farming system.

Keywords : organic farming ,bean rust, audpc, ecofriendly management.

1 INTRODUCTION

French bean (*Phaseolus vulgaris* L.) is one of the important leguminous vegetable crops. In Manipuri dialect it is commonly known through various names as *Coli hawai/ Konsam hawai/ Tankhul hawai* and usually grown during the months of March to July. The crop usually suffers from a number of diseases. The rust of bean caused *by Uromyces appendeculatus* is one of the important fungal pathogens. There is frequent occurrence of rust in the bean fields. Rust usually reach epidemic scale in most regions of the world, also there is recurrent occurrence of bean rust in Manipur. The outbreak of bean rust is possible in any region where a relative humidity of 95% or more is maintained for a period of eight hours or more. [1]. This condition is usually experienced during bean growing seasons in Manipur and it could be considered that Manipur lies in the zone of bean rust epidemic. But complete failure of crops as seen in many conventional fields was rarely observed in home gardens where crops were usually raised through organic means. Local growers usually follow the organic mode of cultivation. This mode of cultivation is passed down the generation. In view of the popularity of organic agriculture in local and global level, and observation of lesser disease development in organic fields, a study is carried out for three years to test the hypothesis that the organic fields do not differ to conventional fields in rust development. Hence study has been done to compare the disease parameters of rust in the organically grown with that grown with synthetic fertilizer. Again an insight on the Agronomic and cultural practices to contain disease, usually followed by the local farmers especially in Manipur is studied. This would help us in understanding the scientific rationale of the agricultural practices usually followed by the local people and may find locally acceptable practices suitable for reducing the impact of rust on bean. Also possibly these techniques would find applicability to farmers especially of the developing and lesser developed countries. Two agronomic practices namely sowing season and intercropping has been studied for their influence on bean rust for a more comprehensive study of the disease management practices. The application of bio fungicides and certain plant extracts permitted in organic farming system has also been studied for finding more resource base for rust disease management in the organic farming system. Although works on ecofriendly management of diseases have been done by many workers, yet only few reported on the disease development in organic environment. This study would help in understanding various ecofriendly management practices of rust which are simple and affordable to a wide range of farmers.

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2 MATERIALS AND METHODS

2.1 Bean seeds and plants selection.

Bean varieties commonly cultivated by the local people were selected. Three varieties which were phenotypically distinguishable and characterised by their black seed coat, brown seed coat and striated seed coat were procured from the local farmers. The three varieties were all pole type varieties.

For the test of plant extracts in the field, ten commonly available plants found in the locality and believed to possess medicinal property according to the local folk were selected. The plants under study were *Artemisia vulgaris, Artocarpous integefolia, Coix lacrymajobi, Citrus maxima, Hedychium coronarium, Lantana camera, Michelia champaka, Passiflora foetida, Punica granatum,* and *Strobilenthus flacidifolius.* The aqueous plant extract were prepared in the ratio of 1:2(w/v) i.e one part plant leaves with two parts water as described by Khare and Shukla [2]. This acts as 100% extract and used for the field application.

2.2 Field Preparation

Beans were sown in (2 X 2) m^2 plots. A spacing of (30 X 10) cm^2 is maintained as commonly practiced by the local folk and as recommended by Bose [3]. FYM is applied at the rate of 20 tonnes per hectare in the plots. The farm yard manure was applied a week prior to sowing of seeds and during the preparation of the field. The experiment was carried out during two growing seasons of the years: 2008, 2009 and 2010. Field was prepared during the month of January and crops were sown by March. The seeds were sown in randomised block design with three replications. Irrigation was carried out as needed.

2.3 Field application of plant extracts.

The plant extract prepared is applied as fresh preparation and is applied at weekly interval, from the fourteenth day after the sowing of seeds. The extracts were applies till the wetting of the leaves using a sprayer .The extracts were applied in the late evening for a prolonged retention of the plant extracts on the leaves due to less evaporation as the temperature drops by evening. The diseases were assayed in weekly intervals since the observation of the first symptoms. About 3 weeks are required to spread the infection sufficient to constitute an epidemic [4]. Hence application of plant extracts weekly would help in reducing the chances of development of bean epidemic, if they have effect on the uredospore germination.

2.4 Field application of *Trichoderma viride.*

Trichoderma is widely used for the management of a variety of plant pathogens especially fungal diseases. Hence the foliar application of *Trichoderma viride* isolated from the market product of Tricho XP (Rom Vijay Bico Tech Pvt.Ltd. Pondicherry) has been used for the foliar spray against the development of rust in two cropping seasons. Pure culture of *Trichoderma viride* is maintained on PDA plates at 25 ± 1^{O}C in the incubator. The conidial suspension was prepared by flooding ten days old Trichoderma grown in conical flask with 10 ml sterile distilled water. The spore suspension is filtered with the help of muslin cloth. The concentration of the spores in the extract is maintained at 10^4 spores /ml by the addition of sterile distilled water. The spore suspension thus prepared was applied on the leaves of the plants with the help of a sprayer in the afternoon. Only distilled water is applied in control plots. The spore suspension is applied at weekly interval.

2.5 Intercropping with maize

Three rows of French bean were planted alternately with two rows of maize and rows of maize are allowed to grow as a border crop around the bean plot to access the effect of maize on bean which is usually intercropped with bean by most of the farmers in Manipur. Necessary agronomic practices were followed.

2.6 Effect of cropping season

Bean could be grown all the year round in Manipur valley but it is mostly grown in the March – June and August – November growing season. This may be due to the favourable soil moisture level during the two periods. A test has been conducted to test the difference of the two periods on the disease parameters of rust .Hence crops were raised for the two growing seasons of the years; 2008,2009 and 2010.Weekly disease parameters were recorded to test the statistical hypothesis that there is no significant differences between the two growing seasons in terms of natural rust disease development and severity. Normal agronomic practices for the cultivation of beans in an organic environment were followed for the plantation of the crop.

2.7 Disease assessment

The disease parameters like percent disease incidence (DI %) and percent disease severity (DS %) of the rust developed from the natural inoculums were observed at weekly interval after the appearance of the first symptoms. From the DS% obtained the area under disease progress curve (AUDPC) and apparent rate of disease growth (r) were worked out. In each plot thirty leaflets were chosen randomly with three canopy levels: top ,middle and bottom and were rated non destructively each week till the pods were ready for harvest in accordance with the methodology of Imhoff *et al* [5], DS% for the disease was calculated using the 0-6 scale of Claudea *et al*, [6]. The statistical parameters were worked out as per the relations

i) DI % = (Number of leaves infected / Total no of leaves studied) X 100

ii) DS % = (Sum of Numerical ratings / (No of leaves examined X Maximum grade)) X 100

iii) AUDPC = $\sum_{i-1}^{n}[(y_{i+1}+y_i)/2][x_{i+1}-x_i]$

(Shaner and Finney, 1977) [7]

Where

y_i and y_{i+1} are the severity in the i th observation and(i+1)th observation

x_i and x_{i+1} are the time (weeks in our study) in the i th and (i+1) th observation

And n is the total no. of observations.

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iv) $$r = \frac{2.3}{t_2 - t_1}\left(\log\frac{x_2}{1-x_2} - \log\frac{x_1}{1-x_1}\right)$$ [8]

(Vander Plank, 1963)

Where,

$t_2 - t_1$ is the time interval,

x_1 and x_2 are the disease severities in time t_1 and t_2 respectively.

The results so obtained were pooled for three years and un-paired t test was applied to test the statistical significance of the differences of disease parameters in various pairs of treatments.

3 Results

3.1 Effect plant extracts on bean rust.

Almost all the plant extracts applied showed reduction in disease parameters, Tables 1.1, 1.2 and 1.3. The plants *A.vulgaris, C.maxima, M.Champaka, L.Camera, S. flacidifolius* showed significant disease reduction. The extract of *C.maxima*, A.vulgaris showed up to 53.58% and 55.77% disease incidence reduction respectively as compared with control. The extract of *A.vulgaris* showed effectiveness in all the varieties.

Table 1.1. Efficacy of Plant extracts treatment on DI% and DS% of bean rust in organic farming system, black bean variety.

Disease parameters	DI %				DS%			
extracts	2009	2010	mean	% over control	2009	2010	mean	% over control
A.vulgaris	34.13	30.11	32.12	51.96	3.12	2.32	2.27	60.86
A.integefolia	68.14	60.15	64.15	4.05	7.78	6.54	7.16	0.86
C.lacrymajobi	57.76	52.42	55.09	17.60	5.56	4.34	4.95	28.78
C.maxima	30.22	31.32	30.77	53.98	3.54	2.00	2.77	60.14
H.coronarium	68.44	59.37	63.91	4.41	5.88	4.53	5.21	25.04
L.camera	54.16	49.37	51.77	22.57	6.03	3.87	4.95	28.78
M.champaka	56.33	44.02	50.18	24.95	5.03	3.33	4.18	39.86
P. foetida	67.42	59.44	63.43	5.13	6.94	4.97	5.96	14.24
P.granatum	63.32	53.17	58.25	12.88	6.98	4.36	5.67	18.42
S.flacidifolius	36.32	32.31	34.32	48.67	3.32	2.53	2.93	57.84
control	70.97	62.74	66.86		7.90	6.00	6.95	
CD(p=0.05)			10.7				1.38	

Table 1.2. Efficacy of Plant extracts treatment on DI% and DS% of bean rust in organic farming system, brown bean variety.

Disease parameters	DI %				DS%			
extracts	2009	2010	Mean	% over control	2009	2010	mean	% over control
A.vulgaris	33.11	27.12	30.12	55.77	3.17	2.00	2.59	71.66
A.integefolia	67.00	59.42	63.21	7.18	9.34	8.00	8.67	16.08
C.lacrymajobi	65.35	57.08	61.22	10.1	9.10	7.98	8.54	22.98
C.maxima	34.04	30.31	32.18	52.75	3.17	2.04	2.61	71.44
H.coronarium	60.80	54.42	57.61	15.40	7.86	5.11	6.49	34.46
L.camera	45.16	44.18	44.67	34.41	6.23	5.46	5.85	46.94
M.champaka	35.16	29.17	32.17	52.76	3.14	2.18	2.66	70.90
P. foetida	63.42	60.00	61.71	9.38	8.90	7.43	8.17	21.55
P.granatum	65.19	57.45	61.32	9.96	8.90	6.85	7.88	21.44
S.flacidifolius	52.11	50.10	51.11	24.95	7.86	6.64	7.25	26.15
control	68.89	60.88	64.89		10.10	8.53	9.32	
CD(p=0.05)			8.54				2.16	

Table 1.3. Efficacy of Plant extracts treatment on DI% and DS% of bean rust in organic farming system, striated bean variety

Disease parameters	DI %				DS %			
extracts	2009	2010	mean	%over control	2009	2010	mean	%over control
A.vulgaris	35.06	31.48	33.27	51.15	4.04	3.34	3.69	59.63
A.integefolia	69.45	64.40	66.93	1.72	8.90	5.30	7.10	22.32
C.lacrymajobi	66.98	68.40	67.69	0.60	8.78	8.34	8.56	6.35
C.maxima	37.12	30.13	33.63	50.62	4.23	3.21	3.72	59.30
H.coronarium	69.33	63.11	66.22	2.76	9.08	8.14	8.61	5.80
L.camera	34.43	32.14	33.29	51.12	4.54	3.04	3.79	58.53
M.champaka	57.38	45.13	51.26	24.73	8.03	6.21	7.12	22.1
P. foetida	70.13	65.00	67.57	0.78	9.18	6.92	8.05	11.93
P.granatum	70.14	60.02	65.08	4.43	9.16	8.03	8.60	5.91
S.flacidifolius	67.35	55.36	61.36	9.9	9.00	6.78	7.89	13.68
control	71.08	65.11	68.10		9.96	8.32	9.14	
CD(p=0.05)			10.47				2.55	

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3.2 Effect of application of *Trichoderma viride* on bean rust.

The application of Trichoderma decreases the disease parameters of rust on all the three varieties (Tables 2.1, 2.2 and 2.3). The application of Trichoderma has a profound impact in the disease incidence, disease severity, AUDPC and apparent rate of disease development of rust developed in French bean. The disease incidence and disease severity has been reduced significantly. The AUDPC and the rate of infection are comparatively low as compared with that of untreated plots. The difference in the disease parameters for the three years pooled data has been found to be statistically significant.

Table 2.1 Effect of *T. viride* treatment on the disease parameters of rust in the organic farming system , Black bean variety

	Disease parameters	DI%@	DS%@	AUDPC@	r@
Treatments	**Biofungicide**	**23.17**	**2.97**	**8.7**	**0.37**
	control	**64.60**	**6.79**	**13.99**	**0.39**
	t value	**10.72***	**3.10***	**2.84***	**0.85**

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

Table 2.2 Effect of *T. viride* treatment on the disease parameters of rust in the organic farming system, brown bean variety

	Disease parameters	DI%@	DS%@	AUDPC@	r@
Treatments	**Biofungicide**	**24.15**	**2.54**	**6.19**	**0.35**
	control	**63.41**	**6.19**	**11.68**	**0.39**
	t value	**13.13***	**3.62***	**4.8***	**3.13***

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

Table 2.3 Effect of *T. viride* treatment on the disease parameters of rust in the organic farming system, Striated bean variety

	Disease parameters	DI%@	DS%@	AUDPC@	r@
Treatments	**Biofungicide**	**22.22**	**1.07**	**3.26**	**0.28**
	control	**66.87**	**5.53**	**16.07**	**0.36**
	t value	**17.39***	**2.78***	**2.87***	**4.92***

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

3.3 Effect of intercropping bean with maize on rust.

The difference in the disease parameters in the two treatments is found to be statistically significant.

Row Intercropping with maize lessens the disease incidence, severity, AUDPC and also the apparent rate of disease development tables 3.1, 3.2 and 3.3. This might be due to the decrease in natural innoculum provided by wind. The maize crops might act as a sort of barrier for the spores to reach the leaf surface of the bean plants. Moreover maize plants might have a negative impact on the rust pathogens.

Table 3.1 Effect of Intercropping on the disease parameters of rust in the organic farming system, Black bean variety)

	Disease parameters	DI%@	DS%@	AUDPC@	r@
Treatments	**Intercropping with maize**	**41.45**	**2.16**	**5.97**	**0.34**
	Non intercropping	**66.35**	**7.10**	**20.73**	**0.39**
	t value	**9.7***	**4.33***	**4.37***	**3.35***

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

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Table 3.2 Effect of Intercropping on the disease parameters of rust in the organic farming system, brown bean variety)

Treatments	Disease parameters	DI%@	DS%@	AUDPC@	r@
	Intercropping with maize	**41.22**	**4.14**	**12.12**	**0.39**
	Non intercropping	**64.71**	**8.27**	**24.36**	**0.39**
	t value	**9.11***	**3.48***	**2.88***	**0.23***

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

Table 3.3 Effect of Intercropping on the disease parameters of rust in the organic farming system, striated bean variety
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Treatments	Disease parameters	DI%@	DS%@	AUDPC@	r@
	Intercropping with maize	**42.47**	**2.52**	**7.37**	**0.33**
	Non intercropping	**66.44**	**6.76**	**18.57**	**0.38**
	t value	**8.08***	**3.63***	**3.04***	**3.41***

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

3.4 Effect of season on bean rust.

As observed from tables 4.1, 4.2 and 4.3, statistically significant differences were observed in the disease development in the two seasons. There was an overall decrease of disease parameters in the August-November cropping season.

Table 4.1 Effect of Cropping season on the disease parameters of rust in the organic farming system, Black bean variety

Treatments	Disease parameters	DI%@	DS%@	AUDPC@	r@
	March-june	**66.35**	**7.04**	**20.73**	**0.38**
	Aug-Nov.	**32.55**	**1.37**	**5.13**	**0.30**
	t value	**13.87***	**4.72***	**3.95***	**2.91***

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

Table 4.2 Effect of Cropping season on the disease parameters of rust in the organic farming system, brown bean variety

Treatments	Disease parameters	DI%@	DS%@	AUDPC@	r@
	March-june	**64.71**	**7.93**	**24.03**	**0.39**
	Aug-Nov.	**33.51**	**1.45**	**3.15**	**0.33**
	t value	**10.62***	**4.42***	**3.41***	**2.15**

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

Table 4.3 Effect of Cropping season on the disease parameters of rust in the organic farming system, striated bean variety

Treatments	Disease parameters	DI%@	DS%@	AUDPC@	r@
	March-june	**66.44**	**6.43**	**18.24**	**0.39**
	Aug-Nov.	**33.73**	**1.48**	**5.4**	**0.33**
	t value	**12.97***	**2.75***	**2.93***	**3.28***

@ pooled mean of three years (2009, 10 & 11)
*significant at p<0.05

4 DISCUSSIONS

Management of rust is inevitable as it occurs throughout the world irrespective of farming system mode or climatic conditions.

The application of the extracts has beneficial effect on reducing the disease severity of rust on bean. The plant extracts might act as a prophylactic effect on the leaves of the bean. Although the incidence has not been lowered due to plant extract treatment, yet the severity has been reduced significantly. This leads to the decrease in the apparent infection rate 'r' and AUDPC. The effect of plant extract on French bean rust has also been worked out by few workers. Arslan *et al* [9], found aqueous extracts of basil, black cumin, black pepper, celery fennel, laurel, rosemary etc. to significantly control rust development. Also Monter Belmont *et al* [10], found manila tamarind ,sweet acacia, abroio, and hibiscus effective in reducing infected foliar area as compared with control., E.O.Monda *et al* [11], found neem, pawpaw, nettle to be effective against bean rust. Thus many plant extracts has the potential to reduce rust disease as also revealed by our study. More and more plants with potential antifungal activity need to be explored. Bean rust fungus is capable of exponential increase with a 3-5 day doubling time. The age of the leaves has no significant effect on the infection of leaves by the pathogen [12]. Thus a constant application of protectant needs to be applied and this could be provided by the less expensive and environmental friendly plant extracts.

Organic treatments have a profound impact in disease development especially in respect of soil borne disease. Also there are reports of effectiveness of organic amendments in the development of foliar disease of plants. There are many resources and findings which indicates lesser disease development in organic fields as compared with conventional farms. The effect of amendments on disease severity depends on the type of material used, its C: N ratio and the time elapsed since incorporation [13]. Regular addition of organic amendments may lead to induced disease suppression [14]. A study of the author in the agro climatic conditions of Manipur reveals the positive effect of certain soil amendments on soil borne pathogens [15]. In the present study though the differences in disease severity and the disease incidence were not statistically significant, yet the AUDPC has been observed to be significantly lower in the organic treatment. This may be due to the enhanced leaf micro flora which might develop due to the organic treatment of the soil. Also it is generally agreed that the nitrogen content of plants grown in organic farms is lower than that of chemical fertiliser treated plants and this leads to the decrease in the susceptibility of the plant due to various pathogens.

Foliar application of Trichoderma spp. has been found to be effective to a number of foliar pathogens. Bankole and Adebanjo [16] found Trichoderma viride to be effective against colletotrichum of cow pea. T. viride was also found to be effective against powdery mildew of cluster bean [17]. Patel [18] found T.viride to be effective against powdery mildew of mustard. And in our study it is found to be effective in reducing the bean rust significantly.

Intercropping of bean with maize has a positive effect in decreasing the disease parameters of rust of bean in the organic environment; hence the common practice of growing maize together with bean is encouraging. Similar results during low rate of disease progress have also been observed in conventional farms. [19]

Disease avoidance is an important cultural practice for the management plant diseases. Venketaratam [20] observed the importance of adjustment of sowing date and varietal selection for bean diseases. Hence the significant differences in disease parameters during the three cropping seasons under study would help in the deciding the season of sowing bean in the region for avoidance of rust bean.

5 CONCLUSION

From the studies and observations it could be safely concluded that the various ecofriendly practices and agronomic practices which were mostly familiar with the local farmers had positive impact on reducing bean rust in the organic farming system. Similar research work at the regional and local level need to be worked out for a sustainable, ecofriendly and regional viable form of agriculture which would integrate to a sustainable global agriculture.

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