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Study of integrated disease management & host resistance against root rot and wilt disease in Rice bean (*Vigna umbellata*)

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Abstract
A field experiment was conducted in experimental and research station of AICRP on forage crops and utilization, at Odisha University of Agriculture and Technology, Bhubaneswar under East and South Eastern Coastal Plain zone of Odisha, taking thirteen treatments during two seasons, kharif 2019 and kharif 2020 to evaluate the performance against wilt incidence and other yield attributing character. From the study, it was found that seed treatment with Carboxin + Thiram @ 0.2% followed by root zone drenching with Metalaxyl + Mancozeb (Ridomil) @ 0.2% was the best treatment compared to others. It recorded the highest germination (90.70%), least wilt incidence (6.63%) and their by reducing the disease by 70.36% over control. It produced the highest green fodder yield 340.80 q/ha as well as highest seed yield of 562.73 kg ha-1 l which revealed an incremental yield of 19.38% and 10.27% respectively over untreated check controlled plot. The seed treatment with Vitavax power @ 0.2% followed by root zone drenching with Validamycin @ 0.1% was found to be next best treatment which reduced the disease by 62.45% and also increased GFY by 18.09% and seed yield by 9.74%. Also seven cultivars of rice bean (JRBJ-10-2, Bidhan-2, Bidhan-3, JRBJ-10-3, KRB- 110, JOR-19-1, JOR-19-2) were evaluated against wilt of rice bean under field condition. Among all varieties JRBJ-10-2 was the best performer with respect to increase in yield and reducing disease incidence in rice bean. Cultivars like JRBJ-10-2, Bidhan-2 and Bidhan-3 were found to resistant to root rot and wilt disease, whereas cultivars like KRB-110 and JRBJ-10-3 were moderately resistant and JOR-19-1 and JOR- 19-2were moderately susceptible variety. The green fodder yield (GFY) obtained was highest (326.0 q ha-1) in JRBJ-10-2. Bidhan-3 and Bidhan-2 were the next best varieties which recorded 295.8 (q ha-1) and 287.5 8 (q ha-1) of GFY respectively. The highest dry matter yield 73.9 8 (q ha-1) was recorded in JRBJ-10-2 followed by Bidhan-3 and Bidhan-2 recorded DMY of 68.1 8 (q ha-1) and 62.5 8 (q ha-1) respectively. The variety JRBJ-10-2 attained maximum plant height (175.3 cm) followed by Bidhan-3 (172.7 cm) and Bidhan-2 (168.5 cm). The highest leaf stem ratio of (1.21) was obtained in Bidhan-2 followed by JRBJ-10-2 (1.14), Bidhan-3 (1.09) and KRB-110 (1.03).

Keywords: rice bean, integrated disease management, *Fusarium wilt*, bio-agent, host resistance

Introduction
Sustainable agriculture, food availability and nutritional security are among the key sustainable development goals of the century. However, food security is now a challenging issue for the rising population due to the limited available resources with progressive climate change throughout the world. Human population is constantly on the rise making it a must to produce more food. Rice bean (*Vigna umbellata*) is a neglected legume regarded as a minor food and fodder crop. Rice bean belongs to the family Fabaceae. It is also known as Climbing mountain bean, Mambi Bean, Oriental bean and Bamboo bean and in Odia as Dangar rani. It is an important legume crop of the tropics whose centre of origin has been reported from southern China and Indian subcontinent. It may be consumed at various stages of its development; green leaves, green pod, green peas and dry grains as well as for fodder purposes. It is an inexpensive source of vegetable protein, which is easily digestible, relatively cheaper and has higher biological values. The ability to fix atmospheric nitrogen makes the crop agriculturally important. The well branched root system provides better soil binding effect and checks soil erosion.
Rice bean is mainly grown for human consumption, though it is also used for fodder and green manure. There has been very little research or development support for this crop and farmers mainly grow landraces. It is grown by subsistence farmers in a very limited scale and most of the produce is consumed at home, although there is a limited market for a short period each year.

The crop contributes to household food security; several food items are prepared from rice bean, it is culturally important and is thought to have important nutritional values (Joshi *et al*. 2007) [2]. Rice bean foliage and dry straw are valuable livestock feed, and when used as a green manure it improves soil fertility.

Like other Vigna species, rice bean (*Vigna umbellata*) is a warm-season annual. Grown mainly as a dried pulse, it is also important as a fodder and as a green manure. The dried seeds are highly nutritious and as the protein is high in lysine they make an excellent addition to a cereal-based diet. The seeds are also high in mineral content, and in vitamins, including thiamine, riboflavin, niacin and ascorbic acid. The presumed centre of domestication is Indo-China-it is thought to be derived from the wild form *V. umbellata* var *gracilis*, with which it is cross-fertile, and which is distributed from Southern China through the north of Vietnam, Laos and Thailand into Burma and India (Lawn, 1995) **[3]**. Wild forms are typically fine-stemmed, freely-branching and small-leaved, with a twining habit, photoperiod sensitivity and indeterminate growth (Lawn, 1995) [3]. Flowering is asynchronous, and there is a tendency to hard seeds. In many areas, landraces which retain many of these characteristics persist, in particular with regard to daylight sensitivity, growth habit and hard seeds. Rice bean is hence, a valuable crop and an integral component of crop rotation systems. But it has remained as an underutilised crop. Rice bean is a drought tolerant crop and can be grown in wide range of climatic conditions throughout the year as both Kharif and Rabi crop. A conventional pulse grown in India has been unable to meet the entire demand and again there is shortage of fodder for livestock production, so rice bean crop can be a good option to address the issue. Besides the high production potential, the nutritive value of rice bean is exceptionally high. The seed protein content has been found to vary from 14 to 25 per cent. The amino acid composition, especially the more limiting ones, methionine and tryptophan are considerably high compared to other *Vigna* species. It contains considerably good amount of thiamine, riboflavin and niacin. Calcium and phosphorus content are appreciably high ranging from 315-450 mg and 197-393 mg per 100 g, respectively (Chandel *et al.*, 1978) [1]. Like many other legumes it fits in cereals-legume rotation. The plant parts of rice bean are pubescent and thus protecting from insects. Rice bean is known to be a disease tolerant crop but outside traditional areas of cultivation it is observed that wilt and root rot diseases causing significant yield loss up to 50 percent. *Fusarium* wilt of rice bean occurs during early seedling stage and early flowering stage. It has shown symptoms such as basal stem swelling, yellowing, withering and drooping of leaves, drying up of stem and occasionally death of plant. Host plant resistance is the most cost effective way to deal the disease. We can use integration of cultural, biological and chemical methods in a compatible way for arriving at a long lasting solution for management of pathogen. The present study focuses on integration of effective fungicides, bioagents, botanicals with eco-friendly practices to develop IDM practices and evaluation of some rulling rice bean varieties for their yield parameters and host resistance to tackle *Fusarium* wilt of rice bean and to boost up production with least disturbance to environment.

Objective

The present investigation was under taken for assessing the performance along with yield attributing parameters rice bean varieties. The field experiment was undertaken to evaluate the yield performance of stress tolerant rice bean varieties also focuses on integration of effective fungicides, bio agents, botanicals with eco-friendly practices to develop IDM practices for their yield parameters and to identify the host resistance to tackle *Fusarium* wilt of rice bean

Materials and Methods

Integrated approach for management of *Fusarium* wilt of rice bean

This experiment was conducted for two years, during kharif 2019 and Kharif 2020, taking seven prominent rice bean varieties and the experiment was conducted in field condition at AICRP on forage crops and utilization. All standard recommended package of practices was followed for cultivation of crop. In order to develop a suitable management schedule against soil borne pathogens a field experiment was designed with one marine extract (Chitosan), one bio agent (*Trichoderma viride*) and three fungicides (Carboxin + Thiram, Metalaxyl + Mancozeb, Validamycin) were selected and tested in combination with each other against wilt disease. The experiment was conducted in field condition at AICRP on forage crops and utilization at experimental station, Bhubaneswar. All standard recommended package of practices was followed for cultivation of crop. A check plot was maintained with keeping all other agronomical measures same in both the plots. The yield attributing characters like Germination percentage Wilt incidence at 15 DAS and 45 DAS, Disease reduction percentage, Green fodder yield (q ha-1) were studied. Data on phenological parameters and crop yield were recorded by per square meter observation method randomly from 3 to 4 places from experimental and check plot. The pooled mean data of these characters for two years were calculated and analyzed statistically. Observations were recorded from 10 randomly selected plants from each genotype in each replication for all the characters.

In this experiment, rice bean Variety-RBL 50 was taken for study and the crop was sown under rain fed condition in the fourth week of July and with irrigation at critical stages of the crop. The crop was raised with recommended agronomic practices, with Recommended fertilizer dose–20:40:40 N_2:P_2O_5:K_2O (kg ha-1) with spacing-30 cm x 10 cm. The seeds were treated with requisite quantity of fungicide /marine extract/bio-agent and then 30 days after sowing, soil application of marine extract/bio agent with cow dung compost/fungicide was done. Three replications for each treatment were maintained. A control treatment sown with untreated seeds was also kept for comparison. The field was irrigated as and when required. Observation on wilt incidence was recorded 45 DAS. Research was held in experimental and research station, of the Odisha University of Agriculture and Technology Bhubaneswar under East and south Eastern Coastal Plain zone of Odisha. The research used experimental methods randomized block design (RBD) with three replications and thirteen treatments including one control check plot. The Plot size was 3m x 2m. The observed characters were, Germination (%), Wilt incidence (%), Disease reduction (%), Green fodder yield (q ha-1), Seed yield (kg ha-1). The data were analyzed using the Fisher test (ANOVA) at α 5%. The treatments are given below in Table 1 as follows.

Table 1: List of treatments used in integrated approach of management

Treatments	Treatment detail
T_1	S.T.–Carboxin + Thiram @ 0.2%
T_2	S.T–Chitosan @ 0.5%
T_3	S.T–*Trichoderma viride* @ 0.5%
T_4	T_1 + R.D-Validamycin @ 0.1%
T_5	T_1 + R.D-Chitosan @ 0.5%
T_6	T_1 + R.D - Metalaxyl + Mancozeb @ 0.2%
T_7	T_2 + R.D-Validamycin @ 0.1%
T_8	T_2 + R.D-Chitosan @ 0.5%
T_9	T_2 + R.D-Metalaxyl + mancozeb @ 0.2%
T10	T_3 + R.D-Validamycin @ 0.1%
T11	T_3 + R.D-Chitosan @ 0.5%
T12	T_3 + R.D-Metalaxyl + Mancozeb @ 0.2%
T13	Untreated control

S.T – Seed treatment, R.D – Root zone drenching

First a germination count was made within 7-12 days of sowing. The observations of wilt incidence was made 15 DAS and its cumulative incidence was recorded at its maximum stage at 45 DAS. Also Green fodder yield (q ha-1) and final seed yield (kg ha-1) was recorded during maximum vegetative growth and final harvest respectively.

Evaluation of rice bean cultivars against wilt caused by *Fusarium oxysporum*

Seed of seven cultivars of rice bean were evaluated against wilt of rice bean (JRBJ-10-2, Bidhan-2, Bidhan-3, JRBJ-10-3, KRB-110, JOR-19-1, JOR-19-2). Observation on disease incidence and yield attributing characters were recorded. On basis of disease incidence, cultivars were categorized as per criterion followed by Nagamma *et al.* (2015) [5].

Table 2: Score chart for disease resistance in cultivars

Category	Disease incidence (%)
Immune	0
Resistant	1-20
Moderately susceptible	21-50
Susceptible	51-80
Highly susceptible	81-100

A Field experiment was conducted during kharif 2019 and kharif 2020, to test the reaction of some varieties against wilt disease caused by *Fusarium oxysporum*. Seeds were collected from Indian Grassland and Fodder Research Institute, Jhansi for conducting the experiment at research field of AICRP on Forage crops and Utilisation, Khandagiri, Bhubaneswar as per details given below.

In this field experiment, a total seven numbers of cultivars were taken for this study named as JRBJ-10-2, KRB-110, JRBJ-10-3, JOR-19-1, JOR-19-2, Bidhan-3, Bidhan-2 and three number replications were taken with (RBD) Design of experiment and the plot size was 4m × 3m with Spacing-30cm × 10cm, Fertilizer dose-20:40:40 N:P_2O_5:K_2O (kg ha-1) and sowing was done last week of July. Recommended agronomical practices were followed.

The wilt disease severity were calculated in per cent count basis. Observation on wilt and root rot was recorded after 15 days and continued at 10 days interval to find the cumulative incidence in different varieties. The host resistance against wilt incidence, green fodder yield (q ha-1) and other yield attributing parameters like dry matter yield (q ha-1), plant height (cm), and leaf stem ratio were recorded to find out the overall performance of the varieties under test. The resistance reaction were recorded as per the scale assigned.

Results & Discussions

Evaluation of Integrated approach of disease management module

A field experiment was conducted under AICRP Forage crops with RBD design having thirteen treatments, three replication each to formulate best management module against *Fusarium* wilt of rice bean.

Table 3: Evaluation of Integrated approach of disease management through field experiment

Treatments		Germination (%)	Wilt incidence (%)		Disease reduction (%)	Green fodder yield (q ha-1)	Increase in Green Fodder Yield (%)	Seed yield (kgha-1)	Increase in Seed Yield in (%)
			15 DAS	45 DAS					
T_1	Seed treatment with carboxin + thiram @ 0.2%	86.5 (75.91)	4.33 (13.37)	7.37 (17.59)	67.05	333.50	16.82	548.73	7.52
T_2	Seed treatment with chitosan @ 0.5%	73.7 (65.68)	14.47 (24.92)	18.40 (26.38)	17.75	300.60	5.30	520.60	2.01
T_3	Seed treatment with *Trichoderma viride* @ 0.5%	78.3 (69.08)	9.63 (20.18)	13.33 (23.79)	40.41	320.47	12.26	528.60	3.58
T_4	T1 + Root zone drenching with validamycin @ 0.1%	88.20 (77.63)	3.63 (12.28)	8.40 (18.46)	62.45	317.10	18.09	560.03	9.74
T_5	T1 + Root zone drenching with chitosan @ 0.5%	85.30 (74.89)	05.47 (15.07)	10.47 (21.00)	53.20	330.63	15.82	543.17	6.44
T_6	T1 + Root zone drenching with metalaxyl + mancozeb @ 0.2%	90.70 (80.36)	03.63 (11.81)	06.63 (16.43)	70.36	340.80	19.38	562.73	10.27

T_7	T2 + Root zone drenching with validamycin @	75.40 (66.94)	13.40 (23.91)	18.63 (28.45)	16.72	306.60	07.40	523.63	02.61
T_8	T2 + Root zone drenching with chitosan @ 0.5%	73.80 (65.75)	15.43 (25.79)	20.83 (30.23)	6.88	292.37	02.42	517.63	01.43
T_9	T2 + Root zone drenching with metalaxyl + mancozeb @ 0.2%	76.60 (67.78)	11.40 (21.89)	15.33 (25.52)	31.47	309.77	8.51	525.93	03.06
T10	T3 + Root zone drenching with validamycin @0.1%	80.60 (73.22)	08.37 (18.67)	12.47 (23.00)	44.26	328.73	15.15	536.87	05.20
T11	T3 + Root zone drenching with chitosan @ 0.5%	77.90 (71.85)	09.80 (20.36)	14.63 (24.91)	34.60	319.70	11.99	530.33	03.92
T12	T3 + Root zone drenching with metalaxyl + mancozeb @ 0.2%	83.90 (73.73)	06.63 (16.72)	09.43 (19.83)	57.85	324.53	13.68	540.20	05.85
T13	Untreated control SE (m)± C.D (5%)	70.60 (63.51)	18.83 (28.68)	22.37 (31.32)		285.47		510.33	
		01.07	0.89	0.99		0.94		0.81	
		03.15	02.63	02.93		02.80		02.38	

The result of wilt management in rice bean during kharif season 2020 revealed (Table-3) the performance of various combination of fungicides and bio-agent and found that treatment T6 (seed treatment with Carboxin + Thiram @ 0.2% followed by root zone drenching with Metalaxyl + Mancozeb (Ridomil) @ 0.2% was the best treatment compared to others.

The germination percentage was highest in T6 (90.70%) followed by T4 (88.20%), seed treatment with Carboxin + Thiram @ 0.2% followed by root zone drenching with Validamycin @ 0.1%) and T1 (86.5 %), (seed treatment with Carboxin+Thiram @ 0.2%).

The wilt incidence was recorded at 15 days after sowing and at 45 DAS which revealed that the least incidence of disease (6.63%) was recorded in T6 followed by 7.73% in T1 then 8.40% in T4 and they are statistically at par. In T6, seed treatment with Carboxin + Thiram (Vitavax power) @ 0.2% and root zone drenching with Metalaxyl+Mancozeb (Ridomil MZ) @ 0.2% found to reduce the disease by 70.36% compared to control.

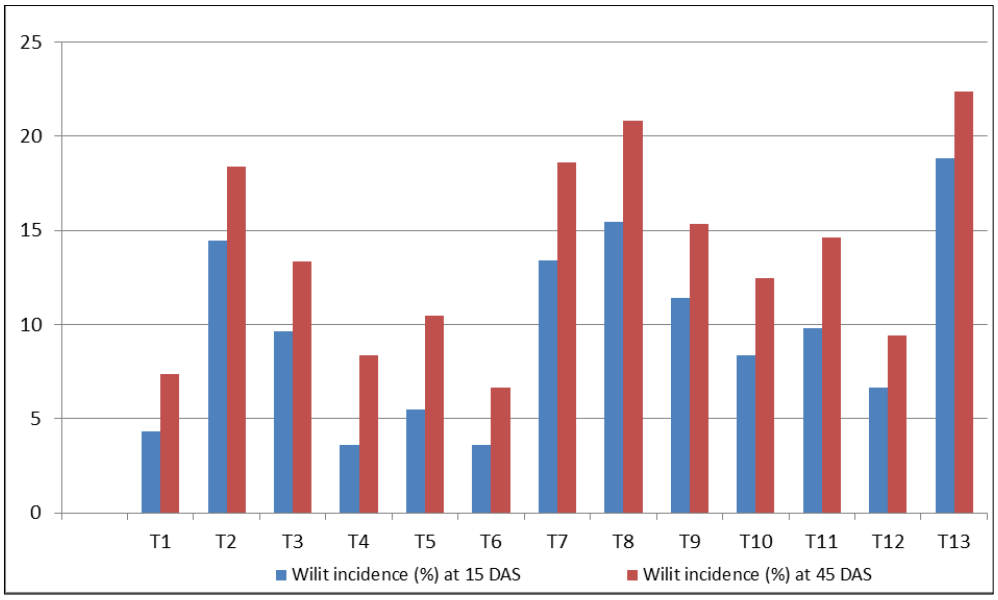

Fig 1: Percentage of wilt incidence in rice bean under different treatments

The T6 also recorded the highest Green fodder yield of 340.80 (q ha-1) and seed yield of 562.73 (kg ha-1) which increased yield by 19.38% and 10.27% respectively and was found to be the most efficacious compared to other treatments. The seed treatment with Vitavax power @ 0.2% followed by root zone drenching with Validamycin@ 0.1% i.e. T4 was found to be next best treatment which reduces the disease by 62.45% and also increased GFY by 18.09% and seed yield by 9.74% followed by T1.In T8, seed treatment with Chitosan (a polymer polysaccharide) @ 0.5% followed by root zone drenching with the same compound was found to be effective in reducing wilt at early stages of growth but it was non efficacious when severity increased at later stage. Studies conducted by Senthil (2003) [10] revealed that combination of seed treatment (4 g/kg seed) and soil application (2.5 kg ha-1) of *T. viride*, soil application of neem

cake 150 kg/ha and soil drenching of Mancozeb (0.3%) effectively suppressed *Fusarium* wilt of cowpea in Kerala and also appreciably increased the biomass and pod yield of crop. Ram and Pandey (2011) [8] demonstrated the effectiveness of *T. viride* as seed treatment alone which supports the present finding where *T. viride* seed treatment @ 5g/kg seed increased germination by 10.91% and reduced wilt by 40.41%. Integration of soil solarization with application of *T. harzianum*, neem extract and Captan (0.01%) resulted in 100% reduction of *Fusarium* wilt of tomato in the vegetable fields of West Bengal (Ojha and Chatterjee, 2012) [7]. So seed treatment followed by rootzone drenching with fungicide was found highly effective against management of *Fusarium* wilt.

Evaluation of cultivars of rice bean against *Fusarium oxysporum* pathogen

The reaction of seven cultivars of rice bean (JRBJ-10-2, Bidhan-2, Bidhan-3, JRBJ-10-3, KRB-110, JOR-19-1, JOR-19-2) against wilt disease was studied under field conditions as per the procedure described in materials and methods and are presented in Table: 4. The variety JRBJ-10-2 was the best performer with respect to increase in yield and reducing disease incidence in rice bean.

Table 4: Evaluation of rice bean varieties against wilt incidence, green fodder yield and other yield attributing parameters

Sl. No.	Rice bean Variety	Plant Height (cm)	Leaf stem Ratio	Green fodder yield (q ha-1)	Dry matter yield (q ha-1)	Wilt incidence (in %)	Resistance reaction
1	JRBJ-10-2	175.3	1.14	326.0	73.9	04.50	Resistant
2	KRB-110	142.4	1.03	250.2	55.2	18.30	Moderately resistant
3	JRBJ-10-3	159.4	0.98	259.3	55.6	13.60	Moderately resistant
4	JOR-19-1	135.7	0.88	219.8	49.5	22.50	Moderately susceptible
5	JOR-19-2	112.2	0.84	200.0	44.7	28.20	Moderately susceptible
6	Bidhan-3	172.7	1.09	295.8	68.1	07.00	Resistant
7	Bidhan-2	168.5	1.21	287.5	62.5	09.80	Resistant
SEM(±)		3.2	0.06	2.53	1.1	0.9	
CD (5%)		9.9	0.21	7.87	3.5	2.8	

From the data presented in table 4, it was revealed that no cultivar was found to be immune to wilt disease out of seven cultivars tested. The least incidence of (4.5%) was recorded in JRBJ-10-2 which was at par with Bidhan -3 (7%) and Bidhan-2 (9.8%). Both Bidhan-2 and Bidhan-3 are commonly grown by farmers and can be considered as checks compared to other five varieties. It was concluded from this study that the rice bean varieties JRBJ-10-2, Bidhan-2 and Bidhan-3 expressed wilt resistant reaction. The varieties KRB-110 and JRBJ-10-3 with incidence of (18.3%) and (13.6%) respectively expressed moderate resistant reaction whereas the varieties JOR-19-2 with (22.5%) and (28.2%) wilt incidence respectively were found to be moderately susceptible to disease. The green fodder yield (GFY) obtained was highest (326.0 q ha-1) in JRBJ-10-2. Followed by varieties Bidhan-3 and Bidhan-2 which recorded (295.8 q ha-1) and (287.5 q ha-1) of GFY respectively. The minimum GFY was recorded with JOR-19-2 (200 q ha-1). The highest dry matter yield (73.9 q ha-1) was recorded in JRBJ-10-2 followed by varieties Bidhan-3 and Bidhan-2 recorded DMY of (68.1 q ha-1) and (62.5 q ha-1) respectively. The variety JRBJ-10-2 attained maximum plant height 175.3 cm followed by Bidhan-3 (172.7 cm) and Bidhan-2 (168.5 cm). The highest leaf stem ratio of 1.21 was obtained with Bidhan-2 followed by JRBJ-10-2 (1.14), Bidhan-3 (1.09) and KRB-110 (1.03).

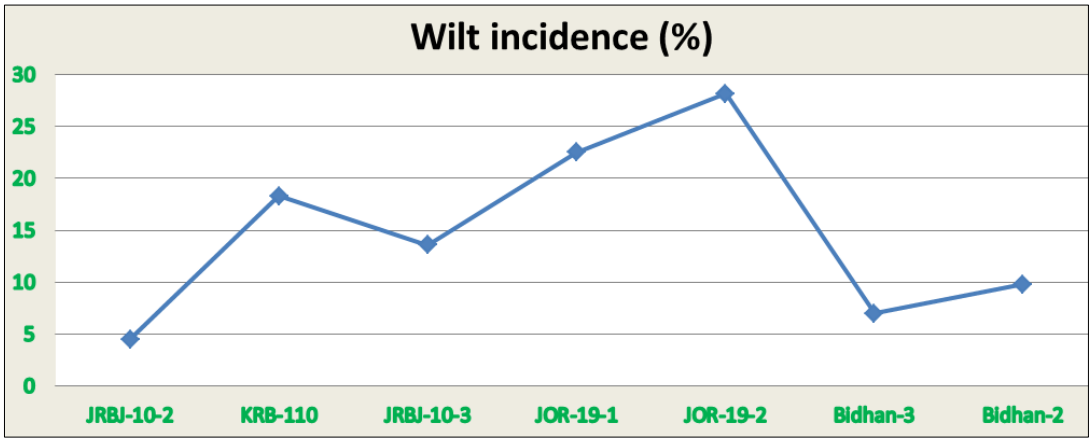

Fig 2: Performance of rice bean varieties against wilt incidence

Malhotra *et al*. (1988) [4] analysed thirteen promising strains of *Vigna umbellata* (RB-4,RB-17,RB-26,RB-32,RB-37,RB-39,RB-40,RB-44,RB-45,RB-46,RB-49,RB-53,RB-56) for anti nutritional factors and higher anti nutritional factor resulted lesser yield loss. Saharan *et al*. (2002) observed higher concentration of saponins, in varieties of faba bean (VH-82-1) and rice bean (RB-32) impart better disease resistance. Srinibas and Durairaj (2007) [9] and Nirmala *et al*. (2014) [6]. experimented on various genotypes of rice bean and identified the source of host resistance against soil borne fungus like *Fusarium oxysporum* incidence in rice bean. Such attempts would help further research in breeding for disease resistant varieties. Hence the varieties like JRBJ-10-2, Bidhan-2 & Bidhan-3 may be taken as a recommendation with integrated

disease management module in rice bean.

Conclusion

The results revealed that in rice bean variety JRBJ-10-2, Bidhan-2 and Bidhan-3 rerecorded host plant résistance to *Fusarium oxysporum* wilt with proper package and practices under rain fed condition in East and South Eastern Coastal Plain zone of Odisha. It was concluded from the study that seed treatment with Carboxin + Thiram @ 0.2% followed by root zone drenching with Metalaxyl + Mancozeb (Ridomil) @ 0.2% was the best treatment for wilt management in rice bean with highest germination percentage (90.70%) and least wilt incidence (6.63%) and reduction in disease incidence by 70.36% over control. It also produced the highest green fodder yield 340.80 (q ha-1) as well as highest seed yield of 562.73 (kg ha-1). The least wilt incidence of (4.5%) was recorded in cultivar JRBJ-10-2 followed by Bidhan-3 (7%) and Bidhan-2 (9.8%).

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Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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