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Evaluation of Castor Bean Varieties and Fungicides Application to Control Rust (*Melampsoraricini*) Disease

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Abstract: Castor bean (Ricinus communis L.) cultivation is affected by different abiotic and biotic factor constraints. Among the biotic factors rust caused by *Melampsoraricini* attack castor at young to old stage cause drying of leaves. It caused 60% of disease incidence and 30% of severity at Wondo Genet agricultural research center. The present study was undertaken to determine the efficacy of different fungicides with Castor bean varieties under field condition for the management of rust disease. Two registered varieties (Abaro and Hiruy), three registered fungicides (propiconazol 25%) (Atracole 32 SC), tebuconazole (Tilt 250 EC), triadimefon (Diprocon) and two controls with no spray treatments were used. The treatments were arranged in randomized complete block design (RCBD) with three replications. The fungicides were sprayed at the recommended rate on the diseased plants at 15day interval for five rounds. Data was recorded on disease severity, disease incidence, plant height, branch number and seed yield (kg)/ha). Among the treatments, Hiruy variety treated with Diprocon (DC=87.6%) was effective fungicides against castor rust disease control whereas, Abaro variety treated with Tilt (DC=60.1%) and Altracole (DC=60.1%) significantly controlled the rust disease under field condition. Thus, the susceptible variety with different fungicides and plant extracts should be studied further for integrated management of castor bean rust.

Keywords: Castor Bean, Rust, Fungicides, Disease Severity, Disease Control, Oil Content

1. Introduction

Castor bean (Ricinus communis L.) belongs to the family Euphorbiaceous and is the sole species of the genus Ricinus. Both Ethiopia and East Africa are mentioned as castor bean's center of origin [10]. It is nonedible oil-bearing plants adapted to dry lands of tropics and semi-arid tropics. The plant is believed to be native of East Africa and probably originated in Ethiopia where it shows tremendous variability. In Ethiopia, Castor grows as annual in the low lands to small tree perennial in the high lands. India, china, Brazil and USA are the major castor producers globally [2]. Castor bears seeds that containing highly valuable industrial oil. It is the only commercial source of a hydroxylated fatty acid or ricinoleic acid. The hydroxyl group in ricinoleic acid is important point of chemical reaction that allows several chemical reactions [8]. Castor oil is highly soluble in alcohol at room temperature that facilitates several chemical reactions [4]. Castor oil has also high viscosity over a wide range of temperatures which makes it a valuable ingredient of lubricants [18].

Mutlu and Meier [11] stated that castor oil is one of the most promising renewable raw materials for the chemical and polymer industries due to its manifold uses and to a series of well-established industrial procedures that yield a variety of different renewable platform chemicals. Castor oil is nonedible and has been used almost entirely for pharmaceutical and industrial applications [17]. Castor oil is unique among vegetable oil because it is the only commercial source of a hydroxylated fatty acid or ricinoleic acid. This unique fatty acid comprises about 90% of the castor oil [18]. No other commercial vegetable oil produces such a high level of ricinoleic acid. It appears that the level of ricinoleic acid is not significantly influenced by environment. Serverino [18] also reported that the high content of ricinoliec acid in castor allows the production of high purity derivatives.

In Ethiopia, castor does well under dry land or moisture stress areas in the rift valley, Eastern and North West Ethiopia. Castor germplasm collected with in Ethiopia is deposited in Institute of Biodiversity Conservation in Addis Ababa. During the last ten years the available germplasm have been characterized at Melkassa and Wondo Genet Agriculture Research Center for further multi location testing [5]. However, castor production constraints by different abiotic and biotic factors [7]. Among the biotic factors rust caused by *Melampsoraricini* attack castor at young to old stage cause drying of leaves and causes incidence (60%) and severity (30%) [13].

So far there is limitation of information on management option of this disease in our country. Evaluation of effective fungicides combining with different host plant resistance is the most effective pest management measures in integrated management strategies. Therefore, the aim of this proposal is to determine the efficacy of different fungicides with host plant resistance under field condition for the management of caster bean rust.

Objectives

1) To evaluate the effectiveness of fungicides with varieties of caster bean to control rust.
2) To identify effective fungicides for the integrated management measures to control rust.

2. Materials and Methods

2.1. Description of the study Area

The experiment was conducted at Wondo Genet Agricultural Research center and Alage site from July 2019 – July 2020 G. C. Wondo genet is located at 7° 192′ N latitude and 38° 382′ E longitudes with an altitude of 1780m above sea level. The site receives a mean annual rainfall of 1000 mm with minimum and maximum temperatures of 10°C and 30°C, respectively. The soil textural class is clay loam with an average pH of 6.4 [2]. Alage is located at longitude of 38° 30' East and a latitude of 7° 30' North, with an altitude of 1600 m.a.s.l. The site is characterized by mild tropical weather with a minimum and maximum temperature ranging from 11°C to 29°C and experiences a bimodal rainfall distribution with an annual average of 800m [12].

2.2. Experimental Design and Treatments Application

A total of eight treatments were used, namely two registered varieties (Abaro and Hiruy), three registered fungicides (propiconazol 25%) (Atracole 32 SC), tebuconazole (Tilt 250 EC), triadimefon (Diprocon) at recommended rate. There were also two controls with no spray. The treatments were arranged in randomized complete block design (RCBD) with three replications (Table 1).

A plot size of 3m × 4m with 60cm × 80cm spacing between plants and rows was used. Spacing between plots and blocks were 1.5m and 2m, respectively to reduce the drift of chemicals and spread of disease by wind and other factors.

Table 1. *List of treatment arrangement.*

No.	Treatments	Code
1	Abaro with Altracole 32 SC	AA1
2	Abaro with Tilt 250 EC	AT2
3	Abaro with Diprocon	AD3
4	Hiruy with Altracole 32 SC	HA4
5	Hiruy with Tilt 250 EC	HT5
6	Hiruy with Diprocon	HD6
7	Abaro control with no spray)	AC7
8	Hiruy control with no spray)	HC8

2.3. Data to Be Recorded

Percentage of disease incidence and severity was calculated by using the following formula.

$$\text{Disease incidence (I)}=\frac{\text{Number of infected plant units}}{\text{Total number (healthy and infected) units assessed}}\times 100 \quad (1)$$

$$\text{Disease severity (S)} = \frac{\text{Area of plant tissue affected by disease}}{\text{Total area of plant (tissue)}}\times 100 \quad (2)$$

Percent disease control (PDC) were calculated using the formula given by [24]. Thus, the Percent disease control was calculated using the following formula:

$$PDC=DC-DT/DC \quad (3)$$

Where, PDC: percentage disease control, DC: disease in control, DT: disease in treated plants.

Estimation of disease severity is made by visual disease assessment key. Disease intensity was assessed using 0 – 4 points rating scale, where 0=no disease (healthy); 1=1 to 25%, 2=26 to 50%; 3=51 to 75%; 4=76 to 100% leaf areas infected. Other agronomic data such as plant height, branch number, number of raceme /plant, length of main raceme (cm), number of capsules /raceme, seed yield (kg)/ha), and 100 seed weight were assessed.

2.4. Data Analysis

The collected data were subjected to analysis of variance (ANOVA) using stastical analysis Software version 9 [16]. Treatment mean separation were done by using least significant differences (LSD at P=0.05).

3. Result

3.1. Efficacy of Fungicides Against Rust on Castor Bean Varieties at Alage and Wondo Genet

The effect of fungicides against leaf rust disease in castor bean varieties were studied in two field locations. The result of the experiment showed that all fungicides applied on rust infested plots significantly ($P<0.05$) showed decreased severity of rust disease over untreated control plots (Table 2).

However, the rust disease incidence was higher at Alage location than Wondo Genet before the application of fungicides. As a result, the rust disease severity remains the same at both locations after fungicides application (Table 2). Among the tested fungicides on both locations, minimum disease severity on leaves were observed on Hiruy variety treated with Diprocon (DS=0.33), whereas maximum disease severity was obtained on Abaro variety treated with Diprocon (DS=2.00) after fungicides application. This indicated that Diprocon was effective in controlling the rust disease on Hiruy than Abaro variety. Hiruy variety treated with Altracole and Tilt (DS=1.00 each) showed reduced leaf rust infestation next to Diprocon on both locations. The fungicide Diprocon showed the best efficacy in controlling rust followed by Altracole for Hiruy variety. Abaro variety treated with Altracole and Tilt showed lower rust severity (DS=1.33 each). The variety Hiruy showed reduced rust severity than the Abaro variety.

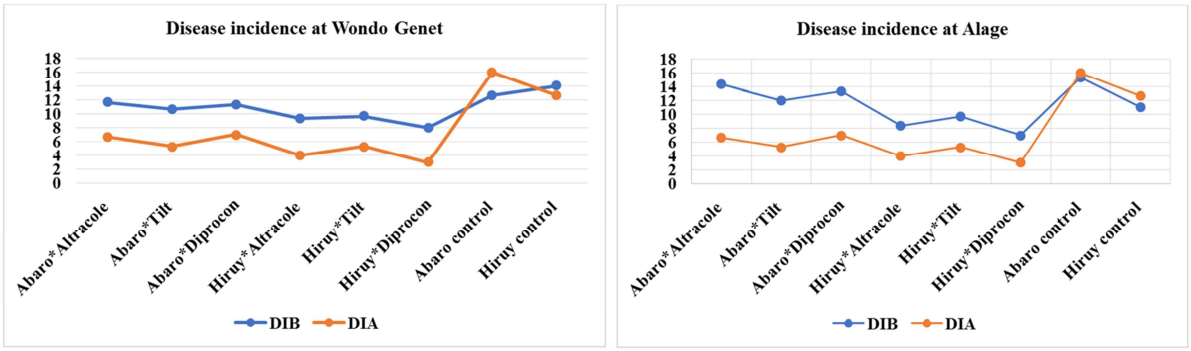
Table 2. *Mean effect of different fungicides and variety on rust severity of castor rust at Wondo genet and Alage.*

No.	Treatments	DSBwg	DSAwg	DSBag	DSAag
1	Abaro*Altracole 32 SC	11.66 abc	1.33 cd	14.33 a	1.33 cd
2	Abaro*Tilt 250 EC	10.66 bcd	1.33 cd	12.00 abcd	1.33 cd
3	Abaro*Diprocon	11.33 abc	2.00 bc	13.33 abc	2.00 bc
4	Hiruy*Altracole 32 SC	9.33 cd	1.00 cd	8.33 de	1.00 cd
5	Hiruy*Tilt 250 EC	9.66 bcd	1.00 cd	9.66 cde	1.00 cd
6	Hiruy*Diprocon	8.00 d	0.33 d	7.00 e	0.33 d
7	Abaro control (no spray)	12.66 ab	3.33 a	15.33 a	3.33 a
8	Hiruy control (no spray)	14.00 a	2.66 ab	11.00 cbd	2.66 ab
	CV %	17.25	37.08	18.55	37.08
	LSD (0.05)	3.29	1.05	3.69	1.05

DSBwg=disease severity before at wondo genet, DSAwg=disease severity after at wondo genet, DSBag=disease severity before at alage, DSAag=disease severity after at alage

3.2. Leaf Rust Disease Incidence Before and After Fungicides Application

The graph below indicated that the castor bean rust incidence was higher before treatment application (Blue line) at wondo Genet location and the rust incidence reduced after fungicide application (red line) except for untreated control plot. Similarly, the disease incidence was high before fungicide applications and low after application at Alage location (Figure 1 (a) and (b)).



(a) (b)

Figure 1. *Efficacy of fungicides against castor bean rust at (a) Wondo Genet and (b) Alage.*

Table 3. *Efficacy of different fungicides for the control of leaf rust disease on castor plant varieties at both locations.*

No.	Treatments	Disease Severity	Disease control
1	Abaro*Altracole 32 SC	1.33 cd	60.1
2	Abaro*Tilt 250 EC	1.33 cd	60.1
3	Abaro*Diprocon	2.00 bc	39.9
4	Hiruy*Altracole 32 SC	1.00 cd	62.4
5	Hiruy*Tilt 250 EC	1.00 cd	62.4
6	Hiruy*Diprocon	0.33 d	87.6
7	Abaro control (no spray)	3.33 a	-
8	Hiruy control (no spray)	2.66 ab	-

PDC=DC-DT/DC, Where, PDC: percentage disease control, DC: disease in control, DT: disease in treated plants.

3.3. Disease Severity Reduction in Percent (Disease Control)

The disease severity reduction percent indicated that Hiruy variety treated with Diprocon showed the highest control of rust disease on both locations. The disease control was higher on Hiruy variety treated with Diprocon (DC=87.6%) followed by Altracole and Tilt (DC=62.4% each). Altracole and Tilt (DC=60.1% each) was effective in controlling rust disease on Abaro variety. However, Diprocon was less effective in rust disease control on Abaro variety. (Table 3).

3.4. Biometrical Observation

The agronomic data result revealed that there were significant differences (P<0.05) in plant height, branch number,

100 seed weight, seed yield and Oil yield among treatments at both locations. The highest plant height was observed on Hiruy (PH=3.98) than Abaro variety. The highest branch number was recorded on Abaro variety (BN=5.26) than Hiruy variety. Hiruy variety had the highest seed weight per hundred (SW=75.06) than Abaro variety (Table 4).

The highest seed yield was recorded from Hiruy variety treated with Diprocon fungicide (312.73 kg/ha) at wondo genet location and Abaro variety untreated control (267.87 kg/ha) at Alage site. The highest oil yield was recorded on the Abaro variety treated with Altracole (42.73kg/ha) at Wondo genet at Wondo Genet location and Hiruy variety untreated control (43.36kg/ha) at Alage location (Table 4).

4. Discussion

In the present study, two castor bean varieties and three fungicides were studied. Hiruy variety was less susceptible to rust than Abaro variety. The fungicides Diprocon was effective in controlling the rust disease on Hiruy variety and less effective on Abaro variety. Tilt and Altracole were effective in controlling the rust disease on both varieties. Resistant cultivars and fungicides have been the main recommended measures for the control of rust diseases.

According to Singh [19] Triadimefon gave good control of rust on French bean in India. It reduced the severity of French bean rust by 55%. Singh and Bahat reported a reduction in pea rust intensity by about 36% in response to the application of Triadimefon. Scherm [17] also found that triazoles performed significantly better in controlling soybean rust severity and increasing yield. These fungicides are effective in controlling some plant pathogens at low doses and induce little or no resistance in phytopathogenic fungi [9]. Oils have a fungistatic effect rather than fungicidal effect, possibly indicating a temporary effect on host physiology [15].

Vegetable oil-based fungicides could represent a good alternative to chemical fungicides [15, 14]. Literature data concerning assessments of the effectiveness of vegetable and mineral oils in the protection of plants against the pathogens, which are the causal agents of rust, are very limited [21-23]. Powder from the seed kernels and leaves has been found to be suppressive against some diseases [1]. Sindhan and Hooda [20], reported bulb extracts of Allium sativum (garlic) and A. cepa (onion) more effective than eucalyptus leaf extract for the control of white rust of castor. It is evident from several reports that plant extracts are effective bio control agents against a wide range of plant pathogens [6].

The application of plant oils for the control of rust diseases of castor bean could be less expensive, easily available, non-polluting and eco-friendly. Unlike many fungicides, resistance to plant oils has not been reported yet. Integrated pest management (IPM) control strategies are needed with the ultimate goal of the management of these rust diseases with little or no synthetic fungicides used within a growing season. Therefore, one of the ways to achieve this goal in IPM may be the use of natural substances that have no adverse effects on environmental or human health.

Table 4. *Mean effect of fungicides for the control of rust on agronomic and yield characters of castor bean varieties at Wondo Genet and Alage location.*

No.	Treatments	Wondo Genet					Alage				
		PH	BN	100SW	SYkg/ha	OYkg/ha	PH	BN	100SW	SYkg/ha	OYkg/ha
1	Abaro*Altracole 32 SC	2.36 b	3.53 a	52.63 d	219.30 d	42.73 a	3.21 b	3.93 ab	62.12 a	258.87 a	38.15a
2	Abaro*Tilt 250 EC	2.56 ab	4.00 a	70.53 abc	293.87 abc	28.91 b	3.35 b	4.20 ab	62.07 a	258.63 a	40.87a
3	Abaro*Diprocon	2.49 b	4.53 a	59.88 bcd	249.50 bcd	39.68 ab	3.51 b	5.33 ab	62.69 a	261.23 a	39.44a
4	Hiruy*Altracole 32 SC	3.98 a	4.44 a	59.04 cd	246.00 cd	36.86 ab	4.32 a	3.53 b	52.27 a	217.80 a	40.36a
5	Hiruy*Tilt 250 EC	2.78 ab	3.60 a	67.20 abc	280.03 abc	37.89 ab	4.30 a	4.46 ab	53.38 a	222.47 a	37.28a
6	Hiruy*Diprocon	2.90 ab	4.60 a	75.06 a	312.73 a	38.75 ab	4.28 a	6.40 a	50.73 a	211.40 a	38.53a
7	Abaro control (no spray)	2.57 ab	5.26 a	56.93 cd	237.20 cd	35.48 ab	3.30 b	4.66 ab	64.28 a	267.87 a	38.170a
8	Hiruy control (no spray)	2.67 ab	4.00 a	73.18 ab	304.97 ab	37.35 ab	4.72 a	4.60 ab	54.64 a	227.70 a	43.36a
	CV %	29.08	30.93	12.25	12.26	18.44	7.60	30.39	13.4	13.4	12.00
	LSD (0.05)	1.42	2.27	13.8	57.52	12.01	0.51	2.47	13.60	56.69	8.86

PH=plant height. BN=branch number, 100SW=one hundred seed weight, SY=seed yield, OY=Oil yield

5. Conclusion

The present study illustrated that the tested fungicides were effective for managing rust disease on castor bean varieties. Among the tested fungicide treatments, Diprocon significantly controlled the rust disease on Hiruy variety compared to the other treatments. Whereas, Tilt 250 EC and Altracole 32 SC significantly controlled the rust disease on Abaro variety compared to the other treatments. However, Diprocon on Abaro variety and Tilt on Hiruy variety were not effective in controlling the rust disease severity. Thus, fungicides were less effective due to certain fungicides can only protect plants from rust disease.

Minimum disease severity on leaves were observed in Hiruy variety treated with Diprocon (DS=0.33) on both locations. This implies Hiruy variety treated with Diprocon showed the highest disease reduction in disease severity (DS=0.33, DC=87.59%) whereas for Abaro variety, high disease severity and lower disease control was observed by Diprocon (DS=2.00, DC=39.93%). The highest seed yield was recorded from Hiruy variety treated with Diprocon fungicide (375.30gm).

Abaro variety at Alage and Wondo Genet location was very susceptible for rust disease than Hiruy variety. Diprocon was more effective for Hiruy variety rust management than

the other fungicides and variety. Tilt and Altracole were effective for the management of Abaro castor variety rust disease. Therefore, Diprocon, Tilt and Altracole 32 SC were effective for the management of castor rust disease depending on varieties and have the potential to be a vital component of integrated pest management of rust disease. The cost benefit analysis should be conducted for the effective fungicides. Thus, further study should test the rust resistance variety and the effective fungicides as a component of integrated pest management and provide effective and safer castor rust disease management. In addition, the rust susceptible variety should be studied further by incorporating different plant extracts to find out effective plant oils for castor bean rust management.

Conflicts of Interest

All the authors do not have any possible conflicts of interest.

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