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Integrated disease management of downy mildew in bottle gourd (*Lagenaria siceraria* (Mol.) Stand)

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Abstract
Downy mildew disease of bottle gourd (*Lagenaria siceraria* (Mol.) Standl) is one of the most important foliar diseases, causing significant loss in India. downy mildew disease found to cause serious losses in bottle gourd crop throughout Rajasthan and other states. Characteristic symptoms are first appear as pale green area on the upper surface of leaves that changes to bright yellow angular or rectangular spots. Leaf spot are irregular or blocky in appearance and are delimited by leaf veins. The minimum disease incidence (4.09%) and maximum yield (338.5q/ha) were observed in treatment T_5(T_0+ Seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of Captan 70% +Hexaconazole 5% WP @ 0.1% 15 days after germination followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% at 10 days interval) while maximum disease incidence (28.54%)and minimum yield (225.7 q/ha)were observed in treatment T_7(Control). Natural products such as herbal extracts may provide alternatives to synthetic fungicides.

Keywords: *Lagenaria siceraria*, downy mildew, integrated disease management

Introduction
Bottle gourd [*Lagenaria siceraria* (Mol.) Standl] is a commonly grown vegetable crop in India, which is also grown in Ethiopia, Africa, Central America and other warmer regions of the world. It is widely grown on open fields as well as in river beds throughout the year. It is also suitable for cultivation in hot dry areas. The fruits can be used as a vegetable or for making sweets. As a vegetable, it is easily digestible, even by patients [1]. It is gaining importance due to its high yield potential, steady market price throughout the season. The fruits contain 0.2% protein, 2.9% carbohydrates, 0.5% fat and 11 mg of vitamin C per 100 g fresh weight [2]. It also has wide medicinal properties such as laxative, digestive and to prevent constipation. There are many factors responsible for the low yield of cucurbits crop production and among them fungal diseases play an important role. The crop is attacked by a number of diseases such as, *Cercospora* leaf spot, *Alternaria* leaf blight, *Sclerotium rolfsii*, *Fusariumn oxysporium* , powdery mildew, downy mildew and anthracnose, Among the various fungal diseases *Pseudoperonospora* causing downy mildew disease are among the most destructive pathogens that attack this vegetable crop [3]. These pathogens cause considerable losses in yields in the field and greenhouse all over the world [4].

Chemical fungicides have been used as the main strategy for control of these fungal diseases and subsequently increase crop production. Unfortunately, the overzealous and indiscriminate use of most of the synthetic fungicides has created different types of environmental and toxicological problems [5]. The development and utilization of ecofriendly botanical alternative have been the main focus of researchers and environmentalists, due to public concern over the toxicity and environmental impact of these conventional synthetic pesticides.

Hence, newer approaches are being explored and one important option is the use of botanical pesticides. Pesticides derived from natural sources support both crop production and the environment by being effective in the plant pathogen management, biodegradable, and are safer than synthetic fungicides Chandra [6]. The pathogen has wide geographical distribution and has been reported in over 100 countries, including environments ranging from semi arid to tropical. This pathogen has a wide host range, infecting approximately 20 different genera of cucurbits [7, 8].

Characteristic symptoms are small gray or white irregular spots with black margin; the centers of these leaf spots are light brown. So far, information available on disease management of downy mildew of bottle gourd under hot arid condition is scanty.

Keeping in view, the present study was therefore designed to investigate the efficacy of cultural, chemical and plant extracts in an integrated manner to the management of downy mildew of bottle gourd in semi arid conditions in Rajasthan.

2. Materials & Methods

2.1 Site and design of Experiment

The field trials were conducted during rainy season of 2015 to2018 at Rajasthan Agricultural Research Institute, Durgapura, Jaipur in vegetable block.

2.2 Treatments of Experiment

A bottle gourd variety "Pusa Naveen" was sown on *Kharif* in all years in the field in Randomized Block Design with three replications for integrated management of downy mildew of bottle gourd through botanical, fungicides, insecticide and their different combinations.

T_0: Growing of two rows of maize as border crops and use of agrisilver mulch sheet.

T_1: T_0 + Seed treatment with Seed Pro @ 25 g/kg and soil drenching of Seed Pro @ 5% at 1st true leaf stage after germination followed by 5-6 spray of Seed Pro (1%) at 10 day interval in rotation with Neem oil (0.2%) alternatively after 15 days after drenching.

T_2: T_0 + Seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of Captan 70% +Hexaconazole 5% WP @ 0.1% at 1st true leaf stage after germination followed by 5-6 spraying of Seed Pro (1%) at 10 day interval in rotation with Neem oil (0.2%) alternatively after 15 days after drenching.

T_3: T_0 + Seed treatment with Seed Pro @ 25 g/kg and soil drenching of Seed Pro @ 5% 1st true leaf stage after germination followed by spraying of Captan 70% + Hexaconazole 5% WP @ 0.1% followed by spraying of (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% followed by Captan 70% + Hexaconazole 5% WP @ 0.1% followed by spraying of (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% at 10 days interval.

T_4: T_0 + Seed treatment with Seed Pro @ 25 g/kg and soil drenching of Seed Pro @ 5% at1st true leaf stage after germination followed by spray of (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by spray of Tebuconazole 50%+Trifloxystrobin 25% @1g/l followed by Fosetyl-Al @ 0.1%, followed by spray of Tebuconazole 50%+Trifloxystrobin 25% @1g/l followed by spray of (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% at 10 days interval.

T_5: T_0 + Seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of Captan 70% +Hexaconazole 5% WP @ 0.1% 15 days after germination followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% at 10 days interval.

T_6: T_0 + Seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of Captan 70% +Hexaconazole 5% WP @ 0.1% 15 days after germination followed by spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by spraying of Captan 70% +Hexaconazole 5% WP @ 0.1% followed by Fosetyl-Al @ 0.1% followed by spraying of Captan 70% +Hexaconazole 5% WP @ 0.1% + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%)%) followed by Fosetyl-Al @ 0.1% at 30 days after drenching and

T_7: Control

Downy mildew disease was observed in the field during both the years.

2.3 Disease severity scale

Disease severity (%) was determined according to the scale of [9]. Plants of each particular treatment were classified into categories as follows: 0 = leaves completely healthy; 1 = 1-2 spots per leaf; 2 = 3-5 spots per leaf; 3 = 6-10 spots per leaf; 4 = up to 25 percent of the leaf area affected; 5 = up to 50 percent of the leaf area affected; 6 =up to 75 percent of the leaf area affected; 7 = more than 75percent of the leaf area affected. The percentage of disease severity (D.S) for each particular treatment was calculated using the following formula:

$$\text{D. S.} = \frac{\Sigma \text{ (Number of infected leaves} \times \text{the representative value of each grade)}}{\text{[Total no. of leaves observed per plant} \times \text{the value of the highest grade 7]}} \text{ X } 100$$

The disease intensity was recorded at just initiation of disease and subsequent recordings were made at weekly intervals from 05 randomly selected plants from each net plot. Data were subjected to analysis of variance (combined for the three years) to determine any significant effects of the different treatments. The experimental data was analysed by using standard methods to test of the significance [10].

3. Results

3.1 Percent Disease Intensity

Data on disease intensity of downy mildew disease are presented in Table 1. All the treatments were found superior than control in case of disease intensity. Downy mildew disease was found with ranging from 4.09 to 28.54 per cent disease intensity. Among 7 treatments, minimum disease intensity was observed in treatment T_5(4.09): (T_0 + Seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of Captan 70% +Hexaconazole 5% WP @ 0.1% 15 days after germination followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% at 10 days intervals) with maximum yield (338.5Q/ha). Treatment T_5 and T_6 are Statistically at per each other.

The next best treatment was observed T_6 (4.79 PDI)(T_0 + Seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of Captan 70% +Hexaconazole 5% WP @ 0.1% 15 days after germination followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% at 10 days interval.) with

yield(324.8Q/ha) and maximum disease intensity was observed in treatment T_7(28.54) with minimum Yield(225.7Q/ha).

Table 1: Integrated Disease Management of Downy Mildew Disease in Bottle Gourd

Treatments	PDI (Downy mildew)	Yield Q/ha
T1	18.96(25.75)*	276.2
T2	16.61(23.98)	285.5
T3	7.32(15.61)	310.4
T4	9.63(18.12)	301.3
T5	4.09(11.50)	338.5
T6	4.79(12.47)	324.8
T7	28.54(32.16)	225.7
SEM ±	1.50	32.16
CD 5%	0.528	11.29

Figures in parentheses are angular transformed value

4. Discussion

Bottle gourd [*Lagenaria siceraria* (Mol.) Standl] is a commonly grown vegetable crop in India. The crop is attacked by a number of diseases such as, *Cercospora* leaf spot, *Alternaria* leaf blight, *Sclerotium rolfsii*, *Fusariumn oxysporium*, powdery mildew, downy mildew and anthracnose, Among thevarious fungal diseases *Pseudoperonospora* causing downy mildew disease are among the most destructive pathogens that attack this vegetable crop. Keeping in mind, it is advisable to the growers to manage downy mildew disease of bottle gourd by adopting management measures of combine treatments(T_0+ Seed treatment with carbendazim 12%+ mancozeb 63% @ 3 g/kg and drenching of Captan 70% +Hexaconazole 5% WP @ 0.1% 15 days after germination followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% followed by spraying of Tebuconazole 50% + Trifloxystrobin 25% @1g/l + spray with (Imidacloprid 17.8 SL @ 7.5 ml/ 15 l + Neem oil 0.2%) followed by Fosetyl-Al @ 0.1% at 10 days interval) This disease may attains an alarming status and may wreak havoc in bottle gourd growing areas if not taken care well in time. Therefore, it is need of the hour to know effective management strategy against this dreaded disease of the crop.

Neem oil derived from *Azadirachta indica* is a botanical control for downy mildew disease on cucurbits [11, 12] studied plant extract on cucumber against downy mildew disease give result all plant extract significantly suppressed the incidence and severity of downy mildew disease and thus enhanced the relative disease control. Also reported that plant extracts significantly reduce the disease severity of downy mildew [13] [14] also supported our study that application of Dithane M-45 (0.3%) at 15 day interval is good to control the downy mildew disease in cucurbits.

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