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Integrated management of wet root rot, yellow mosaic, and leaf crinkle diseases of urdbean by seed treatment and foliar spray of insecticide, fungicide, and biocontrol agent

S.C. Dubey*,[1], Birendra Singh, Aradhika Tripathi

Division of Plant Pathology, ICAR-Indian Agricultural Research Institute, New Delhi, 110012, India

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ABSTRACT

Various seed treatment combinations comprising insecticide, fungicide, and a biocontrol agent along with foliar sprays of insecticides were evaluated for the management of leaf crinkle (*Urdbean leaf crinkle virus* [ULCV]), yellow mosaic (*Mungbean yellow mosaic virus* [MYMV]), and wet root rot (WRR; *Rhizoctonia solani*) diseases of urdbean (*Vigna mungo*) under field conditions. Seed treatment with a combination of imidacloprid, carboxin + tetramethylthiuram disulfide (TMTD), and Pusa 5SD (*Trichoderma virens*) provided the highest seed germination (77.5%) and grain yield (953.3 kg/ha) with the lowest WRR (3.7%), mungbean yellow mosaic (MYM, 17.2%), urdbean leaf crinkle (ULC, 12.1%) diseases, and whitefly population (13.5–6.7 per plant). Among foliar sprays, the first spray of imidacloprid at 30 days after sowing (DAS) followed by the second spray of spinosad at 45 DAS showed less disease development (10.6% MYM and 7.5% ULC diseases) and whitefly populations (21.2–2.1 per plant) with the highest grain yield (1035.4 kg/ha). Among the interactions of seed treatment and foliar spray, a combination of seed treatment with imidacloprid, carboxin + TMTD, and Pusa 5SD (*T. virens*) and foliar sprays of imidacloprid and spinosad at 30 and 45 DAS, respectively, provided the lowest incidence of all three diseases (2.9% WRR, 7.0% yellow mosaic, and 4.2% leaf crinkle diseases) and whitefly populations (11.7–1.0 per plant) along with the highest grain yield (1258.6 kg/ha). Identical seed treatments may be combined with foliar sprays of dimethoate and spinosad at 30 and 45 DAS, respectively. These seed treatments and foliar sprays individually and in combinations reduced the whitefly populations responsible for the spread of the viral diseases.

1. Introduction

Urdbean (*Vigna mungo* (L.) Hepper) commonly known as black gram is an important grain legume cultivated in various parts of South East Asia and Africa. Several biotic and abiotic factors are responsible for the low productivity of the crop. Among biotic factors, urdbean leaf crinkle (ULC; *Urdbean leaf crinkle virus* [ULCV]), mungbean yellow mosaic (MYM; *Mungbean yellow mosaic virus* [MYMV]), and wet root rot (WRR; *Rhizoctonia solani* Kühn) diseases are the major constraints, and these diseases cause considerable yield loss (Nene, 1988; Ravinder Reddy et al., 2006; Dubey and Singh, 2013; Gautam et al., 2016). ULC disease causes 35–81% yield loss depending upon genotypes, location, and stages of crop infected (Bashir et al., 1991). Among previous studies, Kadian (1982) reported up to 95% grain yield loss of the most popular variety of urdbean T9 because of the ULC disease. Another estimate showed up to 100% grain yield loss because of the ULC disease (Kanimozhi et al., 2009). MYM disease results in US$ 350 million loss annually in urdbean, mungbean, and soybean in India (Varma et al., 1992).

Both ULCV and MYMV are transmitted by the whitefly *Bemisia tabaci* Genn. (Dubey and Singh, 2010; Baranwal et al., 2015). Additionally, ULCV is transmitted through soil inoculation, grafting, and seeds. In India, the majority of the urdbean varieties are susceptible to MYMV, and those varieties that are tolerant to the MYM disease are highly susceptible to the ULC disease (Beniwal et al., 1979; Varma et al., 1998; Dubey and Singh, 2016). Therefore, the management of the ULCV along with MYMV is more important. WRR disease also causes substantial yield loss in India (Dubey, 2003; Dubey and Singh, 2013). This disease caused up to 57% yield loss of mungbean in Iran (Kaiser, 1970). The WRR disease incidence caused by *R. solani* ranged from 6.8% to 22.2% in pulse crops including urdbean in 16 agro-ecological regions of India covering 21 states and 72 districts (Dubey et al., 2014).

* Corresponding author. Division of Plant Quarantine, ICAR-National Bureau of Plant Genetic Resources, New Delhi, 110012, India.
E-mail address: sunil.dubey@icar.gov.in (S.C. Dubey).
[1] Present address-Division of Plant Quarantine, ICAR-National Bureau of Plant Genetic Resources, New Delhi 110012, India.

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Because this disease is primarily soil and seed borne, its management is difficult after the appearance of the disease in the field. Seed treatment with either chemicals or bioagents is only the option available for farmers. The *Trichoderma virens*–based bioformulation Pusa 5SD proved effective against *R. solani* that causes WRR (Dubey et al., 2011; Dubey and Singh, 2013).

The most economical and practical approach to manage these diseases is to grow resistant cultivars. The lack of resistance of cultivars against these diseases is one of the major limitations (Varma et al., 1998; Karthikeyan et al., 2009; Dubey and Singh, 2013). Because both ULCV and MYMV are transmitted by insect vectors, insecticidal spray is the best option available to manage them. In an earlier study, it was observed that a combination of seed soaking in 0.1% imidacloprid for 2 h and dry seed treatment with carbendazim + thiram followed by a foliar spray of imidacloprid and carbendazim was found as the best treatment to minimize MYMV and Cercospora leaf spot (CLS) disease with a higher grain yield of urdbean (Dubey and Singh, 2006). In case of mungbean, thiamethoxam proved to be superior compared to imidacloprid (Dubey and Singh, 2010). The insecticides dimethoate and spinosad were found to be effective in controlling the population of insects including whitefly, which is known as a vector of viral diseases (Yadav and Singh, 2014; Yadav et al., 2015; Kumar et al., 2017). In previous studies, ULC disease has not been considered, as it was considered as a minor disease with irregular appearance, but presently, it has become a major threat to the urdbean cultivation, especially for the varieties that are tolerant to MYMV.

Therefore, the present study was conducted with an aim to manage ULCV along with MYMV and WRR by application of the insecticides imidacloprid, dimethoate, spinosad, and the *T. virens*–based seed dressing bioformulation Pusa 5SD.

2. Materials and methods

Experiments were conducted in field during rainy seasons of 2013 and 2014 at Indian Agricultural Research Institute, New Delhi, in a factorial randomized block design. Two factors as seed treatment at three levels (Table 2) and foliar spray at twelve levels (Table 3) totaling to 36 treatment combinations consisting of insecticides (imidacloprid, dimethoate, and spinosad), fungicides (carbendazim and thiram individually and as a combined formulation), and a biocontrol agent (*T. virens*–based Pusa 5SD-) were evaluated (Table 4) in three replications. Sowing of the highly susceptible urdbean variety Barabanki local was done on July 24, 2013, and July 26, 2014, in a plot of size 9 m^2 and with 25 cm × 10 cm spacing.

Seed treatment was done with the insecticide imidacloprid (6 g/kg); the fungicide carbendazim (1 g/kg) and thiram (1 g/kg) individually and in combination as Vitavax Power (2 g/kg), a combined formulation of carbendazim and thiram as per treatment combinations (Tables 1 and 2); and the *T. virens*–based seed dressing bioformulation Pusa 5SD at 4 g/kg (10^8 CFU/g) seed in combination with pesticides. The sprays of imidacloprid (0.1%), dimethoate (0.15%), and spinosad (0.05%) were applied on 30 and 45 days after sowing (DAS) as required in the respective treatments (Tables 1 and 3). The controls were kept untreated and water sprayed. ASPEE Green Magic Knapsack Sprayer (AGM/001) with NTM nozzle (M/s Navyug Krishi Sadhan Private Limited, India) was used to apply pesticide spray at 500 L/ha (0.45 L/plot).

Plant emergence was recorded on 15 DAS, and the incidence of WRR and ULC diseases was recorded 10 days after the last spray by using the formula Disease incidence (%) = Number of plants showing disease symptoms x 100/total plant stand (Dubey and Singh, 2013). The intensity of MYM disease was measured by using a scale with 1–9 points (1 = no visible symptoms on leaves, 2 = small lesions with up to 5% leaf area infected, 3 = 6–25% of the leaf area infected, 5 = 26–50% of the leaf area infected, 7 = 51–75% of the leaf area infected, and 9 = more than 75% of the leaf area infected). Three to four plants per row depending on plant populations were randomly selected for disease scoring 10 days after the last spray. Eight leaves per plant were randomly selected from the bottom to the top of the plant for scoring. Three hundred randomly selected leaves per replication were considered for calculation of disease intensity by using the formula Disease intensity (%) = Sum of all disease ratings x 100/total number of rating x maximum grade (Dubey and Singh, 2010). Numbers of whitefly were counted on five randomly selected plants per replication on 25 DAS and 5 days after the first and second sprays (35 and 50 DAS). The grain yield/plot was also measured after harvesting the crop.

The data recorded were analyzed for all the parameters and subjected to analysis of variance (ANOVA). The observations recorded in percentage were transferred into angular values before analysis (Gomez and Gomez, 1984) using SAS software (SAS Institute, version 9.1, Cary, NC). The effect of treatments on all variables was determined by pooled analysis, and the mean of two years' data is presented in tables. Fisher's protected least significant difference (LSD) was computed only when ANOVA showed significant differences for any particular effect.

Table 1
Fungicide and insecticides used for seed treatment and foliar spray on urdbean.

Fungicide/ Insecticide	Active ingredient	Application rate
Bavistin[a]	Carbendazim (50%)	1 g/kg seed in combination
Thiram[b]	Tetramethylthiuram disulfide (75%)	1 g/kg seed in combination
Vitavax power[c]	Carboxin (37.5%) + Thiram (37.5%)	2 g/kg seed
Gaucho[d]	Imidacloprid (48%)	6 ml/kg seed
Confidore[d]	Imidacloprid (17.8%)	1 ml/L of water (0.1%)
Rogor[e]	Dimethoate (30%)	1.5 ml/L of water (0.15%)
Tracer[f]	Spinosad (45%)	0.5 ml/L of water (0.05%)

[a] Provided by Crystal Crop Protection.
[b] Provided by Modern Insecticide Limited.
[c] Provided by Dhanuka Agritech Limited.
[d] Provided by Bayer Crop Sciences.
[e] Provided by Cheminora India Limited.
[f] Provided by Dow AgroSciences.

3. Results

A similar trend of observations for all the variables recorded was obtained for both years of experimentation. Therefore, the mean value of two years' data is presented after pooled analysis.

3.1. Effect of seed treatment

The effect of seed treatment was significant (p = 0.05) for all the variables represented by the mean value. The effect of seed treatment (Table 2) clearly indicated that both seed treatment combinations, namely, T1 (imidacloprid 6 ml/kg + carbendazim 1 g/kg + TMTD 1 g/kg + Pusa 5SD (*T. virens*) 4 g/kg (10^8 CFU/g)) and T2 (imidacloprid 6 ml/kg + carboxin + TMTD (Vitavax Power) 2 g/kg + Pusa 5SD (*T. virens*) 4 g/kg (10^8 CFU/g)), were significantly superior compared to the untreated control (T0) for all the variables recorded. The seeds treated with a combination of imidacloprid + carboxin + TMTD + Pusa 5SD (*T. virens*) (T2) provided the highest seed germination (77.5%) and grain yield (953.3 kg/ha) along with the lowest incidence of WRR (3.7%), MYM (17.2%), and ULC (12.1%) diseases and whitefly population on 35 (5.3 per plant) and 50 (6.7 per plant) DAS following treatment T1. The whitefly population recorded in these two treatments on 35 and 50 DAS was statistically similar.