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Influence of Fungicidal Spray on Powdery Mildew Epidemics and Major Yield-Attributing Characters of Mungbean

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The influence of fungicidal spray was assessed on powdery mildew epidemics caused by *Erysiphe polygoni* D.C. and on yield-attributing characters of mungbean [*Vigna radiata* (L.) Wilczek]. Mildew attack adversely affected the yield-attributing characters of mungbean and exhibited negative significant correlation with pod length (-0.57), pods/plant (-0.74), pod weight (-0.68), 100 seeds weight (-0.69), 100 seeds swell weight (-0.59), and seed germination (-0.71). These characters had direct or indirect effects on grain yield, which was also adversely affected due to mildew attack (-0.89). Powdery mildew was significantly retarded due to the single spray of carbendazim (0.05%) at 30-day-old crop, where the apparent rate of infection (r) was minimum at 0.0095/unit/day and with low (11.44%) powdery mildew intensity. Other fungicides like tridemorph (0.075%) and penconazole (0.05%) were equally effective against the mildew disease where the disease intensity was less than 20% and the values of r were 0.0134 and 0.039/unit/day respectively, as compared with the control at 0.267/unit/day. Fungicide spray influenced the yield-attributing characters besides controlling the disease. Such effects were more pronounced in carbendazim (0.05%)-treated plots due to its phytotonic nature where pod length (7.59 cm), pods/plant (29.75), pod weight (8.16 g), 100 grain weight (3.94 g), and swell weight of 100 seed (9.49 g) were maximum resulting to the highest yield (480 kg/ha) as compared with that of control (224 kg/ha). Spray of carbendazim also improved seed germination (74.5%). Spray of other fungicides like carbendazim with copper oxychloride in 1:1 ratio, tridemorph (0.075%), and penconazole (0.05%) was equally effective against powdery mildew of mungbean. These fungicides also exhibited positive effects on yield-attributing characters of the crop and finally increased yield. These systemic fungicides were more effective in controlling powdery mildew disease of *V. radiata* in the rainy season compared with wettable sulphur.

Keywords : Epidemics, *Erysiphe polygoni*, fungicides, powdery mildew, *Vigna radiata*.

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Mungbean [*Vigna radiata* (L.) Wilczek] popularly known as green gram or golden gram is widely grown in Southern Asia, Thailand, Laos, Cambodia, Vietnam, Indonesia, Malaysia, South China, Cosmosa, Philippines, and Taiwan. In India, powdery mildew caused by *Erysiphe polygoni* DC. is an important disease of this crop in Southern and Central states between 12° to 24°N. This disease becomes epidemic and reduces the mungbean yield in rainy as well as post- rainy seasons under short spell of favorable weather conditions (Saxena and Saxena, 1991; Thakur and Agrawal, 1995). Due to lack of stable resistance against powdery mildew in mungbean, fungicidal sprays are the most effective means of controlling the disease (Moghe et al., 1982; Zote et al., 1985; Singh et al., 1986; Saxena and Saxena, 1999). Previous studies provide valuable information about the effectiveness of various fungicides against *E. polygoni* DC., but their effects on powdery mildew epidemics and yield-controlling characters of *V.radiata* were not discussed. Therefore, the present study was undertaken to evaluate best-suited fungicides to reduce the powdery mildew epidemic in the rainy season and to find out their overall impact on yield-attributing characters.

Materials and Methods

Field experiments. Field experiments were laid out at the Agriculture Research Station Khargone Madhya Pradesh (India) under the J.N. Agriculture University, Jabalpur situated at 21.22°-22.35°N and 74.14°E and 259 m altitude. During the rainy season, susceptible cultivar *V. radiata* K-851 was grown in randomized block design by following standard agronomic practices in plot size 5 m × 3 m with three replications. Fungicides carbendazim 0.05% (Bavistin 50 WP, BASF), copper oxychloride 0.25% (Phytolon 50 WP, Travancore Chemicals & Manufacture Co. Ltd.), carbendazim (0.05%) + copper oxychloride (0.25%) in 1:1 ratio, chlorothalonil 0.2% (Kavach 74 WP, Chith Chemicals Ltd.), mancozeb 0.25% (Dithane M-45, 75 WP, Northern Minerals Ltd.), penconazole 0.05% (Topas 10 EC, Ciba-Geigy), neem oil 0.2% (Nimbicidine, T. Stains & Co.), tridemorph (Calaxin 75 EC 0.05%, BASF), and wettable sulphur 0.3% (80 WP, Ciba) were sprayed once at the initiation of powdery mildew symptoms in the lower leaves of mungbean, except on the control. These symptoms usually appear at 30-day-old plants in the area.

Disease assessments. The apparent infection rate (r)/unit/day of powdery mildew under each treatment was calculated on the basis of the powdery mildew intensity of the week. The observations were recorded up to 4 weeks until the crop reached physiological maturity. The mildew severity was assessed as percent leaf area covered on the ten plants chosen at random from each replicate. The observations were recorded at weekly intervals. The difference between two intensities of disease (x), i.e., the mildew severity at the start of the week and at the end of week, was calculated. The disease severity in a week (x) and its logit {Log e [x/(1-x)]} values were plotted against time intervals and a regression line fitted to the observed points (Van der Plank, 1963).

Effects on yield-attributing characters. The effect of powdery mildew on yield- attributing characters of mungbean was studied during the crop growth and after the crop harvest for the two consecutive rainy seasons. The regression coefficient and standard error were estimated for the different treatments based on the degrees of freedom. Yield parameters like pod characters such as pods/plant, pod length, and pod weight; and seed characters such as 100 seed weight, 100 seed swell weight, and seed germination were assessed in each treatment. Yield of the crop was then recorded, including that of unsprayed control. The observations were recorded for 2 years and eight possible pairs were made. Correlation analysis for the eight possible pairs was done (Snedecor and Cochran, 1988). After testing the significance, these were further subjected to path coefficient analysis by taking powdery mildew intensity as dependent parameter over yield-attributing characters, which served as independent parameters (Daborker, 1992).

Results and Discussion

Influence of powdery mildew on yield-attributing characters and yield. The effect of powdery mildew was assessed on pod and seed characters of mungbean, determining the yield (Table 1). Disease intensity exhibited negative and significant correlation with pod characters like pod length (-0.57), pods/plant (-0.74), and pod weight (-0.68) and with seed characters like seed weight (-0.59), seed swell weight (-0.59), and seed germination (-0.71). The adverse effect of the disease on these characters was low yield, exhibiting significant negative correlation with disease intensity (-0.69).

All pod and seed characters had significant positive correlation with grain yield, indicating their direct relationship with the crop yield (Table 1). Any adverse effect of the powdery mildew on these yield-contributing parameters affected the grain yield of mungbean. These findings confirm earlier reports about the losses in yield due to powdery mildew on *V. radiata* under favorable weather conditions (Saxena and Saxena, 1999).

The correlations between powdery mildew intensity and yield-attributing parameters were further subjected to path coefficient analysis (Dewey and Lu, 1959) to assess the effect of powdery mildew on each yield parameter. The direct and indirect effects of powdery mildew on pod and seed characters of mungbean are presented in Table 2. Among the pod characters, pod weight had the profound direct effect (0.99) on grain yield, followed by pod length (0.48) showing positive significant correlation with grain yield. This indicates that adverse effects of the disease on pod weight and pod length significantly reduced grain yield because of their high direct effect on yield. The direct effect of pods/plant was nullified by the high negative indirect effect of 100 seed weight, but the additive indirect effects of pod weight and pod length showed significant positive correlation with grain yield, revealing the importance of indirect effects in the present study. Similarly, among the seed characters, direct effect of 100 seed weight on grain yield was high (0.73) followed by 100 seed swell weight (0.32). These characters had significant positive correlation with yield. The indirect effect of 100 seed weight on 100 swell seed weight reduced its direct effect on grain yield, but it was nullified by the indirect effect of pod weight, suggesting that mungbean had significant positive corre-

Table 1. Correlation matrix of powdery mildew intensity, yield, and yield-attributing characters of *Vigna radiata*

Characters correlated	Powdery mildew intensity	Pod/ plant	Pod length	Pod weight	100 seed weight	100 Seed swell weight	Seed Germination	Grain Yield
Powdery mildew intensity	1							
Pods/plant	-0.74*	1						
Pod length	-0.57*	0.56*	1					
Pod weight	-0.68*	0.85*	0.67*	1				
100 seed weight	-0.52*	0.80*	0.80*	0.85*	1			
100 Seed swell weight	-0.59*	0.86*	0.54*	0.78*	0.80*	1		
Seed Germination	-0.71*	0.87*	0.56*	0.62*	0.57*	0.80*	1	
Grain yield	-0.69*	-0.73*	0.68*	0.89*	0.61*	0.67*	0.59*	1

*P= 0.05.

Table 2. Direct and indirect effects of powdery mildew intensity and yield-attributing characters on grain yield of *Vigna radiata*

Characters	Powdery mildew incidence	Pods/ plant	Pod length	Pod weight	100 Seed weight	100 Seed swell weight	Seed germination	Correlation with grain yield
Powdery mildew incidence	**-0.0227**	-0.0538	-0.2754	-0.6739	0.3783	-0.1948	0.1529	-0.6893*
Pods/plant	0.0168	**0.0728**	0.2721	0.8529	-0.5878	0.2801	-0.1756	0.7313*
Pod length	0.0129	0.0409	**0.4843**	0.6710	-0.5890	0.1755	-0.1199	0.6756*
Pod weight	0.0153	0.0622	0.3256	**0.9978**	-0.6252	0.2497	-0.1334	0.8920*
100 grain weight	0.0117	0.0582	0.3884	-0.8495	**0.7343**	0.2619	0.1219	0.6050*
100 Seed swell weight	0.0136	0.0625	0.2605	0.7638	-0.5895	**0.3262**	-0.1713	0.6657*
Seed Germination	0.4169	0.0595	0.2704	0.6200	-0.0162	0.2601	**-0.2148**	0.5944

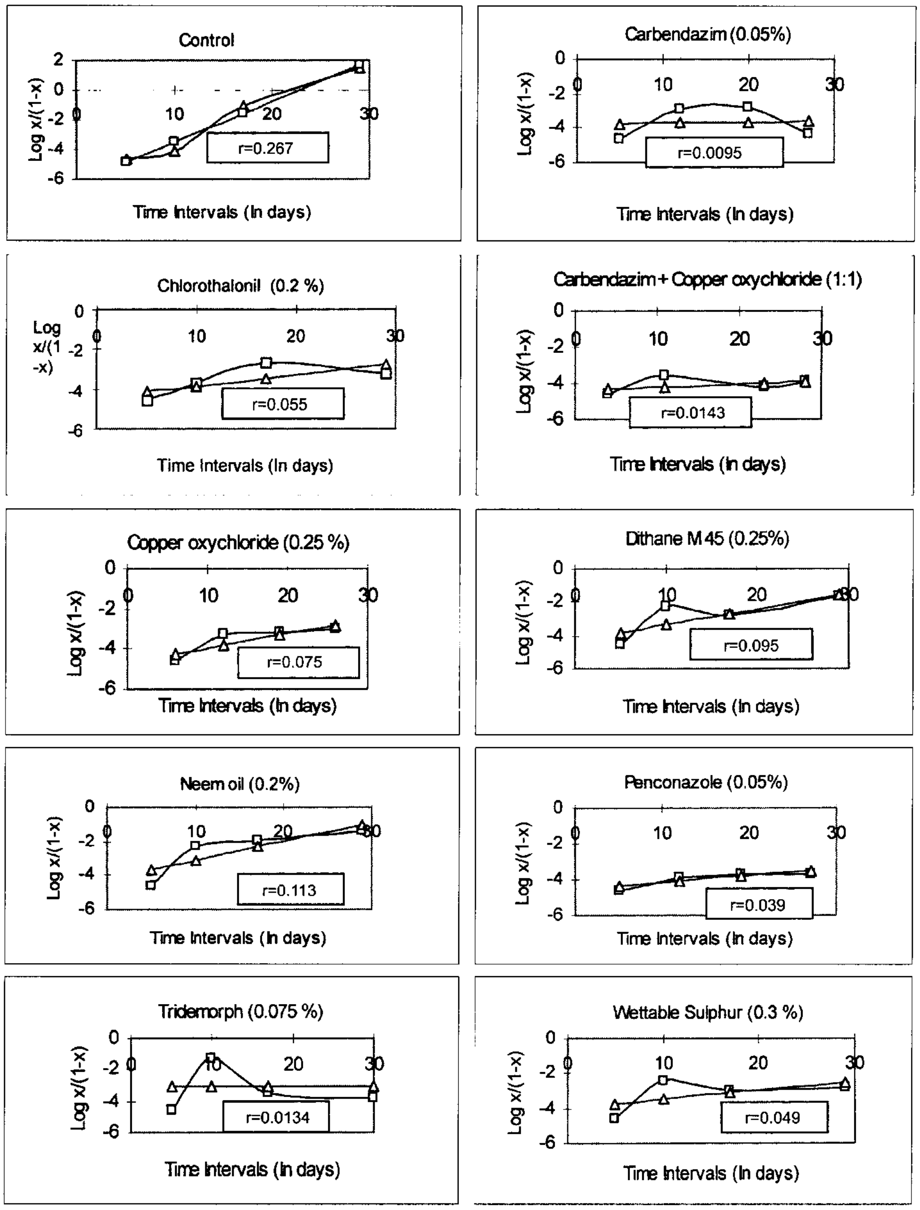
Residual = 0.1484
*P=0.05
Values in bold denote direct effects.

lation with healthy seed which swell. Due to mildew attack, mungbean seeds did not swell and finally affect the yield as well as swell weight of seed, exhibiting significant negative correlation (-0.59) with the disease. The negative significant correlation between seed germination and powdery mildew (-0.71) clearly indicates that powdery mildew at flowering stage adversely affected the mungbean seed and reduced grain yield.

The direct effect of powdery mildew on grain yield was negative (-0.02), which was supported by previous studies on yield-contributing characters, mainly due to pod weight (-0.67), followed by pod length (-0.28), swell grain weight (-0.19), and pods/plant (-0.05). These resulted to negative significant correlation with grain yield (-0.69). The above results reveal that powdery mildew attack has significantly reduced the grain yield of mungbean through negative effects on yield-contributing characters. Sharma et al. (1997) also found such effects of yield components on mungbean yield. The low residual value of 0.1484 indicates that the effect of powdery mildew on other yield-contributing characters on grain yield was less. This is due to the fact that powdery mildew which appear on 1-month-old crop, influenced the reproductive phase rather than its vegetative phase.

Influence of fungicides on powdery mildew epidemics. The log in [(Log x/(x-1)] values of powdery mildew intensity plotted against time intervals indicate that in unsprayed control, the disease became epidemic under a short period of time (Fig. 1). The average apparent infection rate (r) of powdery mildew in control was maximum 0.227 per unit/day. The fast spread of powdery mildew under favorable weather conditions has also been reported (Saxena and Saxena, 1991) on mungbean, confirming the present findings. The infection rate was minimum 0.0095 per unit/day in carbendazim (0.05%)-treated plants, indicating that a single spray of this systemic fungicide at 30-day-old crop not only controlled the powdery mildew development at initial stages but also inhibited the further spread of the disease by its systemic action. The superiority of carbendazim over other fungicides against powdery mildew of mungbean has also been previously reported (Kotasthane and Gupta, 1985; Tiwari and Kotasthane, 1986; Khosala et al., 1988). The powdery mildew progress values in tridemorph and a mixture of carbendazim + copper oxychloride were r = 0.0314/unit/day and r = 0.0143/unit/day, respectively. The apparent infection rate in wettable sulphur was r = 0.049/unit/day and in the neem oil derived from plants, it was r = 0.113/unit/day, which was higher than those of some chemical fungicides. The results indicate that carbendazim, tridemorph, and a mixture of carbendazim + copper oxychloride are better than wettable sulphur in controlling mungbean powdery mildew during rainy seasons. Because of the systemic properties of the fungicides, they enter into the system of the plant body and reduce the threat of washing of fungicide in the rainy season, whereas, sulphur fungicides on the surface of the plant body can be easily washed by rains (Moghe et al., 1982). However, other fungicides such as chlorothalonil, copper oxychloride, and Dithane M-45 were not effective against powdery mildew.

Influence of fungicides on powdery mildew intensity and mungbean yield. Single spray of carbendazim at 30-day-old mungbean crop at a rate of 0.05% significantly controlled powdery mildew. Other fungicides such as tridemorph (0.075%), copper oxychloride (0.25%) + carbendazim (0.05%) in 1:1 ratio, penconazole (0.05%), and chlorothalonil (0.2%) were equally effective against powdery mildew of *V. radiata* as compared with carbendazim. Maximum of 48.36% mildew intensity was recorded in unsprayed control during rainy season on mungbean. Spray of wettable sulphur (0.3%) on mungbean during the rainy season was not very much effective against powdery mildew as compared with the systemic fungicides tested. This may be due to the washing of non-systemic fungicides



□ = Observed and Δ = Estimated Values for transformed values of powdery mildew intensity
r = Apparent Infection Rate of powdery mildew per unit per day

Fig. 1. Progress of powdery mildew in different treatments of fungicides and unsprayed control on *Vigna radiata.*

due to rains in the rainy season. These results confirm earlier findings of Saxena and Saxena (1999) regarding the use of systemic fungicides for the control of mungbean powdery mildew in the rainy season. However, effectivity of two sprays of sulphur fungicide was reported by Zote et al. (1985). Maximum yield of mungbean (488 kg/ha) was recorded in carbendazim 0.05% (Fig. 2), which differs significantly from the rest of the treatments. The other fungicides like Dithane M 45 and copper oxychloride were not very much effective against the disease, hence, *V. radiata* yield remained at par with the control (224 kg/ha). The higher yield in carbendazim over other treatments may be due to the low powdery mildew incidence and its phytotonic effect, as reported in soybean by Julio et al. (1982).

Influence of fungicides on yield attributing characters

Effect on pod characters. Fungicidal sprays influenced the pod characters of *V. radiata* besides controlling powdery mildew (Fig. 2B). Carbendazim (0.05%)-treated plants had

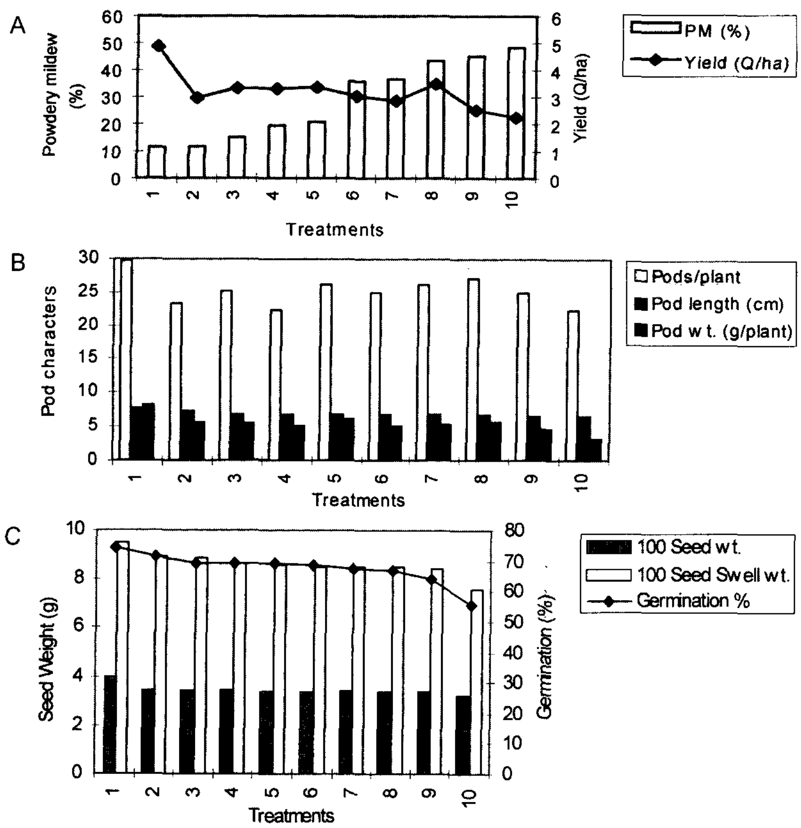


Fig. 2. Influence of fungicides on powdery mildew intensity, yield and yield attributing characters of *Vigna radiata*. 1=Carbendazim, 2=Tridemorph, 3=Carbendazim+copper oxychloride, 4=Penconazole, 5=Chlorothalonil, 6=Wettable sulphur, 7=Neem oil, 8=Dithane M 45, 9=Copper oxychloride, 10=Unsprayed control.

significantly the highest pod/plant (29.75), pod length (7.59 cm), and pod weight/plant (8.16 g) followed by tridemorph (0.075%). There were no significant differences in the pod characters of plant treated with other fungicides. However, in unsprayed control, pods/plant and pod weight/plant were significantly reduced. There was no significant effect of fungicides on average pod length except in carbendazim. It is clear from this finding that the increase in pod length in carbendazim was more due to the phytotonic effect rather than to powdery mildew control. Such effects of carbendazim were also described in other crops (Singh and Kang, 1984; Cook, 1980). The pod weight (g/plant) was significantly higher in carbendazim-treated plants as compared with the rest of the treatments, where the differences were at par, but significantly superior to the control. This indicates that the control of powdery mildew in fungicide-sprayed plants significantly increased the pod weight over control. Hence, losses due to powdery mildew can be overcome easily by spraying either one of the fungicides.

Effect on seed characters. The 100 seed weight was significantly highest at 3.94 g in carbendazim (0.05%) and was at par with the rest of the treatments (Fig. 2C). The effect of powdery mildew on seed vigor was estimated by swell weight of seed after dipping them in water. In carbendazim-treated plants, the 100 swell seed weight was highest at 9.49 g, followed by tridemorph (9.04 g), and was at par with the rest of the treatments while significantly superior to the control. This indicates that powdery mildew which appear during the flowering and pod formation stage adversely affected the seed vigor and can be overcome by controlling the disease at proper time through spraying of fungicides. The path coefficient analysis as mentioned earlier also revealed that swell seed weight had high direct effect on grain yield. Spray of the fungicides improved the germination of mungbean seeds as compared with that of unsprayed control. Maximum (74.5%) seed germination was recorded in carbendazim (0.05%)-treated mungbean plants, which differed significantly from the rest of the treatments. This indicates that powdery mildew significantly influenced seed germination, hence, for good seed production, care should be taken to control the disease in the standing crop.

Based on the results of the present study, it can be concluded that powdery mildew is an important disease of *V. radiata* grown in the rainy season because the disease adversely affects the yield-contributing parameters and thereby significantly reduces the yield. This disease can be most effectively controlled by a single spray of fungicide to about 1-month-old crop. Spray of fungicides like carbendazim, tridemorph, and penconazole is more effective because of their systemic nature as compared with other fungicides like wettable sulphur, which are liable to washing in the rainy season. These fungicides, especially carbendazim (0.05%), increased the yield because of their phytotonic effect beside controlling the disease. Therefore, for sustainable production of *V. radiata* particularly in powdery mildew epidemic areas, the disease can be effectively controlled by a single spray of carbendazim (0.05%).

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