

**EFFECT OF FUNGICIDES ON FOLIAR BLIGHT OF BELL PEPPER
(*Capsicum annuum* L.) IN MORANG, NEPAL**

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DOI: <https://doi.org/10.51193/IJAER.2021.7407>

ABSTRACT

An experiment was conducted to manage foliar blight (*Phytophthora* spp.) of bell pepper in the research field of GPCAR from February to August 2020 in a randomized completely blocked design with three replications and seven treatments including control. The treatments consist of foliar spray of Moximate 72% WP (Cymoxanil 8% + Mancozeb 64%), Amistar top 29.6% SL (Azoxystrobin a.i. 18.2% + Difenconazole a.i. 11.4%), Tebuconazole 25% WG, Ridomil Gold (Metalaxyl 4% + Mancozeb 64%), Difenconazole 25% EC, SAAF (Carbendazim 12% + Mancozeb 63%) and Control. The treatments were applied after the initial symptoms appeared and disease parameters were recorded at 60, 75, and 90 days after transplantation and fruits were harvested at weekly intervals. Moximate were recorded as least diseases severity with high fruit yield as compared to the control and Tebuconazole and Amistar top showed satisfactory result whereas Ridomil gold and SAAF did not perform well. Therefore, Moximate is the best-recommended fungicide while Tebuconazole and Amistar top could be the best alternative for the management of foliar blight of bell pepper.

Keywords: *Phytophthora* spp., Severity, Satisfactory, Fungicide.

1. INTRODUCTION

Foliar blight caused by *Phytophthora capsici* is one of the major problems of bell pepper in the Morang district, especially in open fields. The total cultivated area covered about 25 ha with 82 Mt production and 3.28 Mt/ha yield (MoAD, 2018/2019). The climatic condition of the Morang district is somewhat varied due to the elevation range from 60 masl to 2410 masl. It has a suitable environment in the hilly areas for bell pepper production, however, it is infected by a various number of diseases, among them, and the foliar blight disease has gained major

importance in bell pepper cultivated in the open fields mainly during the rainy season. Foliar blight is one of the most widely distributed diseases causing yield loss from 43-100 percent (Liang et al., 1992). The pathogen infects all the parts of a plant, including leaves, stem & shoots, branches, and fruits and survives in infected plant debris in the soil as mycelium and spore form. It spreads in two ways, i.e. over short distances through water and contaminated farm equipment and over long distances primarily in infected transplants or in the soil carried with pathogens (Agrios, 1988). The symptoms may appear on the foliar part of the host plant such as leaf blight, stem & shoot blight, and fruit rot which causes defoliation in the host plant. The initial symptoms appear as water-soaked to dull or faded green leaf tissue area rapidly enlarges covering the entire leaf under humid conditions, resulting in premature leaf fall. Symptoms appear as dark-green water-soaked spots in contrast to the light green colour of the healthiest fruit tissue and these spots enlarge rapidly covering the entire fruit causing rotting of fruit (Gupta et al., 2018). Management of foliar blight is very difficult due to its catastrophic nature, complex soil ecosystem and also its unpredictability. So integrated management strategy is necessary to control soil-borne disease, which may include the use of chemicals, exploitation of biological agents and botanicals as disease management tools.

2. MATERIALS AND METHODS

The experiment was conducted from February to August 2020 in a Randomized Complete Block Design (RCBD) layout of seven treatments and three replications with an individual plot size of 6.25 m². The soil condition of the research field was sandy loam, slightly acidic with medium organic matter, medium nitrogen, low phosphorus and low potash content. The recommended dose of farmyard manure (FYM) and fertilizers was applied during land preparation and other management practices were followed as per recommendation. The 'Indra' variety of bell pepper seedlings was transplanted to the research field on 11th April, maintaining the spacing of 45cm plants to plant and 45cm row to row apart.

Table 1: Treatments used in field experiments

S.N.	Treatments	Symbol	Recommended Dose
1	Moximate 72% WP (Cymoxanil 8% + Mancozeb 64%)	T1	2 gm/litre water
2	Amistar Top (Azoxystrobin a.i. 18.2% + Difenoconazole a.i. 11.4%)	T2	1 ml/litre water
3	Tebuconazole 25% WG	T3	0.25 gm/litre water

4	Ridomil Gold 68% WP(Metalaxyl 4% + Mancozeb 64%)	T4	2 gm/litre water
5	Difenoconazole 25% EC	T5	0.5 ml/litre water
6	SAAF 75% WP(Carbendazim 12% + Mancozeb 63%)	T6	1 gm/litre water
7	Control	T7	-----

After the initial symptoms appeared, the treatments (i.e. fungicides) was applied as a foliar spray in different days intervals, such as Moximate, Amistar top & Ridomil gold was applied in 10 days interval of 1st spray and Tebuconazole, Difenoconazole and SAAF was applied in 15 days interval of 1st spray. The spray number varied from 3-4 and irrigation as per the need and also followed by the intercultural operation in 20-30 days interval after transplant. Disease parameters such as disease severity were recorded in 60, 75 and 90 days after transplant (DAT), the number of infected and non-infected fruits and their weights were also recorded weekly. The disease scoring was recorded for foliar blight with the appearance of disease symptoms on the canopy of the plant either leaf blight, stem and shoot blight and fruit rot with the help of disease scale index (0-5) which was given by Monroy-Barbosa & Bosland (2010). The recorded data were subjected to the ANOVA with the help of Rstudio application (R Development Core Team, 2008) and mean comparison among significant variables was done by LSD test at the 5% level of significance.

Table 2: Disease scoring scale index for Phytophthora Blight of Bell Pepper

Severity Scale	Symptoms
0	No symptoms
1	Small lesion under the paper disc area (small, dry spot, with defined borders; lesion associated with hypersensitive response), the paper disc was removed from the original place to uncover lesion, discolouration in this leaf is produced by the paper disc.
2	The dark green, water-soaked lesion is bigger than the paper disc area, surrounded by pale yellow undefined borders (the paper disc was moved from its original place to show lesion borders).

- | | |
|---|--|
| 3 | 15% to 49% of leaf area is wilted (scalded) or necrotic). |
| 4 | 50% or more of the leaf is wilted. |
| 5 | 100% of the leaf is necrotic or the leaf has dropped off from the plant. |
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3. RESULTS

3.1 Isolation

Various scientists were proven that the isolates from diseased plant parts of the foliar blight of bell pepper were identified as *Phytophthora capsici*. Verma (1997) studied the pathogenicity test on bell pepper variety California Wonder and observed the characteristic disease symptoms on leaves and fruit after 30 and 32 h of inoculation with the sporangial suspension of *Phytophthora capsici*. Likewise, other more workers were also proved the pathogenicity of *Phytophthora capsici* at different development stages of the host plant resulting in foliar blight, seedling death, root rot, stem blight and fruit rot (Babadoost and Islam, 2003; Hausbeck and Lamour, 2004). The variability on isolates of *P. capsici* can be observed from one location to another, among different plants in the same location and different organs on the same plants (da Costa Ribeiro and Bosland, 2012). The pathogen *P. capsici* also infect the cucumbers and squash that causes lesions on fruits that are typically covered with white sporangia and cause fruit rot or stem rot (Ristaino & Johnston, 1999).

3.2 Disease Severity

There was a highly significant difference ($p \leq 0.001$) among the treatments in disease severity at all three observations. Disease severity was recorded highest in control at all three dates of observation. At 60 DAT, the disease was not observed in Moximate (0.00 ± 0.00) treated plot, lowest disease severity was observed in Tebuconazole treated plots (1.33 ± 0.58), followed by Amistar Top (2.67 ± 1.15). At 75 DAT, the least disease severity was in Moximate (1.33 ± 0.58) treated plot, followed by Tebuconazole (2.67 ± 2.31), Amistar Top (6.67 ± 1.15) and Difenconazole (9.33 ± 1.15). And from final observation (90 DAT), the lowest disease severity was recorded in Moximate (6.67 ± 1.15), followed by Tebuconazole (18.67 ± 2.31), Difenconazole (24.00 ± 0.00) and Amistar Top (25.33 ± 3.06) treated plots. Among them, the effect of Moximate was best in all three observations, but a little fluctuation was seen between Amistar Top and Difenconazole in comparison with two observations i.e. 75 DAT and 90 DAT. The least mean disease severity was recorded in Moximate (2.67 ± 0.33) and followed by Tebuconazole (7.56 ± 0.69) and Amistar Top (11.56 ± 1.67).

Table 3: Effect of different fungicides on the foliar blight of bell pepper at three observation dates in research field at GPCAR, Gothgaun, Morang during 2020.

Treatments	Foliar Blight Severity (%)			
	(60 DAT)	(75 DAT)	(90 DAT)	Mean FBS
1. Moximate	0.00 ^e ±0.00	1.33 ^d ±0.58	6.67 ^f ±1.15	2.67 ^f ±0.33
2. Tebuconazole	1.33 ^{de} ±0.58	2.67 ^d ±2.31	18.67 ^e ±2.31	7.56 ^e ±0.69
3. Amistar Top	2.67 ^d ±1.15	6.67 ^c ±1.15	25.33 ^d ±3.06	11.56 ^d ±1.67
4. Difenoconazole	5.33 ^c ±1.53	9.33 ^{bc} ±1.15	24.00 ^d ±0.00	12.89 ^d ±0.19
5. Ridomil Gold	6.67 ^{bc} ±1.15	10.67 ^b ±1.15	32.00 ^c ±2.00	16.44 ^c ±1.02
6. SAAF	8.00 ^b ±1.00	12.00 ^b ±2.00	40.00 ^b ±5.29	20.00 ^b ±1.67
7. Control	12.00 ^a ±1.00	18.67 ^a ±2.31	50.67 ^a ±3.06	27.11 ^a ±1.84
Mean	5.14	8.76	28.19	14.03
LSD _{0.05}	1.79	2.73	4.88	2.10
CV(%)	19.52	17.49	9.73	8.39
F-Test	***	***	***	***

PROC: Percentage Reduction Over Control; LSD: Least Significant Difference; CV: Coefficient of Variation; *: Significant at 0.05 level of significance; **: Significant at 0.01 level of significance; ***: Significant at 0.001 level pf significance; Values with same letters in a column are not significantly different at 5% level of significance by LSD test and figures after ± indicate standard error values.

3.3 Yield

The number of non-infected fruit, infected fruit and yield per plant were highly significant different ($p \leq 0.001$) among the treatments. Moximate (5.44±0.19) was the highest number of non-infected fruit producers, followed by Tebuconazole (4.33±0.67), Difenoconazole (4.00±0.58) and Amistar Top (3.56±0.96). The least number of infected fruit was carried out by the Moximate (0.00±0.00) treated plot, followed by Tebuconazole (0.11±0.19), Difenoconazole (0.44±0.09), Amistar Top (0.44±0.38) and SAAF (0.56±0.09). The highest plant yield (gm/plant) was recorded in Moximate (520.50±24.41) treated plot, followed by Tebuconazole (418.30±7.61) and Difenoconazole (394.63±8.14) and the least yield was recorded in the Control (148.33±8.94) plot.

Table 4: Effect of treatments over foliar blight disease concerning yield of bell pepper in research field at GPCAR, Gothgaun, Morang during 2020.

Treatments	Number of fruits		Yield (gm/plant)
	Non-Infected	Infected	
1. Moximate	5.44 ^a ±0.19	0.00 ^e ±0.00	520.50 ^a ±24.41
2. Tebuconazole	4.33 ^{ab} ±0.67	0.11 ^{de} ±0.19	418.30 ^b ±7.61
3. Difenoconazole	4.00 ^b ±0.58	0.44 ^{cd} ±0.09	394.63 ^b ±8.14
4. Amistar Top	3.56 ^{bc} ±0.96	0.44 ^{cd} ±0.38	300.83 ^c ±10.90
5. SAAF	2.56 ^{cd} ±0.96	0.56 ^c ±0.09	227.68 ^d ±15.46
6. Ridomil Gold	2.11 ^d ±0.38	1.22 ^b ±0.19	207.59 ^d ±23.76
7. Control	1.44 ^d ±0.77	2.56 ^a ±0.19	148.33 ^e ±8.94
Mean	3.35	0.76	316.84
LSD _{0.05}	1.14	0.33	29.66
CV(%)	19.20	24.8	5.26
F-Test	***	***	***

PIOC: Percentage Increase Over Control; LSD: Least Significant Difference; CV: Coefficient of Variation; *: Significant at 0.05 level of significance; ***: Significant at 0.001 level of significance; Values with same letters in a column are not significantly different at 5% level of significance by LSD test and figures after ± indicate standard error values.

4. DISCUSSION

4.1 Effect of fungicides on disease severity of foliar blight of bell pepper

The study revealed the outstanding result in maximum disease reduction was brought by the Moximate, whereas, the Tebuconazole was also good enough to foliar blight and fair with Amistar Top and Difenoconazole whereas SAAF did not show better performance.

The result of this study was supported by findings that of Samoucha & Cohen (1988), who proves that cymoxanil performs better than metalaxyl which means Moximate is the far better fungicide than Ridomil gold. Cymoxanil 8% + Mancozeb 64% has the highest protection (100%) with maximum yield against *Phytophthora spp.* which causes late blight of potato under field condition (Sharma & Saikia, 2013; Kumar et al., 2018). NA & MS (2016), reported that

Cymoxanil 8%+Mancozeb 64%) with Hexaconazol 5% was very effective for the control of foliar blight. Gupta and Jarial (2010), recorded that Cymoxanil + Mancozeb was exhibited 100 percent disease control against leaf blight and fruit rot of bell pepper. Mhatre et al. (2020), proved that mancozeb-cymoxanil + mancozeb and chlorothalonil-ametoctradin + dimethomorph were best fungicidal against late blight of potato with resulting highest yield parameters.

Furthermore, Tebuconazole shows the second-best performance after Moximate, which was also the better alternative for blight diseases and followed by Amistar Top and Difenconazole. The available literature on different fungicides also revealed the efficacy of copper oxychloride, mancozeb, captafol, Ridomil-MZ and Sectin against the different *Phytophthora* spp. causing leaf blight and fruit rot of bell pepper plants (Chaudhary and Banyal, 2013). Tebuconazole has a good effect on foliar blight reduces maximum disease severity and its foliar application also gave the best result and reduced the late leaf spot intensity (Padmaja, 2013). Saha et al. (2018) reported that the combination of fungicides: trifloxystrobin (25%) + tebuconazole (50%) showed the best control against leaf spots in both in vitro and in vivo conditions. Amistar top has been proven to effective inhibitory for foliar blight where better results were performed (Sing, 2015; Rebollar-Alviter & Ellis, 2005). Elansky et al. (2016), mentioned that the difenoconazole performance was a good inhibitor against late blight of tomato and potato under the laboratory test on Agar growth medium with detached leaf in *Cercospora* leaf spot in okra (Beura et al., 2013). The last performance was recorded by the SAAF in comparison with Moximate where various supports gave as Gupta & Jarial (2010) revealed that the Carbendazim 12% + Mancozeb 63% performed low disease control against foliar blight and fruit rot in bell pepper. Also recorded least disease control with the lowest yield and low cost-benefit ratio in the late blight of potato (Kumar et al., 2018; Khadka et al., 2020).

Ridomil gold cannot show good performance in the present research study against the foliar blight of bell pepper. However, it showed a good effect in other journals of researchers, i.e. (Babadoost et al., 2015; Matheron and Porchas, 2008). Also perform well on *Cercospora* leaf spot on chilli without showing any phytotoxicity symptoms (Kumar et al., 2016), late blight of potato (NA & MS, 2016).

In addition, the agrometeorological data showed that there was heavy rainfall occurred from the 2nd week of June to the 3rd week of July with low temperature, which might be suitable for the growth of the *Phytophthora* pathogen and leads to increased disease severity and loss in yield. These were supported by Chaudhary and Banyal (2013) reported that the temperature and relative humidity are the most important environmental factors contributing to foliar blight disease development and presented 80 to 85 percent of disease severity in bell pepper. Similarly, Bhardwaj et al. (1985) also reported that the disease development was positively correlated with high relative humidity, rainfall and temperature.

4.2 Effect of Fungicides on Yield of Phytophthora blight of Bell Pepper

The enhancement in fruit yield of the bell pepper with foliar sprays of Moximate, Tebuconazole and Difenoconazole might be the reduction in disease due to which plants get less stress and become healthy and bearing healthy, quality and nutritious fruits with maximum size which leads to the increase in yield. There were no phytotoxicity observed in the application of such fungicides with the recommended dose and helps in the suppression of harmful fungal diseases like foliar blight, root rot, stem blight, fusarium wilt, fruit rot, Cercospora leaf spots, etc.

The literature relates to Beard et al. (2004), who was reported that the rate of disease progression was retarded with the application of fungicides. Cymoxanil + Mancozeb (i.e. Moximate) has high disease control capacity with leading to the highest yield (Sharma & Saikia, 2013). Nithya Meeakshi et al. (2006), reported the non-phytotoxic nature of Azoxystrobin and difenoconazole with the recommended dose at or below for field application.

5. CONCLUSION

Among all the treatments, Moximate 72% WP (Cymoxanil 8% + Mancozeb 64%) performed best in the reduction of disease severity of foliar blight with a higher fruit yield of Bell Pepper whereas Tebuconazole 25% WG, Amistar Top (Azoxystrobin a.i. 18.2% + Difenoconazole a.i. 11.4%) and Difenoconazole 25% EC was also done well as satisfactory. Therefore, Moximate becomes the best fungicide for the control of the foliar blight disease of bell pepper. However, other works of literature reported that Ridomil Gold 78% WP was performed well, but in my research, evaluation, Ridomil Gold 78% WP (Metalaxyl 4% + Mancozeb 64%) and SAAF 75% WP (Carbendazim 12% + Mancozeb 63%) had an at least performance with comparison to Moximate 72% WP. Therefore, Moximate (cymoxanil 8% + Mancozeb 64%) is the best-recommended fungicide for the control of foliar blight of bell pepper and is worth it.

ACKNOWLEDGEMENTS

I would like to express my special thanks of gratitude and a sense of appreciation to Mr. Nirmal Adhikari, Assistant Lecturer at Purbanchal University - G. P. Koirala College of Agriculture and Research Centre (GPCAR) for his continuous guidance, supports, constant motivation, affection, encouragement and valuable suggestions during the entire period of research. I'm grateful to Mr. Shashan Devkota, Guest Lecturer of GPCAR and also my sincere thanks to my parents, colleagues, GPCAR Student Team and all helping hands for their valuable help and cooperation.

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