Research Article

CONTROLLING DOWNY MILDEW IN BUCKWHEAT USING FUNGICIDE

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ABSTRACT

Downy mildew caused due to *Peronospora fagopyri* is the most important fungal pathogen that contributed to significant yield loss in buckwheat genotypes. Efficacy of six fungicides namely SAAF (Carbendazim 12% + Mancozeb 63%) @ 3 g/l, Krilaxyl (Metalaxyl 8%+ Mancozeb 64% WP) @ 2 g/l, Bavistin (Carbendazim 50% WP) @ 2g/l, Hexazol (Hexaconazol 5% SC) @ 2 g/l of water, Dithane M-45 (Mancozeb 75% WP) @ 2.5 g/l and Cyclon (Tricyclazole 75% WP) @ 2 g/l of water against one control with three replicates were tested at Hill Crops Research Program, Kabre, Dolakha during summer season of two consecutive years 2019 and 2020 against downy mildew of buckwheat. First spray was given just after the appearance of disease symptom in the field. Two sprays were given at an interval of 10 days. Data were recorded before every spray using 1-9 scoring scale on 10 randomly tagged plants/plot. All the fungicides were found to be effective in controlling the disease. Carbendazim 12% + Mancozeb 63% (SAAF) was the most effective in reducing the disease severity (≤30%) and enhancing yield, followed by Mancozeb 75% WP (Dithane M-45) when compared to the unprotected control with highest disease severity (>75%). The use of these fungicides is recommended in an integrated disease management strategy, incorporating host resistance and cultural practices.

Keywords*: Downy mildew, Peronospora fagopyri, fungicides, chemical control.*

INTRODUCTION

Buckwheat (*Fagopyrum* spp.) is the sixth most important food crop in Nepal which accounts for 3% of the total area under cultivation of cereal crops (MoALD, 2020). It is regarded as a poor man's crop and an alternative grain, providing an essential food source in isolated mid-hills and highlands (HCRP, 2020). Buckwheat has healing potential in addition to being a source of income for households. Diabetes sufferers can use it in addition to their regular diet (Kawa *et al*., 2004).The leaf generated rutin, an essential medicinal substance that is used to prepare tea to cure hypertonia (McGregor and McKillican, 1952).The flowers, which bloom for nearly a month, generate high-quality nectar for bees. Because of its short

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life cycle, it is the ideal crop at higher altitudes in terms of adaptability to varied climatic factors, water stress regimes, and infertile soil, and it is easily adapted to different cropping patterns (Subedi *et al*., 2020). Despite the fact that the scope and demand for buckwheat are growing due to its medicinal and nutritional characteristics, the yield potential is diminishing due to various constraints. Nepal produces 11,464 mt of buckwheat from 10,311 ha with an average productivity of 1.11 mt/ha (MoALD, 2020). Disease is a key biotic barrier that reduces buckwheat production while also lowering product quality and economic value. Buckwheat plants are susceptible to a wide range of infections, the most common of which are fungal diseases. Among fungal diseases, downy mildew caused due to *Peronospora fagopyri* was the primary fungal pathogen that contributed to the large yield disparity in buckwheat genotypes (HCRP, 2021). The most common symptom is large circular chlorotic lesions that develop on the uppermost leaves. As the disease develops, systemic infection ensues, resulting in shorter internodes on top stems and epinasty (leaf bending downward). Some seriously diseased leaves exhibit a mosaic-like look (Nyvall, 1989). Conidia clumps are purple, visible with the naked eye, and found on lower leaf surfaces. Seedlings are stunted and have a short stem diameter, with rugose and mottled leaves (Zimmer, 1984). Controlling plant diseases using chemicals is now a global practice. Because of concerns about residues, biodegradation, phytotoxicity, and pollution associated with chemical control approaches have encouraged researchers to consider safer and milder fungicides as an alternative control option. The study primarily aimed to evaluate the efficacy of fungicides for their ability to control the growth of *P. Fagopyri* under field condition.

MATERIALS AND METHODS

The experiments were laid under natural epiphyotic condition following Randomized Complete Block Design having six treatments with different fungicides against one control with three replicates of each during summer of two consecutive years 2019 and 2020 at Hill Crops Research Program, Kabre, Dolakha. The research area is located at 27038' N latitude and 86080' E longitude, at an altitude of 1740 masl; with the annual average rainfall of 2350 mm, average maximum temperature of 29 °C and average minimum temperature of 0.5 °C. During buckwheat season, recently released variety Tite Phapar-2 (ACC# 2227-1) was planted on second week of September in a unit plot size of 3 m x 2 m where 25 cm row and continues plant spacing was maintained. After completion of the sowing, the plots were kept under constant supervision from sowing to harvest. Agronomic practices were followed as recommended. First spray was given just after the appearance of disease symptom in the field. Two sprays were given at an interval of 10 days. Data were recorded before every spray using 1-9 scoring scale on 10 randomly tagged plants/plot. The fungicides used as the treatments were SAAF (Carbendazim 12% + Mancozeb 63%) @ 3 g/l, Krilaxyl (Metalaxyl 8%+ Mancozeb 64% WP) @ 2 g/l, Bavistin (Carbendazim 50% WP) @ 2 g/l, Hexazol (Hexaconazole 5% SC) @ 2 g/l of water, Dithane M-45 (Mancozeb 75% WP) @ 2.5 g/l and Cyclon (Tricyclazole 75% WP) @ 2 g/l of water. The control plots received only plain water during the treatments application time in other plots. Percent Disease Index (PDI) was computed according to the formula (Wheeler, 1969) and calculation was based on the final data recorded at 15 days after the last spray. Percent Disease Control (PDC) was calculated on the basis of the formula developed by Shivankar and Wangikar (1993). At harvest, data on thousand grain weight and grain yield were recorded with yield data presented in terms of kilogram per hectare. Yield increase over the control was calculated. All data were analysed statistically using Genstat 18th edition computer package program. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at 5% levels of significance. The correlation among percent yield increased over control and percent disease control was also calculated.

RESULTS AND DISCUSSION

All treatments had significant ($P \leq 0.05$) effect on downy mildew disease severity (DS), percent disease index (PDI), gain yield and thousand grain weight (TGW) on the experimental plots compared to the control in 2019. The lowest percent disease index (25.76%) with highest yield (1967 kg/ha) was recorded in the plot sprayed with SAAF (Carbendazim 12% + Mancozeb 63%) @ 3 g/l of water followed by Dithane M-45 (Mancozeb 75% WP) @ 2.5 g/l of water (PDI-29.12% and grain yield-1678 kg/ha). The lowest crop yield (804 kg/ha) and highest disease index (73.92%) was recorded from the control plot where no any fungicides were sprayed (Table 1).

In 2020, the trends of disease control and yield were similar when compared with the previous year (2019). The lowest percent disease index was recorded in the plot sprayed with SAAF at 3 g/l of water (29.87%) followed by plot sprayed with Dithane M-45 @ 2.5 g/l of water (31.73%). The highest crop yield was also recorded from the plot sprayed with SAAF (1939 kg/ha), followed by plot sprayed with Dithane M-45 (1659 kg/ha). The lowest crop yield (752 kg/ha) with higher disease index (77.65%) was recorded in control plot (Table 2). The higher percent disease control (PDC) and Percent Yield increase (PYI), i.e. 65.15% and 144.51% in 2019 (Table 1) and 61.54% PDC with 158% YI during 2020 (Table 2) respectively were found in the plots sprayed with SAAF at 3 g/l followed by plots sprayed with Dithane M-45 @ 2.5 g/l of water compared to control plot which received no treatment.

Table 1. Effect of fungicides on downy mildew disease severity and yield performance of tartary buckwheat (ACC# 2227-1) at Kabre, Dolakha during 2019 summer

Treatments	Downy mildew		GY (kg/ha)	TGW (g)	PDC (%)	PYI (%)
	DS (1-9)	PDI (%)				
SAAF - 3 g/l of water	2.50[e†]	25.76[f]	1967[a]	18[a]	65.15	144.51
Krilaxyl -2 g/l of water	5.50[b]	51.52[b]	1011[f]	14[de]	30.30	25.69
Bavistin - 2 g/l of water	4.50[c]	42.56[c]	1131[e]	16[bc]	42.42	40.61
Hexazol- 2 g/l of water	3.50[d]	35.84[d]	1218[d]	15[cd]	51.52	51.39
Dithane M-45 – 2.5 g/l of water	3.50[d]	29.12[e]	1678[b]	17[ab]	60.61	108.58
Cyclon- 2 g/l of water	3.50[d]	34.72[d]	1367[c]	16[bc]	53.03	69.91
Control (water spray)	7.50[a]	73.92[a]	804[g]	13[e]		
Grand mean	4.36	41.92	1310.71	15.57		
P-value	<.001	<.001	<.001	<.001		
LSD (0.05)	0.93	2.09	49.42	1.74		
CV,%	12.00	2.80	2.10	6.30		

[†]Means of 3 replications, means in column with same superscript is not significantly different by DMRT $_{(P<0.05)}$ .Krilaxyl (Metalaxyl 8% + Mancozeb 64% WP), Bavistin (Carbendazim 50% WP), SAAF (Carbendazim 12% WP + Mancozeb 63% WP), Dithane M-45 (Mancozeb 75% WP), Hexazol (Hexaconazole 5% SC), Cyclon (Tricyclazole 75% WP), WP- wettable powder, GY-grain yield, PDI- percent disease index, DS- disease severity, TGW-thousand grain weight, PDC- percent disease control, PYI- percent yield increase, kg/ha- kilogram per hectare, g-gram, l- litre,

Relationship between percent disease control (PDC) and percent yield increase (PYI)

During experimental period (2019-2020), the yield increase in buckwheat was found significantly ($P \leq 0.05$) positive correlation ($r = 0.85$) with the downy mildew disease control using different fungicides in field condition. The predicted linear regression line was i.e. $y = 2.84x - 54.71$, with regression coefficient R2 = 0.72, where 'y' denoted predicted yield increase of buckwheat and 'x' stood for disease control using fungicides (Fig. 1). The estimated regression line indicated that control in downy mildew disease of buckwheat enhance the crop yield.

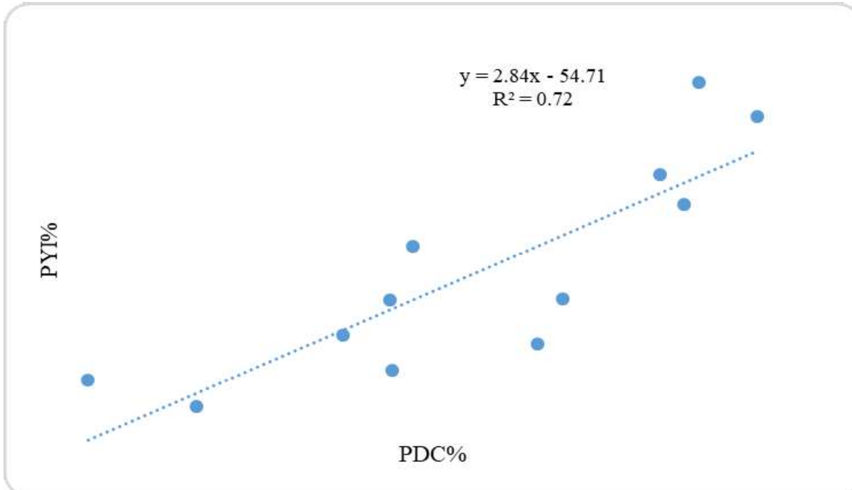

Fig. 1. Relationship between PDC and PYI of fungicides used to control downy mildew of buckwheat

Relationship between grain yield (kg/ha) and percent disease index (PDI)

During experimental period (2019-2020), a significant ($P \leq 0.05$) linear negative correlation (r =-0.89) between yield and PDI was observed representing the best fit having R^2 = 79% (Fig. 2). Obviously the yield decreased with the increase in Percent Disease Index (PDI) of downy mildew.

Because of the changing climatic scenario, the evolution of new fungal species and their attack on relatively new crops and location is both predictable and unsurprising. Although downy mildew in buckwheat is a minor disease, it has been reported in a number of countries, including Nepal (HCRP, 2021), India (Gopi *et al.*, 2015), the United States (Econopouly *et al.*, 2016), Canada (Zimmer, 1978), and the Czech Republic (Petrželová *et al*., 2015). Downy mildew, which was previously a minor disease (Joshi and Paroda, 1991) but is now a major economic concern in buckwheat. This disease can be effectively controlled by using resistant varieties (Subedi *et al*., 2020). Fungicides can, however, reduce disease losses in the absence of resistant cultivars. Chemical disease management is the most widely used method in cereal crops worldwide. However, crop growers are most concerned about the safer use of fungicides in terms of application method and doses in order to control plant diseases. There were numerous reports on controlling downy mildew disease in vegetables and fruit crops, but very few reports (Econopouly *et al*., 2016) on controlling downy mildew in buckwheat were discovered.

In this study, the application of all fungicides significantly reduced downy mildew disease severity and, as a result, increased buckwheat yield in the fungicide treatments when compared to the unprotected control. However, the plot sprayed with SAAF (Carbendazim 12% + Mancozeb 63%) had the lowest disease severity (25-30%), followed by Dithane M-

45 (30-32%), while the untreated control plot had the highest disease severity (74-78%). Similar results were reported in onion (Raziq *et al*.,2008) and cucumber (Pandit *et al*., 2020) who reported that Ridomil (Metalaxyl + Mancozeb) and Krilaxyl were found to be the most effective in reducing downy mildew severity and increasing yield in onion and cucumber crops respectively followed by Derosal (carbendazim). Mondal (2004) reported that Ridomil MZ 72 WP (Metalaxyl 8%+Mancozeb 64% WP) which is mixture of systemic and contact fungicides, was found to give the best protection against root rot incidence in both common and tartary buckwheat. Application of fungicide, Metalaxyl, 25% WP to control downy mildew was futile to increase seed yield of buckwheat (Gubbels *et al*., 1990). A similar study was conducted by Zuntini *et al*. (2019), who assessed the control of downy mildew in soybean by application of mixture of different fungicides to the mixture of Triazoles and Strobilurins and found significant reduction of disease by application of mixture of mancozeb to Benzimidazole, Strobilurins and Triazoles.

Table 2. Effect of fungicides on downy mildew disease severity and yield performance of tartarybuckwheat (ACC# 2227-1) at Kabre, Dolakha during 2020 summer

Treatments	Downy mildew		GY (kg/ha)	TGW (g)	PDC (%)	PYI (%)
	DS (1-9)	PDI (%)				
SAAF - 3 g/l of water	2.50[e†]	29.87[e]	1939[a]	18.50[a]	61.54	158.00
Krilaxyl -2 g/l of water	6.50[b]	59.36[b]	1027[f]	12.50[d]	23.56	36.67
Bavistin - 2 g/l of water	4.50[c]	47.04[c]	1165[e]	13.50[cd]	39.42	54.99
Hexazole- 2 g/l of water	4.50[c]	44.80[cd]	1272[d]	14.00[c]	42.31	69.18
Dithane M-45 – 2.5 g/l of water	3.50[d]	31.73[e]	1659[b]	16.00[b]	59.13	120.71
Cyclone- 2 g/l of water	4.50[c]	43.68[d]	1438[c]	16.00[b]	43.75	91.35
Control (water spray)	8.00[a]	77.65[a]	752[g]	11.00[e]		
Grand mean	4.86	47.73	1321.76	14.50		
P-value	<.001	<.001	<.001	<.001		
LSD (0.05)	0.89	3.01	42.38	1.01		
CV,%	10.30	3.50	1.80	3.90		

[†] Means of 3 replications, means in column with same superscript is not significantly different by DMRT $_{(P<0.05)}$. Krilaxyl (Metalaxyl 8% + Mancozeb 64% WP), Bavistin (Carbendazim 50% WP), SAAF (Carbendazim 12% WP + Mancozeb 63% WP), Dithane M-45 (Mancozeb 75% WP), Hexazol (Hexaconazole 5% SC), Cyclon (Tricyclazole 75% WP), WP- wettable powder, GY-grain yield, PDI-percent disease index, DS- disease severity, TGW-thousand grain weight, PDC- percent disease control, PYI- percent yield increase, kg/ha- kilogram per hectare, g-gram, l- litre

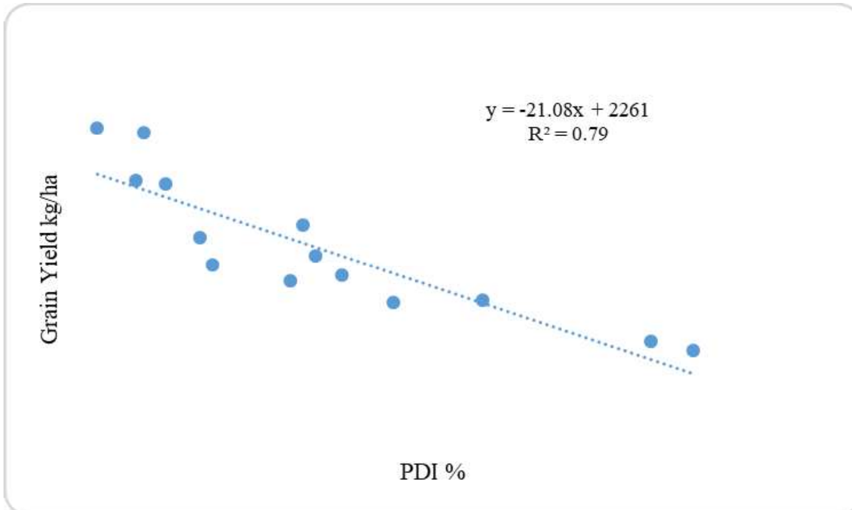

Fig. 2. Relationship between grain yield (kg/ha) and PDI of fungicides used to control downy mildew of buckwheat

CONCLUSION AND RECOMMENDATIONS

The application of fungicides minimized the downy mildew severity and consequently increased yield in buckwheat. Application of fungicide SAAF (Carbendazim 12% + Mancozeb 63%) at the rate of 3 g/l, followed by Dithane M-45 at the rate of 2.5 g/l, at an interval of 10 days for two times were comparatively more effective than the other fungicides in reducing downy mildew severity and increasing yield. These fungicides should be used as part of an integrated disease management strategy, incorporating host resistance and cultural practices. The spray should be started on the appearance of the disease symptoms, especially if weather conditions are conducive to the development of the disease.

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