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Effect of systemic and contact fungicides on late blight disease and tuber yield of potato

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Late blight of potato is a major agricultural problem in most parts of the world where potatoes are grown. The disease is primarily controlled by rigorous application of fungicides. The aim of this work was to evaluate the efficacy of systemic and contact fungicides on late blight disease and tuber yield. Three systemic fungicides (Fostylalluminum, Curzate, Ridomil Gold) and three contact fungicides (Revus, Antracol, Blue copper) were tested for their effects on late blight of potato and consequent tuber yield in field conditions, applied as foliar sprays at seven day interval. Both types of fungicides were found highly effective in reducing disease severity level and disease progress. However, systemic fungicides more effectively controlled diseases severity and the disease progress than contact fungicides. Compared to control, disease severity and area under disease progress curve (AUDPC) were significantly reduced by systemic fungicide Curzate corresponding to significant increase in tuber yield. Contact fungicides contributed to reduction in disease severity and AUDPC; however, they had no effects on tuber yield. Results recorded efficacy of the tested fungicide groups in the order systemic > contact and among the systemic fungicides as Curzate > Ridomil Gold.

Keywords: disease severity, yield losses, Phenyl amides, *Phytophthorainfestans*

Introduction

After more than 150 years of its first striking appearance in Ireland in the 1840s, late blight of potato still remains a challenging problem in global agriculture system, causing enormous crop and monetary losses to potato growers (Fry, 2008). Cold and humid environments are ideal for late blight epidemics (Johnson *et al.*, 1997; Majeed*et al.*, 2011). The disease is managed by rigorous applications of fungicides with plausible results. However, selection of appropriate fungicides for controlling late blight of potato is

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important in regard to frequent reports about the occurrence of phenylamide-resistant strains of *P. infestans* emerged in different parts of the world during the last three decades (Kim *et al.*, 2003; Perez *et al.*, 2009). In general, two types of fungicides, contact and systemic, are used for late blight management. Appearance of late blight symptoms in the potato field, spray intervals and environmental conditions are the key determinants for the efficacy of either type of fungicides. Systemic fungicides are more effective than contact fungicides in controlling late blight severity; however, these chemicals contain phenylamides as active ingredients whose frequent applications has been reported to have caused increased resistance in isolates of *P. infestans* to such chemicals (Runno and Koppel, 2006). Contrarily, contact fungicides are protective and non-specific in action-a property highlighting them superior to systemic fungicides in the context of resistance induction tendency in the pathogen; however, because of their non-absorption capacity into host tissues, they are effective only when applied at shorter intervals (Kato *et al.*, 1997; Fernandez-Northcote*et al.*, 2000).

Efficacy of systemic and contact fungicides against late blight of potato in field conditions has been widely documented. Namanda *et al.* (2004) reported that contact fungicide Dithane was effective for reducing late blight disease progress and increasing potato yields. Mantecon (2007) documented systemic fungicides more effective than contact fungicides in reducing early and late blight disease severity and increasing tuber yields. In a study conducted during 1983 to 2007 systemic and contact fungicides programs were evaluated for late blight and tuber yields; both fungicides programs significantly controlled foliar blight of potato and contributed to tuber yield increments with major contribution from systemic fungicides (Dowley*et al.*, 2008). Rahman *et al.* (2008) reported reduced leaf infection (43 %) and increased yields (20.56 %) comparative to control by applying foliar sprays of Filthane M-45.The objective of this study was to evaluate the efficacy of three systemic and three contact compounds against late blight disease and on tuber yields in Kaghan valley which provides ideal conditions for *P. infestans*.

Material and methods

Potato seed tubers (cv. Desiree) were sown in experimental farm at Sharan, Kaghan valley. The experiment was established in a randomized complete block design (RCBD) with four replications. Potato seeds were grown in four row plots, 3 meter long with spacing of 70 cm between rows and 30 cm within rows. Sowing was done on 20-06-2009. Experiment was laid out under natural conditions. Plants were harvested on 30-09-2009.

Application of fungicides and late blight assessment

Three systemic fungicides, Fostylalluminium, curzate and ridomil gold and three contact fungicides Revus, antrcol and blue copper were applied as foliar sprays as per manufacturers' recommendations. First spray was done immediately after first visible symptom appeared on potato leaves with subsequent sprays at seven day interval till last assessment of data. Unsprayed plants were kept as control for comparison of data.

Late Blight severity was recorded at weekly interval during the season on the basis of proportion of diseased foliage on a scale from 0 to 5 (Mantecon, 2009) (where 0 = no disease; 1 = first foliar symptom present and no defoliation; 2 = up to 25% defoliation plus foliar blight; 3 = up to 50% defoliation and plus foliar blight; 5 = 100% defoliation). The percent diseased foliage data were used to calculate area under disease progress curve (AUDPC) as described by Shaner and Finney (1977). On maturity, plants were harvested and tuber yield (t/ha) for each treatment was determined. Specific gravity of tuber was measured by weigh-in-air/weigh-in-water method as reported by Copas*et al.* (2009).

Data on late blight diseases severity, area under disease progress curve (AUDPC), specific gravity of tubers and total tuber yield were subjected to analysis of variance (ANOVA). For determination of significance differences among means of the studied parameters, Least Significant Differences (LSD) test was performed at $p \leq 0.05$.

Results

Disease severity (%)

Our results demonstrated significant variations in disease severity for systemic and contact fungicides (Table 1). In control plants, maximum defoliation occurred as a result of late blight and maximum disease severity (97.50 %) was recorded. Foliar sprays of systemic fungicides resulted in decreased percent disease severity. Among the systemic fungicides, plots treated with Curzate showed 61.25 % disease severity followed by Ridomil Gold (70.18 5) and FostylAluminum (82.50 %) respectively when compared to control where disease severity was 97.50 %. Contact fungicides also lowered disease severity of foliar late blight comparative to control; however, they were less effective than systemic chemicals. Contact fungicides used in this study were Antracol, Blue copper and Revus which resulted in foliar disease severity 86.11, 84.78 and 90.37 % respectively.

Data on reduction in disease severity level is presented in Fig. 1. Systemic fungicide Curzate reduced disease severity by 36.25 % which was highly effective as compared to other chemicals. Another fungicide, Ridomil Gold also contributed to reduction in disease severity (27.32 %), however, less effective than Curzate. Efficacy of contact fungicides on reducing disease severity level ranged from 7.13-12.72 %. Oveall, average disease severity recorded for contact group of fungicides was 87.08 % while systemic group resulted in the lowest didease severity 71.31 % when compared to control where maximum disease severity 97.50 % was observed (Fig. 2).

Area under disease progress curve (AUDPC)

Statistically different results were recorded for area under disease progress curve (AUDPC) in plants treated with foliar sprays of fungicides. Maximum AUDPC values 1645 was measured in control plants followed by plants treated with contact fungicide Revus which revealed non-significant AUDPC 1639 (Table 1). Comparing to control, significantly lower values for AUDPC were yielded by systemic fungicide Curzate (1003) followed by FostylAluminum and Ridomil Gold (1121 and 1114). Among the tested contact fungicides, Antracol and Blue copper decreased disease progress curve to significant extant (1314 and 1320 respectively) as compared to control (AUDPC=1645); Revus completely failed to check disease progress curve.

Tuber yield and specific gravity of tubers

Like other parameters under the study, differences for tuber yield were variable in different treatments. Lowest tuber yield was obtained from control plants which yielded only 11.40 tons hectare-1 (Table 1). Yields reached to significantly elevated level of 14.98 tons hectare-1 in plants sprayed with systemic fungicide Curzate. Another yield increment was observed in Ridomil gold treated plants which produced 13.48 tons hectare-1. These results were significantly different from control plants which yielded only 11.40 tons hectare-1. Systemic fungicide FostylAluminum did not affected the tuber yield. Results showed that contact fungicides had no significant effect on tuber yield. Tuber yield obtained from plants sprayed with contact fungicides ranged from 11.49-11.63 tons hectare^{-1} which was significantly similar to those of control (Fig. 3). Similarly, specific gravity of tubers was neither affected by systemic nor by contact fungicides and almost consistent values were recorded for all treatments. In control plots, specific gravity of tubrs was 1.074 while in fungicides treated plots (systemic and contact) it ranged between 1.074-1.076 (Table 1).

Table 1. Effect of systemic and contact fungicides on disease severity, AUDPC, tuber yield and specific gravity. Means in each column with different letters are significantly different from control ($p \leq 0.05$). Values in parenthesis represent average of the respective parameter for each fungicide group.

Fungicides	**Disease severity (%)**	**AUDPC**	**Tuber yield (t/ha)**	**Specific gravity**
Control	97.50a	1645a	11.40a	1.074a
		Systemic		
Curzate	61.25b	1003b	14.98b	1.075a
Fostyl Aluminum	82.50c	1121c	11.76a	1.074a
Ridomil Gold	70.18d	1114c	13.48c	1.076a
	(71.31)	(10.79)	(13.46)	(1.075)
		Contact		
Antacol	86.11e	1314d	11.52a	1.076a
Blue copper	84.78cef	1320d	11.63a	1.076a
Revus	90.37g	1639a	11.49a	1.076a
	(87.08)	(1424)	(11.54)	(1.076)
LSD values	6.34	1403	1.390	0.0015

Values in each column followed by different alphabets are significantly different ($p \leq 0.05$)

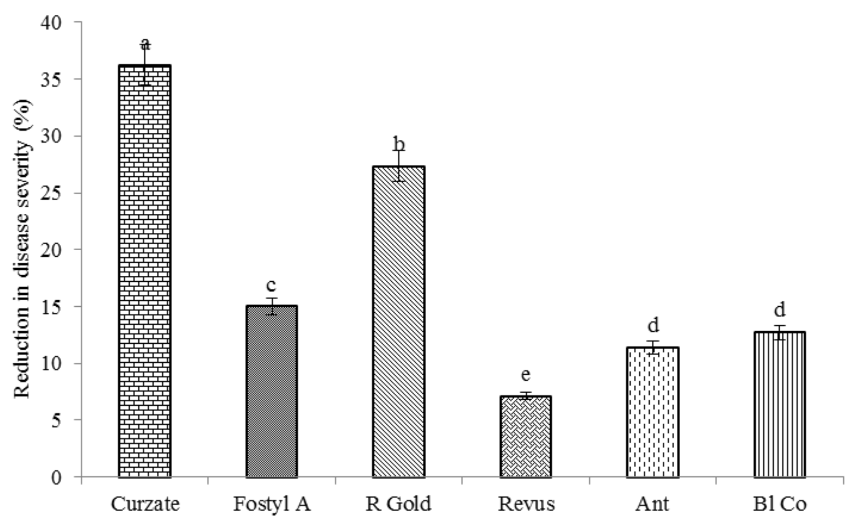

Fig. 1. Effect of systemic and contact fungicides on reduction of disease severity level (%). Bars with different letters reveal significant differences.

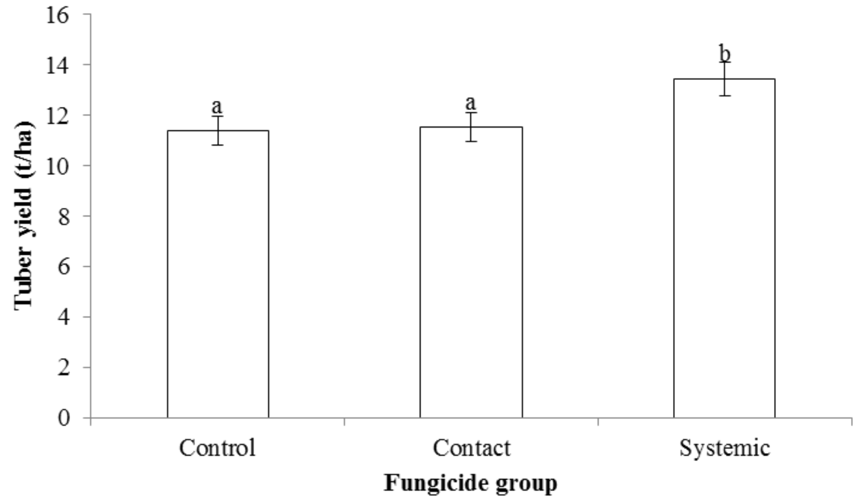

Fig. 2. Effect of systemic and contact fungicides on the average tuber yield of potato.

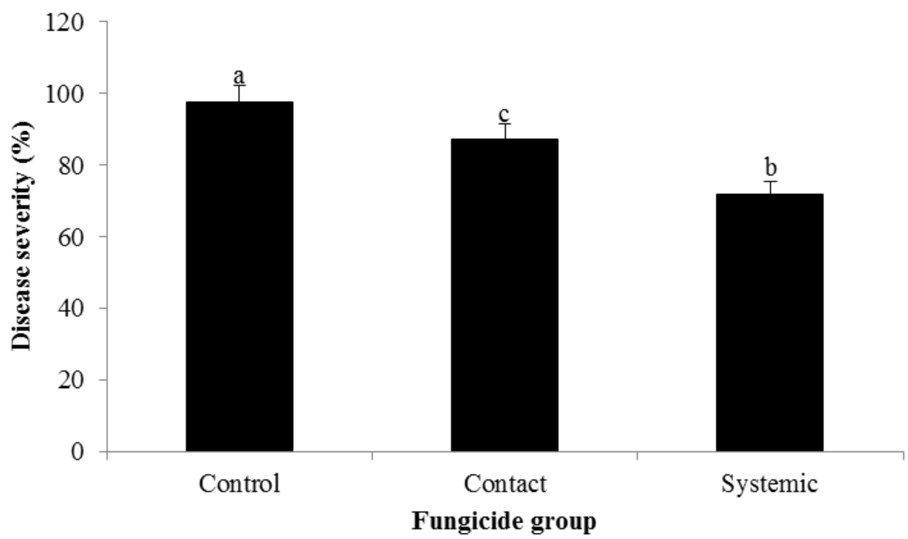

Fig. 3. Effect of systemic and contact fungicides on mean disease severity determined as percent defoliation.

Discussion

Climatic conditions are one of the most important factors in determination of late blight disease severity since the pathogen can infect and sporulatein moist and cold environments with greater intensity causing considerable crop damages in the absence of appropriate fungicides application. Experimental site this study provides ideal conditions for late blight disease with heavy rainfall and temperature below 13 °C. Thus, greater disease severity in control plants could be assigned to the conducive environment of the experimental field. Reduced disease severity in this study in plants treated with systemic and contact fungicides comparative to control may be attributed to fungistatic, anti-sporulationg capacity and inhibitory action of the fungicides used during the study. Our results are in good agreement with previous reports on the efficacy of systemic and contact fungicides (Mantecon, 2007; Dowley*et al.*, 2008; Rahman*et al.*, 2008). Singh, (1998) reported that fungicides application inhibits spore germination, sporulation and intercellular mycelia growth of late blight pathogen.

Area under disease progress curve (AUDPC) is a resistance parameter, calculated from the percentages of leaf area affected by late blight and its greater value corresponds to rapid spread and progress of the disease (Namanda *et al.*, 2004). In this study, greater values of AUDPC were recorded for control plots indicating greater acceleration of the disease spread. Fungicides application lowered AUDPC values to a significant extent, primarily by inhibiting spore germination and sporulation which act as agents for further progress of the disease.

Yield losses due to late blight can be quantified by recording differences in yield between fungicides treated and untreated plots. Maximum tuber yield was obtained from plants treated with systemic fungicides, particularly with foliar sprays of Curzate. Lowest tuber yield (11.40 t/ha) was obtained for the untreated control where both the level of defoliation at the end of the season and AUDPC values were higher. The variation in tuber yield under different treatments in the present investigation is primarily due to variation in late blight severity for different treatments. Effects of late blight on different treated plots were different. Disease spread was more intensive in unsprayed plots than fungicides treated plots. Increase in tuber yield under fungicides application could be attributed to low level of disease severity and consequently higher rate of photosynthate in such plants.

Specific gravity of tubers is an important qualitative parameter and is often used as a criterion of potato quality because of its close relationship to dry matter contents of tubers (Copas *et al.*, 2009). Results of this study indicated that specific gravity of tubers was neither affected by late blight severity nor by fungicide applications. Christ (1990) reported that specific gravity of tubers is negatively affected blight disease contradicting the findings of Manzer *et al.* (1965) quoting no significant effects of late blight or fungicides on specific gravity of tubers.

In general, systemic fungicides were more effective than contact fungicides by reducing the disease severity, AUDPC and increasing tuber yield.

It is generally accepted that systemic fungicides are superior to contact fungicides in that systemic fungicides have the ability to penetrate deep into host tissues and translocate up and down in the plant parts providing a barrier to *P. infestans*' further growth and development (Fernandez-Northcote*et al.*, 2000; Majeed and Muhammad, 2013). On the other hand, contact fungicides can only check the pathogen through surface action without penetration to host tissue.Their efficacy may be lost when eroded by wind or washed down by rain splashes. Our results are in good agreement with previous reports on the efficacy of systemic and contact fungicides (Mantecon, 2007; Dowley *et al.*, 2008; Rahman *et al.*, 2008).

In conclusion, foliar blight and disease progress was significantly reduced by foliar application of systemic and contact fungicides. Increments in tuber yields were only recorded for systemic fungicides Curzate and Ridomil gold; contact fungicides did not affect yield of potato. Efficacy of the two groups of fungicides was in the order systemic > contact.

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