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Comparative Efficacy of Different New Fungicides against Powdery Mildew Disease of Fieldpea (*Pisum sativum* L.)

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A B S T R A C T

The present study was conducted during consecutive *Rabi* season of year 2014-15 and 2015-16 at farmers field of Village *Amethi* in Gariyaband district of Chhattisgarh Plains to test efficacy of some new fungicides in controlling powdery mildew diseases of field pea. Results revealed that tebuconazole + trifloxystrobin (75 WG) recorded highest reduction of powdery mildew disease incidence before 2nd spray, before 3rd spray and after 3rd spray of fungicides and was found significantly superior as compared to other tested fungicides followed by azoxystrobin + difenoconazole (325 SC) and azoxystrobin + benovindiflupyr (55 EC). Highest percent disease incidence was recorded with untreated control plot. As far as other observations regarding yield and yield attributing characteristics of field pea, Tebuconazole + trifloxystrobin (75 WG) recorded highest plant height, length of pods, breadth of pods, number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seed weight and seed yield of field pea followed by azoxystrobin + difenoconazole (325 SC) and azoxystrobin + benovindiflupyr (55 EC). Lowest yield and yield attributes was found with untreated control.

Introduction

Peas are an important crop because of their diversity of utilization and extensive production area (Boros and Wawer, 2009). Pea (*Pisum sativum* L.) belonging to family leguminosae is one of the important vegetable crops of subtropical and temperate areas. The seeds of the crop are consumed as a vegetable and are used as a delicacy with other food stuff (Yawalkar, 1992). Field peas are often grown in continuous cropping systems as break crops. They are harvested at physiological maturity providing forage for animal feed (Jensen, 1987; Cousin, 1997; Borreani *et al*., 2007). It provides a variety of vegetarian dishes and hence it is liked throughout the world. Field peas are grown as a forage crop for cattle or as a green manure crop for soil improvement or as a cover crop to reduce the soil erosion or as a mature seed. The mature seed may be used as whole or split into '*dal*' and prepared in various ways for human consumption. Beside this, Peas are an excellent source of protein, fibre, minerals and vitamins (McPhee, 2004; Corre-Hellou and Crozat, 2005). One pound of green peas contains 13.7 gm fat, 36.1 gm carbohydrates, 45 mg calcium, 249 mg phosphorus and 54 mg ascorbic acid (Khan, 1994).Pea seed is also a source of vitamins A, B, C and contains 35 - 40% starch, 4 - 7% fibre and relatively

high levels of lysine. This makes it an appropriate dietary complement to cereals (Dhama *et al*., 2010) addition to their ability to fix atmospheric N, peas enhance soil structure, and provide breaks for disease control which means they have an important role in modern agricultural systems (McPhee, 2004; Martin *et al*., 2008).

Globally, pea is grown in an area of 1.1 million ha with total production of 9.2 million tonnes and the productivity is 8.35 tonnes ha^{-1}. Half of this production is used for livestock feed, and the remaining half for human consumption, mainly in developing countries (Martin-Sanz *et al*., 2011). In India, field pea occupies an area of 0.77 million hectare with a production 0.71 million tonnes and productivity 915 kg ha^{-1} (Singh, 2008). Uttar Pradesh, Madhya Pradesh, Chhattisgarh, Orissa, Bihar, Assam, Rajasthan, Punjab, Himachal Pradesh, Jharkhand, Haryana and Uttarakhand are major pea growing state in India. The average yield in major pea growing countries *viz.*, France (15.5 q ha^{-1}), Hungary (15.5 q ha^{-1}) and Netherland (14.3 q ha^{-1}) (Anonymous, 2002), while in India, the average yield is 9.15 q ha^{-1} (Singh, 2008), the wide gap between the attainable yield potentials and farmers field are due to various biotic, abiotic and socio-economic factors. Despite the potential for pea crops in agriculture, they still face challenges due to competition from weeds, insect attack, disease incidence, instability of productivity and a lack of successful nodulation (Date, 2000; Lemerle *et al.*, 2006; Martin-Sanz *et al*., 2011).

Among the various diseases of pea, Powdery mildew caused by *Erysiphe pisi var. pisi* are one of the major diseases causing severe loss with in short period of time. Powdery mildew appears in epidemic form when the plants are in the pod stage towards the end of January and in February. Severe infection may result in 24-27% reduction in pod weight, 21-30% reduction in pod number and up to 70% reduction in total yield (Prasad and Dwivedi, 2007). The disease can also hasten crop maturity and affects pea quality. Current powdery mildew control methods include early planting, the use of fungicides and of resistant cultivars. Chemical control is feasible with a choice of protective and systemic fungicides. Chemical control of the disease has been reported to be effective if applied at proper time (Jarial and Sharma, 2005) and different chemicals have been tested for their efficacy against the disease from time to time (Kotasathane, 1975; Upadhayay and Gupta, 1994; Kapoor and Sugha, 1995).

Considering above point, this study was undertaken at farmers field of Gariyaband district to test efficacy of some new fungicides in controlling rust diseases of fieldpea.

Materials and Methods

The present study was conducted during consecutive *Rabi* season of year 2014-15 and 2015-16 at farmers' field of Village *Amethi* in Gariyaband district of Chhattisgarh Plains. The experiment was planned and laid out in Randomized Block Design with four treatments including untreated control, each replicated six times with plot size of one acre. The soil of the farmers' field was sandy loam in texture, neutral in reaction and had low nitrogen, medium phosphorus and potassium contents. Three different new fungicides were tested for control of powdery mildew in fieldpea during experimentation. The treatments contains T_1 – Tebuconazole + Trifloxystrobin (75 WG), T_2 – Azoxystrobin + Difenoconazole (325 SC), T_3 – Azoxystrobin + Benzovindiflupyr (55 EC) and T_4 – Untreated control. Fieldpea variety Shubhra was selected as a test variety for the

study. The crop was sown from seed drill with spacing of 30 cm between rows using a certified seed with seed rate of 80 kg ha^{-1}. To prevent the crop from soil and seed borne diseases, the seeds were treated with thiram @ 3 g kg^{-1} seed and *rhizobium* culture.

The crop was fertilized with basal dose of 20, 60 and 30 kg N, P_2O_5 and K_2O ha^{-1}, respectively and was grown under irrigated condition by adopting all agronomic practices as per recommendation of IGKV, Raipur except fungicide application. The crop was protected from the infestation of both sucking pests and pod borers through blanket application of selective insecticides in all experimental fields uniformly to avoid the yield losses due to insects.

Percent Disease Incidence (PDI)

Plants were observed over time to investigate the powdery mildew severity under natural conditions. Data were recorded on the basis of symptoms.

Disease severity data were recorded three times for each treatment with one before application of fungicides. The time interval was maintained as 15 days. First spray of fungicides as per treatments, was taken up after initial appearance of disease in crop and further sprays were given at 15 days interval with knap sack sprayer at the rate of 500 liter of spray fluid per hectare for thorough coverage of foliage with spray fluid.

The severity of powdery mildew were recorded one day before the second and third spray from four randomly selected area of each plot with the help of 1 m^2 quadrate and is expressed in term of percentage and finally 10 days after third spray. After each observation, their mean percentage was calculated by using following formulae:

$$\text{Percent Disease Incidence (PDI) \%} = \frac{\text{Number of Plants infected by disease}}{\text{Total Number of plants observed}} \times 100$$

Plant height (cm)

Five randomly represented selected plants from four randomly selected square meter area were measured using a measuring tap for each treatment and averaged.

The harvesting was done manually with the help of sickle, when the crop attained full maturity. The produce of a square meter from four randomly selected of each plot was tied into bundle and allowed to sun drying in respective plots.

The harvested bundles were transported to threshing floor. Threshing of produce of each plot was done separately by multicrop thresher and weighed.

Number of pods $plant^{-1}$, seeds pod^{-1}, Length (cm) and Breadth (cm) of pod

Number of pods per plant was calculated by counting the total number of pods from four randomly selected square meter area plants and was presented by its average value number. Before counting the number of seeds in pod, these pods were subjected for measuring of pod length and breadth. Thereafter these pods are subjected for counting number of seeds per pod by taking their average value.

1000 seed weight (g)

After counting of number of seeds per pod, total numbers of 1000 seeds from each treatment are weighed and its average value was noted down.

Seed yield (q ha^{-1})

Seed yield of the net plot was noted down, after threshing, winnowing and drying and calculated in q ha^{-1}.

The data were subjected to statistical analysis after using transformations for per cent disease incidence.

Results and Discussion

In general, the incidence of powdery mildew disease in field pea was slightly higher during first year of experimentation *(Rabi* 2014-15) when compared to the next year (*Rabi* 2015-16) (Table 1). All the tested fungicides was found effective against control of powdery mildew disease and also found significant differences over untreated control. The mean per cent powdery mildew disease incidence was ranged from 5.19 to 36.60 per cent.

Percent Disease Incidence (PDI)

The result on per cent disease incidence of powdery mildew is presented in table 1. Data revealed that all three tested fungicide was found effective in controlling powdery mildew disease of field pea. Application of fungicide showed significant reduction in per cent disease incidence with maximum reduction in Tebuconazole + trifloxystrobin followed by Azoxystrobin + difenoconazole and Azoxystrobin + Benzovindiflupyr. The mean disease incidence from both experimental years with respect to different fungicides ranged from 5.19 to 36.60 per cent.

As far as effect of fungicide before second spray, Tebuconazole + trifloxystrobin was found significantly superior as compared to other tested fungicides, and recorded 13.03 and 12.52 per cent powdery mildew incidence in both the experimental year, respectively with mean per cent of 12.78. The maximum powdery mildew disease incidence in both experimental year before second spray of 2014-15 and 2015-16 was found in untreated control plot (26.57 and 25.10 per cent, respectively) with mean per cent of 25.84. Spraying of other chemical fungicides used under trial *i.e.* azoxystrobin + difenoconazole and azoxystrobin + benzovindiflupyr also reduced disease incidence of powdery mildew and recorded mean per cent of 18.27 and 16.66 in both consecutive year, respectively.

Data regarding percent disease incidence before third application of different fungicides showed significant differences from each other. The mean highest reduction in disease incidence (11.20) was observed in tebuconazole + trifloxystrobin treated plots followed by azoxystrobin + difenoconazole (14.92) and azoxystrobin + benzovindiflupyr (17.38). Although, Tebuconazole + trifloxystrobin treated plots was found significantly differ from rest other fungicides. The maximum disease incidence was observed in untreated control plots in both crop seasons of 2014-15 and 2015-16 (30.72 and 29.15, respectively) with mean percent of 29.94.

Data pertaining to percent disease incidence after third application of fungicide were significantly different in different fungicidal treatment. However, all the fungicides reduced the disease incidence of powdery mildew ranged from 37.67 to 4.93 with maximum reduction in tebuconazole + trifloxystrobin treated plots and minimum in untreated control plots. However, Tebuconazole + trifloxystrobin treated plots recorded significantly higher reduction in mean disease incidence and was found superior over any other treatments, followed by azoxystrobin + difenoconazole (10.18) and azoxystrobin + benzovindiflupyr (12.78). The highest disease per cent incidence in both years was observed under untreated control

plots (37.67 and 35.53 per cent, respectively) with mean per cent of 36.60.

Fuzi (1995) also concluded with the result of field trials with control fungicides to compare their efficacy with that of systemic sterol biosynthesis inhibiting fungicides against rust (*Uromyces pisi*) and powdery mildew (*Erysiphe pisi*) of peas. While, Gupta and Shyam (1998) observed the efficacy of Triademefon, Hexaconazole, Difenaconazole, Flusilazole, Fenarimol, Penconazole, Mancozeb and Chlorothalonil, among these Hexaconazole (0.10%) and Difenoconazole (0.01%), were best against powdery and increased yield. Ransom *et al*., (1991); Alam *et al*., (2007); Loganathan *et al*., (2011) have reported the role of triazoles like tebuconazole, propiconazole and flusilazolein managing the pea powdery mildew and increasing the pod yields. Hexaconazole has been reported to be effective against pea powdery mildew by Gupta and Shyam (1998). Jarial and Sharma (2011) have also reported hexaconazole and carbendazim to be effective against the disease and increasing the pod yield and other yield parameters correspondingly. Jarial *et al*., (2015) recorded maximum disease severity was found in the plots sprayed with dimethomorph which was however significantly lower than the untreated check.

Plant height (cm)

Results on effect of different fungicidal treatments for control of powdery mildew disease on plant height of fieldpea was recorded and presented in table 2. The results revealed that average tallest plant (41.81 cm) was recorded under tebuconazole + trifloxystrobin treated plots and was found significantly longer than any other treatments. Tebuconazole + trifloxystrobin was followed by azoxystrobin + difenoconazole and azoxystrobin + benzovindiflupyr with average plant length of 41.05 cm and 39.20 cm, respectively. Untreated control plots recorded shortest plant in both year of experimentation (31.66 cm and 32.20 cm) with average height of 31.93 cm. Alam *et al*., (2007) also find similar results considering plant height of fieldpea and stated that the highest plant height was observed in propiconazole and lowest plant height was obtained from control plots

Number of pods plant^{-1}

Data concerning the effect of different fungicides used under trial on total number of pods plant^{-1} in consecutive year of *rabi* 2014-15 and 2015-16 was depicted in tabular form and presented in table 3. The data revealed that different tested fungicides were found significant on number of pods plant^{-1}. More number of pods plant^{-1} was found under treatment tebuconazole + trifloxystrobin treated plots in both experimentation year with average number of 10.04, and was found significantly superior over rest other treated plots. Azoxystrobin + difenoconazole and azoxystrobin + benzovindiflupyr also recorded significantly higher number of pods plant^{-1} with average value of 9.89 and 8.76, respectively than untreated control plots. Lesser number of pods plant^{-1} was recorded under untreated control plots in both year (6.17 and 6.32) with mean number of 6.25. Alam *et al*., (2007) also find similar results and stated that the highest pods plant^{-1} was observed in propiconazole and lowest pods plant^{-1} was obtained from control plot.

Length and breadth of pods

The effect of various fungicidal treatments spray on average length and breadth of pods was found significant. Highest mean value of maximum length and breadth of pod in both experimentation year was recorded under tebuconazole + trifloxystrobin (4.83 cm and

1.16 cm, respectively) and was found significantly longer and wider pods among rest other treatments, followed by azoxystrobin + difenoconazole (4.68 cm and 1.12 cm) and azoxystrobin + benzovindiflupyr (4.60 cm and 1.08 cm) sprayed plots. Untreated control plots recorded shorter and thinner pods with mean measure of 3.88 cm and 0.98 cm, respectively. Alam *et al*., (2007) also find similar results considering length and breadth of pod.

Number of seeds pod^{-1}

Response of different fungicides used under trial showed that they were significantly different from each other as far as number of seeds pod^{-1} was concerned. Results revealed that, more number of seeds per pod of fieldpea was recorded under treatment Tebuconazole + trifloxystrobin in both the experimentation year (6.22 and 6.32) with average number of seeds pod^{-1} of 6.27 and was found significantly superior over than any other fungicidal treatment. However other fungicides used under trial also gave significantly higher number of seeds pod^{-1} as compared to untreated control. The lowest number of seeds pod^{-1} was observed under untreated control plot (5.20 and 5.36) with mean number of 5.28. There are normally 5 - 6 seeds contained in a pea pod but this depends on the cultivar and the growing conditions (Knott, 1987). Alam *et al*., (2007) also find similar results considering yield contributing characters (plant height, pods plant^{-1}, length of pod and breadth of pod and seed pod^{-1}) of fieldpea.

1000 seed weight (g)

1000 grain weight of fieldpea from the experimental plots was recorded separately during 2014-15 and 2015-16 crop seasons. During both crop seasons, Tebuconazole + trifloxystrobin fungicide sprayed plots recorded heavier 1000 seed weight of fieldpea in both year of experimentation (145.21 g and 148.06 g) and was found significantly superior than any other treatments with mean weight of 146.64 g. However other two fungicidal treatments, azoxystrobin + difenoconazole and azoxystrobin + benzovindiflupyr also recorded significantly mean heavier 1000 seed weight (139.51 g and 135.32 g, respectively) than untreated control (132.84 g). Seed weight is the most stable yield component (Littleton *et al*., 1979; Saxena, 1980; Saxena and Sheldrake, 1980; Saxena *et al*., 1983). Pea seeds differ in size and shape, with size ranging from about 90 mg seed^{-1} to 400 mg seed^{-1} (Knott, 1987).

Seed yield (q ha^{-1})

Data regarding effect of fungicidal treatments on seed yield of fieldpea was presented in tabular form. Significant differences were observed with different fungicidal treatment for control of powdery mildew disease. Among different fungicides, Tebuconazole + trifloxystrobin treated plots produced 12.24 q ha^{-1} and 12.56 q ha^{-1} of seed yield in both consecutive year of experimentation, respectively with mean yield of 12.40 q ha^{-1}. However, this treatment was found significantly superior and produced more seed yield than any other treatments. Spraying of other fungicides *i.e*, azoxystrobin + difenoconazole and azoxystrobin + benzovindiflupyr fungicides for powdery mildew control also recorded significant higher seed yield in both crop season with mean seed yield of 11.72 q ha^{-1} and 10.48 q ha^{-1}, respectively as compared to untreated control plots (7.41 q ha^{-1}). The number of pods plant^{-1} and plants unit area^{-1} have been demonstrated to be the yield components most strongly correlated to pea seed yield (French, 1990).

Table.1 Effect of different fungicides on powdery mildew disease incidence per cent of field pea before 2nd spray, before 3rd spray and after 3rd spray

Treatment	Percent Disease Incidence (PDI)								
	Before 2nd Spray		*Mean*	Before 3rd Spray		*Mean*	After 3rd Spray		*Mean*
	2012-13	2013-14		2012-13	2013-14		2012-13	2013-14	
T_1 – Tebuconazole + Trifloxystrobin (75 WG)	13.03	12.52	***12.78***	11.57	10.82	***11.20***	5.45	4.93	***5.19***
T_2 – Azoxystrobin + Difenoconazole (325 SC)	16.42	16.90	***16.66***	14.92	13.52	***14.22***	10.24	10.12	***10.18***
T_3 – Azoxystrobin + Benzovindiflupyr (55 EC)	18.33	18.20	***18.27***	17.38	16.58	***16.98***	12.68	12.88	***12.78***
T_4 – Untreated Control	26.57	25.10	***25.84***	30.72	29.15	***29.94***	37.67	35.53	***36.60***
SEm±	**0.70**	**0.96**		**0.61**	**0.53**		**0.57**	**0.56**	
CD (P=0.05)	**2.10**	**2.05**		**1.83**	**1.59**		**1.72**	**1.67**	

Table.2 Effect of different fungicides on plant height, length and breadth of pods of fieldpea

Treatment	Plant Height		*Mean*	Length of pods		*Mean*	Breadth of pods		Mean
	2012-13	**2013-14**		**2012-13**	**2013-14**		**2012-13**	**2013-14**	
T_1 – Tebuconazole + Trifloxystrobin (75 WG)	41.45	42.16	***41.81***	4.8	4.85	***4.83***	1.15	1.17	***1.16***
T_2 – Azoxystrobin + Difenoconazole (325 SC)	40.86	41.23	***41.05***	4.66	4.7	***4.68***	1.1	1.13	***1.12***
T_3 – Azoxystrobin + Benzovindiflupyr (55 EC)	38.75	39.65	***39.20***	4.52	4.68	***4.60***	1.06	1.09	***1.08***
T_4 – Untreated Control	31.66	32.2	***31.93***	3.87	3.89	***3.88***	0.96	1	***0.98***
SEm±	**0.15**	**0.27**		**0.03**	**0.06**		**0.03**	**0.03**	
CD (P=0.05)	**0.44**	**0.58**		**0.09**	**0.17**		**0.08**	**0.06**	

Table.3 Effect of different fungicides on Number of pods plant^{-1}, number of seeds pod^{-1}, 1000 seed weight and seed yield of fieldpea

Treatment	No of pods plant^{-1}		Mean	No of seeds pod^{-1}		Mean	1000 seed weight (g)		*Mean*	Seed yield (q ha^{-1})		Mean
	2012-13	2013-14		2012-13	2013-14		2012-13	2013-14		2012-13	2013-14	
T_1 – Tebuconazole + Trifloxystrobin (75 WG)	9.85	10.22	***10.04***	6.22	6.32	***6.27***	145.21	148.06	***146.64***	12.24	12.56	***12.40***
T_2 – Azoxystrobin + Difenoconazole (325 SC)	9.76	10.02	***9.89***	6.08	6.25	***6.17***	138.44	140.57	***139.51***	11.58	11.85	***11.72***
T_3 – Azoxystrobin + Benzovindiflupyr (55 EC)	8.65	8.90	***8.76***	5.86	6.00	***5.93***	134.97	135.66	***135.32***	10.33	10.63	***10.48***
T_4 – Untreated Control	6.17	6.32	***6.25***	5.20	5.36	***5.28***	132.32	133.35	***132.84***	7.25	7.56	***7.41***
SEm±	**0.07**	**0.15**		**0.06**	**0.11**		**0.98**	**1.60**		**0.27**	**0.40**	
CD (P=0.05)	**0.20**	**0.31**		**0.18**	**0.23**		**2.94**	**3.41**		**0.80**	**0.85**	

Istran (1996) also reported similar results that Opus (epoxyconazole) was the most effective in increasing yield, while several formulation combining polyram DF (metiram) with Altro combi (cyproconazole + carbendazim) or Kumulus-S (sulfur). Singh and Singh (1997) also revealed that all the fungicide treatments significantly reduced the disease severity and increased the grain yield of pea. Gupta and Shyam (1998) also in conformity with the results obtained and observed the efficacy of Triademefon, Hexaconazole, Difenaconazole, Flusilazole, Fenarimol, Penconazole, Mancozeb and Chlorothalonil against powdery mildew control and found Difenoconazole (0.01%), were best against powdery mildew and increased yield

Alam *et al*., (2007) found a significant negative correlation between PDI of powdery mildew and yield (kg ha^{-1}), which indicated that with the increase of PDI of powdery mildew there was a progressive fall in the yield.

A linear regression was fitted between yield and PDI of powdery mildew. Jarial and Sharma (2011) have also reported hexaconazole and carbendazim to be effective against the disease and increasing the pod yield and other yield parameters correspondingly. Jarial *et al*., (2015) also reported that minimum pod yield was recorded in the untreated control plots under both natural and protected conditions.

In conclusion, from present study, it was concluded that spraying of tebuconazole + trifloxystrobin (75 WG) were highly effective in controlling the incidence of powdery mildew disease of fieldpea. This also concluded that tebuconazole + trifloxystrobin increased the seed yield and yield attributing characteristics like length of pods, breadth of pods, number of pods $plant^{-1}$, number of seeds pod^{-1} and 1000 seed weight.

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