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Field evaluation of different new fungicides against rust disease of fieldpea (*Pisum sativum* L.)

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ABSTRACT

The present study was conducted during consecutive *Rabi* season of year 2012-13 and 2013-14 at farmers field of village Potiya in Gariyaband district of Chhattisgarh plains to test efficacy of some new fungicides in controlling rust diseases of fieldpea. Results revealed that Propiconazole + cyproconazole (330 EC) recorded highest reduction of rust 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 250 SC and difenoconazole 250 SC. Highest per cent disease incidence was recorded with untreated control plot. As far as other observations regarding yield and yield attributing characteristics of fieldpea, Propiconazole + cyproconazole (330 EC) 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 fieldpea followed by azoxystrobin 250 SC and difenoconazole 250 SC. Lowest yield and yield attributes was found with untreated control.

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INTRODUCTION

Peas are an important crop because of their diversity of utilization and extensive production area (Boros and Wawer, 2009). Pea plants were first grown in the Mediterranean region in 7000 B.C. to provide food for humans and animal feed. From this origin, peas have spread over most temperate regions (McPhee, 2004) and are now grown for human consumption and for hay, or silage to support animal production (Uzun *et al*., 2005). 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 and Borreani *et al*., 2007). Beside this, peas are an excellent source of protein, fibre, minerals and vitamins (McPhee, 2004 and Corre-Hellou and Crozat, 2005). Peas are a rich source of protein having 26 per cent crude protein (Fenwick, 1969). One pound of green peas contains 13.7 g fat, 36.1 g carbohydrates, 45 mg calcium, 249 mg phosphorus and 54 mg ascorbic acid (Khan, 1994). Pea seed is a source

of vitamins A, B, C and contains 35 - 40 per cent starch, 4 - 7 per cent fibre and relatively high levels of lysine. This makes it an appropriate dietary complement to cereals (Gul *et al*., 2006 and 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 and Martin *et al*., 2008).

The total cultivated dry pea area in the world is about 6.2 M ha with an average yield of 1.68 t ha^{-1} producing an estimated 105 M t. 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). Green peas are grown on 2.1 M ha which produce 16 M t (FAOSTAT, 2009).

In India, pea is grown over an area of 0.77 million hectare with a production 0.71 million tonnes and productivity 915 kg/ha (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 and Martin-Sanz *et al*., 2011). Rust is one of the most important fungal foliar disease of pea in India, which regularly appears in mild to severe form every year specially in timely sown crop at poding stage (Gupta *et al*., 1990). However, in Chhattisgarh, the occurrence of rust is a regular feature. Disease usually appears late in season, reaching maximum intensity during the pod formation stage. Singh and Tripathi (2004) have also concluded that rust is one of the major disease of field pea and it is responsible for substantial losses in grain yield. Many reaserchers tried to control this diseases chemically world wide (Suhag and Rana, 1984; Verma, 1984; Rahman *et al.*,1984; Bakr and Rahman, 1998; Rahman *et al.*, 2005; Ahmed *et al.*, 2006). The disease can be controlled by applying a number of management strategies including biological, cultural, chemical and planting resistant varieties (Marshi *et al*., 1982). Among these, use of resistant varieties and application of fungicides are more effective.

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.

MATERIAL AND METHODS

The present study was conducted during consecutive *Rabi* season of year 2012-13 and 2013-14 at farmers field of village Potiya in Gariyaband district of Chhattisgarh Plains. This experiment was planned 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 fungicides were tested during experimentation. The treatments contains T_1– Propiconazole + Cyproconazole (330 EC), T_2 – Azoxystrobin (250 EC), T_3– Difenoconazole and T_4 – Untreated control. Fieldpea variety Ambika, which is succeptible to rust was selected for the study. The crop was sown manually with spacing of 30 cm and 10 cm between rows and plants, respectively 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 rainfed 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 field uniformly to avoid the yield losses due to insects.

Per cent disease incidence (PDI) :

Plants were observed over time to investigate the rust 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 lit. of spray fluid per hectare for thorough coverage of foliage with spray fluid. The severity of rust 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 per centage and finally 10 days after third spray. After each observations, their mean percentage was calculated by using following formulae:

$$\text{Per cent disease incidence (PDI) \%} = \frac{\text{Number of plants infected by disease}}{\text{Total number of plants observed}} \text{x100}$$

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 beating with wooden sticks then seeds were cleaned manually 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 qha^{-1}.

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

RESULTS AND DISCUSSION

In general the incidence of rust disease in fieldpea was slightly higher during *Rabi* 2012-13 when compared to next year *Rabi* 2013-14 (Table 1). All the tested fungicides was found effective against rust disease and also found significant over untreated control. The mean per cent rust disease incidence was ranged from 5.85 to 38.95 in different experimental treatments.

Per cent disease incidence (PDI) :

The results on per cent disease incidence is presented in Table 1. Data revealed that all three tested fungicide was found effective in controlling rust disease of fieldpea. Application of fungicide caused significant reduction in disease incidence of rust with maximum reduction in Propiconazole + cyproconazole followed by Azoxystrobin and Difenoconazole. The average disease incidence in different fungicide ranged from 5.85 to 38.95 per cent.

As far as effect of fungicide after first spray or say before second spray, Propiconazole + cyproconazole was found significantly superior as compared to other tested fungicides and recorded 14.42 and 13.22 per cent rust incidence in both the experimental year, respectively. The maximum rust disease incidence in both experimental year before second spray of 2012-13 and 2013-14 was found in untreated control plot (28.45 and 26.85%, respectively) with mean per cent of 27.65. Spraying of

Table 1: Effect of different fungicides on rust disease incidence per cent of fieldpea before 2nd spray, before 3rd spray and after 3rd spray

Treatments	Per cent 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 – Propiconazole + Cyproconazole 330 EC	14.42	13.22	13.82	12.22	11.76	11.99	6.40	5.85	6.12
T_2 – Azoxystrobin 250 SC	18.45	17.65	18.05	15.71	14.26	14.98	11.24	11.00	11.12
T_3 – Difenoconazole 250 SC	20.23	19.25	19.74	18.33	17.66	17.99	13.96	13.22	13.59
T_4 – Untreated control	28.45	26.85	27.65	31.80	30.50	31.15	38.95	36.73	37.84
S.E.±	0.76	0.97		0.57	0.56		0.64	0.57	
C.D. (P=0.05)	2.28	2.06		1.71	1.68		1.92	1.72	

azoxystrobin and difenoconazole also reduced disease incidence of rust and recorded mean per cent of 18.05 and 19.74 in both consecutive year, respectively.

Data regarding per cent disease incidence before third application of different fungicides showed significant differences.The mean highest reduction in disease incidence (11.99) was observed in Propiconazole + cyproconazole treated plots followed by azoxystrobin (14.98) and difenoconazole (17.99). Although, Propiconazole + cyproconazole treated plots was found significantly differ from rest other fungicides. The maximum rust incidence was observed in untreated control plots in both year of 2012-13 and 2013-14 (31.80 and 30.50) with mean per cent of 31.15.

Data pertaining to per cent disease incidence after third application of fungicide were significantly different in different fungicidal treatment. Overall, the fungicides reduce the disease incidence of rust ranged from 38.95 to 5.85 with maximum reduction in propiconazole + cyproconazole treated plots and minimum in untreated control plots. However, Propiconazole + cyproconazole treated plots recorded significantly higher reduction in mean disease incidence and was found superior over any other treatments, followed by azoxystrobin (11.12) and difenoconazole (13.59). The highest disease per cent incidence was observed with untreated control plots.

Alam *et al.* (2007) also observed the similar findings in which they reported that all fungicides resulted significantly better performance over control. Considering per cent disease index (PDI), Propiconazole performed better than other fungicides. The highest PDI of both diseases was observed in control treatment, where as the lowest PDI and per cent disease reduction over control was recorded in propiconazole may be used for controlling powdery mildew and rust disease and increasing pod yield of garden pea.

Rahman *et al*. (2005) and Ahmad *et al*. (2006) also reported that Tilt 25 EC (propiconazole) @ 0.05 per cent was the most effective fungicide against rust disease. Singh and Tripathi (2004) also find similar result. Gupta and Shyam (2000) concluded that Cyperconazole, Flusilezole, Penconazole and Hexaconazole completely inhibited rust incidence and rust severity on leaves. 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 rust and increased yield. Diaz Franco and Perez Garcia (1995) also reported the effect of Propiconazole, Triademefon and Triforine to control rust of chickpea (*Uromyces ciceris-arietini*). And observed that propiconazole decreased the infection. Hegab and Beshir (1994) also reported similar findings that Mancozeb was the most effective fungicide and significantly reduced disease severity as compared to the unsprayed control. McEwen and Yeoman (1990) reported largest average yield by Mancozeb. Bayleton was better than Calaxin in minimizing the attack of rust and increasing the yield. Khaled and Moity (1995) used different fungicides but Mancozeb was more effective in reducing the disease intensity of pea rust. Upadhyay and Gupta (1994) found that Bayleton and Calaxin were effective against pea rust. Similarly, the same trend was found by Marcellos and Moore (1995); Pande and Srivastava (1995); Ayub *et al.* (1996) and Singh (1997).

Plant height (cm) :

Results on effect of different fungicidal treatments on plant height of fieldpea was recorded and presented in Table 2. The results revealed that average highest plant height (41.57cm) was recorded under propiconazole + cyproconazole treated plots and was found significantly longer than any other fungicides used in trial. Propiconazole + cyproconazole was followed by azoxystrobin and difenoconazole with average plant length of 39.75 cm and 38.71 cm, respectively. Untreated

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

Treatments	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 – Propiconazole + Cyproconazole 330 EC	41.14	42.01	41.57	4.86	4.94	4.90	1.19	1.24	1.22
T_2 – Azoxystrobin 250 SC	38.99	40.52	39.75	4.74	4.79	4.77	1.15	1.18	1.17
T_3 – Difenoconazole 250 SC	37.92	39.49	38.71	4.62	4.76	4.69	1.11	1.15	1.13
T_4 – Untreated control	30.01	32.35	31.18	3.95	3.97	3.96	1.00	1.03	1.02
S.E.±	0.41	0.66		0.03	0.08		0.03	0.03	
C.D. (P=0.05)	1.24	1.40		0.09	0.17		0.08	0.07	

control plots recorded shortest plant in both year of experimentation (30.01 cm and 32.35 cm) with average height of 31.18 cm.

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}), propiconazole performed better than other fungicides.

Number of pods plant^{-1} :

Data concerning the effect of different fungicides used in trial on total number of pods plant^{-1} in consecutive year of *Rabi* 2012-13 and 2013-14 was depicted in tabular form and presented in Table 2. The data revealed that different tested fungicides were found significant. More number of pods plant^{-1} was found under propiconazole + cyproconazole treated plots in both experimentation year with average number of 10.12 and was found significantly superior over rest other treated plots. Azoxystrobin and difenoconazole also recorded significantly higher number of pods plant^{-1} with average value of 9.82 and 8.74, respectively. Lesser number of pods plant^{-1} was recorded under untreated control plots in both year (5.66 and 6.30) with mean of 5.98. 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}), propiconazole performed better than other fungicides.

Length and breadth of pods :

The effect of various fungicidal treatments spray on the average length and breadth of pods was found at significant difference with control. However, mean value of maximum length and breadth of pod in both experimentation year was recorded in Propiconazole + cyproconazole (4.90 cm and 1.22 cm, respectively) and was found significantly longer and wider pods among rest other treatments, followed by azoxystrobin (4.77 cm and 1.17 cm) and difenoconazole (4.69 cm and 1.13 cm) sprayed plots. Untreated control plots recorded shorter and thinner pods with mean value of 3.96 cm and 1.02 cm, respectively. 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}), propiconazole performed better than other fungicides.

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 propiconazole + cyproconazole in both the experimentation year (6.40 and 6.48) with average number of seeds pod^{-1} of 6.44. Although, it was found significantly superior over any other fungicidal treatment against rust. However, other fungicides used under trial also give 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 (5.25 and 5.50) with mean number of 5.38. 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}), propiconazole performed better than other fungicides (Table 3).

1000 seed weight (g) :

1000 grain weight of the fungicides sprayed plots was recorded separately during 2012-13 and 2013-14 crop seasons. During both crop seasons of 2012-13 and 2013-14, Propiconazole + cyproconazole fungicide sprayed treatment was found significantly superior than any other treatments and untreated control with mean weight of 150.64 g. However, other two fungicidal

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

Treatments	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 – Propiconazole + Cyproconazole 330 EC	9.86	10.38	10.12	6.40	6.48	6.44	149.38	151.89	150.64	12.42	13.07	12.75
T_2 – Azoxystrobin 250 SC	9.43	10.20	9.82	6.13	6.32	6.23	143.94	144.85	144.40	11.82	12.18	12.00
T_3 – Difenoconazole 250 SC	8.30	9.17	8.74	6.07	6.02	6.05	138.71	139.00	138.86	10.83	10.87	10.85
T_4 – Untreated Control	5.66	6.30	5.98	5.25	5.50	5.38	133.50	132.03	132.77	7.58	7.47	7.53
S.E.±	0.12	0.12		0.07	0.07		1.17	1.67		0.24	0.36	
C.D. (P=0.05)	0.36	0.39		0.21	0.22		3.52	3.56		0.74	0.76	

treatments azoxystrobin and difenoconazole also recorded significantly mean heavier 1000 seed weight (144.48 g and 138.86 g, respectively) than untreated control (132.77 g).

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 in seed yield of fieldpea with different fungicidal treatment for control of rust disease. Among different fungicides, Propiconazole + cyproconazole treated plots produced 12.42 q ha^{-1} and 13.07 q ha^{-1} of seed yield with mean seed yield of 12.75 q ha^{-1}. However, this treatment was found significantly superior and produced more seed yield than any other fungicidal treatments. Spraying of azoxystrobin and difenoconazole fungicides for rust control also recorded significant higher seed yield in both crop season with mean seed yield of 12 q ha^{-1} and 10.85 q ha^{-1}, respectively as compared to untreated control plots (7.53 q ha^{-1}).

Singh and Tripathi (2004) also reported similar findings in a field experiment and they found that 2 to 3 spray of Baycor 0.1 per cent at 15 days interval was most effective in reducing the disease severity and resulted in appreciable increase in grain yield. While, Mahanta *et al.* (2000) observed that Bavistin was most effective (27.16%) in decreasing per cent disease index (PDI) for leaf spot and rust and increased the yield (20.25 kg/ha) compared to the control (17.43 kg/ha). Mancozeb decreased the PDI for leaf spot and rust to 21.54 per cent and had the highest yield (21.99 kg/ha). Gupta and Shyam (1998) observed that, the efficacy of Triademefon, Hexaconazole, Difenaconazole, Flusilazole, Fenarimol, Penconazole, Mancozeb and Chlorothalonil were tested for the rust control in among these Hexaconazole (0.10%) and Difenoconazole (0.01%), were best against rust and increased yield. Singh and Singh (1997) also revealed that all the fungicide treatments significantly reduced the disease severity and increased the grain yield of pea. Istran (1996) reported 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).

Conclusion :

From present study, it was concluded that spraying of propiconazole + cyproconazole were highly effective in controlling the incidence of rust disease in fieldpea. This also concluded Propiconazole + cyproconazole 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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