International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; SP-8(2): 125-129

Received: 13-01-2020
Accepted: 15-02-2020

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Influence of sowing dates and fungicides sprays on incidence of powdery mildew of cowpea incited by *erysiphe polygoni* (DC)

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DOI: https://doi.org/10.22271/chemi.2020.v8.i2c.9670

Abstract
Adjustment of sowing dates along with fungicide sprays is an obviously good strategy to minimize the diseases and obtained better yield. Therefore, the present work was carried out to study the effect of sowing dates along with fungicides spray on incidence of powdery mildew of cowpea incited by *Erysiphe polygoni* during the year 2012-13 and 2013-14. The cowpea variety *Konkan sadabahar* was sown at three different dates and sprayed with seven different fungicides against powdery mildew disease. The results indicated that the subsequent delay in sowing caused progressive increase in the powdery mildew intensity. The mean disease intensity was found minimum in crop sown on 15th Nov. (23.32%) followed by 1st Dec. (24.73%) and 15th Dec. (26.20%). In case of fungicidal treatments out of seven fungicides tested, Hexaconazole (0.05%) was found to be most superior with 18.18 per cent disease reduction followed by Triademefon (0.1%), Karathane (0.2%), Wettable sulphur (0.2%) and Carbendazim (0.1%) with 19.33, 20.44, 21.91 and 22.67 per cent reduction in disease over control, respectively.

Keywords: Cowpea, *erysiphe polygoni*, powdery mildew, fungicides, incidence

Introduction
Powdery mildew is one of the serious disease of cowpea caused by *Erysiphe polygoni* (DC) causing considerable losses during *Rabi* season in the state of Maharashtra including Konkan region. Powdery mildew generally appears at early flowering to pod maturity stage and its development depends on cultivars, sowing date and prevailing weather conditions. There was considerable reduction of seed/pod yield (46.15%), plant height (21.67%), no. of pods (35.11%), green fodder yield (27.40%) and seed yield (50%) reported by Saxena [11] *et al.*, (1992) due to high incidence of powdery mildew on cowpea. In a cent per cent powdery mildew infected crop, the reduction in number of pods per plant is estimated to be 28.6 per cent reported by Rathi and Tripathi [9] (1994). Singh and B Anilkumar[14] (1986) also observed that normal incidence of powdery mildew reduces the 20 per cent yield of cowpea. The disease can be managed by adjusting sowing dates to avoid susceptible stage of crop to the disease and by spraying of systemic and non-systemic fungicides. Therefore, the present study was undertaken to find out the effect of sowing dates and spraying of fungicides on mildew incidence, development and severity and yield of crop.

Materials and Methods
The field experiment was conducted at Department of Agril. Botany, College of Agriculture, Dapoli during *Rabi*, 2012-13 and 2013-2014. The cowpea crop was sown at three different dates (i.e. D_1= 15th Nov, D_2=1st Dec and D_3= 15th Dec). Seven fungicides were used for the control of powdery mildew of Cowpea. (F_1-Hexaconazole (0.05%), F_2 -Karathane (0.2%), F_3-Carbendazim (0.1%), F_4-Triadimefon (0.1%), F_5-Wettable Sulphur (0.2%), F_6-Zineb + Hexaconazole (0.1%), F_7 -Thiophanate methyl (0.1%) and F_8 -Control) by applying split plot design with three replications. The 1st spray of fungicides was given at initiation of powdery mildew disease followed by two sprays at 15 days interval. Recommended dose of fertilizers were applied and plots were irrigated for better seed germination. All intercultural operations were performed regularly. For recording observation on powdery mildew incidence 5 plants per treatment per replication were randomly selected and tagged. Visual observation on

mildew intensity was recorded at 30, 45 and 60 DAS on the bottom, middle and top trifoliate of selected plants. Numerical grades were assigned to the amount of disease observed applying 0-5 disease rating scale (Singh [16] *et al*., 1994) and per cent disease intensity was computed by applying the formulae (Wheeler [20], 1969) as given below:

$$PDI = \frac{\text{Sum of Numerical Rating}}{\text{No. of leaves observed /plant X Maximum grade}} \times 100$$

Result and Discussion

The data depicted in Table. 1 indicated that powdery mildew intensity was found to differ significantly with respect to sowing dates, fungicides spray and interaction of sowing dates and fungicides sprays. During *Rabi* 2012-2013 average powdery mildew intensity in three different sowing dates were observed at 30, 45 and 60 DAS which ranged from 6.13% to 10.67%, 18.67% to 40.53% and 16.53% to 49.60%, respectively. However the minimum mildew intensity was recorded in early sown crop (D_1) 15th Nov. As regards with fungicidal sprays, initially at 30 DAS all the fungicidal sprays were found significant but at 45 DAS and 60 DAS hexaconazole, karathane, triadimefon and wettable sulphur played significant role in reducing the disease intensity. Hexaconazole (0.05%) was exhibited disease intensity in the range of 6.84% to 18.93% followed by triadimefon (0.1%) (7.29% to 20.09%). The maximum disease intensity was recorded in control 49.60%. In all the interaction effects, all sowing dates combined with hexaconazole spray were found most superior followed by the triadimefon spray.

The interaction effect of sowing dates and fungicide spray, per cent disease intensity ranged between 16.53 to 49.60 per cent. The minimum disease intensity (16.53%) was recorded in treatment D_1F_1. It was followed by the treatments D_1F_4 (17.07%) and D_2F_1 (17.60%) which were at par with each other. Among the remaining treatments, D_1F_4, D_2F_1, D_3F_1, D_1F_2 and D_2F_4 were at par with each other and superior. The maximum disease intensity (49.60%) was recorded in the treatment D_3F_8.

Similar results were found during *Rabi* 2013-2014 (Table.2). Results revealed that early sown crop 15th Nov. (24.37%) suffered less as compared to mid sown (25.70%) and late sown (27.13%) (*viz*, 1st Dec. and 15th Dec) from powdery mildew incidence. In fungicides spray hexaconazole (0.1%) was found superior and recorded 18.93% powdery mildew incidence followed by triadimefon (0.1%) (20.09%). karathane (0.1%) showed minimum incidence 21.07% next to triadimefon. The interaction effect of different sowing dates and sprays of different fungicides, the per cent disease intensity was within a range of 18.13 to 52.80 per cent. The minimum disease intensity was recorded in treatment D_2F_1 (18.13%) and was statistically at par with D_3F_1 (19.20%) and D_1F_1 (19.47%). Remaining treatments were also significantly effective in reducing the disease intensity as compared to control. The highest intensity of powdery mildew was recorded in treatment D_3F_8 (52.80%).

The pooled analysis of the data (Table. 3) indicated that average powdery mildew intensity observed at 30, 45 and 60 DAS was ranged from 6.53 to 11.87, 21.07 to 43.20 and 18.00 to 51.20 per cent, respectively in the crop sown at different dates. The crop sown on 15th Nov. (D_1) was suffered less from powdery mildew to the tune of 23.32 per cent. The disease development gradually increased on late sown crop. Among the seven fungicidal treatments hexaconazole (0.05%) and triadimefon (0.1%) were found significant and at par with each other and recorded disease intensity of 18.18 and 19.33 per cent, respectively. In interaction effect of different sowing dates and different fungicides spray the per cent disease intensity was recorded within range of 17.87 to 51.20 per cent. The minimum disease intensity was recorded in treatment D_2F_1 (17.87%). It was followed by the treatments D_1F_1 (18.00%), D_3F_1 (18.67%) and D_1F_4 (18.67%) and D_2F_2 (19.20%) and were at par with each other. The highest intensity of powdery mildew was recorded in treatment D_3F_8 (51.20%).

In present study, it was observed that the average powdery mildew intensity was found minimum at 30 DAS, maximum at 45 DAS and moderate at 60 DAS. The maximum powdery mildew intensity was observed at 45 DAS i.e. crop susceptible at 45-50 DAS and during month of Jan, Feb due to congenial weather conditions prevailed.

Crop sown early (15th Nov.) was found to suffer least from powdery mildew due to high temperature which leads to higher germination of seeds and eventually increased plant population. Simultaneously, high temperature hampered germination of the fungal spores, thereby decreasing the initial inoculum. Hence, less disease incidence was recorded in the crop sown in 15th Nov. as compared to other sowing dates.

The yield data (Table. 4) indicated that the crop sown on 15th Nov. recorded significantly superior grain yield (10.62 q ha^{-1}). It was followed by the crop sown on 1st Dec. (10.27 q ha^{-1}). The lowest grain yield of 9.87 q ha^{-1} was obtained sown crop on 15th Dec. The treatment F_1 recorded significantly superior grain yield (11.55 q ha^{-1}) and was followed by treatments F_4, F_2, F_3, F_5, F_6 and F_7 with 11.01, 10.88, 10.53, 10.34 and 9.90 q ha^{-1}, grain yield respectively as against of control (7.34 q ha^{-1}).

The treatment combination D_1F_1 recorded significantly superior grain yield (12.10 q ha^{-1}) over rest of the treatment combinations. It was followed by treatment D_2F_1, D_1F_4, and D_1F_2 with grain yield of 11.50, 11.39 and 11.25 q ha^{-1}, respectively. The treatment comprising late sowing and no spraying of fungicides (D_3F_8) recorded significantly lower yield (7.06 q ha^{-1}). The findings of present investigation are in accordance with earlier reports.

Sharma [12] (1999) while working on powdery mildew of fenugreek, Sharma and Sharma [13] (2002) and Gupta and Raut[3] (2001) while working with powdery mildew of pea reported that early sowing of the crop significantly reduced disease severity and increased the yield. Thakur [17] *et al*. (2004) and Wadaje [19] *et al*. (2008) working with green gram and Parashar and Lodha [8] (2012) working on fennel powdery mildew also reported less disease intensity and more yield in early sown crop.

Use of chemicals to manage the disease incidence is an age old practice in plant pathology in the absence of resistant varieties or where there is a breakdown of resistance in commercial varieties due to evolution of virulent strain of the pathogens. Use of fungicides is useful in reducing the losses due to powdery mildew epidemics.

The results were also in agreements with several workers like Begum [1] (1989), Upadhyay and Gupta [18] (1994), Kapoor and Sugha [5] (1995), Rathore and Rathore [10] (1995), Singh [10] *et al*. (2000), Khunti [6] *et al*. (2002) and Jagtap and Khalikar [4] (2012).

Out of the seven fungicides tested in the present study, the fungicides belonging to trizole group *viz.*, hexaconazole and triademefon were the most effective against the disease. These fungicides interfere with the biosynthesis of fungal sterols and inhibit ergosterol biosynthesis. Ergosterol is

essential for the structure of cell wall and its absence causes irreparable damage to the cell wall leading to the death of fungal cells (Brent [2] 1995). They also interfere with the process of formation of conidia and haustoria. They change the sterol content and saturation of the polar fatty acids leading to alternations in membrane fluidity and behaviour of membrane bound enzymes (Nene and Thapliyal [7] 1993).

Table 1: Effect of sowing dates combined with fungicide spray on incidence of powdery mildew of cowpea during year 2012-2013.

	30 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	6.13 (14.33)*	6.67 (14.96)	7.20 (15.56)	6.93 (15.26)	7.73 (16.14)	7.20 (15.55)	7.47 (15.85)	9.07 (17.52)	7.30 (15.65)		SE m±	CD
D_2	6.93 (15.26)	7.47 (15.85)	7.73 (16.14)	7.47 (15.85)	8.53 (16.98)	6.93 (15.25)	8.53 (16.98)	9.07 (17.52)	7.83 (16.23)	D	0.04	0.14
D_3	7.47 (15.85)	8.53 (16.98)	7.47 (15.85)	7.47 (15.85)	7.73 (16.14)	7.73 (16.14)	8.27 (16.71)	10.67 (19.06)	8.17 (16.57)	F	0.40	1.14
MEAN	6.84 (15.15)	7.56 (15.93)	7.47 (15.85)	7.29 (15.66)	8.00 (16.42)	7.29 (15.65)	8.09 (16.51)	9.60 (18.03)		D X F	0.70	2.12
	45 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	18.67 (25.58)	21.87 (27.87)	23.20 (28.79)	19.73 (26.37)	22.93 (28.61)	25.60 (30.39)	26.13 (30.73)	34.13 (35.75)	24.03 (29.26)		SE m±	CD
D_2	18.67 (25.59)	20.53 (26.94)	22.67 (28.42)	19.73 (26.37)	21.60 (27.69)	23.20 (28.79)	23.73 (29.15)	34.67 (36.07)	23.10 (28.63)	D	0.06	0.22
D_3	19.47 (26.18)	21.33 (27.50)	22.40 (28.25)	20.80 (27.13)	22.40 (28.25)	24.27 (29.51)	24.53 (29.69)	40.53 (39.54)	24.47 (29.50)	F	0.52	1.49
Mean	18.93 (25.78)	21.24 (27.44)	22.76 (28.48)	20.09 (26.62)	22.31 (28.18)	24.36 (29.56)	24.80 (29.86)	36.44 (37.12)		D X F	0.53	1.59
	60 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	16.53 (23.99)	18.67 (25.59)	20.80 (27.13)	17.07 (24.40)	19.47 (26.18)	21.87 (27.88)	22.13 (28.06)	41.60 (40.16)	22.27 (27.92)		SE m±	CD
D_2	17.60 (24.80)	19.73 (26.37)	21.07 (27.32)	18.67 (25.59)	20.80 (27.13)	21.87 (27.88)	22.93 (28.61)	47.47 (43.55)	23.77 (28.91)	D	0.04	0.14
D_3	18.13 (25.20)	21.07 (27.32)	22.93 (28.61)	20.00 (26.56)	22.13 (28.06)	23.73 (29.15)	24.53 (29.69)	49.60 (44.77)	25.27 (29.92)	F	0.49	1.40
Mean	17.42 (24.66)	19.82 (26.43)	21.60 (27.69)	18.58 (25.52)	20.80 (27.12)	22.49 (28.30)	23.20 (28.79)	46.22 (42.83)		D X F	0.52	1.57

*Figures in parentheses are arc sin transformed values

Table 2: Effect of sowing dates combined with fungicide spray on incidence of powdery mildew of cowpea during year 2013-2014.

	30 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**MEAN**			
D_1	6.93 (15.26)	7.47 (15.85)	7.73 (16.14)	7.73 (16.14)	7.73 (16.13)	8.00 (16.42)	8.53 (16.98)	10.67 (19.06)	8.10 (16.50)		SE m±	CD
D_2	7.73 (16.13)	8.27 (16.71)	8.80 (17.25)	8.27 (16.71)	9.33 (17.79)	8.27 (16.71)	9.07 (17.52)	11.20 (19.54)	8.87 (17.29)	D	0.05	0.18
D_3	8.53 (16.98)	8.53 (16.98)	8.80 (17.25)	8.27 (16.71)	8.80 (17.25)	10.40 (18.81)	9.07 (17.52)	13.07 (21.19)	9.43 (17.83)	F	0.45	1.28
Mean	7.73 (16.12)	8.09 (16.51)	8.44 (16.88)	8.09 (16.52)	8.62 (17.05)	8.89 (17.31)	8.89 (17.34)	11.64 (19.93)		D X F	0.68	2.06
	45 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	23.47 (28.97)	25.07 (30.04)	26.40 (30.92)	25.07 (30.04)	25.87 (30.57)	27.47 (31.60)	27.20 (31.43)	39.47 (38.92)	27.50 (31.56)		SE m±	CD
D_2	23.47 (28.97)	24.53 (29.69)	26.13 (30.74)	23.73 (29.15)	25.60 (30.39)	28.53 (32.28)	27.20 (31.43)	40.80 (39.70)	27.50 (31.56)	D	0.07	0.23
D_3	23.73 (29.15)	26.13 (30.74)	26.67 (31.08)	25.07 (30.04)	27.20 (31.43)	29.33 (32.79)	29.07 (32.62)	45.87 (42.63)	29.13 (32.56)	F	0.55	1.57
Mean	23.56 (29.03)	25.24 (30.15)	26.40 (30.91)	24.62 (29.74)	26.22 (30.80)	28.44 (32.23)	27.82 (31.83)	42.04 (40.42)		D X F	0.50	1.52
	60 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	19.47 (26.17)	20.80 (27.12)	22.13 (28.06)	20.27 (26.75)	21.60 (27.69)	22.93 (28.60)	22.40 (28.24)	45.33 (42.32)	24.37 (29.37)		SE m±	CD
D_2	18.13 (25.20)	20.53 (26.94)	23.47 (28.97)	19.73 (26.37)	22.40 (28.24)	25.07 (30.04)	25.60 (30.39)	50.67 (45.38)	25.70 (30.19)	D	0.03	0.11
D_3	19.20 (25.99)	21.87 (27.88)	25.60 (30.39)	20.27 (26.75)	25.07 (30.04)	25.60 (30.39)	26.67 (31.08)	52.80 (46.61)	27.13 (31.14)	F	0.65	1.86
Mean	18.93 (25.79)	21.07 (27.31)	23.73 (29.14)	20.09 (26.62)	23.02 (28.66)	24.53 (29.68)	24.89 (29.90)	49.60 (44.77)		D X F	0.52	1.52

Table 3: Pooled mean of effect of sowing dates combined with fungicide spray on incidence of powdery mildew of cowpea

	30 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	6.53 (14.80)	7.07 (15.41)	7.47 (15.86)	7.33 (15.71)	7.73 (16.15)	7.60 (15.99)	8.00 (16.43)	10.13 (18.56)	7.73 (16.11)		SE m±	CD
D_2	7.33 (15.70)	7.87 (16.28)	8.27 (16.70)	7.87 (16.28)	8.93 (17.39)	7.60 (15.99)	8.80 (17.25)	9.87 (18.30)	8.32 (16.74)	D	0.04	0.13
D_3	8.00 (16.43)	8.53 (16.98)	8.13 (16.57)	7.87 (16.28)	8.27 (16.70)	9.07 (17.52)	8.67 (17.12)	11.87 (20.15)	8.80 (17.22)	F	0.38	1.07
Mean	7.29 (15.64)	7.82 (16.23)	7.96 (16.38)	7.69 (16.09)	8.31 (16.74)	8.09 (16.50)	8.49 (16.93)	10.62 (19.00)		D X F	0.69	2.09
	45 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	21.07 (27.31)	23.47 (28.97)	24.80 (29.87)	22.40 (28.24)	24.40 (29.60)	26.53 (31.00)	26.67 (31.09)	36.80 (37.34)	25.77 (30.43)		SE m±	CD
D_2	21.07 (27.32)	22.53 (28.34)	24.40 (29.60)	21.73 (27.78)	23.60 (29.06)	25.87 (30.57)	25.47 (30.30)	37.73 (37.90)	25.30 (30.11)	D	0.06	0.21
D_3	21.60 (27.69)	23.73 (29.15)	24.53 (29.69)	22.93 (28.61)	24.80 (29.87)	26.80 (31.17)	26.80 (31.17)	43.20 (41.09)	26.80 (31.06)	F	0.43	1.22
Mean	21.24 (27.44)	23.24 (28.82)	24.58 (29.72)	22.36 (28.21)	24.27 (29.51)	26.40 (30.92)	26.31 (30.86)	39.24 (38.78)		D X F	0.52	1.57
	60 DAS											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	18.00 (25.10)	19.73 (26.37)	21.47 (27.60)	18.67 (25.59)	20.53 (26.94)	22.40 (28.24)	22.27 (28.16)	43.47 (41.24)	23.32 (28.66)		SE m±	CD
D_2	17.87 (25.00)	20.13 (26.66)	22.27 (28.15)	19.20 (25.99)	21.60 (27.69)	23.47 (28.97)	24.27 (29.51)	49.07 (44.47)	24.73 (29.56)	D	0.03	0.11
D_3	18.67 (25.60)	21.47 (27.60)	24.27 (29.51)	20.13 (26.66)	23.60 (29.06)	24.67 (29.78)	25.60 (30.39)	51.20 (45.69)	26.20 (30.54)	F	0.45	1.30
Mean	18.18 (25.23)	20.44 (26.87)	22.67 (28.42)	19.33 (26.08)	21.91 (27.90)	23.51 (29.00)	24.04 (29.35)	47.91 (43.80)		D X F	0.52	1.55

Table 4: Effect of sowing dates combined with fungicide spray on grain yield of cowpea.

	Effect of sowing dates and fungicidal sprays on grain yield of cowpea during year 2012-13.											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	12.07	11.33	10.79	11.51	10.86	10.83	10.22	8.64	10.78		SE m±	CD
D_2	11.25	10.67	10.25	10.66	10.29	10.12	9.58	7.82	10.07	D	0.05	0.17
D_3	10.75	10.17	9.75	10.16	9.79	9.62	9.08	7.32	9.58	F	0.22	0.62
Mean	11.36	10.72	10.26	10.77	10.31	10.19	9.62	7.92		D X F	0.18	0.53
	Effect of sowing dates and fungicidal sprays on grain yield of cowpea during year 2013 - 14.											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	12.12	11.17	10.75	11.16	10.79	10.61	10.22	6.80	10.45		SE m±	CD
D_2	11.75	11.33	10.79	11.51	10.86	10.62	10.12	6.65	10.45	D	0.01	0.05
D_3	11.39	10.64	10.54	10.96	10.60	10.21	10.19	6.80	10.17	F	0.13	0.39
Mean	11.75	11.04	10.69	11.20	10.75	10.48	10.18	6.75		D X F	0.11	0.33
	Pooled mean of effect of sowing dates and fungicidal sprays on grain yield of cowpea during the years 2012-13 and 2013-14.											
Treat.	**F_1**	**F_2**	**F_3**	**F_4**	**F_5**	**F_6**	**F_7**	**F_8**	**Mean**			
D_1	12.10	11.25	10.77	11.39	10.83	10.72	10.22	7.72	10.62		SE m±	CD
D_2	11.50	11.00	10.52	11.08	10.58	10.39	9.86	7.26	10.27	D	0.03	0.10
D_3	11.07	10.40	10.16	10.56	10.19	9.91	9.63	7.06	9.87	F	0.14	0.39
Mean	11.55	10.88	10.48	11.01	10.53	10.34	9.90	7.34		D X F	0.11	0.33

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