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Survey for the Occurrence of Powdery Mildew and It's Effect of Weather Factors on Severity of Powdery Mildew in Guntur District

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A B S T R A C T

A roving survey was undertaken on the incidence and severity of powdery mildew disease during *rabi* 2015-16 in Guntur district of Andhra Pradesh. Disease incidence and severity of powdery mildew were surveyed in villages of Tadikonda, Veticherukuru, Pedanandipadu and Kakumanu mandals of Guntur district. Incidence was ranged from 13.69% (Pedanandipadu mandal) to 87.01 % (Tadikonda mandal) incidence and severity were ranged from 11.61 (Kakumanu mandal) to 88.08% (Tadikonda mandal), respectively. Correlation studies with weather parameters and crop age on powdery mildew disease severity revealed that positive correlation of disease was recorded with crop age and maximum temperature. Multiple regression analysis yielded seven distinct equations with R^2 values ranging from 0.991 to 0.412 ($P < 0.05$). However, the best-fit equation was obtained in maximum temperature, wind speed, RH (8.30 am), Minimum temperature as independent variables showed 86.6 per cent role of tested independent variables on powdery mildew severity.

Introduction

Black gram (*Vigna mungo* (L.) Hepper) is a stable crop originated from central Asia and commonly cultivated in South Asia. *Vigna mungo* is also grown for forage crop, often used as dry season intercrop in rice or wheat, cover crop, and green manure (Göhl, 1982; Jansen, 2006). It prefers on loamy soils or black vertisols, well-drained soils with a pH 6-7 (Arora *et al.*, 1989 and Baligar *et al.*, 2007). It can withstand acidic soils if lime and gypsum (down to pH 4.5) are added to the soil and sensitive to alkaline and saline soils (Sharma *et al.*, 2011; Baligar *et al.*, 2007). It is drought-tolerant and thus suitable for semi-arid areas (Arora *et al.*, 1989). Globally it accounts for over and above 40% of total legume seeds traded (CRN India, 2011).

Pod husks of *Vigna mungo* are an excellent substitute to rice bran as a feed for *Artemia* sp. regarding for survival, growth, production of nauplii and fecundity (Yoganandhan *et al.*, 2000). In India it is a third important pulse crop cultivated in an area of 2.29 M ha with 1.96 M t production and 500 kg ha^{-1} productivity (Department of Agriculture and Cooperation, Government of India, 2014). In India, major *urdbean* growing areas are

Andhra Pradesh, Gujarat, Karnataka, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, Sikkim, Tamil Nadu and Uttar Pradesh and Andhra Pradesh (A.P). In *Kharif*, it is grown in 0.25 Lakh ha, producing 0.17 Lakh t with a productivity of 676 kg ha^{-1}. In *Rabi*, it occupies 4.29 Lakh ha, producing 3.39 Lakh t with a productivity of 790 kg ha^{-1} (Department of Agriculture and Co-operation, Government of A.P. 2014). The crop is of special significance in A.P as it fits well in rice-pulse cropping system as a relay crop particularly in Krishna -Godavari and North Coastal zones. As per graminae, *Vigna mungo* plant genome sequence (http://archive.gramene.org/db) the genomes (7) and genes (1) literature (107) and ontology (72). Powdery mildew (*Erysiphe polygoni*) De Condolle (1802) described many species of the genus. Powdery mildew caused by *Erysiphe polygoni* D C a wide spread plant diseases that are conspicuous by their superficial white mycelia and powder-like conidia (Yarwood, 1957; Kiss and Szentivanyi, 2001). Current classification Fungi, Dikarya, Ascomycota, Pezizomycotina, Leotiomycetes, Leotiomycetidae, Erysiphales, Erysiphaceae, *Erysiphe polygoni.* Obligate synonyms; *Ischnochaeta polygoni* (DC.) and *Microsphaera polygoni* (DC.) Facultative synonymns: *Alphitomorpha communis* Wallr, *Alphitomorpha horridula* Wallr, *Erysiphe communis* var. *leguminosarum* Link, *Erysiphe communis* var. *ranunculacearum* Link. (*www.mycobank.org.in*).

Blackgram abides from biotic stress due to fungal, bacterial and viral diseases resulting in heavy yield losses (Nene, 1972). Powdery mildew reported as a serious problem in all areas of rice-based cropping systems of the country (Abbaiah, 1993) causing considerable yield loss every year due to the reduction in photosynthetic activity and physiological changes (Legapsi *et al.*, 1978). Although the disease was reported to cause considerable loss, information on its prevalence particularly after the advent of the survey and epidemiological factors influencing the disease development.

Materials and Methods

The present investigation was carried out during *rabi* 2015-16, Agricultural College Farm and Department of Plant Pathology, Agricultural College, Bapatla, Guntur District. Geographically the Agricultural College Farm, Bapatla is situated at an altitude of 5 m above the mean sea level and at 80^0 $30^{'}$ E Longitude and 15^0 $54^{'}$ N Latitude and seven km away from the coast of Bay of Bengal.

Survey for the Incidence and severity of Powdery mildew disease of *Urdbean*

Survey was conducted during 2015-16 *rabi* season in major *urdbean* growing mandals of Guntur district, Andhra Pradesh. Four mandals were chosen based on statistics of preceeding year where the crop concentration was more. Based on the information, in each mandal two villages and in each village, two fields were surveyed at random. In each field 20 plants were selected at five locations, four corners of the field and one at the centre to record the incidence and severity of powdery mildew, were fixed.

Per cent disease incidence for powdery mildew disease was calculated by using the following formula:

$$\text{Per cent disease Incidence (PDI)} = \frac{\text{Number of infected plants}}{\text{Total number of plants}} \times 100$$

The incidence and severity of powdery mildew were recorded mandal-wise. Powdery mildew severity was assessed by disease rating (AICRP, MULLaRP, 2013) (Table 1).

The per cent disease index (PDI) was computed from the above scale by using the following formula (Wheeler, 1969).

$$PDI = \frac{\text{Sum of all the numerical ratings}}{\text{Number of observations} \times \text{maximum disease grade}} \times 100$$

Influence of weather conditions on severity of powdery mildew in *Urdbean*

A trial was conducted to determine the influence of weather conditions on the severity of powdery mildew disease in blackgram. Highly susceptible blackgram cultivar PU 31 was planted in a bulk plot of 10 x 10 m^2 during *rabi* 2015-16 at Agricultural College Farm, Bapatla, Andhra Pradesh. The severity of powdery mildew disease was recorded at every five days interval from 35 DAS to one week prior to harvesting. Meteorological data such as rainfall, maximum temperature, minimum temperature, relative humidity at morning and evening hours and wind velocity was collected from the Meteorological Station located at Agricultural college farm, Bapatla. Correlation and regression analyses were conducted to determine the influence of weather conditions on the severity of powdery mildew disease in blackgram.

Results and Discussion

Survey for the incidence and severity of powdery mildew disease of *Urdbean*

In Guntur district, a total of 16 fields of eight villages *viz.,* Kantheru, Ponnekalu, Kothapalem, Manchala, Vargani, Nagalupadu, Bhallupadu and Appapuram, belonging to four mandals *viz.*, Tadikonda, Veticherukuru, Pedanandipadu and Kakumanu were surveyed in which PU 31, LBG 752, LBG 623 are being cultivated (Fig. 1). Age of the crop varied in different fields due to variation in dates of sowing. The crops were approximately 40- 60 DAS (Table 2). Since the age of the crop is one of the important factors for occurrence and development of powdery mildew. The results of the survey are presented based on an age of the crop as follows. In 40 days old crop the mean powdery mildew disease incidence was maximum in Kothapalem village (57.76%) of Veticherukuru mandal followed by Kantheru village (46.44%) of Tadikonda mandal and minimum in Bhallupadu village (3.43%) of Kakumanu mandal followed by Vargani village (3.67%) of Pedanandipadu mandal and severity was maximum in Kothapalem (51.32%) followed by Ponnekalu village (37.16%) of Tadikonda mandal and minimum in Bhallupadu (2.35%) followed by Vargani (5.73%) (Table 2).

In 60 days old crop the mean powdery mildew disease incidence was maximum in Kantheru (87.01%) followed by Kothapalem (83.10%) and minimum in Vargani (21.91%) followed by Bhallupadu (39.94%) and mean per cent disease index (severity) was maximum in Kantheru (88.08%) followed by Kothapalem (83.73%) and minimum in Vargani (19.16%) followed by Bhallupadu (33.56%) (Table 2 and Fig. 2). The mean disease incidence was in the range of 3.43% (Bhallupadu village at 40 DAS) to 87.01% (Kantheru village at 60 DAS) and severity was in the range of 2.35% (Bhallupadu village at 40 DAS) to 88.08% (Kantheru village at 60 DAS). Highest mean incidence and mean severity was recorded in Tadikonda mandal (81.83 % and 80.76% respectively) and lowest (42.18% and 37.16%) in Pedanandipadu mandal. The variation in disease at various locations may be mainly due to cultivated variety, crop age and climatic factors and cultural practices.

Among the weeds species associated with *urdbean* fields *viz., Euphorbia geniculate, Convolvulus arvensis, Sida cordifolia, Abutilon indicum, Acalypha indica,*

Achyranthes aspera, Andrographis paniculata, Crotalaria verrucosa, Celosia argentina, Digera arvensis, Cleome viscosa, Xanthium strumarium and *Mimosa pudica etc. Euphorbia geniculate* was found infected with powdery mildew disease in all the four mandals. Findings of Dinesh *et al.,* (2010) reported that powdery mildew disease varied in different locations depending on the crop age. Nour (1958) reported that *Euphorbia* species were an alternate host for powdery mildew infection. Similarly, field bindweed (*Convolvulus arvensis*) is highly susceptible to powdery mildew infection as reported by Karkanis *et al.,* (2012).

Symptomology and morphology

The infected leaf surface, petioles, stem and pods appeared as small, round, whitish, powder-like spots (Plate 2). Symptoms first appeared on crown leaves on shaded lower leaves and on leaf under surfaces. These white powdery colonies grew in size and cover both sides of the leaf, petioles and young stems. When disease progressed lower leaves showed and chlorosis, distortion and premature leaf fall due to infection of *E. Polygoni.* Severe infection of inflorescence was found to affect pod setting where as severe infection at later stages showed shrivelled and dried appearance to immature pods. The morphology of *E. polygoni* noted that the fungus produced amphigenous dirty white hyaline mycelium and barrel shaped conidia measuring 1.089 µm × 0.7131 µm at 40 × magnification (Plate 1).

Effect of weather factors and age of the crop on powdery mildew severity

A correlation study was undertaken at Agricultural College, Bapatla to study the relationship between severity of powdery mildew disease with weather parameters and crop age. The mean data on the weather parameters *viz*. maximum temperature (max), minimum temperature (min) (^{0}C), morning relative humidity (RH) (%), evening relative humidity (RH) (%), wind speed (kmph) and rainfall (mm) was recorded from 20 DAS at five days interval upto 65 DAS on PU 31 during *rabi* 2015-2016 (Fig. 3).

The maximum temperature varied from 26.90 ^{0}C to 33.80 ^{0}C, minimum temperature varied from 15.30 ^{0}C to 26.00 ^{0}C. Relative humidity during morning and evening ranged from 87 to 93 per cent and 63 to 89 per cent, respectively. The disease severity ranged from 0 per cent to 90.85 per cent (Table 3).

Fig.1 Powdery mildew incidence at 40 and 60 DAS in *urdbean* in Guntur district during *rabi* 2015-16

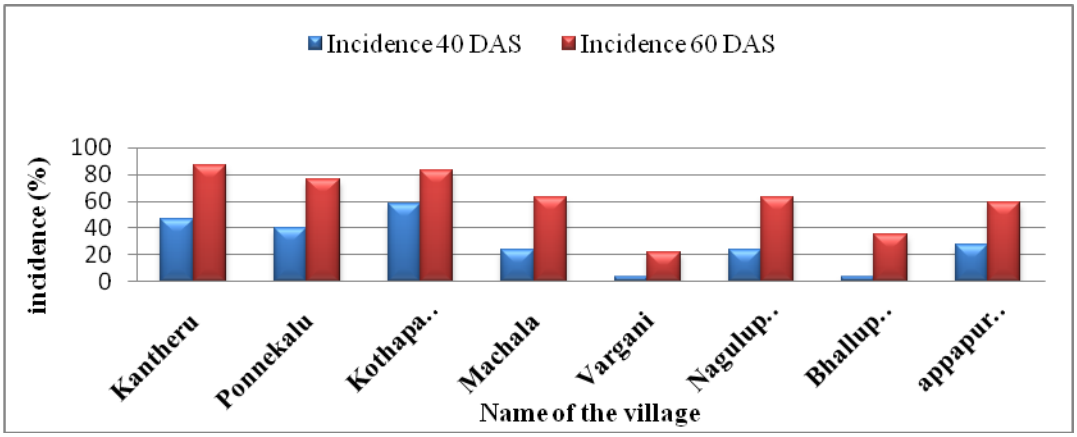


Fig.2 Powdery mildew severity at 40 and 60 DAS in *urdbean* in Guntur district during *rabi* 2015-16

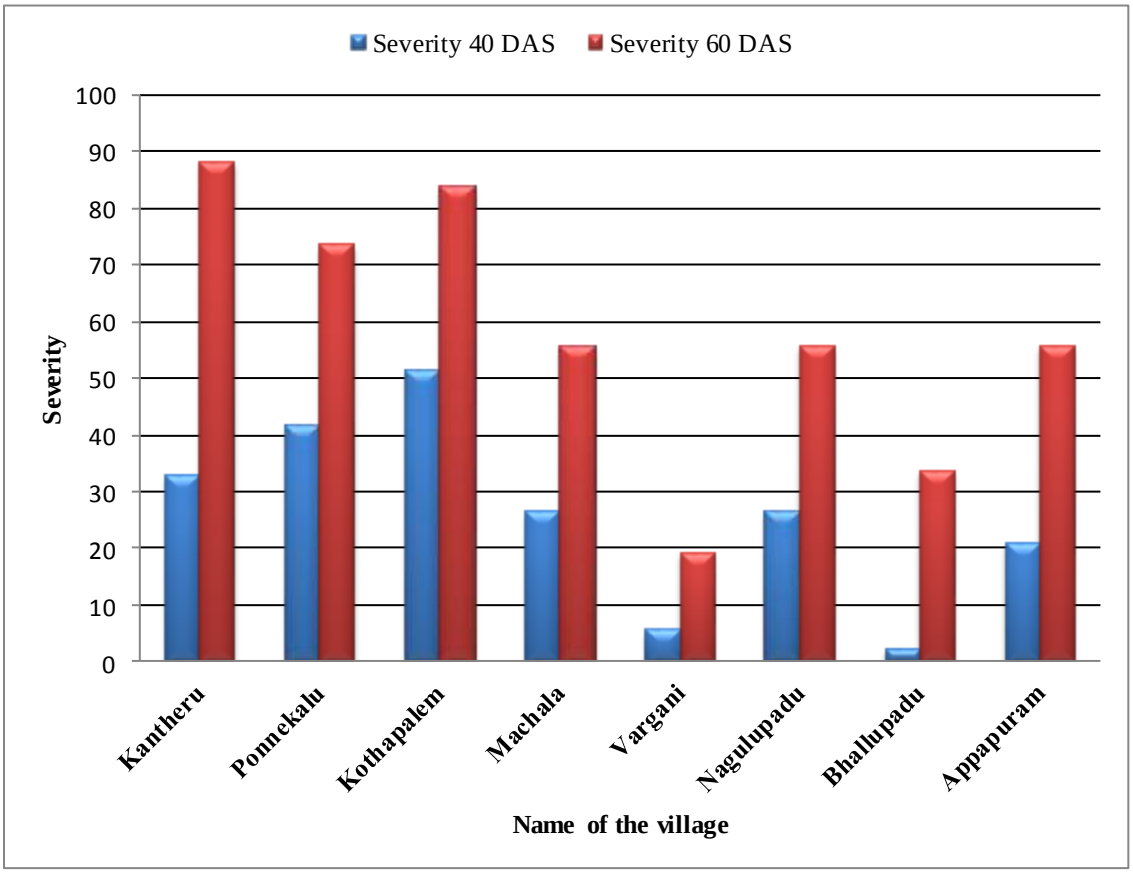


Plate.1 Morphology of fungus powdery mildew caused by *Erysiphe polygoni* (10X and 40X)

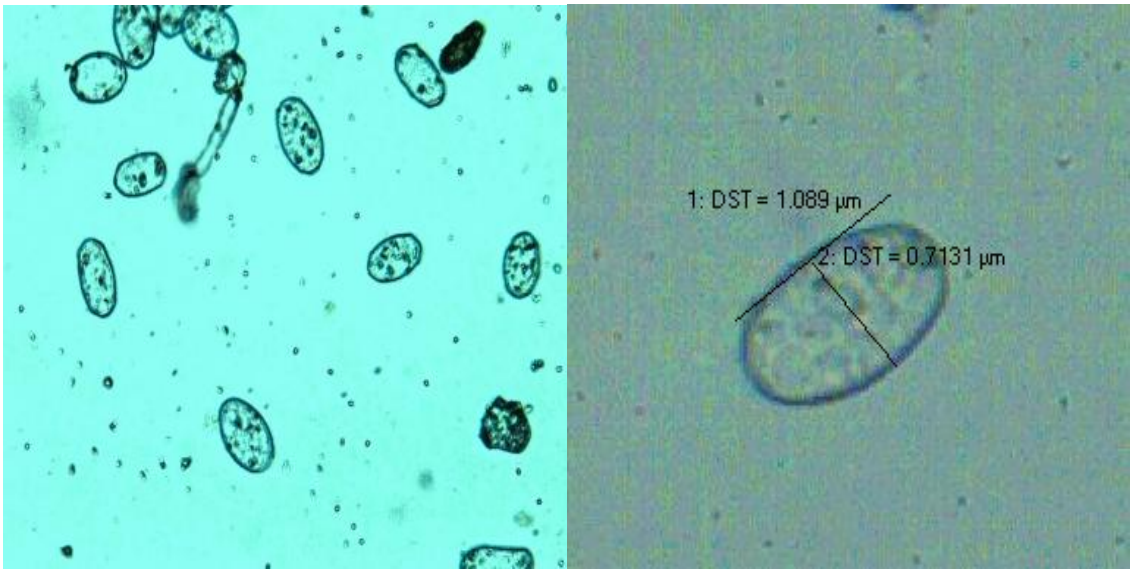


Plate.2 Symptoms of powdery mildew disease under field conditions

Table.1 Modified MULLaRP scale (0-5)

Grade	Description	Reaction
0	Plants free from infection on leaves, stems free from the disease	Free (F)
1	Plants showing traces to 10% infection on leaves, stems free from the disease	Highly Resistant (HR)
2	Slight infection with thin coating of powdery growth on leaves covering 10.1-25% leaf area, slight infection on stem and the pods usually free	Moderately Resistant (MR)
3	Dense powdery coating on leaves covering 25.1-50 % leaf area, moderate infection on pods	Moderately Susceptible (MS)
4	Dense powdery coating covering 50.1 -75% leaf area, stems heavily and pods moderately infected. Infected portion turns grayish.	Susceptible (S)
5	Severe infection with dense powdery growth covering 75% area of the whole plant including pods, stems etc. resulting in premature defoliation and drying.	Highly Susceptible (S)

Table.3 Powdery mildew severity and crop age in relation with weather variables during *rabi,* 2015-16			
S. No.	**Crop age**	**Date of observation**	**Severity**
1	20	20-Jan	0.00
2	25	25-Jan	0.00
3	30	30-Jan	0.00
4	35	04-Feb	10.41
5	40	09-Feb	28.92
6	45	14-Feb	38.88
7	50	19-Feb	49.49
8	55	24-Feb	71.60
9	60	29-Feb	85.61
10	65	04-Mar	90.85

Table.4 Correlation between powdery mildew disease severity and weather factors during *rabi* 2015-2016

Sl. No.	Variable	Correlation co-efficient (r)
1	Maximum temperature (^{0}C)	0.657*
2	Minimum temperature (^{0}C)	0.063
3	Relative humidity at 8.30 A.M (%)	-0.355
4	Relative humidity at 5.30 P.M (%)	-0.486
5	Rainfall (mm)	-0.405
6	Wind speed (Kmph)	-0.527
7	Crop age	0.984*

* Significant at 5% r tab value=2.306 N= 10

Table.2 Survey on the incidence and severity of powdery mildew disease in *urdbean* in Guntur district of A.P during *rabi*, 2015

Sl. No.	Mandal	Name of the village	Date of observation	Area (in acres)	Variety	Total plants	40 DAS		60 DAS		Preceeding / Surrounding crops	Weed flora
							Per cent disease incidence	PDI	Per cent Disease incidence	PDI		
1	Tadikonda	Kantheru	22-Oct	2	LBG 623	106	45.51	26.28	87.14	86.92	Rice/ Blackgram	*Euphorbia geniculate, Sida cordifolia*
				1	LBG 752	116	47.38	39.04	86.89	89.24	Rice/ Blackgram	*Abutilon indicum, Acalypha indica, Achyranthes aspera, Andrographis paniculata, Euphorbia geniculate*
		Village Mean					46.44	32.66	87.01	88.08		
		Ponnekalu	21-Oct	1.5	PU 31	100	32.51	33.68	76.24	77.60	Rice/ Blackgram	*Euphorbia geniculate, Crotalaria verrucosa Convolvulus arvensis Celosia argentina, Digera arvensis, Cleome viscosa, Xanthium strumarium*
				2	LBG 752	100	47.87	49.64	77.09	69.28	Rice/ Maize	*Abutilon indicum, Acalypha indica, Achyranthes aspera, Crotalaria verrucosa, Celosia argentina, Cleome viscosa,*

												Sida cordifolia
		Village Mean					40.19	41.66	76.66	73.44		
		Mandal mean					43.31	37.16	81.83	80.76		
2	**Veticherukuru**	**Kothapalem**	28-Oct	3.5	LBG 752	121	54.40	50.52	83.12	87.80	Rice/ Blackgram	*Euphorbia geniculate, Crotalaria verrucosa, Celosia argentina,*
				1	LBG 752	100	61.13	52.12	83.08	79.67	Rice/ Blackgram	*Sida cordifolia, Xanthium strumarium*
		Village Mean					57.76	51.32	83.10	83.73		
		Machala	1-Nov	2	PU 31	94	25.82	32.58	69.02	63.00	Rice/ Blackgram	*Achyranthes aspera, Sida cordifolia, Xanthium strumarium*
				3	PU 31	109	21.61	20.38	55.87	48.52	Rice/ Blackgram	*Abutilon indicum, Acalypha indica, Convolvulus arvensis Achyranthes aspera, Cleome viscosa, Sida cordifolia, Xanthium strumarium*
		Village mean					23.71	26.48	62.44	55.76		
		Mandal Mean					37.23	39.90	72.77	69.74		

3	**Pendanadipadu**	**Vargani**	**15-Nov**	**2**	**LBG 752**	**96**	**0.00**	**0.00**	**16.51**	**16.67**	**Rice/ Blackgram**	***Abutilon indicum, Acalypha indica, Achyranthes aspera, Crotalaria verrucosa,***
				2.5	LBG 752	108	7.34	11.46	27.31	21.64	Rice/ Blackgram	*Abutilon indicum, Acalypha indica, Achyranthes aspera, Celosia argentina, Digera arvensis, Cleome viscosa, Sida cordifolia*
		Village Mean					3.67	5.73	21.91	19.16		
		Nagulupadu	23-Nov	1.5	LBG 752	107	6.00	6.02	18.70	13.96	Rice/ Maize	*Andrographis paniculata, Euphorbia geniculate, Convolvulus arvensis*
				3	PU 31	99	14.87	16.47	45.09	35.30	Blackgram / Maize	*Abutilon indicum, Euphorbia geniculate Celosia argentina,*
		Village Mean					23.72	26.48	62.45	55.76		
		Mandal mean					13.69	18.97	42.18	37.46		

4	**Kakumanu**	**Bhallupadu**	**24-Nov**	**2**	**LBG 752**	**107**	**0.00**	**0.00**	**34.78**	**32.74**	**Rice/ Blackgram**	***Mimosa pudica, Acalypha indica,***
				1	LBG 752	100	6.86	4.70	35.10	34.38	Rice/ Blackgram	*Abutilon indicum, Achyranthes aspera, Andrographis paniculata,*
		Village Mean					3.43	2.35	34.94	33.56		
		Appapuram	28-Nov	2.5	PU 31	106	9.02	6.72	39.02	38.34	Rice/ Blackgram	*Abutilon indicum, Digera arvensis, Cleome viscosa*
				4	LBG 623	105	45.78	33.44	78.26	73.28	Rice/ Blackgram	*Abutilon indicum, Celosia argentina, Digera arvensis, Cleome viscosa, Sida cordifolia, Xanthium strumarium*
		Village Mean					27.40	20.88	58.64	55.81		
		Mandal Mean					15.41	11.61	46.79	44.68		
	Total Mandal mean						27.41	26.91	60.89	58.16		

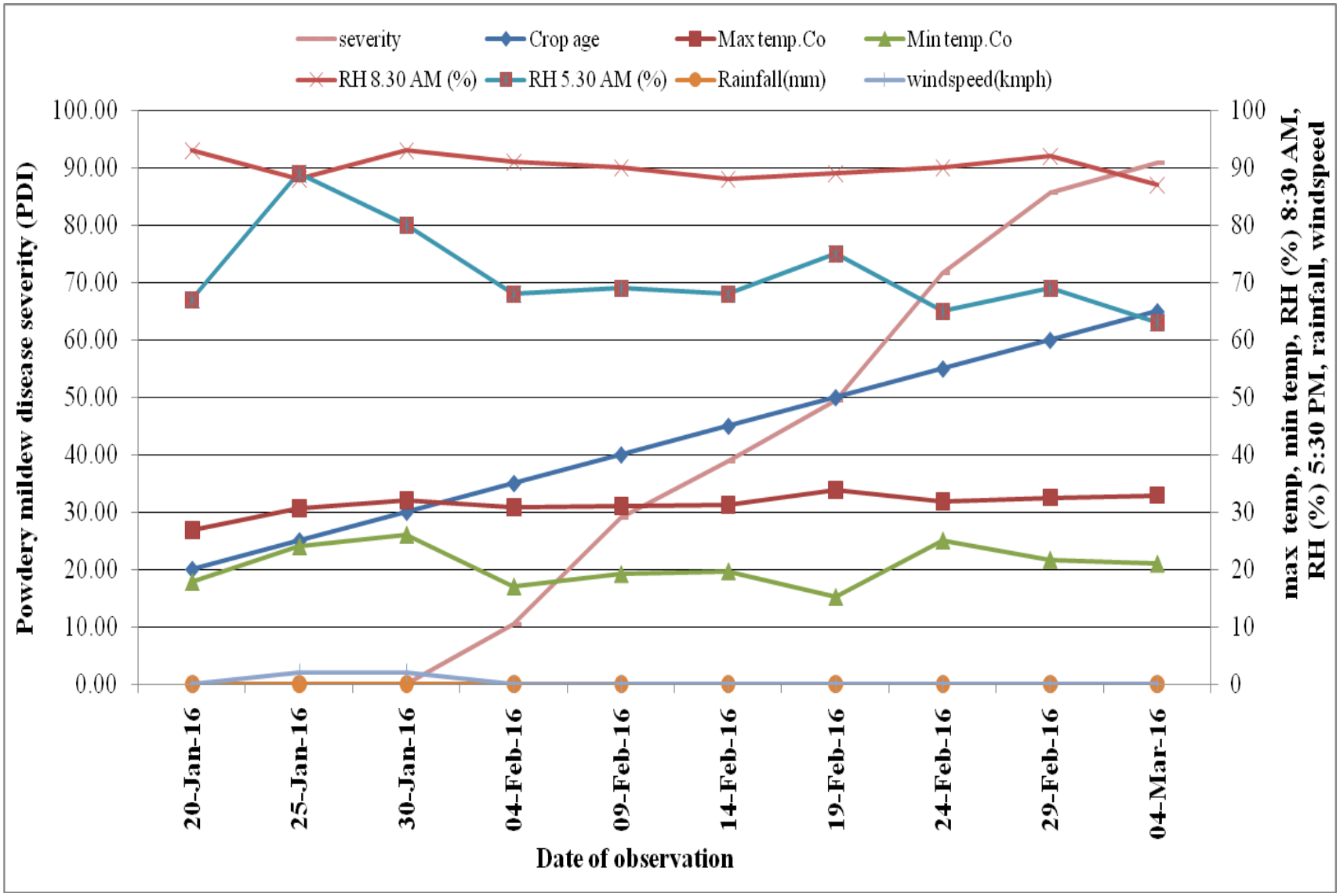
Table.5 Regression equations of certain weather variables on severity of powdery mildew disease during *rabi* 2015-16

Sl. No.	Regression equations	F value	Standard error	R^2
1	$y = -337.21 + 11.944x_1$*	6.075	4.88	0.412
2	y = -320.669+-11.708x1*+22.900 x2*	7.940	3.83	0.681
3	$y = -186.221+11.092x_1+-22.611\ x_2+-1.279x_3$	4.540	4.00	0.701
4	$y = -279.80+10.017\ x_1$*+-35.57x_2*+1.070 x_3+5.5803 x_4*	9.290	15.98	0.866
5	$y=-102.369+-8.025\ x_1+10.280\ x_2+-0.657\ x_3+-0.970x_4+3.383\ x_5$*	211.82	3.137	0.891
6	$y= 180.478+-9.317\ x_1$* +13.349x_2+0.400x_3+-0.484 x_4+3.420x_5*+-0.399 x_6	243.33	2.67	0.990
7	$y= -568.65+-24.0\ x_1+34.534\ x_2+1.760x_3+-1.751x_4+4.542x_5+-1.052x_6+-4558.346.2\ x_7$	211.88	2.65	0.991

S. No.	Variables	Partial regression Coefficients (b)	Standard Error (E)	P value
1	Maximum temperature	10.017*	3.173	0.025
2	Wind speed	-35.577*	8.203	0.007
3	RH (8.30 am)	-1.0705	2.747	0.713
4	Minimum temperature	5.5803*	1.986	0.038

***Significant at p ≤ 0.05**	Intercept (a)=-279.193	N =10	
X_1 = Maximum temperature	X_2 = Wind speed	X_3= Relative humidity (8.30 am)	X_4=Minimum temperature
X_5 = Crop age	X_6 = Relative humidity (5.30 am)	X_7 = Rainfall (mm)	

Fig.3 Powdery mildew severity in relation to weather parameter s and crop age factors during *rabi*, 2015-16



The severity had a high significant positive correlation with crop age (r = 0.984) and maximum temperature (r = 0.657). Non-significant correlation was observed between severity and rest of the independent variables (Table 4). These observations are in agreement with the findings of Thakur and Agarwal (1995); Solanki *et al.,* 1999; Yarwood (1957); Bhattacharya and Shukla, 2002; Gupta and Sharma, 2009 and Kanzaria *et al.,* 2013. The maximum temperature during the period of occurrence of powdery mildew up to last observation on severity was in the range of 30.90^{0}C -33.80^{0}C) and is well within the favourable range of 28 ^{0}C- 36 ^{0}C for powdery mildew (Delp, 1954; Schnathorst, 1960; Manners *et al.,* 1963). Hence, the maximum temperature showed a strong positive influence on powdery mildew severity.

Regression analysis with performed by powdery mildew severity as dependent variable and maximum temperature, minimum temperature, morning relative humidity, evening relative humidity, rainfall, wind speed and crop age as independent variables to find out the best fit multiple regression equation by using the coefficients of determination (R^2).Stepwise multiple regression analysis was performed using the following equation:

$$y = bo + b_1x_1 + b_2x_2 + b_3x_3 \ldots\ldots\ldots\ldots\ldots\ldots\ldots + b_nx_n$$

Where y = per cent disease index, b_o = intercept, b_1, b_2…….b_n = regression coefficient, and x_1, x_2, ……..x_n = independent variables. The results were presented in the Table 4.

Multiple regression analysis yielded seven distinct equations with R^2 values ranging from 0.991 to 0.412 (P < 0.05). However, the best fit equation was obtained in maximum temperature, wind speed, RH (8.30 am), minimum temperature as independent variables (equation 4).

Y = - 279.80 +10.017 (max temp)*+-35.57(wind speed)*+1.070 (RH morning) +5.5803(min temp)*

N = 10 R^2 = 0.86 F value = 9.29 Standard error = 15.98

* Significant at 5% level

The best fit equation showed 86.6 per cent role of tested independent variables on powdery mildew severity (Table 5). Results were in accordance with the reports of earlier workers (Solanki *et al.,* 1999; Bhattacharya and Shukla, 2002; Gadre *et al.,* 2002; Gupta and Sharma, 2009; Kanzaria *et al.,* 2013). Similarly, maximum and minimum temperature was favourable for disease development as reported by earlier findings (Yarwood *et al.,* 1957). Wind speed effected an instantaneous dispersal of conidia of *Erysiphe polygoni* which was reported by Hammett and Manners (1974).

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