

Original Research Article

<https://doi.org/10.20546/ijcmas.2018.705.014>

Role of Meteorological Factors and Relative Impact of Rust Disease Management in Field Peas through Fungicides and Botanicals in Tarai Region of Indo-Gangetic Plains

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A B S T R A C T

In present study, we followed the two strategies for efficient disease management practice to control rust of field peas in the Tarai region of Indo-Gangetic plains of India. This primarily included the assessment of the meteorological factors affecting the disease severity (DS) to assist in designing the superior disease models and simultaneously evaluated the relative impact of effective botanicals with comparison to frequently used extremely harmful fungicides on pea rust severity. The study revealed the high positive correlation between rust DS and average maximum temperature. Conversely, minimum relative humidity (RH) has shown a highest negative correlation with DS, followed by maximum RH, whereas rainfall exerted no effect. Likewise, regression analysis also confirmed the maximum temperature as a most important disease promoting factor followed by minimum temperature and minimum RH. To assess the effective and efficient disease control measures, we evaluated the actual impact of fungicides and botanicals. Among fungicides, propiconazole (tilt) treatment was found most effective among others in reducing the DS (62.27%) and improving the grain yield, whereas in botanicals, neem extract was observed best in minimizing DS (64.26%) and achieving higher grain yield. In addition, treatment of 10% of botanicals spray was optimized as best optimum concentration for disease control. Thus, the disease model based on studied meteorological factors and use of botanical of environmental friendly and economic properties, could serve as efficient alternatives in pea rust disease management in future.

Keywords

Botanicals, Chemicals, Disease management, Meteorological factors, Rust

Article Info

Accepted:
04 April 2018
Available Online:
10 May 2018

Introduction

The Indo-Gangetic Plains covers nearly one-sixth of the total geographical area of the subcontinent and is inhabits nearly 42 per cent of the total population of 1.3 billion of South Asia. Field pea (*Pisum sativum* L.) is a high quality protein rich crop natively belongs to south west Asia and legume crop majorly in

the Indo-Gangetic regions of India. Field pea (dry) occupies an area of 0.73 mha with a production 0.60 million ton and productivity of 822 kg/ha in India (FAO, 2014). The major field pea producing states in India are Uttar Pradesh, Madhya Pradesh, Orissa, Bihar, Rajasthan, Punjab, Himachal Pradesh, Haryana and Uttarakhand. However, the production of field pea is badly affected by a

number of pathogens. Among them, the rust of pea caused by *Uromyces fabae* (Pers.) de Bary cause huge damage to the crop under warm and humid environment conditions across the globe (FAOSTAT, 2014; Chand *et al.*, 2004)

The evaluation of meteorological factors and their impact on severity of disease and its progression is imperative to determine the suitable time of emergency application of control measures, aside from regular one. Previously, effect of variable temperature on rust disease progression were thoroughly studied (Chand *et al.*, 1997; Gupta, 1990) in addition to however, hitherto studies on evaluation of other meteorological factors including relative humidity, total rainfall on disease progression were very limitedly documented. In addition, to control the pathogenic legume rust effectively, myriads of chemicals/pesticides had been utilized previously (Narsinghani *et al.*, 1980; Sokhi *et al.*, 1974; Kumar *et al.*, 1994; Sharma, 1998), however, excessive use of pesticides field on regular basis led to serious environmental and health consequences to both human and animal (Chauhan *et al.*, 1991; Batra and Stavely, 1994; Gross and Venette, 2001).

Conversely, botanicals in a form of plants extract have been established as potential and environmental friendly alternative to the chemical pesticides that possess significant antimicrobial properties and could efficiently reduce the use of harmful pesticides (Accantino, 1964; Alam *et al.*, 2007). However, fewer studies related to evaluation of botanicals in legumes have been conducted (Diaz-Franco and Garcia, 1995; Chen *et al.*, 2015; Van Maele-Fabry *et al.*, 2010; Wigle *et al.*, 2009; Agrios, 2005). Moreover, the straight forward comparative evaluation of impact of botanicals and chemical pesticides on disease severity (DS) were not thoroughly documented. Keeping the above points in mind, the research work was undertaken to

study the effect of important meteorological factors on pea rust DS to directly assess the requirement and magnitude of treatment under the influence of certain meteorological factors. Simultaneously, we performed the comparative thorough evaluation of the effect of different fungicides and more economic, efficient and environment safe botanicals on rust DS, to support the environmental friendly initiative and provide the best alternative in disease management.

Materials and Methods

Geographically, Pantnagar situated in the humid subtropical zone and located between 29°N latitude and 79.3°E longitude with an altitude of 243.84 m above sea level (mean). The present investigation was carried out during *rabi* season, 2013-14 at Pathology Block, Norman E. Borlaug Crop Research Centre and laboratory work was conducted in the Department of Plant Pathology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, Uttarakhand, India. Field trial was conducted in randomized block design with three replications using highly rust susceptible cultivar HFP-4.

Meteorological factors

In order to study the role of meteorological parameters prevailing atmospheric temperature, relative humidity and rainfall data were collected from the meteorological observatory located adjacent to the experimental plot. DS of at least one year was correlated with meteorological factors viz. temperature, relative humidity and rainfall recorded in respective years.

Fungicide application

Eight different fungicides viz. carbendazim (Bavistin), mancozeb (DithaneM-45), zineb (Dithane Z-78), propineb (Antracol),

chlorothallonil (Kavach), metalaxyl 8%+ mancozeb 64% (Ridomil MZ-72), hexaconazole (Contaf) and propiconazole (Tilt) were selected for evaluation under field conditions. First spray was done at the appearance of the rust symptoms (60 days after sowing) and repeated for three times at 15 days interval. DS was recorded before the beginning of first spray and subsequent observations were recorded before each spray. Final DS was recorded 15 days after last spray.

Optimization of botanicals and implications

Plant extracts from six locally available plants viz. Eucalyptus, Onion, Garlic, Neem, Oak, Coriander at different concentrations viz. 5%, 10%, 20% were prepared by dissolving required amount of extract paste in double distilled water and proper homogenization. Spraying of botanicals was performed similarly to fungicide spray in field conditions. DS was evaluated in case of all three treatments of botanicals. Appropriate concentration was estimated and analyzed through least significant difference (LSD) test as in STAR (IRRI, Philippines) statistical package.

Yield trait evaluation

For yield evaluation, different yield contributing traits were selected and measured including thousand grain weight (g), grain yield (kg/ha) and per cent yield increase. One thousand grains were counted from each plot and weight (g) was recorded. Matured plants were harvested, threshed and cleaned to obtain the seeds for analyzing grain yield. Before observation, moisture content of seed was ensured to be in the range of 10-12 % by weight. The grain yield per plot was recorded in gram per meter², and converted into Kg/ha. Per cent increase yield in the treatment plot was estimated using the following formula:

$$\frac{(\text{Yield in treated plot} - \text{Yield in check plot})}{\text{Yield in check plot}} \times 100$$

Results and Discussion

We evaluated the main influencing meteorological factors including temperature (°C), relative humidity (%) and total rainfall (mm) in response to rust disease severity (DS) in field-based conditions. In this study, the field trials were conducted during crop season to correlate the meteorological factors namely temperature (°C), relative humidity (%) and total rainfall (mm) with the development of rust severity in pea plants (Table 1, Fig. 1 and 2). The disease was observed to start appearing in the second week of February in case of both of the seasons. For instance, in season 2013-14, it was started when there was maximum and minimum relative humidity (RH) of 90.0 and 47.0 percent respectively, while, maximum temperature was around 24.8°C and minimum 7.2°C with average rainfall of 10.8 mm. The same pattern was observed in subsequent season. Furthermore, the DS increased steadily and reached a maximum 13th standard meteorological week in both seasons. In season, 2013-14, the highest increase of percent disease incidence (20.5%) was observed between 9th to 10th meteorological weeks. This suggested that the little change in temperature suddenly influence the disease incidence and thus DS, in addition to the humidity and furthermore indicates towards the ambient temperature required for *Uromyces* to cause disease (Fig. 3). Nevertheless, the DS touched to its maximum at slightly increase in the night temperature and drop in RH with the apparent effect of rainfall in enhancing the DS. This trend was consistent across both of the seasons. The correlation of DS with meteorological factors revealed the significant positive correlation with minimum temperature and rainfall and a negative correlation with RH (Table 1, Fig. 1 and 2).

This result was consistent with similar kind of report obtained in past by researchers (Al-Samarrai *et al.*, 2005).

Across both of the seasons, the consistent positive correlation was detected between night temperature (minimum temperature) and DS, although in only 2013-14, day temperature (maximum temperature) showed the positive correlation with DS. In additional, the ambient RH was detected to influence on DS in both season suggested the importance of considering the high and low RH across the day to estimate the proposed incidence of disease. The similar kinds of finding were obtained previously (Al-Samarrai *et al.*, 2005; Ganapathy and Narayansamy, 1990). Thus, steady increase in temperature especially night temperature and RH played a crucial role in disease incidence progression and its severity. These combinatorial study of environmental factors and comparative study could be incorporated and implemented into development of disease models used for crop management programmes (Ghewande *et al.*, 1993) and efficient disease management (Rizvi *et al.*, 1998; Sajid *et al.*, 1995).

Disease management: relative impact of fungicide and botanicals

Application of foliar spray of fungicides significantly decreases rust severity when compared with check. In season 2013-14, three sprays of propiconazole resulted in minimizing disease severity (59.55 %) over check followed by ridomil (58.55%) and mancozeb (58. 31) respectively, In yield evaluation, maximum grain weight and maximum grain yield was recorded in three foliar spray of propiconazole 174.6 g and 1480.55 kg/ha respectively with 28.76 percent increase in grain yield over check whereas, minimum value of grain weight and grain yield was observed in the propineb spray with 159.66g and 1377.42 kg/ha respectively with 19.79 percent increase in grain yield over

check (Table 2). The observations were consistent with the results reported by researchers in past (Tripathi and Rathi, 2003; Kushwaha *et al.*, 2006). Similarly, (Prasada and Verma, 1948) found the effectiveness of propiconazole (Tilt 406) at 2.0 per cent in broad bean plants as an effective control of *U. fabae*. Interestingly, in the consecutive season i.e. 2014-15, same trend was observed with the effect of the chemical treatment indicated the consistency in the experimental outcomes.

Nevertheless, regular use of chemicals as a controlling agent is an expensive alternative to environment and animal/human health (Accantino, 1964; Alam *et al.*, 2007). Considering the fact, we evaluated the effect and efficacies of natural extract referred as 'botanicals' in controlling the rust disease progression and severity. In case of application of significant number of botanicals, all were found significantly effective in reducing the DS over check (Fig. 4). We furthermore optimized the optimal effective dose of botanicals in field conditions that was not previously in-depth studied. The 10% concentration of botanicals was revealed as significantly effective ($p<0.05$) than that of 5% of botanicals application in each case (Fig. 5). Nonetheless, since result of 20% of extract concentration did not show any significant difference with 10% in reducing DS, 10% concentration was considered optimum and further used in experiment for economic and efficient evaluation.

Among all, in both of the season, neem extract was found most effective in controlling the DS with 61.92 % (in case of 2013-14) and 64.26 % (in case of 2014-15) control over check, respectively, followed by oak extract which was at par and coherent with the previous studies in both of the seasons (Diaz-Franco and Garcia, 1995; Chen *et al.*, 2015; Van Maele-Fabry *et al.*, 2010; Wigle *et al.*, 2009; Agrios, 2005).

Table.1 Effect of temperature (in degree Celsius), relative humidity (%) and rainfall (in mm) on disease severity with correlation, regression values and % increase in disease. The results were represented in $P \leq 0.01$ significant level (mentioned as **)

Standard week	2013-14							2014-15							
	Temp°C		Relative Humidity (%)		Rainfall (mm)	Disease Severity (%)	% increase in disease Max.	Min.	Temp°C		Relative Humidity (%)		Rain fall (mm)	Disease Severity (%)	% increase in disease
	Max.	Min.	Max.	Min.					Max.	Min.	Max.	Min.			
05	22.4	6.31	94	47	0.0	-	--		24.7	7.2	88	50	2.0	-	--
06	24.8	7.2	90	47	10.8	8.3	8.3		25.0	8.0	91	51	9.8	8.5	8.5
07	22.7	11.2	88	58	2.8	9.2	0.9		26.2	8.5	86	55	3.0	10.2	1.7
08	22.7	8.6	91	47	0.4	10.4	1.2		27.5	9.0	84	50	1.5	12.1	1.9
09	23.3	9.5	89	49	2.5	24.0	13.6		25.0	8.2	88	56	0.0	31.0	18.9
10	24.5	9.0	89	38	0.0	44.5	20.5		28.2	10.8	88	54	0.0	42.2	11.2
11	29.3	13.0	88	38	0.0	64.2	19.70		29.4	12.5	85	41	0.0	58.0	15.8
12	32.4	13.4	83	28	0.0	75.5	11.3		29.9	15.2	84	45	5.4	84	26
13	31.9	15.6	83	33	9.2	89.0	13.5		30.7	13.4	82	32	2.2	84	0
Correlation	0.939**	0.885**	-0.867**	-0.870**	0.631	--	--		0.914**	0.93***	-0.867**	-0.840**	0.711	--	--
Regression	0.881	0.784	0.753	0.757	0.003	--	--		0.872	0.810	0.823	0.72	0.004	--	--

Table.2 Effect of fungicides on grain yield, yield increase over check and 1000 grain weight. The results were represented in P \leq 0.01 significant level. Grain yield corresponds to yield in kg/ha and thousand grain weight in grams

Fungicides	2013-14			2014-15		
	Yield (Kg/ha)	% yield increase over check	1000-Grain weight (g.)	Yield (Kg/ha)	% yield increase over check	1000-Grain weight (g.)
Carbendazim (0.1%)	1448.26	25.95	167.73	1550.25	28.7	172.2
Mancozeb (0.25%)	1455.2	26.56	169.66	1595.23	32.43	176.23
Zineb z-78 (0.25%)	1428.12	24.2	165.66	1495.62	24.16	169.2
Propineb (0.25%)	1377.42	19.79	159.66	1422.45	18.09	165.67
Kavach (0.1%)	1401.03	21.85	162.06	1452.32	20.57	166.22
Ridomil (0.2%)	1472.21	28.04	173.46	1502.34	24.72	180.2
Contaf (0.1%)	1445.48	25.71	161.13	1500.02	24.53	163.44
Tilt (0.1%)	1480.55	28.76	174.6	1575.23	30.77	184.524
Check	1149.84		158.2	1204.56		161.32
SEm±	24.91	2.14	-	20.24	2.86	-
CD (P\leq0.01)	102.87	8.86	-	105.6	9.22	-
CV (%)	8.33	2.24	-	9.02	3.02	-

Table.3 Effect of botanicals on grain yield, yield increase over check and 1000 grain weight. The results were represented in P \leq 0.01 significant level. Grain yield corresponds to yield in kg/ha and thousand grain weight in grams

Botanicals	2013-14			2014-15		
	Yield (Kg/ha)	Percent yield increase over check	1000-grain weight	Yield (Kg/ha)	Percent yield increase over check	1000-grain weight
Oak	1317.88	14.61	168.66	1422.22	18.07	172
Neem	1339.59	16.50	175.93	1388.78	15.29	182.24
Garlic	1297.22	12.82	157.66	1321.21	9.68	165.02
Onion	1314.83	14.35	163.86	1360.21	12.92	171.02
Eucalyptus	1256.77	9.30	151.80	1333.21	10.68	155.50
Coriander	1304.51	13.45	158.33	1375.00	14.15	160.34
Check	1149.84	-	158.20	1204.56	-	161.32
SEm±	24.91	2.34	-	26.20	1.454	-
CD (P$<$0.01)	102.87	10.13	-	104.56	9.23	-
CV (%)	8.33	2.54	-	7.86	1.86	-

Fig.1

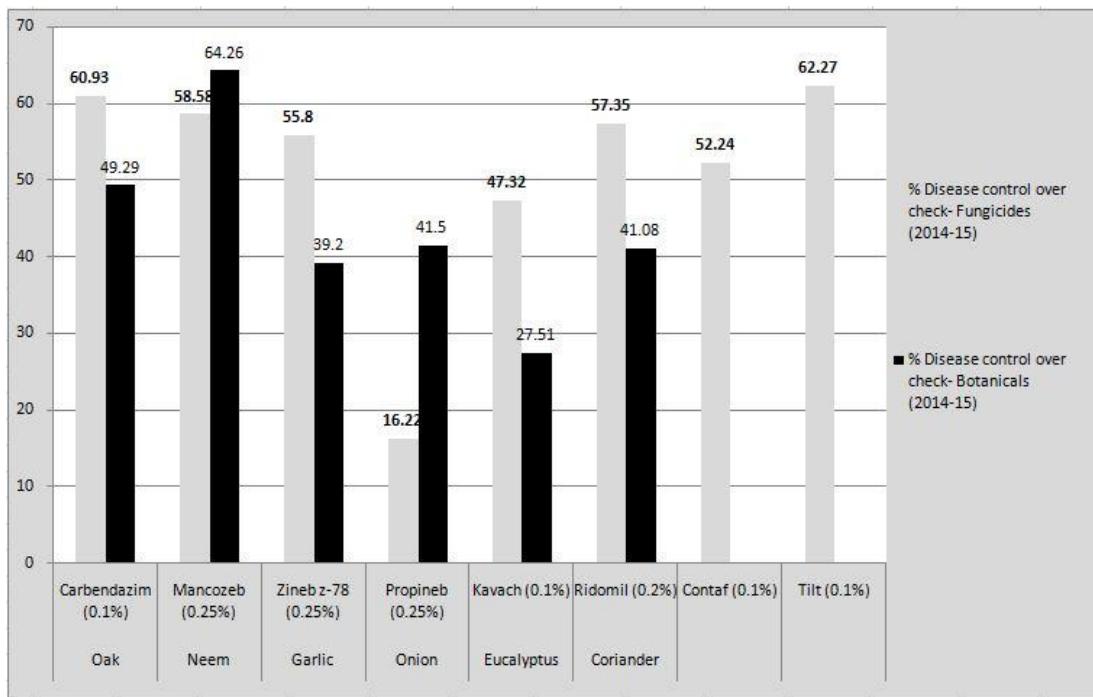


Fig.2

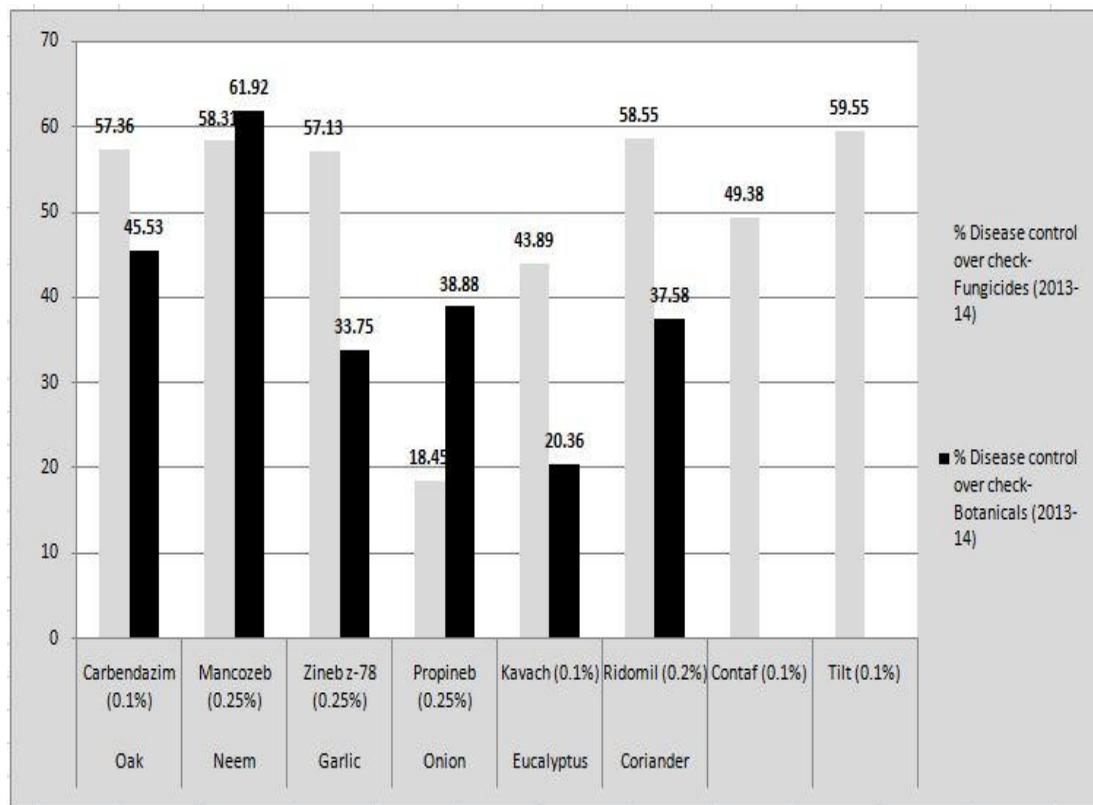


Fig.3

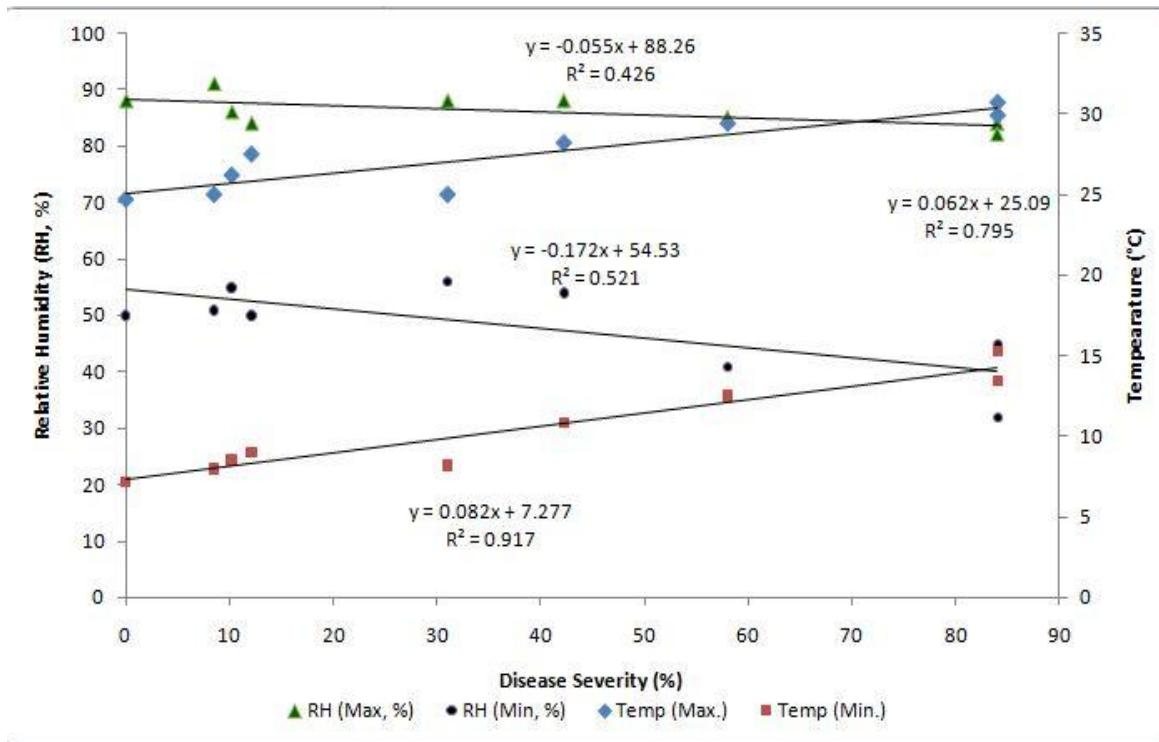


Fig.4

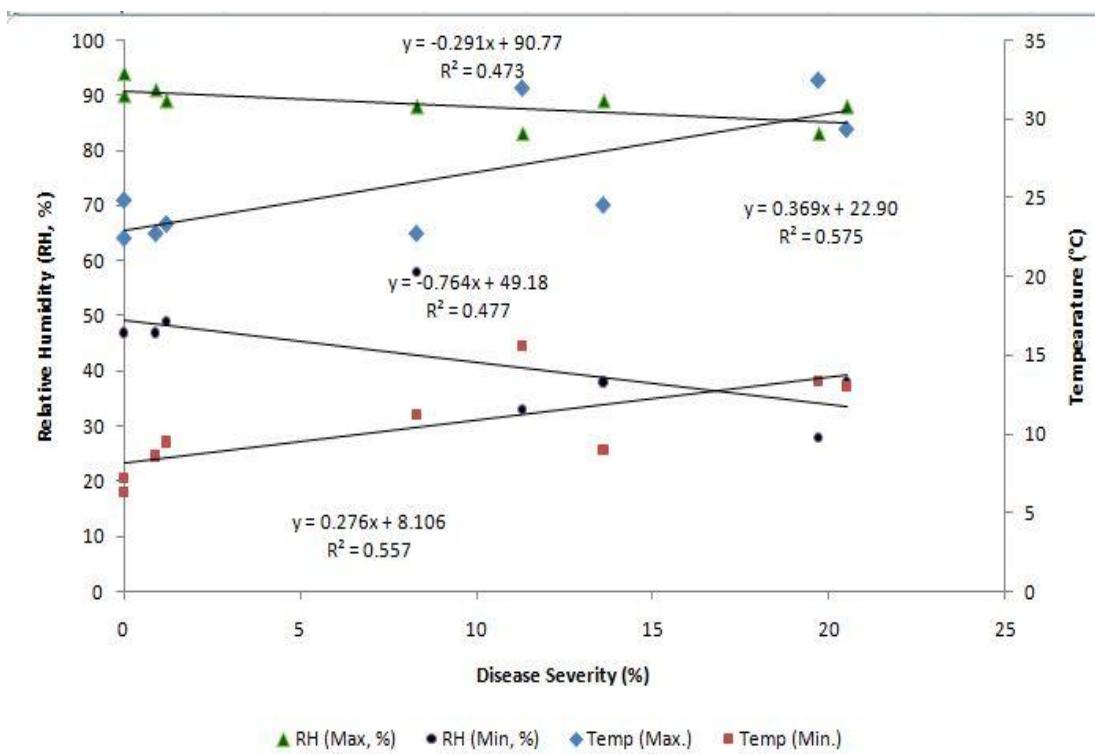
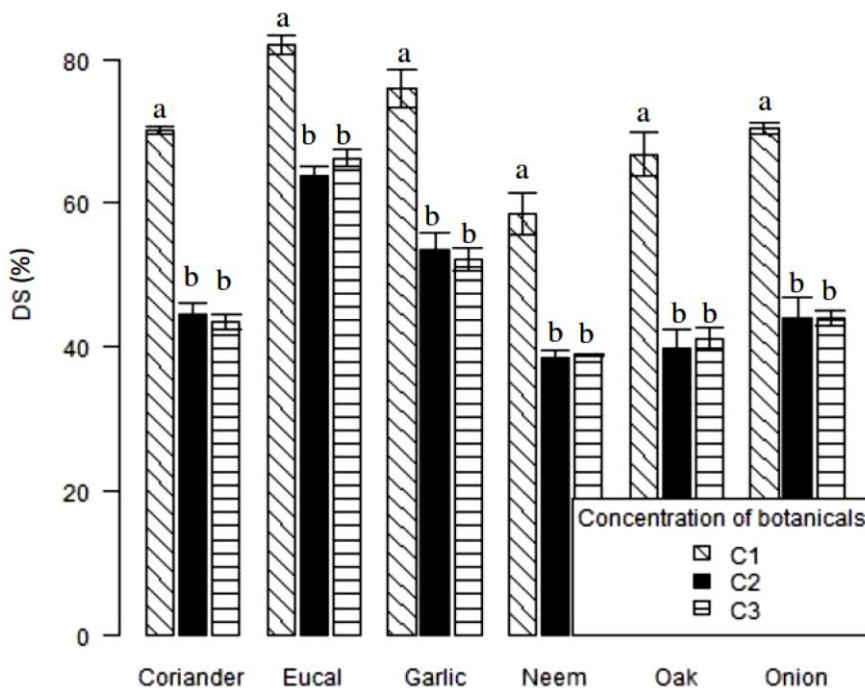


Fig.5



Significant least reduction of disease over control was recorded in case of treatment with eucalyptus extract (20.36 %) followed by garlic extract (33.75 %).

In yield trait evaluation, higher yield was recorded in plants previously treated with the foliar spray of neem extract and exhibited the maximum grain weight and grain yield of 175.93 g and 1339.59 kg/ha in 2013-14 and 182.24 g and 1388.78 kg/ha in 2014-15, respectively with 16.50 and 15.29 percent increase in grain yield over check (Table 3). The minimum grain weight and grain yield was recorded in the foliar spray of eucalyptus relatively less increase in grain yield over check across the seasons.

Thus, as an outcome, neem extract was shown to be more effective in control of DS than that of the different concentrations of chemical fungicide used. Similarly, foliar spray with neem oil was revealed as effective for the management of rust of field pea (Roger *et al.*,

1999; Coakley *et al.*, 1999; De Wolf and Isard, 2007; Agrios, 2005; Chen *et al.*, 2015) effectively used the *Azadirachta indica* (neem) and *Lawsonia inermis* (henna) extracts for the control of *Puccinia arachidis* causing rust of groundnut.

Hence, this study successfully demonstrated that role of various meteorological factors dramatically influencing the pea rust disease progression and its severity. In addition, the exclusive study of different meteorological effect on rust disease severity of field pea might effectively assist in developing and improving disease prediction models eventually would improve our understanding of conducive conditions for pea rust disease and thereby led to enable the efficient disease management. In addition, we unveiled the enormous potential of useful botanicals over the fungicide in pea rust disease management with the optimized effective dose, would helpful to organic way manage disease and thereby assisting in organic farming. As a outcome, aside from neem, the

extract of onion, garlic, oak and coriander were revealed as a more effective or at least at par than that of their chemical substitutes and emerged as a significant alternative to address the environmental problem and health hazards caused owing to their use.

Acknowledgement

The authors are grateful to Dr. Saurabh Badoni for helpful discussion and critically reading the manuscript. This work was supported by research grant from the Directorate of Research of G.B.P.U.A and T. Pantnagar, India.

Compliance with the Ethical standard

The authors declare that they have no conflict of interest. The authors and manuscript comply with the ethical standards and regulation of the journal. The research did not involve any human and animal study.

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How to cite this article:

Shweta Badoni, K.P.S. Kushwaha and Archana Negi. 2018. Role of Meteorological Factors and Relative Impact of Rust Disease Management in Field Peas through Fungicides and Botanicals in Tarai Region of Indo-Gangetic Plains. *Int.J.Curr.Microbiol.App.Sci.* 7(05): 106-116.
doi: <https://doi.org/10.20546/ijcmas.2018.705.014>