

1 Epidemiology and management of MYMV disease in Mung bean (*Vigna radiata* (L.))

2

3 ABSTRACT

4 Mung bean is a short-duration ancient legume crop that can be grown as a sole or intercrop
5 for grain and green manure in all three crop seasons, including winter, summer and rainy in
6 various regions of the country. MYMV (Mungbean Yellow Mosaic Virus) disease is one of
7 the most destructive diseases transmitted by whitefly (*Bemisia tabaci* Genn) persistently.
8 Weather parameters have no direct effect on MYMV, but affect the whitefly population.
9 Field experiments were conducted for three consecutive years from 2019-2021 as to know the
10 effect of weather parameters on the whitefly population. Development of whitefly population
11 and MYMV disease severity were recorded in mungbean crops at 7 days interval starting
12 from 20 days after sowing (DAS). The present study showed that whitefly population builds
13 up starting in July and reached to maximum at end of August to early September. There are
14 various factors influencing the build-up of whitefly population viz., maximum temperature
15 $36\pm 2^{\circ}\text{C}$, minimum temperature $25\pm 2^{\circ}\text{C}$, morning relative humidity more than 90 percent,
16 more sunshine hours and no rainfall prevailing during that period. Whitefly population had
17 positive significant correlation with maximum temperature and bright sunshine hours while
18 evening relative humidity and rainfall were recorded as negatively significant. Three-year
19 data is very helpful in guiding the farmers for timely and preventive sprays based on existing
20 infections and the population of whitefly in a season.

21 **Keywords:** Persistent manner, MYMV Disease, *Bemisia tabaci*, bright sunshine hours,
22 whitefly and preventive spray.

23 1. INTRODUCTION

24 “Mung bean (*Vigna radiata* (L.) Wilczek) is a very ancient annual crop that originated
25 in India or the Indo- Burmese region, which is commonly known as green gram, green bean,

26 moong, mash bean, golden gram and green soy. Mung bean (*Fabaceae*) is well suited for a
27 large number of cropping systems. More than 90% of world's mungbean production comes
28 from Asia" (Karthikeyan *et al.*, 2015). "Mungbean is a short-duration legume crop, which
29 can be grown in varying environmental conditions, such as in all three crop seasons viz.,
30 kharif, summer and rabi in different parts of the country, as sole or intercrop for grain and
31 green manure" (Dharajiya *et al.*, 2018). "The global mungbean area is about 7.3 million ha
32 with global output of about 5.3 million tones. The average grain yields (0.73 t/ha) of
33 mungbean are quite low in India. India is the world's largest producer of mungbean
34 cultivated over an area of 3.44 million ha with a production of 1.4 million tones and
35 productivity of 406.98 kg/ha in India". (<http://agropedia.iitk.ac.in>).

36 "The standard yield of mungbean worldwide is very low (730 kg/ha) and the main
37 reasons are various diseases of mungbean. Out of all diseases MYMV disease is one of the
38 most prevalent and destructive diseases" (Sudha *et al.*, 2013). "The most vulnerable stage is
39 from 30 to 45 days of sowing" (Sudha *et al.*, 2013). "MYMV a member of the *Geminiviridae*
40 family, belongs to the genus *Begomovirus* that was identified in 1955 and it was observed
41 that it is not transmitted mechanically but transmitted by whitefly (*Bemisia tabaci* Genn) in
42 persistent manner" (Iqbal *et al.*, 2011). "Mungbean plants are infected at the seeding stage, so
43 it can lead to 85-100% loss in yield" (Sudha *et al.*, 2013). "MYMV disease can be recognized
44 by its typical symptoms which start appearing on the young leaves of the plant at vegetative
45 stage in form of mild yellow spots" (John *et al.*, 2015). "These gradually spread all over the
46 upper leaves, which turn to yellow and ultimately, reduce plant size, number of flowers and
47 pods" (Brown *et al.*, 1991). "Affected plants generate fewer flowers and pods, which also
48 develop mottling and remain small and contain fewer, smaller and shrunken seeds" (Patel *et*
49 *al.*, 2018).

50 “Plant disease emergences have dramatically increased recently as a result of global
51 changes, especially concerning trade, host genetic uniformity, and climate change”
52 (Willoquet *et al.*, 2020). “The mungbean yellow mosaic virus (MYMV) is prevalent in the
53 major mungbean-growing areas in India. A severe outbreak of MYMV in the southern and
54 northern states of India is currently causing serious concern to mungbean growers and to the
55 industrialist in these regions. In past, different varieties had responded differently to. MYMV
56 disease in the field under different temperatures, relative humidity, sunshine hours, wind
57 speed and rainfall. Many weather-driven epidemiological models have been developed and
58 used to predict plant disease epidemics under variable climates” (Datta *et al.*, 2010). The
59 present investigation was conducted to form an epidemiological model which may direct the
60 farmers toward early and preventive spraying based on the level of disease incidence and
61 whitefly population during the season.

62 2. MATERIALS AND METHODS:

63 The present investigation was conducted in the Research Area, Department of Plant
64 Pathology, CCS Haryana Agricultural University, Hisar during Kharif 2019-2022. CCS
65 Haryana Agricultural University is situated in the semi-arid climate at 29° 17’ N latitude and
66 75° 47’E longitude at an altitude of 215.2 meters above mean sea level in the subtropical
67 climatic zone of India. The mean weekly values of all the weather parameters during the
68 crop-growing season were recorded at the Meteorological Observatory of the Research Farm,
69 CCS Haryana Agricultural University, Haryana, India.

70 To understand the whitefly population and incidence of MYMV disease, a field experiment
71 was conducted to know the effects of various weather factors on the whitefly population and
72 disease severity for three consecutive years. The correlation analysis was performed among
73 disease severity, whitefly population and weather parameters. Mungbean cultivars MH 421 as
74 resistant, TMB 37 as moderately resistant and. SML 1082 as susceptible was grown in a

75 randomized block design (RBD) during kharif seasons (2019-2021) in plots. In India, Kharif
76 season lies from May to September.

77 **Disease severity**

78 The disease severity was recorded at 7 days interval starting from 20 DAS (Days after
79 sowing) by using the 0-6 scale in Table 1 (Ali *et al.*, 2005). Percent disease index (PDI) was
80 calculated by using the method of McKinney, 1923. **The correlation** was **analzsed** between
81 PDI with the different weather parameters.

82 The percent disease index (PDI) was calculated by using McKinney's (1923) formula:

$$\text{Per cent disease index} = \frac{\text{Sum of all numerical ratings}}{\text{No. of plants examined} \times \text{maximum disease rating}} \times 100$$

86 **Management through biorationals and chemicals approaches:**

87 **Treatment details:**

88 T₁: Malathion 50 EC @ 450ml/ acre

89 T₂: Dimethoate EC @ 250ml/ acre

90 T₃: Neem oil @ 5ml/kg as seed treatment + spray @5ml/L

91 T₄: Salicylic acid @ 150 mg/litre as seed treatment + spray

92 T₅: Sarpagandha leaves extract @10% as seed priming + spray @100ml/L

93 T₇: Faba bean seed extract @ 10 % as seed priming + spray @100ml/L

94 **3. RESULTS:**

95 **A. Whitefly population at weekly interval:**

96 Whitefly population build up on all three cultivars was higher during August as
97 compared **to the rest of** months. It was recorded that in early stages of crop growth whitefly
98 population was less and build-up started with advances in crop growth. Whitefly population
99 was observed first during the month of July (initial crop growth stages). Thereafter, **the**

100 whitefly population increased, except during rainfall and high wind speed periods. Whitefly
101 population was ranged between 1.5-8 adults/leaf/plant with an average of 4 adults/leaf/plant
102 on mungbean (Table 2-4). The whitefly population increased up to 45 DAS that might be due
103 to increase in maximum temperature, sunshine hours and decrease in wind speed. The
104 whitefly population builds up started in August. Maximum average whitefly population was
105 recorded (8.42) on SML 1082 followed by TMB 37 (7.19) and minimum (5.08) was
106 recorded on MH 421 at 36.4°C, no rainfall (0.00 mm), minimum relative humidity (53%) and
107 maximum bright sunshine (7.9h) during *kharif* 2019. Among the three cultivars maximum
108 average population was recorded on SML 1082 during the course of disease development in
109 all the three season.

110 Whitefly population on all three cultivars exhibited positive significant correlation with
111 bright sunshine hours. SML 1082 exhibited positive significant correlation with bright
112 sunshine hours (0.487) while maximum temperature (0.470) and morning relative humidity
113 (0.417) was recorded as negatively non-significant factor (Table 5). However, evening
114 relative humidity (0.846), wind speed (0.471) and rainfall (0.650) was negatively (non-
115 significant) correlated, while minimum temperature (0.470) was recorded positively non-
116 significant with whitefly population. Almost similar correlation matrix was found in case of
117 TMB 37. MH 421 grown as resistant cultivar against MYMV disease also exhibited the same
118 kind of correlation with weather parameters and whitefly population.

119 **B. Disease severity at weekly intervals**

120 The MYMV disease occurred throughout the growing season of mungbean crop. The disease
121 initiated in the field at 20 days after sowing in the form of vein clearing of leaves on 2 to 3
122 young leaves followed by yellowing of leaves. The higher terminal PDI was observed on
123 SML 1082 (73.32%) cultivar as compared to TMB 37 (41.66%) and MH 421 (10.55) (Table
124 6-8). At the time of initiation of disease, the maximum temperature was 38±2°C with more

125 than 85 percent morning relative humidity. As the crop growth, the PDI increased significantly.
126 Slow progress in disease was observed in the weeks which had lower whitefly population due to
127 unfavourable weather conditions, i.e. high wind speed (7.21 km/h), less bright sunshine hours
128 (3.82 h) and less total rainfall (83.7mm). They thrive best under hot and humid conditions and
129 the population also towers with higher temperatures. The progress in disease was also noticed
130 during post rainfall periods. The maximum PDI was observed in last week of August and first
131 week of September. The highest PDI (73.32) was recorded on SML 1082 at 55 DAS during first
132 week of September.

133 PDI on three cultivars SML 1082 exhibited positive non-significant correlation with
134 minimum temperature, morning relative humidity and bright sunshine hours. However,
135 maximum temperature, wind speed and rainfall were negatively (non-significant) correlated
136 (Table 9). The evening relative humidity is the only factor that has significant effect on PDI
137 that is highly significant (negative) for all the three cultivars.

138 Positive relationship was found between whitefly population and disease severity. At initial
139 stages of crop growth, whitefly population and disease incidence were found to be lower but
140 later due to favourable weather conditions increase in whitefly population led to increase in
141 MYMV disease. The incidence started at 20 DAS with varying whitefly population on all
142 three cultivars. The correlation between whitefly population and MYMV PDI was found
143 positively significant. Table 10 shows that MH 421 (0.958) was positively highly significant
144 and SML 1082 (0.831) and TMB 37 (0.888) were found positively significant which clearly
145 indicated that vector population directly affected the MYMV disease on mungbean crop.

146 **C. Management of MYMV disease in mungbean:**

147 The results revealed that all the treatments had significant effect on increased the
148 yield as well as test weight. Test weight of all treatments was significantly higher than the
149 control. In all treated plots significantly lower PDI was recorded during all the periods of

150 observations. Amongst the chemicals, Dimethoate EC recorded significantly less terminal
151 PDI with maximum increase in yield (58.68) followed by Melathion 50 EC @ 450ml/ acre
152 (Table 11). Faba bean seed extract as seed treatment + spray @5ml/L shows maximum
153 percent increase in yield (54.68) followed by the use of Neem oil as seed treatment + spray
154 @5ml/L which is at par with the use of salicylic acid as seed treatment + spray @5ml/L.
155 In order to guide farmers toward early and preventive spraying based on the degree of disease
156 incidence and whitefly population throughout the season, a biorational approaches in
157 mungbean is very helpful.

158 **4. DISCUSSION:**

159 For the sake of epidemiological studies temperature, relative humidity, rainfall, wind velocity
160 and sunshine hours were considered as most important factors. The whitefly population and
161 percent disease index (PDI) was observed throughout the growing season on three mungbean
162 cultivars. The disease initiated at 20 DAS and maximum progress in PDI was noticed on
163 SML 1082 followed by TMB 37 and MH 421. The highest terminal PDI (75.8%) and
164 whitefly population (7.50) was observed on SML 1082. The maximum whitefly population
165 and PDI were observed during last week of August and early September. This might be due
166 to more favourable weather conditions, i.e. maximum temperature 36 ± 2 °C and low evening
167 relative humidity (<54%) with more sunshine hours during this period. No rainfall prevailing
168 during that period. In previous studies, Khan *et al.*, 2018 observed maximum whitefly
169 population at higher temperature (38°C) and relative humidity (66%), which were congenial
170 for prevalence of the mungbean yellow mosaic disease. Similarly, Singh & Gurah (1994)
171 found that hot weather with little or no rainfall was conducive for multiplication of MYMV
172 and *Bemisia tabaci*. Meti *et al.*, 2018 observed that decrease in whitefly population was
173 mainly due to higher rainfall and lower minimum temperature, whereas increase in whitefly
174 population was due to higher maximum temperature and no rainfall. Cooler weather and high

175 relative humidity are detrimental to whitefly population (Sharma *et al.*, 2014) and present
176 study is in agreement with his findings.

177 Both the whitefly population and PDI were found negatively significant with evening
178 relative humidity, whereas all other factors were reported having no significant effect.
179 Earlier, Khan *et al.*, (2012) and Ansar *et al.*, (2014) have reported negative correlation
180 between maximum temperature and whitefly population. There was positive significant
181 correlation between whitefly population and sunshine hours, which was also observed by
182 Meti *et al.*, (2018). The high wind speed and more total rainfall have detrimental effect on
183 whitefly population. In present findings, the lesser number of whiteflies were observed in the
184 weeks, which have high wind speed and more rainfall, and a negative correlation was found
185 with wind speed and rainfall. Similarly, Marabi *et al.*, (2017) has also recorded significant
186 negative correlation with wind speed and rainfall. Present findings were corroborative with
187 the findings of Ali *et al.*, (2015) and Suman *et al.*, (2016) who reported that the maximum
188 temperature has a significant negative correlation with MYMV disease incidence and Khan
189 *et al.*, (2018) who established negative correlation of the disease with rainfall and wind speed
190 but there was positive correlation of MYMV disease with maximum temperature.

191 Management of MYMV disease by controlling its vector *Bemisia tabaci*, through use
192 of resistance inducers and biorationals was tried. The present result revealed that suppression
193 of MYMV disease could be achieved through use of biorational approaches and
194 nonconventional chemicals. Dubey *et al.*, (2011) observed that application of neem seed
195 kernel extract and foliar spray of neem oil is effective. Reang *et al.*, 2018 also used different
196 botanicals and out of them, neem @ 0.2% showed lowest disease incidence (10.49%) and
197 severity (9.58%) in case of virus disease.

198 Studies conducted in tropical agricultural areas of Latin America such as Venezuela (Olivares
199 *et al.* 2018; Hernandez *et al.* 2018; Orlando *et al.* 2018) and Panama have shown that MYMV

200 disease is also a major constraint to mungbean production in these regions (Montenegro *et al.*
201 2021a; 2021b; Bertorelli and Olivares, 2020; Olivares and Hernández, 2019). The disease is
202 transmitted by the same vector, *Bemisia tabaci*, and causes similar symptoms in infected
203 plants as in India. In Venezuela, MYMV disease has been reported to cause yield losses
204 ranging from 20% to 80%, depending on the severity of the infection (Demey *et al.* 2016).
205 The disease is more prevalent during the rainy season (May to October) (Rey *et al.* 2019;
206 Parra *et al.* 2012; Cortez *et al.* 2018), and the whitefly population is high (Hernandez *et al.*
207 2017; Hernandez *et al.* 2020). Management of MYMV disease in Venezuela involves the use
208 of similar strategies as in India, such as cultural practices, chemical control, and host
209 resistance (Guevara *et al.* 2012; Olivares, 2017).

210 In Panama, MYMV disease is also a major constraint to mungbean production, especially in
211 the central and western regions of the country (the disease is more prevalent during the dry
212 season (December to April) (Pitti *et al.* 2021), and the whitefly population is low.
213 Management of MYMV disease in Panama involves the use of similar strategies as in India
214 and Venezuela, but the focus is on host resistance. MYMV disease is a major viral disease
215 that affects mungbean production in India and other tropical regions around the world,
216 including Latin America. Management of MYMV disease in these regions involves the use of
217 several strategies such as cultural practices, chemical control, and host resistance. Host
218 resistance is considered the most effective and sustainable approach for managing MYMV
219 disease in mungbean.

220 **5. CONCLUSION:** The whitefly population builds up started in July and reached to
221 maximum at end of August to early September. There are various reasons for build-up of
222 whitefly population *viz.*, maximum temperature $36\pm 2^{\circ}\text{C}$, minimum temperature $25\pm 2^{\circ}\text{C}$,
223 morning relative humidity more than 90 per cent, more sunshine hours and no rainfall
224 prevailing during that period. For the management of MYMV disease biorationals were used

225 and amongst all Fabia bean seed extract @ 150 mg/liter as seed priming and then foliar spray
226 @ 150 mg/L recorded significantly less terminal PDI with maximum percent disease control
227 (54.68%).

228 **6. ACKNOWLEDGMENTS:** All sort of assistance rendered by the Department of Plant
229 Pathology, CCS Haryana Agricultural University, Hisar and Dr. Vinod Kumar Malik for the
230 above study is gratefully acknowledged without whom this work wouldn't have reached its
231 completion.

232 **7. CONFLICT OF INTEREST:** None.

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369 **Table 1: Disease severity scale (Ali *et al.*, 2005)**

Rating	Category	Severity Range
0	Immune	0%
1	Highly resistant	1-10%
2	Moderately resistant	11-25%
3	Tolerant	26-50%
4	Moderately susceptible	51-60%
5	Susceptible	61-70%
6	Highly susceptible	71-100%

370

371 **Table 2: Effect of weather parameters on whitefly population on three cultivars of**
 372 **mungbean during *kharif* 2019**

Time of observation	Whitefly population/ leaf			Temperature (°C)		Relative Humidity (%)		Average wind velocity (km/h)	Bright sunshine hours (h)	Total Rainfall (mm)
	MH	TMB	SML	Max.	Min.	M	E			
	421	37	1082					7.21	3.81	23.3
25-07-2020	1.443	2.083	2.593	38.6	24.2	89	74	5.02	4.4	83.7
1-08-2020	1.140	1.570	2.083	35.4	20	89	72	7.5	7.1	1.1
8-08-2020	2.217	3.891	4.590	36.6	26	83	63	4.97	3.2	14.4
15-08-2020	3.797	6.007	6.897	34.4	23.2	91	68	5.18	7.9	0.0
22-08-2020	5.087	7.197	8.420	36.4	25	83	54	4.7	6.2	27.7
29-08-2020	4.830	5.817	6.900	33.5	25.5	85	57			
CD (P=0.05)	1.117	1.029	0.704							
SE±	0.35	0.32	0.22							

373

374 **Table 3: Effect of weather parameters on whitefly population on three cultivars of**
 375 **mungbean during *kharif* 2020**

Time of observation	Whitefly population/ leaf			Temperature (°C)		Relative Humidity (%)		Average wind velocity (km/h)	Bright sunshine hours (h)	Total Rainfall (mm)
	MH	TMB	SML	Max.	Min.	M	E			
	421	37	1082					6.7	8.0	38.4
16-07-2020	0.00	0.00	0.00	36.0	26.5	89	64	8.7	5.7	111.1
23-07-2020	1.21	3.17	3.32	34.6	25.9	92	75	4.8	7.3	14.7
30-07-2020	3.43	3.48	4.53	34.5	26.8	87	60	5.9	6.6	0.0
06-08-2020	3.76	3.46	4.82	36.4	27.0	84	66	6.9	6.6	32.8
13-08-2020	4.84	4.53	5.67	35.3	27.5	88	62	6.5	6.7	17.5
20-08-2020	5.13	5.34	6.12	35.3	26.9	90	77	7.7	6.4	11.7
27-08-2020	5.28	5.67	6.28	32.6	25.4	91	76	7.5	6.8	0.0
3-09-2020	5.89	5.91	7.50	33.9	25.6	90	64			

376

377 **Table 4: Effect of weather parameters on whitefly population on three cultivars of**
 378 **mungbean during *kharif* 2021**

Time of observation	Whitefly population/ leaf			Temperature (°C)		Relative Humidity (%)		Average wind velocity (km/h)	Bright sunshine hours (h)	Total Rainfall (mm)
	MH	TMB	SML	Max.	Min.	M	E			
	421	37	1082					6.7	8.0	38.4
22-07-2020	0.00	0.00	0.00	26.9	35.9	63	86	4.8	8.2	9.0
29-07-2020	1.24	3.34	3.76	27.4	33.7	76	92	8.4	5.9	56.0
5-08-2020	3.78	3.87	4.53	26.5	31.9	79	94	7.6	6.9	149.9

12-08-2020	4.21	4.21	5.22	26.6	35.6	58	88	4.7	7.2	0.0
19-08-2020	4.99	4.78	5.78	26.3	37.1	54	80	4.9	8.4	0.0
26-08-2020	5.65	5.78	6.58	26.7	34.7	69	86	5.9	3.6	0.5
2-09-2022	5.67	6.21	7.32	25.9	35.9	65	88	7.8	5.8	15.7
9-09-2022	5.93	6.43	5.48	25.8	32.7	75	95	6.9	7.4	100.2

379

380 **Table 5: Correlation matrix of weather parameters and whitefly population on different**
381 **varieties of mungbean during kharif 2019**

S. No	Variety	Temperature (°C)		Relative humidity (%)		Wind speed (km/h)	Sunshine hours (h)	Rainfall (mm)
		Maximum	Minimum	Morning	Evening			
1	MH421	-0.477 ^{NS}	0.507 ^{NS}	-0.450 ^{NS}	-0.884 [*]	-0.549 ^{NS}	0.525 ^S	-0.548 ^{NS}
2	TMB37	-0.469 ^{NS}	0.535 ^{NS}	-0.393 ^{NS}	-0.827 [*]	-0.462 ^{NS}	0.462 ^S	-0.661 ^{NS}
3	SML1082	-0.470 ^{NS}	0.539 ^{NS}	-0.417 ^{NS}	-0.846 [*]	-0.471 ^{NS}	0.487 ^S	-0.650 ^{NS}

382 NS = Non significant, * = Significant

383 **Table 6: Effect of weather parameters on percent disease index (PDI) on three cultivars**
384 **of mungbean during kharif 2019**

Time of observation	Percentage disease index (PDI)			Temperature (°C)		Relative Humidity (%)		Average wind velocity (km/h)	Bright sunshine hours (h)	Total Rainfall (mm)
	MH 421	TMB 37	SML 1082	Max.	Min.	M	E			
								7.21	3.81	23.3
25-07-2020	1.66	6.10	20.02	38.6	24.2	89	74	5.02	4.4	83.7
1-08-2020	1.98	8.88	33.33	35.4	20	89	72	7.5	7.1	1.1
8-08-2020	4.21	17.73	42.77	36.6	26	83	63	4.97	3.2	14.4

15-08-2020	6.11	26.10	49.44	34.4	23.2	91	68	5.18	7.9	0.0
22-08-2020	8.33	32.77	57.77	36.4	25	83	54	4.7	6.2	27.7
29-08-2020	10.55	41.66	73.32	33.5	25.5	85	57			
CD (P=0.05)	3.95	5.57	8.93							
SE±	(1.23)	(1.74)	(2.80)							

385 • M: Morning Relative Humidity, E: Evening Relative Humidity

386 **Table 7: Effect of weather parameters on percent disease index (PDI) on three cultivars**
 387 **of mungbean during *kharif* 2020**

Time of observation	Percentage disease index (PDI)			Temperature (°C)		Relative Humidity (%)		Average wind velocity (km/h)	Bright sunshine hours (h)	Total Rainfall (mm)
	MH	TMB	SML	Max.	Min.	M	E			
	421	37	1082					6.7	8.0	38.4
16-07-2020	0	0	0	36.0	26.5	89	64	8.7	5.7	111.1
23-07-2020	0	0	2.14	34.6	25.9	92	75	4.8	7.3	14.7
30-07-2020	5.83	4.17	6.7	34.5	26.8	87	60	5.9	6.6	0.0
06-08-2020	6.67	9.17	13.3	36.4	27.0	84	66	6.9	6.6	32.8
13-08-2020	9.17	16.67	26.7	35.3	27.5	88	62	6.5	6.7	17.5
20-08-2020	13.33	22.50	50.0	35.3	26.9	90	77	7.7	6.4	11.7
27-08-2020	15.00	26.67	70.8	32.6	25.4	91	76	7.5	6.8	0.0
3-09-2020	18.33	29.17	75.8	33.9	25.6	90	64			

388 • M: Morning Relative Humidity, E: Evening Relative Humidity

389 **Table 8: Effect of weather parameters on percent disease index (PDI) on three cultivars**
 390 **of mungbean during *kharif* 2021**

Time of observation	Percentage disease index (PDI)	Temperature (°C)	Relative Humidity	Average wind	Bright sunshine	Total Rainfall
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						(%)		velocity	hours (h)	(mm)
	MH	TMB	SML	Max.	Min.	M	E	(km/h)		
	421	37	1082					6.7	8.0	38.4
22-07-2020	0	0	2.88	26.9	35.9	63	86	4.8	8.2	9.0
29-07-2020	0	4.15	5.77	27.4	33.7	76	92	8.4	5.9	56.0
5-08-2020	4.72	9.57	7.88	26.5	31.9	79	94	7.6	6.9	149.9
12-08-2020	5.87	12.45	15.66	26.6	35.6	58	88	4.7	7.2	0.0
19-08-2020	10.12	19.64	36.99	26.3	37.1	54	80	4.9	8.4	0.0
26-08-2020	14.77	24.58	48.97	26.7	34.7	69	86	5.9	3.6	0.5
2-09-2022	17.88	28.69	67.74	25.9	35.9	65	88	7.8	5.8	15.7
9-09-2022	19.66	32.19	74.89	25.8	32.7	75	95	6.9	7.4	100.2

391 • M: Morning Relative Humidity, E: Evening Relative Humidity

392 **Table 9: Correlation of weather parameters and PDI on different varieties of Mungbean**

S.No	Variety	Temperature (°C)		Relative humidity (%)		Wind speed	Sunshine hours	Rainfall
		Maximum	Minimum	Morning	Evening			
1	MH421	0.763*	0.533 ^{NS}	0.469 ^{NS}	-0.882*	-0.575 ^{NS}	0.510*	-0.426 ^{NS}
2	TMB37	0.797*	0.612 ^{NS}	0.446 ^{NS}	-0.872*	-0.591 ^{NS}	0.490*	-0.421 ^{NS}
3	SML1082	0.878*	0.436 ^{NS}	0.473 ^{NS}	-0.865*	-0.622 ^{NS}	0.619*	-0.306 ^{NS}

393 **NS = Non significant, * = Significant**

394 **Table 10: Correlation matrix of whitefly population and PDI on three mungbean**
395 **varieties**

S.No.	Variety	Disease severity
1	MH 421	0.958**
2	TMB 37	0.888*
3	SML 1082	0.831*

396 ** = Highly significant, * = Significant

397 **Table 11: Management of MYMV disease in mungbean**

Treatment No.	Treatments	Percent increase in yield	Percent increase in test weight	B:C Ratio
T1	Malathion 50 EC @ 450ml/ acre	58.68	17.98	1.96
T2	Dimethoate EC @ 250ml/ acre	52.77	16.32	1.84
T3	Neem oil @ 5ml/kg as seed treatment + spray @5ml/L	46.76	13.56	1.69
T4	Salicylic acid @ 150 mg/litre as seed treatment + spray	44.69	12.87	1.56
T5	Sarpagandha leaves extract as seed treatment + spray @5ml/L	38.76	12.37	1.52
T6	Faba bean seed extract as seed treatment + spray @5ml/L	54.68	16.78	1.86
T7	Control	--	--	1.26

398