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CHARACTERIZATION OF ENVIRONMENTAL FACTORS CONDUCIVE FOR URDBEAN LEAF CRINKLE (ULCV) DISEASE DEVELOPMENT

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Abstract

In order to see the impact of environmental conditions on Urdbean leaf crinkle disease development, 20 genotypes viz., 6022-22, 95009, 6036-12, 96 CM-016, AARIM-32, AARIM-164, M-17, M-3, 95024, Mash-88, 6036-7, ES-1, NCH-3-3, 6036-7, Mash-1, 4 CM-717, IAM 33-40, 3 CM-706, 6036-14 and Mash-97 from the reaction groups viz. MR, MS, S and HS were sown for 4 seasons (spring and summer) during 2005-2006. It was observed that disease incidence differed in each growing season whereas it showed overall significant correlation with maximum and minimum temperature and no correlation with relative humidity, rainfall and wind speed in each growing season, respectively. When data were split by genotypes the level of correlation decreased. To characterize the environmental conditions conducive for the disease epidemics, it was found that maximum ULCV disease severity/incidence was recorded at 35-42^{o}C (maximum temperature) and 21-29^{o}C (minimum temperature). There was absolutely no correlation with weekly relative humidity, rainfall and wind movement.

Introduction

Urdbean also called blackgram (*Vigna mungo* (L.) Hepper) is an important pulse crop grown all over the world including Pakistan. It occupies an area of 34.5 thousand hectares, yielding an annual production of 16.5 thousand tonnes of grains with an average grain yield of 488 kg/ha (Anon., 2006). The crop is highly susceptible to leaf crinkle disease caused by Urdbean leaf crinkle virus (ULCV) than greengram and other pulses (Kadian, 1980; Rishi, 1990). Thus the disease is economically important, destructive, widespread and inflicts heavy losses annually. The disease is characterized by the appearance of extreme crinkling, curling, puckering and rugosity of leaves, stunting of plants and malformation of floral organs. The virus has been reported to decrease grain yield from 35 to 81% depending upon genotype and time of infection (Bashir *et al*., 1991). Research on epidemiological aspects to explain the dynamics of the disease under local conditions is of primary importance. Weather is one of the important parameter that influences plant disease epidemics. Hence, understanding of weather and climatic conditions is required to provide base line information for developing simple and reliable disease prediction systems. Not so much work has been done in relation to environmental conditions conducive for the Urdbean leaf crinkle disease development. The impact of environmental conditions and their fluctuation in relation to inoculum build up and spread of disease is not quantitatively studied. Therefore, the present study was initiated to characterize environmental conditions conducive for the Urdbean leaf crinkle disease development and the results will be helpful to develop a disease forecasting system in future.

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Materials and Methods

Urdbean disease screening nursery consisting of 20 genotypes was established for four seasons (spring and summer) during 2005-2006 in the Research Area of Department of Plant Pathology, University of Agriculture, Faisalabad, Pakistan. Seeds of these genotypes were not treated with chemicals in order to increase the chances of primary infection of disease. Each genotype was planted in a row of 3 meter in length with 50 cm row-to- row distance. The planting was done on 25th March and 25th July, 2005-06. One row of a most susceptible check (imported mash) was planted after every two test entries in addition to two rows of susceptible check all around the experiment and disease nursery was sown in three replications. Environmental data were collected from Meteorological Station of Department of Crop Physiology at the University of Agriculture, Faisalabad (UAF). Maximum and minimum air temperature, relative humidity, rainfall and wind velocity were recorded on daily basis from March 2005 and March 2006 to October 2005 and October 2006 and weekly average was calculated. Disease ratings were taken on weekly basis following the scale of Bashir *et al.* (2004) starting from the initiation of Urdbean leaf crinkle symptoms up to 7 weeks when the crop was towards maturity. The environmental factors (maximum temperature, minimum temperature, relative humidity, rainfall and wind velocity) were correlated with ULCV disease incidence and the epidemiological factors were characterized through regression analysis.

Results

Correlation of environmental conditions with ULCV disease development: Weekly progression of the Urdbean leaf crinkle disease was recorded on the basis of typical symptoms through visual observation. The results of disease progression clearly indicated that the initial period of 3-4 weeks in each season was highly critical for the development and spread of leaf crinkle disease. In order to see the impact of environmental conditions on Urdbean leaf crinkle disease development, all the genotypes were selected from the reaction groups viz., moderate resistant (MR), moderate susceptible (MS), susceptible (S) and highly susceptible (HS). No variety/line was selected from highly resistant and resistant groups because due to their resistant genetic make up there was no need of any treatment/prediction.

Disease incidence differed in each growing season (Table 1) whereas it showed overall significant correlation with maximum and minimum temperature and no correlation with relative humidity, rainfall and wind speed in each growing season, respectively (Table 2). When data were split by genotypes the level of correlation decreased and only 11 genotypes out of 20 gave positive significant correlation with maximum temperature against ULCV disease incidence. All genotypes showed significant positive correlation with minimum temperature during spring-2005 (Table 3). During 2005-06, the maximum temperature in spring season did not differ significantly. However, minimum temperature, relative humidity and rainfall of spring 2006 were significantly higher compared to similar environmental parameters of spring 2005. The difference in these environment conditions may have resulted in higher disease incidence in spring 2006 compared to 2005. The disease incidence in summer 2006 was significantly higher in 2005. This may be attributed to significantly lower maximum temperature and higher relative humidity. It may be pointed out that air temperature (maximum / minimum) played a crucial role in the development of ULCV as indicated by its significant correlation with ULCV in spring and summer of 2005-06. During summer-2005, 18 genotypes showed significantly positive correlation with maximum and minimum air temperature (Table 4). The genotypes responded differentially to the changing environmental conditions during four seasons i.e. spring, summer-2005 and 2006, respectively.

Table 1. Comparison of weekly environmental conditions and ULCV disease incidence on urdbean genotypes during spring – summer 2005-2006.

Environmental parameters	2005		2006		LSD
	Spring	Summer	Spring	Summer	
Max temperature (°C)	37.08 b	42.10a	37.34b	38.28b	3.45
Min temperature (°C)	21.26b	26.52a	25.66a	27.12a	3.06
Relative humidity (%)	35.25b	22.85c	52.28a	43.51ab	9.21
Rainfall (mm)	0.695a	0.56a	2.63a	2.60a	2.66
Solar radiation (mJ/m^2/day)	11.28a	10.73ab	8.77c	9.07bc	1.76
Wind speed (km/h)	5.00a	5.04a	4.72ab	3.630b	1.11
Disease incidence (%)	8.52b	9.70b	10.70ab	12.38a	2.38

Table 2. Correlation of weekly environmental conditions with ULCV disease incidence recorded on 20 urdbean genotypes during spring – summer 2005 – 2006.

Environmental parameters	2005		2006	
	Spring	Summer	Spring	Summer
Max temperature (°C)	0.361*	0.328*	0.413*	0.338*
	0.000	0.000	0.000	0.000
Min temperature (°C)	0.501*	0.331*	0.311*	0.221*
	0.000	0.000	0.015	0.000
Relative humidity (%)	-0.175	0.204	0.195	0.214
	0.156	0.250	0.133	0.028
Rainfall (mm)	-0.051	-0.201	0.186	-0.210
	0.258	0.128	0.041	0.228
Wind speed (km/h)	0.275	0.103	0.095	0.108
	0.802	0.263	0.302	0.203

*Upper values in a column indicate Pearson's correlation coefficients
Lower values in a column indicate significant level at p = 0.05

Table 3. Correlation of environmental factors with ULCV disease incidence recorded on 20 genotypes during spring, 2005.

Vigna mungo (Urdbean) genotypes	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%)	Rainfall (mm)	Wind speed (km/h)
6022-22	0.479	0.828*	-0.124	0.041	0.497
95009	0.524	0.828*	-0.181	-0.064	0.422
6036-12	0.603	0.870*	-0.280	-0.060	0.465
96 CM-016	0.755*	0.923**	-0.448	-0.158	0.473
AARIM-32	0.544	0.824*	-0.230	-0.041	0.382
AARIM-164	0.822*	0.892**	-0.286	-0.053	0.506
M-17	0.613	0.884**	-0.273	-0.065	0.476
M-3	0.546	0.857*	-0.192	-0.051	0.495
95024	0.614	0.884**	-0.288	-0.003	0.468
Mash-88	0.768*	0.895**	-0.303	-0.097	0.506
6036-7	0.792*	0.891**	-0.375	-0.193	0.435
ES-1	0.842*	0.902**	-0.301	-0.090	0.522
NCH-3-3	0.786*	0.826*	-0.534	-0.441	0.555
6036-7	0.774*	0.927**	-0.474	-0.212	0.498
Mash-1	0.692	0.893**	-0.375	-0.176	0.434
4 CM-717	0.760*	0.929**	-0.382	-0.116	0.538
IAM 33-40	0.496	0.824*	-0.153	0.020	0.437
3 CM-706	0.862*	0.960**	-0.568	-0.246	0.580
6036-14	0.764*	0.895**	-0.288	-0.033	0.502
Mash-97	0.836*	0.937**	-0.584	-0.149	0.526

NS = Non-significant (p>0.05), * = Significant (p<0.05), ** = Highly significant (p<0.05)

Table 4. Correlation of environmental factors with ULCV disease incidence recorded on 20 genotypes during summer, 2005.

Vigna mungo (Urdbean) genotypes	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%)	Rainfall (mm)	Wind speed (km/h)
6022-22	0.010	0.091	0.588	0.191	0.559
95009	0.921**	0.917**	-0.632	-0.652	0.304
6036-12	0.860*	0.878**	-0.664	-0.539	0.314
96 CM-016	0.852*	0.911**	-0.616	-0.599	0.415
AARIM-32	0.958**	0.944**	-0.587	-0.498	0.139
AARIM-164	0.839**	0.854*	-0.751	-0.573	0.279
M-17	0.810*	0.812*	-0.352	-0.575	0.208
M-3	0.815*	0.788*	-0.561	-0.605	0.119
95024	0.766*	0.915**	-0.695	-0.533	0.008
Mash-88	0.775*	0.830*	-0.729	-0.552	0.227
6036-7	0.867**	0.923**	-0.601	-0.652	0.286
ES-1	0.883**	0.808*	-0.846	-0.546	0.098
NCH-3-3	0.609	0.675	-0.256	0.399	0.558
6036-7	0.831*	0.845*	-0.609	-0.681	0.271
Mash-1	0.910**	0.884**	-0.728	-0.557	0.081
4 CM-717	0.945**	0.939**	-0.592	-0.540	0.326
IAM 33-40	0.868*	0.928**	-0.354	-0.202	0.251
3 CM-706	0.948**	0.978**	-0.697	-0.427	0.372
6036-14	0.784*	0.972**	-0.472	-0.272	0.371
Mash-97	0.766*	0.919**	-0.534	-0.473	0.528

NS = Non-significant ($p>0.05$), * = Significant ($p<0.05$), ** = Highly significant ($p<0.05$)

During spring-2006, 15 and 11 genotypes expressed significant correlation with maximum and minimum temperature, respectively (Table 5) whereas during summer-2006, 11 and 10 genotypes exhibited significant correlation with maximum and minimum temperature, respectively (Table 6). Other environmental parameters like relative humidity, rainfall and wind speed did not show significant correlation with leaf crinkle disease incidence in any growing season for two consecutive years (2005, 2006).

Characterization of environmental conditions conducive for ULCV disease development: During spring-2005, maximum ULCV disease incidence/severity was recorded at 34-40ºC and 18-25ºC, maximum and minimum air temperature, respectively whereas during summer-2005, maximum disease incidence was observed at 37-40ºC and 25-29ºC, maximum and minimum air temperature, respectively (Figs. 1 and 2). This relationship was best explained by linear regression models as indicated by high r-values > 0.74.

During spring-2006, maximum disease incidence took place at 40-44ºC and 23-27ºC, maximum and minimum temperature respectively and in summer-2006, maximum disease development was recorded at maximum temperature ranging from 35-44ºC and minimum temperature ranging from 23-30ºC. There was linear relationship of increasing air temperature with increased disease incidence indicating that leaf crinkle disease of urdbean/blackgram is high temperature disease (Figs. 4.2 and 4.3). Disease incidence continued to rise up till the temperature range remained favourable i.e., 21-29ºC. The optimum air temperature recorded for ULCV disease development ranged from 25-42ºC.

Table 5. Correlation of environmental factors with ULCV disease incidence recorded on 20 genotypes during spring, 2006.

Vigna mungo (Urdbean) genotypes	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%)	Rainfall (mm)	Wind speed (km/h)
6022-22	0.478	0.904*	-0.153	0.711	0.400
95009	0.763*	0.754*	-0.536	0.607	0.170
6036-12	0.915**	0.515	-0.365	0.333	0.199
96 CM-016	0.751*	0.758*	-0.409	0.641	0.298
AARIM-32	0.776*	0.491	-0.268	0.550	0.425
AARIM-164	0.849*	0.837*	-0.495	0.440	0.100
M-17	0.849*	0.473	-0.489	0.117	0.260
M-3	0.686	0.504	-0.133	0.515	0.506
95024	0.843*	0.015	-0.277	-0.004	-0.240
Mash-88	0.798*	0.792*	-0.530	0.436	0.054
6036-7	0.800*	0.390	-0.489	0.481	-0.239
ES-1	0.758*	0.778*	-0.470	0.493	0.002
NCH-3-3	0.920**	0.413	-0.428	0.118	0.161
6036-7	0.774*	0.776*	-0.245	0.675	0.368
Mash-1	0.887**	0.444	-0.331	0.226	0.230
4 CM-717	0.920**	0.782*	-0.440	0.276	0.028
IAM 33-40	0.825*	0.832*	-0.354	0.345	0.087
3 CM-706	0.775*	0.454	-0.547	0.080	-0.360
6036-14	0.572	0.778*	-0.014	0.732	0.590
Mash-97	0.839*	0.816*	-0.522	-0.032	-0.202

NS = Non-significant (p>0.05), * = Significant (p<0.05), ** = Highly significant (p<0.05)

Table 6. Correlation of environmental factors with ULCV disease incidence recorded on 20 genotypes during summer, 2006.

Vigna mungo (Urdbean) genotypes	Maximum temperature (ºC)	Minimum temperature (ºC)	Relative humidity (%)	Rainfall (mm)	Wind speed (km/h)
6022-22	0.072	-0.191	0.177	0.226	-0.292
95009	0.309	-0.044	-0.254	0.154	-0.092
6036-12	0.341	0.551	0.206	-0.156	-0.081
96 CM-016	0.136	-0.092	0.212	0.176	-0.330
AARIM-32	0.356	0.550	0.267	-0.073	-0.055
AARIM-164	0.803*	0.747*	-0.319	-0.581	-0.184
M-17	0.623	0.237	-0.508	-0.459	-0.535
M-3	0.821*	0.478	-0.553	-0.590	-0.285
95024	0.545	0.520	-0.283	-0.498	0.362
Mash-88	0.963**	0.836*	-0.387	-0.530	0.382
6036-7	0.653	0.312	-0.327	-0.039	0.256
ES-1	0.895*	0.855*	-0.369	-0.626	0.378
NCH-3-3	0.778*	0.756*	0.212	-0.065	0.360
6036-7	0.895**	0.968**	-0.046	-0.387	0.332
Mash-1	0.755*	0.903**	-0.207	-0.525	0.397
4 CM-717	0.754*	0.755*	-0.244	-0.565	0.335
IAM 33-40	0.619	0.765*	-0.442	-0.703	0.409
3 CM-706	0.823*	0.829*	-0.196	-0.551	0.308
6036-14	0.824*	0.471	-0.559	-0.675	-0.076
Mash-97	0.860*	0.987**	-0.107	-0.511	0.372

NS = Non-significant (p>0.05) , * = Significant (p<0.05), ** = Highly significant (p<0.05)

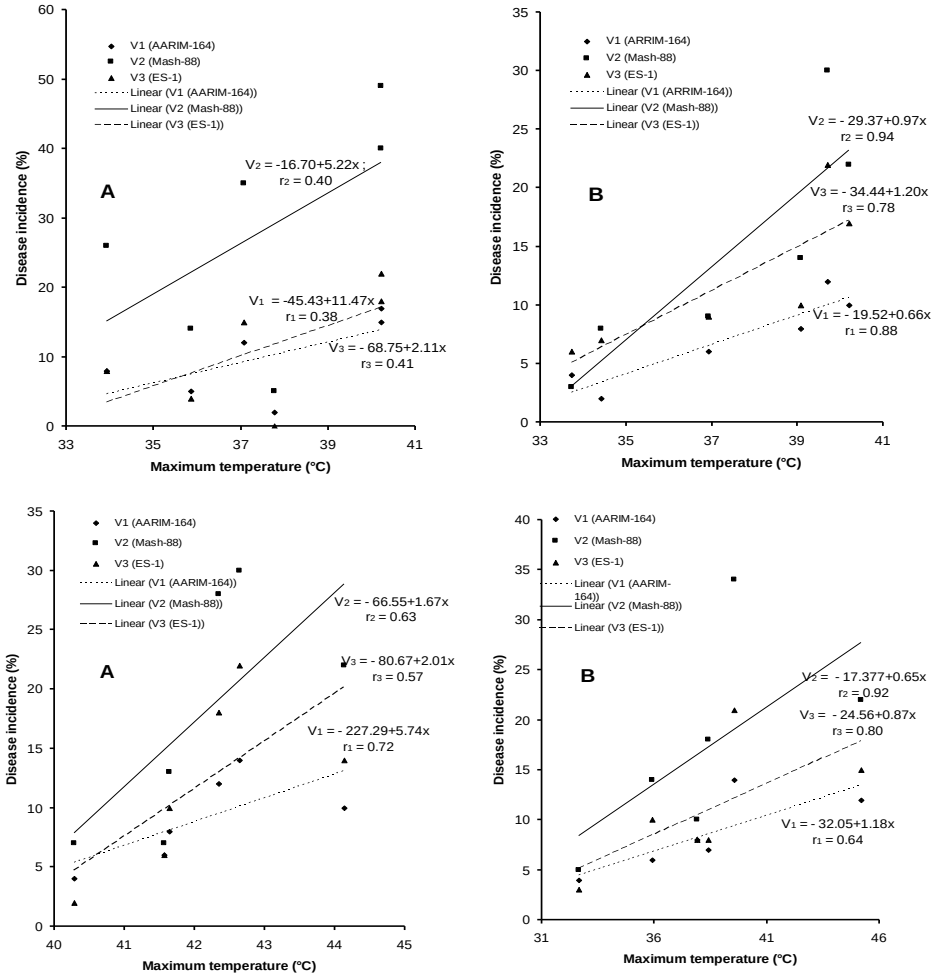

Fig. 1. Relationship of maximum temperature with ULCV disease incidence recorded on three *Vigna mungo* genotypes (V1=AARIM 164, V2= Mash-88, V3= ES-1) during spring (A) – summer (B) seasons 2005 (Upper) and 2006 (Lower)

Discussion

Urdbean leaf crinkle virus (ULCV) is undoubtedly an important, serious and destructive disease in all the urdbean growing countries of the world including Pakistan (Kadian, 1980; Rishi, 1990; Bashir *et al*., 1991; Ashfaq *et al*., 2007). As high as 81 % yield losses due to ULCV are on record (Bashir *et al*., 1991). In view of ubiquitous nature of this disease, the epidemiological factors responsible for disease development and spread were investigated under field conditions for two consecutive years (2005, 2006) during two seasons each Spring and Summer.

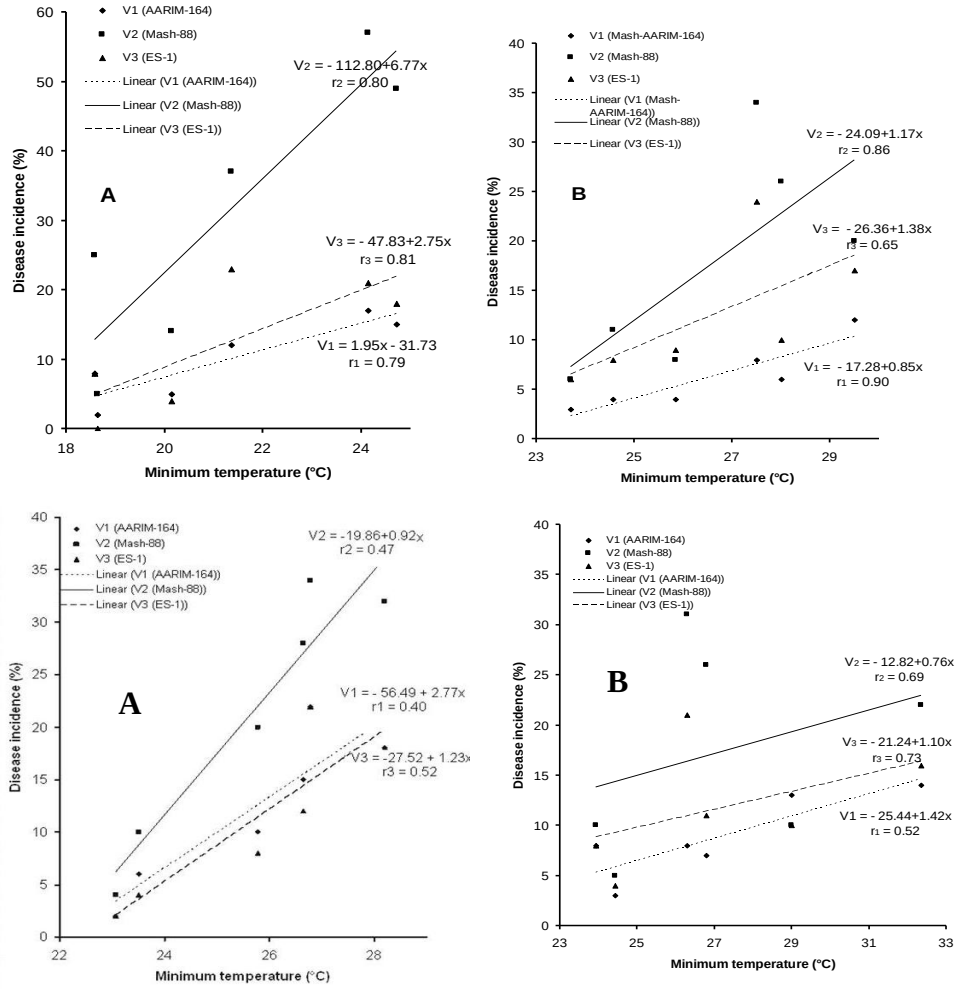

Fig. 2. Relationship of minimum temperature with ULCV disease incidence recorded on three *Vigna mungo* genotypes (V1=AARIM 164, V2= Mash-88, V3= ES-1) during spring (A) – summer (B) seasons 2005 (Upper) and 2006 (Lower) .

In the preset studies only maximum and minimum temperature showed significant correlation with Urdbean leaf crinkle disease. Maximum disease incidence developed at maximum temperature of 35-42ºC and minimum temperature of 21-29ºC. These results are in conformity with Kadian (1989) who reported maximum disease development at 35 ± 2ºC and 25± 2ºC, maximum and minimum temperature, respectively. There was non-significant impact of relative humidity, rainfall and wind speed on disease incidence regarding cultivars at Faisalabad and these results are in disagreement with Kadian (1989) who reported that above 70% RH is favourable for disease development. According to Tresh (1990, 1991) large scale use of varieties that were not tested adequately proved to be extremely vulnerable to un-important pests and pathogens in

many developing countries. Initial build up and pressure of the leaf crinkle disease was quite high to overcome any factor of disease escape mechanism. As already stated that initial period of 3-4 weeks in each season (spring and summer) was highly critical for the developments of leaf crinkle disease. The initiation of primary infection was considered to be originated through seed-borne inocula of the virus (Nene, 1972; Kotle & Nene 1972; Narayansamy & Jaganthan, 1975; Bashir *et al*., 1991; Negi & Vishunavat, 2004). Under field condition, leaf crinkle virus was also transmitted by leaf feeding beetle (*Henosepilachna dodecastigma* Wied (Beniwal & Bharathan, 1980; Bharathan & Beniwal 1984), whitefly (Narayansamy & Jaganthan, 1973) and two aphid species (Dhingra, 1975; Dubey *et al*., 1983). Early infection in spring and summer seasons accounts for young stage of crop, introduction of viruliferous vector, source of primary inoculum and establishment of infection, whereas secondary spread for the presence of viruliferous vectors. The decline of infection in the genotypes could not be attributed to temperature fluctuations or low vector populations, but probably to crop approaching maturity (Cohen & Harpaz, 1964).

Disease incidence/severity also varied according to geographical distribution as Kadian (1983) reported more prevalence of leaf crinkle disease in northern parts of Haryana, India and more severe on rainy season crops of urdbean and mungbean. Sahay *et al*. (1999) also reported that ULCV was a major disease of urdbean in north eastern hilly regions in India and suggested resistant/tolerant varieties to manage this disease. It is concluded that not only environment factors are responsible for Urdbean leaf crinkle disease development but other above mentioned factors also have contribution in disease development.

References

Anonymous. 2006. *Agricultural Statistics of Pakistan*. Ministry of Food, Agricultural and Livestock. Govt. of Pakistan. Food and Agric. Division. Planning Unit Islamabad.

Ashfaq, M., M. Aslam Khan, S. M. Mughal, N. Javed, T. Mukhtar and M. Bashir. 2007. Evaluation of urdbean germplasm for resistance against Urdbean leaf crinkle virus. *Pak. J. Bot*., 39(6): 2103-2111.

Bashir, M. 2004. Studies on viral diseases of major pulse crops and identification of resistant sources. Technical Annual Report (April, 2003 to March, 2004) of ALP Project. Crop Sciences Institute, NARC, Islamabad. pp. 149.

Bashir, M., S.M. Mughal and B.A. Malik. 1991. Assessment of yield losses due to leaf crinkle virus in urdbean (*Vigna mungo* (L) Hepper). *Pak. J. Bot*., 23: 140-142.

Beniwal, S.P.S. and N. Bharathan. 1980. Beetle transmission of Urdbean leaf crinkle virus. *Indian Phytopathol*., 33(4): 600-601.

Beniwal, S.P.S., S.J. Kolte and Y.L. Nene. 1980. Nature and rate of spread of Urdbean leaf crinkle disease under field conditions. *Indian J. Mycol. Plant Pathol*., 98(2): 88-92.

Bharathan, N. and S.P.S. Beniwal. 1984. Transmission characteristics of Urdbean leaf crinkle virus by the Epilachna beetle, *Henosepilachna dodecastigma. Indian Phytopathol*., 37: 660-664.

Cohen, S. and I. Harpaz. 1964. Periodic rather continual acquisition of a new tomato virus by its vector, the tobacco whitefly (*Bemisia tabaci* Genn.). *Exp. Appl. Entomol*., 7: 155-166.

Dhingra, K.L. 1975. Transmission of Urdbean leaf crinkle virus by two aphid species. *Indian Phytopathol*., 28(1): 80-82.

Dubey, G.S., I. Sharma and N. Prakash. 1983. Some properties of Urdbean leaf crinkle virus. *Indian Phytopathol*., 36(4): 762-764.

Kadian, O.P. 1989. Effect of environment on incidence and development of leaf crinkle disease in urdbean. *Indian Phytopathol*., 42: 272.

Kadian, O.P. 1980. *Studies on leaf crinkle disease of urdbean (Vigna mungo (L.) Hepper), mung bean (V. radiata (L.) Wilczek*) *and its control*. *Ph.D. Thesis*, Dept. Plant Pathology, Haryana Agric. Univ., Hisar. India. pp. 177.

Kadian, O.P. 1983. Occurrence and incidence of leaf crinkle disease on urdbean and mungbean in Haryana. *Haryana Agric. Univ. J. Res*., 13(1): 121-126.

Kolte, S.J. and T.L. Nene. 1972. Studies on symptoms and mode of transmission of leaf crinkle virus of urdbean (*Phaseolus mungo*). *Indian Phytopathol*., 25(3): 401-404.

Narayanasamy, P. and T. Jaganathan. 1975. Studies on the seed transmission of black gram leaf crinkle virus effect of age of plants at infection. *Madras Agric. J*., 62(5): 287-290.

Narayansamy, P. and T. Jaganthan. 1973. Vector transmission of black gram leaf crinkle virus. *Madras Agric. J*., 60(7): 651-652.

Negi, H. and K. Vishunavat. 2004. Role of seed-borne inocula of leaf crinkle virus in disease development and yield of urdbean. *Ann. Plant Protect. Sci*., 12(2): 452-453.

Nene, Y.L. 1972. A survey of viral diseases of pulse crops in Uttar Pradesh. *G. B. Pant Univ. Agric. and Tech. Res*. *Bull*., 4: 191.

Rishi, N. 1990. Seed and crop improvement of northern Indian pulses (*Pisum* and *Vigna*) through control of seed- borne mosaic viruses. *Final Technical Report, (US-India Fund) Dept. Plant Pathology, CCS Haryana Agric. Univ. Hisar, India*: 122 pp.

Sahay, G., B.K. Sharma, H.S. Gupta, K.A. Pathak and M.S. Prasad. 1999. Biotic stresses of pulses in North Eastern Hill regions of India. *Indian J. Hill Farm*., 12(1/2): 8-16.

Tresh, J.M. 1990. Plant virus epidemiology. The battle of genes: In: *Recognition and Response in plant virus interaction*. (Ed.): R.S. Fraser, NATO ASI Series H. Cell Biol.). Springer-Verlag N.Y. 41: 93-121.

Tresh, J.M. 1991. The ecology of tropical viruses. *Plant Pathol*., 40: 324-330.

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