



Relationship of weather parameters and date of sowing on vector-borne disease, stem necrosis of potato

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Summary

Stem necrosis is a hot spot disease caused by Tospovirus, a groundnut bud necrosis virus strain for Rajasthan. The minimum per cent incidence (5.56%) of stem necrosis was recorded with the variety Kufri Sindhuri and Kufri Pushkar (7.69%), while the maximum per cent incidence (24.87%) in Kufri Pukhraj and Kufri Bahar (23.75%). Out of three sowing dates, minimum disease incidence was recorded on 3rd planting date. The maximum and minimum temperature was highly significant, with a positive correlation against stem necrosis on the first planting date. A highly significant positive correlation between stem necrosis and the thrips population was detected. The maximum area under the disease progress curve (AUDPC) value was found on 1st date of sowing. The 3rd date of sowing produced the maximum number of tubers per plot, marketable yield and total tuber yield (q/ha). However, the maximum per cent dry matter was recorded in K. Sindhuri (22.27%) and K. Pushkar (21.01%). Thus, the experiment results suggested that the variety of Kufri Sindhuri and Kufri Pushkar with planting in the last week of October caused a significant reduction in stem necrosis disease leading to a corresponding increase in tuber yield of potato.

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Keywords: Potato, stem necrosis, thrips, AUDPC, percent dry matter, tuber yield

Introduction

The potato (*Solanum tuberosum*) is belonging to family Solanaceae of dicotyledons and is well known as the king of vegetables. Potatoes are commended around the globe as the powerhouse of energy. It is known for sustaining millions of lives by providing food and nutrition during war and hunger (Awasthi & Verma 2017). The United Nations declared the year 2008 the International Year of the potato to increase awareness of the importance of potato in addressing issues of global concern, including hunger, poverty and threats to the environment FAO. 2008). It is also rich in protein, calcium and vitamin C and have an especially good amino acid balance. A single medium-sized potato contains about half the daily adult requirement of vitamin C; other staples, such as rice and wheat have none. Boiled has more protein than maize, and nearly twice the calcium (Umadevi et al. 2013). The potato crop suffered from many biotic and abiotic burdens. The biotic agents like fungi, bacteria, viruses, and several insects are reported to attack and damage the potato in the field, transportation and storage. Annual yield losses due to potato viruses, are estimated on an average 30-40% infection causing about 25- 30% yield reduction (Khurana 1999).

Potato stem necrosis disease (PSND) is a severe problem in the early planted potato crop when high

temperatures (30-35°C) and dry weather during September – October favour thrips activity to the maximum extent and thus potentially caused higher incidence of disease (Kaushal et al. 2010; Meena & Yadav 2022). Potato stem necrosis disease (PSND) is caused by a tospovirus transmitted through viruliferous thrips, particularly *Thrips palmi* from the virus-infected potato plant showing typical stem/petiole and foliar necrosis to potato seedlings, causing systemic infection (Khurana et al. 1997).

Temperature and humidity show an important role for the multiplication of vector population and subsequent development of disease in early potato due to transmission of GBNV (Bhatnagar et al. 2011). A unique feature of the thrips – tospovirus relationship is that only adults which acquired the virus at the first larval stage are able to transmit the virus (Sakimura 1962). Thrips can cause 20- 60% damage to early potato crop depending upon climatic conditions. With the increasing temperature due to global climate change, the incidence of thrips is expected to increase in central India (Bhatnagar et al. 2014; Jatav et al. 2016). Khurana et al. (1997) reported 90% disease incidence in Madhya Pradesh and Rajasthan. Breeding for stable resistance remains the most promising method of control and some resistance; susceptible genotypes were screened with three planting dates. Therefore, the main objective of this study was to evaluate the possessions of potato varieties with three planting windows to find out the reduction of disease in South Eastern Rajasthan's potato growing areas.

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Material and Methods

Influence date of sowing

Among four varieties, two varieties as, resistant Kufri Sindhuri, Kufri Pushkar and susceptible Kufri Bahar and Kufri Pukhraj were sown for experiment under disease control conditions in plots of 3.6×3.0 m at a distance of 60 cm from row to row and plant to plant 20 cm. All recommended agronomical practices were adopted except insecticide sprays. Disease data was recorded as described by Khurana et al. (1997) by maintaining 10 random plants under each disease grade based on 1-5 disease rating scale. To assess the effect of various weather parameters such as temperature, relative humidity and rainfall on vector population and per cent disease incidence of Kufri Bahar, Kufri Sindhuri, Kufri Pukhraj and Kufri Pushkar varieties of potato with three dates of sown at every ten days interval i.e. 10, 20 and 30 Oct 2019-20 were showed.

Vector and disease correlation with weather parameters

The present investigations were undertaken to find out the relationship between different weather parameters and disease development with respect to three different dates of planting for the investigation of stem necrosis disease of potato crop. The intention behind conducting the trial with three different planting dates was to expose the most vulnerable stage of the crop for disease development. The weather parameters (independent variables) namely, maximum relative humidity, minimum relative humidity, maximum and minimum temperatures, rainfall, evaporation and bright sunshine hours were along with the Percent disease intensity (dependent variable) and thrips population for each observation, were considered for investigation. Disease plants were tagged at regular intervals by maintaining 10 random plants under each disease grade based on 1-5 disease rating scale. The meteorological data for the experimental period were collected and correlated with early blight disease severity. Analysis of the correlation coefficient was estimated by using OPSTAT software given by Sheoran et al. 1998.

AUDPC

The area under the disease progress curve and was measured by following equations

The area under disease progress curve

$$AUDPC = \sum_{i=1}^n [(Y_{i+1} + Y_i) \times 0.5] [T_{i+1} - T_i]$$

Where; Y_i = Severity (%) at the 1st observation; T_i = Time of 1st

Observation: n = Total number of observations

Vector population

Thrips infestation was recorded with 5 plants randomly selected from each plot and tagged. The observations on the population of thrips were recorded in the morning hours at weekly intervals starting from 21 days of sowing till harvesting of the crop. The thrips population was recorded on three randomly selected leaves from each tagged plant; the mean number of thrips per leaves was worked out described by Khurana (1999).

Effect of planting date on yield parameters of potato varieties

Grade wise highest number of tubers, marketable yield and total tuber yield were recorded.

Dry matter

Different dates of planting, as well as varieties wise per cent dry matter, was calculated.

Results and Discussion

Influence date of sowing

During cropping season *Rabi* 2019-20, maximum disease incidence (24.87%) was recorded in early planted K. Pukhraj variety of potato as compared to mid (10.5%) and late planted (4.4%). Early planted (10 October) crop showed fast progress of disease while late planted (30th October) potato variety K. Pukhraj showed late appearance of disease and slow progress of disease due to late planting crop escaped early infection and prevalence of low temperature during December and January further slow the progress of the disease. Likewise, Minimum disease incidence (5.56%) was recorded in early planted K. Sindhuri variety of potato compared to mid and late planted (3.19%). Similarly, the maximum incidence of thrips population was recorded on 10th October planted crop in all four varieties as compared to the second and third planting dates. These findings are in agreement with Khurana et al. (2001) concluded that the maximum incidence of the thrips population (5.80/plant) was recorded on 15th September planted crop with rains at planting and 10 days after haulm cutting. However, the population of thrips remained active on the early and late planted crop but its viruliferous nature was restricted to the early crop, as early crop showed the incidence of stem necrosis disease. Rajashekara et al. (2012) concluded that more disease incidence of stem necrosis (16%) was recorded in early planted crops (24th October) while late planted (23th November) K. Bahar showed less disease incidence (3%).

Vector and disease correlation with weather parameters

The correlation between the disease incidence and weather factors revealed that maximum and minimum temperature was highly significant with positive correlation in all four varieties i.e. K. Bahar, K. Sindhuri, K. Pukhraj and K. Pushkar in the first planting date (10th Oct 2019). On the third planting date (30th Oct 2019), all four varieties showed a non-significant, negative correlation with maximum and minimum temperature. Morning relative humidity was observed non-significant in all three dates of planting. Evening relative humidity was highly significant with a positive correlation in the first date of planting but showed non-significant with a negative correlation in third date of planting. BSS was non-significant, with a negative correlation with all three dates of planting. Rainfall was non-significant with a negative correlation in all three dates of sowing.

Similarly, the correlation between the thrips population and weather factors revealed that maximum and minimum temperature was highly significant with positive correlation in all four varieties i.e. K. Bahar, K. Sindhuri, K. Pukhraj and K. Pushkar in the first date of planting. In third date of planting, the maximum and minimum temperature was showed non-significant with a negative correlation. Morning relative humidity was

observed as non-significant with a positive correlation in all three planting dates. Evening relative humidity was highly significant with a positive correlation on the first planting date but non-significant with a negative correlation on the third planting date. BSS was non-significant with a positive correlation on the first planting date; all four varieties showed non-significant with a negative correlation on the third date of planting. Evaporation was significant with a positive correlation on the first planting date but non-significant with a negative correlation in the third date of planting. Rainfall was non-significant with a negative correlation on all three dates of planting.

The correlation between the stem necrosis and thrips population was observed highly significant with positive correlation in all three dates of planting. These finding are in agreement with the earlier finding Singh et al. (2017) showed that maximum incidence of 5.19% was observed in early planted crop while late planted crop was almost free from this disease. There is a direct relationship between the early planting and activity of viruliferous thrips resulting high % incidence of stem necrosis disease in early potato crop. The high temperature (30-35°C) and the dry weather during September / early October is favourable for the development of stem necrosis disease. Bhatnagar (2011) showed that the high incidence of stem necrosis disease in month of September planted crop was attributed to higher temperature and lower humidity prevalent on crop which was also favourable for the vector, thrips to develop and multiply. Higher temperature ($35 \pm 1^\circ\text{C}$) are highly suitable for both thrips and tospovirus development. Singh et al (2003) found that highest percent incidence of PSND (74%) was recorded in case of early planting on October 2 followed by 9 October (51.50%).

Positive correlation of DI and DX of PSND with higher temperature and lower humidity corroborates the prevalence of vector thrips responsible for spread of the tospovirus (Parrella & Lewis 1997). Progressive decline in disease upon delayed planting (20th Oct to 30th Oct) may be due to cool weather affecting the thrips activity/movement, non-significant with negative correlations have been recorded in case of the virus infecting groundnut (Amin et al. 1981).

AUDPC

In present study, highest Area under disease progress curve value was found in 1st date of planting in all four varieties. However minimum AUDPC was recorded in 3rd date of planting in varieties K. Sindhuri (162.75) and K. Pushkar (180.25). Also, the minimum AUDPC was recorded in K. Sindhuri (166.25) in 2nd date of planting.

Table 1. The disease, thrips population appearance on the varieties at different sowing dates

Date of sowing	Varieties	Initial appearance of the disease (DAS)	Initial thrips population (DAS)	AUDPC
D1: 10/10/2019-20	V1: K. Bahar	22 (45 th week)	22 (44 th week)	1281
	V2: K. Sindhuri	3 (44 th week)	14 (44 th week)	297
	V3: K. Pukhraj	9 (44 th week)	24 (44 th week)	1330
	V4: K. Pushkar	6 (44 th week)	16 (44 th week)	399
D2: 20/10/2019-20	V1: K. Bahar	12 (46 th week)	22 (46 th week)	400
	V2: K. Sindhuri	2.5 (46 th week)	18 (46 th week)	166

These findings are in agreement with Rajashekara et al. (2012) concluded that more disease index, disease severity and AUDPC was recorded in early planted (24th October) K. Bahar. Delay in planting from 24th October to 8 November and to 23 November significantly reduced the disease incidence.

Vector population

Maximum thrips population was recorded in 10th October planted crop in all four varieties as compared to the second and third planting date. The finding is in conformity with Bhatnagar et al. (2017) showed maximum population of thrips with maximum temperature, minimum temperature and evaporation. The activities of virus vector may be reduced due to lower temperature in the month of November and December than October and consequent lower incidence of the disease in late planted crop (Sanger 1996). Bhatnagar & Thakur (2008) reported that favourable period for the activity of *Thrips palmi* on early planted potato crop.

Effect of planting date on yield parameters of potato varieties

The yield data showed that the maximum total no of tuber, marketable yield (q/ha) and total tuber yield (q/ha) were recorded in 3rd date of planting. Among the varieties, the maximum total tuber yield and marketable yield (q/ha) i.e. 142.6, 156.3, 126.5, 150.7 and 118.8, 145.0, 112.3, 133.7 were obtained in K. Bahar, K. Sindhuri, K. Pukhraj and K. Pushkar, respectively. However, the minimum total tuber yield and marketable yield (q/ha) were obtained in 1st date when planted on 10th October as compare to 3rd date of planting i.e. 30th October in all varieties. These findings are in conformity with Ahmad and Rashid (1980) reported that tuber yield was found to be maximum with planting on 23rd November. Similar observations in potato with respect to yield reported by Singh et al. (2001) that maximum production at Kota was recorded, in crop planted on 29th October and/or 5th November while the minimum yield was obtained for the earliest planting i.e. first October. A gradual increase in yield was seen with delayed planting towards the optimum date (end of October and beginning or middle of November at Kota, Gwalior, Chindwara and Deesa).

Dry matter

Per cent dry matter was observed ranged from 19.69-21.23 in first, second and third date of planting. Whereas, maximum per cent dry matter was recorded in K. Sindhuri (22.27%) and K. Pushkar (21.01%) varieties of potato. Such a response that tuber size distribution is affected by the genotype is confirmed by the results of Singh et al. (2001). Since, weather parameters influence the development and further spread of disease.

D3: 30/10/2019-20	V3: K. Pukhraj	14 (46 th week)	24 (46 th week)	528
	V4: K. Pushkar	6.5 (46 th week)	20 (46 th week)	243
	V1: K. Bahar	8 (48 th week)	8 (48 th week)	180
	V2: K. Sindhuri	3.5 (48 th week)	9 (48 th week)	162
	V3: K. Pukhraj	8 (48 th week)	14 (48 th week)	217
	V4: K. Pushkar	5.5 (48 th week)	10 (48 th week)	197

Table 2. A correlation matrix with per cent disease incidence of stem necrosis and weather parameters in potato crop during *Rabi* 2019-20

Date of sowing	Varieties	T. max	T. min	RH max	RH min	BSS	EVA	Rainfall
D1	V1: K. Bahar	0.752**	0.748**	0.240 ^{NS}	0.708**	0.044 ^N _s	0.419 ^N _s	- 0.201 ^N _s
	K. V2: K. Sindhuri	0.828**	0.844**	0.238 ^{NS}	0.766**	- 0.023 ^N _s	0.492 ^N _s	- 0.224 ^N _s
	V3: K. Pukhraj	0.758**	0.771**	0.240 ^{NS}	0.691**	0.015 ^N _s	0.433 ^N _s	- 0.216 ^N _s
	V4: K. Pushkar	0.869**	0.878**	0.164 ^{NS}	0.757**	0.013 ^N _s	0.603*	- 0.236 ^N _s
D2	V1: K. Bahar	0.536*	0.587*	0.492 ^{NS}	0.476 ^{NS}	- 0.205 ^N _s	0.275 ^N _s	- 0.173 ^N _s
	V2: K. Sindhuri	0.441 ^{NS}	0.513 ^{NS}	0.469 ^{NS}	0.404 ^{NS}	- 0.257 ^N _s	0.253 ^N _s	- 0.192 ^N _s
	V3: K. Pukhraj	0.468 ^{NS}	0.525*	0.433 ^{NS}	0.412 ^{NS}	- 0.182 ^N _s	0.234 ^N _s	- 0.225 ^N _s
	V4: K. Pushkar	0.471 ^{NS}	0.528*	0.463 ^{NS}	0.476 ^{NS}	- 0.235 ^N _s	0.214 ^N _s	- 0.219 ^N _s
D3	V1: K. Bahar	-0.117 ^{NS}	-0.019 ^{NS}	0.286 ^{NS}	-0.180 ^{NS}	- 0.355 ^N _s	0.012 ^N _s	- 0.159 ^N _s
	V2: K. Sindhuri	-0.153 ^{NS}	-0.034 ^{NS}	0.148 ^{NS}	-0.264 ^{NS}	- 0.320 ^N _s	- 0.009 ^N _s	- 0.086 ^N _s
	V3: K. Pukhraj	-0.105 ^{NS}	0.002 ^{NS}	0.370 ^{NS}	-0.111 ^{NS}	- 0.476 ^N _s	- 0.025 ^N _s	- 0.131 ^N _s
	V4: K. Pushkar	-0.126 ^{NS}	-0.005 ^{NS}	0.257 ^{NS}	-0.175 ^{NS}	- 0.406 ^N _s	- 0.004 ^N _s	- 0.116 ^N _s

*significant; **highly significant

Table 3. Correlation matrix on thrips population and weather parameters in potato crop during *Rabi* 2019-20

Date of sowing	Varieties	T. max	T. min	RH max	RH min	BSS	EVA	Rainfall
D1	V1: K. Bahar	0.902**	0.874**	0.064 ^{NS}	0.845**	0.117 ^{NS}	0.587*	-0.224 ^{NS}
	V2: K. Sindhuri	0.879**	0.837**	-0.145 ^{NS}	0.819**	0.235 ^{NS}	0.595*	-0.221 ^{NS}
	V3: K. Pukhraj	0.899**	0.873**	0.039 ^{NS}	0.838**	0.132 ^{NS}	0.600*	-0.243 ^{NS}
	V4: K. Pushkar	0.872**	0.833**	-0.166 ^{NS}	0.806**	0.244 ^{NS}	0.601*	-0.235 ^{NS}
D2	V1: K. Bahar	0.537*	0.556*	0.370 ^{NS}	0.533*	-0.084 ^{NS}	0.230 ^{NS}	-0.186 ^{NS}
	V2: K. Sindhuri	0.523*	0.542*	0.387 ^{NS}	0.533*	-0.114 ^{NS}	0.159 ^{NS}	-0.204 ^{NS}
	V3: K. Pukhraj	0.490 ^{NS}	0.521*	0.394 ^{NS}	0.494 ^{NS}	-0.129 ^{NS}	0.228 ^{NS}	-0.214 ^{NS}

	V4: K. Pushkar	0.493 ^{NS}	0.519 [*]	0.385 ^{NS}	0.501 ^{NS}	-0.112 ^{NS}	0.171 ^{NS}	-0.219 ^{NS}
D3	V1: K. Bahar	-0.742 ^{**}	-0.680 ^{**}	0.423 ^{NS}	-0.695 ^{**}	-0.558 [*]	-0.506 ^{NS}	0.258 ^{NS}
	V2: K. Sindhuri	-0.238 ^{NS}	-0.119 ^{NS}	0.315 ^{NS}	-0.221 ^{NS}	-0.509 ^{NS}	-0.118 ^{NS}	-0.067 ^{NS}
	V3: K. Pukhraj	-0.613 [*]	-0.483 ^{NS}	0.395 ^{NS}	-0.495 ^{NS}	-0.586 [*]	-0.483 ^{NS}	0.370 ^{NS}
	V4: K. Pushkar	-0.428 ^{NS}	-0.337 ^{NS}	0.309 ^{NS}	-0.334 ^{NS}	-0.567 [*]	-0.233 ^{NS}	0.015 ^{NS}

*significant; **highly significant

Table 4. Correlation between stem necrosis and thrips population in potato crop during *Rabi* 2019-20

Date of sowing	Varieties	Stem necrosis and thrips population
D1	V1: K. Bahar	0.935 ^{**}
	V2: K. Sindhuri	0.874 ^{**}
	V3: K. Pukhraj	0.922 ^{**}
	V4: K. Pushkar	0.873 ^{**}
D2	V1: K. Bahar	0.929 ^{**}
	V2: K. Sindhuri	0.796 ^{**}
	V3: K. Pukhraj	0.970 ^{**}
	V4: K. Pushkar	0.927 ^{**}
D3	V1: K. Bahar	0.429 ^{NS}
	V2: K. Sindhuri	0.908 ^{**}
	V3: K. Pukhraj	0.450 ^{NS}
	V4: K. Pushkar	0.887 ^{**}

*significant; **highly significant

Table 5. Effect of planting date on yield parameters of potato varieties during *Rabi* 2019-20

Treatments	Total no. of Tuber/plot	Marketable yield (q/ha)	Total tuber yield (q/ha)	Per cent dry matter
A. Date				
D₁	308.8	116.8	132.6	19.69
D₂	309.1	119.3	135.0	19.93
D₃	345.3	146.3	164.4	21.23
SEm (±)	4.44	2.62	3.20	0.16
CD (P=0.05)	13.01	7.68	9.38	0.46
B. Variety				
V₁	315.2	118.8	142.6	19.07
V₂	334.0	145.0	156.3	22.27
V₃	314.9	112.3	126.5	18.79
V₄	320.0	133.7	150.7	21.01
SEm (±)	5.12	3.02	3.69	0.18
CD (P=0.05)	15.02	8.86	10.83	0.53

Here, D₁: 10/10/2019-20

D₂: 20/10/2019-20

D₃: 30/10/2019-20

V₁: K. Bahar

V₂: K. Sindhuri

V₃: K. Pukhraj

V₄: K. Pushkar

Conclusion

Among the four varieties and three dates of planting with respect to the minimum per cent incidence of stem necrosis i.e. 5.56% and 7.69% was recorded in variety Kufri Sindhuri and Kufri Pushkar and maximum per cent incidence was found in variety Kufri Pukhraj (24.87%) and Kufri Bahar (23.75%). Out of three dates of planting, minimum disease incidence was recorded in 3rd date of planting i.e. 30th October, 2019 in K. Sindhuri (3.19%) followed by K. Bahar (3.62%), K. Pushkar (3.94%) and K. Pukhraj (4.44%) as compared to 1st and 2nd date of planting i.e. 10th Oct, 2019 and 20th Oct, 2019. The studies on epidemiological aspects indicated that

maximum and minimum temperature was highly significant with positive correlation which was responsible for disease incidence in 1st date of sowing. Maximum area under disease progress curve (AUDPC) value was found in 1st date of planting (10th Oct, 2019) in all four varieties. Potato sown on 30th October was produced maximum total number of tubers per plot, marketable yield and total tuber yield (q/ha). Whereas, maximum per cent dry matter was recorded in K. Sindhuri (22.27%) and K. Pushkar (21.01%). Hence, 3rd date of planting and last week of October i.e. 30th Oct, 2019 could be considered as an effective to minimize

stem necrosis disease of potato in Kota zone of Rajasthan, which was hot spot of stem necrosis.

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Declarations of interests

All authors of this manuscript declare that they have no conflict of interest.

Data sharing

All relevant data are within the manuscript.

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