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RESEARCH ARTICLE

Evaluation of leaf blotch tolerance in turmeric genotypes from the terai region of West Bengal

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Abstract

The current investigation was done in the research farm of Uttar Banga Krishi Viswavidyalaya for finding out the genetic potential of yield characters of 30 genotypes of turmeric and screening them against the leaf blotch disease in the field during 3 cropping seasons 2019–2020, 2020–2021 and 2021–2022 respectively. Performance of genotypes against the leaf blotch disease was evaluated by estimation of their individual response in area under disease progress curve (AUDPC) and relative area under disease progress curve (rAUDPC) values during 3 cropping seasons 2019–2020, 2020–2021 and 2021–2022 and percentage disease index (PDI) taken at the time of infestation. According to scale of tolerance, in leaf blotch PDI, maximum PDI of leaf blotch disease was observed in Tarakeswar local (50.02 %) and minimum was found in Duggirala (5.57 %) and in overall identification of 30 genotypes, 10 genotypes were found resistant for leaf blotch disease, 9 genotypes were moderately resistant and 10 genotypes were found susceptible and Tarakeswar local was the only genotype which was found highly susceptible. Resistant genotypes can be chosen for the crop improvement programme for releasing varieties in future.

Keywords: area under disease progress curve; *Curcuma longa*; leaf blotch disease; percentage disease index; relative area under disease progress curve; resistant; susceptible; turmeric; *Taphrina maculans*

Introduction

Turmeric (*Curcuma longa* L.) is called the "golden spice" and it holds paramount significance as one of India's most essential and ancient spices (1) where global output was projected to 1.5 million tonnes by the end of 2027. It was expected a compound annual growth rate (CGAR) of around 3.9 % during the time between 2020–2027 and simultaneously pharmaceutical and other industries will grow by 3.6 CGAR (2). In the year 2022–2023, an area of 3.24 lakh ha was under turmeric cultivation with a total production of 11.61 lakh tonnes (over 75 % of total turmeric production) (3). It is a herbaceous perennial plant (4) which belongs to the family Zingiberaceae, order Zingiberales and genus *Curcuma*. Its geographical origin is attributed to the Indo Malayan region (5). It has been extensively used as a spice, food preservative and as colouring material in South Asian countries from ancient time (6). It has attracted much attention due to its significant medicinal potential (7).

Leaf blotch disease can lead to severe yield losses in turmeric, ranging from 37.6 % to 52.9 %, making it a significant concern for turmeric production (8). Leaf blotch disease, caused by the fungus *Taphrina maculans*, typically manifests its symptoms on lower leaves during the months of October and November when there is high and continuous humidity in the atmosphere with temperature range of 25–30 °C (9, 10). It belongs to the family Taphrinaceae. The individual spots are small 1–2 mm in width and are mostly rectangular in shape. The disease is characterised by the appearance of several spots on both the surfaces of leaves, being generally numerous on the upper surface (9). The primary source of inoculum is soil borne which survives in the dried leaves of the host plant in the field. Once inside the leaf tissue, the fungus starts to multiply and colonise the intercellular spaces. This disrupts the normal growth and function of the leaves, helps to form the symptoms of leaf spot disease (11). Till now disease management was done with the help of few fungicides applications or phytosanitary measures were used like burning the infected plants in the field although the development of resistant or tolerant genotypes of this disease is of immense importance depending on different agro-climatic regions of India.

As there are not abundant leaf blotch resistant turmeric varieties depending on different agro-climatic zones of India, developing resistant or tolerant turmeric varieties is very essential and in the need of the hour in this region of West Bengal. In order to

fill the research gap of releasing varieties resistant against this disease, the objectives of the investigation was set as (i) to evaluate the performances of genotypes against leaf blotch diseases by observing the % disease index (ii) to investigate disease progress critically since infection by area under disease progress curve (AUDPC) of the genotypes and grouping all types tolerant genotypes for state and national level varietal release in future.

Materials and Methods

An investigation was done in 30 turmeric genotypes collected from different regions of West Bengal and India in UBKV instructional farm, Pundibari, West Bengal. The statistical design was adopted as complete randomized block design (CRBD) with plot size of 3 × 2 m and plant-to-plant and row-to-row spacing of 30 cm and 20 cm, respectively.

Identification of leaf blotch disease in the field

Symptoms appeared on lower leaves in October. The disease was characterised by the appearance of several spots on both the surfaces of leaves, being generally numerous on the upper surface. The individual spots were small 1–2 mm in width and are mostly rectangular in shape. They were arranged in rows along the veins. The infected leaves were distorted, with reddish brown appearance. The spots were discrete, brown to black and mostly confined to lower leaves. (9, 11).

Evaluation of percentage disease index (PDI)

The disease rating was recorded by adopting 0–6 scale as mentioned by previous researchers (7). Where 0 = no infection, 1 = 0.1–10 % necrotic leaf area, 2 = 10.1–20.0 % necrotic leaf area, 3 = 20.1–30 % necrotic leaf area, 4 = 30.1–40 % necrotic leaf area, 5 = 40.1– 50 % necrotic leaf area; 6 = more than 50 % necrotic leaf area.

The percent disease intensity (PDI) calculated according to the formula suggested is given as below (12).

$$\text{PDI} = \frac{\text{Sum of all disease ratings}}{\text{No. of leaves observed x Max. disease score}} \times 100$$

Table 1. Categorisation of percentage disease index (PDI) values of leaf blotch disease

Grade	PDI	Category
1	Upto 5 %	Highly Resistant
2	5 – 10 %	Resistant
3	11 – 25 %	Moderately resistant
4	26 – 50 %	Susceptible
5	> 50 %	Highly susceptible

The mean data of PDI of the scores taken from all the four observations were calculated and final score was evaluated in each turmeric genotype in all the replications. Categorization of the PDI scores of the genotypes was done according to the scale (12) (Table 1).

Area under disease progress curve (AUDPC) evaluation

To have an idea about the progress of disease with time, AUDPC based on disease severity score was calculated using the following formula suggested by previous researchers (10).

$$\text{AUDPC} = \sum_{I=1}^{n-1} \left(\frac{y_i + y_{i+1}}{2}\right)(t_{i+1} - t_i)$$

AUDPC = $\Sigma_i=1$; Where, y_i= disease severity measured on the i^{th} date; t_{i+1}–t_i = time interval (days) in-between 2 consecutive dates of disease scoring; n = number of dates on which disease symptom was observed; "t" is the time of each reading, "y" is the percentage of affected foliage at each reading.

The AUDPC was used to measure the disease intensity over time and for comparison across cropping seasons (2019–2020), (2020–2021 and 2021–2022). For estimation AUDPC values in 30 genotypes, first data recording of infected leaf area by this disease started in the 3rd week of October. Ten plants were randomly selected per replication of each genotype in both the diseases where 3 leaves were observed from lower, middle and upper part of the selected plant. Second observation of infected leaf area by this disease was done in each replicated genotypes as it was done in the first observation after 15 days interval of the first observation. In the same way third and fourth observation and evaluation of AUDPC was done in this investigation (Fig. 1–5).

Relative area under disease progress curve (rAUDPC) evaluation

A moderately resistant genotype grown under favourable conditions with severe infection may produce same AUDPC value, as a susceptible genotype grown under conditions not conducive to severe infection. To standardise the AUDPC, it is important to estimate the rAUDPC. Relative AUDPC was calculated for evaluation of this disease in order to observe the relative growth of the diseases as referred by (13).

$$\text{rAUDPC} = \frac{\text{Total AUDPC}}{\text{Total number of days interval from first observation to last observation}} \times 100$$

Fig. 1. Progression of leaf.

Fig. 2. Highly Susceptible genotype (Tarakeswar local).

Fig. 3. Moderately resistant genotype (Nagaland local).

Fig. 4. Resistant genotype (Duggirala).

Fig. 5. Susceptible turmeric genotype (South Tripura).

The rAUDPC is calculated by dividing the AUDPC by the "maximum potential AUDPC". The maximum potential AUDPC is simply the AUDPC a genotype would have if it had 100 % infection at all readings. It is calculated by multiplying the total number of days between the first and last readings by 100 (13).

Results

From the 3 years mean performance, highest PDI was found in the genotype Tarakeswar local (50.02 %) followed by Megha turmeric (42.41 %), NH-1 (39.08 %) and rest of the genotypes in ascending order of the values of PDI (Table 2). Tarakeswar local was also found to have the highest AUDPC (2450.28) and rAUDPC (51.43 %) (Table 2). Lowest PDI was recorded in the genotype Duggirala (5.75 %) followed by Tufanganj local (6.07 %), TCP-190 (6.60 %) and rest of the genotypes (Table 2). Similarly, Duggirala was found lowest AUDPC (297.93) and rAUDPC (5.53 %) value. Genotypes were grouped into different disease response categories based on their mean PDI value following the scale (14) (Table 3).

From the 3 years combined study, from the results, it was found that 10 genotypes were resistant for leaf blotch disease namely Duggirala, Holdi-4, Holdi-6, Nadia local, NDH-128, TCP-120, TCP-190, TCP-232, TCP-235 and Tufanganj. Nine genotypes were moderately resistant namely Jalpaiguri local, Kedaram, LTS-1, Nagaland, Pratibha, Sugana, TCP-111, TCP-2 and TCP-94. Ten genotypes were found susceptible Holdi-2, Megha turmeric, Midnapure, NH-1, Prabha, PTS-43, Pundibari local, Rajendra Sonia, South Tripura local and TCP-11. Tarakeswar local was the only genotype which was found highly susceptible (Table 3).

AUDPC and the leaf blotch disease progress trend

For each genotype, AUDPC (Fig. 6) was found where trend of disease progress was identified for three seasons. In 3rd season (2021–2022), disease intensity was high for few genotypes and some were found to have more severe disease intensity in 2nd year.

Discussion

In case of PDI evaluation**,** similar results were found in earlier reports where reported TCP-11 and TCP-82 as highly tolerant against leaf blotch and IISR Prabha showed moderate resistance to leaf blotch (15). Thus, considerable variability in tolerance to leaf blotch disease was observed was identified in 30 turmeric genotypes in this investigation. The variability was found because of their genetically different levels of resistance against leaf blotch disease.

Disease intensity is highly influenced by environmental factors (16). Nature of infestation of this disease happened when inoculum spread through air which could be severe in intensity during the months of October and November, when ambient temperature falls to 21–23 °C with relative humidity of 80 % (16). The change of the curves of infection was found in each genotype (Fig. 6) because of the differential range of temperatures were found in different years from October to November (Table 4) in this region which helped to manifest different intensity of infestation of the disease in total turmeric population (Table 2).

Table 2. Mean percentage disease index (PDI), area under disease progress curve (AUDPC) and relative area under disease progress curve (rAUDPC) values for leaf blotch disease (2019–2020, 2020–2021 and 2021–2022)

Genotypes	Leaf blotch		
	PDI	AUDPC	rAUDPC
Duggirala	5.75	297.93	5.53
Holdi-2	30.36	1559.60	30.48
Holdi-4	8.66	463.33	8.56
Holdi-6	11.49	559.15	11.71
Jalpaiguri local	24.87	1285.88	25.09
Kedaram local	13.00	716.85	12.89
LTS-1	10.41	507.22	10.71
Megha turmeric	42.41	2149.60	43.43
Midnapure	34.91	1746.05	34.97
Nadia local	8.93	482.97	8.77
Nagaland local	14.59	722.42	14.56
NDH-128	8.19	433.08	8.48
NH-1	39.08	1906.46	39.56
Prabha c.v.	30.84	1553.23	30.71
Pratibha c.v.	11.03	557.49	10.81
PTS-43	32.10	1547.91	32.47
Pundibari Local	26.08	1263.37	25.77
Rajendra Sonia c.v.	38.67	1972.95	38.84
South Tripura Local	32.56	1675.22	33.18
Suguna c.v.	21.86	1071.18	22.05
Tarakeswar Local	50.02	2450.28	51.43
TCP-11	29.48	1408.06	30.84
TCP-111	11.30	565.98	11.53
TCP-120	8.18	405.36	8.63
TCP-190	6.60	323.84	7.04
TCP-2	24.31	1150.62	24.12
TCP-232	7.40	378.85	7.71
TCP-235	8.72	457.25	9.08
TCP-94	11.30	557.99	11.86
Tufanganj local	6.07	290.97	6.02
SEm±	4.90	-	-
C.D.	13.69	-	-
C.V.	46.98	-	-

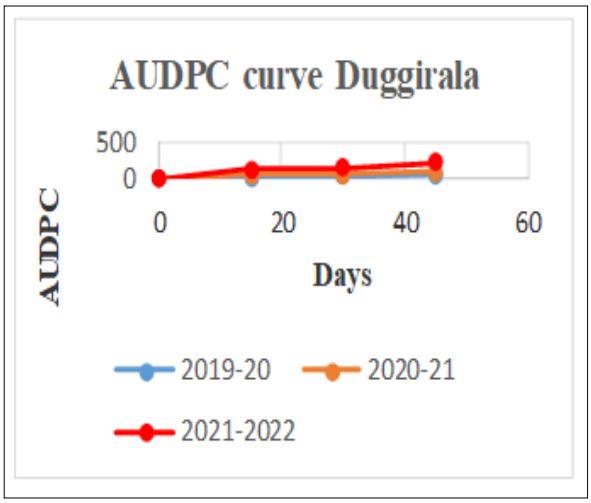
Table 3. Grouping of genotypes according to level of tolerance against leaf blotch disease

Sl. No.	Genotypes	Disease response ability
1	Duggirala c.v.	Resistant
2	Holdi-4	Resistant
3	Holdi-6	Resistant
4	Nadia Local	Resistant
5	NDH-128	Resistant
6	TCP-120	Resistant
7	TCP-190	Resistant
8	TCP-232	Resistant
9	TCP-235	Resistant
10	Tufanganj local	Resistant
11	Jalpaiguri local	Moderately Resistant
12	Kedaram local	Moderately Resistant
13	LTS-1	Moderately Resistant
14	Nagaland local	Moderately Resistant
15	Pratibha c.v.	Moderately Resistant
16	Suguna c.v.	Moderately Resistant
17	TCP-111	Moderately Resistant
18	TCP-2	Moderately Resistant
19	TCP-94	Moderately Resistant
20	Holdi-2	Susceptible
21	Mejha Turmeric	Susceptible
22	Midnapure	Susceptible
23	NH-1	Susceptible
24	Prabha	Susceptible
25	PTS-43	Susceptible
26	Pundibari	Susceptible
27	Rajendra Sonia	Susceptible
28	South Tripura	Susceptible
29	TCP-11	Susceptible
30	Tarakeswar	Highly Susceptible

Table 4. Meteorological parameters of the location for entire cropping season (2019–2022)

Month	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Max	Min	Max	Min	
CROPPING SEASON -1 (2019–2020)					
APR-19	30.92	20.30	77.20	60.73	137.00
MAY-19	30.42	22.71	86.90	74.87	254.80
JUNE-19	33.11	24.81	86.77	73.60	427.10
JULY-19	30.89	25.35	91.68	83.39	1135.70
AUG-19	34.34	26.10	85.52	73.42	349.70
SEPT-19	31.37	24.46	93.10	80.57	12.63
OCT -19	30.70	21.52	84.55	69.03	54.90
NOV-19	30.07	17.66	79.80	57.60	4.20
DEC-19	23.88	10.61	83.87	57.68	0.00
JAN-20	22.82	9.86	91.13	59.68	0.80
FEB-20	26.05	10.84	84.03	49.66	11.00
CROPPING SEASON - II (2020–2021)					
MAR-20	29.05	16.13	74.68	51.16	43.40
APR-20	30.76	18.52	70.50	56.40	107.40
MAY-20	30.64	21.61	82.97	71.45	393.50
JUNE-20	31.29	24.33	92.77	81.50	1107.80
JULY-20	30.58	24.68	96.48	85.97	1368.90
AUG-20	33.19	25.40	89.10	76.26	409.80
SEPT-20	30.18	23.93	93.37	84.00	1426.70
OCT -20	32.94	22.16	79.74	66.77	90.20
NOV-20	29.56	14.02	70.70	49.20	0.00
DEC-20	26.02	10.23	81.03	55.42	0.00
JAN-21	22.76	8.30	86.39	65.13	0.00
FEB-21	27.73	9.42	79.39	44.82	0.00
CROPPING SEASON – III (2021–2022)					
MAR-21	30.80	14.52	68.19	46.32	49.70
APR-21	32.34	17.11	66.80	54.77	130.40
MAY-21	30.74	19.25	84.06	71.68	268.60
JUNE-21	32.20	21.85	87.73	75.73	574.00
JULY-21	32.12	22.88	90.10	77.87	695.10
AUG-21	31.27	22.37	94.16	84.23	868.90
SEPT-21	33.73	22.47	83.67	70.40	323.00
OCT -21	31.81	19.79	81.77	69.42	267.80
NOV-21	29.45	12.40	74.40	50.60	0.00
DEC-21	26.99	12.24	79.13	51.10	1.20
JAN-22	24.10	11.08	90.16	54.61	4.20
FEB-22	24.37	11.24	82.11	51.36	46.60

Source: Integrated agro-met advisory service Unit-Pundibari from 2019–20, 2020–21 and 2021–2022 respectively.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20
40
60
Days
2019-20
2020-21
2021-2022

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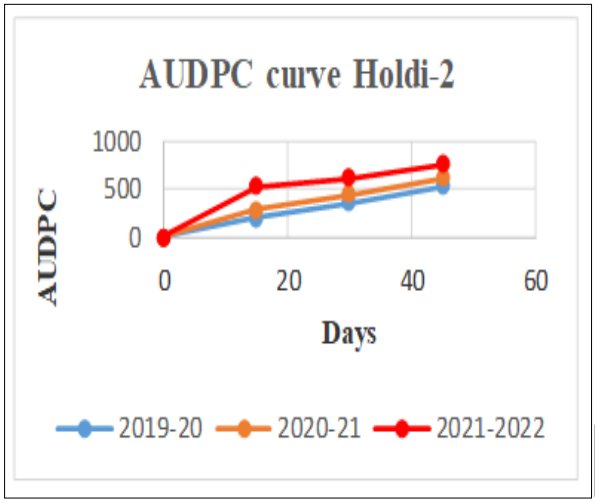
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AUDPC
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40
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Days
2019-20
2020-21
2021-2022

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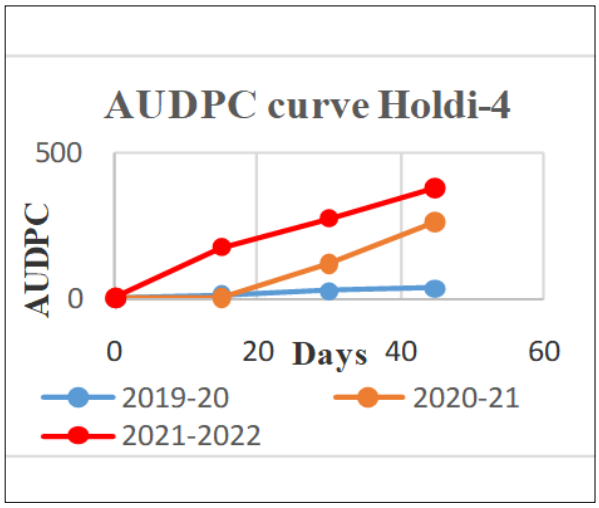
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0
20
Days
40
60
2019-20
2020-21
2021-2022

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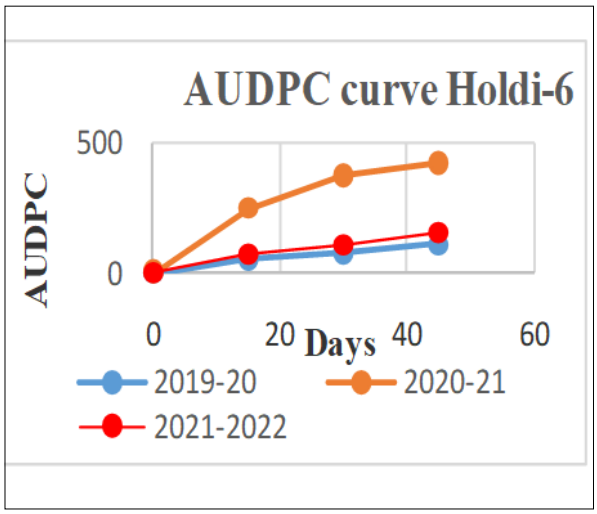
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AUDPC
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20
Days
40
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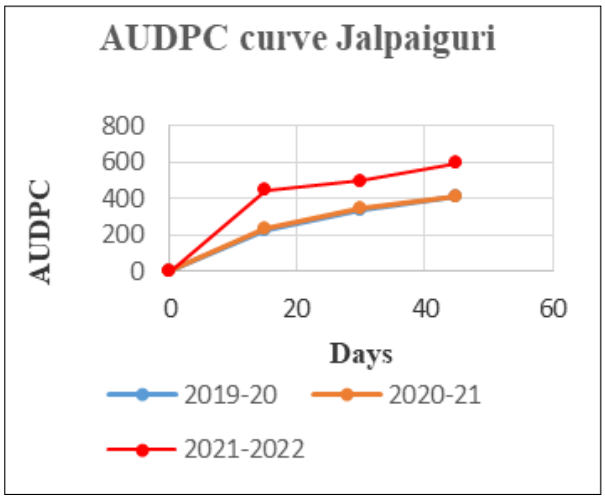
2019-20
2020-21
2021-2022

4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Days
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2021-2022

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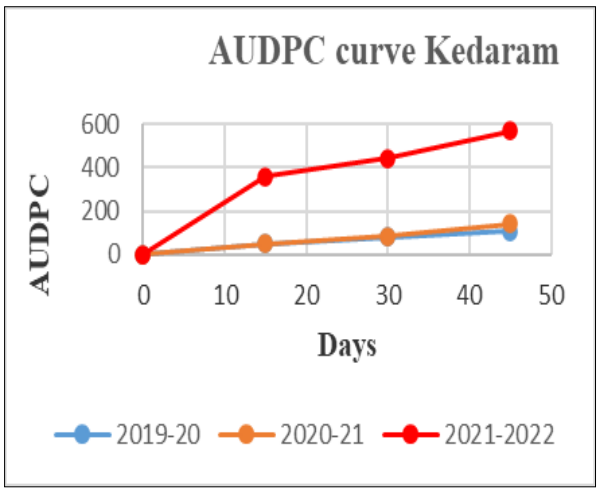
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Days
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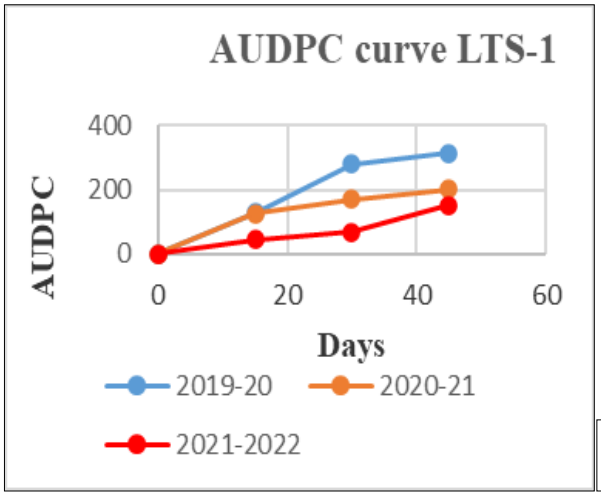
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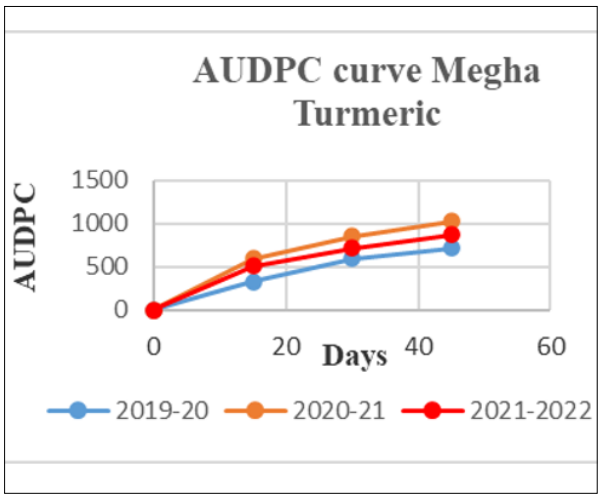
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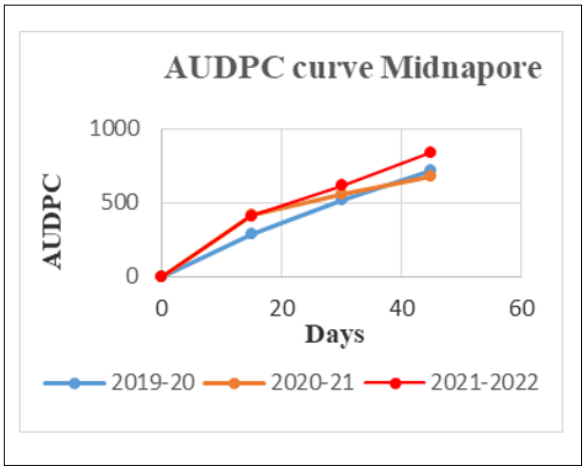

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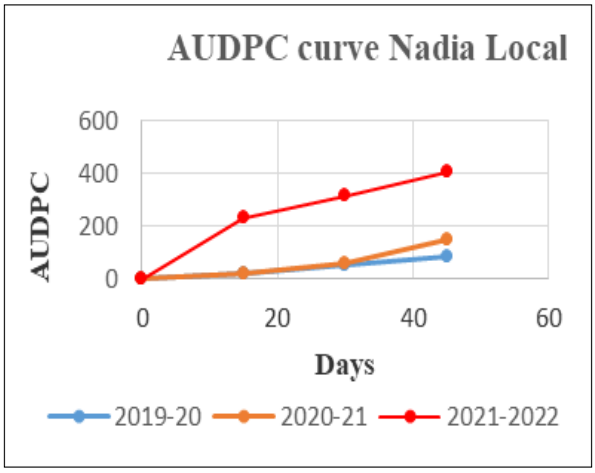

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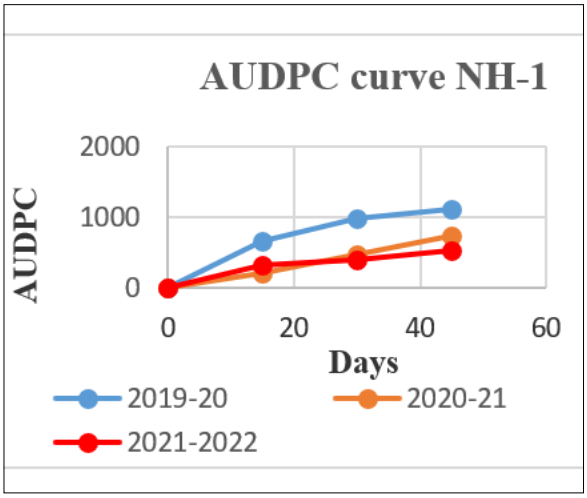

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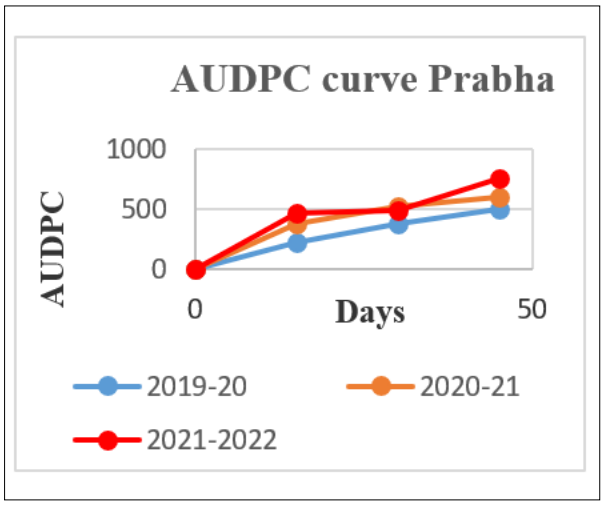

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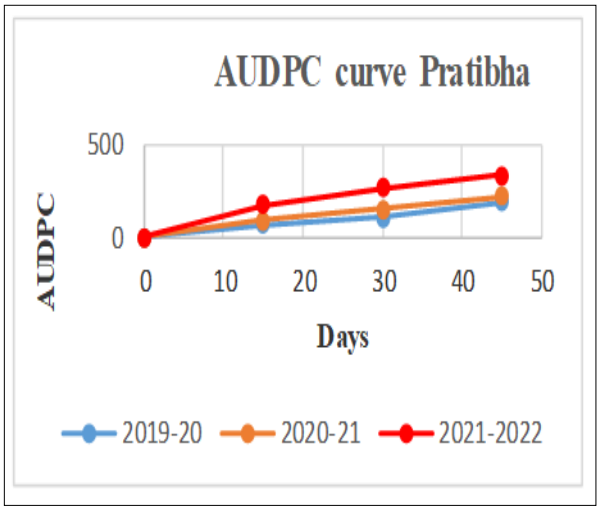

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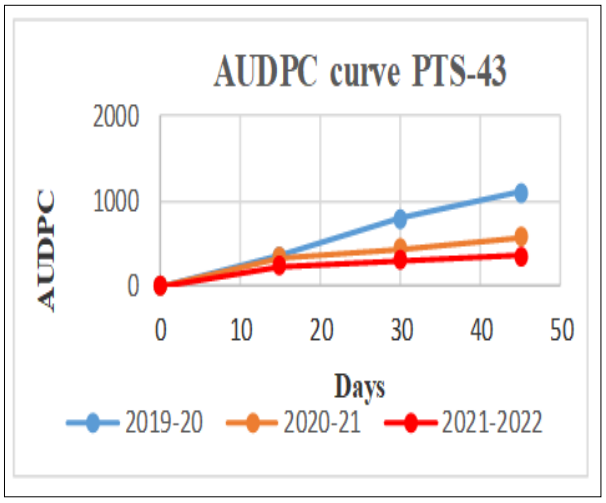

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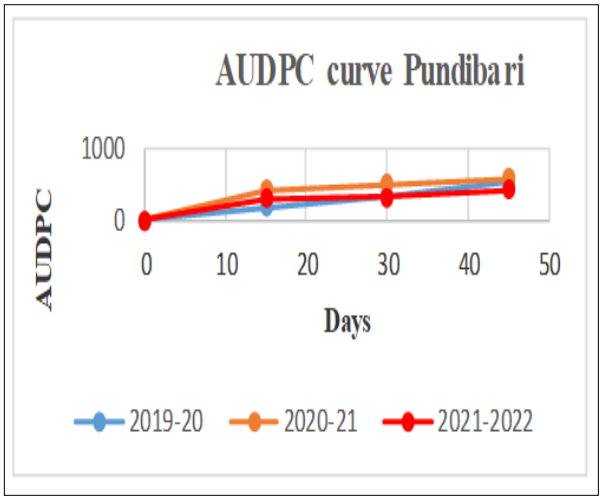

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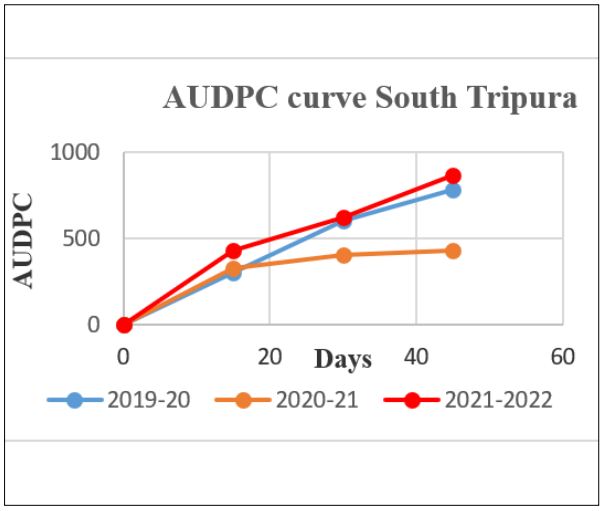

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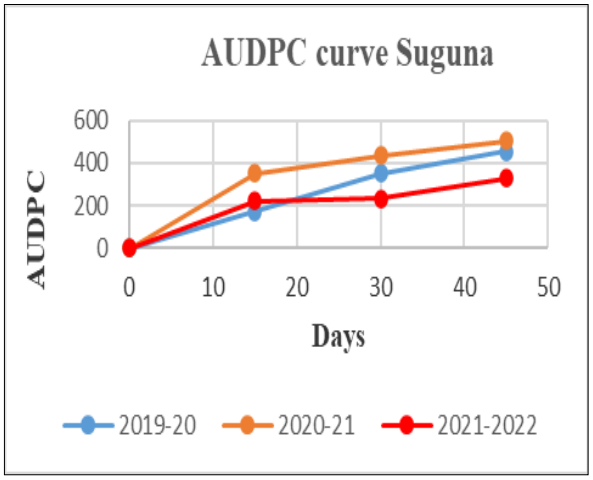

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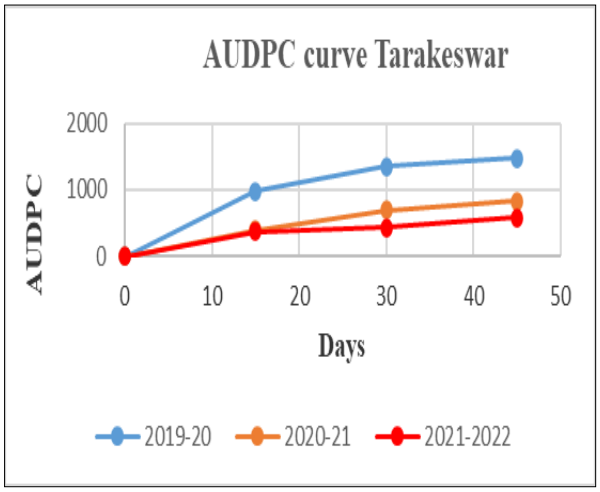

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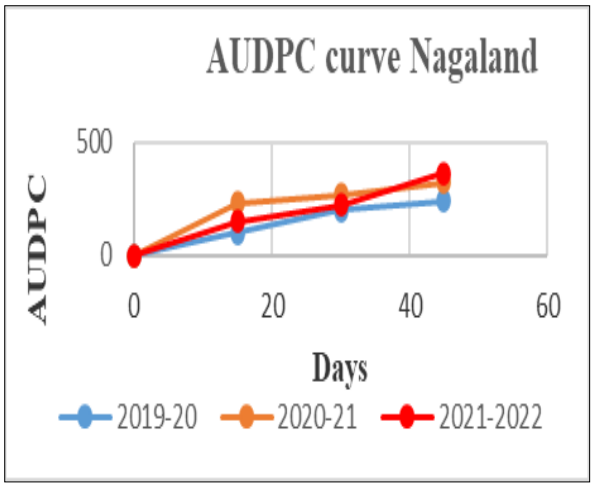

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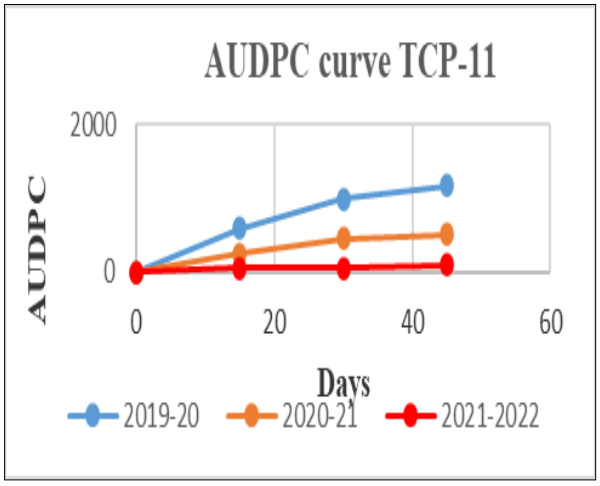

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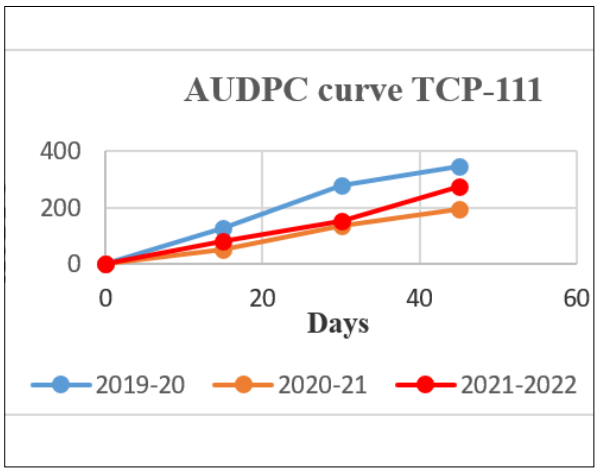

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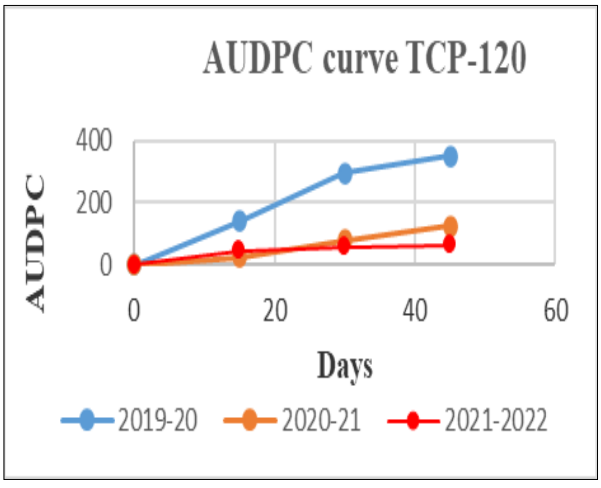

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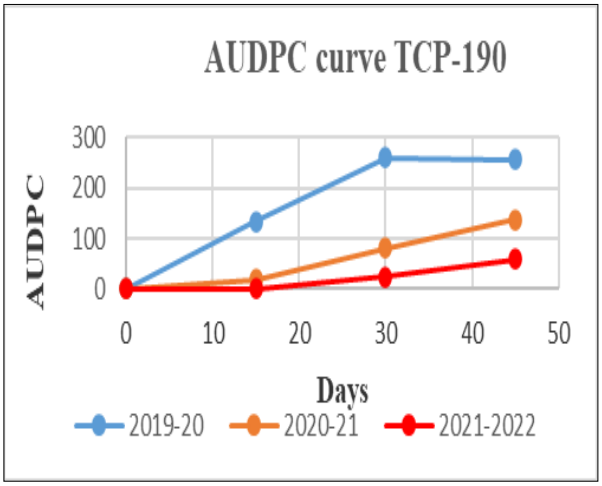

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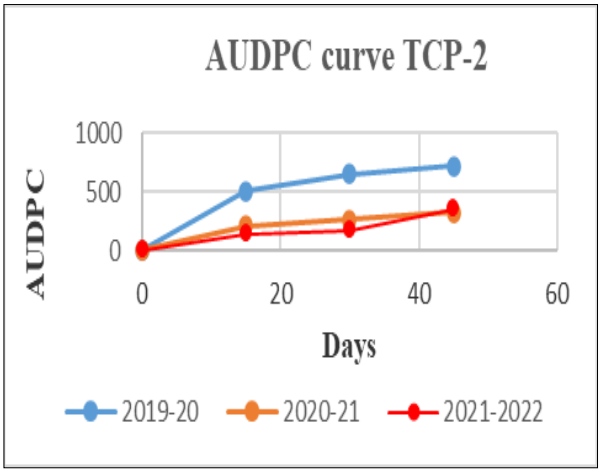

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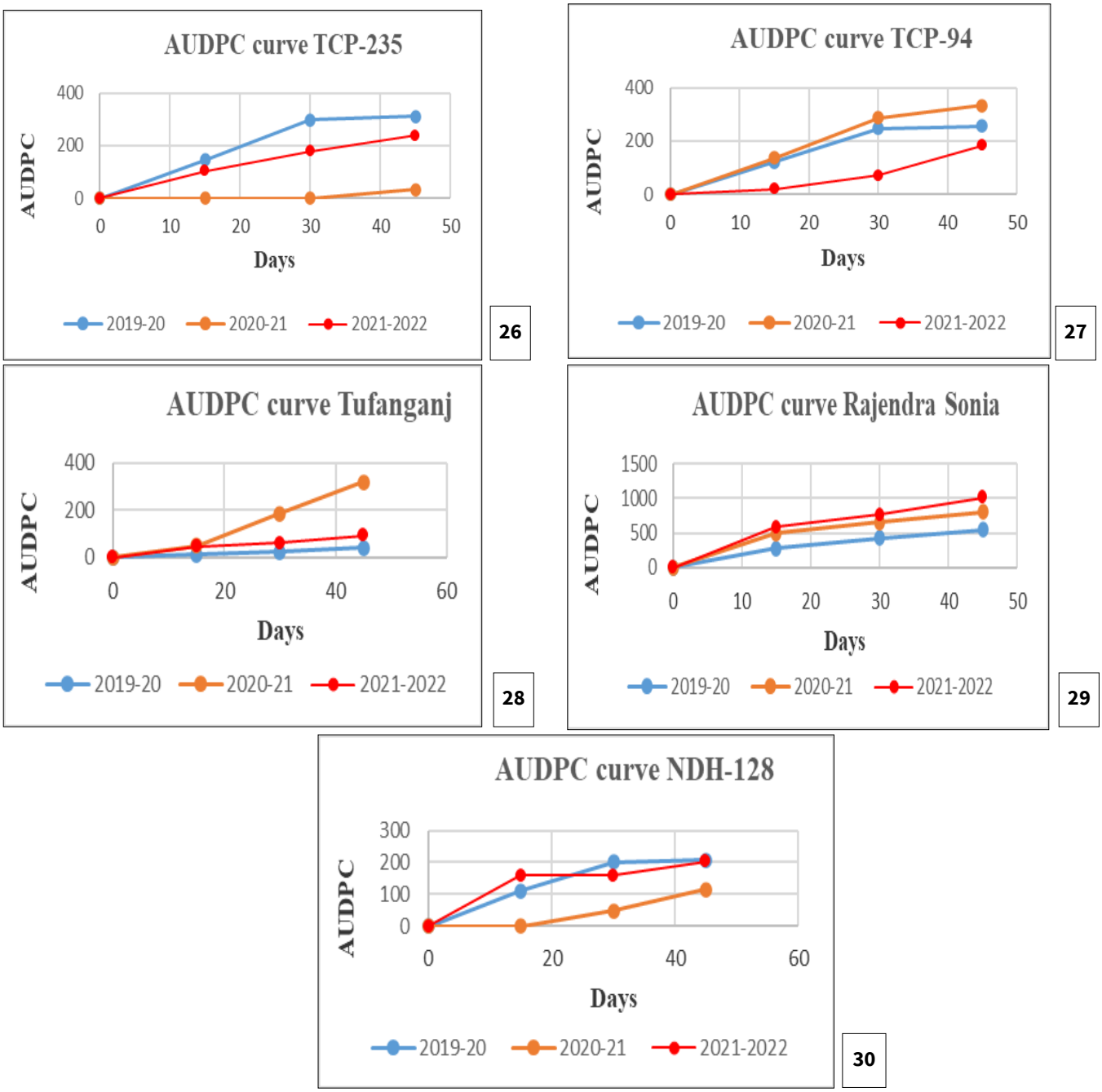

Fig. 6. Area under disease progress curve of 30 turmeric genotypes for leaf blotch disease. (1) Duggirala, (2) Holdi-2, (3) Holdi-4, (4) Holdi-6, (5) Jalpaiguri, (6) Kedaram, (7) LTS-1, (8) Megha Turmeric, (9) Midnapore, (10) Nadia Local, (11) NH-1, (12) Prabha, (13) Pratibha, (14) PTS-43, (15) Pundibari, (16) South Tripura, (17) Suguna, (18) Tarakeswar, (19) Nagaland, (20) TCP-11, (21) TCP-111, (22) TCP-120, (23) TCP-190, (24) TCP-2, (25) TCP-232, (26) TCP-235, (27) TCP-94, (28) Tufangunj Local, (29) Rajendra Sonia and (30) NDH-128.

The values of rAUDPC values were close to PDI values of each genotype of the Table 2 because rAUDPC values were mean values of the observations made from the first day to the final day of the infected leaves and PDI values were the observations of the final day of each genotype.

Secondary infection was caused by ascospores which discharged from the maturing asci of the fungus and infected fresh leaves without any dormancy. The disease spreads through ascospores and blastospores from matured asci and spreads in the soil and fresh leaves. The primary infections are found less harmful than secondary ones, helps to develop many spots throughout the entire foliage (17). The nature of infection caused the progress of the disease very high after some days of the primary infection which was also reflected in all those AUDPC curves where they were found a sharp rise of the graph from first reading (Fig. 6) till the last reading in each genotype of the investigation.

Conclusion

From this investigation, identification of different tolerance level of 30 genotypes were identified. Most susceptible to leaf blotch disease was found in Tarakeswar local and highly tolerant was found in 10 genotypes. 9 genotypes were moderately resistant and 10 genotypes were found susceptible. Duggirala, Holdi-4, Holdi-6, Nadia local, NDH-128, TCP-120, TCP-190, TCP-232, TCP-235 and Tufanganj local were found highly tolerant genotypes in this investigation. From the AUDPC and rAUDPC values also same trend of infestation was found by the leaf blotch disease in all genotypes.

Highly tolerant genotypes could be chosen for crop improvement programme for releasing the resistant turmeric varieties in future.

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Authors' contributions

DB conducted all the experiments in the field as part of the doctoral thesis programme. SC planned the experiments and supervised the study as the main mentor throughout the years. SK guided the disease-related aspects and developed the disease assessment and recording plan. MC coordinated and aligned the manuscript. RM performed the calculations included in the manuscript. AS carried out the proofreading of the manuscript. AK organised and arranged the photographs in the manuscript. All authors read and approved the final manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None

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