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ASSESSMENT AND SCREENING OF DIFFERENT VARIETIES OF TOMATO WITH SPECIAL REFERENCE TO LATE BLIGHT DISEASE IN GARO HILLS OF MEGHALAYA

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ABSTRACT

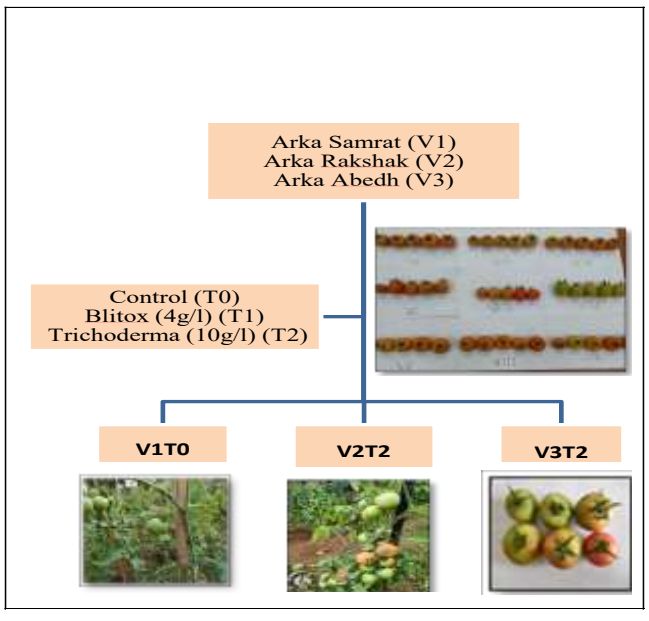
Aim: The aim of the present study was to assess and screening of different varieties of tomato against late blight diseases

Methodology: On the basis of resistance capacity of the cultivars 3 varieties (Arka Samrat, Arka Rakhshak and Arka Abedh) were selected for trial. Treatments like control, blitox and *Trichoderma* were taken and its interaction effects were studied. Trial was laid out in factorial RBD with nine interaction treatments and here replications.

Results: Treatment combination of Arka Abedh in Blitox resulted highest plant height (97.13cm) followed by Arka Samrat in Blitox treated plot (88.42cm). Whereas, the earliness and days to first flower were observed in interaction between tomato variety Arka Abedh with Trichoderma (31.67). Yield attributes like average fruit weight was highest in Arka Samrat in Control Plot(78.42g) followed by Arka Samrat in Blitox treated Plot (78.07g), number of fruits per plant was highest in Arka Rakshak in Trichoderma treated plot(148.33) followed by Arka Samrat in Blitox Treated Plot(122.00), fruit diameter found to be bigger in Arka Abedh in Blitox treated plot (17.79cm) followed by Arka Abedh in Trichoderma treated Plot(17.16cm), and highest yield was obtained in Arka Rakshak in *Trichoderma* treated plot (10.96kg/plot) followed by Arka Samrat in Blitox treated plot (9.63kg/plot). Moderately late blight disease incidence was found in Arka Samrat (V1) (11.72 %). Low disease incidence was found in Arka Rakshak (V2) (3.7%) and Arka Abedh (V3) (2.47%). Correlation studies revealed that Number of leaves, Number of branches, Number of harvests, Fruit yield per plot, Average fruit weight, Fruit Diameter are positively correlated whereas Days to first harvest and Days to first flower are negatively correlated.

Interpretation: The investigation highlighted the key finding on impact of late blight disease on different varieties their traits with the treatment under study in tomato and recommended the V2T2 (Arka Rakshak with Trichoderma) and V3T2 (Arka Abedh with Trichoderma) for the farming community.

KEYWORDS: Tomato, height, yield, disease incidence, Principal Component Analysis



Tomato var. Arka Rakshak and Arka Abedh with *Trichoderma* application as seed treatment @10 g/l of water followed by seedling root dip treatment @10g/l of water for half an hour before transplanting followed by soil application with enriched FYM @ 10g/kg of FYM in the main field is recommended for farmers of Garo Hills of Meghalaya

KEYWORDS: Tomato, late blight, disease incidence, principal component analysis

1. INTRODUCTION

Tomatoes are one of the most popular vegetable crop due to its high nutritional value both in the plains and hills of North-eastern India. It has a long history of use in Indian Cuisine, making it one of the most adaptable fruit and rich in lycopene a powerful antioxidant. Late blight disease is a devastating disease attacking tomato plants causing serious economic loss in Garo hills of Meghalaya. The rainy and humid climate, heavy rainfall, low soil fertility, scarcity of resistant cultivars, ineffective management methods, and frequency of pests and diseases all hinder the production of tomato in Meghalaya. One of the major impediments to tomato production is late blight, which is caused by *Phytophthora infestans* (Mont) de Bary resulting crop and yield losses is very high up to 75.53% (Sandeep Kumar *et al*., 2022). Host resistance is a crucial control strategy, but till date no tomato cultivars are available globally that are tolerant or resistant to the late blight pathogen; *P. infestans* (Islam *et al*. 2013). Research on tomato cultivar resistance to late blight is limited and less information is reported on the correlation of yield and quality component traits on late blight incidence under natural habitat of host-disease interaction. Considering the facts on tomato cultivar resistance to late blight, its biological control and traits interaction, the present investigation was proposed to screen and assess the resistance of different tomato cultivars in Garo Hills of Meghalaya.

2. MATERIAL AND METHODS

2.1. Plant materials and treatments details

Three tomato cultivars *viz*., Arka Samrat, Arka Rakshak and Arka Abedh were collected from Indian Institute of Horticulture Research (IIHR) utilized as one factor for screening and performance study on natural hotspot of late blight disease (*Phytophthora infestans*). Tomato plants were raised in protrays and transplanted in experiment plots 25 DAS at 60cm x 45cm spacing in 3m x 3m size plots using factorial randomized block design (FRBD) with replications. Blitox (4g/l), Trichoderma (10g/l) and without treatment (control) were considered as second factor applied in the experiment plot in the experimental farm of College of Community Science, Central Agricultural University during 2022-23 rabi season. The blitox was applied @of 4g/l of water at the first appreance of the disease followed by three sprays at weekly interval for three consecutive weeks. Trichoderma was applied as seed treatment @10 g/l of water followed by seedling root dip treatment @10g/l of water for half an hour before transplanting followed by soil application with enriched FYM @ 10g/kg of FYM in the main field.

2.2. Observation

The experimental plots were inspected regularly to record the traits under study *viz*., plant height, number of leaves, number of branches, days to 1st flower, days to harvest, number of harvest, average fruit weight, number of fruit per plant, fruit yield, fruit diameter and disease incidence (%). Randomly, five plants were tagged to record the traits observation.

2.3. Late blight assessment

Late blight severity was assessed at weekly intervals from transplanting to final harvest on five randomly selected plants tagged in a plot. Severity on leaves was assessed by using 0-5 scale where, 0=no symptoms, 1=1 to 11% disease (midpoint 6%), 2=12 to 38% disease (midpoint 25%), 3=39 to 61% disease (midpoint 50%), 4=62 to 88% disease (midpoint 75%), 5=89 to 100% disease (midpoint 95%) (Seidl-Johnson *et al*., 2015). Per cent disease index (PDI) was calculated based using the formula given by Wheeler1969.From multiple severity assessments made at periodical intervals, Area under disease progress curve for each variety was worked as per equation (Wilcoxson *et al*., 1975). Where, Si=disease severity at the end of week i, K = the number of successive evaluations of disease and d=interval between two evaluations.

2.4. Statistical analysis

Data obtained on seed yield and associated traits over two seasons were subjected combined analysis of variance using the online software; KAU GRAPES version 1.1.0 (Gopinath *et al*., 2020) after performing the test of homogeneity using Bartlet's test (Bartlett, 1937). The correlation matrix was used to conduct principal component

analysis, which turns correlated quantitative characteristics into uncorrelated characters known as primary components and examines at the relationships among them using KAU GRAPES version 1.1.0.

3. RESULTS AND DISCUSSION

Table 1. Mean performance of tomato varieties against late blight

Treatments	PH	NL	NB	DF	DH	NH	AFW	NFP	FYP	FD	LB
V1T0	81.72	27.94	3.33	32.33	85.33	7.67	78.42	113	8.81	14.55	14.81
V1T1	88.42	27.27	4	34	86.33	7	78.07	122	9.63	16.73	12.96
V1T2	74.93	24.67	3.4	32.67	91	6.67	72.05	80	6	16.76	7.4
V2T0	72.59	20.17	2.47	37	102	5.67	58.23	117	6.84	14.94	5.55
V2T1	76.07	20.87	3.47	38.33	107	5.33	51.73	90.67	4.69	14.07	3.7
V2T2	62.42	21.33	3.27	38	108.33	5.67	74	148.33	10.96	15.96	1.85
V3T0	78.26	17.2	2.87	37	110.67	5.67	64.27	65.67	4.34	15.6	3.7
V3T1	97.13	21.8	3.67	36.33	102.67	6	77.27	110.33	8.04	17.79	1.85
V3T2	69.94	16	3	31.67	108.33	5.33	72.4	66.33	4.79	17.16	1.85
SEm (±)	2.627	0.794	0.244	0.679	0.949	0.779	4.531	17.186	1.302	0.299	1.838
CD (p=0.05)	7.872	2.379	0.731 (NS)	2.035	2.844	2.333 (NS)	13.577	51.493	3.902	0.897	5.506 (NS)

V1= Arka Samrat, V2= Arka Rakshak, V3= Arka Abedh, T0= control, T1= Blitox (4g/l), T2= *Trichoderma* (10g/l), PH= plant height (cm), NL= number of leaves, NB= number of branches, DF= days to 1st flower, DH= days to harvest NH= number of harvest, AFW= average fruit weight, NFP= number of fruit per plant, FYP= fruit yield per plot, FD= fruit diameter, LB= late blight disease incidence (%)

Results obtained revealed that the highest significant growth characters were observed in case of interaction between Arka Abedh in blitox treated plot (97.13cm) for plant height followed by Arka Samrat in blitox treated plot (88.42cm), for other growth parameter like number of leaves was more for Arka Samrat in control plot (27.94) followed by Arka Samrat in blitox treated plot (27.27). Whereas, the earliness days to first flower were observed in interaction between tomato variety Arka Abedh with *Trichoderma* (31.67) followed by Arka Samrat in control plot (32.33). On the other hand, days to first harvest was significantly observed in Arka Samrat in control plot (85.33) followed by Arka Samrat in blitox treated plot (86.33). Yield attributes like average fruit weight was highest in Arka Samrat in control plot (78.42g) followed by Arka Samrat in blitox treated plot (78.07g) and Arka Abedh in blitox treated plot (77.27g), number of fruits per plant was highest in Arka Rakshak in *Trichoderma* treated plot(148.33) followed by Arka Samrat in blitox treated plot (122.00), fruit diameter found to be bigger in Arka Abedh in blitox treated plot (17.79cm) followed by Arka Abedh in *Trichoderma* treated Plot(17.16cm), and highest yield was obtained in Arka Rakshak in Trichoderma treated Plot(10.96kg/plot) followed by Arka Samrat in Blitox treated Plot(9.63kg/plot). Moderately late blight disease incidence was found in Arka Samrat (V1) (11.72 %). Low disease incidence was found in Arka Rakshak (V2) (3.7%) and Arka Abedh (V3) (2.47%). There is no significant interaction between varieties and disease management treatments on late blight disease incidence though there is significant varietal difference in disease incidence.

4. Combine correlation study of traits

4.1. Under control condition

To enumerate the relationship among the traits under study, the combine correlation was plotted using correlation coefficient matrix, scatter plot and phenotypic frequency distribution for PH, NL, NB, DF, DH, NH, AFW, NFP, FYP, FD and LB (figure 1a). Correlation coefficient value (r) revealed PH had positive significant relation with NH (0.68) indicated increase in number of harvest of tomato varieties; Arka Samrat, Arka Rakshak and Arka Abedh with increase in plant height. PH also had positive correlation with all other growth traits except DF (-0.49), DH (-0.35) and FD (-0.17) but found non-significant. For individual variety PH had close and neutral relationship with all traits. NL showed significant negative correlation with DF (-0.89) and DH (-0.97) revealed late flowering and harvesting periods which also reflected in V1, V2 and V3. Higher number of leaves aggravated late blight (LB, 0.91) infested as these had high significant positive correlation followed by AFW (0.71). NB had non-significant relationship with all the traits with r value varied from 0.48 (LB) to -0.47 (DF). Days to 1st flower strongly associated with DH (0.89), AFW (-0.80) and LB (-0.93). DH reported high positive correlation with fruit diameter (0.68), DH (0.89) and negative correlation with all most all traits where LB (-0.96) and NL (-0.97) greatly affected the trait value (figure 1a). Number of harvest maintained close and neutral relationship with all traits while high positive correlation with PH. For V1, V2 and V3 the average fruit weight showed strong association with NL (0.72), LB (0.77), DF (-0.80), DH (-0.67) where highly significant positive and negative relationships, respectively, were observed. With r value; 0.93, Number of fruits per plant (NFP) had high positive

correlation with FYP while with other traits had neutral or close associations. Tomato varieties; V1, V2 and V3 were greatly differ in fruit yield per plant (FYP) which was influenced significantly by NFP (0.93) and LB (0.67). Fruit diameter (FD) had non-significant negative association with all traits except DH (0.68) and greatly affected with late blight incidence (-0.68). Higher PH, NL, NB, NFP, AFW and FYP aggravated the LB incidence in tomato and in consequence it caused early flowering and harvesting with reduction of fruit diameter as negatively correlated. The tomato variety; Arka Rakshak was least affected with LB observed negative correlation (figure 1a). Similar kind of correlations were studied by Gutie´rrez *et al*. (2023) in faba bean for plant height, yield and quality associated traits under well watered and drought conditions. Our experimental results were consistent with earlier workers in different crops (Prasad *et al*., 2001 in fine grain rice genotypes; Megloire *et al*., 2005 in African cowpea genotypes; Rangare *et al*., 2012 in exotic and Indian rice; Debsharma *et al*., 2020 in elite germplasm of rice; Hu *et al*., 2022 in Adzuki Bean).

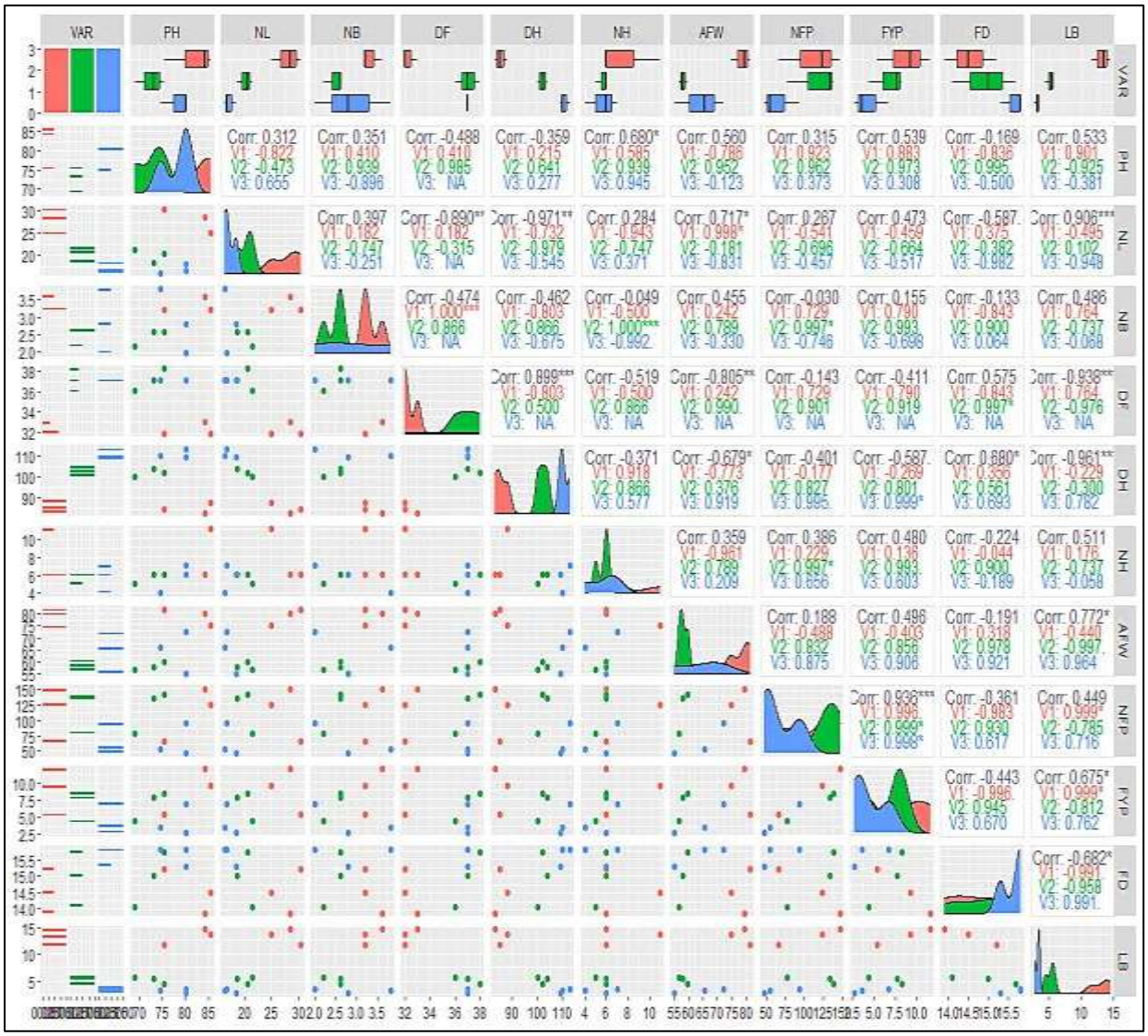


Figure 1a: Combine correlation graph showing Pearson's correlation coefficient matrix, scatter plot, phenotypic frequency distribution and box plots of traits; PH= plant height (cm), NL= number of leaves, NB= number of branches, DF= days to 1st flower, DH= days to harvest NH= number of harvest, AFW= average fruit weight, NFP= number of fruit per plant, FYP= fruit yield per plot, FD= fruit diameter, LB= late blight disease incidence (%) displaced above the diagonals, below the diagonals, diagonals and horizontal bar respectively. *p ≤ 0.05, ** p ≤ 0.01, and *** p > 0.001 show significance level. V1= Arka Samrat, V2= Arka Rakshak, V3= Arka Abedh.

4.2. Under treatment condition

Figure 1b depicted the correlation of traits under variety and treatments interaction displaying Pearson's correlation coefficient matrix above the diagonal. Plant height (PH) showed close and neutral relationship with all the traits under variety x treatments interaction with coefficient correlation value varies ranged from 0.44 to -0.35. V3T2 (Arka Abedh + Trichoderma@ 10g l^{-1}) variety x treatment interaction observed with non-significant negative correlation value for most of the traits except DH (0.96) and NL (-0.99) indicating early harvesting with less number of leaves. For treatment combination V2T2 (Arka Rakshak + Trichoderma@ 10g l^{-1}) and V1T1 (Arka

Samrat + Blitox@ 4gl^{-1}), PH revealed significant correlation with FYP (0.99) and DF (-0.99) respectively explained favourable effect of variety and chemical treatment resulted high yield and change in flowering time (figure 1b). The number of leaves per plant had strong association with NB (0.59), DH (-0.84) and LB (0.81). Significant negative correlation was observed in NL-LB and NL-FD for V1T1, V1T2 and V2T1, V3T1 treatment combinations respectively indicating increase in NL increased late blight incidence and lower fruit diameter. Likewise, NB had significant positive and negative correlation with LB (0.49) and DH (-0.52) reflected in V3T2 interaction with change in days to 1st harvest. A close and neutral association was observed between days to 1st flowering with other traits under different treatment combination explained no significant effect. Overall, a strong negative relation was observed for days to 1st harvest with NL (-0.84), NB (-0.52) and LB (-0.92) which was reflected in V3T2 and V2T2 indicated adverse effect of *Trichoderma* application in Arka Rakshak and Arka Abhed. Number of harvest directly correlated with AFW (0.49), FYP (0.62) and LB (0.51). AFW had significant positive interaction with FD (0.56) for which most of the treatment combination was observed with non-significant negative correlation value (figure 1b). Likewise, number of fruits per plant was closely associated with fruit yield per plot had positive significant r value (0.95) and V2T2 was found highly interactive. FYP showed positive interaction with NH (0.62) and NFP (0.95) indicated the traits were major contributing where V1T2 and V2T2 observed with significant r value. FD had close association with all the traits under study except AFW (0.56) while V2T1, V3T1 and V2T2 appeared to be significant for NL and NB respectively. Under variety and treatments interaction conditions LB projected strong association with NL, NB, DH and NH. The different treatment combination witnessed varied response to late blight incidence with reduction in trait value reflected as negative correlation value while V3T2 showed positive interaction between LB and AFW (figure 1b). The results were consistent with earlier findings which revealed that the growth, yield and biochemical traits were correlated differently under drought and control condition in faba bean (Gutie´rrez *et al*., 2023).

5. Multivariate analysis and cluster analysis

Correlation studies revealed formation of eight PCs among which first four PCs were deemed to be significant (Eigen value >1) whereas other PCs were found non-significant (Table 2). The PCs also indicated existence of unknown factors which responsible for variation in our experiment but that were found non-significant. The traits namely, days to 1st flower, number of fruits per plant, fruit yield per plot and fruit diameter had maximum contribution towards the PC 2 and rest other traits were attributed to PC 1. The bubble size and intensity indicated the magnitude of contribution towards total variation (Figure 2). To get more clarity on trait and treatment relation the recorded data were subjected to PCA biplot construction.

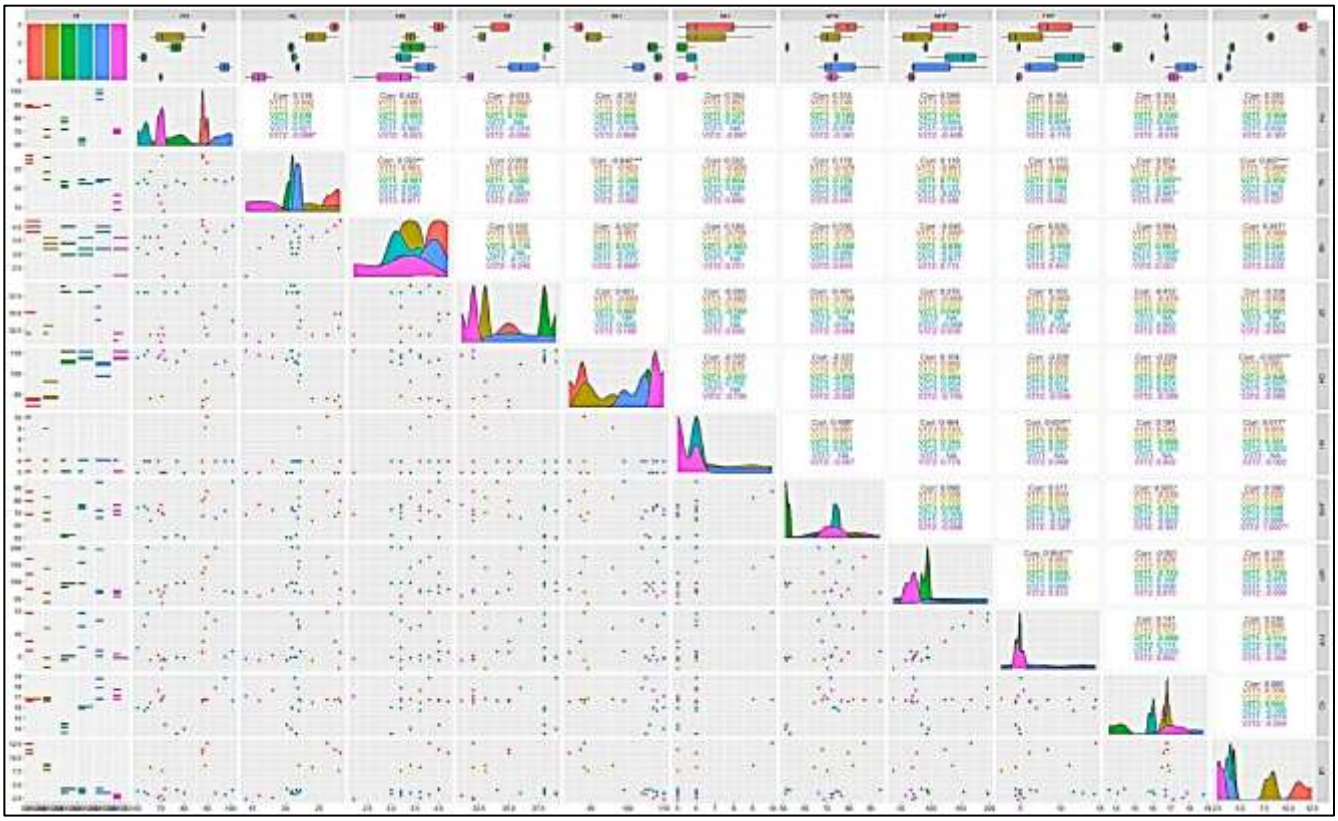


Figure 1b: Combine correlation graph plotted for varietal and treatments interaction (VT); V1T1 (Arka Samrat + Blitox@ 4gl^{-1}), V1T2 (Arka Samrat + *Trichoderma*@ 10g l^{-1}), V2T1 (Arka Rakshak + Blitox@ 4g l^{-1}), V2T2 (Arka Rakshak + *Trichoderma*@ 10g l^{-1}), V3T1 (Arka Abedh + Blitox@ 4gl^{-1}) and V3T2 (Arka Abedh + *Trichoderma*@ 10g l^{-1}). Diagonal represents phenotypic frequency distribution, above diagonal represents

Pearson's correlation coefficient matrix, below the diagonals represents scatter plot and horizontal bar represents box plots of traits; DF= days to 1st flower, DH= days to harvest NH= number of harvest, AFW= average fruit weight, NFP= number of fruit per plant, FYP= fruit yield per plot, FD= fruit diameter, LB= late blight disease incidence (%). *, ** and *** indicate $p \leq 0.05$, $p \leq 0.01$ and $p > 0.001$ respectively.

Table 2: Extracted Eigenvalues and correlation values for yield associated traits and disease incidence with the first three principal components

Variables	Principles components		
	PC1	PC2	PC3
Extracted Eigenvalues	5.395	1.992	1.805
Explained variance (%)	49.048	18.111	16.405
Cumulative variance (%)	49.048	67.158	83.564
Yield attributing traits and disease traits			
Plant height	0.494	-0.311	0.199
Number of leaves	0.933	0.218	-0.171
Number of branches	0.631	-0.062	0.403
Days to 1st flower	-0.513	0.685	0.22
Days to harvest	-0.929	0.073	0.307
Number of harvest	0.936	-0.044	-0.277
Average fruit weight	0.734	-0.281	0.456
Number of fruit per plant	0.437	0.799	0.354
Fruit yield	0.656	0.557	0.436
Fruit diameter	0.157	-0.582	0.753
Disease incidence	0.835	0.038	-0.514

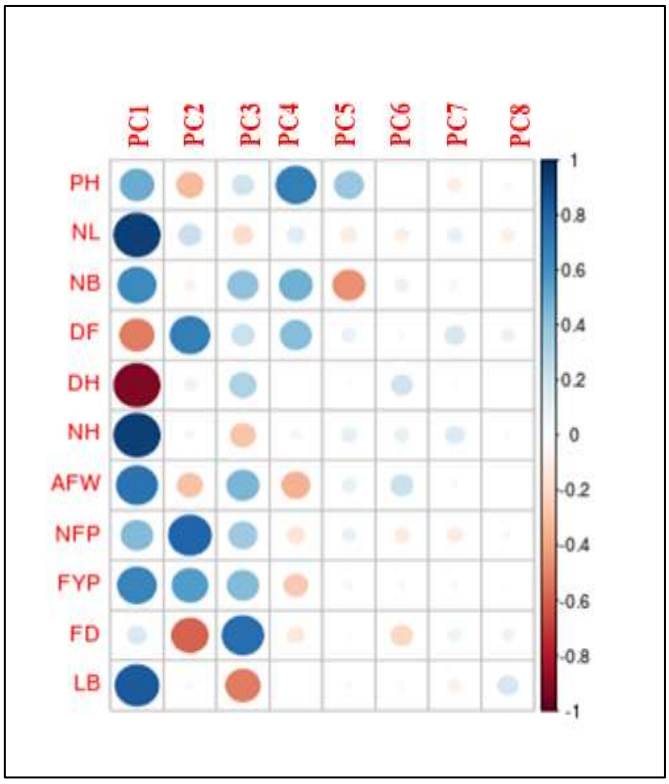


Figure 2: Correlation between traits and PCs

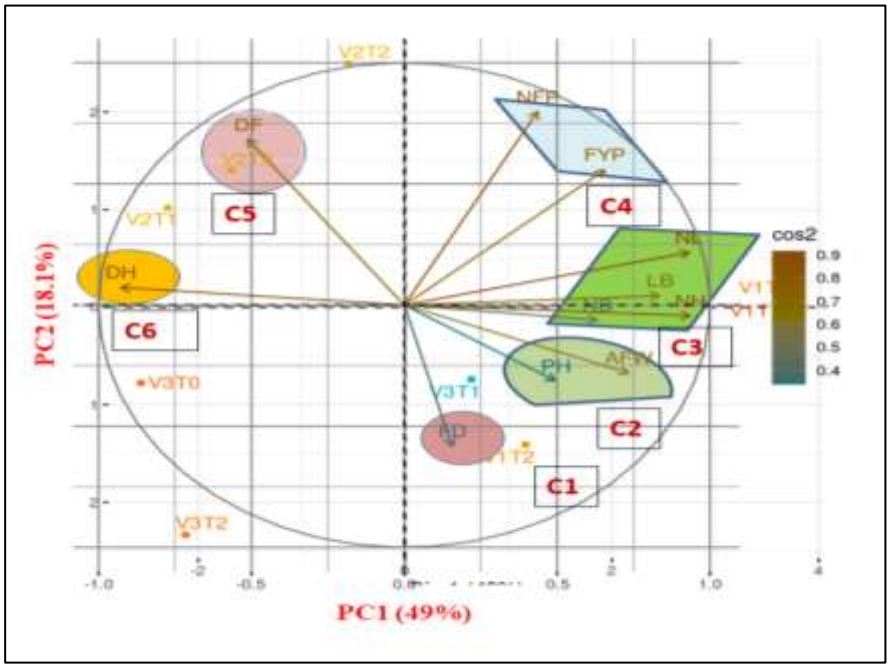


Figure 3: PCA biplot showing interaction and grouping of eleven traits

The two PCs 1 and 2 found significant (49%; 18.1%) and contributed maximum towards total variation. So used for biplot construction (Figure 3). The traits and treatment were assigned in different axes as per their involvement in the creation of variation which were scattered in different axes. The traits near the horizontal axes contributed more towards the PC 1 and other found near to vertical axes to PC 2. The traits were joined with different color of vector and length indicating their contribution and interaction between them. The acute angle between vector indicated positive interaction (C1, C2 and C3 traits), right angle indicated independent relation (NL-FD; PH-NFP) and opposite vectors meaning negative correlation between the traits (DH-NH; DF-PH). The late blight incidence found interacting with most of the traits under study but the traits; number of leaves, number of branches, number of harvest were found highly interactive indicated these traits were most affected with late blight. The V1 was found most affected with late blight whereas V2 shows high degree of tolerance. The PCA gives straight forward interpretation on trait and treatment interaction and justifies the consideration of traits under study was found sufficient. This recommended considering these traits in future research programme on this aspect.

6. CONCLUSION

The incidence of late blight is major constraint in tomato cultivation in Meghalaya as the region act as hotspot of the disease causing serious crop failure and loss to the growers. The investigation highlighted the key finding on impact of late blight disease on different varieties their traits with the treatment under study in tomato and recommended the V2T2 (Arka Rakshak with Trichoderma) and V3T2 (Arka Abedh with Trichoderma) for the farming community. Further Tomato breeders and pathologist should evaluate more their material in different region of Northeast area for identification of resistant germplasm and testing field efficacy of management measures evolved against this disease.

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