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Predicting the effect of weather parameters on yield performance of tomato genotypes under late *rabi* planting condition

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Abstract
In the present investigation an attempt has been made to study the effect of weather parameters on phenological stages and fruit yield components in tomato under late *rabi* planting condition. The experiment was conducted in a randomised block design with three replications. The results on mean sum of square revealed the existence of significant variation among the tested genotypes for all the characters studied except days to 50% flowering. Among the genotypes BT-106 recorded the highest number of fruits per plant (12.88) and fruit yield (134.75 q/ha). Plant height, number of branches per plant and number of flower clusters per plant showed positive correlation with maximum temperature (0.337; 0.598; 0.228) and minimum temperature (0.872; 0.892; 0.865) but negative correlation with relative humidity (-0.525; -0.979; -0.582). Fruit yield exhibited negative correlation with maximum temperature (- 0.331), minimum temperature (- 0.329) and evapotranspiration (-0.663) and positive correlation with relative humidity (0.304). This study revealed that fruit yield is influenced by mean temperature and evapotranspiration rather than maximum temperature and relative humidity under late *rabi* planting condition.

Keywords: Tomato, weather parameters, late *rabi* planting, phenological stages, yield

Introduction

Amongst vegetable crops, tomato is the most important horticultural crop worldwide. It is the main supplier of many plant nutrients and provides an important nutritional value to the human diet (Willcox *et al.*, 2003) [17]. The demand for the crop is year-round, owing to the versatility of its usage in both fresh and processed food preparation. It is also an excellent source of vitamin C and antioxidants. As tomato is a warm season crop, it is usually cultivated in sub-tropical and mild cold climatic regions.The commercial production of tomato particularly grown under open field conditions is severely affected by various weather parameters like temperature, rainfall and humidity. These three weather parameters ultimately affect yield and quality. Due to high temperature physiological disorder like flower and fruit abscission are seen in tomato. In combination with elevated temperatures, decreased precipitation could cause reduction in availability of irrigation water and increase in evapotranspiration, leading to severe crop water-stress conditions which mostly threaten tomato production. Hence there is a need to protect tomato crop for sustainability against the climate change scenario (Datta, 2013) [4].

Uzun (2007) [16] observed the effect of mean daily temperature and cumulative daily light intensity on fruiting behavior of greenhouse-grown tomato. Rajasekar *et al.* (2013) [13] observed the influence of environmental variables i.e., temperature, relative humidity and light intensity on growth and yield of tomato under both shade net and open field. Ajibowu (2014) [2] studied the effect of rainfall and air temperature on the growth and yield of tomato. Yuan (2016) [18] investigated the effect of day/night temperature difference (DIF) on photosynthetic characteristics of tomato plants (*Solanum lycopersicum*, cv. Jinguan 5). Hussain *et al.* (2017) [7] studied the effect of climate resilient technologies on the quality, disease and insect pest infestation in tomato. Pragyan Kumari *et al.* (2017) [12] investigated the influence of temperature on wheat yield in Jharkhand region.

In Odisha tomato is cultivated in an area of 96,550 ha with a total production of 13, 82,780 tonnes (Anonymous, IHDB 2013) and the demand for tomato is constantly high throughout the year. However, the production is limited during off-season months, particularly in extreme dry

(February-March planting) months or wet (June-July planting) months in coastal plain zone of Odisha. Though many research works had been conducted to study the effects of weather variables on fruit yield of tomato, but no research work has been initiated to identify the weather parameters that limits tomato yield in coastal plain zone of Odisha under late *rabi* planting condition. Therefore the present investigate is undertaken to study and predict the effect of weather parameters in influencing fruit yield under late *rabi* planting condition in coastal plain zone of Odisha.

Materials and methods

The present investigation was conducted taking three state released tomato varieties namely Utkal Pallavi (BT-1), Utkal Deepti (BT-2), Utkal Kumari (BT-10) and five advanced lines (developed at OUAT) BT-101, BT-106, BT-136, BT-317 and BT 44-2. The eight tomato genotypes were evaluated in a randomised block design with three replications at central farm, OUAT, Bhubaneswar during 2016-17. Nursery sowing of the eight tomato genotypes was done towards the last week of December, 2016 and the seedling were transplanted in the main field towards the last week of January with a spacing of 60 cm × 40 cm, 2017. Recommended package of practices were followed to raise the crop. Five plants were selected at random from each plot to record observations on plant height, number of branches, stem girth, days to 50 % flowering, number of flower clusters per plant, number of flowers per cluster, fruits per cluster, fruits per plant, fruit weight and fruit yield. Weather parameters like maximum temperature, minimum temperature, relative humidity and evapotranspiration were collected from Agrometeorology department of O.U.A.T, Bhubaneswar. ANOVA, correlation and regression analysis was done following SAS 9.3 version.

Data were analyzed to establish a relationship between various growth stages and weather elements considered using the bi-variate correlation method and analysis of variance (ANOVA) as prescribed by Panse and Sukhatme (1984) [10]. Significance test was done by calculating F- value from ANOVA table and critical difference (CD) was evaluated to compare the means.

Results and discussion

The maximum temperature, minimum temperature, relative humidity, wind velocity, bright sunshine hour and evapotranspiration are presented in Table 1. During the growing season under late *rabi* planting condition the maximum temperature ranged from to 29.2 to 37.8 ^{0}C; minimum temperature ranged from 12.6 to 26.0 ^{0}C; relative humidity varied from 80.0 to 95.0 %; wind velocity ranged from 1.1 to 9.5 km/hr; bright sunshine hour ranged from 3.7 to 11.2 and evapotranspiration ranged from 3.4 to 7.6 mm (Table 1).

Table 1: Meteorological data recorded during the growing period of the crop (2016-17)

Week	Date	Temperature (^{0}C)		RH (%)		WV (km/hr)	BSH	ET (mm)
		Max.	Min.	Morning	Afternoon			
51st (Dec.)	17-23	29.8	12.6	80	33	1.6	8.0	3.7
52nd Dec.)	24-31	29.5	14.6	84	43	1.2	5.5	3.5
01st (Jan.)	1-7	29.2	16.0	86	46	1.1	3.7	3.4
02nd (Jan.)	8-14	29.5	14.6	83	38	3.3	6.5	3.6
03rd (Jan.)	15-21	29.2	12.7	86	33	2.3	8.0	3.7
04th (Jan.)	22-28	30.7	14.1	91	36	1.8	6.6	3.5
5th (Jan-Feb.)	29-4	31.3	17.6	95	40	2.0	7.0	3.7
6th (Feb.)	5-11	33.3	17.2	94	32	2.2	8.2	3.7
7th (Feb.)	12-18	33.6	17.4	92	36	2.1	8.3	3.7
8th (Feb.)	19-25	35.1	22.4	92	42	5.3	7.8	3.8
9th (Feb-Mar.)	26-4	35.7	20.6	94	35	3.6	8.1	4.1
10th (Mar.)	5.-11	33.2	22.8	93	54	5.0	5.0	4.3
11th (Mar.)	12-18	33.1	21.6	92	40	4.0	7.1	5.0
12th (Mar.)	19-25	35.9	22.7	89	37	4.5	8.0	5.3
13th (Mar-Apr.)	26-1	35.6	25.3	88	44	9.5	7.8	5.6
14th (Apr.)	2-8	35.6	26.0	88	48	6.6	11.2	7.0
15th Apr	9-15	37.8	26.0	86	43	7.4	7.2	7.6
16th Apr	16-22	36.0	25.9	88	58	8.2	9.8	7.3

Performance of tomato genotypes

Analysis of variance revealed significant variation among the genotypes in respect of different growth and yield attributing characters (Table 2).

Table 2: Mean sum of squares in respect of different characters

S. No.	Characters	DF	SS	MS
1	Plant height (cm)	7	674.660	96.380*
2	No. of branches/ plant	7	5.833	0.833*
3	Stem girth (cm)	7	4.224	0.603*
4	No. of flower clusters /plant	7	76.958	10.994*
5	No. of flowers/ cluster	7	0.572	0.082*
6	No. of fruits /plant	7	186.290	26.613*
7	No. of fruits /cluster	7	7.292	1.042*
8	Fruit length	7	4.748	0.678*
9	Fruit girth	7	115.298	16.471*
10	Fruit weight	7	1435.391	205.056*
11	Per plant yield (gm)	7	81820.154	11688.593*
12	Total yield (kg)	7	112.509	16.073*

The growth parameters of tomato genotypes are presented in Table 3. From these data, it was observed that the genotype BT 44-2 recorded significantly the highest plant height (64.73 cm) and was statistically at par with BT-317 (57.67 cm). The genotypes BT-1, BT-2 and BT-10 recorded significantly maximum number of branches per plant (7.67). BT 44-2 recorded the highest stem girth (4.45 cm) and BT-2 recorded the lowest stem girth (3.16 cm).

Table 3: Performance of tomato genotypes in respect of growth parameters

Genotypes	Plant height (cm)	Number of branches per plant	Stem girth (cm)
BT-1 (Utkal Pallavi)	48.53	7.67	3.27
BT-2(Utkal Deepti)	49.00	7.67	3.16
BT-10(Utkal Kumari)	48.47	7.67	3.47
BT-101	56.40	6.67	4.03
BT-106	55.60	7.00	3.83
BT-136	56.27	6.33	4.05
BT-317	57.67	7.00	4.05
BT44-2	64.73	6.67	4.45
GM	54.54	7.08	3.79
SE(m)+	2.57	0.30	0.14
CD (0.05)	7.70	0.90	0.43
CV (%)	8.15	7.22	6.57

The performance of the genotypes in respect of yield attributing traits is presented in Table 4. From the data presented in Table 4 it was observed that BT-317 took minimum days (34.33) for 50% flowering. BT-1 recorded maximum number of flower clusters per plant (9.67) than rest of the genotypes and statistically at par with BT-317 (9.0), BT-106 (9.00) and BT-101 (8.33). BT-106 recorded maximum number of flowers per cluster (5.60) and statistically at par with BT-1, BT-317, BT-2 and BT-106. Significantly maximum number of fruits per cluster was recorded by BT-1 (3.67). BT-106 recorded significantly the highest number of fruits per plant (12.88) followed by BT-317 (10.37) and BT-1 (10.16). Maximum fruit length (5.07 cm) was recorded in genotype BT-1. Maximum fruit girth (18.01 cm) was recorded in BT 44-2 and it was statistically at par with BT-101 (17.51 cm). The genotype BT-101 recorded the highest fruit weight of 43.61 g and statistically at par with BT 44-2 (43.49 g). Significantly highest fruit yield was recorded in BT-106 (10.78 kg/plot; 134.75 q/ha) followed by BT-1 (8.67 kg/plot; 108.38 q /ha).

Effects of weather parameters on phenological stages and fruit yield components

The influence of weather parameters on plant height at week intervals is presented in Fig.1. During 1st week (45 DAS) it was observed that BT 44-2 had recorded the maximum plant height (34.40 cm) followed by BT-136 (32.93 cm). The lowest plant height was recorded in BT-1 (19.00 cm). During 2nd week (52 DAS) the maximum plant height (41.07 cm) was recorded in BT 44-2 followed by BT-136 (39.60 cm). The lowest plant height was recorded in BT-1 (24.20 cm). During 3rd week (59 DAS) plant height of genotypes was found to vary from 31.13 cm in BT-1 to 48.27 cm in BT44-2. The percentage increase of plant height in BT 44-2 is 36.35% as compared to 45 DAS. During 4th week (66 DAS) the maximum plant height was recorded in BT 44-2 (54.87 cm) and the lowest plant height was recorded in BT-1 (37.53 cm). During 5th week (73 DAS) plant height of genotypes was found to vary from 41.13 cm to 57.00 cm (BT 44-2) and the lowest was being recorded in BT-1 (41.13 cm). During 6th week (80 DAS) plant height of genotypes was found to vary from 44.80 cm to 57.67 cm. The maximum plant height was recorded in BT44-2 (57.67cm).

During 7th week (87 DAS) BT 44-2 recorded the maximum plant height (64.73 cm) cm) and the lowest plant height was recorded in BT-10 (48.47 cm) instead of BT-1. As per ranking of genotypes it was observed that BT 44-2, BT-317, BT-101, BT-136, BT-106, BT-2, BT-1 and BT-10 secured 1st, 2nd, 3rd, 4th, 5th, 6th, 7th and 8th rank respectively. This result clearly showed that BT 44-2 consistently recorded the maximum plant height. During this observation period the maximum temperature ranged from 33.1 to 35.7 ^{0}C; the minimum temperature ranged from 17.2 to 25.3^{0}C; relative humidity ranged from 88 to 94 % and evapotranspiration ranged from 3.7 to 5.6 mm.

Observation on number of branches per plant was recorded at 60, 67, 74, 81, 88, 95, 102 DAS and at final harvesting stage (Fig. 2). At 60 DAS, it was observed that BT-106 and BT-317 had recorded the maximum number of branches per plant (3.00). The lowest number of branches was recorded in BT-136 (1.67). BT-106 recorded maximum number of branches per plant (4.00) at 67 DAS. At 74 DAS BT-136 recorded the maximum number of branches per plant (4.67) followed by BT-106 (4.33). At 81 DAS BT-317 recorded the maximum number of branches per plant (6.67) followed by BT-106 (6.33).

Table 4: Performance of tomato genotypes in respect of fruit yield components

Varieties	Days to 50 % flowering	No. of flower clusters per plant	No. of flowers per cluster	No. of fruits per cluster	No. of fruits per plant	Fruit length (cm)	Fruit girth (cm)	Fruit weight (gm)	Fruit yield (kg/plot)	Fruit yield (q/ha)
BT-1 (Utkal Pallavi)	41.33	9.67	5.53	3.67	10.16	5.07	11.63	25.45	8.67	108.38
BT-2 (Utkal Deepti)	39.00	5.67	5.40	2.33	9.27	3.67	11.54	22.45	4.72	59.00
BT-10 (Utkal Kumari)	36.00	7.00	5.33	2.33	6.68	3.79	14.73	36.85	7.61	95.13
BT-101	38.33	8.33	5.27	2.00	5.20	4.61	17.51	43.61	6.13	76.63
BT-106	39.00	9.00	5.60	2.33	12.88	4.03	14.47	27.39	10.78	134.75
BT-136	35.33	6.00	5.20	1.67	5.50	4.06	14.31	28.07	3.46	43.25
BT-317	34.33	9.00	5.53	2.67	10.37	3.77	14.34	27.80	7.47	93.38
BT-44-2	34.67	4.33	5.20	2.67	4.75	4.19	18.01	43.49	5.73	71.63
GM	37.25	7.38	5.41	2.46	8.10	4.15	14.57	31.89	6.82	85.29
CD (0.05)	2.73	2.15	0.27	0.85	2.28	0.41	0.73	7.75	1.68	21.04
CV(%)	4.19	16.87	2.81	19.85	16.05	5.75	2.86	14.04	14.10	14.09

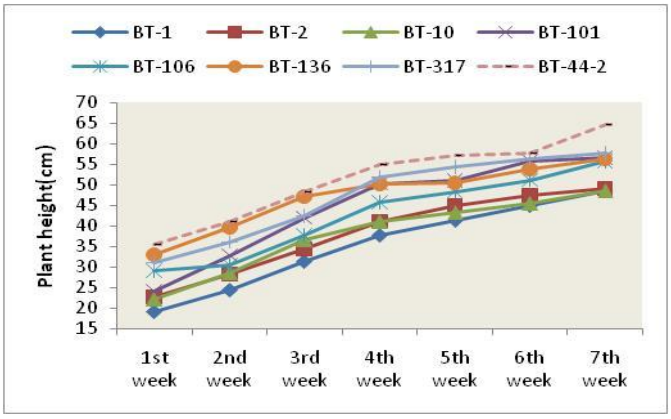

Fig 1: Plant height at week intervals

BT-101, BT-106 and BT-317 recorded maximum number of branches per plant (6.67) at 88 DAS. BT-10, BT-101, BT-106 and BT-317 recorded maximum number of branches per plant (6.67) at 95 DAS. At 102 DAS, BT-2 and BT-10 recorded 7.67 no. of branches per plant followed by BT-1 (7.33). At the time of final harvest BT-1, BT-2 and BT-10 recorded maximum number of branches per plant (7.67) followed by BT-106 and BT-317 (7.00). While taking observation on number of branches per plant at weekly interval it was observed that the maximum temperature ranged from 30.7 to 37.8 ^{0}C; the minimum temperature ranged from 14.1 to 26.0 ^{0}C; relative humidity ranged from 86 to 94 % and evapotraspiration ranged from 3.5 to 7.6 mm.

Observation on number of flower clusters per plant at 40, 47, 54, 61, 68, 75 and 82 DAS is depicted in Fig.3. At 40 DAS, it was observed that BT-106 and BT-317 had recorded the maximum number of flower clusters per plant (2.33). At 47 DAS, the number of flower clusters per plant was found to vary from 2.00 to 3.67.

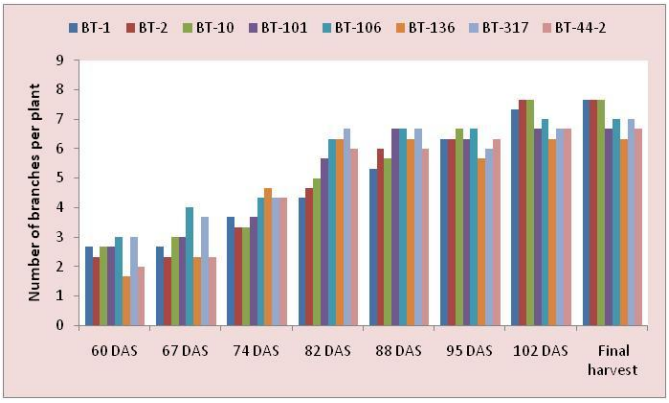

Fig 2: Number of branches per plant at week intervals

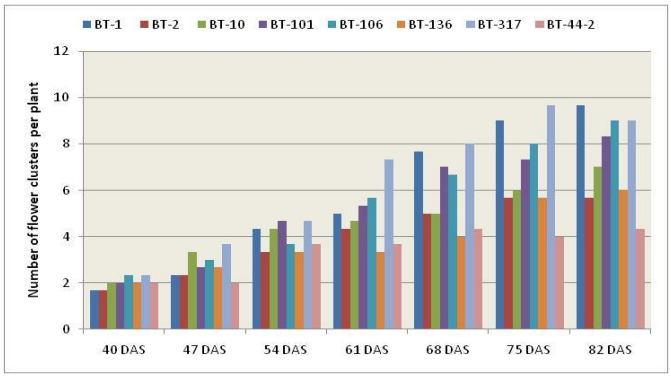

Fig 3: Number of flower clusters per plant at week intervals

The maximum number of flower clusters per plant was recorded in BT-317 (3.67) followed by BT-136 (3.00). The lowest number of flower clusters per plant was recorded in BT 44-2 (2.00). At 54 DAS, the maximum number of flower clusters per plant was recorded in BT-101(4.67) and BT-317. At 61 DAS, BT-317 recorded the maximum number of flower clusters per plant (7.33) followed by BT-106 (5.67). The lowest number of flower clusters per plant was recorded in BT-136 (3.33). At 68 DAS, number of flower clusters per plant was found to vary from 4.00 to 8.00. The maximum number of flower clusters per plant was recorded in BT-317 (8.00) followed by BT-1 (7.67). The lowest number of flower clusters per plant was recorded in BT-136 (4.00). At 75 DAS, the maximum number of flower clusters per plant was recorded in BT-317 (9.67) followed by BT-1 (9.00). At 82 DAS, number of flower clusters per plant was found to vary from 4.33 to 9.67. The maximum was being recorded in BT-1 (9.67) followed by BT-317 (9.00) and BT-106 (9.00). The lowest number of flower clusters per plant was recorded in BT 44-2 (4.33). While taking observation on number of flower clusters per plant at weekly interval it was observed that the maximum temperature ranged from 29.2 to 33.6 **^{0}C;** the minimum temperature ranged from 12.7 to 17.6 **^{0}C**; relative humidity ranged from 83 to 95 % and evapotraspiration ranged from 3.5 to 3.7 mm.

Observation on number of fruits per plant was taken at 60, 67, 74, 81 and 88 DAS. (Fig. 4). At 60 DAS, it was observed that BT-317 had recorded maximum number of fruits per plant (3.33) followed by BT-10 and BT 44-2 (2.33) while the lowest number of fruits per plant was recorded in BT-1 (1.00). At 67 DAS, the maximum number of fruits per plant was recorded in BT-317 (6.00) followed by BT-10 (4.00) while the lowest number of fruits per plant was recorded in BT-1 (2.00). At 74 DAS the maximum number of fruits per plant was recorded in BT-317 (7.67) followed by BT-2 (6.00) while the lowest number of fruits per plant was recorded in BT-136 (3.67). At 81 DAS, number of fruits per plant was found to vary from 4.33 to 10.67. The maximum number of fruits per plant was recorded in BT-1(10.67) and BT-317 (10.67) followed by BT-106 (8.33). At 88 DAS, the data recorded on the number of fruits per plant revealed that BT-106 had the highest number of fruits per plant (12.88). The second highest number of fruits per plant was observed in BT-317 (10.37) followed by BT-1 (10.16). From this observation it was revealed that BT-317 gave consistently the highest number of fruits per plant. While taking observation on number of fruits per plant at weekly interval it was observed that the maximum temperature ranged from 33.1 to 35.7 ^{0}C; the minimum temperature ranged from 17.4 to 22.8 ^{0}C; relative humidity ranged from 92 to 94 % and evapotraspiration ranged from 3.7 to 5.0 mm.

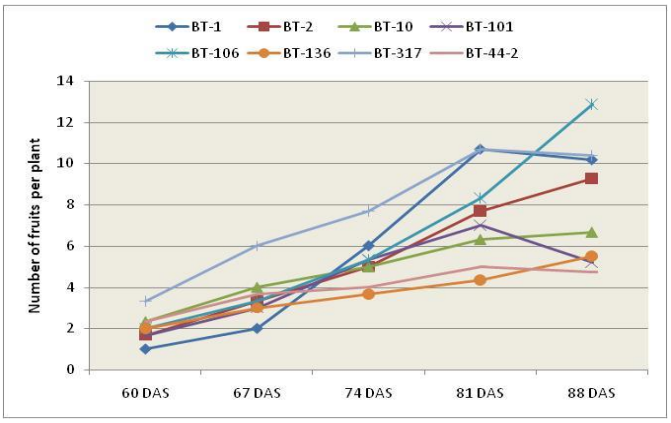

Fig 4: Number of fruits per plant at week intervals

Influence of weather parameters on fruit yield per plot is presented in Fig. 5. During 1st picking fruit yield ranged from 1.010 kg to 3.330 kg. BT-317 secured the 1st rank (3.330 kg) followed by BT 44-2 (2.763 kg) while minimum yield was recorded in BT-2 (1.010 kg). During 2nd picking BT-317 recorded the maximum yield (5.118 kg) followed by BT-106 (4.261 kg) while the minimum yield was recorded in BT-1 (1.748 kg). During 3rd picking BT-106 surpassed BT-317 and recorded the highest fruit yield (4.119 kg) followed by BT-317 (2.760 kg). During 4th picking BT-106 gave the highest fruit yield (4.833 kg) followed by BT-1 (4.805 kg). During 5th picking fruit yield ranged from 0.449 kg to 4.566 kg. The highest fruit yield was recorded in BT-1 (4.566 kg) followed by BT-106 (3.647 kg) while the minimum yield was recorded in BT-136 (0.449 kg). During 6th picking fruit yield ranged from 0.871 kg to 5.167 kg. Maximum fruit yield was recorded in BT-106 (5.167 kg) followed by BT-1 (4.632 kg) while the minimum yield was recorded

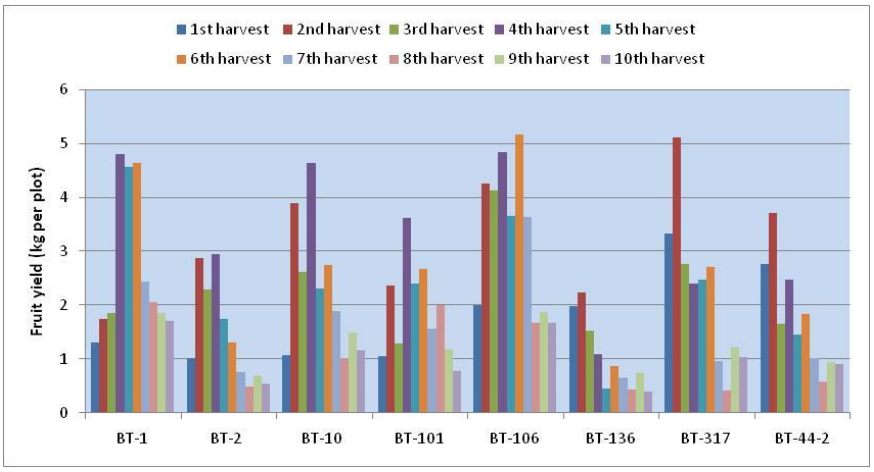

Fig 5: Fruit yield (kg) per plot of the genotypes at week intervals

in BT-136 (0.871 kg). During 7th picking fruit yield ranged from 0.655 kg to 3.640 kg. Maximum fruit yield was recorded in BT-106 (3.640 kg) followed by BT-1 (2.431 kg). During 8th picking fruit yield ranged from 0.424 kg to 2.061 kg. Maximum fruit yield was recorded in BT-1 (2.061 kg) followed by BT-106 (1.670 kg) while the minimum yield was recorded in BT-317 (0.424 kg). At 9th picking the top most yielder was BT-106 (1.871 kg) and the 2nd top most yielder was BT-1 (1.861 kg). At final harvest BT-1 secured 1st rank (1.716 kg) followed by BT-106 (1.665 kg).Starting from 1st picking to final picking it was observed that the maximum temperature ranged from 33.1 to 35.7 ^{0}C; the minimum temperature ranged from 21.6 to 25.3^{0}C; relative humidity ranged from 88 to 94 % and evapotraspiration ranged from 4.1 to 5.6 mm.

Correlation co-efficient analysis between weather parameters and different traits

Association of different traits with weather parameters is presented in Table 5. From the data it was revealed that plant height of the genotypes showed high positive correlation with minimum temperature (0.871), weak positive correlation with maximum temperature (0.337) and negative correlated with relative humidity and evapotranspiration (-0.525 and -0.644). Number of branches per plant had high positive correlation with minimum temperature (0.892), positive correlation with maximum temperature (0.598) and evapotranspiration (0.761) and negative correlation with relative humidity (-0.978). Number of flower clusters per plant had high positive correlation with minimum temperature (0.865), weak positive correlation with maximum temperature (0.228) and negative correlation with relative humidity and evapotranspiration (-0.582 and -0.560). Number of fruits per plant showed positive association with minimum temperature (0.445), weak positive correlation with relative humidity and evapotranspiration (0.182 and 0.127) and negative correlation with maximum temperature (-0.440). As yield is a complex trait so it depends not only on number of fruits per plant but also on average fruit weight which decreases due to increase in maximum temperature, minimum temperature and evapotranspiration. These three weather parameters reduce the average fruit weight and thereby reduce the yield. Relative humidity had shown positive effect on fruit weight and it increased fruit yield.

Table 5: Association of different traits with weather parameters

Character	Weather parameters			
	Max. Temp.	Min. Temp.	RH	ET
Plant height (cm)	0.337	0.872	-0.525	-0.645
No. of branches per plant	0.598	0.892	-0.979	0.762
No. of flower clusters per plant	0.228	0.865	-0.582	-0.560
No. of fruits per plant	-0.440	0.446	0.182	0.128

Association of weather parameters with fruit yield is presented in Table 6. All the genotypes showed negative correlation with maximum temperature. Fruit yield showed negative correlation with minimum temperature and evapotranspiration in case of all the genotypes except BT-1. Fruit yield showed positive association with relative humidity in case of all the genotypes except BT-1 and BT-101. Average fruit yield showed weak positive correlation with relative humidity (0.303), negative correlation with maximum temperature (-0.331), minimum temperature (-0.329) and evapotranspiration (-0.662) and these results are clearly reflected in Fig. 7, 8, 9 and 10.

Table 6: Correlation coefficient between fruit yield and weather parameters

Genotypes	Yield			
	Max. Temp.	Min. Temp.	RH	ET
BT-1 (Utkal Pallavi)	-0.039	0.525	-0.239	0.062
BT-2 (Utkal Deepti)	-0.215	-0.445	0.272	-0.742
BT-10 (Utkal Kumari)	-0.093	-0.140	0.064	-0.495
BT-101	-0.053	0.156	-0.098	-0.293
BT-106	-0.224	-0.071	0.133	-0.424
BT-136	-0.525	-0.907	0.724	-0.756
BT-317	-0.514	-0.750	0.635	-0.798
BT-44-2	-0.567	-0.721	0.659	-0.782
Average	-0.331	-0.329	0.304	-0.663

Predicting the response of tomato genotypes to changing weather parameters

Multiple regression analysis in respect of phenological stages and yield attributes was performed to predict the response of tomato genotypes to changing weather parameters (Table 7). From the regression equation, it is evident that per unit increase/ decrease in the minimum temperature the plant height increases/decreases by 2.863 units. The minimum temperature explains 76.01% of the variation in plant height. Number of branches/plant depends on relative humidity and evapotranspiration; number of flower clusters per plant depends on minimum temperature and it explains 74.90 % of the variation in number of flower clusters per plant. Number of fruits per plant depends on minimum temperature and evapotranspiration and these two parameters together explain 62.3 % of the variation in number of fruits per plant.

Table 7: Multiple regression equation for different attributes

genotype	Regression equation	R^2-value
Plant height	$-17.57 + 2.863\ x_2$	0.7601
No. of branches/ plant	$58.605 - 0.611\ x_3 + 0.3143\ x_4$	0.9582
No. of flower clusters/ plant	$-7.211 + 0.5703\ x_2$	0.7490
No. of fruits/ plant	$-5.788 + 0.415\ x_2 - 0.272\ x_4$	0.6230

x_1- T_{max} x_2- T_{min} x_3- RH x_4- ET

Multiple regression equation for predicting fruit yield in different genotypes is shown in Table 8. Fruit yield in case of BT-1 depended on minimum temperature and evapotranspiration; in BT-2 and BT-10 yield depended on relative humidity and evapotranspiration; BT-101 and BT-106 did not execute their response to environmental factors ; BT-136 depended only on minimum temperature; BT-317 and BT 44-2 depended only on evapotranspiration. This result indicated that the genotypes were not uniform in their yield response to weather parameters and showed variable response. The average yield over genotypes showed dependency on minimum temperature and evapotranspiration under late *rabi* planting condition.

Table 8: Multiple regression equation for predicting yield in different genotypes

Character	Regression equation	R^2- value
BT-1 (Utkal Pallavi)	$-21550 - 1450.72\ x_2 - 1870.20\ x_4$	0.734
BT-2 (Utkal Deepti)	$47319 - 433.47\ x_3 - 1203.80\ x_4$	0.787
BT-10 (Utkal Kumari)	$62768 - 591.63\ x_3 - 1311.70\ x_4$	0.506
BT-101	-	-
BT-106	-	-
BT-136	$9681.34 - 349.21\ x_2$	0.823
BT-317	$8913.86 - 1054.10\ x_4$	0.637
BT 44-2	$6371.11 - 732.28\ x_4$	0.611
Average	$-404.35 + 365.332\ x_2 - 1035.9\ x_4$	0.601

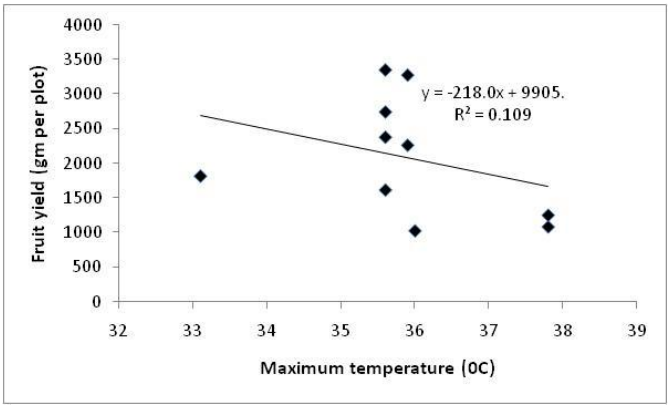

Fig 7: Scatter plot showing relationship between fruit yield and maximum temperature

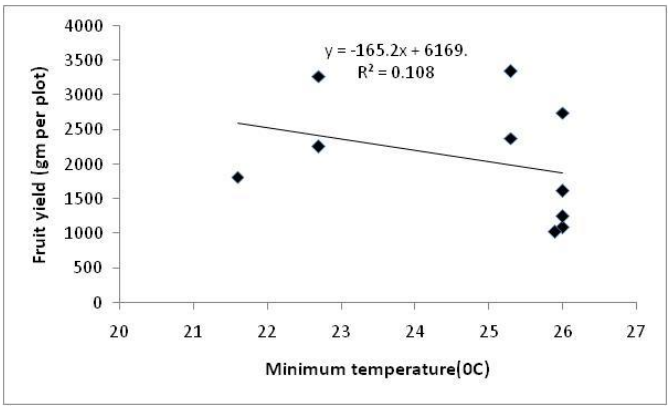

Fig 8: Scatter plot showing relationship between fruit yield and minimum temperature

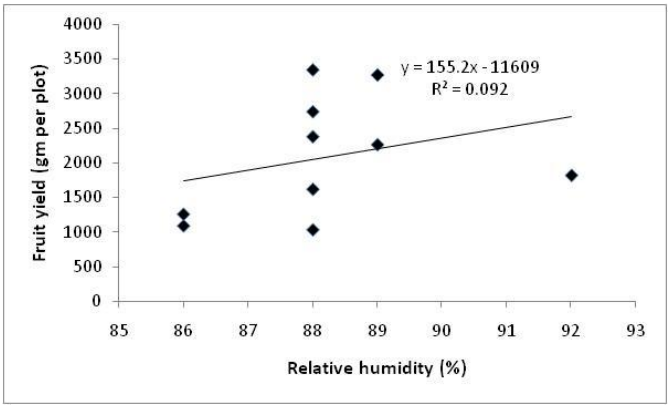

Fig 9: Scatter plot showing relationship between fruit yield and relative humidity

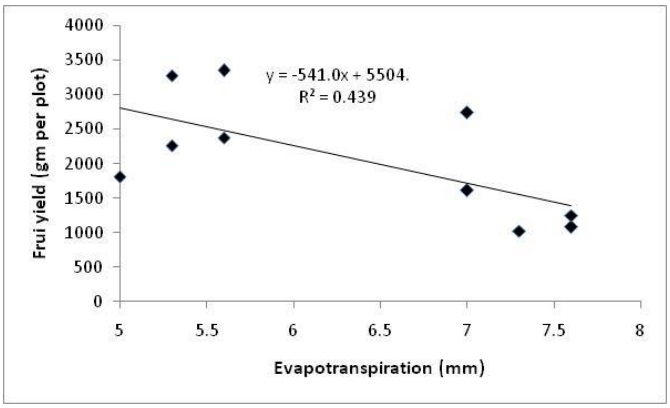

Fig 10: Scatter plot showing relationship between fruit yield and evapotranspiration

The present investigation dealt with the effect of weather parameters on growth and yield of tomato. The important weather variables considered for the present study were maximum temperature, minimum temperature, relative humidity and evapotranpiration. Several studies were made by others to visualize the effect of weather parameters on different vegetable crops. Hurd and Graves (1985) [6] suggested that by elevating the temperature often increases the fruit growth rate, but it has a greater effect in hastening maturity and, as a result, the final mean weight of tomato fruits is reduced. De Koning (1990) [5] suggested that plants exposed to a fluctuating temperature regime often suffer no overall loss of yield when compared with those grown in a constant regime having the same mean temperature. Adams *et al.* (2001) [1] studied the effect of temperature on growth and development of tomato fruits and their results revealed that tomato fruits ripened at 95, 65, 46 and 42 days after flower opening when plants were grown under controlled environmental conditions at 14, 18, 22 and 26^{0}C respectively. Ploeg and Heuvelink (2005) [11] reported that temperature had a large effect on all aspects of development. At sub-optimal temperatures, fruit set was reduced as a result of poorer pollen quality. Growth rate of the fruit at a certain developmental stage was independent of temperature; fruits became larger at sub-optimal temperature. Tshiala and Olwoch (2010) [15] investigated the relationship between tomato production, monthly average temperature and seasonal average. The results showed that tomato yield could be increased by application of robust farming practices and improved technology. However, from the trend analysis, results demonstrated that there are possible negative impacts of climate change on crop yield, especially on farmers without advanced technology and good modern agricultural practices. Oladitan and Akineseye (2014) [9] studied the influence of weather elements on phenological stages and yield of tomato varieties in rainforest ecological zone of Nigeria. In the present experiment fruits yield showed positive correlation with relative humidity. Sarada *et al.* (2015) [14] reported that the mean minimum temperature and annual rainfall had significant positive correlation on the chilli production and productivity in Guntur district whereas the mean maximum temperature and mean sun shine hours had negative correlation with production and productivity of chilli. In the present investigation it was reported that BT-106 was the highest yielder (134.75 q/ha) under late rabi planting condition. Besides BT-106 did not show its dependency with any environmental variables which indicated that it was somehow stress tolerant. Nandi *et al*. (2017) [8] while evaluating the performance of tomato genotypes BT-1, BT-2, BT-10, BT-101, BT-106, BT-136 and BT-317 during rainy season reported that BT-106 was the topmost yielder (106.70 q/ha).

From this study it may be concluded that BT-106 and BT-1 performed well under late *rabi* planting condition. The maximum temperature which is an important weather parameter has no impact on fruit yield, however, combined weather parameters i.e. minimum temperature and evapotranpiration showed effect on fruit yield of tomato under late *rabi* planting condition in coastal plain zone of Odisha.

Fig 11

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