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DA Mutkule
Department of Agricultural Meteorology, Vasantrao Naik Marathwada Agriculture University, Parbhani, Maharashtra, India

RA Jadhav
Department of Agricultural Meteorology, Vasantrao Naik Marathwada Agriculture University, Parbhani, Maharashtra, India

AM Khobragade
Department of Agricultural Meteorology, Vasantrao Naik Marathwada Agriculture University, Parbhani, Maharashtra, India

Correspondence
DA Mutkule
Department of Agricultural Meteorology, Vasantrao Naik Marathwada Agriculture University, Parbhani, Maharashtra, India

Influence of different thermal regimes and phenophases on fruit yield of tomato varieties

DA Mutkule, RA Jadhav and AM Khobragade

Abstract
An experiment was carried out in factorial randomized block design with three replication and eight treatments. The two varieties of tomato *viz.* Phule raja and PKM-1 were planted with four different dates of sowing D_1-1st September (35-MW), D_2- 15th September (37- MW), D_3- 30th September (39- MW) and D_4- 14th October (41- MW) during 2014-15 at VNMKV Parbhani. The influence of thermal regimes and phenology were studied in tomato with different dates of sowing. Among the different thermal regimes on phenology of tomato the significantly less days of flowering (35) and maximum days to flowering (58), days to first maturity (94) and days to end of first harvest (110) were recorded in second date of sowing (D_2) as compare to other treatments. In case of different thermal regimes on mean maximum and minimum air temperature at different stages of phenophase, D_2 (15th September) period found congenial condition for getting maximum fruit yield in Phule raja (411.10q/ha) as compared to PKM-1(369.44 q/ha). It is also confirmed that correlation between fruit yield and weather, the phenophase (P_1) was positively correlated with RH-I, RH-Mean and rainfall. Whereas, fruit yield was noticed positive correlation in phenophase P_2.

Keywords: Thermal regimes, tomato, weather parameters, correlation, maturity, sowing dates

Introduction
Tomato (*Lycopersicon esculentum* Mill.) is one of the most important vegetable crops which belongs to family *solanaceae and* believed to be the native of Western South America. Total area under tomato crop in India is assessed to be 777 thousand ha with the production of 18286 TMT. In Maharashtra tomato is cultivated over an area of 35.45 thousand ha with the production 762.16 TMT. Tomato during *rabi* season is often affected by temperature fluctuation in Parbhani district. Thermal stress during *rabi* season reduces the duration of each developmental stage and thereby the productivity. Effect of different thermal stress on crop phisiology is expressed directly on the phenology. Present paper reports the influence of different thermal regimes on mean maximum and minimum air temperature, correlation coefficient between tomato fruit yield and weather parameters prevailed in different phenophases of tomato varieties at Parbhani district. Climate is primary determinant of agricultural productivity and as such, it influences types of vegetation. In agriculture is a complex sector involving different driving parameters (such as physical, environmental, economic and social). It is now well recognized that crop production is very sensitive to weather condition. Tomato is a tender perennial crop, which is susceptible to frost as well as high temperature, but it is being grown in a variety of climatic conditions. Tomatoes grown best under temperature of 20.0-27.0 ^{0}C. Fruit setting is poor when average temperature exceeds 30.0 ^{0}C or fall below 10.0 ^{0}C. (Bushra *et.al*. 2012).The growth and development of any crop including tomato are influenced by three major regimes viz. moisture, thermal and light regimes. The thermal regime influences the development activities in a crop while light regime influences its growth. (Nasser-U-Rahman 2008). Thermal stress during *rabi* season reduces the duration of each developmental stage and thereby the productivity. The temperature fluctuations affect the quality of fruit besides studied duration.

Materials and Methods
A field experiment was laid out in Rabi season of 2014-2015 at department of Horticulture, VNMKV, and Parbhani. Raised beds of 6m x 1m (L x B) size were prepared. The upper layer of 5 cms of each raised bed was mixed with equal quality of well rotten farmyard manure and sieved soil. Seeds were sown in rows at 10 cms apart on 4 different dates of sowing i.e. 1st September 2014 (35-MW), 15th September 2014 (37-MW), 30th September 2014 (39-MW) and 14th October 2014 (41MW) at 15 days intervals. Watering was done regularly by rose-can. Raised beds were kept clean by weeding regularly. 40 days old seedlings were

transplanted in the main field. The experiment was laid out with two varieties of tomato and four dates of sowing. Present investigation was conducted to provide correlation coefficient between tomato fruit yield and weather parameters prevailed in different phenophases of tomato. Varieties: 1.Phule raja, 2. PKM-1 Phenological observations were recorded on duration for transplanting to first flowering, flowering to fruit setting, fruit setting to maturity and maturity to harvest. The experimental details are given below.

Sl No.	Dates of sowing	Notation
1	1st September	D_1
2	15th September	D_2
3	30th September	D_3
4	14th October	D_4

Results and Discussion

Effect of different thermal regimes on phenology of tomato varieties presented in table 1. In case of Phule raja variety D_1 (35- MW) required maximum number of days to end of first harvest whereas D_4 (41-MW) required minimum number of days to end of first harvest. In case of PKM-1 D_1 (35-MW) required maximum number of days to end of first harvest whereas D_4 (41-MW) required minimum number of days to end of first harvest.

Maximum and minimum air temperature were recorded every day and the mean values at different growth stages of the two varieties of tomato during the four dates of sowing have been computed and are showed in table 2. The mean temperature during the period from transplanting to first flowering revealed that the mean temperature were highest in D_1 (35-MW) followed by in D_2 (37-MW), D_3 (39-MW) and D_4 (41-MW). This is clear indication during initial stages, the temperature were highest as compared to other dates. Same situation was observed during the period from flowering to fruit setting. But the temperature, both maximum and minimum temperature was highest in late sown crops from fruit setting to maturity and maturity to harvest.

Varietal treatment Phule raja the average maximum temperature during the period from fruit setting to maturity in D_1 was 28.7 ^{0}C and it gradually increased in D_3 (39-MW) and D_4 (41-MW) with averages 29.8^{0}C, 32.2 ^{0}C respectively. This indicates that during the maturity period there was thermal stress at later dates of sowing. Similarly the average minimum temperature during the period from maturity to harvest of variety Phule raja at D_1 was 10.1^{0}C and again it gradually increased in D_2, D_3 and D_4 with average values of 13.6^{0}C, 13.7^{0}C and 14.4 ^{0}C respectively. Similar trend was also found in PKM-1 variety. Similar result was observed by Gote *et al.* (2006).

Table 1: Effect of different thermal regime on phenology of tomato varieties

Dates of sowing	Days to first flowering(P_1)	Days to first fruiting(P_2)	Days to first maturity(P_3)	Days to end of first harvest(P_4)
Phule raja				
(D_1) 01/09/2014	40	56	91	111
(D_2) 15/09/2014	35	58	94	110
(D_3)30/09/2014	37	54	93	109
(D_4) 14/10/2014	42	59	91	102
PKM-1				
(D_1) 01/09/2014	39	54	90	112
(D_2) 15/09/2014	36	60	95	110
(D_3) 30/09/2014	38	58	91	109
(D_4) 14/10/2014	40	54	89	100

Table 2: Effect of different thermal regime on mean maximum and minimum air temperature at phenophase different stages of tomato varieties

Dates	D_1(01/09/2014)		D_2(15/09/2014)		D_3(30/09/2014)		D_4(14/10/2014)	
Temperature(^{0}C)	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
P_1(Mean temperature during transplanting to first flowering)								
Phule raja	33.0	18.3	31.9	16.1	31.2	14.5	29.5	10.9
PKM-1	33.1	17.6	31.8	15.9	30.7	13.6	29.6	10.6
P_2(Mean temperature during flowering to fruit setting)								
Phule raja	31.4	11.8	30.0	11.0	28.1	8.9	28.3	8.6
PKM-1	31.3	14.3	30.0	11.1	28.0	11.2	27.9	9.0
P_3(Mean temperature during fruit setting to maturity)								
Phule raja	28.7	10.8	28.5	10.2	29.8	11.7	32.2	13.5
PKM-1	28.6	10.7	28.2	9.6	29.9	10.9	31.6	13.1
P_4(Mean temperature during maturity to harvest)								
Phule raja	29.5	10.1	31.5	13.6	34.0	13.7	32.0	14.4
PKM-1	29.4	9.9	31.2	13.4	32.5	13.4	32.9	15.4

Effect of dates of sowing

The data on mean fruit yield plant^{-1} and yield hectare^{-1} was influenced significantly by different dates of sowing and yield plant^{-1} and hectare^{-1} significantly more in D_2 (37-MW) (1.125 kg) and (401.17 qt) respectively than other treatment, while less yield of fruit plant^{-1} and hectare1 found in D_4 (41-MW) i.e (0.799 kg) and (295.92 qt) because it was observed that all the growth, yield attributes and yield was drastically reduced under delayed sown condition. This result was similar to Patel *et.al.* (2003).

Response of varieties

The yield of fruit plant^{-1} and hectare^{-1} was influenced significantly by different varieties. The variety V_1 (Phule raja) produced more fruit yield plant^{-1} and hectare^{-1} i.e. (1.122 kg), (411.10 qt) than V_2 (PKM-1) i.e. (1.008kg), (369.44 qt) respectively.

Correlation between fruit yield and weather parameters

The correlation studies were undertaken to assess the impact of different weather parameter prevailed during crop life for

the phonological stages which were important in utilizing the weather resources for the synthesis of yield are considered. The phases studies days after transplanting are days to first flowering (P_1), days to first fruiting (P_2), days to first maturity (P_3), days to end of first harvest (P_4). The correlation coefficient between fruit yield and weather relation prevailed in this stage were estimated and are presented in table 3.

The correlation study was carried out between weather parameters prevailed during P_1 to P_4 stages of different variety under different dates of sowing. The correlation coefficient showing degree of association between fruit yield and weather parameters prevailed during phenophases of tomato variety are presented in table 4. The data revealed that during P_1 stage (i.e. Days to first flowering) rainfall, RH-I and RH-Mean showed significant positive correlation while BSS showed significant negative association with fruit yield however, in this phenophases other weather parameters exhibited non significant association. During P_2 stage (i.e. days to first fruiting) RH-I and RH-II showed significant positive correlation with fruit yield of tomato.

During P_3 stage (i.e. Days to first maturity) no one weather parameters exhibited significant effect on fruit yield. During P4 stage (i.e. Days to end of first harvest) rainfall, rainy day, RH-I and RH-Mean showed significant negative association with fruit yield of tomato. The negative relationship with rainfall during fruit ripening is probably due to rain enhancing fruit drop during the ripening phase. Similar result was found by Weerakkody *et al*. (1997).

Table 3: Mean fruit yield plant^{-1}(kg) and hectare^{-1}(qt) as influenced by different treatments

Treatments	Yield plant-1 (kg)	Yield hectare-1(qt)
Dates of sowing(D)		
D1-MW-35	0.899	322.96
D2-MW-37	1.125	401.17
D3-MW-39	1.011	370.11
D4-MW-41	0.799	295.92
S. Em±	0.08	31.68
CD at 5%	0.25	95.95
Varieties(V)		
V1-Phule Raja	1.122	411.10
V2-PKM -1	1.008	369.44
S. Em±	0.06	22.4
CD at 5%	0.18	67.84
Interaction (D×V)		
S. Em±	0.12	44.8
CD at 5%	N.S.	N.S.

Table 4: Correlation coefficient between tomato fruit yield and weather parameters prevailed in different phenophases of tomato

Weather Parameters	Phenophase stages			
	P_1	P_2	P_3	P_4
Rainfall (mm)	0.786**	0.200	0.561	-0.745*
Rainy day	0.206	0.200	0.561	-0.786**
Max.Temp. (^{0}C)	0.047	-0.143	-0.348	0.307
Min.Temp. (^{0}C)	0.406	-0.137	-0.237	0.299
Mean Temp.(^{0}C)	0.325	-0.139	-0.300	0.240
RH-I (%)	0.691*	0.764**	0.118	-0.866**
RH-II (%)	0.251	0.741*	0.329	-0.487
RH-Mean (%)	0.648*	0.329	0.230	-0.730*
BSS/hrs/day	-0.759*	-0.505	-0.450	0.567

*: Significant at 5% * *: Significant at 1%

P_1: Days to first flowering, P_2: Days to first fruiting, P_3: Days to first maturity, P_4: Days to end of fruit harvest

Conclusion

The thermal regimes on phonologies on different dates of sowing in tomato varieties it is concluded that D_2 date of sowing (15th September) was recorded maximum fruit yield and other parameters. During the studies, in two varieties Phule raja was found significantly superior over PKM-1 for getting maximum fruit yield

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