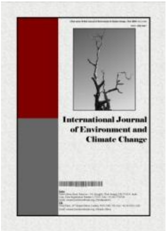

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Impact of Phenophase Wise Climatic Parameters on Growth and Fruit Yield of Autumn Tomato (*Solanum lycopersicum L.*)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted during *kharif* season 2019to study and identify the impact of weather on growth and fruit yield of tomato under open field Crop was planted on eight different dates viz., 02 Jul, 12 Jul, 22 Jul, 02 Aug, 11 Aug, 23 Aug, 03 Sep and 13 Sep as main plots and two cultivars viz., US 440 and TO-3251 (Saaho) as sub-plots in split plot design and replicated thrice. Result revealed that, significantly more yield attributes and fruit yield of tomato was recorded with maximum temperature range of 30.7 to 32.8ºC during vegetative phase, morning Relative humidity (RH) of 88 to 92% during fruit development phase, Vapour Pressure Defficient (VPD) of 0.6 to 0.7 kPa and 0.4 to 0.6kPa during fruit development and harvest phase. Further correlation studies revealed that the most critical weather parameter from fruit initiation to first picking stage was morning RH as this was negatively correlated with drymatter production at fruit development (-0.93**),

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harvest (-0.95**) and total fruit yield (-0.91**) of tomato, which accounted for 86%, 89% and 83% variation in drymatter production during fruit development, harvest phase and total fruit yield respectively.

Keywords: Correlation; drymatter production; fruit yield; regression; tomato; climatic parameters.

1. INTRODUCTION

Tomato is one of the most important protective food crops of India having an area of 880 thousand hectares with an annual production to the tune of 18227 thousand metric tonnes, contributing to 9.4% of total vegetable area and 11.5% of total vegetable production. The productivity of tomato in India (19.6 mt ha^{-1}) is much less than the average productivity (28.2 mt ha-1) of the world [1]. In India tomato is grown an area of 8,76,410 hectares with a production of 17,848,160 MT [2]. In Telangana it occupies an area of 47,070 hectares primarily under irrigated conditions with a productivity of 26.09 t ha^{-1} [3]. Tomato is one of the most valued vegetable crops grown throughout the world owing to its high nutritive value as well as its antioxidant and curative properties [4]. Tomato can play an important role in human diet and known as protective food because of its special nutritive value.

As tomato neutral plant, many varieties are planted round the year. But there is a need to ascertain appropriate planting date to achieve higher quantitative and qualitative yield. The commercial production of tomato particularly grown under open field conditions is severely affected by various weather parameters like temperature, rainfall and humidity, and ultimately affect the yield and quality of fruit. Temperature and relative humidity play a vital role in tomato growth, fruit setting, number of seeds and thereby the shape of fruits [5]. Also yield of tomato was negatively correlated with rainfall. It implies that heavy rainfall during flowering may have led to drop off, the fruit dropping and consequently, declined crop yields [6]. It becomes very essential to find out the best date of transplanting to expose the plants to most conducive atmosphere for growth, fruit setting and quality characters. Any deviation from it may result in poor yield and ill shaped fruits. Hence there is a need to find out critical weather parameters which influence the tomato production [7] as the optimum planting time provides the most optimum environmental condition for growth and development of tomato. Therefore, the experiment was planned with the objectives to find out the optimum planting date of *kharif* tomato and to find out the critical weather parameter which effects the yield and yield attributes of tomato.

2. MATERIALS AND METHODS

A field experiment was conducted in semi arid environment during *kharif* season of 2019 at Agricultural Research Institute farm, PJTSAU, Rajendranagar, Hyderabad having 17^0 19’ N latitude, 78^0 23’ E longitude and 542.3 m above mean sea level (Figure 1). The soil of the experimental site was sandy loam in texture, neutral in reaction, low in available nitrogen, phosphorus and high in available potassium. The crop was planted in eight dates of planting : 02 Jul, 12 Jul, 22 Jul, 02 Aug, 11 Aug, 23 Aug, 03 Sep and 13 Sep as main plots and two cultivars viz., US 440 and TO-3251 (Saaho) as sub-plots in split plot design and replicated thrice. The nursery of 20 days old was transplanted in the main field with a spacing of 60 x 45 cm. A fertilizer dose of 150 kg nitrogen as urea, 90 kg P_2O_5 as diammonium phosphate and 90 kg K_2O as muriate of potash was applied. A basal dose entire P_2O_5 and K_2O was applied and the nitrogen was applied in three equal splits at 30 DAT, 45 DAT and 60 DAT. Other cultural operations and plant protection measures were followed as per the recommendation.

The weather data during experimental period was recorded from the meteorological observatory located at Agricultural Research Institute, Rajendranagar, Hyderabad. The total crop growth period of tomato was devided into four phenophases such as transplanting to first flower (P_1 stage), First flower to fruit initiation (P_2 stage), Fruit initiation to first picking (P_3 stage) and first picking to last picking (P_4 stage) as suggested by Mutkule et al. [8].

Phenophase wise weather parameters like maximum temperature, minimum temperature, mean temperature, morning relative humidity, afternoon relative humidity, rainfall, sunshine hours and vapour pressure deficit were computed and depicted in Fig. 2. The correlation coefficients were worked out between weather parameters during different phenophases with drymatter production, yield attributes and fruit yield of tomato. Regression analysis was carried out considering those weather parameters, which had significant influence on crop growth, yield and yield attributes were entered in this analysis to derive prediction models separately [9].

Fig. 1. Satellite view of the location of the experimental site

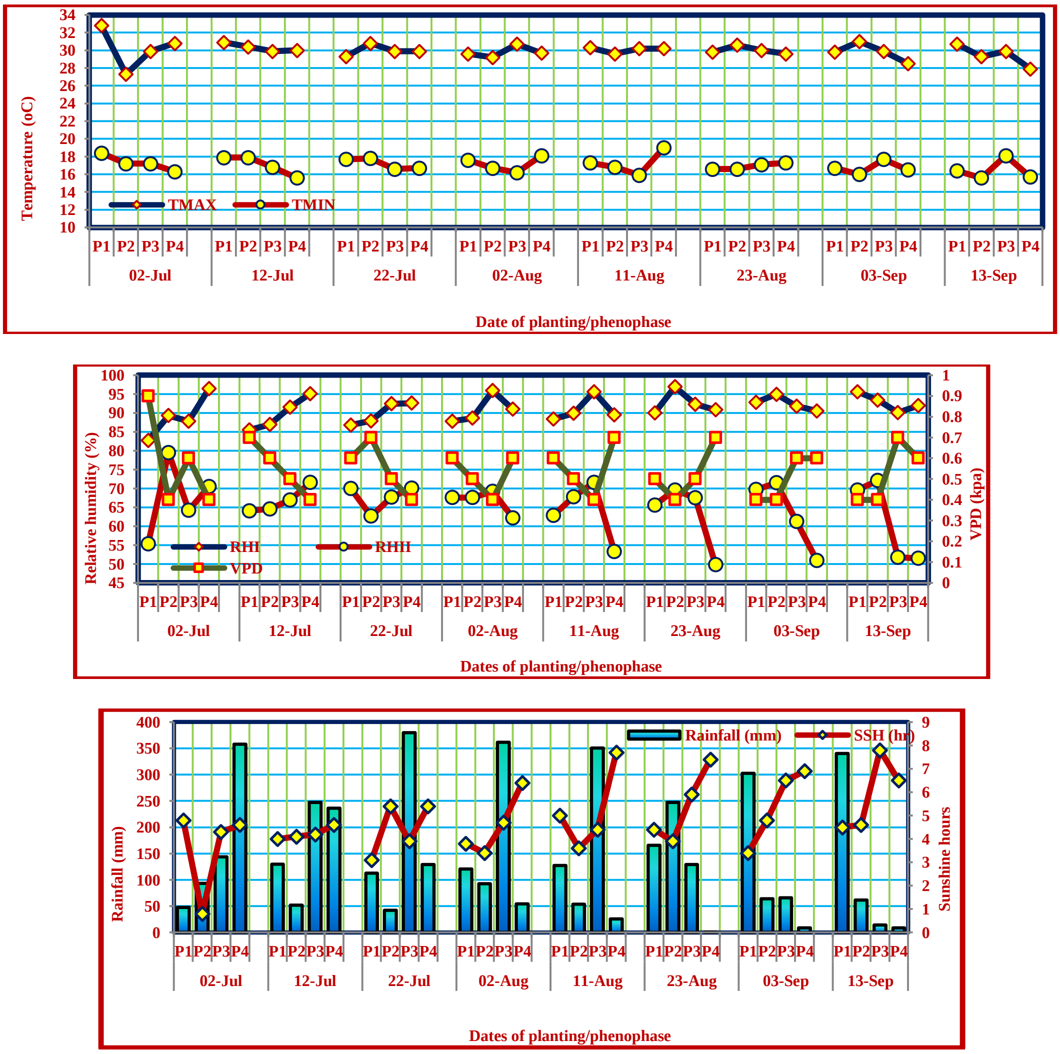

Fig.2. Mean morning and afternoon relative humidity, vapour pressure deficit (VPD), rainfall and sunshine hours during different phenophases of tomato under different dates of planting

3. RESULTS AND DISCUSSION

3.1 Correlations Studies

The correlation studies were undertaken to assess the influence of dry matter production and yield attributes (number of fruits plant^{-1} and average fruit weight) with fruit yield of tomato was calculated and discussed below.

Correlation studies showed that, drymatter production (Table 1) at the vegetative phase (0.61*) was significant and was positively correlated with maximum temperature at the P_1 stage (from transplanting to the first flower). Drymatter production at the flowering phase was significantly positively correlated with maximum temperature (0.62**) and mean temperature (0.50*) at the P_1 stage (from transplanting to the first flower). Dry matter production at the fruit development phase was significantly positively correlated with maximum temperature (0.63**) at P_1 stage (from transplanting to the first flower), afternoon RH (0.48*) at P_2 stage (from the first flower to fruit initiation), and minimum temperature (0.76**), VPD (0.87**) at P_3 stage (from fruit initiation to first picking). However drymatter production at the fruit development phase was significant and negatively correlated with maximum temperature (-0.78**), morning RH (-0.93**), afternoon RH (-0.69**), and rainfall (-0.69*) at P_3 stage (from fruit initiation to first picking). Drymatter production at harvest phase was significantly and positively correlated with maximum temperature (0.68**), mean temperature (0.53*) at P_1 stage (from transplanting to the first flower), minimum temperature (0.75**), mean temperature (0.55*) and VPD (0.87**) at P_3 stage (from fruit initiation to first picking), morning RH (0.74**) and rainfall (0.54*) at P_4 stage (from first picking to last picking). However, drymatter production at the harvest phase was significant and negatively correlated with maximum temperature (-0.74**), morning RH (-0.95**), afternoon RH (-0.67**), rainfall (-0.69**) at P_3 stage (from fruit initiation to first picking) and minimum temperature (-0.88**), mean temperature (-0.69**), SSH (-0.55*) and VPD (-0.61*) at P_4 stage (from first picking to last picking).

Table 1. Correlation coefficients between weather parameters and drymatter and yield of tomato during different phenophases

Growth stage	TMAX	TMIN	TMEAN	Morning Relative Humidity (RHI)	Afternoon Relative Humidity (RHII)	Rainfall (RF)	Sunshine Hours (SSH)	Vapour Pressure Defficient (VPD)
Vegetative phase (Transplanting to first flower)								
P_1	0.61*	0.08	0.45	0.02	-0.24	0.23	0.12	0.17
Flowering phase (First flower to fruit initiation)								
P_1	0.62**	0.15	0.50*	-0.002	-0.22	0.24	0.02	0.19
P_2	-0.24	0.002	-0.19	0.02	0.46	-0.22	-0.17	-0.2
Fruit development phase (Fruit initiation to first picking)								
P_1	0.63**	0.10	0.48	0.04	-0.22	0.28	0.06	0.16
P_2	-0.22	-0.04	-0.20	0.07	0.48*	-0.21	-0.16	-0.24
P_3	-0.78**	0.76**	0.54	-0.93**	-0.69**	-0.69*	0.31	0.87**
Harvest phase (First picking to last picking)								
P_1	0.68**	0.14	0.53*	-0.01	-0.29	0.23	0.1	0.22
P_2	-0.29	-0.03	-0.25	0.07	0.55*	-0.16	-0.24	-0.28
P_3	-0.74**	0.75**	0.55*	-0.95**	-0.67**	-0.69**	0.29	0.87**
P_4	-0.17	-0.88**	-0.69**	0.74**	0.22	0.54*	-0.55*	-0.61*

** Significant at 5% level; ** Significant at 1% level*

Note: P_1= Transplanting to first flower stage; P_2= First flower to fruit initiation stage; P_3= Fruit initiation to First picking stage; P_4 = First picking to last picking; Tmax=Maximum temperature (°C); Tmin= Minimum temperature (°C); Tmean= Mean temperature (°C); RHI= Morning relative humidity (%); RHII= Afternoon relative humidity (%); RF=Rainfall (mm); SSH= Sunshine hours (hr); VPD= Vapour pressure deficit (kPa)

The number of fruits plant^{-1} (Table 2) was positively correlated with maximum temperature (0.63**) during P_1 stage (from transplanting to the first flower), minimum temperature (0.76**), mean temperature (0.54*), VPD (0.87**) at P_3 stage (from fruit development to first picking) and morning RH (0.71**) at P_4 stage (from first picking to last picking). However, the number of fruits plant^{-1} was significant and negatively correlated with maximum temperature (-0.77**), afternoon RH (-0.69**), rainfall (-0.70**) at P_3 stage (from fruit development to first picking) and minimum temperature (-0.90*), mean temperature (-0.73**), SSH (-0.52*) and VPD (-0.59*) at P_4 stage (from first picking to last picking). The average fruit weight was significantly and positively correlated with maximum temperature (0.61*) at P_1 stage (from transplanting to the first flower), afternoon RH (0.49*) at P_2 stage (from the first flower to fruit initiation), and minimum temperature (0.61*) and VPD (0.72**) at P_3 stage (from fruit initiation to first picking) and morning RH (0.60*) at P_4 stage (from first picking to last picking). However, the average fruit weight was significantly and negatively correlated with maximum temperature (-0.68**), morning RH (0.80**), afternoon RH (-0.53**), rainfall (-0.59**) at P_3 stage (from fruit development to first picking), and minimum temperature (-0.70**), mean temperature (-0.54*) and VPD (-0.48*) at P_4 stage (from first picking to last picking). Ajithkumar [10] from Trissur also reported a significant negative correlation of morning RH with the average fruit weight of tomatoes.

Tomato fruit yield (Table 2) was significant and positively correlated with maximum temperature (0.65**), mean temperature (0.49*) at P_1 stage (from transplanting to the first flower), afternoon RH (0.51*) at P_2 stage (from the first flower to fruit initiation) and minimum temperature (0.76**), mean temperature (0.56*) and VPD (0.87**) at P_3 stage (from fruit initiation to first picking) and morning RH (0.71*), rainfall (0.50*) at P_4 stage (from first picking to last picking). Sarada *et al.,* [11] also reported a positive correlation between maximum temperature and fruit yield. Conversely to the above results, tomato fruit yield was significantly and negatively correlated with maximum temperature (-0.73**), morning RH (-0.91**), afternoon RH (-0.70**), rainfall (-0.59**) at P_3 stage(fromfruit initiation to first picking) and minimum temperature (-0.89**), mean temperature (-0.73**), SSH (-0.53*) and VPD (-0.59*) at P_4 stage (from first picking to last picking). Titilayo [6] also found a negative correlation between rainfall and the fruit yield of tomatoes. Ashokrao [12] and Jedrzcyk [13] also reported decreased fruit yield of tomatoes with high rainfall.

3.2 Regression Studies

Regression analysis was carried out between independent weather variables during different phenophases dry matter production and total fruit yield of tomato and was presented in Table 3.

3.2.1 Prediction of dry matter production

3.2.1.1 Model-I

$Y = -91.16 + 2.38P_1Tmax + 0.36P_1RHII$ $R^2 = 0.64$
Y= Predicted drymatter production at vegetative phase
P_1Tmax = Mean maximum temperature (^{0}C) from transplanting to the first flower
P_1RHII = Afternoon relative humidity (%) from transplanting to the first flower

The mean maximum temperature and afternoon RH that prevailed during P_1 stage (from transplanting to the first flower) together accounted for 64% variation in dry matter production at the vegetative phase.

3.2.1.2 Model-II

$Y = -233.66 + 8.09P_1Tmax + 4.58P_2SSH$ $R^2 = 0.77$
Y= Predicted drymatter production at flowering phase
P_1Tmax = Mean maximum temperature (^{0}C) from transplanting to the first flower
P_2SSH = sunshine hours (hr) from the first flower to fruit initiation

Maximum temperature prevailed during P_1stage (from transplanting to the first flower) and Sunshine hours at the P_2 stage (from the first flower to fruit initiation) together accounted for 77% variation in dry matter production at the flowering phase.

3.2.1.3 Model-III

$Y = 555.97 - 5.36P_3RH1$ $R^2 = 0.86$
Y= Predicted drymatter production at the fruit development phase
P_3RH1 = Morning relative humidity (%) from fruit initiation to first picking

Morning RH prevailed during P_3 stage (from fruit initiation to first picking) was the most critical weather parameter, which accounted for 86% variation in dry matter production at fruit development phase.

3.2.1.4 Model-IV

Y= 321.66 - 3.02P_3RH1 R^2 = 0.89

Y= Predicted drymatter production at harvest phase
P_3RH1 = Morning relative humidity (%) from fruit initiation to first picking

Morning RH prevailed during P_3 stage (from fruit initiation to first picking) as the critical weather parameter, which accounted for 89% variation in dry matter production at the harvest phase.

3.2.2 Prediction of fruit yield of tomato

3.2.2.1 Model-V

Y= -29.50 + 10.40P_3Evp, R^2 = 0.94
Y = Predicted fruit yield at first picking
P_3Evp = Evaporation (mm day^{-1}) from fruit initiation to first picking

Evaporation prevailed during P_3 stage (from fruit initiation to first picking) was the critical weather parameter for yield, which accounted for 94% variation in yield at the first picking phase.

3.2.2.2 Model-VI

Y= 764.91 -7.83P_3RH1 R^2 = 0.83
Y= Predicted total fruit yield of tomato
P_3RH1 = Morning relative humidity (%) from fruit initiation to first picking

Morning RH prevailed at P_3 stage (from fruit initiation to first picking) was accounted for 83% variation in total fruit yield.

Table 2. Correlation coefficients between weather parameters during different phenophases and yield attributes and fruit yield of tomato

Growth stage	TMAX	TMIN	TMEAN	RHI	RHII	RF	SSH	VPD
Number of fruits plant^{-1}								
P_1	0.63**	0.08	0.47	0.04	-0.23	0.28	0.09	0.16
P_2	-0.21	-0.03	-0.18	0.09	0.47	-0.16	-0.16	-0.25
P_3	-0.77**	0.76**	0.54*	-0.92**	-0.69**	-0.70**	0.32	0.87**
P_4	-0.22	-0.90**	-0.73**	0.71**	0.19	0.49	-0.52*	-0.59*
Average fruit weight (g)								
P_1	0.61*	0.12	0.48	-0.03	-0.31	0.18	0.16	0.22
P_2	-0.25	-0.02	-0.22	0.08	0.49*	-0.13	-0.23	-0.26
P_3	-0.68**	0.61*	0.41	-0.80**	-0.53*	-0.59*	0.23	0.72**
P_4	-0.11	-0.70**	-0.54*	0.60*	0.16	0.47	-0.43	-0.48*
Fruit yield (kg ha^{-1})								
P_1	0.65**	0.09	0.49*	0.05	-0.24	0.29	0.10	0.16
P_2	-0.25	-0.07	-0.24	0.08	0.51*	-0.18	-0.19	-0.26
P_3	-0.73**	0.76**	0.56*	-0.91**	-0.70**	-0.71**	0.34	0.87**
P_4	-0.23	-0.89**	-0.73**	0.71**	0.19	0.50*	-0.53*	-0.59*

** Significant at 5% level; ** Significant at 1% level*

Table 3. Regression models (simple and multiple) at various growth phases to predict dry matter production and fruit yield of tomato

Model	Growth phase	Regression model	R^2
Model I	Dry matter production at vegetative phase	Y= -91.16 + 2.38P_1Tmax + 0.36P_1RHII	0.64
Model II	Dry matter production at flowering phase	Y = -233.66 + 8.09P_1Tmax + 4.58P_2SSH	0.77
Model III	Dry matter production at fruit development phase	Y= 555.97 - 5.36P_3RH1	0.86
Model IV	Dry matter production at harvest phase	Y= 321.66 - 3.02P_3RH1	0.89
Model V	Fruit yield at first picking	Y= -29.50 + 10.40P_3Evp	0.94
Model VI	Total fruit yield	Y= 764.91 -7.83P_3RH1	0.83

Y = Predicted value, P_1Tmax = Mean maximum temperature (^{0}C) from transplanting to the first flower, P_3RH1 = Morning relative humidity (%) from fruit initiation to first picking, P_1RHII = Afternoon relative humidity (%) from transplanting to the first flower, P_2SSH = sunshine hours (hr) from the first flower to fruit initiation, P_3Evp = Evaporation (mm day^{-1}) from fruit initiation to first picking

4. CONCLUSION

From the above experiment, it was concluded that planting of tomato from 02 Jul to 12 Jul and 13 Sep was recorded significantly more yield attributes and fruit yield due to favourable maximum temperature of 30.7 to 32.8°C during the vegetative phase, morning RH of 88 to 92% during the fruit development phase, VPD of 0.6 to 0.7kPa and 0.4 to 0.6kPa during fruit development and harvest phase. Morning RH from fruit initiation to first picking was found to be a critical weather parameter and was significantly negatively correlated with drymatter production at fruit development (-0.93**), harvest (-0.95**), which accounted for 86%, 89%, and total fruit yield (-0.91**) of tomato and 83% variation in drymatter production during fruit development, harvest phases and total fruit yield (69.5 t ha^{-1}) of tomato respectively.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Anonymous. Indian Horticulture Database. NHB, Department of Agriculture Cooperation, Ministry of Agricultureand Farmers Welfare. Government of India; 2009. Available:http://pphouse.org/ijbsm-article-details.php?article=233.
2. Singh SK, Ashok KT, Sharma HR, ArtiShukla and Upender Singh. Influence of Mulch and Biofertilizer on Growth and Yield of Tomato. Int. J. Bio-res. Stress. Mang. 2014;5(2):186-193.
3. Horticultural Statistics at a Glance. Statistics Division. Government of India; 2018. Avaialble:https://agricoop.nic.in/sites/default/files/Horticulture%20Statistics%20at%20a%20Glance-2018.pdf
4. Kahkashanarzoo, Biswas SK. Effect of Plant Extracts as Seed Treatments on Growth Parameters, Seedlings Mortality and Biochemical Changes in Tomato. Int. J. Bio-res. Stress. Mang. 2013;4(1): 047-053.
5. Sharma NK and Tiwari RS. Effects of dates of planting on growth and yield of Tomato (*Lycopersicon esculentum Mill.)* cv. "Pusa Ruby". Prog. Hort. 1992;24(34):188-191.
6. Titilayo O, Oladitanfolorunso M and Akinseye. Influence of Weather Elements on Phenological Stages and Yield Components of Tomato Varieties in Rainforest Ecological Zone, Nigeria. J. Nat. Sci. Res. 2014;4(12): 19-23.
7. Datta S. Impact of climate change in Indian Horticulture. Int. J. Sci. Environ. Tech. 2013;2:661-671.
8. Mutkule DA, Jadhav RA, Khobragade AM. Influence of different thermal regimes and phenophases on fruit yield of tomato varieties. J. Pharmacog. Phytochem. 2018;1:3029-3031.
9. Draper N.R. and Smith H. Applied regression analysis. John, Wiley and sons, New York;1996.
10. Ajithkumar B. Crop Weather Relationship in Tomato (*Lycopersicon esculentum* Mill.). *Master's research. Thesis.* College of Horticulture, Vellanikkara, Kerala, Thrissur; 1999.
11. Sarada C, Ratnam M, Naram Naidu L, Venkataramana C, Rajani A, Vijayalakshmi T. Chilli production and productivity in relation to seasonal weather conditions in Guntur district of Andhra Pradesh. Int. J. Pure. Appl. Biosci.2015;3(1):207-213.
12. Ashokrao DM. Influence of weather parameters on growth, yield and quality of tomato (*Lycopersico nesculentum* Mill.). *M. Sc. Thesis.* Vasantraonaik marathwada krishi vidyapeeth, Maharashtra; 2015.
13. Jedrszczyk E. Skowera B, Kopcinska J andAmbroszczyk MA. The Influence of Weather Conditions During Vegetation Period on Yielding of Twelve Determinate Tomato Cultivars. Not Bot HortiAgrobo.2012;40(2):203-209.

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