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ORIGINAL ARTICLE

Effect of different transplanting dates and PGR on physiology determining parameters and yield of tomato (*Solanum lycopersicum* L.)

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ABSTRACT
This study was carried out to examine the effect of different transplanting dates and PGR. Salicylic acid (SA) and Auxin (NAA) are the growth regulator that modified plant growth and development by inducing changes in cell processes, physiology and morphology. The experiment consisted of three dates of sowing on 30th November (Normal sowing), 30th December (Late sowing) and 30th January (Very late sowing). Under this experiment determine the effect of high temperature, SA and NAA on various physiology and yield parameters. Results were revealed that yield parameters viz. Chlorophyll content index: (31.18), Membrane injury index (MII %) (29.24 %), Desiccation tolerance (m Mhos sec-1) (1.49), Light transmission ratio (15.99), Energy interception (0.52), Relative water content (74.07 %), Water saturation deficit (25.92 %), Fruit set (69.07 %), Yield per plant (1.15 kg) and Yield (374.70 q/ha), were higher in timely sowing compare to late and very late sowing. May be improved that the recorded by treatment combinations of T5 (50ppm SA + 50ppm NAA) under normal, late and very late sown conditions. Among the treatment combinations Kashi Amrit planted on November 30th emerged as the best combination with regard to physiology determining parameters and yield of tomato. SA and NAA spray treatment mitigates the effect of high temperature on yield and yield attributes traits in tomato with a better result in yield. The findings of this study will not only help in getting economical yield under high-temperature conditions but will also play its role in ensuring food security under a global warming scenario.
Keywords: *Heat stress, PGR, physiological parameters, yield, tomato*

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INTRODUCTION

Tomato (*Lycopersicon solanum* L.) is one of the most important popular fruit vegetable belong to Solanaceae family which is grown throughout the world. It is rich in vitamins and minerals and dietary fibre [12]. High temperature can induce substantial oxidative damage due to the production of reactive oxygen species like superoxide and hydrogen peroxide [9, 10]. Resistance to heat stress involves various complex tolerance and avoidance mechanisms, the membrane is thought to be a site of primary physiological injury by heat [14] and measurement of solute leakage from the tissue can be used to estimate the damage to membranes. Low crop yield and low seed quality are caused by temperature extremes [3]. The effect of different transplanting dates on growth, flowering and fruit yield of tomato. Three transplanting were done at an interval of 10 days. The experimental results showed that different planting dates showed significant influence on growth and reproductive characters of tomato including fruit yield. The first transplanting date, December 10 resulted in improvement of all the attributes including increased plant height (70.22 cm at 60 cm DAT), leaf number (62.3), branch number (9.07), cluster number (17.43), number of flowers plant^{-1} (148.7), fruit number (86.38), number of fruit plant^{-1} (86.08), fruit diameter (5.51 cm), fruit length (6.29 cm) and yield per hectare (66.46 t) compared to 2nd transplanting date, December 20 and 3rd transplanting date, December 30. Therefore, it is suggesting that earlier transplanting produced higher fruit yield of tomato (Afsana at al. 2017). Reported that the effect of foliar spray salicylic acid on the tomato vegetative growth, yield and fruit quality. These factors included salicylic acid in three levels (0.25mM, 0.5mM and 0.75mM) applied on tomato. Results indicated that germination and vegetative & reproductive growth of tomato severely reduced by high temperature. The exogenous applications of salicylic acid improved the yield contributing factors that resulted in significant increases in tomato fruit yield (Singh et al. 2017). Observed that the effect of varying levels of NAA, 2, 4-D and GA3 on growth, quality and yield of tomato and to ascertain the best concentration of NAA, 2, 4-D and GA3 for vegetative growth and fruit quality of tomato. The experiment consisted tomato variety viz. Kashi vishesh (H-86) and different levels of NAA (15, 30, 45 ppm), 2, 4-D (5, 10, 15 ppm) and GA3 (20, 30, 40 ppm) of different concentrations were used. The effect of NAA has been observed mainly as cell elongation, improves phototropism, apical formation, respiration and flower bud initiation Kumar et al. [9].

MATERIAL AND METHODS

The experiment was conducted at Horticulture Complex, Department of Horticulture, College of Agriculture JNKVV, Jabalpur (M.P.) during Rabi season of 2019-20 & 2020. Has been pooled data given the tables based on average both the years. The Jabalpur has situated in the "Kymore Plateau and Satpura Hills" agro-climatic region of Madhya Pradesh. The climate is semi-arid and subtropical, with hot summer and moderately cool winter. with a relative humidity of 80-90%, temperature low to high (6.3°C to 40.1°C) having annual rainfall varies from 1200-1500 mm, with an average of 1350 mm and R.H of 80-90%%. The soil of the experimental plot was categorized as have medium to deep depth and black colour with sandy clay-loam texture with neutral soil reaction and well-drained. The soil of the experimental field was medium black and good a drainage uniform texture. The experiment was laid out in Randomized Complete Block Design (RCBD- Asymmetrical factorial) with three replications. The field experiment consisted of 36 treatments involving the combination of Salicylic acid and NAA. There were two plant growth regulators Salicylic acid (0ppm, 50ppm, 75ppm and 100ppm) and NAA (0pmm, 25ppm and 50ppm) were use with different combinations as a foliar spray at pre-flowering. The experiment consisted of three dates of sowing at 30^{th} November (Normal sowing), 30th December (Late sowing) and 30th January (Very late sowing) with the spacing of 60 cm × 50 cm and NPK @120:50:50 kg per ha was applied as per recommended dose. The recorded physiological parameters were Chlorophyll content index: (SPAD-502), Membrane injury index (%), Desiccation tolerance (m Mhos sec^{-1}), Light transmission ratio, Energy interception, Relative water content (%), Water saturation deficit (%), Fruit set (%), Yield per plant (kg) and Yield (q/ha).

Table 1: Details of treatment

Treatment combinations	Treatment details	Treatment combinations	Treatment details
D1T1 (S1N0) Control	Without application	D1T7 (S3N0)	75 ppm SA + 0 ppm NAA
D1T2 (S1N1)	0 ppm SA + 25 ppm NAA	D1T8 (S3N1)	75 ppm SA + 25 ppm NAA
D1T3 (S1N2)	0 ppm SA + 50 ppm NAA	D1T9 (S3N2)	75 ppm SA + 50 ppm NAA
D1T4 (S2N0)	50 ppm SA + 0 ppm NAA	D1T10 (S4N0)	100 ppm SA + 0 ppm NAA
D1T5 (S2N1)	50 ppm SA + 25 ppm NAA	D1T11 (S4N1)	100 ppm SA + 25 ppm NAA
D1T6 (S2N2)	50 ppm SA + 50 ppm NAA	D1T12 (S4N2)	100 ppm SA + 50 ppm NAA
D2T1 (S1N0) Control	Without application	D2T7 (S3N0)	75 ppm SA + 0 ppm NAA
D2T2 (S1N1)	0 ppm SA + 25 ppm NAA	D2T8 (S3N1)	75 ppm SA + 25 ppm NAA
D2T3 (S1N2)	0 ppm SA + 50 ppm NAA	D2T9 (S3N2)	75 ppm SA + 50 ppm NAA
D2T4 (S2N0)	50 ppm SA + 0 ppm NAA	D2T10 (S4N0)	100 ppm SA + 0 ppm NAA
D2T5 (S2N1)	50 ppm SA + 25 ppm NAA	D2T11 (S4N1)	100 ppm SA + 25 ppm NAA
D2T6 (S2N2)	50 ppm SA + 50 ppm NAA	D2T12 (S4N2)	100 ppm SA + 50 ppm NAA
D3T1 (S1N0) Control	Without application	D3T7 (S3N0)	75 ppm SA + 0 ppm NAA
D3T2 (S1N1)	0 ppm SA + 25 ppm NAA	D3T8 (S3N1)	75 ppm SA + 25 ppm NAA
D3T3 (S1N2)	0 ppm SA + 50 ppm NAA	D3T9 (S3N2)	75 ppm SA + 50 ppm NAA
D3T4 (S2N0)	50 ppm SA + 0 ppm NAA	D3T10 (S4N0)	100 ppm SA + 0 ppm NAA
D3T5 (S2N1)	50 ppm SA + 25 ppm NAA	D3T11 (S4N1)	100 ppm SA + 25 ppm NAA
D3T6 (S2N2)	50 ppm SA + 50 ppm NAA	D3T12 (S4N2)	100 ppm SA + 50 ppm NAA

D1 : 30^{th} Nov. date of sowing (Normal)
D2 : 30^{th} Dec. date of sowing (Let)
D3 : 30^{th} Jan. date of sowing(Very let)
SA : Salicylic acid
NAA : Naphthalene acetic acid

RESULTS AND DISCUSSION

Effect of date of transplanting and foliar spray of plant growth regulator on physiological parameters of tomato

Due to the date of transplanting significant difference was observed for Chlorophyll content index: (SPAD-502), Membrane injury index (%) and Desiccation tolerance (m Mhos sec-1) ($p < 0.001$). The highest Chlorophyll content index first date of transplanting (D1: 30th November). Results revealed recorded was significantly Chlorophyll content index (28.88) and highest significantly was observed for the Membrane injury index (29.32 %), Desiccation tolerance (1.50 m Mhos sec-1) third date of transplanting (D3: 30th January) in average of both years. Similar findings of Singh et al. [16] and Jat et al. [8], reported that the total leaf chlorophyll was found to be significantly higher in normal time of transplanting and Tejpal et al. [20] with findings the membrane injury increased during the vegetative and flowering stages of the crop with delay in transplanting, the lowest Chlorophyll content index was observed for the third date of transplanting (D3: 30th January) was significantly Chlorophyll content index (18.43) and lowest significantly was observed for the Membrane injury index (29.32 %), Desiccation tolerance (1.50 m Mhos sec^{-1}) first date of transplanting (D1: 30th November) in average of both years (Table no. 2), respectively. With respect to foliar spray of plant growth regulator consortium, a significant difference was observed for maximum Chlorophyll content index, Membrane injury index and Desiccation tolerance ($p < 0.001$). The highest Chlorophyll content index was observed for T5 (50 ppm SA and 25 ppm NAA) (31.18) and maximum Membrane injury index and Desiccation tolerance were observed for T1 (Control Without application) in all three stages (39.57 %) and (1.76 m Mhos sec^{-1}) uniformly over in average of both years, respectively. The minimum Chlorophyll content index: T1 (Control Without application), in all stages uniformly over both years, Chlorophyll content index (17.30) and minimum Membrane injury index and Desiccation tolerance were observed for T5 (50 ppm SA and 25 ppm NAA) in all three stages (29.24 %) and (1.49 m Mhos sec^{-1}) uniformly over in average of both years, respectively (Table no. 2). While the lowest value of Membrane injury index and Desiccation tolerance, the more suitable it is for tolerance to high temperature. These results are in accordance with findings of [5, 8], they reported that SA as a foliar spray may increase the chlorophyll content and relative water content [17] in treated plants as compared to untreated plants.

Effect of date of transplanting and foliar spray of plant growth regulator consortium on physiological parameters of tomato

Due to the date of transplanting significant difference was observed for Light transmission ratio, Energy interception, Relative water content (%) and Water saturation deficit (%) in average of both years ($p < 0.001$). Significantly observed for the third date of transplanting (D3) maximum Light transmission ratio (22.41) and Water saturation deficit (36.26 %), while significantly observed for the first date of transplanting (D1) maximum Energy interception (0.52) and Relative water content (75.92 %) in average of both years, respectively. In contrast, significantly observed for the first date of transplanting (D1) minimum Light transmission ratio (17.12) and Water saturation deficit (24.07 %), while significantly observed for the third date of transplanting (D3) minimum Energy interception (0.43) and Relative water content (63.73 %) in average of both years, respectively. The mean relative water content decreased during the vegetative and flowering stages of the crop with delay in sowing [20]. With reported to a foliar spray of PGR consortium, a significant difference was observed for Light transmission ratio, Energy interception, Relative water content (%) and Water saturation deficit (%) ($p < 0.001$) in average of both years. The highest Light transmission ratio (23.95) and Water saturation deficit (40.75 %) was observed due to treatment T1 (Control Without application), while highest Energy interception (0.52) and Relative water content (74.07 %) was observed due to treatment T5 (50 ppm SA and 25 ppm NAA) in uniformly over in average of both years, respectively (Table no. 2). Similar results were also found by Gupta *et al.* [5] and Mohamed *et al.* [11] it was observed that. The lowest Light transmission ratio (15.99) and Water saturation deficit (25.92 %) was observed due to treatment T5 (50 ppm SA and 25 ppm NAA), in all stages uniformly over in average of both years, while minimum Energy interception (0.45) and Relative water content (59.24 %) was observed due to treatment T1 (Control Without application) in all stages uniformly over both years, respectively (Table no. 2). The lowest value of Light transmission ratio and Water saturation deficit the more suitable for tolerance to high temperature due to physiology activity influenced the use of plant growth regulators. Similar results were also found by Parauha et al. [13] it was observed that significantly maximum the sunlight use efficiency (i.e. converting light energy to dry matter) has long been the main research focus to obtain sustainable fruit production and quality in fruit.

Effect of date of transplanting and foliar spray of plant growth regulator consortium on yield of tomato

Significant difference was observed for fruit set (%), yield per plant (kg) and yield (q/ha) in average of both years ($p < 0.001$). Significantly observed for the first date of transplanting (D1) maximum fruit set (70.24 %), yield per plant (1.28 kg) and yield (428.55 q/ha) in average of both years, respectively. In contrast, minimum fruit set (57.15 %), yield per plant (0.44 kg) and yield (148.05 q/ha) were observed for the third date of transplanting (D3) in average of both years (Table no. 3), respectively. At the high temperature regime, significant increase in the flower drop percentage was observed reported by Srivastava et al. [19] with reported the earlier transplanting produced higher fruit yield of tomato Islam et al. [6]. Similar research was observed by Ali et al. [2]. As morphological characters the yield of tomato is also significantly reduced by late transplanting. With reported to a foliar spray of PGR consortium, a significant difference was observed on fruit set (%), yield per plant (kg) and yield (q/ha) ($p < 0.001$) in average of both years. The maximum fruit set, yield per plant and yield were observed due to treatment T5 (50 ppm SA and 25 ppm NAA) uniformly over both the years, fruit set (69.07 %), yield per plant (1.12 kg) and yield (374.70 q/ha), respectively. In contrast, minimum fruit set (58.91 %), yield per plant (0.52 kg) and yield (173.50 q/ha) being observed for the T1 (Control Without application) in uniformly over in average of both years (Table no. 3), respectively. Similar results were also found by Elkader et al. [4], Jakhar et al. [7], Shinwari et al. [15] and Siwna et al. [18] are an application of different plant growth regulators to increase the yield per plant and total yield of tomato. On the basis of research to say that the use of plant growth regulators increases the total yield of tomato and develops the ability to tolerate high temperature.

Table 2. Effect of date of transplanting and plant growth regulator on the Physiological parameters of tomato

Effect of DAT	Chlorophyll content index	Membrane injury index (MII %)	Desiccation tolerance (m Mhos sec^{-1})	Light transmission ratio	Energy interception	Relative water content (%)	Water saturation deficit (%)
Factor A							
D1 (Normal date of transplanting)	28.88	29.32	1.50	17.12	0.52	75.92	24.07
D2 (Late date of transplanting)	22.12	33.80	1.59	17.54	0.47	63.79	36.20
D3 (Very late date of transplanting)	18.43	40.74	1.65	22.41	0.43	63.73	36.26
SEm±	0.08	0.11	0.009	0.061	0.002	0.16	0.10
C.D. (P=0.05)	0.22	0.33	0.027	0.173	0.005	0.47	0.29
Factor B							
T1 (Control Without application)	17.30	39.57	1.76	23.95	0.45	59.24	40.75
T2 (25 ppm NAA)	20.26	38.19	1.64	18.29	0.40	61.68	38.31
T3 (50 ppm NAA)	18.75	37.74	1.62	16.19	0.46	66.23	33.76
T4 (50 ppm SA)	20.22	36.71	1.60	17.70	0.49	67.06	32.93
T5 (50 ppm SA + 25 ppm NAA)	31.18	29.24	1.49	15.99	0.52	74.07	25.92
T6 (50 ppm SA + 50 ppm NAA)	27.28	32.11	1.55	18.06	0.48	69.61	30.38
T7 (75 ppm SA)	22.92	35.14	1.57	20.25	0.47	68.96	31.03
T8 (75 ppm SA + 25 ppm NAA)	23.49	33.17	1.56	19.98	0.50	69.15	30.84
T9 (75 ppm SA + 50 ppm NAA)	24.07	34.01	1.54	20.31	0.47	70.08	29.91
T10 (100 ppm SA)	23.23	34.08	1.57	18.56	0.48	68.49	31.50
T11 (100 ppm SA + 25 ppm NAA)	23.56	32.66	1.53	19.52	0.49	67.91	32.08
T12 (100 ppm SA + 50 ppm NAA)	25.45	32.87	1.55	19.49	0.47	71.29	28.70
SEm±	0.16	0.23	0.009	0.122	0.004	0.33	0.20
C.D. (P=0.05)	0.45	0.66	0.027	0.34	0.010	0.95	0.58

Table 3. Effect of date of transplanting and plant growth regulator on the yield of tomato

Effect of DAT	Fruit set (%)	Yield per plant (kg)	Yield (q/ha)
Factor A	70.24	1.28	428.55
D1 (Normal date of transplanting)	64.05	0.76	254.53
D2 (Late date of transplanting)	57.15	0.44	148.05
D3 (Very late date of transplanting)	0.19	0.003	1.03
SEm±	0.55	0.009	2.92
C.D. (P=0.05)			
Factor B	58.91	0.52	173.50
T1 (Control Without application)	61.58	0.56	189.18
T2 (25 ppm NAA)	63.06	0.65	217.51
T3 (50 ppm NAA)	64.04	0.70	233.50
T4 (50 ppm SA)	69.07	1.12	374.70
T5 (50 ppm SA + 25 ppm NAA)	67.01	0.99	329.64
T6 (50 ppm SA + 50 ppm NAA)	66.38	0.80	268.49
T7 (75 ppm SA)	61.22	0.91	303.74
T8 (75 ppm SA + 25 ppm NAA)	64.37	0.94	313.96
T9 (75 ppm SA + 50 ppm NAA)	63.86	0.86	289.64
T10 (100 ppm SA)	64.22	0.94	315.15
T11 (100 ppm SA + 25 ppm NAA)	62.06	0.94	315.53
T12 (100 ppm SA + 50 ppm NAA)	0.38	0.006	2.07
SEm±	1.10	0.018	5.85
C.D. (P=0.05)			

CONCLUSION

The results concluded that yield of tomato was significantly affected by different sowing dates and plant growth regulators. PGR play important role on physiology and yield attributes of tomato. The finding revealed that treatment T5 (50 ppm SA and 25 ppm NAA) recorded the maximum yield pr plant (kg) and yield (q/ha).

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