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Effect of gibberellic acid on growth, quality and yield of tomato varieties (*Lycopersicon esculentum* Mill.)

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Abstract
An experiment was conducted to find out the effect of different concentration of Gibberellic acid on tomato varieties at Horticulture Farm, RAK College, of Agriculture Sehore, Madhya Pradesh during *Kharif* 2017. The experiment consisted of two tomato variety-Amrutha (V_1) and Abhilash (V_2) with six treatments and five levels of Gibberellic acid (12.5 ppm, 25 ppm, 37.5 ppm, 50 ppm and 62.5 ppm), arranged in randomized block design with three replications. The highest plant height, Number of leaves, Leaf area, No. of Branches, Shoot girth (cm), Number of fruits and Fresh fruit weight has been observed and total soluble solid (TSS) was estimated for GA_3 62.5 ppm.

Keywords: Tomato, *Lycopersicon esculentum Mill.*, GA3 spray, ppm, growth, yield

1. Introduction
Tomato (*Lycopersicon esculentum* Mill.) of the family Solanaceae is said to be native of Peru of South America but occupies an important position among the vegetable crops. Tomato is the most important warm season fruit vegetable grown throughout the world. Among vegetables, tomato occupies 4th position in area and 2nd position in production in India. In India tomato covers an area about 7.9 lac ha with 19.5 MT production and productivity was 23.2 tones/ha. (Anonymous 2016) [1]. In MP tomato covers an area of about 0.70 lac ha with 2.1 MT production and productivity was 30.8 tones/ha. (Anonymous, 2016) [1] Plant growth regulators (also called plant hormones) are numerous chemical substances that profoundly influence the growth and differentiation of plant cells, tissues and organs. Plant growth regulators function as chemical messengers for intercellular communication. In tomato, different growth regulators play a pivotal role in germination, root development, branching, flower initiation, fruiting, lycopene development, synchronization and early maturation, parthenocarpic fruit development, ripening, TSS, acidity, seed production etcetera. To boost the tomato production in India these versatile resources greatly help the professionals and researchers. (Pramanik *et al*., 2017) [9]. The influence in yield and quality may vary greatly depending upon the type of plant growth regulator and their concentration and its method of application. Presently a large number of plant growth regulators are available in the market but their method of application and concentrations may vary crop to crop, season to season and climate to climate. Hence, they are very meager available in this crop. So there is urgent need to identify the most suitable plant growth regulators and their appropriate concentrations to increase yield as well as quality parameters of tomato for higher production and for commercial applications to the farmers. Use of plant growth regulators (PGR's) might be a useful alternative to increase crop production. Recently, there has been global realization of the important role of PGR's in increasing crop yield. GAs constitute a group of plant hormones that control developmental processes such as germination, shoot elongation, tuber formation, flowering, and fruit set and growth in diverse species. The most widely available plant growth regulator is GA_3 or gibberellic acid, which induces stem and internode elongation, seed germination, enzyme production during germination and fruit setting and growth (Davies, 1995). gibberellic acid is an important growth regulator that may have many uses to modify the growth, yield and yield contributing characters of plant (Rafeekher *et al*., 2002).

2. Materials and Methods
This study was conducted at Horticulture Farm, RAK College, of Agriculture Sehore, (Madhya Pradesh) during *Kharif* 2017). The experiment consisted of two tomato variety-Amrutha (V_1) and Abhilash (V_2). The tomato verities seeds were sown in nursery on July 15, 2017. Healthy seedlings of about one-month old were used for transplanted in the

experimental plots. Total six treatments and five levels of Gibberellic acid (12.5 ppm, 25 ppm, 37.5 ppm, 50 ppm and 62.5 ppm), arranged in randomized block design with three replications. and six treatments (T0- water spray, T_1- 12.5 ppm GA_3, T_2- 25 ppm GA_3, T_3- 37.5 ppm GA_3, T_4- 50 ppm GA_3, T_5- 62.5 ppm GA_3. The required weight of the PGRs was taken using electronic sensitive balance and solution was prepared by dissolving in 1 mg L-1. The solution was poured into hand-held sprayer and was directly sprayed on the plants two times at 20 and 40 days after transplanting. Spraying was performed early in the morning to avoid rapid drying of the spray solution, due to transpiration. All the recommended cultural practices were followed during the conduction of the experiment. Data were collected from selected plants in the rows. The collected data includes average plant height (cm), average number of leaves, average number of fruits, average fresh fruit weight (kg), total soluble solids (°Brix). Statistical analysis of the data was worked out using Randomized Block Design (Factorial) and Completely Randomized Block Design (Factorial) for each character and treatment were compared by critical difference at five percent and one percent levels of significance.

3. Results and Discussions

3.1 Plant height (cm): The plant height per plant at maturity of the crop is presented in (Table- 1). The effect of different concentration GA_3 was significant for plant height. The plant height increases with the advancement in growth stage up to at maturity. It was observed that application of GA_3 concentration increase plant height significantly as compared to control (84.30 & 83.76) at maturity treatment V1H6 and treatment V2H6 had significantly the tallest plants (90.18cm, and 87.84cm) and it was at par with other treatments.

3.2 No. of Branches/plant: The number of branches per plant at maturity of the crop is presented in (Table-1). The treatment V1H6 (25.15) and treatment V2H6 (25.03) exerted significant effect on number of branches per plant over other treatments. However treatment V1H5 (24.10) produced higher number of branches as well as V2H5 (23.37) produced higher number of branches per plant at maturity. An increasing trend in number of branches per plant was observed with the increase in concentration of plant growth regulators. Different in combination of plant growth regulators there was a corresponding increment in number of branches per plant and each increment was found statistically significant. Tomar and Ramgiry (1997) and Rai *et al.* (2006) [10] reported that tomato plant treated with 50 ppm GA3 showed significantly higher number of branches per plant than untreated control.

3.3 No. of leaves/plant: The number of leaves/plant at maturity of the crop is presented in (Table-1). The number of leaves per plant was significantly influenced by the different treatments. It was observed that there was a continuous increase in the number of leaves at all the stages of crop growth. Significantly higher number of leaves per plant was observed by treatment V1H6 (301.03) than treatment V2H6 (300.33) at maturity, respectively.

3.4 Leaf area (cm^2): The data of subsequent observations are shown in (Table-1). The leaf area increased with the advancement in growth stage up to at maturity. At maturity treatment V1H6 and treatment V2H6 had significantly higher leaf area (354.46 cm^2 and 352.22 cm^2 respectively) than other treatment.

3.5 Shoot girth (cm): The data on mean girth of shoot as affected by different treatments are presented in (Table-1) In general, the girth of shoot increased with the advancement in crop age, irrespective of the treatment and reached maximum at maturity. The girth of shoot was significantly the highest in treatment VIH6 (1.42 cm), and minimum shoot girth with treatment V1H1 (1.31 cm) at all the crop growth stages.

Table 1: Effect of different concentration of GA_3 on plant height, No. of Branches/plant, No. of leaves/plant, Leaf area (cm^2) and shoot girth (cm) at maturity

Treatments	Plant height (cm)	No. of Branches/plant)	No. of leaves/plant	Leaf area (cm^2)	Shoot girth (cm)
V1H1	84.30	16.35	271.06	301.59	1.31
V1H2	85.56	18.09	276.14	310.80	1.34
V1H3	86.53	19.30	278.93	322.60	1.37
V1H4	87.16	22.30	297.38	332.17	1.38
V1H5	88.13	24.10	300.53	340.71	1.40
V1H6	90.18	25.15	301.03	354.46	1.42
V2H1	83.76	16.06	270.23	301.21	1.31
V2H2	84.83	17.11	275.07	309.71	1.33
V2H3	85.40	19.16	278.42	320.51	1.35
V2H4	87.00	21.10	295.95	331.36	1.36
V2H5	87.64	23.37	300.25	340.12	1.38
V2H6	87.84	25.03	300.33	352.22	1.41
SE (m) ±	0.33	0.32	0.28	0.55	0.006
CD at 5%	0.98	0.96	0.85	1.65	0.02

V1= Amrutha, V2 = Abhilash, DAT-Day after transplanting
H1 = Application of water spray
H2= Application of 12.5 ppm GA_3 20 DAT followed by 12.5 ppm GA_3 40 DAT
H3= Application of 25 ppm GA_3 20 DAT followed by 25 ppm GA_3 40 DAT
H4= Application of 37.5 ppm GA_3 20 DAT followed by 37.5 ppm GA_3 40 DAT
H5= Application of 50 ppm GA_3 20 DAT followed by 50 ppm GA_3 40 DAT
H6 =Application of 62.5 ppm GA_3 20 DAT followed by 62.5 ppm GA_3 40 DAT

Table 2: Effect of GA_3 on First flower bud initiation (Days), First flower initiation (Days), 50% Flowering (Days), First Fruit set (Days), Number of flowers per plant, Percentage fruit set and Days to 50% Fruit maturity at different successive growth stages

Treatment	First flower initiation (Days)	50% Flowering (Days)	First Fruit set (Days)	Number of flowers /plant	Percentage fruit set	50% Fruit maturity (Days)
V1H1	27.66	43.66	49.66	27.48	64.26	73.66
V1H2	27.33	42.66	49.00	27.51	65.41	71.00
V1H3	27.00	42.00	48.00	30.78	66.04	69.33
V1H4	26.33	41.33	46.33	32.90	68.87	68.00
V1H5	26.00	41.00	45.00	33.67	70.27	66.00
V1H6	25.00	40.66	44.00	35.14	71.13	64.00
V2H1	27.00	42.33	49.00	26.74	63.56	72.33
V2H2	26.66	41.66	48.66	27.46	64.29	70.00
V2H3	26.33	41.33	47.00	29.05	65.40	68.66
V2H4	26.00	41.00	45.00	32.78	68.11	67.00
V2H5	25.33	40.66	44.33	33.08	69.51	65.00
V2H6	24.00	39.66	43.00	34.46	70.60	63.00
SE (m) ±	24.00	39.66	43.00	34.46	70.60	63.00
CD at 5%	0.14	0.28	0.24	0.42	0.13	0.14

3.6 First flower initiation (Days): The first flower initiation was significantly varied due to different treatments while treatment V1H4,V1H5,V2H2,V2H3 and V2H4 produced statistically at par effect for days first flower initiation (26.00 to 26.66 days) but these values were significantly lower than that produced by treatment V1H1 (27.66 days) treatment. The synergetic effect of plant growth regulators at higher concentration on flower initiation. Similar results reported by Choudhury *et al.* (2013) [4] and Rahman *et al*. (2015) [11].

3.7 50% Flowering (Days): The data 50% flowering as affected by various treatment have been presented in (Table-2) The data indicate that treatment V1H1 (43.66 days) recorded significantly maximum days for 50% flower initiation than other treatments, while treatment V2H6 (39.66 days) required minimum days for 50% flowering. Similarly, increasing PGR slightly decreased the days required for 50% flowering.

3.8 First Fruit set (Days): A review of the data shows that treatment V2H6 (43.00 days) took significantly minimum days for fruits set than other treatment and maximum days of first fruit set is treatment V1H1 (49.66 days), while the lowest and highest level of PGR registered maximum and minimum days for first fruit set, respectively. The synergetic effect of plant growth regulators at higher concentration fruit set. Similar results reported by Bokade *et al.* (2006) [3] and Ali *et al.* (2012) [2].

3.9 Number of flowers per plant: The number of flowers per plant was significantly varied due to different varieties & PGR. Treatment V1H6 & V2H6 produced statistically similar number of flowers (35.14 & 34.46 flowers/plant) but these values were significantly higher than other treatments. An evaluation of data (Table-2) indicates that application of plant growth regulators at higher concentration had increased number of flowers per plant over its application at lower concentration. Further, treatments of both the higher levels of plant growth substance i.e. V1H5 to V1H2 being at par to each other resulted in significantly lower number of flowers per plant (33.67 to 27.51 flowers/plant) over the treatments of lower level of plant growth regulator i.e. H1 (27.48 flowers/plant).

3.10 Percentage fruit set: The treatment V1H6 (71.13%) recorded maximum percentage of fruit set while treatment V2H1 (63.56%) recorded lowest percentage of fruit set (Table -2). Crop sprayed with higher PGR resulted in significantly highest percentage of fruit set as compared to the fruit set obtained from the crop when sprayed with lower PGR. However the difference between both lower levels did not touch the level of significance.

3.11 Days to 50% Fruit maturity: The treatment showed significant effect on 50% fruit maturity. The treatment V2H6 (63.00 days) recorded minimum number of days to 50% fruit maturity was significantly superior to treatment V1H1 (73.66 days). (Table-2). Treatment at lower levels reduced the days to 50% fruit maturity over higher levels. The mean minimum days to 50% fruit maturity was obtained under treatment V2H6 (63.00 days). Which was compared with middle levels of plant growth regulator treatment i.e. V2H1 (72.33 days), the days to maturity recorded under middle levels was significantly both higher and lower levels.

Table 3: Effect of GA_3 on Total soluble solid, Number of fruits/plant, Weight of fruit/ plant (g), Wt of fruit/ Plot (kg) & Wt of fruit/ ha (q) at different successive growth stages

Treatment	TSS (^{0}Brix)	Number of fruit/plant	Wt of fruit/plant (g)	Wt of fruit/Plot (kg)	Wt of fruit/ha (q)
V1H1	3.99	17.66	681.66	17.40	242.39
V1H2	4.28	18.00	740.33	19.76	260.31
V1H3	4.59	20.33	771.66	20.54	284.74
V1H4	4.76	22.66	877.66	22.95	309.44
V1H5	4.91	23.66	969.33	24.53	332.41
V1H6	5.24	25.00	1103.33	26.03	350.51
V2H1	3.84	17.00	624.33	15.72	243.77
V2H2	4.13	17.66	681.33	16.39	254.87
V2H3	4.45	19.00	750.00	18.57	280.48
V2H4	4.67	22.33	819.66	21.46	306.56
V2H5	4.84	23.00	889.33	23.71	327.67
SE (m) ±	5.02	24.33	1048.33	25.72	347.94
CD at 5%	0.03	0.25	7.15	0.43	1.02

3.12 Total soluble solid: The data indicated that the treatment combination exerted significant impact on TSS. The treatment V1H6 significantly increases higher (5.24 ^{0}Brix) TSS followed by treatment V2H6 and V1H5 than other treatments and lower TSS found in treatment V2HI (3.84 ^{0}Brix). Increasing the concentration of GA_3 increased the TSS. (Table-3) respectively. Similar results were reported by Mourya *et al.* (2013) [6], Akash *et al.* (2014), and Chovatia *et al*. (2014) [5].

3.13 Number of fruits/plant: Number of fruits/plant per plant was significantly influenced (Table No. 3) by different treatment. Treatment V1H6 (25 per plant) recorded in significantly the highest fruit and at par with treatment V2H6 (24.33 per plant) over rest of the other treatments. The minimum number of fruit was registered with treatment V2H1 (17 per plant). Increasing levels of plant growth substance significantly increased the number of fruit per plants significantly. Furthermore, each increase in the concentration of plant growth regulators was associated with corresponding significant increasing in number of fruits per plant. Similar results were reported by Ali *et al.* (2012) [2].

3.14 Weight of fruit/plant (g): Crop sprayed with higher concentration of GA_3 produced significantly higher fruit weight per plant. Application of treatment V2H6 produced significantly higher fruit weight per plant (1048.33 g) than other concentrations. Lower fruit weight plant was obtained in treatment V2H1 (624.33 g). Maximum weight of fruit per plant was recorded with the treatment V1H6 (1103.33 g). Results of present investigation further revealed that higher weight of fruit per hectare was registered with highest level of plant growth substance (125 ppm GA_3). Similar results were reported by Sasaki *et al.* (2005) [12], Masroor *et al.* (2006) [7], Orzolek and Kaplan (2006) [8], and Ali *et al.* (2012) [2].

3.15 Wt of fruit/Plot (kg): Mean data of weight of fruit per plot as influenced by different treatment are presented in [Table-3). The overall effect of varieties on weight of fruit per plot was found significant weight of fruit per plot Variety V1H6 (26.03 kg) significantly higher than Variety V2H6 (25.72 kg).

3.16 Wt of fruit/ha (q): Application of plant growth regulator at lower concentration recorded significantly lower fruit yield (243.08 q/ha) than higher concentration. Further the data revealed on weight of fruit per ha indicated that higher levels of plant growth substance significantly increased the weight of fruit over lower levels. Treatment V1H6 higher yield (350.51) as compare to other treatments.

4. Conclusion
In tomato, different growth regulators play a pivotal role in germination, root development, branching, flower initiation, fruiting, lycopene development, synchronization and early maturation, parthenocarpic fruit development, ripening, TSS, acidity, seed production etcetera. To boost the tomato production in India these versatile resources greatly help the professionals and researchers.

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