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Impact of Mulch and Biomolecules on Growth and Yield of Tomato

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ABSTRACT

A field experiment was conducted to study the impact of mulch and biomolecules on plant height, number of fruits per cluster, average fruit weight, marketable yield and non-marketable yield of Tomato (*Solanum lycopersicum* L.) under irrigated condition. The experiment was laid out in split splitplot design with two replications with four main plots consisting of hybrids, three subplots consisting of mulching practices and four sub-sub plots consisting of different levels of biomolecules application. The results revealed that TO-1057 hybrid, application of polythene mulch and Ratchet @ 240 ml/acre recorded significantly higher plant height, fruits per cluster, fruit weight, marketable yield per plant, marketable yield per acre and non-marketable yield per acre. Hybrid X Biomolecules practice resulted in significant difference on growth attributes, yield attributes and yield.

Keywords : Tomato, Mulching, Plant Height, Marketable Fruit yield

INTRODUCTION

Tomato belongs to *Lycopersicum* genus under family Solanaceae. Tomato fruit has special nutritive value and is one of the most important and versatile vegetable crops which is used by Indians for culinary purposes. Tomato fruits are oval to flat and round having prominent features with or without green coloured shoulder. An average yield of tomato is about 30-35 tonnes per hectare having an average crop duration of about 135 days (recent reference).

Proper understanding of characteristics and selection of right planting material plays a very important role in yield optimization. TO-1057 (Syngenta) hybrid is a semi-indeterminate type with high plant vigour and yielding potential showing uniform fruit ripening whose fruit harvesting starts 60-65 days after transplanting (Sidrah *et al.,* 2017). Tomato hybrid Garv (Monsanto) has strong and determinate plant type, quick maturity and higher yield potential with fruit weight of 90-100 grams (Nishkruti *et al.,* 2018). Whereas, Ashoka (Monsanto) is a strong and highly determinate plant type with medium fruit weight of about 80-90 gram. Hybrid Arka Rakshakis a strong plant, fruits are square round and deep red in colour with an average fruit weight of about 90-100 grams. It is a high yielding hybrid and has good post harvest life which is suited for the fresh market (Sadashiva *et al*., 2017). All these four hybrids are high yielding, resistant to diseases and will produce good quality fruits and hence the ultimate yield obtained will be highly

satisfying.

Agronomic practices are very much essential in improving the yield of the crop. Mulching is one of such a practice wherein the soil is covered by organic or inorganic materials, this practice helps in decreasing the soil deterioration as it prevents the soil runoff. It also hinders the weed growth as there is no light for the weed seeds to emerge and thereby reduce the weed infestations and reduces the loss of water through evaporation. It also helps in retaining the soil moisture and controls the fluctuations in temperature, enhances all the physical, chemical and biological soil properties, as the organic mulches adds nutrients to the soil upon decomposition and ultimately increases the growth and yield (Ausra*et al.,* 2009).

Humic acid will act as plant growth stimulator and plays a direct role in enhancing the formation of plant and help in increasing the seed germination. Humic acid when applied to the root zone improves the nonspecific resistance among the plants towards various stress conditions like abnormal increase in temperature, drought conditions and against strong radiations on plants. These humates will have influence on plant nutrient uptake, respiration process, amount of amino acids, sugars and reduces the nitrate accumulation. It improves the fruit setting, decreases the fruit drop and accelerates the ripening of fruits. This also helps in enhancing the transfer and availability of all the nutrients and micronutrients in the plants (Hoang and Michael, 2001).

Lipo Chito Oligosaccharides (LCO) when applied on plants have the capacity to enhance the seedling emergence, promote somatic cell embryo mutant rate, stimulate plant photosynthesis, increase the leaf area and dry matter plants (Chen *et al.,* 2007). Foliar application of LCO is known to alleviate yield losses under water deficit condition and facilitate in improving root biomass. Initially LCO application helps in increasing the flowering, fruiting and subsequently prevents flower abortion, which inturn result in obtaining higher fruit yield and biomass of fruits or vegetable crops.

MATERIALS AND METHODS

A field experiment was conducted to study "Impact of mulch and biomolecules on growth and yield of tomato" at farmers' field, Settahalli, Kolar during summer season for two years, 2016 and 2017 under irrigated conditions. Shettihalli in Kolar district which falls in the Eastern Dry agro-climatic zone in Karnataka state and it experiences a semi-arid climate, characterized by typical monsoon tropical weather with hot summers and mild winters. The site has an elevation of 839 meters from mean sea level (MSL). The details of the materials used, methods and experimental techniques adopted during investigation are presented in this article.

Treatment and Experimental Design:

The experiment was laid out in split-split plot design consisting of 48 treatment combinations replicated twice. First factor consisted of four hybrids namely TO-1057 (H1), Garv (H2), Ashoka (H3) and Arka Rakshak (H4) in Main plot, second factor comprised of three types of mulches viz., Polythene Mulch (M1), Crop Mulch (M2) and No Mulch (M3) as a control in Sub plot

and third factor consisted of four biomolecules namely Ratchet @ 120 ml/acre (B1), Ratchet @ 240 ml/acre (B2) and Proventus @ 1000 g/acre (B3) and no biomolecules (B4) as a control in sub-sub plot.

Crop management

Tomato seedlings were raised using healthy treated seeds in 98 cavity seedling trays during January 2016 and 2017 with proper nursery management. At the time of sowing, the land was prepared to a fine tilth which is red sandy loam soil having pH of 6.5. FYM and fertilizers were applied at the recommended dose of 250:250:250 Kg/Ha NPK during bed preparation and throughout the crop duration. Drip laterals were laid after preparing raised beds with the discharge of 4 L/Hr. Planting beds were covered with silver-black coloured30-micron poly mulch, crop mulch using finger millet straw materials and no mulch as per treatments.

Thirty days old seedlings were transplanted on 16.2 m2 gross plot size (2.4 X 6.75 m) with spacing of 120 X 45 cm between rows and plants respectively. Mulching was done before transplanting and small holes were made as per the spacing on the mulching beds for planting of each seedling. Thirty plants were planted in each treatment and a drip irrigation system was followed for the uniform watering. Wooden poles and GI wires were used for the proper staking of each plant.

Application of Biomolecules

Ratchet @ 120 ml/acre (B1), Ratchet @ 240 ml/acre (B2) and Proventus @ 1000 g/acre (B3) were applied at the crop stage of 20 and 40 days after planting.

Observations recorded

Ten plants were selected randomly from each treatment and tagged with label for taking various biometric observations. Height of tagged plant was measured from ground level of plant to tip of main shoot and mean plant height was worked out and expressed in centimetres (cm). Yield attributes *viz.*, number of fruits per cluster was counted from tagged ten plants at full fruit load (at 85 days after transplanting) and average fruit weight (gram) was recorded three times during third, sixth and ninth harvests. Sample sizes of 40 fruits per treatment were collected and mean fruit weight was recorded. Total marketable yield and unmarketable yield were recorded separately (kg/plant) by grading based on their size, shape, colour, diseased and damaged fruits at each harvest and cumulative marketable and unmarketable yield was recorded out of total 12 harvests and total plot yield was divided by number of plant to record yield per plant (kg).Per acre yield data was calculated by multiplying per plant yield to number of plants per acre.

Statistical Analysis

Analysis of variance (ANOVA) was calculated by using Tukey HSD software and treatment means were separated by Duncan's Multiple Range Test (DMRT) (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Various factors influence the growth and yield of crop. Hybrid selection, response to biomolecules and mulching practices were studied. Selection of good hybrids suitable for location has been ongoing research with respect to desirable traits (yield and quality). Further, variations in response of

different hybrids to varied practices are well established facts. Efforts were initiated to study the interactions of hybrids and biomolecules under different mulching practices. The results of the experiment were conducted to illustrate the effect of mulch and biomolecules on yield and fruit quality of tomato (*Solanum lycopersicum* L.) During summer 2016 and 2017 at the location details are presented in this article.

An experiment with four tomato hybrids (TO 1057, Garv, Ashoka and Arka Rakshak) was conducted in the summers of 2016 and 2017. The experiment was conducted by taking hybrids as main plot, mulching as sub-plot and biomolecules as sub-sub-plot. Various yield and yield related traits were measured and subjected to ANOVA (Analysis of Variance).For all the plant growth and yield parameters, pooled data from two years were taken into consideration for comparing results.

Plant growth parameters

Plant height (cm)

Among the hybrids, pooled values of TO-1057 (H1) recorded significantly higher plant height of tomato (136.8 cm)as compared to other hybrids. Garv (H2) and Arka Rakshak (H4) recorded at par with each other (119.4 and 117 cm respectively) but significantly higher than Ashoka (H3) which recorded lowest plant height (113.3 cm). Similar trend was observed in 2016 and 2017 in individual years (Table 1). Physiological difference associated with the hybrids is attributed to variation in genetic traits (Bhattarai *et al*., 2018)

Mulching practices influenced the plant height significantly (Table 1). Polyethylene mulch (M1) recorded significantly higher plant height *i.e.*, 138.8 cm followed by Crop mulch (M2) (116.2 cm) when compared with no mulch treatment M3 (109.3 cm).Results are in corroboration with findings of Singh, (2005) which resulted in differential response of tomato plants accounted due to differential physiological changes on account of mulching.

However, among the biomolecules, pooled values of Ratchet @ 240 ml/acre (B2) and Proventus @ 1000 g/acre (B3) recorded significantly higher plant height(126 and 126.8 cm respectively) than B1, Ratchet @ 120 ml/acre (118 cm) and B4, Control (114.2 cm) but no significant difference in plant height between B1 and B4 (Table 1).Application of LCO (lipo-chito-oligosaccharide) molecule enhances the plants nutritional capabilities that drive natural growth processes, enhances seed germination, enhances photosynthetic rates in both legume and non-legume crops (Prithiviraj *et al.,* 2000). Large leaf surface for better light absorption and photosynthesis, earlier canopy closure for soil moisture preservation and reduced weed competition, improved plant health for better stress tolerance and higher yield potential (Chen *et al.,* 2007). Similar results were observed by (Aracon *et al*., 2003) who also observed increased plant height, leaf area, dry matter weight of shoots and roots in crops and increased fruit number in plants when the humic acid obtained from plant wastes, food wastes, vermicompost and cattle waste was applied. Recent literature has shown that humic acid could be used as growth regulator to regulate hormone levels, improves plant growth and enhance stress tolerance (Serenella *et al.,* 2002).

Table 1: Comparative performance of hybrids, mulching practices and biomolecules on plant growth and fruits per cluster traits in summer 2016, 2017 and pooled year

		Plant Height (cm)			Fruits Per Cluster		
		2016	2017	Pooled	2016	2017	Pooled
Hybrid	H1	138.3 a	135.5 a	136.9 a	4.67a	4.73 a	4.7a
Treatment	H2	122.7b	116.2 b	119.4 b	4.73a	4.50 b	4.61a
	H3	120.9b	113.1 b	113.3 c	4.7a	4.65 ab	4.68a
	H4	113.5c	113.1 b	117.0bc	4.71 a	4.58 ab	4.65a
Mulching	M1	144.7 a	132.9 a	138.8 a	4.93 a	4.73 a	4.83 a
Treatment	M2	121.7b	116.2 b	118.9 b	4.67 b	4.70 a	4.69 b
	M3	105.1 c	109.3 c	107.2 c	4.51 c	4.40 b	4.45 c
Bio Molecules	B1	121.0 b	115.1 b	118.0 b	4.67 b	4.63 b	4.64 b
Treatment	B2	128.7 a	123.2 a	126.0a	5.03 a	4.88 a	4.95 a
	B3	128.0 a	125.4 a	126.8a	4.78 b	4.72 ab	4.75 b
	B4	117.4 c	114.2 b	115.8 b	4.34 c	4.23 c	4.28 c

Same letters indicate non-significant at 0.95 level of significance.

H1: TO-1057; H2: Garv; H3: Ashoka; H4: Arka Rakshak;

M1: Polythene Mulch; M2: Crop Mulch; M3: No Mulch;

B1: Ratchet @ 120 ml/acre; B2: Ratchet @ 240 ml/acre; B3: Proventus @ 1000 g/acre; B4: Control

Effect of hybrids, mulching practices, biomolecules and their interactions on plant height of tomato during both the seasons of experimentation are presented in Table 2. Among the various hybrids, mulching practices and biomolecules treatment interactions, Hybrid X Mulching practice alone resulted in significant difference but interaction between Hybrid X Bio Molecules, Mulching X Bio Molecules and Hybrid X Mulching X Bio Molecules has shown no significant difference on plant height in both the seasons. Effect of Hybrid and Mulching on plant height recorded highly significant in both the seasons.

Fruits per cluster

Among the hybrids, TO-1057 (H1), Garv (H2), Ashoka (H3) and Arka Rakshak (H4) there was no significant difference recorded with respect to average fruits per cluster in tomato (Table 1).

Polyethylene mulch (M1) recorded significantly higher fruits per cluster (4.8) than Crop mulch (M2) and No Mulch (M3).Number of fruits per cluster in M2 recorded 4.69 which was significantly higher than M3 (4.45) as shown in the Table 1.

However, among the biomolecules, pooled data of Ratchet @ 240 ml/acre (B2) recorded significantly higher fruits per cluster (4.95) than remaining treatments. Proventus @ 1000 g/acre (B3) recorded 4.75 and Ratchet @ 120 ml/acre (B1) recorded 4.64 fruits per cluster which were on par with each other and significantly lower fruits per cluster was recorded in control 4.28 (B4). Similar trend was observed in 2016 and 2017 as well (Table 1). This was mainly due to the drastic increase in the photosynthetic efficiency and by this higher accumulation of dry matter was observed. Similar results were observed by Minami *et al*., (1996). This also

helped in the formation of new nodules and organs and helped in initiating the plant morphoses as observed by Perret *et al.,* (2000).

Effect of hybrids, mulching practices, biomolecules and their interactions on average fruits per cluster of tomato during both the seasons of experimentation are presented in Table 2. Among the various hybrids, mulching practices and biomolecules treatment interactions, Hybrid X Biomolecules practice alone resulted in significant difference during 2016 and 2017 but interaction between Hybrid X Mulching, Mulching X Bio Molecules and Hybrid X Mulching X Bio Molecules has shown no significant difference on fruits per cluster in both the seasons.

Fruit weight (g)

Pooled values of TO-1057 (H1) fruit weight recorded significantly higher at 3rd, 6th and 9th harvests(99.71, 86.91 and 80.04 respectively). Garv (H2), Ashoka (H3) and Arka Rakshak (H4) were shown on par each other at 3rd harvest (94.57, 93.53 and 93.31 respectively)but similar trend was observed only with H2at 6th harvest (84.29) and 9th harvest (74.56)but H3 shown 73.2 gat 9th harvest which was significantly higher than H4.Whereas fruit weight of H4at 6th and 9th harvest (82.45 and 69.89 respectively) shown significantly lower than rest of the treatment (Table 3).

Mulching practices have played a crucial role in fruit weight retention across harvests. Polythene mulch (M1) recorded significantly higher fruit weight at 3rd, 6th and 9th harvest (99.63 g, 88.15 g and 78.48 g respectively) than Crop Mulch (M2) (93.86 g, 83.04 g and 73.03g) and No mulch (M3) (92.34 g, 80.92 g and 71.75 g).Fruit weight in M2 observed significantly higher than M3. Similar trends observed in 2016 and 2017 in each mulching practice (Table 3).

Table 2: Analysis of variance (mean type III sum of squares) for plant growth characters studied in four tomato hybrids in the summer seasons of 2016, 2017 and pooled.

Source	df	Plant Height	Fruits Per Cluster	Plant Height	Fruits Per Cluster	Plant Height	Fruits Per Cluster
		2016		2017		Pooled	
Hybrid (H)	3	2618.40**	0.018	2784.22**	0.24*	5263.86**	0.06
Mulching (M)	2	12687.92**	1.47**	4692.31**	1.08**	16329.13**	2.32**
Biomolecules (B)	3	741.00**	1.98**	771.56**	1.83**	1482.94**	3.79**
H X M	6	186.97**	0.13	251.61**	0.15	174.12	0.16
H X B	9	13.54	0.16*	20.2	0.16*	24.11	0.15
M X B	6	28.43	0.13*	22.57	0.06	28.18	0.15
H X M X B	18	9.152	0.059	41.33	0.14*	24.13	0.1
Error	48	20.802	0.06	33.95	0.06	58.59	0.08
Total	96						
Corrected Total	95						

*Indicate 95% confidence

** indicates 99% confidence.

All the statistical analyses were performed using Tukey HSD software.

However, among the biomolecules, Ratchet @ 240 ml/acre (B2) recorded the highest fruit weight 97.15 g, 88.9 g and 73. 89g at 3rd,6th and 9thharvest respectively. Proventus @ 1000 g/acre (B3) recorded (95.83 g, 85.56 g and 75.31g at 3rd, 6th and 9thharvests respectively) which showed on par with B2 at all the three harvest stages but therewere no significant difference values between Ratchet @ 120 ml/acre (B1) and Control (B4)as shown in the Table 3.

Effect of hybrids, mulching practices, biomolecules, and their interactions on fruit weight of tomato during both the seasons of experimentation are presented in Table 4. Interaction between hybrid and mulching showed significant difference during 2016, 2017 and pooled analysis at 3rd, 6th and 9th harvests but no significant difference observed between hybrid and biomolecules similarly in mulching X biomolecules and hybrid X mulching X biomolecules.

Table 3 : Comparative performance of hybrids, mulching practices and biomolecules fruit size at 3rd, 6th and 9th harvests in summer 2016, 2017 and pooled year

		Fruit Weight (g) 3rd Harvest			Fruit Weight (g) 6th Harvest			Fruit Weight (g) 9th Harvest		
		2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Hybrid	H1	100.40 a	99.01 a	99.71 a	87.43 a	86.40 a	86.91 a	78.74 a	81.34 a	80.04 a
Treatment	H2	96.64 b	92.50 b	94.57 b	84.65 b	83.92 b	84.29 b	74.24 b	74.89 b	74.56 b
	H3	93.69 c	93.36 b	93.53 b	82.13 c	82.89 b	82.51 c	72.02 b	74.39 b	73.20 b
	H4	93.81 c	92.80 b	93.31 b	81.87 c	83.02 b	82.45 c	68.93 c	70.85 c	69.89 c
Mulching	M1	102.28 a	96.99 a	99.63 a	89.47 a	86.83 a	88.15 a	78.29 a	78.67 a	78.48 a
Treatment	M2	94.18 b	93.54 b	93.86 b	82.56 b	83.53 b	83.04 b	71.30 b	74.77 b	73.03 b
	M3	91.95 c	92.73 b	92.34 c	80.03 c	81.82 b	80.92 c	70.85 b	72.65 c	71.75 c
Bio	B1	94.42 b	92.92 c	93.67 c	82.72 b	82.87 b	82.80 b	72.47bc	74.85 ab	73.66 ab
Molecules	B2	98.35 a	95.95 a	97.15 a	85.67 a	86.11 a	85.89 a	75.17 a	76.62 a	75.89 a
Treatment	B3	96.41 ab	95.25 ab	95.83 ab	85.57 a	85.54 a	85.56 a	74.59 ab	76.04 a	75.31 ab
	B4	95.36 b	93.56bc	94.46bc	82.11 b	81.72 b	81.91 b	71.70 c	73.95 b	72.83 b

Same letters indicate non-significant at 0.95 level of significance.

Marketable yield per plant (kg) and yield per acre (tons)

Among the hybrids, significantly higher pooled marketable yield from TO-1057 (H1) obtained per plant and per acre of tomato (3.27kg and 24.53tons respectively) as compared to other hybrids. Garv (H2) yielded2.56 kg/plant and 19.17 tons/acre significantly higher than Ashoka (H3) (2.25 kg and 16.87 tons) and Arka Rakshak (2.17 kg and 16.26 tons) respectively but both H3 and H4 were recorded lower side yield and non-significantly each other. However, a similar trend was observed in 2016 and 2017 years as well (Table 5). Similar results were obtained by Chapagain *et al.,* (2020) where the genotype TO-1057 recorded the highest marketable yield.

We have observed greater yield advantages on polythene mulch compared to crop and without mulch in the experiment. Pooled values of Polythene mulch (M1) recorded significantly higher yield/plant (3.13) and yield/acre (23.44) than Crop mulch (M2) and No mulch (M3) which were yielded (2.33 kg and 17.48 tons) and (2.23

Table 4: Analysis of variance (mean type III sum of squares) for fruit weight at 3rd, 6th and 9th harvests studied in four tomato hybrids in season of 2016, 2017 and Pooled years.

Source	df	Fruit Wt. 3rd Harvest	Fruit Wt. 6th Harvest	Fruit Wt. 9th Harvest	Fruit Wt. 3rd Harvest	Fruit Wt. 6th Harvest	Fruit Wt. 9th Harvest	Fruit Wt. 3rd Harvest	Fruit Wt. 6th Harvest	Fruit Wt. 9th Harvest
		2016			2016			Pooled		
Hybrid (H)	3	238.92**	161.95**	408.53**	228.05**	63.36**	458.18**	433.30**	211.28**	857.66**
Mulching (M)	2	944.91**	764.80**	556.67**	163.65**	207.44**	298.38**	947.36**	883.12**	816.84**
Biomolecules (B)	3	68.34**	83.67**	66.13**	48.31**	106.45**	34.16**	113.31**	188.68**	97.22**
H X M	6	66.85**	30.57*	24.36*	52.62**	47.74**	12.48*	106.70**	58.67**	30.56**
H X B	9	2.08	6.59	1.52	1.73	11.62	3.18	2.89	12.09	3.09
M X B	6	4.73	3.98	3.17	1.1	7.31	1.55	3.7	3.42	3.96
H X M X B	18	1.2	1.58	4.21	1.08	3.81	2.9	1.61	3.52	5.32
Error	48	7.42	7.72	7.29	4.67	8.07	5.27	8.79	8.59	6.77
Total	96									
Corrected Total	95									

*Indicate 95% confidence and
** indicates 99% confidence.
All the statistical analyses were performed using Tukey HSD software.

kg and 16.7 tons) yield/plant and yield/acre respectively. Fruit yield per plant and acre was recorded lowest in no mulch which is significantly lower than M1 and M2 (Table 5). Similarly, Hedau *et al.,* (2002) recorded that application of silver polythene mulch recorded higher yield as compared to pea straw as mulch. Reduced growth and yield in crop mulch might be due to some crop species used as mulch might become weed problem, these organic mulches can keep the soil too moist, restricts oxygen in the root zone in poorly drained soils (Lal *et al.,* 2003).If the mulch is applied close to the stem of the plant, trapped moisture creates a conducive environment for the development of pests and diseases. Most of the organic mulches provide home for the breeding of snails, slugs, rats etc., which might attack the plants and hence reduce the growth and yield of the crop. Similar reports were obtained by Patil *et al.,* (2013) showing that the application of crop mulches increased the diseases, pests and rodents attacking the crop and thereby there was a drastic yield reduction on tomato crop. Non mulching treatments usually showed less growth and yield because there was less water and nutrient use efficiency, less soil nutrient status, more weed competition which can be overcome by plastic mulching, the same experimental result was obtained by Singh *et al.,* (2005) that mulching practices will increase the fruit yield. Plastic mulches conserve the soil moisture, enhance the nutrients status of soil, regulate soil temperature, control the erosion losses, suppress the weeds in crop plants, and remove the residual effects of pesticides, fertilizers, and heavy metals. Similar results were recorded by Chakraborty and Sadhu (1994).Further, reported that mulching boosts the yield by 50-60 % over no mulching (Dilipkumar *et al*., 1990).

However, among the biomolecules, pooled values of Ratchet @ 240 ml/acre (B2) recorded highest marketable yield per plant

Table 6: Analysis of variance (mean type III sum of squares) for yield characters studied in four tomato hybrids in the summer season of 2016, 2017 and pooled.

Source	df	Mark. Yield /Pl	Mark. Yield/ Acre	Non-Marke. Yield/Pl	Non-Mark. Yield/ Acre	Mark. Yield/ Pl	Mark. Yield/ Acre	Non-Marke. Yield/Pl	Non-Mark. Yield/ Acre	Mark. Yield/ Pl	Mark. Yield/ Acre	Non-Mark. Yield/Pl	Non-Mark. Yield/ Acre
		2016				2017				Pooled			
Hybrid (H)	3	6.27**	352.90**	0.12**	6.76**	5.82**	327.66**	0.10**	5.75**	12.07**	679.02**	0.11**	10.87**
Mulching (M)	2	9.24**	519.92**	0.23**	13.28**	6.40**	360.29**	0.17**	9.69**	15.46**	870.06**	0.09**	22.81**
Bio-Molecules (B)	3	0.32**	18.13**	0.02*	1.40*	0.49**	28.08**	0.009	0.51	0.81**	45.62**	0.03	1.77
H X M	6	0.13**	7.79**	0.007	0.36	0.15**	8.91**	0.008	0.43	0.27**	15.33**	0.009	0.67
H X B	9	0.01	0.6	0.003	0.146	0.012	0.65	0.001	0.05	0.009	0.49	0.002	0.1
M X B	6	0.01	0.71	0.008	0.43	0.008	0.44	0.003	0.15	0.018	1.01	0.008	0.32
H X M X B	18	0.006	0.311	0.007	0.374	0.007	0.41	0.001	0.08	0.009	0.48	0.003	0.18
Error	48	0.041	2.305	0.009	0.532	0.03	1.69	0.011	0.69	0.038	2.12	0.015	0.5
Total	96												
Corrected Total		95											

*Indicate 95% confidence,
** indicates 99% confidence.
All the statistical analyses were performed using Tukey HSD software

and yield per acre(2.69 and20.2 respectively) followed by Proventus @ 1000 g/acre (B3) recorded (2.65 and 19.86), Ratchet @ 120 ml/acre (B1) (2.48 and18.58) and Control (B4) 2.42 and 18.18 respectively but all the four treatments (B1, B2, B3 and B4) were showed non-significantly each other as shown in the Table 5.Similarly, Eyheraguibel *et al.,* (2008)and Mora *et al*., (2010) observed when humic acid is applied to the plants, it helps in enhancing the rate and percentage of speed germination, elongates the roots of seeds, enhances plant growth, root, shoot and leaf biomass and in total there will be increased uptake of water, nutrients and minerals there by increasing the overall yield attributes.

Effect of hybrids, mulching practices, biomolecules and their interactions on marketable yield per plant and yield per acre of tomato during 2016, 2017 and pooled data are presented in Table 6. Among the various hybrids, mulching practices and biomolecules treatment interactions, Hybrid X Mulching practice alone resulted in significant difference but interaction between Hybrid X Biomolecules, Mulching X Bio Molecules and Hybrid X Mulching X Bio Molecules has shown no significant difference on marketable yield per plant and yield per acre in both the seasons and pooled. Panthee *et al.,* (2013) and Osei *et al.,* (2018) have reiterated differential response of the hybrids to the changes in environment mainly due to genotype to environment interaction.

Non-Marketable yield per plant (kg) and yield per acre (tons) :

Non-marketable yield was obtained by grading harvested fruits based on their size, shape, colour, diseased and damaged fruits at every harvest. Amount of non-marketable yield recorded here is showing negative

traits and lesser value indicates better performance in each treatment. Pooled values of 2016 and 2017 were considered for the comparison. Among the hybrids, TO-1057 (H1) recorded lower non-marketable yield per plant and per acre of tomato which was found beneficial (0.76 and 5.51 respectively) as compared to other hybrids. Garv (H2), Ashoka (H3) and Arka Rakshak (H4) recorded on par results with each other and observed (0.84 and 6.33), (0.86 and 6.47) and (0.85 and 6.37) non-marketable yield per plant and per acre respectively, however highest non-marketable yield was observed in Ashoka compared to other hybrids (Table 5).

Polythene mulch (M1) influenced the non-marketable yield per plant and per acre significantly lower (0.78 and 5.54 respectively) compared with other mulching treatments i.e., Crop mulch (M2) and No mulch (M3) which are showing non significantly each other. We have observed higher non-marketable yield per plant and per acre in M2 (0.85 and 6.37) and M3 (0.84 and 6.3) as shown in Table 5.

Among the biomolecules, Ratchet @ 120 ml/acre (B1), Ratchet @ 240 ml/acre (B2), Proventus @ 1000 g/acre (B3), and Control (B4) on non-marketable yield per plant and per acre recorded nonsignificant difference among the treatments as shown in the Table 5.

Effect of hybrids, mulching practices, biomolecules, and their interactions on non-marketable yield per plant and per acre of tomato were shown in Table 6. but there were no significant interaction differences observed among Hybrid X Mulch, Hybrid X Biomolecules, Mulching X Biomolecules and Hybrid X Mulching X Biomolecules.

CONCLUSION

Hybrid TO-105 was found to be optimum for higher productivity, performance with respect to tomato plant growth and yield parameters as compared to Garv, Ashoka, and Arka Rakshak as it produced higher yield and better-quality fruits of tomato. Among application of mulch, application of polythene mulch produced an effective result with respect to growth, yield, quality fruits, thereby the productivity and profitability increased. Among the applications of biomolecules, the application of Ratchet @ 240 ml/acre recorded optimum with respect to growth and yield parameters during all the growing seasons.

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