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Screening Tomato Varieties Based on Growth, Yield and Quality Attributes as Influenced by Different Organic Treatments

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Abstract—*The present investigation was conducted at Organic Experimental Farm of Ramakrishna Mission Vivekananda University, F/C: IRTDM, Morabadi, Ranchi under the South Chhotanagpur Plateau of Jharkhand during rabi-summer seasons of 2014-15 and 2015-16. The experiment was proposed after split plot design by employing five varieties of the crop, viz. V_1: Pusa Ruby; V_2: Swarna Lalima; V_3: PKM-1; V_4: Patharkutchi; and V_5: Arka Rakshak along with their three replications under the illumination of four different sets of organic treatments like, T_1: FYM @ 10 t.ha^{-1} + Wood Ash @ 10 t.ha^{-1}; T_2: T_1 + application of Shasyagavya (15%) four times at 15 days intervals initiated at 15 DAT; T_3: T_1 + T_2 + Azotobacter @ 3 kg.ha^{-1}; and T_4: T_1 + T_2 + T_3 + application of fermented mustard oil cake solution (10%) @ 15 days interval for four times instigated at 7 DAT. Several studied growth, yield and quality attributes of the crop were found to be significant among varieties and treatments or even in the cases of interaction effects between variety and treatment. The gradual rise of the level of organic inputs in different organically designed treatments revealed favourable results over yield and associated attributes of different varieties of the crop climaxed with the highest yield (56.97 t.ha^{-1}) and B: C ratio (7.77) in Swarna Lalima (V_2) under the exposure of T_4 treatment. When quality attributes were taken into account, it was observed that quality attributes had inverse relationship with yield of the crop culminated with higher TSS (7.93^{0}Brix) in T_1V_3, lycopene (2.53 mg.100g^{-1}) in T_2V_1 and ascorbic acid (44.00 mg.100g^{-1}) in T_2V_3. From the present findings, it may be concluded that organic farming has greater potential to provide substantial amount of higher and quality yield of tomato if suitable variety and organic production package are to be harmonized properly.*

Keywords*: Tomato, Solanum lycopersicum, Organic Farming, Growth, Yield, Quality, B: C Ratio.*

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.), a native of Tropical America is the edible, second most important remunerative solanaceous vegetable after potato. It is consumed in diverse ways including raw as an ingredient in many dishes, sauces, salads, drinks, soups, pickles *etc*. Tomatoes contain vitamin-A, vitamin-C, potassium, phosphorous, magnesium and calcium. It also contains lycopene, an antioxidant of cancer fighting ability [1]. India is second largest producer of tomato just after China with global share in area and production are 18.9% and 11.2%, respectively [2]. Our country has 882.0 thousand hectares of land under tomato cultivation with the production of 18735.9 thousand metric tonnes and productivity of 21.2 t.ha^{-1} [3]. Jharkhand has remarkable share in production of tomato with its 22.3 thousand hectares of land under this crop and the production of about 401.6 thousand metric tonnes [4]. In Jharkhand, tomato is extensively cultivated in Ranchi, Lohardaga, Hazaribagh and Godda district that covers approximately 13.9% of the area under vegetable cultivation.

Toxic synthetic pesticides and chemical fertilizers are mostly used by growers for tomato cultivation in order to alleviate pest menace and nutrient demand of the crop. These chemicals are rapidly accumulating in the environment causing deterioration of quality of soil, water and air. Excessive dose of nitrogenous fertilizers in tomato cultivation has been linked to nitrate contamination of ground and surface water [5]. Misuse of pesticides and chemical fertilizers in tomato also lead to adverse effects on environment and human health besides being economic losses to farmers [6]. In this context, organic farming is a suitable alternative which largely excludes or completely avoids the use of synthetically compounded pesticides, fertilizers, growth regulators, preservatives and livestock feed additives *etc.* Jharkhand is a tribal dominated state and most farmers of the state particularly the farmers of South Chhotanagpur plateau belong within the brackets of marginal and small categories. They cannot afford high cost of inputs for conventional chemical farming. So, emphasis should be given on easily available resources, which can be made available by the villagers in village level at reasonable price. Cow dung, cow urine and agricultural waste are usually available in most of the Indian villages. It is also estimated that in India nearly 700 million tonnes of organic waste is generated annually which is either burned or land filled [7]. These huge quantities of organic

wastes can easily be utilized for the preparation of different organic liquid formulations like *Shasyagavya*. Numerous research findings have been conducted at the organic experimental farm of IRTDM Faculty Centre of Ramakrishna Mission Vivekananda University; Ranchi revealed the feasibility such organic liquid formulations over beneficial effects on increasing yield and quality of different vegetable crops in general and tomato in particular. Growth, yield and nutritive value including antioxidant level enhanced in tomato with application of *Kunapajala*, an organic liquid formulation [8].

Based on above valuable information, the present investigation has been steered with highlighting on the following specific objectives:

- To study the performance of different tomato varieties based on their growth and yield attributes under organic management condition.
- To investigate the quality contributing attributes of tomato varieties as influenced by organic treatments.
- To estimate the B: C ratio of the crop grown through organic farming under different organic treatment conditions.

2. MATERIALS AND METHODOLOGY

The experiment was conducted at organic experimental farm of Ramakrishna Mission Vivekananda University, Ranchi campus during *rabi-summer* seasons of 2014-15 and 2015-16 under temperature regimes of 24.4^0C-31.2^0C (Max.) and 14.6^0C-22.7^0C (Min.). The experimental site was situated at 23.23^0N latitude and 85.23^0 E longitude with the elevation of 2,140 feet above MSL. Five varieties of the crop suitable for the region were constituted the experimental materials and they were subjected to grow using four organically designed treatments. The varieties were: V_1: Pusa Ruby; V_2: Swarna Lalima; V_3: PKM-1; V_4: Patharkutchi; and V_5: Arka Rakshak and those of treatments were: T_1: FYM @ 10 t.ha^{-1} + Wood Ash @ 10 t.ha^{-1}; T_2: T_1 + application of *Shasyagavya* (15%) four times at 15 days intervals initiated at 15 DAT; T_3: $T_1 + T_2$ + *Azotobacter* @ 3 kg.ha^{-1}; and T_4: $T_1 + T_2 + T_3$ + application of fermented mustard oil cake solution (10%) @ 15 days interval for four times instigated at 7 DAT. '*Shasyagavya*' an effective organic liquid manure prepared by utilizing easily and locally available resources like cow-dung, cow-urine, agricultural wastes and water at 1:1:1:2 ratios and kept the mixture as such for 9-11 days for fermentation. During fermentation, the mixture was stirred twice daily preferably during morning and afternoon hours. Final product obtained after fermentation had 50% strength and required strength (15%) was formulated by further mixing of water in it. The quantity of water was determined by using the formula $V_1S_1 = V_2S_2$ (where V_1 and V_2 are the initial and final volume, repectively and S_1 and S_2 are initial and final strength of *Shasyagavya*, correspondingly). Organic inputs of T_1 and *Azotobacter* (mixed with FYM of T_1) were incorporated with soils of experimental plots during final land preparation just before transplanting. The experiment was laid out through split plot design by allotting five varieties and four treatments coupled with their three replications in 60 experimental plots of 2.70 m x 2.70 m sizes. As an organic approach, seeds before sowing in pro-trays were treated with 10% cow urine of indigenous bred for 15 minutes. One month old healthy seedlings were transplanted at a spacing of 45 cm x 45 cm that accommodated 36 plants in each experimental plot. Tobacco stalk decoction (10%) and 10g turmeric powder mixed with one litre of whey water solution (whey water: water @ 1:2 proportion) were alternatively used at weekly interval throughout the growing and reproductive phases of the crop as precautionary measures against fruit borers or other insect-pests and blight or other fungal diseases, respectively. Different growth, yield and quality attributes of the crop varieties *viz.* plant height (cm), number of fruits.plant^{-1}, average fruit weight (g), fruit yield (t.ha-1), TSS (^{0}Brix), lycopene (mg.100g^{-1}) and ascorbic acid content of fresh pulp (mg.100g^{-1}) were taken time to time. Standard methodologies were adopted for analyses of quality attributes like for lycopene [9] and for ascorbic acid [10]. Both years' pooled data obtained were subjected to statistical analyses of variance (ANOVA) at 0.05 level of probability. The means were thereafter separated by using Duncan's Multiple Range Test (DMRT) [11].

3. RESULTS AND DISCUSSION

3.1. Growth and yield attributes of tomato

3.1.1. Plant height

The plant height of five varieties of tomato recorded statistically significant differences among different varieties and treatments ($P \leq 0.05$) and in this direction the maximum plant height was recorded in V_4 (87.36 cm) as contrast to the lowest as documented in V_1 (56.63 cm) but in the case of treatment T_4 emerged as the best treatment with maximum plant height (73.92 cm) as against the lowest value in this regard was estimated from T_1 treatment (64.65 cm). When interaction between variety and treatment was taken into account, it was observed that T_4V_4 is the best combination with the highest plant height (95.67 cm), whereas T_1V_1 is the worst performing combination with lowest plant height (49.90 cm). Such observation is obvious because level of organic inputs increase with treatment as designed in the present investigation that accentuate the more plant height (one of the most important yield associated traits of tomato) in the case of T_4 treatment [Table 1]. FYM, *Azotobacter* and other liquid organic manure might have enhanced the soil microbial activity and favourable soil microenvironment with a balanced nutritional environment to the soil plant nutrition system [12, 13] culminated with better growth of plant in T_4. However, all varieties were not performed well in the context of plant height under the illumination of T_4 because genetic entity and

growing environment determine the ultimate performance of a crop species.

3.1.2. Number of fruits.plant^{-1}

Number of fruit.plant^{-1} of five varieties of tomato under the influence of organically designed four treatment showed statistically significant differences (Table 1). The maximum no. of fruits.plant^{-1} was found in V_1 (33.44) among the varieties and that of T_3 (25.17) in the cases of treatments, while the lowest number of fruits.plant^{-1} was harnessed from T_1 treatment (14.06). The interaction effect showed that T_4V_1 combination as the best with maximum number of fruits.plant-1 (44.00) as contrast to the lowest as observed in the cases of T_1V_4 (8.00). The findings highlighted that except few instances most of the cases higher number of fruits.plant^{-1} was harvested from varieties grown through T_4 treatment.

3.1.3. Average fruit weight

The average fruit weight of five tomato varieties and performances of four organic treatments showed significant ($P \leq 0.05$) among themselves. The observation clearly indicated that V_2 is outstanding variety with the highest fruit weight (149.59 g), while Pusa Ruby (V_1) emerged as the small fruited variety among the varieties under studied with average fruit weight of 42.58 g. Among treatments T4 once again emerged as the best with average fruit weight of 85.80 g, although remaining three treatments recorded at per effect in this context (Table 1). The interaction effect showed that T_3V_2 as the best combination (average fruit weight: 154.33g) but at par effects with T_4V_2 and T_2V_2 (152.67 g) while T_1V_2 recorded significant difference with other three treatments and variety (V_2) combination. Results emphasized that Swarna Lalima (V_2) is the performer under the exposures of organic growing conditions. The observation also established the varietal selection as one of most important factors for determining better performance under definite sets of organic production packages.

3.1.4. Fruit yield

The results clearly indicated V_2 is the best variety in terms of yield (46.11 t.ha^{-1}) with significant differences with other four varieties of the crop under studied. Similarly, four different treatments performed independently with the best results in the context of yield as recorded in the case of T4 treatment (35.69 t.ha^{-1}). The interaction effects further intensified that T_4V_2 is the best combination with yield potentiality of 56.97 t.ha^{-1}, while worst combination in this context is T_2V_4 (9.53 t.ha^{-1}). Observations over the yield clearly indicated that T_3 and T_4 performed better than T_1 and T_2 treatments (Table 1). The findings further established the beneficial effects of *Azotobacter* over the yield and its associated attributes in tomato. The results obtained over the yield of the crop corroborate well with earlier findings [14, 15].

3.2. Quality attributes of tomato

3.2.1. TSS content of fruit pulp

The data on total soluble solids (TSS) as influenced by different organic treatments in several varieties of tomato were significantly varied, although almost all treatments recorded at par effect except in the case of T_4 (6.19^0Brix). The interaction effect showed the highest mean value of TSS (7.93^0Brix) in T_1V_3, whereas the same treatment in combination with V_2 recorded the lowest value of TSS (4.30^0Brix) [Table 2]. The results on TSS content of fruit pulp are close conformity with earlier findings [8]. The finding established the inverse relationship between the yield and quality attributes of crop species. The observation also recognized genetic entity of crop is more responsive towards the expression of quality traits.

3.2.2. Lycopene content of fruit pulp

The lycopene content of fruit pulp recorded significant differences ($P \leq 0.05$) among varieties and treatments of the experiment (Table 2). The highest lycopene was detected in V_1 (1.99 mg.100g^{-1}) among varieties and that of T_2 (1.31 mg.100g^{-1}) emerged with higher amount of lycopene accumulative organic treatment among all other treatments. Interaction effects further revealed that T_2V_1 (2.53 mg.100g^{-1}) as best combination followed by T_3V_1 (2.02 mg.100g^{-1}) as contrast to the lowest lycopene as detected in the case of T_4V_2 (0.38 mg.100g^{-1}). The findings further support the hypothesis that higher yield inversely proportional to the quality attributes of crop. The data obtained in this study over lycopene content of fruit pulp corroborate well with the recent findings [16]. Lycopene is associated with deep red colouration of ripe tomato [17] and more amount of lycopene as detected in Pusa Ruby (V_1) variety justified its bright red colouration over the other four varieties of the present investigation.

3.2.3. Ascorbic acid content of fruit pulp

Ascorbic acid content in all the five varieties of tomato and four treatments were recorded significant difference at 0.05 probability level (Table 2). Among varieties V_5 (29.38 mg.100g^{-1}) recorded the highest ascorbic acid content. While in the cases of treatments, T_3 (33.25 mg.100g^{-1}) emerged as the best treatment. The interaction effect showed T_2V_3 (44.00 mg.100g^{-1}) as the best combination as contrast to the T_1V_5 (8.75 mg.100g^{-1}) when ascorbic acid content of fruit pulp is taken into account. The results also warranted beneficial effects of liquid organic formulation '*Shasyagavya*' over ascorbic acid synthesis in tomato.

3.3. Economics of growing tomato organically

Table 3 emphasized the economic feasibility of organically designed treatments treatment over different varieties of tomato. The findings highlighted that T4 is the best profitable treatment for almost all varieties under studied. In majority of the cases, higher level of B:C ratios were estimated due mainly to lower level of cost incurred with different organic

treatments. From the study, it was revealed T_4V_2 as the best combination with higher B: C ratio (7.77) followed by the T_2V_2 (6.83), T_4V_5 (6.24), T_3V_2 (6.12) as against the lowest in T_2V_4 (1.35). The higher level of B: C ratios in the present investigation corroborated well with the previous findings [18].

4. CONCLUSION

From the above findings, it may be concluded that the performance of growth and yield attributes of tomato was the best under the T_4 treatment. Moreover, the quality attributes were exposed indifferently in different treatments but treatment T_4 in this context emerged as average performer. Among five varieties under the study, V_2 (Swarna Lalima) emerged as the best variety in term of yield under organic management condition of T_4 treatment, but quality view point PKM-1 (V_3) emerged as the best under the influences of different organic treatments. The economics study further revealed V_2 (Swarna Lalima) as the best variety under T_4 condition with the highest B: C ratio (7.77) as contrast to the V_4 (Patharkutchi) when grown with T_2 treatment showed the lowest B: C ratio (1.35). The findings of the study exhibited the feasibility of organic farming in tomato in terms of both profitability and quality viewpoints under the South Chhotanagpur plateau of Jharkhand.

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Table 1. *Per se* performance of growth and yield attributes of tomato varieties as influenced by various organic treatments

Variety	Plant Height (cm)	No. of Fruits.Plant^{-1}	Average Fruit Weight (g)	Yield (t.ha^{-1})
V_1	56.63c	33.44a	42.58d	26.27b
V_2	58.27c	16.39d	149.59a	46.11a
V_3	59.63c	17.42b	45.42d	13.56e
V_4	89.86a	16.88c	78.58b	15.69d
V_5	83.17b	16.92c	66.83c	23.79c
SEm(±)	2.23	0.15	3.07	0.08
$CD_{P\leq0.05}$	5.22	0.36	7.16	0.20
Treatment				
T_1	64.65c	14.06d	77.47b	19.76c
T_2	66.60c	17.52c	69.40b	19.48d
T_3	70.87b	25.17a	73.73b	25.39b
T_4	75.92a	24.09b	85.80a	35.69a
SEm(±)	1.49	0.10	2.14	0.05
$CD_{P\leq0.05}$	3.78	0.24	4.86	0.13
Interaction				
T_1V_1	49.40	22.62	45.67	25.54
T_1V_2	52.67	20.33	138.67	35.21
T_1V_3	57.17	9.33	39.33	11.75
T_1V_4	80.67	8.00	105.00	13.84
T_1V_5	83.33	10.00	58.67	12.46
T_2V_1	49.50	23.48	33.00	12.74
T_2V_2	52.67	21.33	152.67	48.17
T_2V_3	58.17	22.00	26.00	13.53
T_2V_4	94.33	8.33	69.33	9.53
T_2V_5	78.33	12.45	66.00	13.43
T_3V_1	63.93	43.66	38.33	28.57
T_3V_2	55.33	11.00	154.33	44.07
T_3V_3	57.33	17.33	36.33	11.92
T_3V_4	88.77	33.84	68.33	18.95
T_3V_5	89.00	20.00	71.33	23.46
T_4V_1	63.67	44.00	53.33	38.23
T_4V_2	72.42	12.88	152.67	56.97
T_4V_3	65.83	21.00	80.00	17.03
T_4V_4	95.67	17.33	71.67	20.42
T_4V_5	82.00	25.22	71.33	45.81
SEm(±)	4.46	0.30	5.23	0.17
$CD_{P\leq0.05}$	9.97	0.73	12.37	0.40

Note: V_1: Pusa Ruby; V_2: Swarna Lalima; V_3: PKM-1; V_4: Patharkutchi; and V_5: Arka Rakshak; **T_1:** FYM @ 10 t.ha^{-1} + Wood Ash @ 10 t.ha^{-1}; **T_2:** T_1 + application of *Shasyagavya* (15%) four times at 15 days intervals initiated at 15 DAT; **T_3:** T_1 + T_2 + *Azotobacter* @ 3 kg.ha^{-1}; and **T_4:** T_1 + T_2 + T_3 + application of fermented mustard oil cake solution (10%) @ 15 days interval for four times instigated at 7 DAT.

Table 2: *Per se* performance of quality attributes of tomato varieties as influenced by various organic treatments

Variety	TSS (^{0}Brix)	Lycopene (mg.100g^{-1})	Ascorbic Acid (mg.100g^{-1})
V_1	5.73c	1.99a	28.13b
V_2	4.98e	0.73d	26.56d
V_3	6.68a	1.22b	28.19b
V_4	5.38d	0.77d	27.82c
V_5	6.40b	0.95c	29.38a
SEm(±)	0.07	0.02	0.20
$CD_{P\leq0.05}$	0.17	0.04	0.49
Treatment			
T_1	5.77b	1.00c	21.75d
T_2	5.72b	1.31a	30.55b
T_3	5.64b	1.01c	33.25a
T_4	6.19a	1.19b	26.25c
SEm(±)	0.05	0.01	0.07
$CD_{P\leq0.05}$	0.11	0.03	0.16
Interaction			
T_1V_1	5.00	1.82	28.75
T_1V_2	4.30	0.89	28.75
T_1V_3	7.93	0.46	13.75
T_1V_4	4.80	0.81	28.76
T_1V_5	6.80	1.04	8.75
T_2V_1	6.10	2.53	22.50
T_2V_2	4.60	0.78	21.25

T_2V_3	6.20	0.92	44.00
T_2V_4	4.90	0.55	26.25
T_2V_5	6.80	1.78	38.75
T_3V_1	6.80	2.02	36.25
T_3V_2	4.80	0.88	27.50
T_3V_3	5.40	1.06	22.50
T_3V_4	5.20	0.63	37.50
T_3V_5	6.00	0.48	42.50
T_4V_1	5.00	1.57	25.00
T_4V_2	6.20	0.38	28.75
T_4V_3	7.17	2.44	32.50
T_4V_4	6.60	1.09	18.75
T_4V_5	6.00	0.49	27.50
SEm(±)	0.15	0.01	0.20
$CD_{P\leq0.05}$	0.35	0.08	0.49

Note: V_1: Pusa Ruby; V_2: Swarna Lalima; V_3: PKM-1; V_4: Patharkutchi; and V_5: Arka Rakshak; **T_1:** FYM @ 10 t.ha^{-1} + Wood Ash @ 10 t.ha^{-1}; **T_2:** T_1 + application of *Shasyagavya* (15%) four times at 15 days intervals initiated at 15 DAT; **T_3:** T_1 + T_2 + *Azotobacter* @ 3 kg.ha^{-1}; and **T_4:** T_1 + T_2 + T_3 + application of fermented mustard oil cake solution (10%) @ 15 days interval for four times instigated at 7 DAT.

Table 3: Economics of growing tomato varieties in one hectare of land through different organically designed treatments

Components	Total Cost of Cultivation (Rs.)	Yield (t.ha^{-1})	Market Price (Rs.kg^{-1})	Gross Income (Rs.)	B: C Ratio
T_1V_1	65000.00	25.54	10.00 (average market price of both years was taken into account; premium price of organic produce was not considered here due to absenteeism of organic certification)	255400.00	3.93
T_1V_2		35.21		352100.00	5.42
T_1V_3		11.75		117500.00	1.81
T_1V_4		13.84		138400.00	2.13
T_1V_5		12.46		124600.00	1.92
T_2V_1	70500.00	12.74		127400.00	1.81
T_2V_2		48.17		481700.00	6.83
T_2V_3		13.53		135300.00	1.92
T_2V_4		9.53		95300.00	1.35
T_2V_5		13.43		134300.00	1.90
T_3V_1	72000.00	28.57		285700.00	3.97
T_3V_2		44.07		440700.00	6.12
T_3V_3		11.92		119200.00	1.66
T_3V_4		18.95		189500.00	2.63
T_3V_5		23.46		234600.00	3.26
T_4V_1	73300.00	38.23		382300.00	5.22
T_4V_2		56.97		569700.00	7.77
T_4V_3		17.03		170300.00	2.32
T_4V_4		20.42		204200.00	2.79
T_4V_5		45.81		458100.00	6.25

Note: V_1: Pusa Ruby; V_2: Swarna Lalima; V_3: PKM-1; V_4: Patharkutchi; and V_5: Arka Rakshak; **T_1:** FYM @ 10 t.ha^{-1} + Wood Ash @ 10 t.ha^{-1}; **T_2:** T_1 + application of *Shasyagavya* (15%) four times at 15 days intervals initiated at 15 DAT; **T_3:** T_1 + T_2 + *Azotobacter* @ 3 kg.ha^{-1}; and **T_4:** T_1 + T_2 + T_3 + application of fermented mustard oil cake solution (10%) @ 15 days interval for four times instigated at 7 DAT.

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