Evaluation of Yield and Yield Attributing Traits of Tomato Obtained from Axillary Shoot Propagation.

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Abstract

Tomato is a widely cultivated commercial vegetable crops, which fruits are consumed directly or through diverse processed products. However the tomato cultivation consist huge production cost due to the higher seed price that have adversely affected the poor farmers livelihood. The experiment was conducted on the four varieties of Tomato varieties; Money Maker, Heinz, Rokkusanmaru and Srijana in the glass house of Kyungpook National University, Daegu, South Korea. The current study focused to grow the tomato crops through seedling obtained by axillary shoot cutting from the mother plant grown through seed. Interestingly, the results showed $p<0.05$ that the total yield and yield attributing traits like plant growth, fruit number and size, fruit weight, and chlorophyll content was found significantly higher as compared to the plant grown through seeds. Moreover, flowering and fruiting time was found 10 days earlier as compared to the mother plant. These results showed that the auxiliary shoot propagation of tomato could yield more, saves time and which could be an alternative for the seeds. However, it was found that the first cluster flower and fruit proximal to root was lately flowered and smaller fruit size as compared to other flower clusters fruit as well as peduncle was long as compared to mother plant in rest of the clusters.

Keywords: Tomato, axillary shoot, axillary shoot propagation.

Introduction

Tomato (*Lycopersicon esculentum* Mill.) also getting an alternative name as *Solanum lycopersicon* (Taylor & Kummer, 1982) a Solanaceous plant; is one of the most popular vegetables in the world. It is the most precocious and famous vegetable crop grown in the world due to its anti-oxidative properties, lycopene and mineral contents (Wu & Kubota, 2008). According to Atherton & Harris, (1986), botanically, the tomato is a fruit of flowering tomato plant in which seeds are attached to the ovary. Propagation is the basic horticultural practices for the production of new plants from selected cultivar for increasing the numbers and preserving the genetic characteristics of the plant (Hartmann et. al., 1997). According to Rick, (1980) tomatoes are easily propagated by sexual and asexual method and is an inexpensive and easy way to get new plants from the existed one. This type of reproduction produce plants which are genetically identical to its parent and most

widely used for commercial purpose showing the least variation among the propagated plants (Murashige, 1974). Among the various method of asexual propagation in tomato, axillary shoot propagation is a special method in which shoots branches are used for producing the plants (Phillips & Hubstenberger, 1995). The practicability and survival of tomato axillary shoot by regenerating rooting were carried out in 2010 on different growing media (Braun et. Al., 2010; Khan et. al., 2011). Possibilities of survival of plantlets in different growing media were examined and yield variation of seedling with rooted variety C-38-D Novo from the adult tissue of tomato shoot tip culture was done but effect of different position of the shoot in the yield, optimum time for taking shoot and precocity measurement through hydroponics and substrate has not been mentioned yet. Therefore this experiment aims to evaluate yield and yield attributing characteristics between mother plant and axillary shoot propagation (ASP) using hydroponically acclimatized. In addition, axillary shoot propagation (ASP) has a number of advantages as it produces the genetically uniform and pathogen-free plant materials in a short time; propagating cultivars which have difficult to obtain through own-rooted cutting and even scheduling the plantlet production closer to the market demand (Bati et al.,2006).

The current study investigates whether axillary shoot propagation (ASP) could be successful technology in terms of plant growth and yield compared with mother plant (Shoot donor plant). Here we introduce such a novel technology which encourage high yield and less cost of production.

Materials and Methods

Seed selection and germination

The 4 varieties of tomato seeds Rokkusanmaru (RKM), Heinz 1706 KNU (HZ), Moneymaker (MM), Nepali variety Srijana (SJ) were selected for the experiment with six replications. The seed of the 4 varieties were kept in the growing chamber of 65% humidity and 25 º C for 3 days until sprouting. After 3 days, the sprouted seeds were transplanted using growing media “Love sleep” (coconut 49.87%, jade course 25%, fill light 1 per-tile 12%, vermiculite 7%, Zeolite 6%, wood 0.004%, fertilizer 0.11%, wetting agent 0.01%; 25-11014, Yeoju, South Korea) to larger plastic trays 12 L to achieve axillary shoots. The germination percentage, the first true leaf emergence, plant height, leaf number was recorded and after 4-5 leaf stage with average height of 12 to 19 cm; after 21 days planting seed; the seedling were transferred to the glasshouse in bigger growing pots mixing Osmocote plus (a slow releasing fertilizer) 20gm/bag with the same compost media, cutting the tip of the root.

Pot experiment

From 8 healthy plants of each 4 varieties, similar size shoot having 10-15 cm long shoots was cut by the sharp blade. They were kept in hydroponics after 30 minutes of adding 1/4th part of MS (Murashige and Skoog Media, Duchefa-Postbus 809,2003 Haarlem, The Netherlands) having concentration 4302.09mg/L (1.0755 gm/L) in 16-liter capacity hydroponic device having 14 holes. The shoot from healthy donor plant was taken as of 10-15 cm long before keeping in hydroponics on dated May, 2018 and Aug, 2018 and compost substrates as regenerated plant to initiate the root. The leaves were removed keeping only 2 apical leaf of the shoot. The EC and pH of the MS solution was measured before and after keeping plantlets in hydroponics (Thermo Scientific Orion Star A, 325, The USA). After 11 days of rooting, the seedlings were transplanted to the pots. The shoots were also tested on the Love apple growing media to generate roots. The shoots were taken after crossing juvenility of the mother plant. The similar height 5 plantlets from each variety were grown in the same pot

at a spacing of 45 cm plant to plant distance for growth and development. The axillary shoots were removed from the shoot donor plants and regenerated plant and plant height, major leaf number, flower cluster, number of flower per cluster, fruit number, fruit weight, 50% flowering and fruiting of fruits were recorded. The flowers were counted at 15 days interval. The plant height was recorded during cutting of the shoots at 7 days interval. The height and other yield attributing traits of the mother plant was recorded. The plant growth promoting attributes like germination percentage, leaf number, plant height, fresh weight, dry weight, fruit yield, chlorophyll (SPAD 502, Minolta Co., Tokyo, Japan) were recorded.

Crop Management

Regular irrigation was applied with the need of field capacity. The insect were aphid, leaf minor, mites and fruit borer. For those pests Imidachloprid 0.5 ml/L for sucking insects like aphid and for mites, miticide 1.7 ml/5L water was applied 7 days interval. Thrice fungicide Tachigaren (high Dongbu fine chemical) was applied at 2 ml/L of water controlling late blight.

Experimental design

The experiment was designed as Control (grown from seeds), Shoot taken plant (STP: the plant grown from seeds from which axillary shoot was attained), Regenerated plant (Plant grown through axillary shoot taken from the STP). Each treatment consist of six replications of individual variety and from those replications 6 more axillary shoots were taken. The experiment was done under glasshouse of the university on 12 L capacity pot and kept aside of the two wall of the glass house pertaining proper sunlight and randomization was done with all variety one by one.

Statistical analysis

Data were subjected to analysis of variance (ANOVA) using the R program version 3.3.2. Significant differences between the means were identified at $p < 0.05$ using the least significant difference (LSD) test.

Results

The plant height was taken on the interval of every 15 days. On 1st 15 days after seedling transplantation it was found that plant height was significantly higher on SJ followed by RKM. At 30 days RKM has a significantly higher plant height at all the treatments and at 45 days SJ and RKM has highest plant height at control and RKM showed significantly higher plant height at STP and regenerated plant Table (1A, 1B, 1C).

Table 1 A.

Plant height of four tomato cultivars grown through seed and axillary shoot (Table.1A)

TAD	Variety	Control	STP	Regenerated plant
15 days	MM	34.23±0.30^{c}	33.17±3.82^{ab}	61.33±2.46^{b}
	HZ	34.93±1.71^{c}	28.67±2.69^{c}	53.33±0.39^{c}
	SJ	39.60±1.11^{a}	26.83±2.12^{c}	78.67±4.11^{ab}
	RKM	38.33±0.51^{ab}	35.17±3.23^{a}	84.00±0.58^{a}

Results are expressed as mean±SD (n=6) and significantly different at a $p < 0.05$. Means sharing the different letter in a same column indicate significant differences.

Table 1B.

Plant height of four tomato cultivars grown through seed and axillary shoot

TAD	Variety	Control	STP	Regenerated plant
30 days	MM	34.23±0.30^{c}	33.17±3.82^{ab}	61.33±2.46^{b}
	HZ	34.93±1.71^{c}	28.67±2.69^{c}	53.33±0.39^{c}
	SJ	39.60±1.11^{a}	26.83±2.12^{c}	78.67±4.11^{ab}
	RKM	38.33±0.51^{ab}	35.17±3.23^{a}	84.00±0.58^{a}

Results are expressed as mean±SD (n=6) and significantly different at a $p < 0.05$. Means sharing the different letter in a same column indicate significant differences.

Table 1C.

Plant height of four tomato cultivars grown through seed and axillary shoot

TAD	Variety	Control	STP	Regenerated plant
45 days	MM	73±4.91^{ab}	71.67±3.66^{a}	93±9.17^{d}
	HZ	69.5±1.74^{b}	64.33±2.11^{ab}	72.83±6.02c
	SJ	87.43±2.79^{a}	55.33±3.67^{b}	123.33±10.7^{b}
	RKM	89±2.40^{a}	71±0.88^{a}	132.33±6.47^{a}

Results are expressed as mean±SD (n=6) and significantly different at a $p < 0.05$. Means sharing the different letter in a same column indicate significant differences

Number of floral bud, flower, and fruit of each individual variety

The flower bud and the open flower were found significantly higher in the control plant; however, the fruit content was higher on shoot taken plant. However, the fruit was significantly higher in a shoot taken plant in moneymaker cultivar. The flower bud and the open flower were found significantly higher in the control plant, whereas, fruit and the open flower were significantly reduced in the control plant in the cultivar. The result shows a total yield of STP and control was significantly different whereas in Rokkusanmaru and Heinz and Srijana.

Moneymaker variety (35 days and 45 days)

30 days	Flower bud	Open flower	Fruit(kg)
Control	50.2±8.34^{a}	3±3.08^{b}	0.4±.44^{b}
STP	22±4.47^{b}	7.4±3.57^{a}	0.8±1.64^{a}
RP	6.5±0.57^{c}	NA	NA
45 days	**Flower bud**	**Open flower**	**Fruit**
Control	16.6± 5.31a	21.6± 12.17a	6.6± 4.66b
STP	9.4± 5.68b	11.4± 7.63b	11.4± 3.5a

Results are expressed as mean±SD (n=6) and significantly different at a $p < 0.05$. Means sharing the different letter in a same column indicate significant differences

Table. 2

Number of Floral bud, flower, and fruit of each individual variety. Heinz variety (30 days and 45 days)

30 days	Flower bud	Open flower	Fruit
Control	19.6±11.54[a]	29.2±22.21[a]	29.25±7.5[a]
RP	11.8±5.54[b]	9.8±9.20[b]	18.6±3.91[b]

Results are expressed as mean±SD (n=6) and significantly different at a $p < 0.05$. Means sharing the different letter in a same column indicate significant differences

45 days	Flower bud	Open flower	Fruit
Control	50.2±8.34[a]	11±3[a]	1.4±0.54[b]
STP	18.8±7.52[b]	8±2.58[b]	2±.07[a]
RP	46.25±2.5[b]	14±2[b]	NA

Results are expressed as mean±SD (n=6) and significantly different at a $p < 0.05$. Means sharing the different letter in a same column indicate significant differences

Srijana variety (30 days and 45 days)

30 days	Flower bud	Open flower	Fruit
Control	28.8±7.88[a]	18.8±7.88[b]	3.8±0.44[b]
STP	13.6±3.13[b]	14±2.91[b]	4±1.87[a]
RP	27±2.94[c]	22±2.91[a]	NA
45 days	**Flower bud**	**Open flower**	**Fruit**
Control	14.2±9.31[a]	20.6±8.5[a]	20.2±.83[a]
STP	4.4±1.94[b]	9.2±4.26[b]	14.4±4.21[b]

Results are expressed as mean±SD (n=6) and significantly different at a $p < 0.05$. Means sharing the different letter in a same column indicate significant differences.

Chlorophyll content

The chlorophyll content of cultivar Rokkusanmaru was found significantly higher in control as compared to shoot taken plant. Whereas, the chlorophyll content showed no significant difference on Moneymaker, Heinz, and Srijana.

Table.3 Chlorophyll content

Variety	Control	STP	Regenerated plant
Moneymaker	41.78±1.58[a]	46.8±1.75[a]	44.15±0.36[a]
Heinz	38±0.97[ab]	41.2±2.82[b]	43.67±1.26[a]
Srijana	39.6±0.4[ab]	46.83±0.35[a]	42.5±0.43[a]
Rokkusanmaru	38.35±0.62[ab]	47.35±0.28[a]	44.07±0.92[a]

Results are expressed as mean ±SD (n=3). Means sharing the different letter in a column indicate a significant difference at $p < 0.05$.

Discussion:

Reports has shown that the ASP in the different plants is quite successful within a short time (Srinivasan et al. 2012). Tomato shoots have the better survival with a high percentage of rooting without using any hormonal treatments (Da Costa et al. 2013). Tomato is generally propagated by seed, and a typical tomato can give up to 200 seeds (Johkan et al, 2016). However, various tomato cultivars have been released which are successfully reproduced through asexual propagation. These cultivars have been rapidly released as they have been developed through mutagenesis and do not require genetic fixation process (Johkan et al, 2008). Asexual propagation in tomato is carried out in order to overcome the sterility barrier as well as to enhance the yield and fruit characteristic. In asexual propagation, the off-springs are genetically identical due to which advantageous traits can be preserved. Virus-free plants can be grown from this propagation using the modern technique like tissue culture. The possibilities of commercial propagation through cutting in tomato has mentioned by some researchers. (El-Eslamboly et al, 2014). Excessive radiation could be harmful to the cuttings or grafted plant and slight shading (65% radiation) would be beneficial (Leonardi and Romano 2002). The importance of tomato is increasing in the world; however, its productivity and production has not overcome the demand of the growing world population. ASP as one of the high yielding asexual propagation technique could be the handy approach for overcoming the bottleneck production problem of tomato year round. Use of hybrid seed in agriculture is common worldwide but the demerit of hybrid seed in F2 generation reduce yield due to genetic segregation. Cost of hybrid per seed 0.1gm (or 39 number) of Moneymaker 3.49 $, Rokkusanmaru 1000 of 75.24 $ and 1gm of Srijana is 1.05 $ in the current global market. Commercially grown tomato need removal of axillary shoots for higher yields and it is time and labor consuming (Tucker, 1976); in a study done in United Kingdom, it was found that 2 hundred million axillary shoots were removed from the tomato field in 1972 and was equal to the cost of 500 pound and equivalent to 5% operational cost (Tucker, 1976). Therefore, ASP from hybrid tomato plant could be an economically viable option to the growers. The tomato varieties used in the experiment were economically important in the world.

The quality yield is the ultimate goal of any commercial agriculture production. In this research we have investigated the yield and yield attributing traits of the tomato plants obtained from the seed and axillary shoot. According to Zheng et. al, (2007) the chlorophyll content, an important parameter of yield attributing trait, was found higher in tomato plant at 40 mg/L dissolved oxygen condition when it was varied from 5.3 to 40mg per L. The Chlorophyll content in the experiment was significantly different in regenerated plant than in control and STP. The plant height of SJ in control was found higher and higher in STP and regenerated plant in RKM at 15 days of records whereas it was not significantly different in MM and SJ in STP and Regenerated respectively. The result also showed that plant height of the regenerated plant was significantly higher over STP and control in all of the verities 45 days. Similar trend was found in chlorophyll content, flower, bud and yield. It was found that the plant regenerated through axillary shoot was more resistant to blight and leaf minor as well as blossom end rot. The fruit number was found significantly different in control with STP and Regenerated plant, however the fruit size was smaller in the control plant as compared to STP and regenerated one (Data not shown). The fruits were optimum in size and weight as the varietal characteristics in STP and Regenerated plant. Some peculiar characteristics were noticed during the growing period of tomato like ASP plant was brittle in

nature, precocious in flowering and fruiting than the seedling originated through plant. There was significant difference in the yield of the tomato in regenerated one with comparison with the control and Shoot donor plant. Besides that the first flower cluster was either shaded or was found lately developed into fruits than the second and subsequent flower cluster. It was also observed that when the first and the third flower cluster was developed into fruit at the similar time laps and fruit size measuring smaller fruit size in the 1st flower cluster followed by normal fruit size in the subsequent flower cluster. It was also noticed that the 1st flower cluster was lately opening the bud and flowered and attained fruit than the subsequent flower cluster. The other flower cluster was noticed with normal fruits as the variety characteristics mentioned. Other disadvantage characteristics were noticed in the regenerated plant like peduncle of the fruit was found longer than the control plant as in ASP and lodging was found due to heavy fruiting. In Heinz 1706 KNU variety, the fruits were found smaller than in the control and STP in few plants. The locule number, color, taste and fruit weight as well as the TSS and Brix percentage of the four tomato varieties in each treatment were also not significantly different (Data not shown). Fruit size and weight per plant was higher in STP and ASP than in control; however total yield and number of the tomato fruit per plant was found higher in control but in plant regenerated and shoot taken plant the number of flower, fruits were not significantly different within the treatments. The first fruit was noticed within 24 DAT (Day after transplanting) in seed plants. The 1st flower cluster fruit size varied from 10 gm to 72 gm in Srijana and Heinz 1706 14 gm to 42 gm to 410 gm to 800 gm in Rokkusanmaru. The average marketable size of tomato plant in each treatment was not significantly different. Regenerated plant from compost substrate and hydroponically rooted plant gave more normal size fruits than the control plant and/or Shoot donor plant.

Summary and Conclusion

The quantitative yield parameters and precocity of the four tomato (*Lycopersicon esculentum,* Mill) varieties (Moneymaker, Srijana, Rokkusanmaru and Heinz 1706), were measured from axillary shoot propagation with their mother plant, in the glasshouse of Kyungpook National University, Daegu, South Korea. The first flowering was noticed in the seeded plant at 14 days after transplanting and in the regenerated plantlets it was 8-10 days of transplanting in both the experiment. The plant height, flower number, open flower, fruit number and chlorophyll content in the four varieties of regenerated plant and control as STP was found significantly different. The fruits were normal in size as compared to control. The highest fruit yield was found in Moneymaker and largest fruit size was found in Rokkusanmaru. Thus, axillary shoot propagation technology is highly recommended for farmers as an alternatives of costly hybrid seed.

Similar types of research on tomato propagation compared through different classes of stem cuttings and seeded plant with their yield parameters did not show significantly differences (Bandara et al, 2019).Therefore, current research findings showed that regeneration of tomato plant through axillary shoot cutting propagation should be a good option for the farmer as an alternative of costly seeds, saves time and labor. Yield and yield attributing traits on field and green house tomato has been done by several researchers. Therefore, this technology could be a boon for the low income farmers with regard to alternative for costly seed production. It's no doubt that axillary shoot propagation yield good as compared to seeded plant and experiment also has focused yield comparison of regenerated plant with mother plant, however it needs further verification though fruit number were not significantly different as ASP plant could not got final yield.

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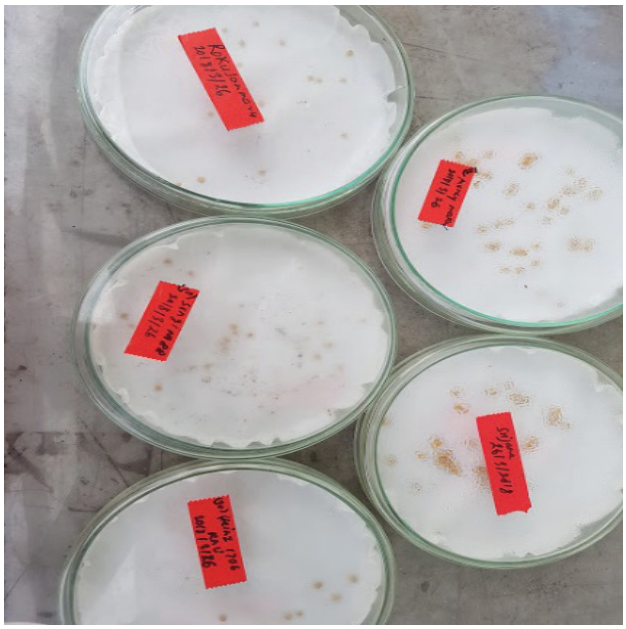
Research Glimpses



Seed kept in germination at 24 degree centigrade

Seedling ready to transfer in the pot

10-15 cm healthy shoot used for the regeneration

Shoot Acclimatized through Hydroponics for rooting

Root development in hydroponics

Shoot tested in the compost media for rooting

Fruiting in the regenerated plant variety Money Maker

Fruits in regenerated variety Srijana

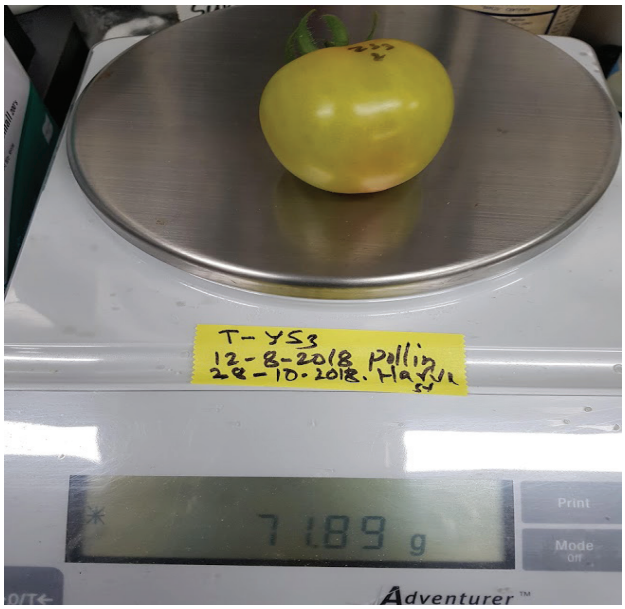
Fruits in regenerated plant of Rokkusanmaru variety

Fruits in Regenerated plants of variety Heinz 1706

Regenerated Maney Maker plant through axillary shoot

Regenerated Srijan Plant from axillary shoot

Randomization of the varieties



Fruit weight in Srijana

Locule of Srijana

Production of fruit from cutting var. Money Maker

Smaller fruit size in the 1st cluster of regenerated plant.

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