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# Variation in indigenous auxin response of tomato genotypes and its association with yield

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**Abstract**
Development of roots from the stem cuttings without auxin treatment indicates presence of indigenous/native auxin in plants. In the present investigation variation in indigenous auxin response of tomato genotypes was studied by dipping the stem cuttings of 25-30 days old seedlings in distilled water. Roots were found to develop from the cuttings and observations were recorded on length of the longest root, number of roots per cuttings, fresh root weight of stem cuttings and frequency of rooted cuttings on 10th day. Root length of the genotypes varied from 0.0 to 5.50 cm with an average of 2.56 cm. Number of roots produced per cuttings varied from 0.0 to 50.5; fresh root weight ranged from 0.0 to 0.152 gram and frequency of rooted cuttings varied from 0.0 to 0.70. Indigenous auxin response of tomato genotypes was expressed in terms of auxin induced rooting index. The yielding ability of the tomato genotypes was evaluated in a randomised block design. High yielding tomato genotypes showed high rooting index. The correlation between auxin induced rooting index and yield was positive (0.250). This indicated that indigenous auxin response could be used as an indicator for preliminary selection of high yielding genotypes.

**Keywords:** Tomato, auxin, rooting, variation, yield, correlation

## Introduction
Stem cutting is an important method of vegetative propagation in many horticultural plants. Stem cuttings when planted in soil induce roots with or without auxin treatment. Root initiation and development from cuttings without auxin treatment indicates presence of native or indigenous auxin. Many researchers studied the effect of auxin on root formation in different crops. Waheed *et al.* (2015) [7] studied the effect of IBA on early root formation of tomato hybrid cuttings. Kachru *et al.* (2017) [3] studied the effect of IBA on root formation in tomato stem cuttings. El-Shafey *et al.* (2017) [1] studied differential *in vitro* regeneration of tomato genotypes on various combinations of growth regulators. Pramanik and Mohapatra (2017) [6] studied the role of auxin on growth, yield and quality of tomato. Ibironke (2019) [19] reported that the Indole -3-butyric acid (IBA) had significant effect on the root emergence and root growth of Bougainvillea species. Mehta *et al.* (2018) [4] conducted a study to find the effect of IBA concentration and time of planting on rooting in pomegranate (*Punicagranatum*) cuttings. Pallavi *et al.* (2018) [5] studied the effect of IBA on rooting and growth of Mulberry cuttings.

Genotypic variation in indigenous auxin level is of paramount importance for selection of genotypes having high native auxin content. High native auxin content encourages profuse rooting in cuttings which helps in better uptake of plant nutrients from the soil for proper growth and development and finally giving more output. Therefore it is logical to expect that variation in native auxin content of the genotypes may give some indications about the yielding ability of the genotypes. In the present investigation the extent of genetic variation in indigenous auxin content of tomato genotypes was assessed and correlated with yielding ability.

## Materials and Methods
### Experimental materials
Twenty two tomato genotypes namely BT 1, BT 10, BT-17, BT-101, BT-106, BT-136, BT-317, BT 12-2, BT 112-1, BT 428-3, BT 442-2, BT 506-1, BT 12-3-2, BT 17-2-5, BT 19-1-1-1, BT 22-4-1, BT 306-1-2, BT 429-2-2, BT 433-2-3, Arka Vikas, Pusa Ruby & Arka Rakshak were taken for this investigation.

Tomato seeds were collected from AICRP on Vegetable Crops, OUAT, Bhubaneswar and sown in the nursery bed as well as in poly pots at AICRP on Vegetable Crops. Tomato genotypes were evaluated in the field as well as in the laboratory to know their yield and indigenous auxin response respectively.

**Field experiment**

The field experiment was conducted in a randomized block design with three replications under All India Coordinated Research Project on Vegetable Crops at Horticultural Research Station, Odisha University of Agriculture and Technology, Bhubaneswar (East and SE Coastal Plain Zone, $20^0$15'N latitude and $85^0$52' E longitude). The plot size was 2 x 2 $m^2$. The experiment was conducted during the year 2017-18 and 2018-19. Seeds of all the genotypes were sown in raised nursery bed on 1st week of November. Twenty five days old seedlings were transplanted in the main field with a spacing of 60 cm x 40 cm. Each genotype was given same management treatments i.e fertilization, irrigation, weeding and spray against pest and diseases. Compost @ 25 tonnes/ha and NPK@ 50:60:60 kg per ha was applied as basal dose during field preparation and additional dose of nitrogen and potassium was applied as top dressing in two equal splits at 30 and 50 days after transplanting. Irrigation was applied as and when necessary. Recommended cultural practices were uniformly followed to raise the crop successfully. Five plants were selected at random from each plot to record observations on different characters like plant height, number of fruits per plant, average fruit weight and fruit yield per plant.

**Laboratory experiment**

The laboratory experiments were conducted at Department of Plant Breeding and Genetics, OUAT, Bhubaneswar following complete randomised design with two replications. Epicotyl portion of 25-30 days old seedlings was excised at a distance of 10 cm from the cotyledon and cuttings of ten seedlings were kept in distilled water for 10 days. Water was changed at regular intervals to avoid rotting.

**Data collection**

Five cuttings were examined randomly for root induction on 10th day for each experiment. The experiments were repeated two times at an interval of 20-25 days. Data were recorded on length of the longest root, number of lateral roots produced per cutting, fresh root weight and frequency of rooted cuttings.

**Data analysis**

**Analysis of variance**

The data collected for each quantitative trait were subjected to analysis of variance (ANOVA) using procedures of SAS version 9.3, after testing the ANOVA assumptions. The difference between treatment means was compared using CD value at 1% probability level.

**Estimaion of auxin induced rooting index (AIRI)**

Auxin response of tomato genotypes was expressed in terms of auxin induced rooting index (AIRI) and that was calculated as follows. The characters under study (root length, number of lateral roots, root fresh weight and frequency of rooted cuttings) were suitably coded as '0' and '1' for below average and above average value respectively. Then the coded values of all the characters were added to obtain auxin induced rooting index. Based on AIRI value tomato genotypes were classified into two groups such as high auxin response (HAR) and low auxin response (LAR) groups.

**Results and discussion**

Results of field experiment and laboratory experiment were presented below. Field experiment was conducted to reveal yield performance of tomato genotypes and lab experiment was done to know variation in indigenous auxin response of tomato genotypes.

**Results of field experiment**

Analysis of variance indicated significant variation among the genotypes in respect of all the characters taken for the study. Among all the genotypes, the tallest plant height was recorded in BT 112-1 (108.30 cm) followed by BT 429-2-2 (102.70 cm) and BT 12-2 (101.1 cm) which were at par. The shortest plant height was observed in BT 12-3-2 (48.50 cm).

Number of fruits/cluster ranged from 3.95 to 6.57 with an average of 5.05. Arka Rakshak recorded the highest number of fruits/cluster followed by BT 1 (6.50) and BT 10 (6.44). The lowest number of fruits/cluster was observed in BT 442-2 (3.95) followed by Pusa Ruby (3.99).

Number of fruits/plant varied from 20.0 to 52.20 with an average of 36.61. The genotype BT 1 recorded the maximum number of fruits/plant (52.20) followed by BT 19-1-1-1 (50.40) and it was statistically at par with Arka Rakshak (48.40).

Fruit weight varied from 17.55 g (BT 1) to 64.50 g (BT 428-3) with an average of 42.10 g. The genotypes BT 101 (54.45 g), BT 136 (58. 80 g), BT 442-2 (55.50 g), BT 442-2 (55.50), BT 506-1(50.65), BT 17-2-5 (57.20) and Arka Rakshak (50.20 g) recorded above fifty gram of fruit weight.

Fruit yield/plant varied from 718.50 to 2437.00 g with an average of 1496.64 g. Arka Rakshak recorded the highest yield of 2437.00 g and at par with BT 101 (2164.00 g). Pusa Ruby recorded the lowest yield (718.50 g) followed by BT 1 (970.50). Genotypes having above average yield (> 1496.64 g) were considered as high yielders. Ten out of twenty two genotypes were noted to have above average yield (V2, V4, V6, V7, V8, V10, V12, V14, V20 and V22) and rest been low yielders.

**Table 1:** Performance of tomato genotypes in respect of growth and yield parameters

| S. No | Genotype | Plant height (cm) | Fruits/ cluster | Fruits/ plant | Fruit wt. (g) | Yield/ Plant (g) |
|---|---|---|---|---|---|---|
| 1 | V1. BT 1 | 54.15 | 6.50 | 52.20 | 17.55 | 970.50 |
| 2 | V2. BT 10 | 52.00 | 6.44 | 35.25 | 46.70 | 1611.50 |
| 3 | V3. BT-17 | 58.80 | 5.80 | 42.80 | 28.80 | 1282.50 |
| 4 | V4. BT-101 | 60.70 | 4.50 | 39.40 | 54.45 | 2164.00 |
| 5 | V5. BT-106 | 70.45 | 4.91 | 38.20 | 29.50 | 1119.50 |
| 6 | V6. BT-136 | 96.40 | 4.78 | 30.30 | 58 .80 | 1742.00 |
| 7 | V7. BT-317 | 66.30 | 5.49 | 39.75 | 46.90 | 1881.00 |
| 8 | V8. BT 12-2 | 101.10 | 4.10 | 41.00 | 43.95 | 1776.50 |
| 9 | V9. BT 112-1 | 108.30 | 4.99 | 29.45 | 46.95 | 1385.00 |

| | | | | | | |
|---|---|---|---|---|---|---|
| 10 | V10. BT 428-3 | 72.20 | 4.20 | 30.15 | 64.50 | 1950.50 |
| 11 | V11. BT 442-2 | 95.40 | 3.95 | 25.55 | 55.50 | 1427.50 |
| 12 | V12. BT 506-1 | 71.90 | 4.43 | 33.85 | 50.65 | 1661.00 |
| 13 | V13. BT 12-3-2 | 48.50 | 4.17 | 38.40 | 25.65 | 974.50 |
| 14 | V14. BT 17-2-5 | 73.15 | 5.11 | 33.65 | 57.20 | 1927.50 |
| 15 | V15. BT 19-1-1-1 | 50.30 | 5.01 | 50.40 | 27.00 | 1379.50 |
| 16 | V16. BT 22-4-1 | 69.15 | 5.26 | 24.20 | 45.85 | 1098.00 |
| 17 | V17. BT 306-1-2 | 67.70 | 5.08 | 34.65 | 41.10 | 1457.00 |
| 18 | V18. BT 429-2-2 | 102.70 | 5.40 | 35.25 | 32.30 | 1178.50 |
| 19 | V19. BT 433-2-3 | 54.70 | 4.70 | 40.38 | 31.70 | 1216.50 |
| 2 | V20. Arka Vikas | 79.60 | 5.74 | 42.30 | 35.95 | 1565.50 |
| 21 | V21. Pusa Ruby | 86.75 | 3.99 | 20.00 | 35.20 | 718.50 |
| 22 | V22. Arka Rakshak | 73.45 | 6.57 | 48.40 | 50.20 | 2437.00 |
| Mean | | 73.35 | 5.05 | 36.61 | 42.10 | 1496.64 |
| CD (0.05) | | 20.31 | 1.42 | 8.54 | 10.49 | 303.99 |
| CV% | | 13.54 | 13.50 | 11.03 | 11.91 | 9.77 |

**Genotypic variation in indigenous auxin response of tomato genotypes**

Stem cutting were able to produce roots when kept in distilled water produced roots indicating presence of indigenous or native auxin in tomato plants. Auxin induced root traits were critically observed to visualise variation in auxin response. Analysis of variance indicated significant differences among the genotypes in respect of different root characters. The length of the longest root, number of lateral roots (number of roots per cutting), root fresh weight and frequency of rooted cuttings under controlled condition are presented in Table 2.

**Variation in root length**

At indigenous level root length of the genotypes varied from 0.0 to 5.50 cm with an average of 2.56 cm. The longest root was produced by the genotype BT 317 (5.50 cm). It was observed that BT 10 had no response in initiating roots at indigenous auxin level. Genotypes giving below average root length (2.56 cm) were BT 1 (1.65 cm), BT 10 (0.0 cm), BT 17 (0.60 cm), BT 101 (1.90 cm), BT 442-2 (0.40 cm), BT 17-2-5 (0.50 cm), BT 19-1-1-1 (0.60 cm), BT 22-4-1 (0.30 cm), BT 306-1-2 (2.10 cm), BT 433-2-3 (1.30 cm) and Pusa Ruby (2.30 cm).

**Variation in number of lateral roots**

Number of lateral roots of the genotypes without IBA treatment ranged from 0.0 to 50.50. Twelve genotypes recorded above average number of roots (20.57) and ten genotypes had below average number of roots. BT 136 ranked first (50.50) and Pusa Ruby ranked second (48.0) in number of lateral roots and they are at par with each other. BT 10 did not show any response to native auxin indicating that its native auxin content was below thresh hold limit so that it could not produce roots from stem cuttings. BT 1 (6.0), BT-101(3.5), BT 442-2 (6.0), BT 17-2-5 (7.0), BT 22-4-1 (5.0) and BT 429-2-2 (8.0) had lower number of lateral roots and they were at par with each other.

**Variation in fresh root weight**

The maximum fresh root weight was observed in case of BT 136 (0.152 g) and it was significantly superior to other genotypes. Fifty percent of the genotypes had above average fresh root weight (> 0.042g).

**Variation in frequency of rooted cuttings**

Frequency of rooted cuttings ranged from 0.0 to 0.80. Maximum frequency was observed in the genotype BT 136. Above fifty percent was observed in thirteen genotypes. The genotype BT 10, BT 112-1, BT 428-3, BT 442-2, BT12-3-2, BT 17-2-5, BT 19-1-1-1, BT 22-4-1 and Pusa Ruby had below average frequency (< 0.46) and rest of the genotypes had above average frequency (> 0.46).

**Table 2:** Rooting in stem cutting of tomato genotypes without auxin treatment

| Genotype | Root length (cm) | No. of lateral roots | Fresh root weight (g) | Frequency of rooted stem cuttings |
|---|---|---|---|---|
| V1. BT 1 | 1.65 | 6.0 | 0.004 | 0.70 |
| V2. BT 10 | 0.00 | 0.0 | 0.000 | 0.00 |
| V3. BT-17 | 0.60 | 36 | 0.075 | 0.50 |
| V4. BT-101 | 1.90 | 3.5 | 0.009 | 0.60 |
| V5. BT-106 | 3.55 | 25.5 | 0.065 | 0.60 |
| V6. BT-136 | 4.50 | 50.5 | 0.152 | 0.80 |
| V7. BT-317 | 5.50 | 22.0 | 0.089 | 0.70 |
| V8. BT 12-2 | 4.25 | 21.0 | 0.051 | 0.50 |
| V9. BT 112-1 | 3.75 | 25.0 | 0.043 | 0.30 |
| V10. BT 428-3 | 4.35 | 30.5 | 0.073 | 0.40 |
| V11. BT 442-2 | 0.40 | 6.0 | 0.002 | 0.10 |
| V12. BT 506-1 | 5.10 | 27.5 | 0.091 | 0.60 |
| V13. BT12-3-2 | 3.95 | 23.0 | 0.067 | 0.40 |
| V14. BT 17-2-5 | 0.50 | 7.0 | 0.002 | 0.20 |
| V15. BT 19-1-1-1 | 0.60 | 18.0 | 0.011 | 0.30 |
| V16. BT 22-4-1 | 0.30 | 5.0 | 0.001 | 0.20 |
| V17. BT 306-1-2 | 2.10 | 24.5 | 0.036 | 0.50 |
| V18. BT 429-2-2 | 3.20 | 8.0 | 0.015 | 0.70 |
| V19. BT 433-2-3 | 1.30 | 15.0 | 0.008 | 0.60 |
| V20. Arka Vikas | 4.00 | 17.0 | 0.037 | 0.50 |

| | | | | |
|---|---|---|---|---|
| V21. Pusa Ruby | 2.30 | 48.0 | 0.053 | 0.40 |
| V22. Arka Rakshak | 2.71 | 34.0 | 0.042 | 0.60 |
| Mean | 2.56 | 20.57 | 0.042 | 0.46 |
| CD (1%) | 0.99 | 11.32 | 0.031 | 0.39 |
| CV% | 4.63 | 5.06 | 4.78 | 5.14 |

**Classification of tomato genotypes based on auxin induced rooting index (AIRI)**

Auxin response of the genotypes was expressed in terms of auxin induced rooting index and its estimation was described in materials and methods. Auxin induced rooting index of two experiments were added and shown in Fig.1. Rooting index of the genotypes varied from 0 to 7 with an average of 2.45.The genotype BT-317 recorded the highest rooting index (7) followed by BT-106 (6) and BT 12-2 (5). Rooting index of some genotypes was found to be more than mean AIRI value (2.45) and these genotypes were considered as having high response to native auxin (HAR). Genotypes having below mean AIRI value were considered to have low response to native auxin (LAR) content.

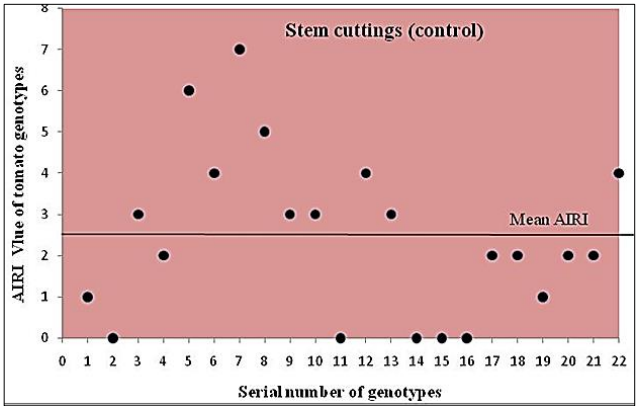


**Fig 1:** Classification of tomato genotypes based on AIRI value

**Analysing relationship between native auxin response and yielding ability**

The relationship between yielding ability and auxin response was analysed following ordination method and correlation study. In ordination method AIRI values were plotted against the fruit yield/plant. In Fig. 2 the AIRI values of different genotypes were plotted against fruit yield/plant. The genotypes having above average yield and high ASI value were represented by numbers (serial number of genotypes was given in Table 1). The HAR (high auxin response) class contained ten genotypes and the LAR class contained twelve genotypes. Ten out of twenty two genotypes were identified as above average yielders. Six out of ten genotypes present in the HAR class were AAYs (frequency = 0.60) and four out of twelve genotypes present in LAR class were AAYs (frequency = 0.33). Conversely, the response of high yielders to auxin indicated that six out of ten AAYs had high auxin response (frequency = 0.60) and four out of ten AAYs had low auxin response (frequency = 0.40).

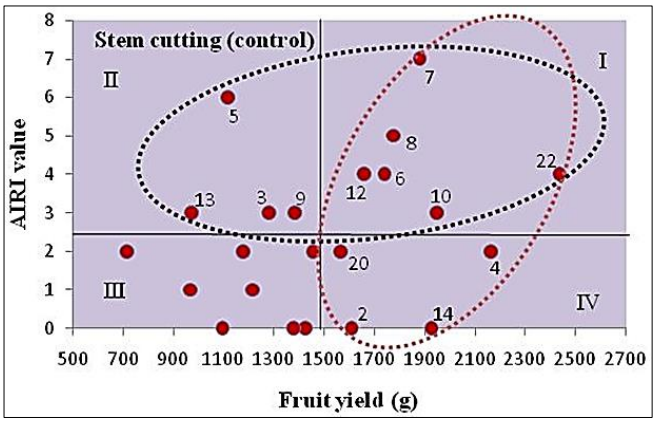


**Fig 2:** Scatter plot of AIRI value and yield/plant of tomato genotypes

AIRI parameter based on all root character showed positive correlation (0.250) with fruit yield. It was observed that root length (RL), fresh root weight (FRW), and frequency of rooted cuttings (FRC) all exhibited positive correlation with yield except number of lateral roots (NLR), which had negative correlation. The correlation coefficient of RL, NLR, FRW and FRC with yield was 0.210, -0.010, 0.140 and 0.098 respectively.

From the present investigation it was observed that roots also appeared from stem cuttings without IBA treatment. This indicates the presence of native auxin in tomato plants which stimulate root formation. Appearance of roots from untreated stem cuttings is quite interesting to study genotypic variation in native auxin content. The positive correlation between auxin induced rooting index and fruit yield indicated that genotypes having high native auxin response may be high yielder and this hypothesis could be repeated further to distinguish low yielding and high yielding genotypes at seedling stage.


V1 (Control) V12 (Control) V5 (Control)

Variation in Rooting of Untreated Stem Cuttings of Some Tomato Genotypes

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