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HORTICULTURE

# Off-season performance evaluation of tomato (*Solanum lycopersicum* l.) genotypes in coastal plain zone of odisha

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**Abstract**

Tomato grown during the rainy season fetches a premium price. But high temperature, rainfall and humidity hinder the success of rainy season tomato crop in coastal plain zone of Odisha. Therefore, a preliminary evaluation was done to predict the performance of twenty five advanced breeding lines along with five state released and two national tomato varieties during off-season in order to identify promising genotypes. The experiment was conducted in a randomized block design with two replications during the year 2012-13. Overall performances of the genotypes in respect of growth characters and fruit characters were expressed in terms of growth index (GI) and fruit index (FI) and selection was done following metroglyph analysis. Analysis of variance indicated significant differences among the genotypes for plant height, number of branches/plant, plant girth, fruit girth, fruit weight, total soluble solids, bacterial wilt incidence (%) and fruit yield except fruit length. From the results of preliminary evaluation it could be suggested that the advanced breeding lines BT 18, BT 101, BT 106, BT 213, BT 317 and BT 433-3-2 are the elite genotypes for off-season cultivation in coastal plain zone of Odisha.

**Highlights**

- Twenty five advanced breeding lines of OUAT were evaluated during rainy season along with five state and two national released tomato genotypes in coastal plain zone of Odisha.
- Following metroglyph analysis, five advanced breeding lines (BT 18, BT 101, BT 106, BT 213, BT 317 and BT 433-3-2) were found promising for off-season cultivation.

**Keywords:** Off- season evaluation, coastal plain, metroglyph analysis, bacterial wilt, tomato

Growing vegetables during the off-season has a lot of prospect for export in foreign country as well as a good earn by the farmers. Among different off-season vegetables, tomato (*Solanum lycopersicum* L.) has prime importance as its demand persists throughout the year. It is also the most important horticultural crop worldwide (FAO 2006, Brown *et al.* 2005). It is the main supplier of many plant nutrients and provides an important nutritional value to the human diet (Willcox *et al.* 2003). Tomato contains much vitamin B and C, iron and phosphorus. Yellow tomatoes have higher vitamin A content than red tomatoes, but red tomatoes contain lycopene, an anti-oxidant that may contribute to protection against carcinogenic substances (Naika *et al.* 2005).

In Odisha, the demand for tomato is constantly high throughout the year. In our state it is cultivated in an area of 96,550 ha with a total production of 13, 82,780 tones (Anonymous 2013). However, the production is limited during off-season months, particularly in extreme dry (February-March planting) months or wet (June-July planting) months in coastal plain zone of Odisha. Tomato production is high during the cooler months (October to February), which is the regular growing season. This results in a bumper

supply of tomato from January to May and meager supply during the rainy months (June to December). Therefore, the price of tomato is much higher during the off-season months and consequently successful tomato cultivation during rainy season in coastal plain zone of Odisha is highly remunerative. The important factors responsible for reducing tomato productivity/production during the rainy season are high temperature, relative humidity and precipitation. Occurrences of major diseases like bacterial wilt, low fruit set and high mortality of seedlings in nursery stage during rainy season, also limit the productivity.

Analysis of climate trends in tomato-growing locations suggests that temperatures are rising and the severity and frequency of above-optimal temperature episodes will increase in the coming decades (Bell *et al.* 2000). Therefore, identification of high yielding and bacterial wilt tolerant genotypes of tomato having superior fruit quality and well adapted to the abiotic stresses of rainy season, is quite essential to increase profit and improve the socio-economic condition of the tomato farmers.

Evaluation and selection of promising genotypes for off-season cultivation is very crucial alongwith different production technology. Noor and Muhammad (2003) screened out suitable pea cultivars for summer cultivation in Dir Kohistan Valley. Aganon *et al.* (2004) studied yield performance of grafted tomato during rainy season in the Philippines. Rokaya *et al.* (2004) studied performance of off-season onion in river basin environment in mid and far western region of Nepal. Pandey *et al.* (2006) made participatory evaluation of rainy season tomato under plastic house condition in Nepal. Gautam *et al.* (2006) evaluated different varieties of onion for off-season production in mid-hills of Nepal. Bozglu *et al.* (2007) evaluated yield performance of fifteen pea cultivars sown during autumn and spring. Narciso and Balatero (2008) evaluated many advanced lines and varieties with potential as off-season varieties in Philippines and reported that variety Rica had outstanding performance. Gautam *et al.* (2013) evaluated four tomato varieties during rainy season in Kaymore plateau and Satpura hills of Madhya Pradesh. Khan *et al.* (2013) evaluated pea cultivars during autumn season under rainfed condition of Potowar region. Deshmukh (2016) evaluated pea cultivars under semi-arid condition of Vidharba region.

To the best of the authors' knowledge, tomato genotypes were never screened during rainy season in coastal plain zone of Odisha. Hence, in the present investigation an attempt has been made to evaluate and identify promising tomato genotypes for off-season cultivation in coastal plain zone of Odisha.

## Materials and methods

The experiment was conducted in a randomized block design with two replications under All India Coordinated Research Project on Vegetable Crops at Horticultural Research Station, Orissa University of Agriculture and Technology, Bhubaneswar (East and SE Coastal Plain Zone, $20^0$15'N latitude and $85^0$52' E longitude). The experimental material comprised of 32 tomato genotypes of which 25 were advanced lines, 5 state released varieties and 2 national varieties (list of the genotypes is presented in Table 2) and the performance of these genotypes during rainy season was evaluated in the year 2012. Seeds of all these genotypes were sown in raised nursery bed on 28th July, 2012. Twenty five days old seedlings were transplanted in the main field with a spacing of 60 cm × 40 cm on 22nd August, 2012. Recommended cultural practices were uniformly followed to raise the crop successfully. Five plants were selected at random from each plot to record observations on plant height (PH), number of

**Table 1:** Mean squares from ANOVA of different growth and fruit characters of tomato genotypes

| Source of variation | DF | Mean squares | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | PH | BN | SD | BWI | FL | FD | FW | TSS | FY |
| Replication | 1 | 0.121 | 0.403 | 0.001 | 3.16 | 0.143 | 0.794 | 1.635 | 1.105 | 0.547 |
| Genotype | 31 | 209.143* | 0.945* | 0.829* | 127.47* | 0.774 | 4.279* | 88.771* | 0.850* | 3.324* |
| Error | 31 | 68.275 | 0.282 | 0.282 | 46.340 | 0.612 | 0.881 | 7.773 | 0.774 | 0.335 |

*$P < 0.05$.

**Table 2:** Growth performance and bacterial wilt incidence of thirty two tomato genotypes grown at Bhubaneswar

| Sl. No. | Genotype | Plant height (cm) | Branches/ plant | Stem diameter (cm) | Bacterial wilt incidence (%) |
|---|---|---|---|---|---|
| | **Advanced line** | | | | |
| 1 | BT 3 | 70.72c | 4.10a | 1.17a | 27.08(31.36)b |
| 2 | BT 17 | 73.26c | 2.20b | 0.61c | 31.25(33.99)b |
| 3 | BT 18 | 91.85b | 3.90a | 1.05a | 12.50(20.70)a |
| 4 | BT 21 | 66.57c | 3.00b | 0.63c | 70.84(57.32)d |
| 5 | BT 12-3 | 88.90b | 2.53b | 0.59c | 22.92(28.60)a |
| 6 | BT 21-2 | 94.51b | 2.10b | 0.66c | 25.00(30.00)ab |
| 7 | BT 101 | 78.73b | 2.10b | 0.59c | 22.92(28.60)a |
| 8 | BT 106 | 76.38c | 3.90a | 1.25a | 25.00(30.00)ab |
| 9 | BT 136 | 92.10b | 2.50b | 0.81b | 33.33(35.26)b |
| 10 | BT 213 | 74.13c | 4.00a | 1.06a | 25.00(30.00)ab |
| 11 | BT 317 | 78.56bc | 3.70a | 1.26a | 20.84(27.16)a |
| 12 | BT 207-2 | 87.38b | 2.88b | 0.64c | 39.58(38.99)bc |
| 13 | BT 428-3 | 84.25b | 2.40b | 0.59c | 54.17(47.39)cd |
| 14 | BT 442-2 | 83.35b | 3.10a | 0.91b | 18.75(25.66)a |
| 15 | BT 224-3-1 | 84.50b | 2.20b | 0.62c | 8.34(16.79)a |
| 16 | BT 306-1-2 | 112.45a | 3.30a | 0.98b | 12.50(20.70)a |
| 17 | BT 429-1-1 | 93.05b | 3.40a | 0.91b | 29.17(32.69)b |
| 18 | BT 429-2-2 | 91.37b | 4.00a | 0.68b | 31.25(33.99)b |
| 19 | BT 433-2-1 | 73.28c | 2.71b | 0.92b | 31.25(33.99)b |
| 20 | BT 433-3-2 | 79.13c | 2.60b | 0.82b | 18.75(25.66)a |
| 21 | BT 437-1-2 | 89.46b | 3.90a | 0.85b | 16.67(24.10)a |
| 22 | BT 215-3-3-1 | 87.89b | 3.30a | 0.79b | 27.08(31.36)b |
| 23 | BT 305-2-4-2 | 74.17c | 2.35b | 0.85b | 16.67(24.10)a |
| 24 | OT Selection | 65.25c | 3.10a | 0.60c | 39.58(38.99)bc |
| | **State released variety** | | | | |
| 25 | Utkal Pallavi | 88.88b | 3.07ab | 0.89b | 27.08(31.36)b |
| 26 | Utkal Deepti (BT 2) | 65.53c | 4.00a | 1.04a | 33.33(35.26)b |
| 27 | Utkal Raja | 85.21b | 3.80a | 1.01a | 31.25(33.99)b |
| 28 | Utkal Kumari (BT 10) | 72.89c | 3.70a | 0.70c | 29.17(32.69)b |
| 29 | Utkal Urbashi (BT 12) | 78.74b | 3.50a | 0.99ab | 35.42(36.52)b |
| 30 | Utkal Pragyan | 72.50c | 4.00a | 1.16a | 39.58(38.99)bc |
| | **National variety** | | | | |
| 31 | Megha tomato | 73.67c | 3.30a | 0.83b | 31.25(33.99)b |
| 32 | Arka Vikash (check) | 84.57b | 3.00b | 0.66c | 20.84(27.16)a |
| Mean | | 81.66 | 3.18 | 0.89 | 28.39 (32.20) |
| CD(0.05) | | 16.77 | 1.08 | 0.27 | 13.82 |

*Different letters in the same column indicate significant differences (P<0.05). The numbers in parentheses indicate arcsine transformed values.*

branches/plant (BN) and stem diameter (SD). Fruit length (FL), fruit diameter (FD), fruit weight (FW) and total soluble solids (TSS) were recorded on the basis of 10 fruits per plot. Bacterial wilt incidence (BWI %) and fruit yield (FY) were recorded on full plot basis for each genotype. The mean data of all observations were statistically analyzed following standard statistical procedures (Panse and Sukhatme, 1978). Metroglyph analysis was done according to the procedure of Anderson (1957). Overall performance of the genotypes in respect of growth and fruit characters were expressed in terms of growth index (GI) and fruit index (FI) which were calculated as follows. Using suitable class intervals, the range of variability with regard to a character was classified into three groups such as low, medium and high. For each character, the genotypes were scored as 0 for low value, 1 for medium value and 2 for high value. The growth index of a genotype was calculated by adding the scored values of all the growth characters such as plant height, number of branches/plant and plant girth. Similarly, fruit index was calculated including all the fruit characters under study, except fruit yield.

## Results and discussion

Analysis of variance (Table 1) indicated significant differences among the genotypes for growth and fruit characters except fruit length. Hence, there is good scope of selection of suitable tomato genotypes for growing during the rainy season, in coastal plain zone of Odisha.

The maximum temperature recorded during the cropping season ranged from 29.7 °C to 32.4 °C and minimum temperature ranged from 19.1 °C to 25.3 °C (Fig. 1). According to Naika *et al.* (2005) the optimum temperature for most tomato varieties lies between 21 and 24 °C. Hence, in the present investigation, the tomato genotypes were invariably subjected to temperatures higher than optimum, which is an imposition of high temperature stress. Mean monthly rainfall varied from maximum of 405.5 mm in July to minimum of 61.6 mm in November (Fig. 1) and afternoon RH % varied from 62 to 82 (Fig. 2). Total amounts of available moisture, and how it becomes available to plants, can affect expression of plant development (Panda *et al.* 2012) and it has been reported by Naika *et al.* (2005) that some local cultivars of tomato give a better yield than imported cultivars even under the heavy environmental stress of the rainy season.

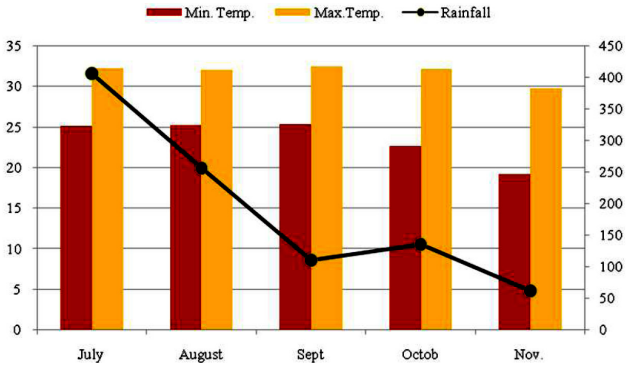


**Fig. 1: Maximum and minimum temperature with rainfall during the growing season**

The mean performances of the varieties in respect of plant height, number of primary branches, stem diameter and bacterial wilt incidence (%) are given in Table 2 while data on fruit length, fruit diameter, fruit weight, total soluble solids (TSS) and fruit yield are presented in Table 3. Among all the genotypes, the tallest plant height was recorded in BT 306-1-2 (112.45 cm) which was significantly superior to rest of the entries evaluated. It was followed by BT 21-2 (94.51 cm) and BT 429-1-1(93.05 cm) which were at par. The shortest plant height was observed in OT Selection (65.25cm) followed by BT 2 (65.53 cm) and BT 18 (66.57 cm) which were statistically at par. Different responses to plant height might be due to genetic characteristic of genotypes and adaptability to a particular environment (Khan *et al.* 2013).

The genotype BT 3 recorded highest number of branches/plant and it was at par with Utkal Deepti (BT 2), BT 213 and BT 429-2-2. Lowest number of branches/plant was observed in genotypes BT 101 and BT 21-2. Stem diameter ranged from 1.26 cm to 0.59 cm with an average of 0.89 cm. Genotype BT 317 recorded the maximum stem diameter (1.26 cm) followed by BT 106 (1.25 cm) and BT 3 (1.17 cm) which were at par.

The potential yield of the genotypes during rainy season often depends on their tolerance or resistance to particular diseases and pests. The major disease prevalent during rainy season at our experimental site was bacterial wilt. Bacterial wilt is also a serious disease of Odisha in particular and India in general. The incidence of bacterial wilt was found to be different in different genotypes. The

highest incidence was observed in BT 21 (70.84%) and the lowest in BT 224-3-1(8.34%) indicating their susceptibility and tolerance to bacterial wilt respectively. Other genotypes which were similar to BT 224-3-1 in tolerance were BT-18, BT 306-1-2, BT 305-2-4-2, BT 437-1-2, BT 433-3-2, BT 442-2, BT 317, Arka Vikash, BT 101 and BT 12-3. Genotypes having less than 25% incidence of bacterial wilt were considered to be tolerant. Palada and Ali (2007) went for grafting of tomato onto eggplant rootstocks and improved plant tolerance against bacterial wilt in rainy season leading to better yields.

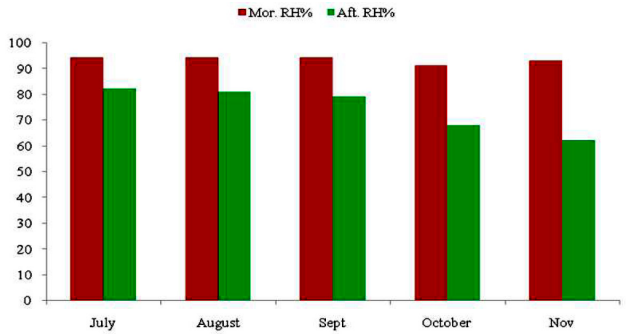


**Fig. 2: Relative humidity at morning and afternoon during the growing season**

Fruit length of the genotypes ranged from 2.97cm to 5.79 cm with an average of 3.96 cm. Genotype BT 305-2-4-2 had maximum fruit length and BT 106 had minimum fruit length. Fruit diameter was maximum in BT 429-1-1 (5.67cm) and minimum in BT 429-2-2 (3.23 cm). Fruit weight varied from 14.60g (BT 1 & BT 17) to 51.67 g (BT 428-3) with an average of 31.76 g. The national check Arka Vikash recorded below average fruit weight (30.80 g). Total soluble solid which is an important quality parameter varied from 3.80 to 6.95$^0$Brix with an average of 5.47$^0$Brix.

The main objective of this experiment was focused on fruit yield. There were significant differences among the genotypes for fruit yield, which ranged from 2.97 t/ ha to 14.09 t/ha with an average of 8.10 t/ha. The genotype BT 18 produced the highest yield of 14.09 t/ha which was significantly superior to rest of the genotypes. It was followed by BT 428-3(11.41 t/ha), BT 306-1-2(11.24 t/ha) and BT 106 (10.67 t/ ha) which were at par. More yields in different genotypes may be due to optimum plant survival, which ultimately contributed significantly towards final yield (Khan *et al.* 2013). The performance of a cultivar mainly depends on interaction of genetic make up and environment.

Metroglyph analysis was done (Fig. 3) following Anderson (1957) to reflect the overall performance of the genotypes at a glance.

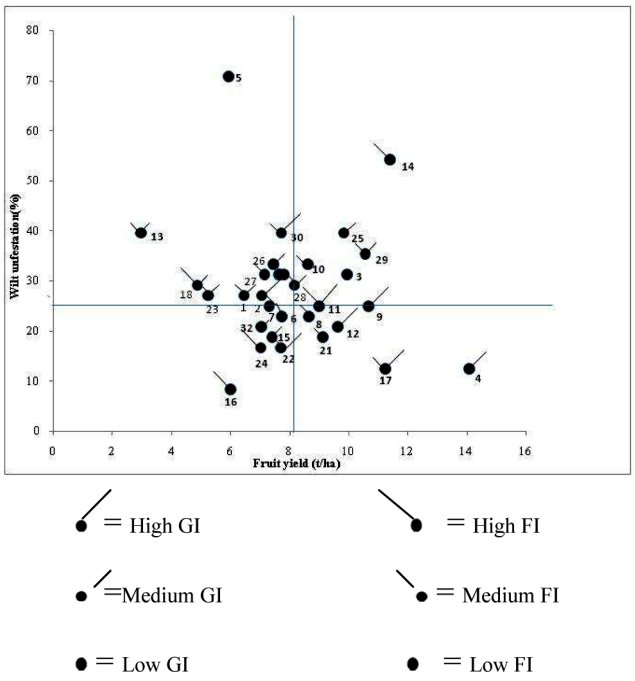


**Fig. 3: Metroglyph analysis of tomato genotypes showing FI and GI values in scatter plot of fruit yield and wilt incidence. Numbers indicate genotypes' serial number as given in Table 2.**

The glyph of three genotypes BT 429-2-2(18), BT 433-2-1(19) and Megha tomato (32) are overlapped with each other in the figure and to avoid clumsiness their serial numbers (18, 19 and 32) as well as their rays on the glyph are not shown in the figure. From the figure it is clear that the thirty two genotypes are distributed in four different quadrants. Five state released varieties are scattered in quadrant I & II. Two national released genotypes are in quadrant II & III. The genotypes present in quadrant-I have above average yield (> 8.10 t/ha) and more than 25% wilt incidence. Among the six genotypes of this quadrant, genotype BT 428-3 (13) the second top yielder (11.41 t/ha) has high wilt incidence (54.17%) and high fruit index value (6.0). The state released variety Utkal Urbashi (30) securing fifth rank among the top yielders has moderate GI and FI values (Table 4). BT 17 (2) present in this quadrant has less wilt incidence, low GI and FI values as compared to Utkal Urbashi and BT 428-3.

Twelve genotypes present in quadrant II have below average yield performance and their wilt incidence

**Table 3:** Performance of tomato genotypes in respect of fruit characters and yield

| Sl. No. | Genotype | Fruit length(cm) | Fruit diameter (cm) | Fruit weight(g) | Total Soluble Solids (°Brix) | Fruit yield (t/ ha) |
|---|---|---|---|---|---|---|
| | **Advanced line** | | | | | |
| 1 | BT 3 | 3.16b | 4.07c | 29.20d | 3.80b | 7.06f |
| 2 | BT 17 | 3.30b | 4.00c | 14.60f | 4.85b | 9.94c |
| 3 | BT 18 | 4.62a | 3.59cd | 25.40d | 5.30a | 14.09a |
| 4 | BT 21 | 3.84b | 3.68c | 26.60d | 4.40b | 5.95gh |
| 5 | BT 12-3 | 4.42a | 3.99c | 36.40bc | 5.80a | 7.74e |
| 6 | BT 21-2 | 4.27a | 4.25b | 38.40b | 5.65a | 7.31f |
| 7 | BT 101 | 3.35b | 4.18c | 37.40b | 5.19a | 8.65d |
| 8 | BT 106 | 2.97b | 3.76c | 24.40e | 5.20a | 10.67b |
| 9 | BT 136 | 4.02b | 4.28b | 35.30c | 5.20a | 8.62de |
| 10 | BT 213 | 4.08b | 4.07c | 30.20d | 5.95a | 9.00d |
| 11 | BT 317 | 3.17b | 4.01c | 28.80d | 5.10b | 9.64cd |
| 12 | BT 207-2 | 4.59a | 3.70c | 25.20d | 6.95a | 2.97i |
| 13 | BT 428-3 | 4.58a | 4.48b | 51.67a | 5.97a | 11.41b |
| 14 | BT 442-2 | 3.39b | 4.16c | 28.33d | 4.65b | 7.41f |
| 15 | BT 224-3-1 | 4.43a | 5.17ab | 38.40b | 5.43a | 6.01g |
| 16 | BT 306-1-2 | 4.53a | 4.43b | 37.60b | 5.25a | 11.24b |
| 17 | BT 429-1-1 | 4.15b | 5.67a | 42.00b | 6.30a | 4.88h |
| 18 | BT 429-2-2 | 3.75b | 3.23d | 28.40d | 5.50a | 7.63e |
| 19 | BT 433-2-1 | 3.97b | 4.16c | 36.60b | 5.30a | 7.68e |
| 20 | BT 433-3-2 | 3.91b | 4.25b | 28.20d | 5.56a | 9.13d |
| 21 | BT 437-1-2 | 4.40a | 4.26b | 39.90b | 5.74a | 7.70e |
| 22 | BT 215-3-3-1 | 4.04b | 4.23bc | 30.70d | 5.48a | 5.24h |
| 23 | BT 305-2-4-2 | 5.79a | 4.69b | 32.00c | 5.49a | 7.03f |
| 24 | OT Selection | 3.02b | 3.60c | 26.60d | 5.35a | 9.84c |
| | **State released variety** | | | | | |
| 25 | Utkal Pallavi | 4.78a | 3.67c | 14.60f | 5.75a | 6.46fg |
| 26 | Utkal Deepti (BT 2) | 3.79b | 3.76c | 27.75d | 4.25b | 7.46e |
| 27 | Utkal Raja | 3.59b | 4.14c | 31.60c | 6.15a | 7.16f |
| 28 | Utkal Kumari (BT 10) | 3.82b | 4.39b | 29.20d | 5.65a | 8.17e |
| 29 | Utkal Urbashi (BT 12) | 4.50a | 3.72c | 31.00c | 6.80a | 10.57bc |
| 30 | Utkal Pragyan | 3.61b | 3.78c | 27.80d | 5.95a | 7.72e |
| | **National variety** | | | | | |
| 31 | Megha tomato | 3.16b | 4.25b | 36.60b | 5.67a | 7.82e |
| 32 | Arka Vikash(check) | 3.65b | 4.01c | 30.80cd | 5.29a | 7.05f |
| Mean | | 3.96 | 4.11 | 31.76c | 5.47a | 8.10e |
| CD(0.05) | | 1.59 | 0.96 | 5.66 | 1.79 | 1.17 |

*Different letters in the same column indicate significant differences (P<0.05).*

is more than 25%. BT 21(5) that is severely affected by wilt has low FI and GI value. The genotypes of this quadrant are not suitable for rainy season. Genotypes present in quadrant-III are seven in number and they have low yield, but they are more tolerant to wilt incidence. The national check Arka Vikash (33) has below average fruit yield (7.05 t/ha) and more tolerance to wilt incidence. BT 224-3-1(15) is least affected by wilt and has high FI value.

Six genotypes present in quadrant-IV have above average yield performance. They are also least

affected by wilt disease. Out of the top five yielders, three genotypes (3, 8 and 16) are present in this quadrant. All the top yielders of quadrant-IV have high GI values.

**Table 4:** GI and FI value of tomato genotypes

| Sl.No | Genotype | Growth index (GI) | Fruit index (FI) |
|---|---|---|---|
| 1 | BT 1 | 3 | 2 |
| 2 | BT 3 | 4 | 2 |
| 3 | BT 17 | 0 | 0 |
| 4 | BT 18 | 5 | 2 |
| 5 | BT 21 | 1 | 0 |
| 6 | BT 12-3 | 1 | 3 |
| 7 | BT 21-2 | 1 | 4 |
| 8 | BT 101 | 0 | 3 |
| 9 | BT 106 | 4 | 1 |
| 10 | BT 136 | 1 | 4 |
| 11 | BT 213 | 4 | 5 |
| 12 | BT 317 | 4 | 2 |
| 13 | BT 207-2 | 2 | 3 |
| 14 | BT 428-3 | 1 | 6 |
| 15 | BT 442-2 | 3 | 2 |
| **16** | BT 224-3-1 | **1** | **5** |
| 17 | BT 306-1-2 | 5 | 4 |
| 18 | BT 429-1-1 | 3 | 7 |
| 19 | BT 429-2-2 | 4 | 2 |
| 20 | BT 433-2-1 | 1 | 4 |
| 21 | BT 433-3-2 | 1 | 3 |
| 22 | BT 437-1-2 | 4 | 5 |
| 23 | BT 215-3-3-1 | 3 | 4 |
| 24 | BT 305-2-4-2 | 1 | 5 |
| 25 | OT Selection | 2 | 1 |
| 26 | BT 2 (U. Deepti) | 3 | 1 |
| 27 | Utkal Raja | 4 | 4 |
| 28 | BT 10(U. kumari) | 2 | 3 |
| 29 | BT 12(U. Urbasi) | 3 | 4 |
| 30 | Utkal Pragyan | 4 | 3 |
| 31 | Megha tomato | 2 | 3 |
| 32 | Arka Vikash | 2 | 2 |

The performance of BT 213 (10) is unique among all. It has above average yield, low wilt incidence and high GI and FI values. The differential behavior of the genotypes was clearly focused in metroglyph and this may be due to variation at genotypic level.

**Photos on kharif tomato**









## Conclusion

From this investigation it may be suggested that all the above average yielders with low incidence of bacterial wilt like BT 18, BT 101, BT 106, BT 213, BT 317 and BT 433-3-2, could perform better for off-season cultivation in the coastal plain zone of Odisha. Further progress in this context is continuing in our research station to identify high yielding stable genotypes for off-season cultivation.

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