**Original Research Article**

**Performance Analysis of Tomato Hybrids under Hill Agro-climatic Zone of Assam**

**ABSTRACT**

**Aim:** A field experiment was conducted to assess the performance of tomato hybrids Arka Abhed and Arka Rakshak under farmers’ field conditions in the Hill agro-climatic zone of Assam.

**Study design:** The trial was laid out in a Randomized Block Design (RBD) with seven replications.

**Place and Duration of the study:** All the seven replications were the seven villages representing three blocks of the district during 2022-23, 2023-24 and 2024-25.

**Methodology:** Two hybrid varieties were taken in the study namely Arka Abhed, and Arka Rakshak and the hybrid variety, Rocky was chosen as check.. Five plants were selected randomly from every treatment to record data on various yield and growth parameters.

**Results:** Results indicated that Arka Abhed outperformed all other tested varieties, including the local check (Rocky), in terms of yield and yield-contributing parameters. Among the three hybrids, Arka Abhed recorded the highest fruit yield (402.06 q/ha), followed by Arka Rakshak (363.42 q/ha) and var. Rocky (282.36 q/ha). Var. Arka Abhed also exhibited superior performance in terms of number of branches per plant (110.53), average fruit weight (126.47 g), and number of fruits per plant (71.22), while var. Arka Rakshak recorded 12.1 branches, 91.66 g average fruit weight, and 53.66 fruits per plant. The local variety Rocky showed the lowest values for these parameters, with 10.3 branches, 86.87 g fruit weight, and 44.36 fruits per plant. Economic analysis revealed that var. Arka Abhed achieved the highest gross profit (Rs. 804,120.00/ha) and benefit-cost ratio (5.75), compared to var. Rocky, which had the lowest gross profit (Rs. 451,776.00/ha) and benefit-cost ratio (3.44).

**Conclusion:** Based on these findings, var. Arka Abhed demonstrates significant potential for adoption in the region and may be recommended for wider cultivation to enhance yield and economic returns for farmers in the Hill zone of Assam.

***Keywords:*** *Tomato hybrids, Arka Abhed, Karbi Anglong, Hill zone, Multiple disease resistance*

1. **Introduction**

Tomato (*Solanum lycopersicum*), a member of the family Solanaceae, is one of the most popular and important vegetables grown throughout the North Eastern region of India, both in the plains and hills. It is cultivated worldwide, both in outdoor and indoor conditions, owing to its wide adaptability and nutritional significance (Singh *et al*., 2014). Tomato is widely used in Indian cuisine-whether cooked, processed, or consumed raw in salads due to its antioxidant and nutritional benefits. It is rich in vitamins, carotenoids, lycopene, and phenolic compounds, making it an important dietary and commercial crop (Palop *et al*., 2010). Lycopene and carotene, in particular, are valued for their anticancer properties (Radzevičius *et al*., 2009). In addition to being consumed as a fresh vegetable, tomato is extensively used in processed products like ketchup, puree, soup, powder, and whole canned fruits. It can be grown in a wide range of soils but performs best in well-drained soils with an optimum temperature of 15°C to 20°C for fruit setting (Anon., 2020).

Karbi Anglong is one of the districts which come under the Hill zone of Assam. The average annual rainfall in the district is 1200 mm, with a maximum temperature of 29°C and a minimum of 17°C. Tomato is one of the major vegetable crops grown in the district, cultivated by both marginal farmers and commercial growers for the fresh market. It is grown over an area of about 608 hectares, producing approximately 12,169 metric tonnes. The main tomato-growing areas in Karbi Anglong include Barlangpher, Diphu, Bokolia, Rajapathar, Bokajan, Natun Basti, Lekthe Basti, and Hogolakota. Most farmers in the hills or interior areas still cultivate traditional varieties, while a few growers in the plains are aware of and use hybrid and improved varieties. Although many hybrid varieties are available in the market, farmers often find them inconsistent in performance across seasons. Additionally, the use of unknown seed sources, poor seed quality and germination, as well as high disease and insect pest incidence, remain significant challenges at the farmers’ level. Keeping these issues in view, an On-Farm Testing (OFT) was conducted by Krishi Vigyan Kendra (KVK), Karbi Anglong, Assam Agricultural University, Diphu, at farmers’ fields to evaluate the best tomato hybrid variety with desirable yield-attributing traits for the district.

1. **Materials and Methods**

The present experiment was conducted at farmers’ fields across seven locations-Shantibasti, Khotkhoti, Barlangpher, Sedang Terang Gaon, Rajapathar, Bokolia, and Diphu during the Rabi seasons of 2022-23, 2023-24, and 2024-25. The experiment was conducted using three treatment options (TO), which included the following tomato hybrid varieties: Arka Abhed (TO1), Arka Rakshak (TO2), and Rocky (Farmers’ practice) as the check. Both Arka Abhed and Arka Rakshak are multiple disease-resistant varieties, showing resistance to Tomato Leaf Curl Virus (ToLCV), Bacterial Wilt (BW), and Early Blight (EB). Additionally, Arka Abhed is also resistant to Late Blight (LB), in addition to the above mentioned diseases.

The study was laid out in a Randomized Block Design (RBD) with three treatments and seven locations serving as replications. Seedlings were raised in nursery beds of 2 m × 1 m size, elevated 5 cm above the soil surface to ensure proper drainage. Seeds were sown in rows spaced 15 cm apart and lightly covered with fine soil.

Transplanting was done using a spacing of 60 cm between plants and 45 cm between rows. All other cultivation practices were carried out according to the recommended Package of Practices of Assam Agricultural University (2023) to ensure healthy crop growth. Regular monitoring and frequent field visits were conducted to maintain proper care of the experimental plots.

For data collection, five tomato plants were randomly selected to record observations on plant height, number of fruits per plant, average fruit weight, fruit length, and fruit breadth. The mean data collected over three years were pooled and statistically analyzed as per the method described by Panse and Sukhatme (1967).

1. **Results and Discussion**

**3.1 Growth parameters**

Plant height is a key agronomic trait influencing the overall growth and vigour of plants (Premalakshmi et al., 2017). As shown in Table 1, the variety Arka Abhed recorded the greatest plant height (110.56 cm), while the check variety Rocky had the shortest (83.43 cm). The observed variation in plant height among hybrids may be attributed to inherent genetic differences, consistent with the findings of Hazarika and Phookan (2005). Regarding the number of primary branches per plant, Arka Abhed exhibited the highest count (14.6), followed by var. Arka Rakshak (12.10), whereas var. Rocky had the lowest (10.30). A greater number of branches in a particular hybrid may be influenced by favourable agro-climatic conditions (Prasad and Bahadur, 2019). Additionally, variation in branching among different varieties may result from their genetic makeup or genotype–environment interactions across locations (Iqbal et al., 2011; Tujuba and Ayana, 2020).

The study also revealed that var. Arka Abhed required the fewest days to reach 50% flowering (33.65), followed by var. Arka Rakshak (36.60), whereas the check variety Rocky took the longest time (39.47 days). These findings align with those reported by Monirul et al. (2011). Earliness in flowering often leads to early yield (Wang, 2004), which might be due to the cultivar’s enhanced capacity to efficiently distribute assimilates throughout the plant, including the apical portions prior to flower initiation (Dieleman and Heuvelink, 1992).

**Table 1:** Performance evaluation of tomato hybrids for growth parameters (pooled data)

|  |  |  |  |
| --- | --- | --- | --- |
| **Treatment options (TO)** | **Plant height (cm)** | **No. of branches** | **Days to 50 % flowering** |
| TO1: Arka Abhed | 110.56 | 14.6 | 33.65 |
| TO2: Arka Rakshak | 98.21 | 12.1 | 36.60 |
| Check: Rocky (FP) | 83.43 | 10.3 | 39.47 |
| SEd | 1.56 | 0.38 | 1.03 |
| CD | 3.44 | 0.83 | 2.27 |

**3.2 Reproductive characters**

The number of fruits per plant is one of the crucial traits to consider while selecting a cultivar for tomato cultivation. In this study, significant differences were observed among the varieties for this trait. Among all the tested varieties, Arka Abhed recorded the highest number of fruits per plant (71.22), while the lowest number was recorded by Rocky (44.36). This variation might be attributed to the fact that an increase in the number of branches leads to a higher number of fruit-producing buds, which ultimately results in a greater number of fruits. These findings are in agreement with earlier reports by Islam *et al*. (2012), Marbhal *et al*. (2016), Kayess *et al*. (2017), and Vijeth *et al*. (2018), all of whom noted that most hybrids performed significantly better than control varieties in terms of total fruit production. Eshteshabul *et al*. (2010) and Falak *et al*. (2011) also reported a wide range of variation in the average number of fruits per plant, ranging from 4.46 to 98.30. In addition to fruit count, fruit size is another important character, as it affects the market appeal and overall quality of the produce. According to the data in Table 2, var. Arka Abhed also recorded the highest fruit length (5.8 cm) and fruit diameter (6.1 cm), whereas the lowest values were again observed in var. Rocky (4.8 cm length and 5.1 cm diameter). The variability in fruit size among the varieties may be attributed to genetic differences, as reported by Ali *et al*. (2012), Saleem *et al*. (2013), Said *et al*. (2014), and Singh *et al*. (2020). Furthermore, biotic and abiotic stresses during the growing period, and each variety's ability to withstand such stresses especially during the reproductive phase may also contribute to differences in fruit development (Tujuba and Ayana, 2020).

In terms of fruit weight, the highest value was recorded by var. Arka Abhed (126.47 g), followed by var. Arka Rakshak (91.66 g), while var. Rocky recorded the lowest fruit weight (86.87 g). Significant differences in yield were also found among the varieties. var. Arka Abhed exhibited superior performance, recording the highest yield of 402.06 quintals per hectare, followed by Arka Rakshak (363.42 quintals per hectare), with var. Rocky showing the lowest yield (282.36 quintals per hectare). This variation in yield could be due to the genetic potential of the variety, greater fruit set, and favorable agro-climatic conditions (Jindal et al., 2018). Additionally, increased yield might also be attributed to traits like greater plant height and higher number of branches, which enhance photosynthetic activity, leading to optimum assimilates utilization and partitioning and thereby increasing the number of active fruit buds (Tujuba and Ayana, 2020).

**Table 2:** Performance evaluation of tomato hybrids for reproductive characters (pooled data)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment options (TO)** | **Fruit length (cm)** | **Fruit diameter (cm)** | **No. of fruits per plant** | **Average fruit weight (g)** |
| TO1: Arka Abhed | 5.8 | 6.1 | 71.22 | 126.47 |
| TO2: Arka Rakshak | 4.9 | 5.5 | 53.66 | 91.66 |
| Check: Rocky (FP) | 4.8 | 5.1 | 44.36 | 86.87 |
| SEd | 0.22 | 0.10 | 1.94 | 1.05 |
| CD | 0.49 | 0.23 | 4.28 | 2.33 |

**4. Economics**

As shown in Table 3, the highest gross profit was recorded for var. Arka Abhed (Rs. 804,120.00) with a benefit-cost ratio of 5.75, followed by var. Arka Rakshak (Rs. 654,156.00) with a benefit-cost ratio of 4.69. In contrast, the lowest gross profit was observed in the case of var. Rocky (Rs. 451,776.00), which had a benefit-cost ratio of 3.44. The higher gross returns observed in hybrid varieties., Arka Abhed and Arka Rakshak can be attributed to a greater number of fruits and higher yield per hectare, which consequently resulted in higher benefit-cost ratios.

**Table 3:** Economics of tomato hybrids (pooled data)

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Treatment options (TO)** | **Yield (q/ha)** | **Gross cost (Rs./ha)** | **Gross profit (Rs./ha)** | **B:C ratio** |
| TO1: Arka Abhed | 402.06 | 139847 | 804120 | 5.75 |
| TO2: Arka Rakshak | 363.42 | 131636 | 654156 | 4.69 |
| Check: Rocky (FP) | 282.36 | 131200 | 451776 | 3.44 |

**5. Conclusion**

Based on the above discussions and results, it can be concluded that the tomato hybrid variety Arka Abhed performed exceptionally well under the agro-climatic conditions of the Karbi Anglong district. This hybrid variety outperformed others in terms of plant height, number of branches, number of fruits per plant, fruit weight, and overall yield. Additionally, var. Arka Abhed recorded reduction in the additional costs associated with managing bacterial blight, leaf curl , early blight, and late blight diseases. Therefore, var. Arka Abhed is recommended for cultivationand, and promoted for large-scale demonstration and adoption in the Karbi Anglong district of Assam to achieve higher yield, productivity and economic returns.

**REFERENCES**

Singh T, Singh N, Bauguna A, Nautiyal M and Sharma VK. Performance of tomato (*Solanum lycopersicum L*.) Hybrids for growth, yield and quality inside polyhouse under mid hill condition for Uttarakhanda. American J Drug Discov Dev. 2014; 4(3), 202-209.

Palop S, Özdikicierler O, Köstekli M, Escriva M, Esteve MJ, Frígola A, *et al*. Ascorbic acid in tomatoes during refrigeration storage with absorbing sheet of ethylene. Inter Con Food Innov. 2010; 1-4.

Radzevičius A, Karklelienė R, Viškelis P, Bobinas Č, Bobinaitė R, Sakalauskienė S. Tomato (*Lycopersicum esculentum* Mill.) fruit quality and physiological parameters at different ripening stages of; Lithuanian cultivars. Agron Res. 2009; 7 (Special issue II), 712–718.

Anonymous: Package of Practices of Cultivation of Vegetables. Punjab Agricultural University, Ludhiana. 2020.

Panse VG and Sukhatme PV. Statistical Methods for Agricultural Workers. Third edition, Indian council of agricultural research, New Delhi. 1984. p-108.

Premalakshmi V, Khuntia S, Kamalkumaran PR and Arumugam T. Evaluation of Indeterminate Tomato (*Solanum lycopersicum* L.) Genotypes for Growth and Yield Traits under Polyhouse Condition. Madras Agric J. 2017; 104(10-12): 405-409

Hazarika TK and Phookan DB. Performance of tomato cultivars for polyhouse cultivation during spring summer in Assam. Ind J Hort. 1992; 62:268-271. http://www.aiscience.org/journal/absj.

Prasad S, Bahadur V. Evaluation of tomato (*Solanum Lycopersicum* L.) hybrids for plant growth, fruit yield and quality in Prayagraj agro climate condition. J Pharmacog Phytochem. 2019; 8(4):3149-3153.

Iqbal M, Niamatullah M, Yousaf I, Munir M, Khan MZ. Effect of nitrogen and potassium on growth, economical yield and yield components of tomato. Sarhad J Agric. 2011; 27(4):545-548.

Tujuba M, Ayana NG. Evaluation of released tomato (*Lycopersicon esculentum* Mill.) varieties for fruit yield and quality parameters in Western Ethiopia. Agric Biol Sci J. 2020; 6(2):100-113.

Monirul Islam, Satyaranjan Saha MD, Hasanuzzaman Akand MD, Abdur Rahim. Effect of spacing on the growth and yield of sweet pepper (*Capsicum annuum* L.). J Central European Agri. 2011; 12(2):228-35.

Wang L. Resistance of tomato line Hawaii 7996 to *Ralstonia solanacearum* Pss4 in Taiwan is controlled mainly by major strain specific locus. Mol Plantmicrobe Interac. 2004; 13: 6-13.

Dieleman JA and Henvelink E. Factors affecting the number of leaves preceding the first inflorescence in the tomato. J Hort Sci. 1992; 67(1):7-10.

Islam MR, Ahmad S, Rahman M. Heterosis and qualitative attributes in winter tomato (*Solanum* *lycopersicum* L.) hybrids. Bangl J Agri Res. 2012; 37:39-48.

Marbhal SK, Ranpise SA, Kshirsagar DB. Heterosis study in tomato for quantitative traits. Int Res J Multidisciplinary Studies. 2016; 2(2):1-6.

Kayess MO, Uddin MJ, Hasanuzzaman M, Rahman MI, Alam MR. Performance evaluation of some productive tomato (*Lycopersicon esculentum* Mill.) hybrids. Int J Biosci 2017; 10(1):279-284.

Vijeth S, Dhaliwal, Jindal SK, Sharma A. Evaluation of tomato hybrids for resistance to leaf curl virus disease and for high yield production. Hort, Environ, Biotechnol. 2018; 59(5):699-709.

Eshteshabul M, Hakim MA, Amanullah ASM, Ahsanullah ASM. An assessment of physiochemical properties of some tomato genotypes and varieties grown at Rangpur. Bangladesh Res Pub J. 2010; 4(3):135-243.

Falak N, Ihasn UI, Syed A, Abdus S, Abdur R. Studies on the growth, yield and nutritional composition of different tomato cultivars in Battal valley of Khyber, Pakistan. Sarhad J Agri. 2011; 27:570-571.

Ali W, Jilani MS, Naeem N, Waseem K, Khan J, Ahmad MJ *et. al*. Evaluation of different hybrids of tomato under the climatic conditions of Peshawar. Sarhad J Agri. 2012; 28(2):200-211

Saleem MY, Iqbal Q and Asghar M. Genetic variability, heritability character association and path analysis in F1 hybrids of tomato. Pak J Agri Sci. 2013; 50(4): 649-653.

Said FA, Farsi KA, Khan IA, Ali A, Khan MM and Iqbal Q. Evaluation of adaptability and nutritional quality of 54 tomato accession grown in Oman. J Food Agri Environ. 2014; 12(2):40-50

Singh M, Ameta KD, Kaushik RA and Rajawat KS. Evaluation of Tomato (*Solanum lycopersicum* L.) Hybrids for Quality Traits, Yield and Fruit under Polyhouse Conditions. Curr J Appl Sci Technol. 2020; 38(6):1-6.

Jindal SK, Dhaliwal MS, Chawla N. Comparative performance of different tomato hybrids under naturally ventilated polyhouse. Int J Hort Sci. 2018; 5(14): 1-12.