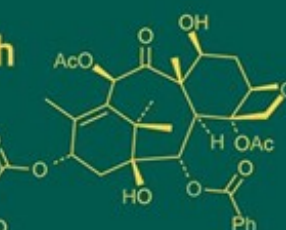


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Comparative study on establishment and growth behaviour in different genotypes of acid lime under Durg district of Chhattisgarh

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ABSTRACT

The present study evaluated the establishment and growth behaviour of seven acid lime (*Citrus aurantifolia*) genotypes under different planting times in the Durg district of Chhattisgarh. The experiment was conducted during 2025–26 at the Instructional Farm, Khudmudi, College of Horticulture and Research Station, Sankara-Patan, Durg (Chhattisgarh), using a Factorial Randomized Block Design (FRBD) with three replications. Results revealed significant variation among genotypes and planting times. NRCC-7 recorded the maximum first shoot length (22.13 cm), while Pramalini produced the highest number of primary branches (11.30). Sai Sharbati showed the maximum secondary branches (9.58) and NRCC-7 had the highest tertiary branches (7.02). Pramalini exhibited the greatest shoot diameter (5.00 mm), whereas NRCC-8 attained the maximum plant height (57.05 cm). Vikram recorded the highest overall survival (94.69%). September planting was superior across most parameters, recording higher shoot length (21.16 cm), secondary branches (8.34), shoot diameter (4.48 mm), plant height (54.15 cm) and survival (88.91%) compared to August planting. Significant genotype × planting time interactions were observed, with Vikram + September yielding maximum shoot length (23.43 cm), Pramalini + August producing maximum primary branches (12.07), NRCC-8 + September showing maximum secondary branches and plant height (10.18 and 61.89 cm) and Pramalini + September achieving the highest survival (96.64%). In conclusion, NRCC-8, NRCC-7, Vikram and Pramalini demonstrated superior growth and establishment performance, with September planting proving more favourable for acid lime cultivation in the agro-climatic conditions of Durg, Chhattisgarh.

Keywords: Acid lime, *Citrus*, FRBD, Genotypes, Growth behaviour, Planting times, Survivability

Introduction

Lime (*Citrus aurantifolia* Swingle) is an economically important citrus fruit crop of India, belonging to the family Rutaceae with a diploid chromosome number of $2n = 2x = 18$. It is believed to have originated in tropical and subtropical Southeast Asia and is commonly known as Kagzi nimbu or Nimbu in India. Considerable genetic diversity and adaptability to varying environmental conditions have been reported in lime (Dubey *et al.*, 2016; Lalramhluna *et al.*, 2016) [1, 2]. India is one of the leading producers of lime, where the crop is cultivated over 11.7 lakh hectares with a production of 177.7 lakh tonnes (Anon., 2026) [3]. In Chhattisgarh, citrus crops occupy about 0.54 thousand hectares with a production of 68.46 thousand tonnes (Anon., 2025) [4].

Acid lime fruits are nutritionally and commercially valuable due to their high vitamin C content, minerals, pectin and antioxidant properties. The fruits are consumed fresh and processed into juice, squash, lemonade, pickle, marmalade, citric acid and essential oil. Lime peel and peel products also have applications in soap and cosmetic industries (Debaje *et al.*, 2011; Kumari *et al.*, 2021) [5, 6]. The fruit also possesses several traditional medicinal properties. About 100 g of fruit juice contains 80% water, 6.05 g acidity, 8.42% TSS and 22.86 mg vitamin C (Carolina *et al.*, 2011) [7].

Successful establishment of an acid lime orchard depends greatly on early vegetative growth and survivability. Planting time is an important management factor because temperature, rainfall, relative humidity and soil moisture prevailing at planting influence root development, nutrient uptake, photosynthesis, cell expansion and overall plant establishment. Proper selection of planting time can therefore promote rapid establishment, vigorous vegetative growth and higher survival, whereas unfavourable conditions may cause moisture stress, poor growth and seedling mortality (Ladaniya *et al.*, 2020; Lunagariya *et al.*, 2022) [8, 9].

Despite its wide adaptability, acid lime production is constrained by poor seedling establishment, slow early growth, variability among plants and limited availability of superior cultivars. Acid lime is commonly propagated through seeds and exhibits a high degree of nucellar embryony (39–60%); however, short seed viability

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ity, poor germination and weak seedling growth remain important nursery and field constraints (Gupta, 1989; Evenari, 1949; Shant *et al.*, 1973) [11, 10, 12]. Further, differences among cultivars in vegetative growth and adaptability necessitate systematic evaluation of their performance under different environmental conditions.

Several acid lime cultivars, including Pramalini, Vikram, Jai Devi, Sai Sharbati and others, are cultivated in India. Cultivar performance varies with genetic constitution and environmental conditions. Vikram, for instance, is known for heavy fruiting, bunch-bearing habit and suitability for off-season production. Hence, identification of genotypes with superior early growth and survivability is essential for successful orchard establishment.

Growth behaviour during the initial establishment phase provides valuable information for identifying vigorous and adaptable genotypes. Since acid lime exhibits distinct growth flushes and its vegetative development is strongly influenced by environmental conditions (Devi *et al.*, 2011) [13], evaluation of genotypes under different planting periods can help identify suitable genotype–planting time combinations. Therefore, the present investigation was undertaken to evaluate the growth behaviour and survivability of different acid lime genotypes under different planting times and to determine their interaction under the agro-climatic conditions of Chhattisgarh.

Materials and Methods

The experiment was conducted at Instructional Farm Khudmudi, College of Horticulture and Research Station, Sankara-Patan, Durg (Chhattisgarh) during the year 2025-26. The investigation was framed in Factorial Randomized Block Design (FRBD) with three replications and Two Factors, For the Factor one Genotype (G) seven genotypes were taken viz, G₁ (Local Collection), G₂ (Vikram), G₃ (Pramalini), G₄ (NRCC-8), G₅ (NRCC-7), G₆ (Sai Sharbati) and G₇ (Jai Devi). While Factor two being Planting time (P) two Planting times were taken namely, P₁ (August) and P₂ (September). Their combination resulted with 14 treatments through which experiment was held. Those treatments were (T₁) Local Collection + August, (T₂) Local Collection + September, (T₃) Vikram + August, (T₄) Vikram + September, (T₅) Pramalini + August, (T₆) Pramalini + September, (T₇) NRCC-8 + August, (T₈) NRCC-8 + September, (T₉) NRCC-7 + August, (T₁₀) NRCC-7 + September, (T₁₁) Sai Sharbati + August, (T₁₂) Sai Sharbati + September, (T₁₃) Jai Devi + August and (T₁₄) Jai Devi + September. Before planting, the experimental field was well prepared. The land was ploughed once using a cultivator and then tilled twice with a rotavator in order to achieve a fine tilth and to get rid of any weeds, stubbles and crop residues. Following ploughing, the field was properly levelled to make it possible to apply uniform irrigation and drainage. Pits measuring 60 cm by 60 cm by 60 cm were dug at the recommended spacing. The pits were left open 15 days before planting so that the soil could be solarized by exposure to the sun, thus helping to reduce soil-borne diseases. On mid-August 2025 and again on mid-September 2025, healthy and uniform genotypes of acid lime were planted in the field. The pits were then filled with top-soil mixed with well-decomposed FYM before planting. While planting the acid lime plants, a row spacing of 3.0 metres and a plant spacing of 2.5 metres was adopted. Bunds and irrigation channels were kept in place between the plots to enable easy irrigation and to carry out intercultural operations. A light irrigation was applied right after planting to promote better root development and uniform growth. Thereafter, irrigations were given at regular intervals according to the soil moisture levels and the prevailing weather conditions. Attention was paid to keeping sufficient moisture in the root zone throughout the experimental period. Excess water was prevented by ensuring good drainage in the field. Observations were made regarding the growth parameters.

The experimental data relating to the various growth parameters obtained during the study were subjected to statistical analysis by means of the method of analysis of variance (ANOVA) for a Two Factor Randomized Block Design (FRBD) as recommended by (Panse *et al.*, 1967) [14]. The significant differences between the treatments were

determined by referring to the critical differences at the 5% level of significance. Statistical analysis was performed using the OPSTAT portal, which is available on the CCS HAU website.

Result and Discussion

Length of first shoot (cm)

The data presented in table 1 revealed the difference between genotypes and planting times was found to be significant. Treatment (T₄) Vikram + September at 120 DAP recorded the maximum length of the first shoot (23.43 cm). This was followed by (T₉) NRCC-7 + August (23.20 cm). Whereas (T₁) Local collection + August recorded the minimum length of the first shoot (13.87 cm). Better utilization of available resources under optimum conditions may have promoted cell division and shoot elongation. Similar interaction effects on vegetative growth were reported in mango by Garcia *et al.* (2024) [15], where cultivar × time interaction significantly influenced shoot growth. Similar findings were reported by Kholia *et al.* (2022) [16] in guava.

Number of primary branches

The significant values were obtained for number of primary branches. Where maximum number of primary branches (12.07) was recorded with (T₅) Pramalini + August at 120 DAP. This was followed by (11.84) with (T₉) NRCC-7 + August. Whereas (T₁) Local Collection + August recorded the minimum Number of primary branches (6.48). Considerable variability in the number of primary branches among different acid lime strains, indicating the existence of substantial genetic diversity for vegetative growth traits in acid lime Shambhulingappa *et al.* (2016) [17]. Early planting provides favourable temperature, humidity and soil moisture conditions which promote better vegetative growth and branch initiation who reported. Similar observations regarding the influence of planting time on vegetative growth parameters have been reported in guava by Dixit *et al.* (2019) [18] and Chandra *et al.* (1995) [19].

Number of secondary branches

As per the obtained values Treatment (T₈) NRCC-8 + September at 120 DAP recorded the highest Number of secondary branches (10.18) followed by (9.96) with (T₁₂) Sai Sarbati + September. Whereas Local (T₂) Collection + September (5.02) recorded the lowest for the same. Number of secondary branches might be due to the specific climatic requirements of the variety and the genetic makeup of the cultivar; similar findings were recorded by Kumar *et al.* (2011) [20] in aonla. Higher secondary branching may be attributed to enhanced vegetative vigour, better nutrient utilization and increased emergence of lateral shoots. Similar genotypic variation in branching behaviour and canopy development has been reported in acid lime by Shambhulingappa *et al.* (2016) [17].

Number of tertiary branches

The investigated parameter differs significantly with. Treatment (T₁₄) Jai Devi + September acquiring greater number of tertiary branches (7.93) followed by (T₁₀) NRCC-7 + September (7.79), whereas (T₁) Local Collection + August having least number of tertiary branches (3.25). This might be attributed to the production of complex organic compounds through photosynthetic activity, which play a vital role in the formation of new tissues and are involved in various metabolic processes. These processes ultimately promote better vegetative growth and development of the plants, resulting in an increased number of tertiary branches. Similar findings have also been reported by Kumar *et al.* (2009) [21], Kotur *et al.* (1997) [22] and Mitra *et al.* (1990) [23].

Diameter of shoot (mm)

The table 1 reveals effect on diameter of shoot which was maximum under the treatment (T₅) Pramalini + August (5.31 mm) at 120 DAP. This was followed by (T₁₀) NRCC-7 + September (5.05 mm), whereas minimum diameter of shoot (3.15 mm) was under (T₁) Local

Collection + August planting. The increase in shoot diameter might also be due to increased cell division and cell enlargement in actively growing shoots (Choudhary *et al.*, 2026) [24] in guava, who observed significant differences in shoot diameter. The improvement in shoot diameter might be attributed to the enhanced microbial activity and improved nutrient uptake, which promoted cell division and cell elongation, thereby resulting in vigorous shoot growth and increased shoot thickness in acid lime by Kumar *et al.* (2026) [25].

Height of plant (cm)

The resulted data for height of plant was found to be significant. The treatment (T₈) NRCC-8 + September at 120 DAP recorded the maximum height of plant (61.89 cm) followed by (T₉) NRCC-7 + August (60.95 cm), while minimum height of plant (42.00 cm) was recorded for (T₁) Local Collection + August planting. The superior genotype recorded maximum plant height, which may be attributed to its inherent genetic potential, better adaptability and higher growth vigour. Similar genotypic variation in plant height was reported in acid lime by Kamatyanatti *et al.* (2016) [26] and Nagarjuna *et al.* (2025) [27].

The superior genotype planted at the optimum planting time recorded maximum plant height due to the combined effect of genetic potential and favourable environmental conditions (Bharty *et al.*, 2022) [28] in cape gooseberry.

Survival percentage (%)

The table 1 revealed the difference between genotypes and planting times according to their survival percentage, as the treatment (T₆) Pramalini + September at 120 DAP recorded the highest survival percentage (96.64%) followed by (95.73%) survival in treatment (T₃) Vikram + August planting. while (T₁) Local Collection + August showed lowest survival (78.92%). Monitoring survival rates can provide insights into the optimal timing for jamun plantation, aiding in maximising survival percentages and overall crop success Priyanka *et al.*, (2024) [29]. Early planting provided suitable environmental conditions for rapid acclimatisation and reduced transplanting shock, resulting in a greater survival percentage. Similar findings were reported in jackfruit by Jayaram *et al.* (2024) [30].

Table 1. Performance of genotypes on growth parameters under different planting times

Genotypes Planting times	Length of 1 st shoot (cm)	No. of Primary Branches	No. of Secondary Branches	No. of Tertiary Branches	Diameter of shoot (mm)	Height of plant (cm)	Survival per- centage (%)
	120 DAP	120 DAP	120 DAP	120 DAP	120 DAP	120 DAP	120 DAP
G ₁	14.45	6.83	5.37	3.45	3.35	42.49	79.40
G ₂	22.10	10.23	7.85	5.33	4.20	52.68	94.69
G ₃	21.39	11.30	8.49	6.05	5.00	55.40	92.03
G ₄	21.65	9.47	8.68	6.76	4.10	57.05	87.71
G ₅	22.13	10.24	7.84	7.02	4.79	55.90	87.68
G ₆	20.75	8.97	9.58	6.05	3.97	55.88	87.57
G ₇	20.50	10.86	8.11	6.81	4.35	52.22	84.15
SE(m)±	0.55	0.43	0.36	0.32	0.21	1.35	1.24
C.D. (5%)	1.60	1.25	1.06	0.93	0.60	3.92	3.61
P ₁	19.69	9.75	7.63	5.38	4.02	52.02	86.29
P ₂	21.16	9.65	8.34	6.47	4.48	54.15	88.91
SE(m)±	0.29	0.23	0.20	0.17	0.11	0.72	0.66
C.D. (5%)	0.85	NS	0.57	0.50	0.32	2.10	1.93
(Interaction G x P)							
G ₁ P ₁	13.87	6.48	5.72	3.25	3.15	42.00	78.92
G ₁ P ₂	15.03	7.17	5.02	3.65	3.35	42.97	79.88
G ₂ P ₁	20.77	9.21	6.89	5.80	3.55	50.29	95.73
G ₂ P ₂	23.43	11.25	8.80	4.85	5.04	55.06	93.66
G ₃ P ₁	20.17	12.07	7.90	5.20	5.31	54.45	87.41
G ₃ P ₂	22.62	10.53	9.08	6.90	4.70	56.36	96.64
G ₄ P ₁	21.13	9.38	7.17	6.10	4.05	52.21	88.14
G ₄ P ₂	22.17	9.56	10.18	7.42	4.15	61.89	87.27
G ₅ P ₁	23.20	11.84	7.96	6.25	4.52	60.95	86.47
G ₅ P ₂	21.05	8.63	7.72	7.79	5.05	50.85	88.89
G ₆ P ₁	19.47	7.98	9.20	5.37	3.56	56.09	84.53
G ₆ P ₂	22.02	9.96	9.96	6.73	4.38	55.66	90.61
G ₇ P ₁	19.20	11.27	8.60	5.68	4.18	48.16	82.87
G ₇ P ₂	21.80	10.46	7.61	7.93	4.51	56.28	85.44
SE(m)±	0.78	0.61	0.52	0.45	0.29	1.91	1.76
C.D. (5%)	2.26	1.77	1.50	1.32	0.85	5.55	5.11

*DAP – Days After Planting

(continued on next page)

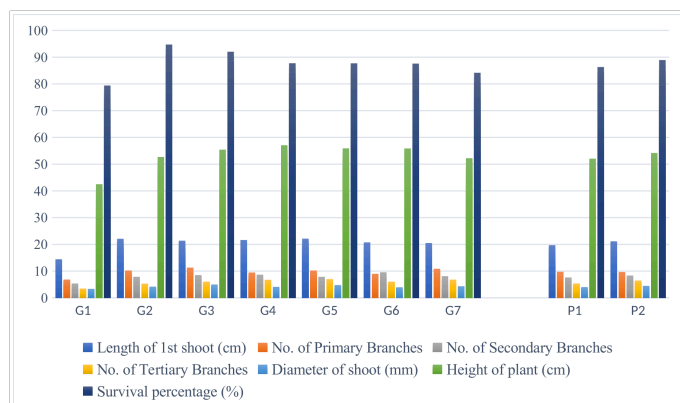


Figure 1. Performance of genotypes on growth parameters under different planting times

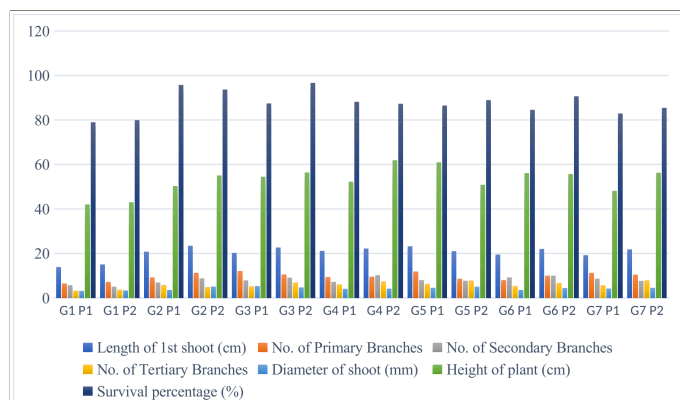


Figure 2. Interaction effect between genotypes and planting times on growth parameters

Conclusion

The conclusion can be drawn as the NRCC-7 recorded the maximum first shoot length and tertiary branches, Pramalini recorded the maximum primary branches and shoot diameter, Sai Sharbati recorded the maximum secondary branches, NRCC-8 recorded the maximum plant height and Vikram recorded the highest survival percentage. September planting generally resulted in better growth and survival than August planting. Among the interactions, Vikram + September recorded maximum shoot length, NRCC-8 + September recorded maximum secondary branches and plant height, while Pramalini + September recorded the highest survival percentage. Overall, NRCC-8, NRCC-7, Vikram and Pramalini performed better, with September planting times being more favourable for acid lime establishment under the Chhattisgarh plain zone.

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