Research Article

Seasonal Evaluation of *Citrus aurantifolia* cv. Kuliana lime for quality attributes under East and South East Coastal Plain Zone of Odisha

Subhrajyoti Mishra* and Dilip Kumar Dash

Department of Fruit Science and Horticulture Technology, College of Agriculture, OUAT, BBSR-03, India

Abstract

Kuliana lime is an elite cultivar of Odisha having a tremendous potential to be included in the future crop improvement programmes owing to its flavour and juice content. This research was conducted at Horticultural Research Station, Department of Fruit Science and Horticultural Technology, Orissa University of Agriculture and Technology, Bhubaneswar, during 2016 and 2017 to evaluate the suitable season in terms of quality parameters. The biometrical observations on various quality attributes were recorded in three different seasons. The best season for fruit quality has determined on the basis of seasonal performances as inter-seasonal variation has tremendous effect for quality of fruit. Spring season produced the best effect for rind thickness (1.30 mm), TSS (6.77 °Brix), sugar content (0.46 per cent), ascorbic acid (32.87 mg per 100 mL of juice) and low acidity (6.19 per cent). Rainy season was the best in terms of fruit volume (29.68 cc) and juice content (16.52 mL/fruit). Our results illustrated that the climatic condition was optimum during the spring season in quality attributes for Kuliana lime under the East and South East Coastal Plain Zone of Odisha.

Keywords: Biochemical, Quality, Acid lime, Kuliana lime, TSS, Rind thickness

***Correspondence**

Author: Subhrajyoti Mishra

Email: subhrajyoti.ss235@gmail.com

Introduction

Citrus (*Citrus* sp.) is the world's leading tree-fruit crop comprising of many tree species and the third most important fruit crop in India next to Mango and Banana. It occupies a place of considerable importance in the fruit economy of the country. Acid lime (*Citrus aurantifolia* Swingle), from the family Rutaceae originated in India and then spread to the Middle East and other tropical and subtropical countries [1]. The major citrus producing countries are Brazil, Spain, USA, Israel, Morocco, China, Mexico, Russia, India, Canada, South Africa *etc*. In India, it is cultivated in 1.055 Mha area with a production of 12.746 MT, among which lemon and lime contribute about 0.255 Mha in area, 2.523 MT on production. The major producing states are Maharashtra, Andhra Pradesh, Punjab *etc*., [2].

Odisha accounts for 9.37 per cent and ranked 4th to the national production of citrus fruits. Mayurbhanj, Keonjhar, Koraput, Ganjam, Gajapati, Dhenkanal are the major lime growing areas in Odisha. The area and production of lime and lemon is 27.97 thousand ha and 261.50 thousand tonne respectively in Odisha [3]. Kuliana lime is a local elite land race of Mayurbhanj district of Odisha, where it is extensively grown as the hot summer and cool winter climate of the area is highly suitable for its cultivation as notified by [4] and [5]. This local land race is traditionally grown in village Kuliana from which the name has come as Kuliana lime and is widely popular in the state for its size and juice content [6]. Since the lime plant has a wide range of soil and climatic adaptation, it is necessary to improve this fruit crop through planned breeding. Hence as a prerequisite, it is essential to study the effective season and basic quality attributes of the fruit crop as this will provides the useful information regarding the potential of the crop in utilizing for further crop improvement.

Materials and Methods

The experiment was conducted on 4 years old air layered acid lime cultivar Kuliana lime, planted at a spacing of 4m×4m in Horticultural Research Station, Department of Fruit Science and Horticultural Technology, Orissa University of Agriculture and Technology, Bhubaneswar, Odisha for three seasons (Rainy, winter and spring) during May 2016 to May 2017. The duration of rainy season was from May-2016 to September-2016, the winter season from October-2016 to December-2016 and that of the spring season was from January-2016 to May-2017 in Bhubaneswar condition. The experimental site comes under the eighteenth agro climatic region of the country *i.e.* "Eastern Coastal

Plain'' and is termed as sub humid. The climate here is warm, humid with distinct summer, rainy and winter seasons. The present experiment was conducted in "Random Effect Model under Proc Mixed through Statistical Analysis System (SAS) software" with three seasons as treatments each replicated ten times. The rind thickness (mm) of fruit was measured by vernier calliper. The juice of fruit (mL) was extracted by lemon squeezer and was measured by the measuring cylinder. The percentage of juice content was calculated in relation to percentage volume of fruit. The total soluble solid was recorded with the help of Erma Hand Refractometer (0-30 °Brix) [7] and expressed in °Brix. Titrable acidity, total sugar, reducing sugar in percentage and ascorbic acid content in mg/100 g of fruit juices was estimated [8]. The percentage of non reducing sugar was estimated by deducting percentage of reducing sugar from percentage of total sugar.

Results and Discussions

Rind thickness

Maximum (1.30 mm) rind thickness (**Figure 1**) was observed in the spring season which is statistically superior over the other (**Table 1**) and it was followed by the winter season (1.07 mm) while rainy season recorded the lowest (1.03 mm). An average of 0.27 mm increase in rind thickness has been observed in spring season over the rainy season (P <0.0001) and 0.23 mm over the winter season (P=0.0001). The impact of winter season in increasing the rind thickness of the fruit was at par with the rainy season. The peel/rind thickness in acid lime ranges from 0.89 mm to 2.13 mm. The period of high humidity during the rainy season might be the factor for less rind thickness in Kuliana lime during that period. Similar findings were already been recorded by [7], [9], [10] and [11].

Figure 1 Cross section of Kuliana lime fruit

Total Soluble Solid (TSS)

Spring season recorded the maximum TSS (6.77 °Brix) in fruit juice which was statistically superior over the winter season (6.49°Brix) and the lowest (5.66 °Brix) was in the rainy season flowering (Table 1). It has been observed that the rainy season shows a decrease of 1.11 °Brix and 0.83 °Brix in the average TSS content of the fruit on spring and winter season respectively (P=<0.0001 each) while winter and spring season were having similar influence for this character of Kuliana lime fruits. During rainy season the high soil moisture might be the reason of decrease in the TSS (°Brix) [11] and during winter, as the start of new vegetative growth utilized a part of reserved carbohydrates, thus the TSS (°Brix) of fruit might be decreased [12]. At cool temperature of spring the concentration of soluble solids in the juice was more as the reserved carbohydrate in spring flush leaves were utilized mainly to support reproductive growth [13].

Volume of juice and percentage of juice per fruit

The rainy season recorded the maximum volume of juice per fruit (16.52 mL) followed by the spring season (13.66 mL) and winter season (9.60 mL) (Table 1). There was no significant influence of rainy season over spring season for enhancing the juice content per fruit in Kuliana lime. However, winter season shows a decrease in the same over the rainy season (6.92 mL) at P= 0.0007 and spring season (4.06 mL) at P=0.028. The analysis revealed that the percentage of juice per fruit varied significantly among the different seasons. During the spring season the maximum

(54.5 per cent) juice per fruit was recorded and was statistically at par with that of the rainy season (52.99 per cent) while the winter season recorded the lowest (45.59). An average increase of 2.4 per cent has been observed in spring season over the winter season (P=0.0027) and 1.52 per cent in rainy season over winter season (P=0.0092). The impact of rainy season in increasing fruit juice percentage was at par with the spring season. The volume of juice per fruit was significantly higher in rainy season might be due to higher atmospheric humidity [12] helps in increasing the juice content of the fruit which were earlier reported by [9], [11], [14] and [15] in other acid lime cultivars. The lesser fruit size or weight of spring season as compared to rainy season might be the result of higher percentage of juice per fruit in Kuliana Lime [16].

Table 1 Influence of season on Rind thickness, TSS, volume of juice, percentage of juice and acidity of the fruit juice in Kuliana lime

Season	Plant	Rind thickness (mm)	TSS °Brix	Volume of juice per fruit (mL)	Juice per fruit (%)	Acidity of fruit juice (%)
Rainy	1	0.96	6.1	19.98	49.99 (44.99)	7.02
	2	0.97	5.9	8.45	41.02 (39.82)	7.4
	3	1.02	5.2	22.12	59.62 (50.53)	8.1
	4	1.05	4.7	28.48	69.02 (56.18)	7.96
	5	1	6.1	14.44	62.78 (42.4)	6.63
	6	1.2	5.9	18.19	58.96 (50.16)	8.75
	7	1	6	13.95	46.72 (43.12)	8.24
	8	1.1	5.4	10.22	47.09 (43.32)	6.71
	9	0.9	5.3	17.22	57.4 (49.26)	6.63
	10	1.1	6	12.17	54.08 (47.34)	6.94
	Mean	1.03	5.66	16.52	52.99 (46.71)	7.44
Winter	1	1.1	6.2	9.82	44.23 (41.68)	6.23
	2	1.02	6.4	9.186	45.7 (42.53)	6.54
	3	1.05	5.9	9.29	47.2 (43.39)	7.2
	4	1.2	6.4	10.06	43 (40.98)	6.92
	5	1.08	6.6	8.1	45.29 (42.29)	5.8
	6	0.98	6.4	14.91	47.5 (43.57)	6.87
	7	1.03	6.8	8.136	46.23 (42.83)	6.54
	8	1.09	6.5	6.98	45.9 (42.65)	6.83
	9	1.1	6.9	8.77	43.2 (41.09)	7.14
	10	1.09	6.8	10.78	48 (43.85)	6.86
	Mean	1.07	6.49	9.60	45.59 (42.49)	6.69
Spring	1	1.2	6.5	11.64	49.97 (44.99)	6.07
	2	1.2	6.8	10.98	51.06 (45.61)	5.9
	3	1.2	6.2	14.49	53.46 (46.98)	5.86
	4	1.13	7.1	10.99	48.21 (43.97)	6.54
	5	1.2	6.9	18.32	62.75 (52.39)	6.73
	6	1.36	6.1	18.12	54.9 (47.81)	5.69
	7	1.3	7.1	13.32	59.8 (50.65)	7.1
	8	1.34	7	13.24	53.4 (46.95)	6.23
	9	1.6	7.1	11.97	53.92 (47.24)	5.64
	10	1.5	6.9	13.55	56.46 (48.61)	6.15
	Mean	1.30	6.77	13.66	54.5 (47.52)	6.19
SE (±) Season		0.03347	0.124	1.2623	1.0247	0.1824
SEd (±) of LSM		0.04733	0.159	1.6978	1.4491	0.2566
Pr >|t|	Rainy spring	<0.0001	<0.0001	NS	NS	0.0001
	Rainy winter	NS	<0.0001	0.0007	0.0092	0.0095
	Spring winter	0.0001	NS	NS	0.0027	NS

Figures in parenthesis denotes Arc Sine value; NS= Non Significant

Acidity of fruit juice

Maximum (7.44 per cent) acidity of fruit juice was observed in the rainy season (Table 1) followed by the winter season (6.69 per cent) and spring season (6.19 per cent). Among the seasons 1.25 and 0.75 per cent of higher acidity

was found in the rainy season over the spring season (P= 0.0001) and winter season (P=0.0095) respectively. There was no significant variation for the same character for the spring season over the winter season. The low acid content of fruit cannot be accounted for by dilution resulting from continuous abundant soil moisture [11]. High temperatures in late spring and summer season [12] may be associated with a low acid content in fruit juice of Kuliana Lime. The slowest rate of acid loss occurred in fruit grown with more relative humidity and cool climate all-round the year [12]. Increasing temperature during the fruit maturation stage was correlated with rapid loss of acid in the fruit due to utilization of the acid in the metabolic process [17].

Table 2 Influence of season on reducing sugar, non-reducing sugar, total sugar and ascorbic acid content of fruit juice of the Kuliana lime

Season	Plant	Reducing sugar (%)	Non reducing sugar (%)	Total sugar (%)	Ascorbic acid content of juice (mg per 100 mL of juice)
Rainy	1	0.19	0.17	0.36	33.24
	2	0.21	0.13	0.34	31.76
	3	0.18	0.14	0.32	32.94
	4	0.16	0.12	0.28	30.2
	5	0.19	0.16	0.35	29.5
	6	0.17	0.13	0.3	32.43
	7	0.2	0.14	0.34	30.33
	8	0.17	0.15	0.32	32.01
	9	0.22	0.14	0.36	30.99
	10	0.16	0.12	0.28	33.3
	Mean	0.19	0.14	0.33	31.67
Winter	1	0.24	0.21	0.45	33.45
	2	0.23	0.2	0.43	33.69
	3	0.25	0.22	0.47	30.43
	4	0.23	0.2	0.43	31.67
	5	0.23	0.2	0.43	32.2
	6	0.24	0.21	0.45	30.95
	7	0.25	0.22	0.47	32.45
	8	0.24	0.22	0.46	33.56
	9	0.23	0.21	0.44	31.7
	10	0.25	0.23	0.48	30.45
	Mean	0.24	0.21	0.45	32.06
Spring	1	0.24	0.22	0.44	32.41
	2	0.25	0.24	0.49	35.79
	3	0.24	0.21	0.45	34.23
	4	0.25	0.22	0.47	30.7
	5	0.26	0.22	0.48	31.64
	6	0.24	0.23	0.47	33.32
	7	0.25	0.22	0.47	33.9
	8	0.25	0.22	0.47	30.47
	9	0.25	0.23	0.48	32.78
	10	0.23	0.2	0.4	33.52
	Mean	0.25	0.22	0.46	32.88
S.E. (±) Season		0.00438	0.00406	0.008051	0.4497
SEd (±) of LSM		0.006194	0.005741	0.01139	0.6269
Pr >|t|	Rainy spring	<0.0001	<0.0001	<0.0001	NS
	Rainy winter	<0.0001	<0.0001	<0.0001	NS
	Spring winter	NS	NS	NS	NS

Reducing, Non reducing and total sugar of fruit juice

Spring season recorded the maximum percentage of reducing (0.25 per cent), non-reducing (0.22 per cent) and total sugar (0.46 per cent) followed by the winter season and the rainy season (**Table 2**). The rainy season recorded a

decrease of 0.06 per cent and 0.05 per cent of average reducing sugar, 0.08 per cent and 0.07 per cent of average non reducing sugar and 0.13 per cent and 0.12 per cent of average total sugar over spring season and winter season at P <0.0001 each, however the spring season over the winter season have no significant variation. Water deficit condition during the fruit developmental stage (March-May) of spring season flowering might be resulted in accumulation of more sugar in the juice sac due to maintenance of high solute concentration. The results are in agreement with the reports of [12] and [16]. Low dry weight in spring flush leaves in Kuliana Lime indicated that reserve carbohydrates might be utilized to sustain the early stage of reproductive development in this season thereby enhancing the sugar accumulation in the fruit than the other two seasons [18].

Ascorbic acid content of fruit juice

The maximum (32.88 mg per 100 mL of juice) ascorbic acid content was observed in the spring season crop followed by the winter season (32.05 mg per 100 mL of juice) and the lowest (31.67 mg per 100 mL of juice) was recorded in the rainy season (Table 2). All the three seasons have similar influence in increasing the ascorbic acid content of the fruit. The increase in ascorbic acid during spring season was associated with rapid increase in total sugar as the fruit synthesizes ascorbic acid hexose sugar precursors [19]. The higher the intensity of sunlight during the growing season, the greater the ascorbic acid content in plant tissues [20]. Ascorbic acid content in fruit can be increased with less frequent irrigation, which is synthesized from sugar supplied through photosynthesis in plants [21]. During the spring season the amount of total chlorophyll content in the leaves of Kuliana Lime [6] were maximum than the other seasons, hence the production of greater amount photosynthates which directly associated with the production of higher amount of ascorbic acid. The results of present study are in close conformity with findings of [6] and [12].

Conclusion

From our study, it can be concluded that the contribution of spring season on the different quality parameters of Kuliana Lime were immense. Quality parameters such as rind thickness, TSS, juice (per fruit and percentage), sugar content and ascorbic acid content of the spring season flowering was significantly higher as compared to the other two seasons. The farmers growing this variety are advised to adopt the bahar treatment for encouraging the spring season flowering. For success in future crop improvement and breeding programmes the spring season flowering must be considered in Kuliana lime.

References

[1] D. K. Salunkhe, B. B. Desai, Post harvests Biotechnology of fruit. Rc-press, In. Boca Raton, Florida, U.S.A., 1984, 2: 148.
[2] NHB, NHB database, National Horticulture Board, Gurgoan, Haryana-122015, 2014, 44-45.
[3] Ministry of Agriculture and Farmer Welfare, Govt. of India. Horticulture statistics at a glance, Oxford publication, 2017, 15, 180 and 237.
[4] S. Mishra, D. K. Dash. Reproductive biology of Citrus aurantifolia cv. Kuliana Lime under east and south east coastal plain zone of Odisha. International Journal of Chemical Studies. 2018b, 6(2): 3556-3561.
[5] S. Mishra. Effect of season on growth and development of Kuliana lime (Citrus aurantifolia). M.Sc. (Ag.) (Fruit Science and Horticulture Technology) Thesis, College of Agriculture, OUAT, BBSR, 2017. http://krishikosh.egranth.ac.in/handle/1/5810030489.
[6] S. Mishra, D. K. Dash. Growth parameters of acid lime (Citrus aurantifolia Swingle) cv. Kuliana Lime. Agric. Sci. Digest, 2018a, 38(4): 297-300.
[7] W. B. Hayes, Fruit Growing in India, Kalyani Publisher, New Delhi, 1975, 280-290.
[8] G. S. Ranganna, Manual of analysis of fruit and vegetable products. Tata Mc Graw Hill publishing company, Ltd. New Delhi: 1977: 12-15.
[9] C. B. S. Rajput, R. S. Haribabu, Citriculture, Kalyani publishers, New Delhi, 1985: 37, 45-60, 65-72.
[10] M. B. Prasad. Clonal variability for physicochemical fruit characters in acid lime. South Indian Hort., 1989, 37(2): 71-74.
[11] W. C. Cooper, A. Peynad, J. R. Furr, R. H. Hilgemanu, G. A. Cahoon, S. B. Boswell. Tree growth and fruit quality of Valencia oranges in relation to climate. Proc. J. Am. Soc. Hort. Sci., 1963, 82: 180-192.
[12] C. E. Kallsen, B. Sanden. Early navel orange fruit yield, quality and maturity in response to late-season water stress. Hort. Science, 2011, 46(8): 1163–1169.
[13] S. Akao, S. Tsukahara, H. Hisada, S. Ono. Contribution of photosynthetic assimilate to development of flower and spring flush in Citrus unshiu Marc. J. Jpn. Soc. Hort. Sci., 1981: 1-9.

[14] G. S. Siddappa. Quality standards for South Indian citrus fruits. Indian J. Hort., 1952, 9(4): 7-24.
[15] M. T. Jawaharlal, T. Thangaraj, I. Irulappan. A Note on the Post Harvest Qualities of Acid Lime. South Indian Hort., 1992, 40(1): 229-230.
[16] G. H. Barry, W. S. Castle, F. S. Davies. Rootstocks and plant water relations affect sugar accumulation of 'Valencia' sweet orange via osmotic adjustment. J. Amer. Soc. Hort. Sci., 2004, 129: 881–889.
[17] S. Hattori, Y. Okamoto, T. Shiizaki. Distribution of chemical component in orange, Nosan Kako Gijustu Kenkyu Kaishi. Chemical Abstract, 1959, 53(6): 37-40.
[18] S. Mishra, K. Pavani, P. Dalei, D. K. Dash. Effect of season on growth dynamics of Citrus aurantifolia cv. Kuliana Lime under Bhubaneswar condition. International Journal of Current Microbiology and Applied Sciences, 2018, 7(02): 2911-2920.
[19] L. W. Mapson, Vitamin in fruits, The Biochemistry of fruits and their products, ed. Hulme A.C. Academic press, New York, 1970, 1: 369-386.
[20] S. H. Vand and T. L. Abdullah. Identification and introduction of Thornless lime (Citrus aurantifolia) in Hormozgan, Iran. Indian Journal of Science and Technology, 2012, 5(11): 3670-3673.
[21] S. K. Lee, A. A. Kader. Pre harvest and postharvest factors influencing vitamin C content of horticultural crops. Postharvest Biology and Technology, 2000, 20: 207–220.

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