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Biodiversity of Woodapple (*Feronia limonia* L.) in Bundelkhand region of Uttar Pradesh

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Abstract
Bundelkhand region is rich in biodiversity for wood apple but less harnessed. The agro-climatic conditions of Bundelkhand have great potential for its commercial cultivation. Keeping these points in view, twenty-five genotypes of wood apple, fruit sample with shoot were collected from diverse areas of Bundelkhand region of utter Pradesh and analysed for various physic-chemical attributes and results of study revealed wide range of variability in morphological quantitative qualitative and biochemical etc. The quantitative variability of different genotypes in wood apple *viz* for fruit length (4.22 cm to 7.46 cm), fruit width (3.06 cm to 6.41 cm), shell thickness (0.10 cm to 0.31 cm), fruit weight (65.9 g to 238.7 g), leaf length (2 cm to 4.3 cm), leaf width (.97 cm to 2.3 cm), seed length (4.7 mm to 8.0 mm), seed width (2.97 mm to 4.77 mm), seed weight (23.76 g to 30.4 g), and No. of seed per fruit (102 to 614). The bio-chemical parameters also showed wide range of variation *i.e.* TSS (10.87 ^{0}Brix to18.09 ^{0}Brix), acidity (2.3% to 6.25%), total sugar (1.55% to 2.38%), reducing sugar (0.86% to 1.28%), non-reducing sugar (0.69% to 1.25%), ascorbic acid (12.63 mg/100g to 35.56 mg/100g). Therefore, on the basis of morphological quantitative and bio-chemical quality attributes, genotypes FS/WA-3, FS/WA-4, FS/WA-5, FS/WA-6, FS/WA-8, FS/WA-10 and FS/WA-25 were screened as promising genotypes. These promising genotypes can be recommended for commercial multiplication, growing at farmer's field and conservation in the field gene bank for further evaluation and crop improvement.

Keywords: Wood apple (*Feronia limonia* L.), variability, total sugar, TSS, and fruits size

Introduction
Wood apple (*Feronia limonia* L.) is a native fruit of India and Sri Lanka belongs to family Rutaceae. It is commonly known as Elephant-apple, monkey fruit, curd fruit and locally known as Kaithbel or Kaitha. Tree is drought resistant survive well without much care. Fruits are rich in quantify the nutritional value along with high antioxidant contents. It is one of the hardy fruits tree mostly found in arid and semi-arid climatic regions mainly southern, central dry forests and Bundelkhand regions of Uttar Pradesh. Bundelkhand region is rich in biodiversity for wood apple. The agro-climatic conditions of Bundelkhand have great potential for its commercial cultivation, due to its hardy nature, long shelf life of fruit and rich nutritional value. Number of indigenous species is only one i.e. *Feronia limonia*. Its cultivation status in India is in cultivated and wild form. Distribution status of wood apple is wide in the country with low germplasm variability. Because of deforestation and urbanization, germplasm erosion status of this fruit tree is very high. Hence the tree needs high collection priority (Gupta *et al*., 1996).

It is commonly grown as a border plant in addition to being found wild form in jungles. In the market, fruit are available from first week of October to March during ripening periods. The fruit is a hard shelled, sticky textured and has numerous seeds, which make it difficult to eat by hand. The fruit is rich in iron, protein and minerals, especially calcium and phosphorus (Rao *et al*., 1989). The flesh is refreshing and aromatic and tastes sour-sweet. The excellent flavour nutritive value and medicinal characteristics of fruit indicate a potentially for processing to value added products. The plant parts like leaf, stem, bark, fruit, and seed have been used for curing various diseases (Sharma *et al.*, 2012) [12]. The fruits contain a myriad of phytochemicals such as polyphenols, phytosterols, saponins, tannins, coumarins, triterpenoids, vitamins, amino acids, tyramine derivatives, etc. (Dar *et al.*, 2013) [1].

It also have curative value for various diseases of bones and joints, bilious diseases, prevention of capillary bleeding, piles, dysentery, cold, influenza, habitual constipation and scurvy (Diengngan and Hasan 2015). Keeping these points in view, the present investigation on diversity of wood apple (*Feronia limonia* L.) fruits under Bundelkhand region of Uttar Pradesh for find out the morphological physico-chemical attribute promising genotypes for further utilization, conservation multiplication, crop improvement and commercial growing under Bundelkhand regions of Uttar Pradesh.

Materials and Method

The present investigation was carried out at Department of Fruit Science, college of Horticulture, Banda University of Agriculture & Technology, Banda (UP) during 2019-20. Thirty genotypes were collected from Bundelkhand region of Utter Pradesh. Twenty-five fruits of *wood apple* were randomly selected from all the direction of marked and selected genotypes, and the bulk of sample of all the selected trees from each site collected then kept into bags and tagged by the number and subjected to physico-chemical analysis in laboratory. Physical parameters like fruit weight measure by electronic weighting machine and fruits length, fruits width shell thickness seed size spine length, and seed size were estimated with the help of digital Vernier Callipers. Ascorbic acid was determined by using 2, 6-Dichlorophenol-indophenols visual titration method (Johnson, 1948). Sugars content were estimated using Fehling's solutions (Lane and Eynon, 1923) and the method as described by (Rangana, 2010) [6], Reducing sugars (Nelson 1944). The percentage of non-reducing sugars was obtained by subtracting the values of reducing sugar from total sugars and multiplying by 0.95 (Somogyi, 1952). The two years' data obtained during experimentation was statistically analysed as per method given by Panse and Sukhatme (1985) and results were evaluated at 5% level of significance.

Results and Discussion

The data pertaining to morphological quantitative and qualitative attributes of wood apple exhibited a significant variation with respect to fruits shape, fruits length, fruits width and fruits weight etc (Table 1, 2 and 3). The fruit length varied between 7.46 cm to 4.22 cm. Among the all genotypes FS/WA-7 produced longest fruit and closely followed by FS/WA-13. The value was found lowest in FS/WA-24. The fruit width varied between 6.41 cm to 3.06 cm. Among genotypes FS/WA-25 showed maximum fruit width followed by FS/WA-13 (6.3 cm). The value was found lowest in genotype FS/WA-12 (3.06 cm). The difference of the fruits size may be due to different genetical character, photosynthetic activity and soil productivity or environmental factor. The similar fruits length variability in wood apple were reported by Shyamala Devi *et al.* (2018) [13], Sharma *et al.* (2014) [11] Vijayakumar *et al.* (2013), Namdev (2010) [6]. The fruit weight varied between 238.76 g to 65.9 g. Among the genotypes, FS/WA-7 (238.76 g) recorded maximum fruit weight whereas, minimum fruit weight was noticed in FS/WA-23(65.9 g). Singh *et al.* (2016) [14] observed that fruit weight of wood apple ranged between 156.45-432.93.). Variations in fruits' weight observed in the present studies may be attributed due to genetic factor or micro climate of germplasm collected area or soil fertility variability Findings were supported by the results of Khan *et al.* (2019) [4] from 110-225 g, Shyamala devi *et al.* (2018) [13] from 241.60 g, Pandey *et al.* (2013) [7] from 140-256 g.

Maximum leaf length was recorded by the genotype FS/WA-18 (4.3 cm.) followed by genotype FS/WA- 25 (4.13 cm.) while, the minimum length of leaf was recorded by the genotype FS/WA- 6 (2 cm.). The genotype FS/WA- 25 had highest leaf width (2.3 cm) and genotype FS/WA -14 had minimum leaf width (.91 cm). Leaf length and width variability in wood apple may be due to cell division process and elongation of new cells formed or other genetic factor or micro climate condition of germplasm site. However, leaf shape revealed all genotypes possess obtuse shaped apex leaf and base leaf is of cuneate shape (FS/WA- 1 to FS/WA-25) These results are in conformity with the earlier findings of Yadav *et al* (2018) [15], Singh *et al.* (2016) [14] Ghosh *et al.* (2012) [3] in wood apple; Awasthi and More, (2009) in Ber, Singh and Singh (2005b) in mahua, Singh *et al.* (2015) in aonla was reported similar results.

The genotype FS/WA-22 had highest seed length (8.05 mm) and genotype FS/WA-8 had minimum seed length (4.7 mm). These results are in conformity with the earlier findings of Yadav *et al.* (2018) [15] from 7.05-10.26 mm, Singh *et al.* (2016) [14] and Ghosh *et al.* (2012) [3]. The significant variation in seed width was observed in all genotypes. The seed width varied between 4.77 mm to 2.97 mm. Among different genotypes, genotype FS/WA- 12 had highest seed width (4.77mm) and genotype FS/WA -16 had minimum seed width (2.97 mm). Similar results were reported by Yadav *et al.* (2018) [15] from 2.35-5.26 mm, Singh *et al.* (2016) [14] and Ghosh *et al.* (2012) [3] in wood apple. The highest seed weight (30.4 g) was recorded by the genotype FS/WA- 19 followed by FS/WA-17(30.3 g) whereas minimum seed weight (23.76 g) was recorded in the genotype FS/WA-18. Singh *et al.* (2016) [14] observed that the seed weight of wood apple ranged between 2.36 to 7.93 g. Similar variations in seed weight of wood apple were reported by Shyamala devi *et al* (2018) [13], Yadav *et al.* (2018) [15] 2.4-7.9 g, Singh *et al.* (2016) [14] from 2.36-7.93 g, Pandey *et al.* (2013) [7] from 7.83-15.66 g and Ghosh *et al.* (2012) [3]. In general, seed shape can be scored as a combination of magnitudes, or by a single magnitude that indicates the percentage of similarity to a given geometric object. Seed shape can be determined by the length/width ratio of wood apple. The study revealed wide variation in wood apple shape among the 25 genotypes. Out of 25 genotypes all have oblong shaped seeds (FS/WA-1 to FS/WA-25). Similar variations in seed shape of wood apple were reported by Shyamala devi *et al.* (2018) [13], Yadav *et al.* (2018) [15], Singh *et al.* (2016) [14], Pandey *et al.* (2013) [7] and Sappandi *et al.*, (2005) [10].

Variability in chemical attributes was found among different elite selected wood apple genotypes. Total soluble solid in different genotypes of wood dapple ranged from 10.87^0 Brix to 18.09^0 Brix. However, among the genotypes of wood apple, maximum (18.09^0 Brix) total soluble solid was noticed in genotype FS/WA-6 followed by genotype FS/WA-8 (17.31^0 Brix). In contrast, minimum total soluble solid (10.87^0 Brix) was noticed by the genotype FS/WA-21, which is on par with the genotype FS/WA-19 (11.40^0 Brix). However, maximum ascorbic acid was found in genotype FS/WA-16 (35.56 mg/100g) followed by FS/WA-19 (28.39 mg/100g), whereas, minimum ascorbic acid was found in FS/WA-12 (12.63 mg/100g).Similar trend of total soluble solid was reported by Yadav *et al.* (2018) [15], Singh *et al.* (2016) [14], Sharma *et al.* (2014) [11] and Ghosh *et al.* (2016) in wood apple and Pandey *et al.* (2006) in bael fruits.

It is evident from the observation that highest reducing sugars were found in genotype FS/WA-13 (1.28%) followed by

FS/WA-17 (1.27%), whereas minimum reducing sugars was recorded in the genotype FS/WA-16 (0.86%). The non-reducing sugar varied between 1.25% to 0.69%. The maximum non-reducing sugar was recorded in genotype FS/WA-8 (1.25%) closely followed by FS/WA-14 (1.22%), While, minimum non-reducing sugar was observed in genotype FS/WA-18 (0.69%). The maximum total sugar content (2.38%) was recorded in genotype FS/WA-20 followed by FS/WA-14 (2.38%), whereas minimum (1.55%) total sugars have been found in FS/WA-14. Similar variations of sugars of wood apple were reported by Singh *et al.*, (2016) [14] & Pandey *et al.* (2013) [7] Yadav *et al.* (2018) [15]. Ram and Singh (2003) and Pandey *et al.* (2006) in bael.

Table 1: Variation of different chemical character of wood apple (*Feronia limonia* L.)

Treatment	TSS (Brix)	Acidity (%)	Reducing sugars (%)	Non-reducing sugars (%)	Total sugars (%)	Vitamin C (mg/100g)
FS/WA-1	13.49	4.23	1.09	0.96	2.05	21.73
FS/WA-2	14.04	4.68	0.95	1.13	2.09	19.70
FS/WA-3	16.03	3.09	0.89	0.88	1.78	22.14
FS/WA-4	15.62	4.61	1.07	0.75	1.82	26.48
FS/WA-5	14.39	6.25	1.05	0.96	2.02	18.52
FS/WA-6	18.09	4.73	1.18	1.03	2.21	14.80
FS/WA-7	14.26	3.84	1.17	1.19	2.36	23.48
FS/WA-8	17.31	3.54	1.03	1.27	2.28	16.87
FS/WA-9	15.21	5.73	1.12	0.93	2.06	20.24
FS/WA-10	13.68	2.92	1.19	1.12	2.32	22.39
FS/WA-11	15.32	4.46	1.15	1.02	2.16	18.53
FS/WA-12	17.27	3.95	0.99	1.00	1.99	12.64
FS/WA-13	14.24	2.30	1.28	1.03	2.31	16.87
FS/WA-14	15.22	4.64	1.17	1.22	2.39	21.13
FS/WA-15	16.39	2.96	1.19	1.03	2.22	22.90
FS/WA-16	13.48	6.15	1.21	1.11	2.32	35.57
FS/WA-17	16.42	5.17	1.27	0.89	2.17	23.42
FS/WA-18	12.63	4.93	0.86	0.69	1.55	27.26
FS/WA-19	11.40	4.17	1.05	1.12	2.18	28.40
FS/WA-20	16.24	3.55	1.21	1.17	2.38	14.47
FS/WA-21	10.87	2.66	1.18	0.95	2.13	22.43
FS/WA-22	13.80	3.53	1.20	1.13	2.32	18.80
FS/WA-23	11.76	4.51	1.26	1.08	2.34	25.09
FS/WA-24	16.24	4.37	1.16	1.03	2.19	18.81
FS/WA-25	14.27	3.42	1.29	0.98	2.27	25.32
C.D.	0.50	0.22	0.05	0.03	0.06	0.63
SE(m)	0.08	0.02	0.01	0.02	0.22	0.10
Mean	14.71	4.18	1.13	1.03	2.16	21.52
Range	10.87 -18.09	2.30 -6.25	0.86 - 1.29	0.69 - 1.27	1.55 -2.39	12.64 -35.57

Table 2: Variation of different quantitative parameters of wood apple (*Feronia limonia* L.)

Treatment	Av. Fruit weight (g)	Av. Length of fruit (cm)	Av. Width of fruit (cm)	Av. Shell thickness of fruits (cm)	Av. Leaf length (cm)
FS/WA-1	201.49	7.11	6.09	0.31	4.00
FS/WA-2	210.88	7.05	5.77	0.23	3.83
FS/WA-3	180.56	7.02	6.09	0.33	2.50
FS/WA-4	139.42	6.76	5.90	0.15	3.13
FS/WA-5	144.71	6.18	5.20	0.20	4.00
FS/WA-6	207.42	7.25	6.13	0.14	2.00
FS/WA-7	238.77	7.47	6.27	0.12	2.90
FS/WA-8	154.37	6.45	4.27	0.21	3.43
FS/WA-9	216.44	7.45	5.79	0.25	3.00
FS/WA-10	210.47	6.73	6.30	0.31	2.47
FS/WA-11	195.88	6.94	5.67	0.12	3.13
FS/WA-12	166.50	6.73	3.06	0.10	3.27
FS/WA-13	222.70	7.31	6.13	0.24	3.43
FS/WA-14	155.95	7.50	5.20	0.30	3.30
FS/WA-15	153.63	7.07	6.00	0.18	3.90
FS/WA-16	200.87	7.11	5.23	0.22	3.10
FS/WA-17	154.86	6.59	5.57	0.23	4.13
FS/WA-18	126.47	5.94	4.26	0.15	4.37
FS/WA-19	105.51	6.68	4.59	0.11	4.00
FS/WA-20	194.42	7.23	6.00	0.21	3.87
FS/WA-21	104.38	5.43	4.55	0.22	3.00
FS/WA-22	110.98	6.22	3.06	0.31	3.63
FS/WA-23	65.90	5.97	4.33	0.42	3.53
FS/WA-24	93.78	4.23	5.09	0.32	3.17
FS/WA-25	184.46	5.73	6.42	0.23	4.13

C.D.	22.17	0.13	0.236	0.04	0.29
SE(m)	7.77	0.05	0.083	0.01	0.10
Mean	165.63	6.65	5.32	0.22	3.41
Range	65.90-238.7	4.32-7.50	3.06-6.92	0.10-0.42	2.0-4.37

Table 3: Variation of different physical parameters of wood apple (*Feronia limonia* L.)

Genotype	Fruit shape	Leaf shape		Seed shape
		Apex	Base	
FS/WA-1	Round	Obtuse	Cuneate	Oblong
FS/WA-2	Round	Obtuse	Cuneate	Oblong
FS/WA-3	Oval	Obtuse	Cuneate	Oblong
FS/WA-4	Oval	Obtuse	Cuneate	Oblong
FS/WA-5	Round	Obtuse	Cuneate	Oblong
FS/WA-6	Flatted	Obtuse	Cuneate	Oblong
FS/WA-7	Round	Obtuse	Cuneate	Oblong
FS/WA-8	Round	Obtuse	Cuneate	Oblong
FS/WA-9	Round	Obtuse	Cuneate	Oblong
FS/WA-10	Round	Obtuse	Cuneate	Oblong
FS/WA-11	Oval	Obtuse	Cuneate	Oblong
FS/WA-12	Oval	Obtuse	Cuneate	Oblong
FS/WA-13	Triangular	Obtuse	Cuneate	Oblong
FS/WA-14	Triangular	Obtuse	Cuneate	Oblong
FS/WA-15	Triangular	Obtuse	Cuneate	Oblong
FS/WA-16	Round	Obtuse	Cuneate	Oblong
FS/WA-17	Round	Obtuse	Cuneate	Oblong
FS/WA-18	Round	Obtuse	Cuneate	Oblong
FS/WA-19	Round	Obtuse	Cuneate	Oblong
FS/WA-20	Oval	Obtuse	Cuneate	Oblong
FS/WA-21	Oval	Obtuse	Cuneate	Oblong
FS/WA-22	Flatted	Obtuse	Cuneate	Oblong
FS/WA-23	Flatted	Obtuse	Cuneate	Oblong
FS/WA-24	Round	Obtuse	Cuneate	Oblong
FS/WA-25	Oval	Apex	Base	Oblong

Conclusions

On the basis of results significant variation was observed in physio-chemical traits of different wood apple genotypes it may conclude from the studied that wood apple genotypes showed wide genetic diversity in the existing population of rainfed areas of Bundelkhand region of the Utter Pradesh, in quantitative, qualitative traits morphological and biochemical traits. Among these genotypes, genotypes FS/WA-3, FS/WA-4, FS/WA-5, FS/WA-6, FS/WA-8, FS/WA-10 and FS/WA-25 were screened as promising genotypes. These promising genotypes can be recommended for commercial multiplication, growing at farmer's field and conservation in the field gene bank for further evaluation and release of cultivar in future.

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