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MORPHOLOGICAL AND QUANTITATIVE CHARACTERIZATION OF WOOD APPLE (*FERONIA LIMONIA* L.) GENOTYPES UNDER AWADH REGION OF UTTAR PRADESH, INDIA

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ABSTRACT

Wood apple (*Feronia limonia* L.) is an important underutilized fruit of the world having great medicinal and religious significance. Awadh of Uttar Pradesh is very rich in biodiversity for wood apple but still less harnessed. Fruit sample with shoot were collected from twenty-nine genotypes of wood apple in diverse areas of Awadh region of Uttar Pradesh and analysed for various physiological attributes and results of study shows a wide range of variability in morphological and quantitative parameters. Among the parameters fruit shape of different genotypes show a variation viz, flattened, round and oval shapes are found. The experiment was laid out in Completely Randomized block Design (CRD) with three replications. Observations revealed rich genetic variations with respect to individual fruit length (5.33-9.43 cm), fruit width (5.57-9.46 cm), fruit weight (113.26-258.86 g), spine length (1.34-3.50 cm), shell thickness (0.16-0.43 mm), seed length (4.54-8.36 mm), seed width (1.95-4.02 mm), seed thickness (1.36-1.67 mm), seed weight per fruit (25.25-31.05 g), number of seeds per fruit (160.0-456.0), among different genotypes. Among these genotypes, Genotypes - G15, G14, G13, G17, G18 and G20 were screened as promising genotypes.

Keywords **:** Underutilized, Biodiversity, Genotype, Variability, Wood apple

Introduction

Wood apple (*Feronia limonia* L.) known as poor man's food (Chavan *et al.*, 2022), is native to India and Sri Lanka (Bakshi *et al.,* 2001; Lande *et al.*, 2010). Traditionally it, has great demand for medicinal purposes. This fruit has chromosome number 2n =18 (Dowarah *et al.,* 2021) and is a member of the Rutaceae family (Mazumder *et al.,* 2006). The tree is given the name *Feronia* in tribute to the Roman forest goddess (Sridhar *et al.*, 2019). Kathbel, Elephant apple, Monkey fruit, Curd apple, Golden apple, Stone apple, etc are the other common names of wood apple generally based on language, place and culture (Khan *et al.,* 2019). It grows in the wild and is also cultivated along roads, the edges of fields as border plant (Khare, 2007) and occasionally in orchards.

Its distribution occurs from moist tropical to sub-tropical growing countries like Pakistan, Srilanka and South East Asia (Bakshi *et al.,* 2001). Wood Apple grows in abundance throughout India's drier regions and cultivated along both peninsulas of the country. The crop grows well upto 450 meters elevation from mean sea level (Orwa *et al.*, 2009) and spread with rich biodiversity heritage in Eastern Parts of Western Ghats (Rajangam and Shankar, 2022). It is grown throughout India, including in the Alavallis of south-eastern Rajasthan, the Etwah and Kanpur districts of Uttar Pradesh (Pandey *et al.*, 2013), some areas of West Bengal (Ghosh *et al.,* 2012), Gujrat (Yadav *et al.,* 2018), Maharastra, and Madhya Pradesh. Although it is grown across the country as a household tree, wood apple is primarily grown in the Rajshali and Kushita

regions of Eastern Uttar Pradesh. The area around Rajshahi and Gazipur has fairly large wood apples (Nath *et al*., 2008). In India, wood apple is not produced as a commercial crop.

The wood apple tree is drought resistant, mostly found in arid and semi-arid climatic regions. It can be grown in wide range of soils. The tree prefers dry climatic conditions during flowering and fruit setting. The wood apple trees can be grown successfully in areas which receiving mean annual rainfall 25-60 cm and mean annual temperature 20-35^{0}C (Yadav, 2018). The wood apple is generally grown from seeds and seed germinate within 7-14 days after sowing. For high yield potential and good plant growth, sandy loam or deep loam and well-drained soils with 7-7.5 pH (Yadav and Singh, 2021) are needed.

Wood apple is a deciduous, glabrous tree with thorny branches that grows to a height of approximately 10m and a girth of around 0.6m to 1.6m (Troup, 1921). In India, the fruits ripen from early October through March (Vijayvargia and Vijayvergia, 2014). The tree will not bear fruit until at least 15 years old. In wood apple, numerous small, normally bisexual flowers born on terminal or axillary panicles, mainly on new shoots. All plant parts viz., leaf, stem, bark, fruit and seed have been used for curing various diseases (Joshi *et al.*, 2011) (Sharma *et al.,* 2012). According to Ayurveda, wood apples can be used to cure ear conditions such as earaches (Sharma *et al.*, 2024). The fruit is rich in iron, protein and minerals, especially calcium and phosphorus (Kerkar *et al.,* 2020). The fruits contain a myriad of phytochemicals such as polyphenols, phytosterols, saponins, tannins, coumarins, triterpenoids, vitamins, amino acids, etc. (Dar *et al.,* 2013). The major chemical compounds in leaf are acidissimin and acidissiminol. Presence of alkaloids, phenolsresins, gum and mucilage, fixed oils and fats are also noted in leaves (Kerkar *et al*., 2020). The diverse pharmacological properties of the fruit include anti-diabetic, anti-ulcerative, anti-cancer hepatoprotective, wound healing, anti-tumor, anti-fertility, neuroprotective and to treat cardiovascular problems (Rashmi *et al.,* 2019). It also has 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). The ripe fruit pulp makes excellent chutney and also consumed as fresh along with sugar (Anuradha, 2015). Wood apple is a highly perishable and seasonal fruit, it can be preserved by processing into various value-added products (Yadav and Singh, 2021) like chutney, fruit bar, RTS, squash, nectar, pickle, jam, jelly, pulp and powder to use it all round the year. The fruit may be eaten raw but it has a resinous taste so it requires sweetening (Mohpatra *et al.,* 2022).

There are no such improved types or recognized varieties of wood apple in India (Dowarah *et al.,* 2021). The Awadh region of Uttar Pradesh has the rich diversity of wood apple genotypes. But no report of the studies on fruit physical properties of such diversified genotypes available in this zone. Although the popularity and the demand of this underutilized fruit crop is very high, the production of this fruit is very meager due to non-availability of recognized superior types. In the absence of suitable cultivars, expected growth in production of this crop has not been accomplished till date. Identification of suitable genotypes, therefore, becomes imperative for promoting its production, productivity and quality. Thus, the present study has been conducted to assess the diversity of some wood apple *(Feronia limonia* L.) genotypes under Awadh region of Uttar Pradesh.

Materials and Methods

The present study, morphological characters were studied at their original location, while physical attributes were carried out in the Laboratory of Department of Horticulture, Babasaheb Bhimrao Ambedkar University Lucknow 226025. The diversity rich areas of Awadh region of Uttar Pradesh Barabanki, Lucknow, Bahraich, Ayodhya and Gonda districts were explored and 29 wood apple genotypes were collected on the basis of preferred horticultural traits like precocity in bearing, less spine intensity, earliness, regular bearing, and dwarf structure of the tree and fruit having strong aroma during year 2021-23. The 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 physical analysis in laboratory. The experiment was laid out in Completely Randomized block Design (CRD) with three replications. Fruits were collected at the mature stage, during the months of November-March. This was indicated by fruits naturally detached from a tree or dull greyish white color of rind (Lamani, 2022). Morphological parameters such as leaf length, leaf width, fruit length, fruit width, fruit diameter, shell thickness, spine length, and seed size were estimated with the help of digital Vernier Calipers, fruit weight by electronic weighting machine and morphological parameters were observed using standard and recommended DUS Testing guidelines of Bael (PPV&FR Authority, 2015).

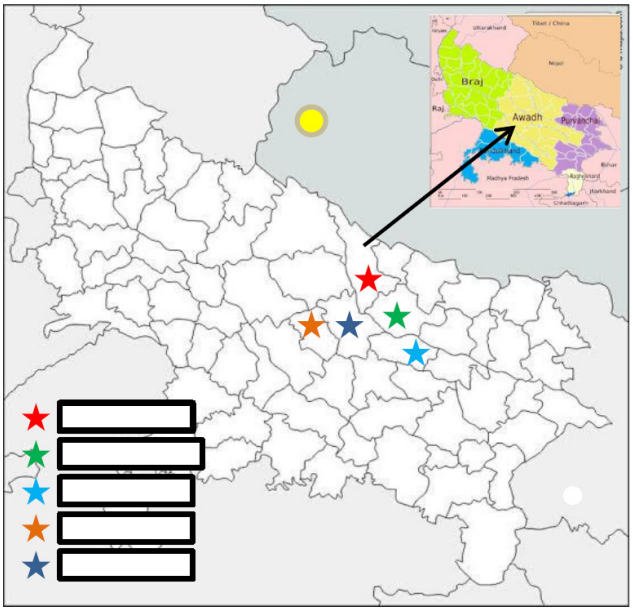

Fig. 1 : Map of Uttar Pradesh showing the locations of populations of wood apple

Results and Discussion

The perusal of data represented in Table-1 clearly reveals that leaf size of 29 different genotypes of wood apple showed significance variation while leaf shape showed no variation. All the genotypes had obtuse shaped leaf apex and cuneate shaped leaf base (G1 to G29). The maximum leaf length was observed in G21 (4.24 cm) followed by G25 (4.23 cm) while minimum leaf length in G3 (2.11 cm). The highest leaf width was noticed in G21 (2.32 cm) followed by G25 (2.25 cm) while the lowest leaf width was recorded in G12 (1.14 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. These results are in conformity with the earlier findings of Yadav *et al.* (2018), Singh *et al.* (2016), Ghosh *et al.* (2012) in wood apple; Awasthi and More, (2009) in Ber, Singh and Singh (2005) in mahua, Singh *et al.* (2015) in aonla was reported similar results.

It is obvious from table 2 that maximum spine length was noticed in G11 (3.50 cm) followed by G8 (3.29 cm) while G22 (1.34 cm) had minimum spine length.

The perusal of data represented in table-1 clearly reveals that all genotypes of wood apple sample showed significance variation in fruit shape. There were three types of fruit shape viz, round, oval and flattened have been observed. Out of 29 genotypes, 11 were flattened shape (Genotypes- G1, G2, G3, G4, G9, G20, G21, G22, G23, G24 and G25), 13 were round shape (Genotypes- G5, G6, G8, G13, G14, G15, G16, G18, G19, G26, G27, G28 and G29) and 5 genotypes were oval shape (Genotypes- G7, G10, G11, G12 and G17). Fruit colour was recorded immediately after the harvest. The types of fruit colour observed were yellowish green, light brown, greenish white, greenish brown and light green. Among these, 10 genotypes were greenish white (G10, G11, G12, G13, G14, G15, G16, G17, G18 and G19), 6 genotypes were yellowish green (G1, G2, G3, G4, G5 and G6), 6 genotypes were greenish brown (G20, G21, G22, G23, G24 and G25), 4 genotypes were light green (G26, G27, G28 and G29) and 3 genotypes were light brown (G7, G8 and G9). The pulp colour was recorded immediately after the harvest. The following types of pulp colours were found: yellow, light yellow, white, brown and brownish white.

The table 2 shows that a wide significance variation in fruit size. The highest fruit length was found in G14 (9.43 cm) among the genotypes while, lowest fruit length was recorded in G28 (5.33 cm). The maximum fruit width was recorded in G14 (9.46 cm) which was at par with G15 (9.45 cm) among the genotypes, minimum fruit width was recorded in G28 (5.57 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), Sharma *et al.* (2014) and Namdev (2010). The maximum fruit weight was observed in G15 (258.86 gm) followed by G14 (250.86 gm). The minimum fruit weight in G28 (113.26 gm). Singh *et al.* (2016) 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 Mani *et al.,* (2020), Khan *et al.* (2019), Shyamala devi *et al.* (2018) and Pandey *et al.* (2013).

The maximum shell thickness was noticed in G10 (0.43mm) followed by G9 (0.39mm) while, minimum shell thickness was found in G25 (0.16 mm) as represented in table 2. Similar results were also found by Kumar *et al.* (2021) and Singh *et al.* (2016) in wood apple. Variability in the various characters of bael fruits of different cultivars might be due to interaction of genetic and environmental factors (Pandey *et al.,* 2020)

The data regarding variation in seed parameters is presented in Table-1 which clearly reveals that there is no variation in wood apple genotypes with respect to seed shape. All the 29 genotypes had the oblong

shaped seeds. In general, seed shape may be a result of combination of magnitudes, or by a single magnitude that indicates the percentage of similarity to a given geometric object. Similar results in seed shape of wood apple were reported by Shyamala devi *et al*. (2018), Yadav *et al.* (2018), Singh *et al.* (2016), Pandey *et al.* (2013) and Sappandi *et al.* (2005). Data represented in table 2, indicates that the maximum seed length was recorded in G7 (8.36 mm) followed by G8 (7.69 mm) while the minimum seed length was observed in G4 (4.54 mm) among all genotypes. The G9 genotype had found maximum (4.02 mm) seed width while G24 had recorded minimum (1.95 mm) seed width. Similar results were also reported by Yadav *et al.* (2018), Singh *et al.* (2016) and Ghosh *et al.* (2012) in wood apple. The maximum seed thickness was noticed in G26 (1.67 mm) which was at par with G8 (1.66 mm) while the minimum seed thickness was recorded in G1 (1.36 mm). The highest seed weight per fruit was observed in G8 (31.05 g) followed by G7 (30.57 g) while the lowest was observed in G21 (25.25 g). Similar variations in seed weight of wood apple were also reported by Kumar *et al.* (2020), Shyamala devi *et al.* (2018), Yadav *et al.* (2018), Singh *et al.* (2016) from 2.36-7.93 g, Pandey *et al.* (2013) from 7.83-15.66 g and Ghosh *et al.* (2012). The maximum number of seeds per fruit was noticed in G15 (456.00) followed by G14 (410.00) while the minimum number of seeds per fruit was recorded in G27 (160.00) among all genotypes as shown in table 2. Similar results were also noticed by Singh *et al*. (2016) in wood apple. Apart from age, vigor, genotype of mother tree, soil and climate of the place of seed origin are important factors affecting the seed traits (Salazar and Quesada, 1987).

Conclusion

Based on the above result, it may be concluded that significant variation was observed in different wood apple genotypes collected from Awadh region of Uttar Pradesh. Among these genotypes, genotype G15, G14, G13, G17, G18 and G20 were screened as promising genotypes as per their morphological and quantitative traits. Thus, these promising genotypes can be recommended to farmers for commercial cultivation, multiplication and conservation in the field gene bank for further evaluation and release as cultivars in the future.

Conference Disclaimer

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Table 1: Variation in Morphological characters of wood apple from Awadh region of Uttar Pradesh, India

Genotypes	Leaf Shape		Fruit shape	Fruit colour	Pulp colour	Seed Shape
	Base	Apex				
G1	Cuneate	Obtuse	Flattened	Yellowish green	Yellowish	Oblong
G2	Cuneate	Obtuse	Flattened	Yellowish green	Yellowish	Oblong
G3	Cuneate	Obtuse	Flattened	Yellowish green	Yellowish	Oblong
G4	Cuneate	Obtuse	Flattened	Yellowish green	Yellowish	Oblong
G5	Cuneate	Obtuse	Flattened	Yellowish green	Yellowish	Oblong
G6	Cuneate	Obtuse	Flattened	Yellowish green	Yellowish	Oblong
G7	Cuneate	Obtuse	Round	Light brown	White	Oblong
G8	Cuneate	Obtuse	Round	Light brown	White	Oblong
G9	Cuneate	Obtuse	Oval	Light brown	White	Oblong
G10	Cuneate	Obtuse	Round	Greenish white	White	Oblong
G11	Cuneate	Obtuse	Oval	Greenish white	White	Oblong
G12	Cuneate	Obtuse	Oval	Greenish white	White	Oblong
G13	Cuneate	Obtuse	Round	Greenish white	White	Oblong
G14	Cuneate	Obtuse	Round	Greenish white	White	Oblong
G15	Cuneate	Obtuse	Round	Greenish white	White	Oblong
G16	Cuneate	Obtuse	Round	Greenish white	White	Oblong
G17	Cuneate	Obtuse	Oval	Greenish white	White	Oblong
G18	Cuneate	Obtuse	Round	Greenish white	White	Oblong
G19	Cuneate	Obtuse	Round	Greenish white	White	Oblong
G20	Cuneate	Obtuse	Flattened	Greenish brown	Yellowish	Oblong
G21	Cuneate	Obtuse	Flattened	Greenish brown	Yellowish	Oblong

G22	Cuneate	Obtuse	Flattened	Greenish brown	Yellowish	Oblong
G23	Cuneate	Obtuse	Flattened	Greenish brown	Yellowish	Oblong
G24	Cuneate	Obtuse	Flattened	Greenish brown	Yellowish	Oblong
G25	Cuneate	Obtuse	Flattened	Greenish brown	Yellowish	Oblong
G26	Cuneate	Obtuse	Round	Light green	White	Oblong
G27	Cuneate	Obtuse	Round	Light green	White	Oblong
G28	Cuneate	Obtuse	Round	Light green	White	Oblong
G29	Cuneate	Obtuse	Round	Light green	White	Oblong

Table 2: Variation in Quantitative characters of wood apple genotypes from Awadh region of Uttar Pradesh, India

S. No.	Genotypes	Leaf length (cm)	Leaf width (cm)	Spine length (cm)	Fruit length (cm)	Fruit width (cm)	Fruit weight (g)	Shell thickness (mm)	Seed length (mm)	Seed width (mm)	Seed thickness (mm)	Seed weight (g)	Number of seeds / fruit
1	G1	3.11	1.65	1.87	8.37	8.55	185.17	0.29	5.70	1.95	1.36	28.48	293.00
2	G2	2.37	1.27	1.69	8.18	8.29	180.30	0.18	5.01	2.16	1.37	28.46	302.50
3	G3	2.11	1.64	2.45	7.73	7.84	184.88	0.29	4.80	2.73	1.39	29.59	382.50
4	G4	2.47	1.59	2.22	8.14	8.37	186.62	0.37	4.54	2.74	1.42	27.72	315.50
5	G5	2.57	1.71	2.90	8.23	8.26	187.09	0.18	6.49	2.56	1.40	28.55	347.50
6	G6	3.20	1.42	2.79	8.11	8.25	151.13	0.21	6.75	2.14	1.41	27.80	373.00
7	G7	3.14	1.23	2.83	7.31	8.13	191.47	0.22	8.36	3.89	1.53	30.57	340.00
8	G8	2.75	1.62	3.29	7.21	8.39	189.05	0.28	7.69	3.87	1.66	31.05	294.00
9	G9	3.31	1.72	2.86	8.78	9.08	204.47	0.39	6.53	4.02	1.52	29.27	345.50
10	G10	3.34	1.93	2.62	8.52	8.27	194.38	0.43	6.59	3.74	1.59	28.02	368.00
11	G11	2.59	1.48	3.50	6.43	6.12	177.43	0.41	6.68	3.60	1.57	29.15	363.50
12	G12	2.76	1.14	2.19	5.93	6.61	178.82	0.35	8.21	3.49	1.62	30.58	297.50
13	G13	3.13	1.68	1.76	9.11	9.17	222.94	0.19	6.32	2.89	1.42	28.05	292.00
14	G14	3.29	1.81	1.67	9.43	9.46	250.17	0.20	6.42	3.59	1.44	26.18	410.00
15	G15	3.57	2.22	2.47	9.33	9.45	258.86	0.26	5.63	3.14	1.51	27.43	456.00
16	G16	2.62	1.35	2.69	7.31	8.69	200.99	0.37	5.67	3.12	1.48	28.49	316.00
17	G17	2.57	1.19	2.45	8.06	8.68	218.09	0.33	5.76	3.06	1.47	27.23	383.50
18	G18	2.65	1.21	2.92	8.45	8.72	211.90	0.23	5.46	2.54	1.42	27.80	370.00
19	G19	2.98	1.28	2.09	7.51	8.55	185.58	0.20	7.34	3.06	1.48	27.23	259.50
20	G20	3.29	1.37	2.97	7.75	8.73	205.28	0.36	5.80	3.50	1.43	26.38	392.50
21	G21	4.24	2.32	2.06	6.85	8.40	176.27	0.26	6.24	2.03	1.53	25.25	227.00
22	G22	3.30	1.25	1.34	7.41	7.56	152.55	0.27	6.17	3.51	1.59	29.13	261.50
23	G23	2.94	1.34	2.39	7.63	7.80	152.02	0.31	6.90	3.68	1.50	28.25	247.00
24	G24	2.80	1.18	2.47	7.37	7.98	152.51	0.28	7.16	4.01	1.39	27.40	302.50
25	G25	4.23	2.25	1.89	6.68	7.95	187.67	0.16	6.00	3.37	1.50	27.43	299.50
26	G26	3.08	1.18	3.20	6.68	8.22	181.30	0.24	5.71	2.96	1.67	30.29	194.00
27	G27	3.35	1.32	2.25	7.40	8.33	185.57	0.34	5.37	2.75	1.47	28.22	160.00
28	G28	2.92	1.28	2.37	5.33	5.57	113.26	0.28	4.78	2.53	1.47	30.19	204.00
29	G29	3.74	1.24	2.45	6.18	6.80	135.98	0.18	6.61	2.54	1.58	28.92	181.50
	Mean	**3.05**	**1.51**	**2.44**	**7.64**	**8.15**	**186.27**	**0.28**	**6.23**	**3.07**	**1.49**	**28.38**	**309.62**
	Min	2.11	1.14	1.34	5.33	5.57	113.26	0.16	4.54	1.95	1.36	25.25	160.00
	Max	4.24	2.32	3.50	9.43	9.46	258.86	0.43	8.36	4.02	1.67	31.05	456.00
	SE(d) ±	0.10	0.05	0.12	0.22	0.28	7.20	0.02	0.20	0.13	0.05	0.32	4.07
	C.D. at 5%	0.20	0.10	0.24	0.44	0.57	14.46	0.03	0.40	0.25	0.09	0.64	8.17

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