Original Research Article

PHYSICO-CHEMICAL STUDIES OF SOME LOCAL WOOD APPLE (*Feronia limonia*L.) GENOTYPES UNDER AWADH REGION OF UTTAR PRADESH

ABSTRACT: India is blessed with varied agro-climatic conditions which have paved a way to grow variety of fruits in different seasons of the year. The Awadh region of Uttar Pradesh are suitable for the cultivation of wood apple. In Wood apple the existing variability is low due to the problem of un exploitation and lack of awareness. Considering the wide genetic diversity in wood apple (*Feronia limonia*L.) in terms of qualitative characters, an extensive survey of diversity rich area of Awadh region of Uttar Pradesh was done and twenty nine genotypes in the form of fruits were collected from the different locations during 2021-23 to identify elite genotypes having desirable horticultural traits. The experimental design employed in this study was Complete Randomized Block Design. The results revealed rich genetic variations with respect to individual fruit length (5.33-9.49 cm), fruit width (5.57-9.54 cm), fruit weight (113.26-263.45 g), shell thickness (0.14-0.43 mm), seed length (4.04-8.46 mm), seed width (1.95-4.17 mm), seed thickness (1.34-1.69 mm), seed weight per fruit (25.25-31.06 g), number of seeds per fruit (134.50-456.0), among different genotypes. The different genotypes also exhibited wide range of variability in qualitative characters, viz. total soluble solids (10.22-18.14 ^{0}Brix), acidity (2.12-6.09 %), TSS/acidity ratio (1.67-8.71), reducing sugars (0.85-1.30 %), non reducing sugars

(0.67-1.06 %), total Sugars(1.55-2.40 %), Vitamin C (15.16-27.95 mg/ per 100 g) and pectin content (1.03-2.09 %) among all 29 genotypes studied for their qualitative characters.

Key words: Wood apple, genotype, unexploited, genetic and diversity.

INTRODUCTION

Wood apple (*Feronia limonia* L.) is a monotypic species, having chromosome number 2n=18 (Mazumder *et al.*, 2006) belongs to the family *Rutaceae* (Raut *et al.*,2023). It is an acidic fruit in unripe condition but gives pleasant flavor when ripe (Das and Das, 2003). In India, it is known by different vernacular names viz., in Tamil (Vilam Pazham), Hindi (Kaitha, Kath bel), Sanskrit (Kapitha), Assamese (Bal, Bael), Bengali (Koth bael), Gujarati (Kothu), Kannada (Beladahannu), Malayalam (Vilam kai), Marathi (Kavath), Oriya (Kaitha or Kainth) and Telugu (Vellagapandu) (Rajangam and Sankar, 2022). Globally, wood apple grows in Thailand, Malasiya, Cambodia and other parts of Southeast Asia. In India, it is found all over the plainsof southern Maharashtra, West Bengal, Uttar Pradesh, Chhattisgarh and Madhya Pradesh.

Wood apple is a potential fruit crop for drought, semi arid tropics, dry forest and suitable for problem soils particularly saline soil (Rajangam *et al.,* 2021). The wood apple is not under regular orcharding, however, along the border of fields, roads, railway lines and as a roadside tree, near villages and banks of the river are the common places where the plants can be found as stray plant. Wood apple is a small to moderate size, deciduous, glabrous tree with thorny branches reaching to a height of 10 meters with 0.6 meters to 1.6 meters girth (Kumar and Deen, 2017).

The wood apple fruit can be consumed raw, added to an array of drinks and sweets or canned as jam. The pulp of *Limonia acidissima* is extracted and consumed raw, either with or without sugar. The fruits are consumed as a good source of juice during its harvesting season due to their low cost and thirst quenching ability. A homemade drink popularly known as "Sarbat" is prepared from the wood apple fruits. The pulp is used in savory chutneys in India. Fruit bars, jam, jelly, chutney and ready-to-serve beverages are all made from fruit pulp (Sharma *et al.,* 2024).

The wood apple pulp is a rich source of beta carotene, a precursor of vitamin-A which also contains significant amount of vitamins B such as riboflavin and thiamine and it had small quantities of ascorbic acid content (Poongodi *et al.,* 2013). Wood apple is a nutrient-rich fruit that contains a surprisingly high amount of protein (10%) and also shows good amount of phenolic content (38.67 mg (GAE)/ g DW) and which corresponds to a good source of antioxidants in dried powder (Sonawane and Arya, 2013). Additionally, the pectin content of the fruit pulp is 3–8% (Kerkar *et al*. 2020). The fruit contains flavonoids, phytosterols, glycosides, saponins, tannins, carbohydrates, triterpenoids, vitamins and amino acids as its chemical constituents (Mahour *et al.* 2008). There are reports that some coumarins and tyramine derivatives were also isolated from the fruits of *Limonia acidissima* (Ilango and Chitra, 2009). Phytochemical analysis of Limonia acidissima ripe fruits indicates presence of flavonoids, steroids, glycosides and various acidic compounds. The major chemical compounds in leaf are acidissimin and acidissiminol. Presence of alkaloids, phenols resins, gum and mucilage, fixed oils and fats are also noted in leafs. The wood apple pulp is very good source of carbohydrates (70.14%), protein (13.8%), fat (4.3%) and dietary fibre (1.7%). Presence of low amount of fat (4.38%), calcium, magnesium, iron, and high amounts of zinc are also reported in this fruit. High amount of phosphorous and calcium are also found out that exerts vital role in bone formation, blood clotting and more other metabolic processes. The presence of iron in fruit indicates effectiveness against anemia, tuberculosis and other disorders (Shukla *et. al.* 2024).

Wide genetic variability exists in wood apple with desirable characters among accessions and its advantages towards the crop improvement program to identify superior genotypes for commercial cultivation. Through intensive survey, collection, conservation, characterization and evaluation there is a chance to derive a promising varieties in wood apple. Moreover, there are limited studies available in basic evaluation program. In this view, an experiment has been conducted in the wood apple field gene bank and the results were furnished for future research perspective.

Fig 1: Selected districts from Awadh region in Uttar Pradesh, India [Barabanki, Lucknow, Bahraich, Ayodhya and Gonda]

MATERIALS AND METHODS

The present experiment was carried out at the Department of Horticultural, School of Agricultural Sciences and Technology, Babasaheb Bhimrao Ambedkar University, Lucknow, India. The diversity rich districts of wood apple was explored and fruits of 29 different genotypes (denoted as G1-G29) were collected from different region such as Barabanki, Lucknow, Bahraich, Ayodhya and Gonda. Wood apple fruit were randomly selected from all the direction of marked genotypes and the bulk of sample of all the selected trees from each site collected into bags and tagged by the number and subjected to biochemical analysis in the departmental laboratory. Qualitative characters in terms of total soluble solids (TSS), titratable acidity, reducing sugars, non reducing sugars, total sugars, vitamin C and pectin content of wood apple fruits were analyzed and recorded. The total soluble solid content of fruit was determined with the help of hand refractometer (ERMA) of 0-32 percent, calibrated at 20ºC. Total acidity was determined by titrating the diluted fruit juice against 0.1 N NaOH solution using phenolphthalein as an indicator and the results were expressed as percentage fresh weight of fruit. The reducing sugar content was determined by titrating the diluted juice against Fehling 'A' and Fehling 'B' solutions by using methylene blue as an indicator. The total sugarscontent was determined by titrating the diluted fruit juice after hydrolysis with hydrochloric acid against Fehling 'A' and Fehling 'B' solutions in presence of methylene blue as an indicator. Vitamin C content of the fruit was estimated by using 2, 6- dichlorophenol indophenol dye titration method as described in AOAC (1995). Pectin content wereanalyzed by the methods outlined in AOAC (1980).The result was expressed in per cent calcium pectate. The experimental design employed in this study was Complete Randomized Block Design and data were statistically analyzed as per method outlined by Panse and Sukhatme (1967).

RESULTS AND DISCUSSION

Among the samples considered in our study shows a wide significance variation in fruit size. The highest fruit length was found in G14 (9.49 cm) among the genotypes while the lowest fruit length was recorded in G28 (5.33 cm) as shown in fig 2. The maximum fruit width was recorded in G14 (9.54 cm) which was at par with G15 (9.43 cm) among the genotypes, minimum fruit width was recorded in G28 (5.57 cm) as presented in fig 3. Fig. 4 shows that the maximum fruit weight was observed in G14 (263.45 gm) followed by G15 (245.59 gm) while the minimum fruit weight was recorded in G28 (113.26 gm). The difference of the fruits size may be due to different genetical character, photosynthetic activity and soil productivity or environmental factor. Findings were supported by the results of Pandey *et al.*(2013), Sharma *et al.* (2014), Shyamala and Kulkarni (2018), Khan *et. al*. (2019) and Mani *et. al.* (2020), Raut *et. al.* (2023), Kumar *et. al.* (2024).

The data on maximum shell thickness was noticed in G10 (0.43mm) followed by G11 (0.41 mm) whilethe minimum shell thickness was found in G18 (0.14 mm) as represented in fig 5. Variations in shell thickness parameters observed in the present studies may be attributed due to genetic factor or differences in climatic conditions, in which different genotypes were grown and collected. Similar results were also found by Pandey *et.al.* (2013), Singh *et.al.* (2016), Shyamala *et al.* (2018), and Kumar *et.al.* (2021) in wood apple.

The study reveals that largest number of seeds per fruit was observed in G15 (456.00) followed by G14 (410.00) while the minimum number of seeds per fruit was recorded in G28 (134.50) among all genotypes as shown in fig 6. Similar results was also noticed by Singh *et al.* (2016) in wood apple.

In the present survey, the maximum seed length was recorded in G7 (8.46 mm) followed by G12 (8.27 mm) while the minimum seed length was observed in G28 (4.04 mm) among all genotypes as shown in fig 7.Similarly the largest seed width was noticed in G16 (4.17 mm) which was at par with G9 (4.10 mm) while minimum seed width was recorded in G1 (1.95 mm) as presented in fig 8. The data on highest seed thickness was also noticed in G12 (1.69 mm) which was at par with G22 (1.67 mm) while the lowest seed thickness was recorded in G2 (1.34 mm) as can be seen in fig 9. The maximum seed weight per fruit was observed in G8 (31.06 g) followed by G26 (30.70 g) while the lowest was observed in G21 (25.25 g) as mentioned in fig 10. Similar results were also reported by Ghosh *et. al*. (2012), Singh *et. al.* (2016) and Yadav *et al.* (2018)in wood apple.

Table 1 shows significant variations among the wood apple genotypes with respect to different qualitative parameters. The data pertaining to total soluble solids content of different wood apple genotypes shows significant difference. The highest value of total soluble solids (18.14^{0} Brix) was noticed in G14 was significantly higher than the remaining genotypes. In contrast, lowest value of total soluble solids was recorded in genotype G8 (10.22^{0} Brix) among all genotypes. Similar trend of total soluble solid was reported by Sharma *et al.*, (2014), Singh *et al.*(2016),Yadav *et al.* (2018), Pandey *et al.* (2020) and Dowarah *et.al.*(2021) in wood apple fruits.

The data on titratable acidity revealed significant differences among all genotypes undertaken for this study. As shown in Table 1 genotype (G11) had the maximum content of titratable acidity (6.09 %) followed by G8 (5.93 %) among genotypes while the minimum acidity was noticed in G14 (2.12%). Environmental conditions, stage of harvesting and genetic factor might be major influence on acidity variability among the genotype of wood apple. Sharma *et al.*,

(2014) also found that ripe fruits were less acidic (1.74%) than both unripe (2.92%) and half-ripe fruits (2.40%), Kumar and Deen (2017), Mani *et.al.* (2020) and Raut *et. al*. (2023) in wood apple.

Different genotypes showed significant variation in their TSS/acidity ratio content. The highest TSS/acidity ratio content was found in G14 (8.71) among the genotypes while, lowest TSS/acidity ratio content was recorded in G8 (1.67) as represented in Table-1. Similar finding were also matched with Kumar and Deen (2017) in wood apple fruits.

The perusal of data represented in table-1 clearly reveals that all genotypes of wood apple sample showed significance variation in total sugars. The maximum total sugars was recorded in G14 (2.40 %) which was at par with G22 (2.38%) among the genotypes, while the minimum total sugars was noticed in G8 (1.55%). Similar variations in total sugarcontent of wood apple were reported by Pandey *et al*., (2013), Singh *et al*., (2016) and Yadav *et al*. (2018). A significant difference in reducing sugars was found among cultivars undertaken for evaluation. The maximum value of reducing sugars was observed in G14 (1.30 %) among the genotypes while, lowest value of reducing sugars was recorded in G8 (0.85 %) as shown in Table-1.The data regarding variation in non reducing sugars is presented in Table-1 which clearly reveals that there is significance variation in wood apple genotypes with respect to non reducing sugars. Genotype G20 (1.06%) showed significantly higher levels of non reducing sugars in comparison to other cultivars under study while the lower levels of non reducing sugars were found in G8 (0.67 %) among all 29 genotypes.

The data on vitamin C revealed significant differences among all genotypes undertaken for study. Genotype G15 (27.95 mg/ 100 g) showed significantly higher levels of Vitamin C in comparison to other cultivars under study while the lower levels of Vitamin C were found in G8 (15.16 mg/100 g) among all 29 genotypes as represented in Table 1. Vitamin C content of the fruits was also found similar with the findings of Singh *et al.* (2016), where they observed that it ranged from 7.08 -19.60 mg/100 g, Mani *et. al.* (2020), Dowarah *et. al.* (2021).

A significant difference in pectin content was found among cultivars undertaken for evaluation. As shown in Table 1 which clearly reveals that the highest pectin content was found in G14 (2.09%) among the genotypes while, lowest pectin content was recorded in G10 (1.03%). Similar variations of pectin content in wood apple were reported by Pandey *et al.* (2013), Sharma *et al.* (2014), Ghosh *et.al.* (2016), Singh *et al.* (2016), Anitha *et.al.* (2016), Shyamala *et al.* (2018), Khan *et.al.* (2019) and Rajangam and Sankar (2022) in wood apple fruit.

CONCLUSION

Wood apple genotypes demonstrated significantly immense variability in quantitative and qualitative studied characteristics.Among these genotypes, genotype G15, G14, G13, G17, G18 and G20 were screened as promising genotypes as per their quantitative traits.Findings with respect to qualitative characters viz; TSS, acidity, TSS/Acidity ratio, total sugars, reducing sugars, non-reducing sugars, vitamin C content and pectin content,the genotypes G22, G13, G7, G14, G20 and G1were screened as promising genotypes. These promisinggenotypes can be recommended for commercialmultiplication, growing at farmer's field, conservation inthe field gene bank and formulating an effective breeding program forits genetic improvement or genetic up gradationofthis valuable crop.

FUTURE PROSPECTS

Woodapple is an important fruit crop with a high market value in both the Indian and global markets. In India, it is an underutilized fruit. Researchers must conduct genetic diversity research on this species, which could lead to future crop enhancing efforts. Thar Gaurav and Thar Prabha are India's sole recently developed varieties and research institutes are required to explore and advocate for the cultivation of this fruit crop, while also undertaking enhancement initiatives to develop high-yield cultivars with superior fruit quality.

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Fig 2: Variability in fruit length (cm) of wood apple genotypes

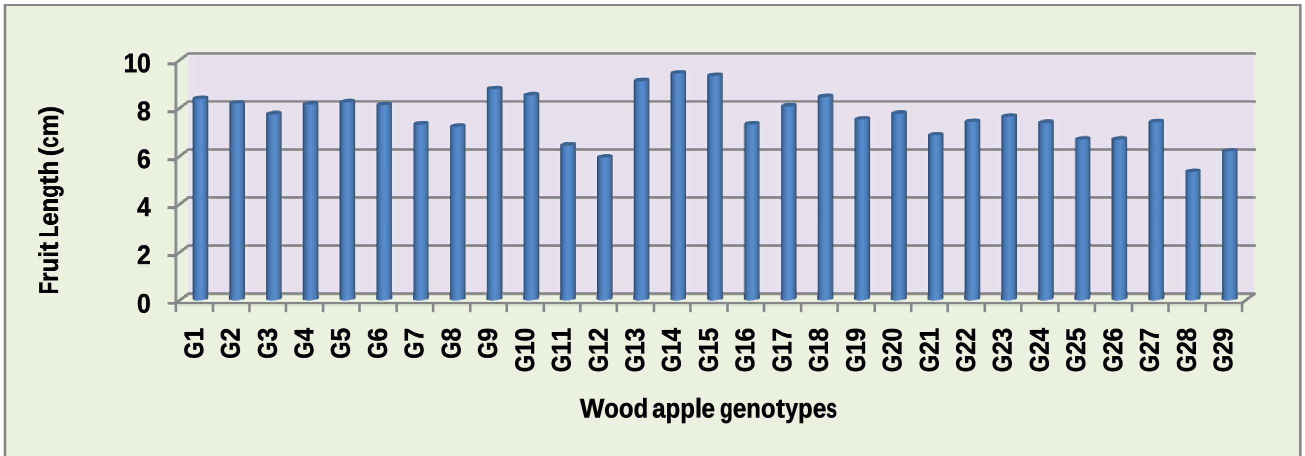

Fig 3: Variability in fruit width (cm) of wood apple genotypes

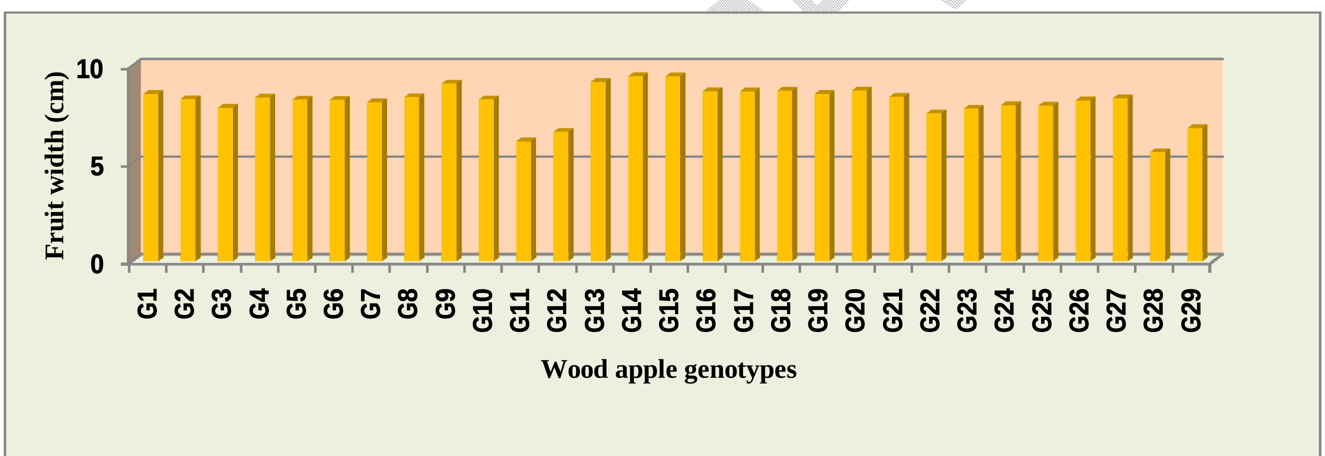

Fig 4: Variability in fruit weight (g) of wood apple genotypes

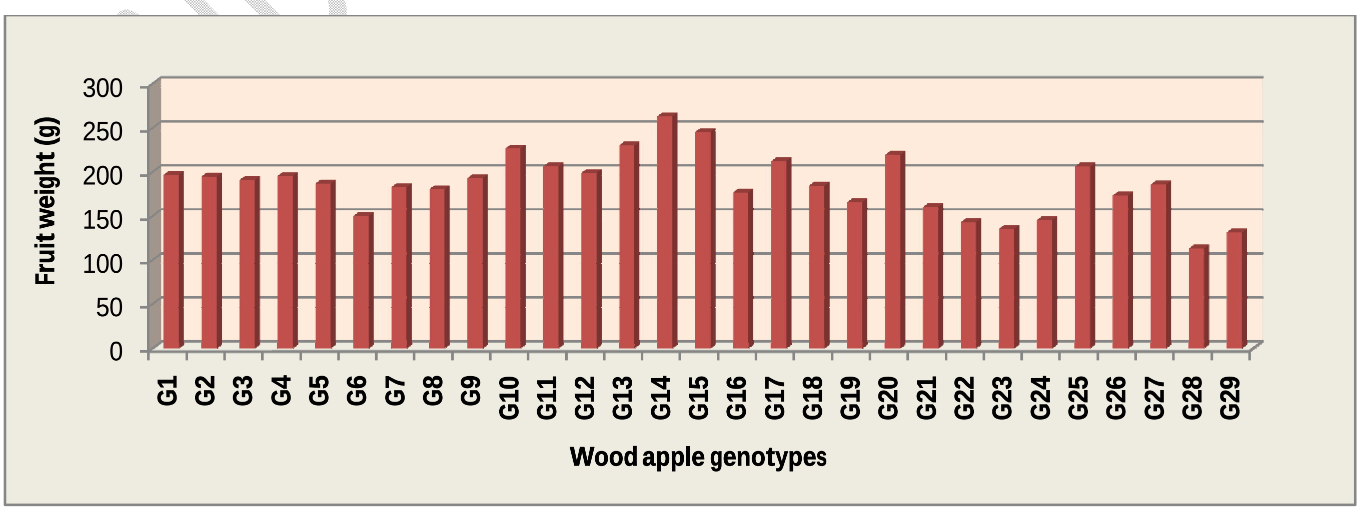

Fig 5: Variability in shell thickness (mm) of wood apple genotypes

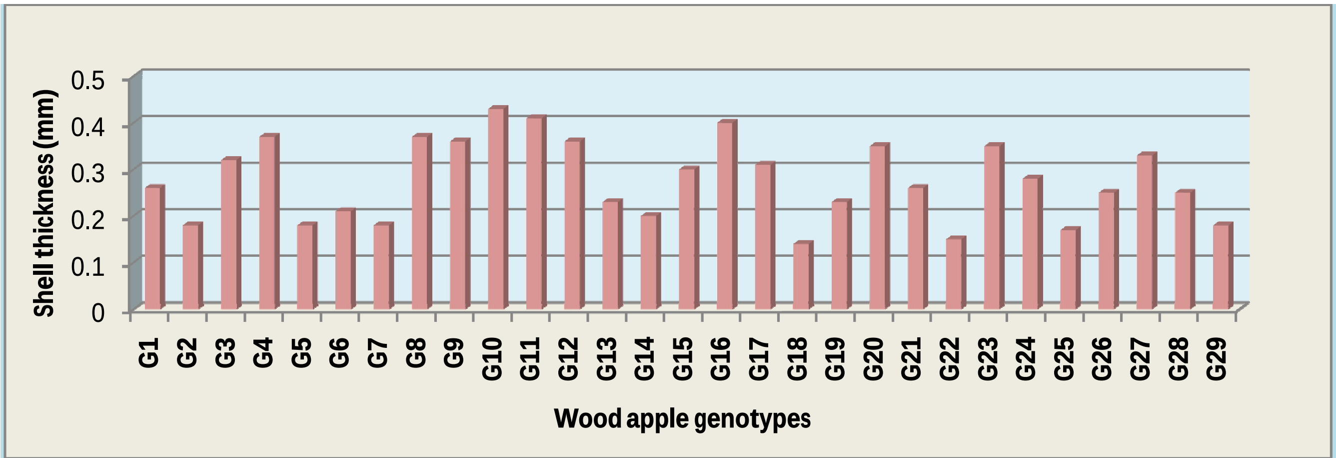

Fig 6:Variability in number of seeds per fruit of wood apple genotypes

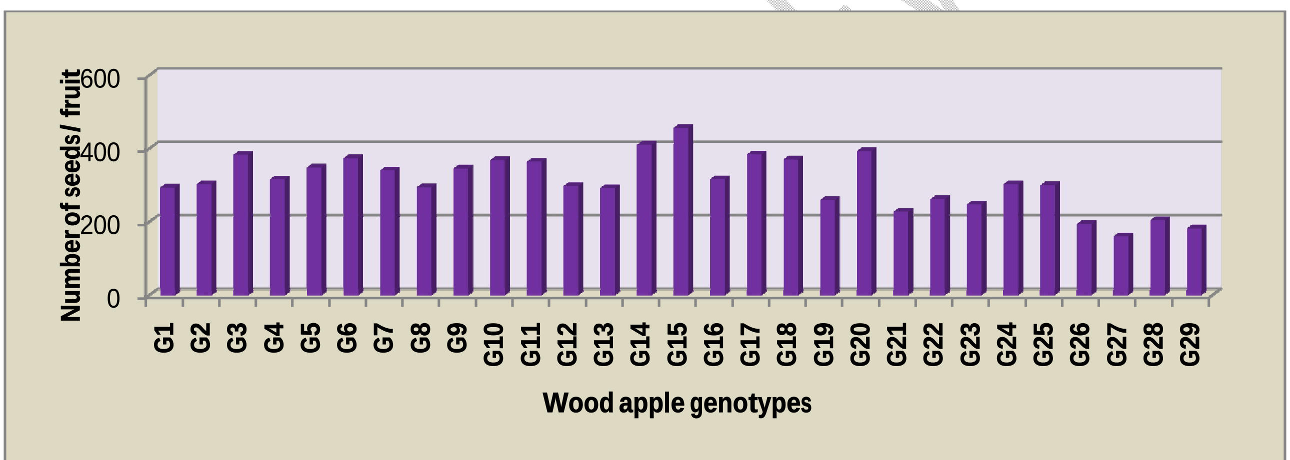

Fig 7: Variability in seed length (mm) of wood apple genotypes

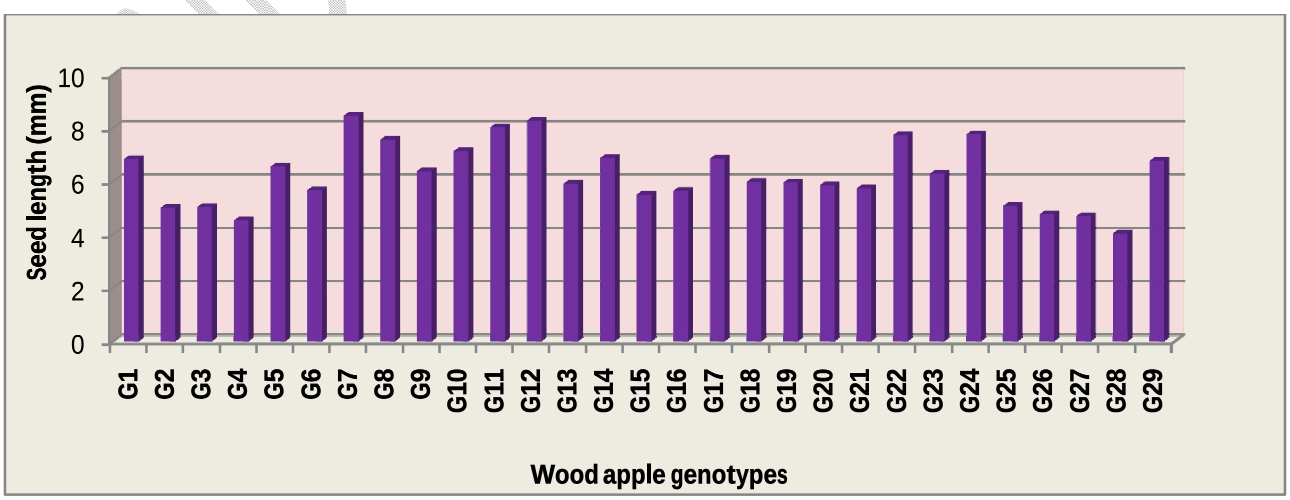

Fig 8. Variability in seed width (mm) of wood apple genotypes

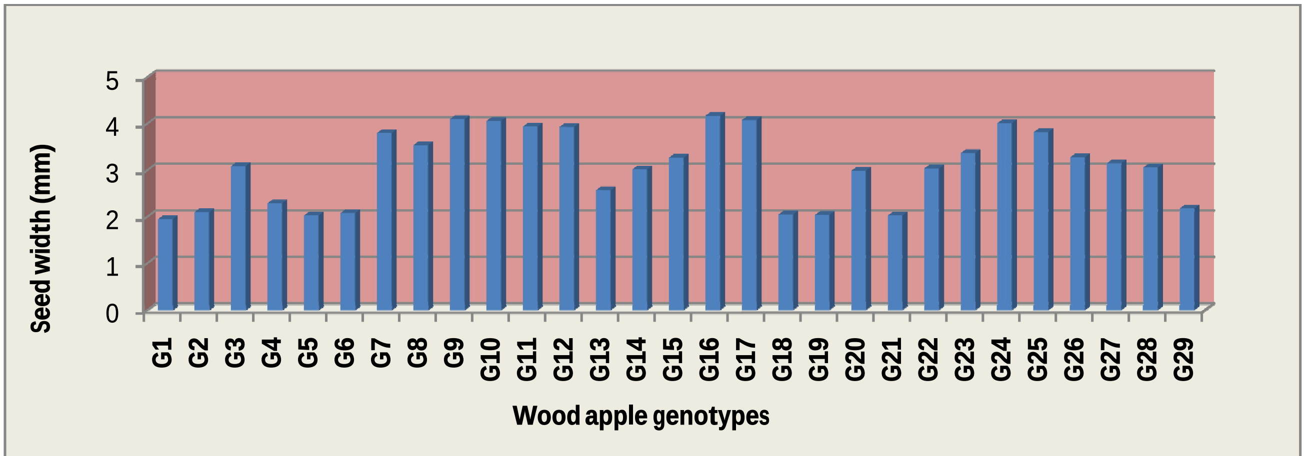

Fig 9: Variability in seed thickness (mm) of wood apple genotypes

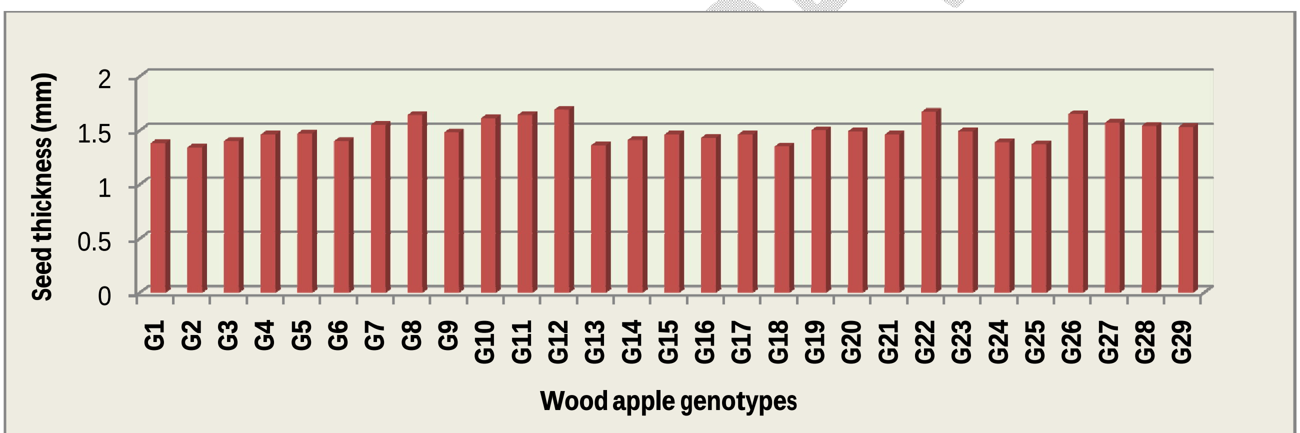

Fig 10: Variability in seed weight (g) of wood apple genotypes

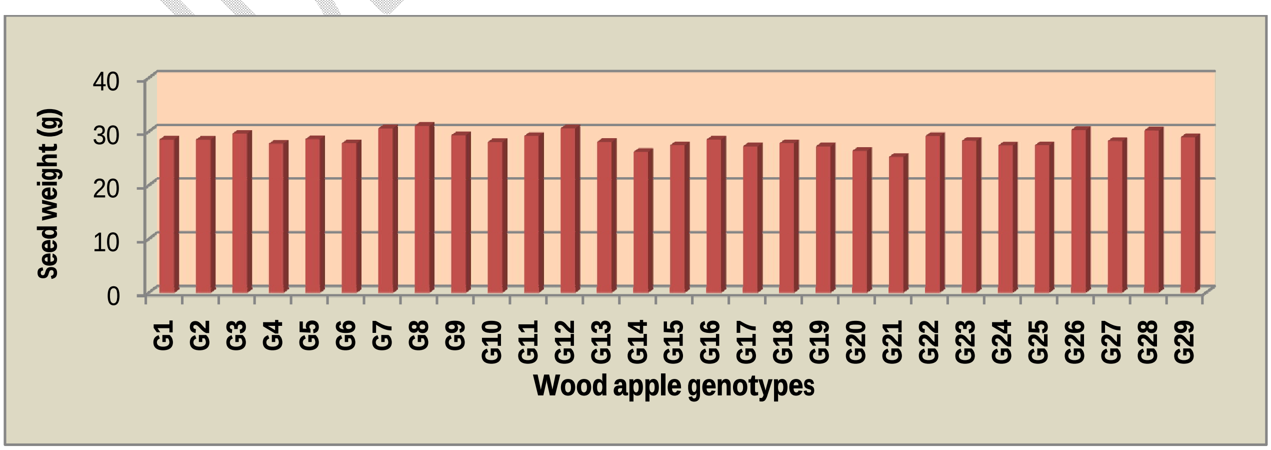

Table 1: Variation in qualitative characters of fruits of wood apple genotypes from Awadh region of Uttar Pradesh, India (pooled data of two years)

Genotypes	TSS (^{0}Brix)	Acidity (%)	TSS/Acidity Ratio	Total Sugars (%)	Reducing Sugars (%)	Non Reducing sugars (%)	Vitamin C (mg/100g)	Pectin (%)
G1	16.96	2.26	7.00	2.31	1.20	1.05	20.51	1.37
G2	15.30	4.23	4.37	2.17	1.12	1.00	18.40	1.25
G3	15.94	3.68	4.82	2.20	1.17	0.98	25.33	1.96
G4	16.02	3.93	4.97	2.18	1.14	0.99	17.52	1.92
G5	13.07	4.17	2.80	1.99	0.98	0.95	21.63	1.36
G6	13.46	4.43	2.91	2.02	1.03	0.94	26.06	1.82
G7	12.08	4.78	2.42	1.83	0.94	0.85	21.30	2.08
G8	10.22	5.93	1.67	1.55	0.85	0.67	15.16	1.97
G9	11.21	5.14	2.19	1.80	0.90	0.86	17.28	1.55
G10	11.95	5.09	2.35	1.82	0.94	0.84	18.06	1.03
G11	10.30	6.09	1.74	1.78	0.86	0.87	16.29	1.37
G12	10.46	5.03	2.04	1.79	0.87	0.87	16.11	1.48
G13	17.73	2.16	8.25	2.36	1.28	1.03	26.10	2.08
G14	18.14	2.12	8.71	2.40	1.30	1.05	25.81	2.09
G15	17.60	2.55	8.03	2.34	1.27	1.02	27.95	1.98
G16	16.65	2.89	5.60	2.30	1.19	1.05	26.60	2.01
G17	16.07	2.82	5.24	2.22	1.18	0.99	19.35	1.55
G18	14.86	3.03	3.79	2.09	1.08	0.95	24.57	1.15
G19	16.75	2.89	6.03	2.31	1.21	1.05	25.06	1.67
G20	17.29	2.27	7.68	2.33	1.21	1.06	25.51	1.69
G21	17.24	2.78	7.53	2.32	1.21	1.05	27.04	1.65
G22	18.05	2.50	8.50	2.38	1.29	1.04	26.97	1.35
G23	16.41	3.05	5.48	2.28	1.19	1.04	27.81	1.78
G24	13.99	3.53	3.47	2.07	1.06	0.96	27.35	1.90
G25	15.78	3.15	4.51	2.18	1.15	0.98	26.48	1.45
G26	12.71	5.06	2.56	1.85	0.98	0.83	20.40	1.81
G27	14.01	4.19	3.35	2.04	1.06	0.93	21.22	2.03
G28	15.13	3.89	4.01	2.14	1.10	0.99	20.06	2.00
G29	16.24	3.04	5.34	2.25	1.14	1.05	20.99	1.70
SE(m)±	0.34	0.13	0.13	0.02	0.01	0.01	0.27	0.06
C.D.at 5%	0.68	0.26	0.26	0.03	0.03	0.03	0.53	0.13