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An Investigation into the Effects of Varying Seasons, Indole-3-Butyric Acid (IBA) and Rooting Media on the Rooting and Longevity of Air-layered Water Apples (*Syzygium samarangense* L.)

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ABSTRACT

Background: The variation observed in sexual propagation often results in slow growth and fruit development, attributed partly to insufficient photosynthates during early growth stages. To address this challenge, vegetative propagation methods such as air layering offer promising solutions. This technique not only accelerates productivity but also enhances the quality of water apples. Recognizing the importance of air layering in water apple cultivation, this experiment was conducted to standardize this technique by examining the impact of different seasons and planting media in the western tropical wet and dry climate of Tamil Nadu.

Methods: The study was conducted to evaluate the variables affecting air layering in water apples in Coimbatore district. The experiment was carried out with three different factors like seasons [August (S_1), September (S_2) and October (S_3)] and IBA [applied at different concentrations of 2000 mg/L (I_1), 3000 mg/L (I_2) and 4000 mg/L (I_3)] along with different rooting media: Cocopeat (M_1) and Sphagnum moss (M_2). The factorial randomized complete block design (FRCBD) was laid out for statistical analysis.

Result: Sphagnum moss performed as a better rooting medium due to its high water holding capacity and good aeration. Increase in the number and early formation of roots were due to more rain fall and high relative humidity in August, that resulted in more nutrient uptake and structural stability. The discovery aids in determining the optimal conditions, including season, dosage and combination (4000 mg/L IBA with sphagnum moss applied in August), for successful air layering in water apple.

Key words: Asexual propagation, August, Clone, Gootee, Interaction, Root initiation, Rose apple, Sphagnum moss, Wax apple.

INTRODUCTION

Water apple is a non-climacteric and important dry land horticulture tropical fruit crop (*Syzygium samarangense* L.). It is known by different vernacular names *viz*., wax apple, rose apple or java apple. It belongs to the family Myrtaceae, having varying chromosome numbers (*e.g*. 33, 42, 44, 66 and 88). It is widely grown throughout Malaysia and in a few of its neighboring nations including Thailand, Indonesia and Taiwan (Moneruzzaman *et al*., 2011). The species of *Syzygium* genus are spread in the tropical and subtropical regions of the world. The fruits are mostly pear-shaped with usually pink, light-red, red, green, sometimes greenish-white, white or cream-colored and in general they are crisp in nature, with sweet taste and aromatic flavor. For every 100 g of fruit weight water apple is found to have 90 per cent water, protein content 0.7 g, fat content 0.2 g, carbohydrates content 4.5 g, fiber content 1.9 g, 253 IU of vitamin A, traces amount of vitamin B1 and B2, 8 mg of vitamin C and 80 kJ/100 g energy (Yassir *et al*., 2022).

Water apple plants can be propagated through sexual method *i.e*., seed and asexual methods *viz*., air layering, grafting and budding. Its inner flesh is white, soft and spongy and it has one or two tiny, spherical, brown seeds (Khandaker *et al*., 2022). Water apple seeds have a very less viability therefore seedlings produced from seed is very difficult and it has long juvenile period. Seed multiplication results vast genetic diversity in shape and size of fruit and colour of peel. To achieve uniform planting and retain genetic purity, vegetative or asexual methods of propagation like as air layering are required. The lack of good quality seedlings is one drawback which hinders the growth of water apple fruit sector.

Air layering, a vegetative propagation method, is gaining popularity due to its cost-effectiveness, ease of use and improved success rates. However, there is considerable variability in the success rate of air layering

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and one factor contributing to this variation is the age of the shoots used. Various factors influence the air layering success in water apple including the mother plants condition, layering timing, rainfall, micro climate, humidity, temperature, the choice of rooting and growing media and the plant growth regulators application. To enhance success rates, contemporary practices involve the use of growth regulators during the rainy season in air layering techniques (Tyagi and Patel, 2004). With respect to fruit crops, similar results were stated by Bharanidharan *et al*. (2023) on West Indian cherry, Chacko *et al*. (2023) on soursop, Khandaker *et al*. (2022) on wax apple and Kushwah *et al*. (2022) on guava.

Currently, the propagation media Sphagnum moss, cocopeat and sawdust are being used widely for the root initiation purpose. But incessant and in discriminate exploiting of epiphytes like *Sphagnum* spp. as rooting medium is having repercussion on ecological balance of tropical forests, where these plants are grown on tall trees. Layering disrupts the downward movement of organic substances. The rooting capacity of air-layered shoots relies on various factors that differ across crops, cultivars and biochemical components of the clone (Sridevi *et al*., 2018). These components include levels of carbohydrates, nitrogen, sugars, starch, phenols and auxin, as well as the seasonal climate (such as temperature, relative humidity, amount of rainfall, *etc*.) at the time of layering (Anandhanambi *et al*., 2016). More than optimum level of all these factors is needed to attain better rooting of water apple layers.

In water apple there is a huge scope for improving the fruit growth, development and quality. Due to lot of variation observed in the sexual propagation the growth and bearing habit for development of the fruit is very slow it is also because of low photosynthates supply at early growth stages. To overcome this hindrance vegetative propagation method like air layering is the best option. This helps in improving the productivity and quality of the water apple. Considering the importance of air layering in water apple an attempt was made to standardize the air layering technique by evaluating the effect of different season and different planting media on water apple at western tropical wet and dry climate of Tamil Nadu.

Materials and Methods

The experiment was carried out at North farm, School of Agricultural Sciences (SAS), Karunya Institute of Technology and Sciences (KITS), Coimbatore, Tamil Nadu, India during 2022-23.

Location and climate

Coimbatore, situated in the western region of Tamil Nadu, can be found at coordinates of approximately 11°00′19.98″ N latitude and 76°57′58.03″E longitude, elevation of 432 MSL. The annual rainfall per year in Coimbatore is around 660 mm. The monsoon season typically begins in the third week of July and continues until the second week of September in 2022, with the majority of the rainfall coming from the South West monsoon. The environmental conditions during the study were given in the Table 1.

Plant materials

Red cultivar of water apple (*Syzygium samarangense* L.) mature shoots were used for this air layering study and chosen from mini orchard maintained at North farm, SAS, KITS, Coimbatore. In mother block, two-year-old plants planted at close spacing of 5 m × 5 m were headed back during the month of March. After 4-5 months, the new shoots were ready for layering operations. Totally nine plants were selected for this study, trees are divided into three equal parts to carry out the research in three different months *i.e.* August, September and October. Three trees in a particular month indicate three different replications and each treatment was imposed to five randomly selected shoots. Totally thirty shoots in each plant were used to impose six different treatments in a single tree, similar method had been followed in other two trees for replicating the treatments.

Treatment details

The experiment was laid out in factorial randomized complete block design (FRCBD). The air layering was done in three months *i.e*., August (S_1), September (S_2) and October (S_3) with three different concentrations of IBA *i.e*., 2000 mg/L (I_1), 3000 mg/L (I_2) and 4000 mg/L (I_3) with two different rooting media *i.e*., Cocopeat (M_1) and Sphagnum moss (M_2). Six layers were prepared for each treatment combination which was replicated three times. There were 18 treatments which comprised of combination of three seasons of air layering, three concentrations of IBA and two different rooting media.

Preparation of different concentration of IBA

To prepare a 2000 mg/L lanolin paste containing 200 milligrams of IBA powder, first, accurately weigh 200 milligrams of IBA powder using a chemical balance and transfer it into a beaker. Next, add 5 milliliters of 95% ethyl alcohol to the powder and vigorously shake it until it completely dissolves. Then, take 100 grams of lanolin paste in another beaker and heat it. Once the lanolin paste has melted, add the dissolved growth regulator to it and swirl the mixture well with a magnetic stirrer or your hands until the ethanol evaporates. This ensures the creation of a homogeneous mixture of IBA and lanolin paste.

Recording the observations

Number of days taken for appearance of roots (No.), number of days taken for bulk appearance of roots (No.) and number of days taken for detachment of layers (No.) in air layers were recorded by periodic observation of air layers by observation through transparent polythene sheet of each treatment. The values for air layers for each treatment was noted and mean expressed in number.

The length of primary roots was measured in centimeters along each layer, starting from the collar region and extending to the tip of the primary root. These measurements were recorded using a measuring scale.

The diameter of primary roots was measured between center of collar region and tip of primary roots by using vernier caliper and measured in millimeters (mm).

Three rooted layers were randomly sampled from each treatment at the time of transfer to rooting media. The polythene sheet and the rooting media were removed carefully using forceps and care was taken to avoid damage to roots. Mean numbers were counted in each rooted layer for number of primary roots (No.), secondary roots (No.) and total roots (No.) per layer.

Observing roots that were visible through the white polythene. Subsequently, the percentage of rooted layers was calculated for different treatment conditions after 45 days. The total count of rooted layers was recorded for each treatment after detachment of layers.

Design of experiment

A factorial randomized complete block design (FRCBD) was employed for this study, with three replicates for each treatment. ANOVA was conducted to analyze all the data and when the F test indicated significance at a p-value of 0.05, Fisher's protected least significant difference (LSD) test was used to differentiate the means.

Results and Discussion

The significant differences were observed between season of air layering done, concentrations of IBA and rooting media on the parameters highlights the importance of considering all three factors in promoting successful root initiation were given in Table 2. The ranges (Season - IBA - Media) seen in various parameters *viz*., days taken for the appearance of roots (21.91 - 22.20 - 19.83), days taken for bulk appearance (42.18 - 43.09 - 40.81), days taken for detachment (71 - 80 - 90), length of the primary root (9.53 - 10.28 - 9.18), diameter of the root (2.36 - 2.52 - 2.40), number of primary roots (25.29 - 26.70 - 24.47), number of secondary roots (52.34 - 42.94 - 49.78), number of roots (78.87 - 82.93 - 74.36), number of rooted layers (108 - 108 - 161) and percentage of rooting in layers (100% - 100% - 99.38%) were observed.

Season

August is found to be appropriate time for layering, considering seasonal variations in variables that influence the environment, such as temperature, moisture and light intensity, which can influence root development. August received maximum rain fall of 363.0 mm for 18 days and with higher relative humidity (88.80%), which favoured root initiation. Agro-climatic conditions of the experimental area also have a greater influence on the success. August and September were favorable seasons for carrying out air layering. Similar findings were recorded by Chauhan *et al*. (2008) and Dhillon and Mahajan (2000) in their research.

IBA concentration

The findings of this investigation indicate that treating the air layers with 4000 mg/L of IBA resulted in the highest root numbers. This suggests that an optimal IBA concentration enhances the amyloplasts breakdown within the cell wall and stimulates cambium activities, thereby facilitating the mobilization of photosynthates from the source to the sites where roots form in air layers, ultimately it helps in promoting root formation. The application of exogenous IBA encourages callus formation, accelerates the dedifferentiation of interfascicular cambium and generates numerous cells that differentiate into root primordia and root cells, consistent with the results of Singh *et al*. (2015). External application of IBA played a crucial role in breaking down starch and reducing amyloplast levels. This specific mechanism was identified as a facilitator for the rooting process (Shahzad *et al*., 2019) and potentially increasing the speed of carbohydrate translocation from leaves to the stem or air layering site, thereby promoting their growth and development (Shekhawat and Manokari, 2016). The results also highlight the significant role of IBA concentrations and appropriate media in promoting root initiation. This might be due to the influence of auxin signalling and root-inducing processes.

Media

The early root appearance in sphagnum moss might be due to favourable conditions like- maximum water holding

Table 1: Mean monthly metrological data for the year 2022-2023 at North farm, Karunya Institute of Technology and Sciences, Coimbatore.

Month, Year	MAX.T	MIN.T	R.F	R.D	R.H	AVG.PRE	AVG.EVP	WS 2M
August, 2022	26.98	20.79	363.0	18.0	88.80	18.95	4.47	2.62
September, 2022	27.29	20.49	52.75	4.0	89.71	5.04	8.39	2.05
October, 2022	27.25	20.26	113.75	11.0	87.22	11.60	7.00	1.21
November, 2022	26.12	19.65	109.55	15.0	89.06	13.69	4.07	1.25
December, 2022	26.34	18.47	90.75	11.0	86.58	2.92	3.55	1.53
January, 2023	26.81	15.56	46.25	2.0	78.45	0.86	8.82	1.63
February, 2023	30.60	14.80	1.75	1.0	64.00	0.20	8.40	1.86

MAX.T- Maximum temperature (°C), MIN.T- Minimum temperature (°C), R.F- Rain fall (mm), R.D- Number of rainy days (No.), R.H- Relative humidity (%), AVG.PRE- Average precipitation (mm), AVG.PRE- Average evaporation (mm), WS 2M- Wind speed at above 2 meter from ground level (km/h).

capacity, proper aeration available to the air-layers which helps in faster growth of callus resulted in early root emergence. Similarly, Rymbai *et al*. (2012) revealed that the sphagnum moss had found superior over cocopeat for rooting.

Interaction effect

The interaction effect between season of air layering done, concentrations of IBA and rooting media on the parameters highlights the importance of considering all three factors in promoting successful root initiation were given in Table 3.

Table 2: Effect of different months, IBA and rooting media on root parameters in air layers of water apple.

Treatment	DAR	DBR	DDL	LPR	DR	NPR	NSR	NR	NRL	PRL
Season										
S_1	21.91	42.18	71	9.53	2.36	25.29	52.34	78.87	108.00	100.00
S_2	23.94	45.06	80	8.58	2.17	24.01	48.39	71.92	108.00	100.00
S_3	25.49	47.01	90	8.25	2.11	21.99	44.16	66.03	105.00	96.29
S.Em.±	0.07	0.07	-	0.05	0.04	0.36	0.64	1.17	-	-
CD (p=0.05)	0.22	0.21	-	0.13	0.10	1.05	1.85	3.38	-	-
Concentration of IBA										
I_1	25.43	46.28	80.33	6.99	1.95	21.39	42.94	64.18	105.00	97.22
I_2	23.71	44.88	80.33	9.08	2.17	23.20	46.54	69.71	108.00	99.07
I_3	22.20	43.09	80.33	10.28	2.52	26.70	55.40	82.93	108.00	100.00
S.Em.±	0.07	0.07	-	0.05	0.04	0.36	0.64	1.17	-	-
CD (p=0.05)	0.22	0.21	-	0.13	0.10	1.05	1.85	3.38	-	-
Media										
M_1	27.73	48.69	80.33	8.39	2.03	23.05	46.81	70.19	160.00	98.15
M_2	19.83	40.81	80.33	9.18	2.40	24.47	49.78	74.36	161.00	99.38
S.Em.±	0.06	0.06	-	0.04	0.03	0.30	0.53	0.96	-	-
CD (p=0.05)	0.18	0.17	-	0.11	0.08	0.85	1.51	2.76	-	-

Table 3: Interaction effect of different months, IBA and rooting media on root parameters in air layers of water apple.

Treatments	DAR	DBR	DDL	LPR	DR	NPR	NSR	NR	NRL	PRL
$S_1I_1M_1$	27.33	48.67	71.00	7.27	1.89	22.73	45.47	68.20	18.00	100.00
$S_1I_1M_2$	19.93	39.67	71.00	8.54	2.12	23.27	46.80	69.80	18.00	100.00
$S_1I_2M_1$	25.80	46.07	71.00	9.51	2.17	24.53	49.07	73.60	18.00	100.00
$S_1I_2M_2$	18.13	38.13	71.00	10.24	2.39	24.67	49.33	74.00	18.00	100.00
$S_1I_3M_1$	24.07	43.40	71.00	10.41	2.30	23.87	53.73	80.60	18.00	100.00
$S_1I_3M_2$	16.20	37.17	71.00	11.19	3.32	32.67	69.67	107.00	18.00	100.00
$S_2I_1M_1$	29.20	50.60	80.00	6.44	1.82	21.60	43.40	65.00	18.00	100.00
$S_2I_1M_2$	21.93	42.13	80.00	7.63	2.10	21.87	43.73	65.60	18.00	100.00
$S_2I_2M_1$	27.93	49.40	80.00	8.60	2.02	23.40	46.80	70.20	18.00	100.00
$S_2I_2M_2$	20.20	41.20	80.00	8.78	2.27	23.47	47.47	70.73	18.00	100.00
$S_2I_3M_1$	26.20	47.07	80.00	9.40	2.21	25.80	51.73	77.53	18.00	100.00
$S_2I_3M_2$	18.20	39.93	80.00	10.60	2.62	27.93	57.20	82.47	18.00	100.00
$S_3I_1M_1$	31.67	52.53	90.00	5.70	1.75	20.00	39.93	59.87	16.00	88.89
$S_3I_1M_2$	22.53	44.07	90.00	6.38	2.03	18.87	38.33	56.60	17.00	94.44
$S_3I_2M_1$	28.73	51.40	90.00	8.24	1.97	21.53	42.93	64.47	18.00	94.44
$S_3I_2M_2$	21.47	43.07	90.00	9.13	2.22	21.60	43.67	65.27	18.00	100.00
$S_3I_3M_1$	28.67	49.07	90.00	9.93	2.14	24.00	48.27	72.27	18.00	100.00
$S_3I_3M_2$	19.87	41.93	90.00	10.13	2.56	25.93	51.80	77.73	18.00	100.00
S.Em. ±	0.18	0.18	-	0.11	0.09	0.89	1.58	2.88	-	-
CD (p=0.05)	0.53	0.52	-	0.32	0.25	2.56	4.54	8.27	-	-

DAR- Days taken for appearance of roots (No.), DBR- Days taken for bulk appearance of roots (No.), DDL- Days taken for detachment of layers (No.), LPR- Length of longest root per air layer (cm), DR- Diameter of roots per layer (mm), NPR- Number of primary roots per layer (No.), NSR- Number of secondary roots per layer (No.), NR- Number of roots per layer (No.), NRL- Number of rooted layers (No.), PRL- Percentage of rooting in air layers (%).

The best result was observed under the $S_1I_3M_2$ treatment combination, which involved layering in the first fortnight of August along with 4000 mg/L IBA in sphagnum moss as rooting media. The ranges seen in various parameters *viz*., days taken for the appearance of roots (16.20), days taken for bulk appearance (37.17), days taken for detachment (71), length of the primary root (11.19), diameter of the root (3.32), number of primary roots (32.67), number of secondary roots (69.67), number of roots (107), number of rooted layers (18) and percentage of rooting in layers (100%) were observed. In terms of interaction effect, Rymbai and Reddy (2010) found that the combined impact of several treatment combinations produced noticeable changes. They discovered that the optimum treatment combinations for air layering of guava cv. L-49 in Andhra Pradesh were IBA @ 4000 mg/L + Sphagnum moss + 15th August (86%). The similar findings were stated by Khandaker *et al*. (2022) in wax apple, Mozumder *et al*. (2017) in plum, Patel *et al*. (2012) in pomegranate and Gowda *et al*. (2006) in apple.

Conclusion

The investigation indicates that the use of external IBA had a significant positive impact on both the rooting and vegetative growth of air layers. This effect was particularly pronounced when applying IBA at a concentration of 4000 mg/L. Among the different rooting media tested, sphagnum moss emerged as the most effective in rapid root development in air layers. The treatment combining 4000 mg/L IBA with sphagnum moss had the highest success rate for root initiation, achieving a 100% success rate in water apple air layering. This discovery aids in determining the optimal conditions, including season, dosage and combination (4000 mg/L IBA with sphagnum moss applied in August), for successful air layering in water apple. Ultimately, this information facilitates the production of high-quality planting materials.

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Conflict of interest

All authors declared that there is no conflict of interest.

References

Anandhanambi, D., Arivazhagan, E., Kandasamy, R. (2016). Influence of plant growth regulators and *Azospirillum* on rooting of air layers in guava (*Psidium guajava* L.). The Asian Journal of Horticulture. 11(2): 261-268.

Bharanidharan, A., Ranchana, P., Gopi, V., Patricia, K.A.J., Kumar, P.D., Irine, C., Giriprasath, R.S., Vishal, S., Prasanth, Y. K., Pavethra, A. (2023). Effect of IBA concentrations and time of air layering of West Indian cherry (*Malpighia glabra* L.) in Coimbatore region. The Pharma Innovation Journal. 12(5): 971-975.

Chacko, I., Ranchana, P., Gopi, V., Srinivasan, J., Kumar, D., Bharanidharan, A., Pavethra, A., Vishal, S., Giriprasath, R.S., Savitha, V. (2023). Effect of time and IBA concentrations on soursop (*Annona muricata*): Air layering. The Pharma Innovation Journal. 12(5): 815-818.

Chauhan, V.S., Ahlawat, V.P., Joon, M.S. (2008). Studies on air layering in Litchi (cv. early large red). Agricultural Science Digest. 28(3): 186-188.

Dhillon, B.S. and Mahajan, B.V.C. (2000). Effect of different dates on the air layering performance of litchi cultivars in sub-montaneous region of Punjab. Agricultural Science Digest. 20(3): 207-208.

Gowda, N.V., Shyamalamma, S., Prakash, G. (2006). Influence of auxin and 1, 2, 4 acids on rooting of roseapple (*Syzigium jambos* L.) air layers. Acta Horticulturae. 727(9): 89-96.

Khandaker, M.M., Saidi, A., Badaluddin, N.A., Yusoff, N., Majrashi, A., Alenazi, M.M., Saifuddin, M., Alam, M.A., Mohd, K.S. (2022). Effects of Indole-3-Butyric Acid (IBA) and rooting media on rooting and survival of air layered wax apple (*Syzygium samarangense)* cv. Jambu Madu. Brazilian Journal of Biology. 82(8): 1-13.

Kushwah, V.S., Singh, K.V., Singh, P., Kumar, A., Sahu, V.K. (2022). Effect of different growing media, Azotobacter and GA_3 on growth and survivability of transplanted air layers in guava (*Psidium guajava* L.) cv. Gwalior-27. International Journal of Advanced Chemistry Research. 4(2): 21-27.

Moneruzzaman, K.M., Al-Saif, A.M., Alebidi, A.I., Hossain, A.B.M.S., Normaniza, O., Boyce, A.N. (2011). An evaluation of the nutritional quality evaluation of three cultivars of *Syzygium samarangense* under Malaysian conditions. African Journal of Agricultural Research. 6(3): 545-552.

Mozumder, S.N., Haque, M.I. Ara, R., Sarker, D., Shahiduzzaman, M. (2017). Effect of air layering time and genotype on success of plum propagation. International Journal of Advanced Research in Biological Sciences. 4(9): 55-61.

Patel, D.M., Nehete, D.S., Jadav, R.G., Satodiya, B.N. (2012). Effects of PGR's and rooting media on air layering of different pomegranate (*Punica granatum* L.) cultivars. The Asian Journal of Horticulture. 7(1): 89-93.

Rymbai, H. and Reddy, G.S. (2010). Effect of IBA, time of layering and rooting media on air layers and plantlets survival under different growing nursery condition in guava cv. L-49. Indian Journal of Horticulture. 67(4): 99-104.

Rymbai, H., Reddy, G.S., Reddy, K.C.S. (2012). Effect of cocopeat and sphagnum moss on guava air layers and plantlets survival under open and polyhouse nursery. Agricultural Science Digest-A Research Journal. 32(3): 241-243.

Shahzad, U., Shahbaz, T., Khan, A.A., Hassan, Z., Naqvi, S.A., Iqbal, M., Abbas, T., Shahjahan, M. (2019). Effects of Auxin (IBA) Concentrations with different dipping time on root ability of grape cuttings (*Vitis vinifera*). The International Journal of Science and Technology. 7(12): 45-48.

Shekhawat, M.S. and Manokari, M. (2016). Impact of auxins on vegetative propagation through stem cuttings of *Couroupita guianensis* aubl.: A conservation approach. Scientifica. 2: 1-7.

Singh, V.P., Nimbolkar, P., Singh, S.K., Mishra, N.K., Tripathi, A. (2015). Effect of growing media, PGRs and seasonal variability on rooting ability and survival of lemon (*Citrus limon* L.) cuttings. International Journal of Agriculture, Environment and Biotechnology. 8(3): 593. doi: 10.5958/2230-732X.2015.00065.0.

Sridevi, R., Monisha, P., Shabna, E., Subhashri, S. (2018). Phytochemistry and pharmacology of *Syzygium aqueum*: A critical review. European Journal of Biomedical and Pharmaceutical Sciences. 5(6): 271-276.

Tyagi, S.K. and Patel, R.M. (2004). Effect of growth regulators on rooting of air layering of guava (*Psidium guajava* L.) cv. Sardar. Orissa Journal of Horticulture. 32(1): 58-62.

Yassir, M., Bakrim, W. B., Mahmoud, M. F., Drissi, B., Kouisni, L., Sobeh, M. (2022). Watery rose apple: A comprehensive review of its traditional uses, nutritional value, phytochemistry and therapeutic merits against inflammation-related disorders. Oxidative Medicine and Cellular Longevity. 11: 1-17.