

Review Article

Effect of foliar sprays of phenylalanine, nano-potash and potassium sulphate on fruit quality attributes of apple (*Malus x domestica* Borkh) cv. Ambri

ABSTRACT

The present investigation entitled “Effect of foliar sprays of phenylalanine, nano-potash and potassium sulphate on fruit quality attributes of apple (*Malus x domestica* Borkh) cv. Ambri” was carried out at Experimental field of Ambri Apple Research Centre (AARC), Shopian, SKUAST-Kashmir, during the year 2022-2023. Eight treatments, viz; control (water spray), potassium sulphate (5 g per litre of water), phenylalanine (@ 0.1, 0.2 and 0.3%), nano-potash (@ 1, 2 and 3ml/l of water) were selected for colour improvement. The treatments were applied 30 days prior to harvest. The experiment was laid in complete randomised block design with 3 replications having 3 trees per replication. The results showed that all the treatments outperformed control in terms of chemical characteristics. The treatment T₄ (Phenylalanine @ 0.3%) significantly excelled in all the treatments applied. Significantly higher anthocyanin content (14.41 mg/100g), antioxidants (75.71 %), total sugars (12.98 %), TSS (16.23 %), fruit chlorophyll (0.59 mg/g fw) and fruit ascorbic acid (23.93 %) was recorded in T₄ (Phenylalanine @ 0.3%) as compared to other treatments. According to the current study, apple cultivar Ambri responded favourably to the application of foliar phenylalanine in improving chemical traits, which otherwise lacks in this cultivar. The application of Phe @ 0.3% , 30 days prior to harvest proved superior in enhancing the quality attributes, notably the anthocyanin content of apple cv. Ambri.

Keywords: Phenylalanine, potassium sulphate, Nano-potash, fruit quality

INTRODUCTION

Apple (*Malus × domestica* Borkh.) is a typical temperate fruit belonging to family Rosaceae and sub family Pomoideae. It is the result of an interspecific hybridization[1]. Apple is one of the major horticultural products, with China and the US having the largest production rates[2]. The cultivation of temperate fruits is Kashmir's speciality. Among these, apples account for the majority of production and area as well as a significant component of the national economy. Apple is the backbone of the rural economy in the Kashmir division. In India, Jammu and Kashmir is the largest producer of apples with an area of about 1.65 lakh hectares and production of 20 lakh MT [3] contributing more than 70 percent of the total apple production in India.

Ambri apple is the only apple that originates in India and is considered as autochthonous to Kashmir. Ambri apple is appealing with a high keeping quality and is chosen for its sweet taste, crispness and fragrance[4]. But poor fruit quality is a significant problem for the marketing of Ambri apples. The skin color of fruit is often a good indicator of its quality and maturity stage. Red fruit is preferred by consumers. Fruit can therefore be priced more and sold more easily because of its red colour, which plays a significant role in its acceptance. Cyanidin-3-galactoside (Idaein) is the main pigment responsible for the red color in apple, which belongs to the anthocyanin group . Natural substances with health-promoting characteristics that are also antifungal and antioxidants are called flavonoids and anthocyanins[5]. They are produced *via* the phenylpropanoid pathway. It is well known that the red pigment formation process depends mainly on environmental factors such as temperature, light quality and light interception. Cultural practices such as pruning, thinning, fertilization (potassium) and plant growth regulators like Phenylalanine influence anthocyanin formation and other bio-chemical characteristics of fruit. Based on the above

propositions, our study entitled “Effect of foliar sprays of phenylalanine, nano-potash and potassium sulphate on fruit quality attributes of apple (*Malus x domestica* Borkh) cv. Ambri” was undertaken at, Ambri Apple Research Centre (AARC) Phanoo, Shopian during the year 2022 with objectives of improving fruit quality particularly fruit colour of cv. Ambri using various chemicals and thereby increasing its consumer acceptability. Also the effect of these chemical sprays was assessed on various bio-chemical characters of Ambri apple.

MATERIAL AND METHODS

The current study entitled “Effect of foliar sprays of phenylalanine, nano-potash and potassium sulphate on fruit quality attributes of apple (*Malus x domestica* Borkh) cv. Ambri” was undertaken at Experimental Fields of Ambri Apple Research centre (AARC) Phanoo, SKUAST-Kashmir, Shopian” which is situated at an altitude of 1594 m amsl between 33.747°N, 74.855°E during the years 2021-2022. The trees selected for the present study were of uniform age (15 ± 2) and vigour, grafted on MM106 rootstock and planted at a distance of 2.5×3 m. Eight different chemical treatments were selected which included: T₀: control (water spray), T₁: Potassium sulphate @ 5 g/L, T₂: Phenylalanine @ 0.1, T₃: Phenylalanine @ 0.2%, T₄: Phenylalanine @ 0.3%), T₅: Nano-potash (@ 1 ml/L, T₆: Nano-potash (@ 2 ml/L and T₇: Nano-potash (@ 3 ml/L were selected for colour improvement. The treatments were applied 30 days prior to harvest. The experimental design was RCBD with three replications in each treatment. The fruit of each treatment were harvested at optimum maturity and were analyzed for different parameters. The total soluble solids contents (TSS) was decided with the assistance of hand refractometre and expressed in terms of degree brix (⁰B) [6]. Quantitative determination of ascorbic acid was done by 2,6-dichlorophenol indophenol visual titration method [6]. The titrable acidity values were estimated [7]. Total sugar were estimated by using the Lane and Eynon method as discussed by [6]. Fruit chlorophyll is estimated by DMSO method by determining the optical density (OD) of known volume of chlorophyll solution at two respective wavelengths (663 and 645 nm) by using spectrophotometer [8]. Anthocyanin was determined according to the method of [9] to determine the optical density at 535 nm, using spectrophotometer. Antioxidant content is measured by 2,20-diphenyl-1-picrylhydrazyl (DPPH) assay method and absorbance was measured at 517nm [10]. The experimental data was then subjected to statistical analysis as per the standard statistical procedure given by Gomez and Gomez (1984)

RESULTS AND DISCUSSION

The data pertaining to (Table.1) shows that the application of potassium sulphate, phenylalanine and Nano-Potash spray at different concentrations had a profound influence on total soluble solids, total sugars and fruit acidity. Maximum TSS (16.23%), total sugars (12.98%) and fruit acidity (0.17%) was found in treatment T₄ (Phe @ 0.3%), followed by treatment T₃ (Phe @ 0.2%) in which total soluble solids, total sugars and fruit acidity of 15.67%, 12.53% and 0.19% was observed respectively. Minimum total soluble solids, total sugars and fruit acidity of 14.10%, 11.28% and 0.31% respectively was found in treatment T₀ (control). The data in table.1 indicated that, phenylalanine were more effective in increasing fruit total soluble solids content. A viable reason for the increase in TSS may be ascribed to the quick metabolic transformation of starch into soluble compounds and rapid translocation of sugars from the leaves to the developing fruits [11,12]. A higher increase in TSS content with foliar application of potassium is associated to vibrant role played by potassium in the process of translocation of sugar from leaves to fruits [13], which thereby results in fruits of adequate quality in context of total soluble solid. The present data indicated in table.1 shows, phenylalanine caused a higher effect in increasing total sugars content than other treatments. A possible reason for rise in total sugar content may be due to an increase in mono and disaccharide from the hydrolysis of starch, which owned a simplest form of sugar and this could be one of the main causes for the increase in total sugar content of fruits [12]. The present results are in conformity with the findings of [14]. The total sugars of “Red Roomy” grape were increased with increasing the concentration of phenylalanine application [15]. Moreover,

Potassium is known to enhance photophosphorylation and dark reaction of photosynthesis resulting in increased accumulation of carbohydrates. Similarly according to the efflux of sucrose to the apoplast is facilitated by potassium availability which thereby increases sugar translocation from source to sink tissues promoting their growth [16]. The titratable acidity decreased with the increase in concentration of phenylalanine and potassium but results were more profound with phenylalanine (table.1). This may primarily be due to the conversion of organic acids into sugars. Phenylalanine also increases membrane permeability, which speeds up the respiration of acids that are held in cell vacuoles [12] and the role of potassium on cell's enzymatic activity [17]. These results show a lot of similarity with the results obtained by Naiema, Neilson and Neilson and Anjum in apple. [18,19,20]

Examination of data (Fig.1) reveals that application of potassium sulphate, phenylalanine and Nano-Potash at different concentrations has a profound influence on fruit ascorbic acid content. The maximum ascorbic acid content (23.93 mg/100g) was noted in case of the treatment T₄ (Phe @ 0.3%). The treatment T₃ (Phe @ 0.2%) was statistically at par with T₂ (Phe @ 0.1%) having a fruit ascorbic acid content of 23.46 and 22.98 mg/100g respectively and treatment T₂ (Phe @ 0.1%) was statistically at par with treatment T₁ (K₂SO₄ @ 5g/l) having a fruit ascorbic acid content of 22.98 and 22.39 mg/ 100g respectively. The minimum fruit ascorbic acid content (19.48 mg/ 100g) was observed in case of treatment T₀ (control). The maximum ascorbic acid content was observed in phenylalanine. This increase in the ascorbic acid content by phenylalanine application may be attributed to the higher synthesis of some metabolic intermediary substances which promoted the greater synthesis of the precursor of ascorbic acid *i.e* Glucuronate [12]. Similar results were obtained by Ommol [21], who found an increase in the ascorbic acid content of plum with applications of phenylalanine's, increased the activity of antioxidant enzymes and the accumulation of ROS scavenging agents, such as ascorbic acid.

As evident from Fig. 2, application of potassium sulphate, phenylalanine and Nano-Potash sprays at different concentrations had a pronounced influence towards fruit antioxidant content. In this context, maximum antioxidant content (75.71 mg/ 100g) was observed in T₄ (Phe @ 0.3%) which was followed by T₃ (Phe @ 0.2 %) and T₂ (Phe @ 0.1%), whereas the least antioxidant content (46.76 mg/ 100g) was observed in control (T₀). Phenylalanine, the precursor of the phenylpropanoid pathway, is an aromatic amino acid existing naturally in plants and derived from the shikimate pathway. Phenylalanine increase secondary metabolites such as anthocyanins, flavonoids, phenols which act as antioxidants, through the phenylpropanoid pathway [22]. Similar findings were made by Ommol [21] who discovered that applying phenylalanine to plum increased its antioxidants level. The positive effect of potassium on antioxidant can be ascribed to the fact that potassium improves primary metabolites in plants that could influence the biosynthesis of some antioxidant compounds [23].

Perusal of data presented in (Fig. 3) reveals that the application of potassium sulphate, phenylalanine and Nano-Potash spray at different concentrations had pronounced influence on chlorophyll of fruit. Lowest fruit chlorophyll (0.59 mg/g fw) was observed in T₄ (Phe @ 0.3%) followed by T₃ (Phe @ 0.2%) and T₂ (Phe @ 0.1%). The highest fruit chlorophyll (1.08 mg/g fw) was found in treatment control (T₀). This may be attributed to the fact that phenylalanine might be involved in the activation of chlorophyllase enzyme that break down chlorophyll and increases anthocyanin content [24]. Similar results were obtained by Fanyuk [22] who found that chlorophyll fluorescence decreased in almost all the phenylalanine treated apples and almost all treatments presented statistical significance. Potassium, however, has a beneficial effect on chlorophyll since it slightly raises the carotenes content in fruit skin, which lowers the amount of chlorophyll in fruit [25].

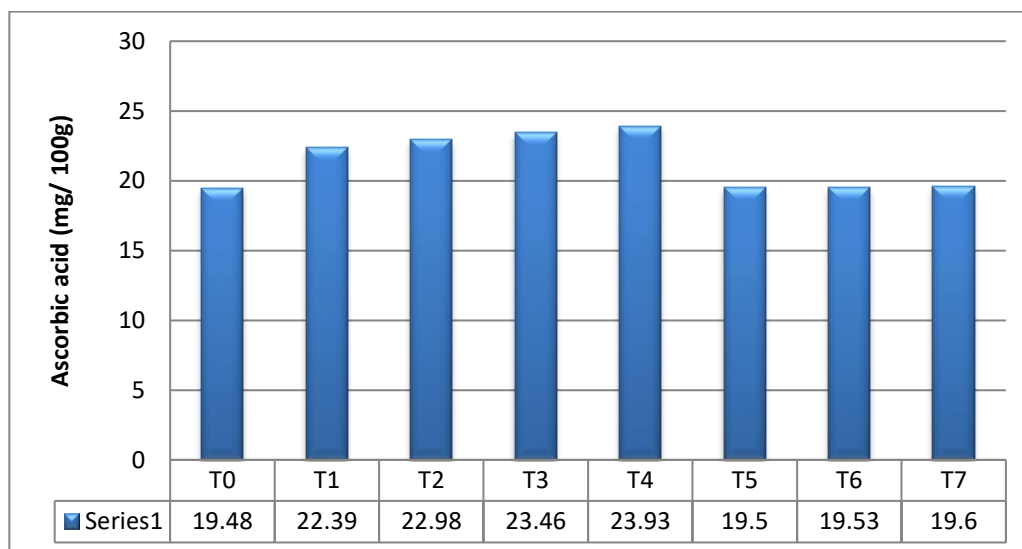
Data presented in Fig. 4 divulges that applying potassium sulphate, phenylalanine and nano-potash sprays at different concentrations had positive influence on anthocyanin content in fruit. Highest anthocyanin content (14.41mg/ 100g) was observed in treatment T₄ (Phe @ 0.3%) and the

lowest (7.88 mg/100g) was observed under treatment T₀ (control). The treatment T₃ (Phe @ 0.2%) exhibited a profound effect on anthocyanin content and was second highest (13.88 mg/100g) after treatment T₃. The increased amount of anthocyanin by phenylalanine could be attributed to their influence on anthocyanin biosynthesis since phenylalanine is the primer compound in the biosynthesis pathway of anthocyanin. The presence of phenylalanine may stimulate the activity of the enzyme phenylalanine ammonia lyase (PLA), which is essential for the production of anthocyanins [12,22]. These results were found to be more in harmony with those obtained by Ommol[21] and [15] who found that anthocyanin pigment was increased with increasing the concentration of phenylalanine applications in “Red Roomy” cultivar. High levels of potassium in tissues improve red pigment formation in apples by enhancing the anthocyanin biosynthesis. It seems that K is an important element in the pathway of anthocyanin and could be a cofactor playing a vital role in the activation of specific enzymes, similar to UDP galactose: flavanoid-3-o-glicosyltransferase [26]. These results are in close proximity to the observations of Mosa[27] in Anna apple.

Table 1. Effect of different chemical sprays on fruit weight (g), fruit length (cm) and fruit diameter (cm) of Apple cv. Ambri

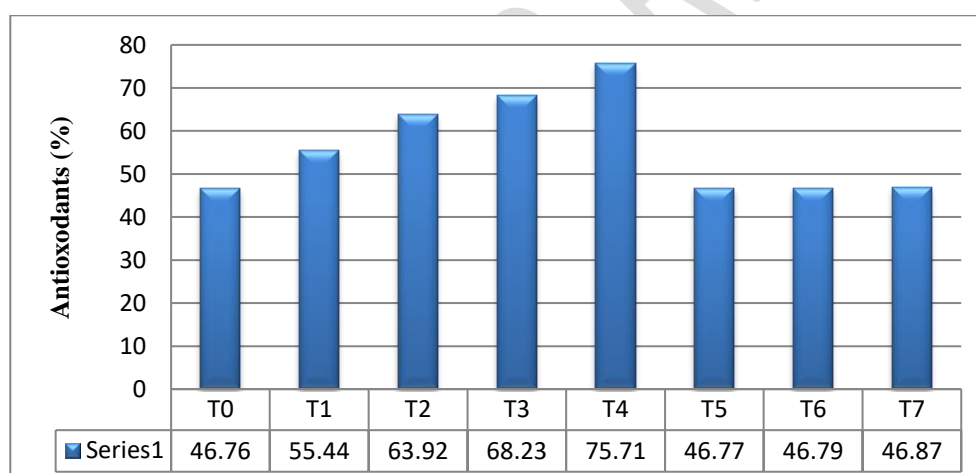
Treatment	Total soluble solids content (%)	Total Sugars (%)	Fruit acidity (%)
T ₀ (Control)	14.10	11.28	0.31
T ₁ (K ₂ SO ₄ @5g/l)	14.67	11.58	0.24
T ₂ (Phenylalanine @ 0.1 %)	15.04	12.03	0.21
T ₃ (Phenylalanine @ 0.2 %)	15.67	12.53	0.19
T ₄ (Phenylalanine @ 0.3 %)	16.23	12.98	0.17
T ₅ (Nano-Potash @ 1ml/l)	14.13	11.36	0.28
T ₆ (Nano-Potash @ 2ml/l)	14.41	11.39	0.28
T ₇ (Nano-Potash @ 3ml/l)	14.56	11.52	0.29
SE(d)	0.041	0.181	0.027
CD (p≤ 0.05)	0.090	0.372	0.058

Figure 1: Effect of different chemical sprays on fruit ascorbic acid (mg/100 g) of Ambri Apple



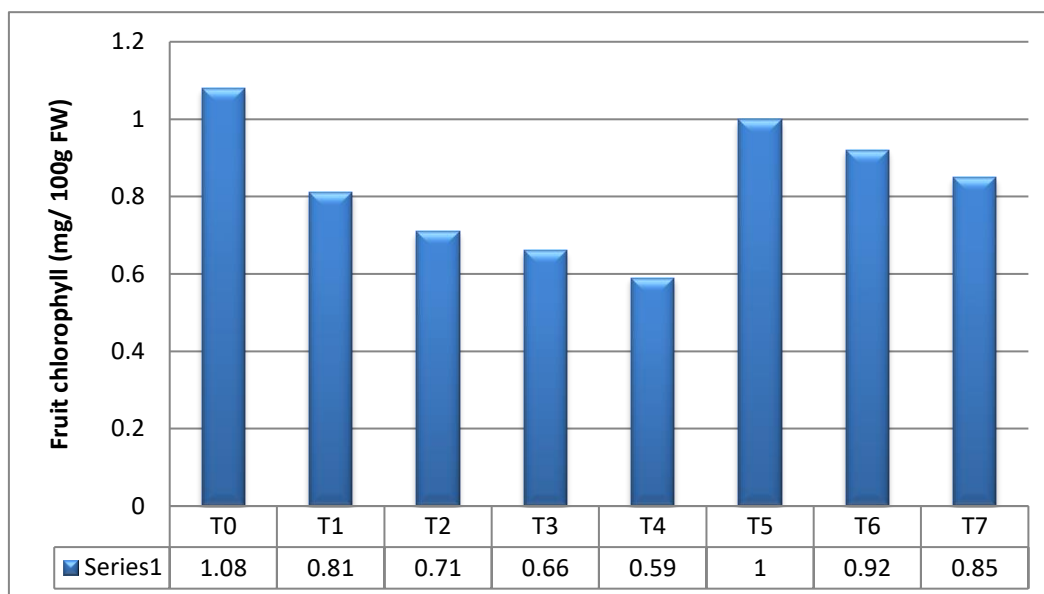
SE(d)	0.087
C.D(p≤ 0.05)	0.174

Figure 2: Effect of different chemical sprays on fruit Antioxidants (peel) (%) of Ambri apple



SE(d)	1.068
C.D(p≤ 0.05)	2.136

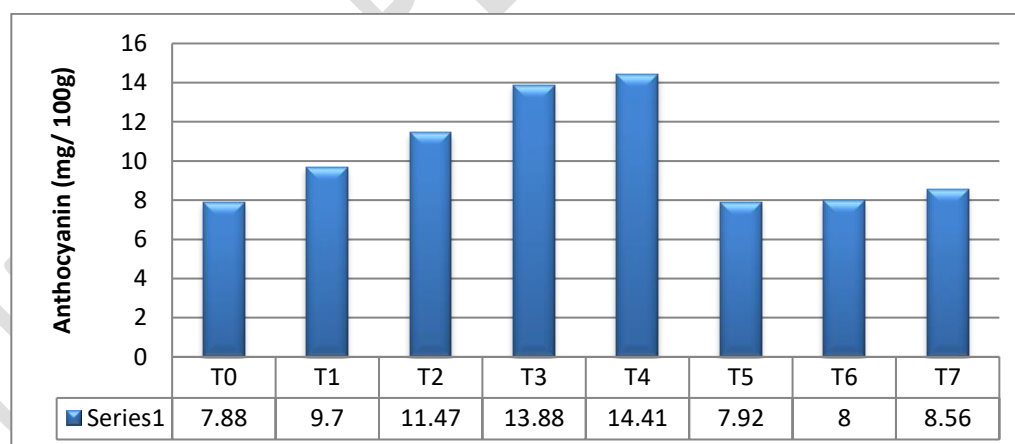
Figure 3: Effect of different chemical sprays on fruit chlorophyll (peel) (mg/100 g fw) of Ambri apple



SE(d)	0.003
--------------	--------------

C.D (p≤ 0.05)	0.007
----------------------	--------------

Figure 4: Effect of different chemical sprays on fruit anthocyanin (peel) (mg/100 g) of Ambri apple



SE(d)	0.327
--------------	--------------

C.D (p≤ 0.05)	0.708
----------------------	--------------

CONCLUSION.

The efficacy of three different chemicals (potassium sulphate, phenylalanine and nano-potash) on anthocyanin, TSS, total sugars, ascorbic acid, chlorophyll and antioxidant content were investigated. Phenylalanine and potassium sulphate treatments gave evidence of improvement in

fruit quality. It was concluded that foliar application of phenylalanine @ 0.3%, 4 weeks before harvest is very much effective in overcoming anthocyanin development problems in Ambri besides helps in obtaining higher quality fruit. In conclusion, the study investigated the impact of foliar sprays of phenylalanine, nano-potash, and potassium sulphate on the fruit quality attributes of apple. Our findings reveal significant enhancements in various quality parameters such as fruit size, color, firmness, sugar content, acidity, and shelf life. The application of phenylalanine exhibited promising results in improving fruit color and sugar content, while nano-potash contributed positively to fruit size, firmness, and shelf life. Additionally, potassium sulphate treatment showed notable improvements in acidity levels. These findings suggest the potential of foliar sprays as a viable strategy for enhancing apple fruit quality. Further research is warranted to explore optimal application methods, dosage levels, and long-term effects on orchard productivity and environmental sustainability. Overall, the findings contribute to the advancement of apple cultivation practices, aiming for improved fruit quality and market competitiveness.

REFERENCES

1. Janick -119., J., Cummins, J., Brown, S. and Hemmat, M. 1996. Apples In: Fruit Breeding Vol I: Tree and Tropical Fruits (Eds. J. Janick and J. N. Moore), Wiley, New York pp. 1-77.
2. FAO, 2021-22. Worldwide Major Apple Producing countries. Food and Agriculture Organization of the United Nations Statistics division (FAOSTAT). <http://www.Fao.Org>.
3. Anonymous, 2020. District wise area and production of major horticultural crops of Jammu and Kashmir state. Department of Horticulture, Jammu and Kashmir.
4. Devi, K., Kour, K., Bakshi, P., Sharma, B.C., Sharma, M., and Sinha, B.K.2021.Assessment of Morphological Diversity in indigenous Ambri apple (*Malus x domestica* Borkh.). Biological Forum 13(2): 325-331.
5. Sauer, M. C. 1990. External control of anthocyanin formation in apple. Scientia Horticulture 42 (3): 181-218.
6. Ranganna, S. 1986. Manual of analysis of fruits and vegetable products. Tata McGraw Hill Publishing Co. Ltd., New Delhi pp. 524.
7. A.O.A.C. 1990. Official and Tentative Methods of Analysis. Association of Official Agricultural Chemists. 15th Edition. Washington, D. C., USA pp. 484.
8. Blanke, M.M .1992. Determination of chlorophyll using DMSO. Vitic. Enol. Sci 47: 32-35.
9. Fuleki, T and F.J. Francis 1968. Quantitative methods for anthocyanins. 1-Extraction and determination to total anthocyanin in cranberries. Journal of Food Science 33: 72-77.
10. Brand-Williams, W., Cuvelier, M. E. and Berset, C. 1995. Use of a free radical methods to evaluate antioxidants activity. Science Direct 28 (1): 25-30.

11. Tripathi, V. K., Ueda, Y. and Shukla, P. K., 2007. Effect of plant bioregulators, zinc sulphate and boric acid on yield and quality of strawberry cv. Chandler. *The Asian Journal of Horticulture* 4: 15-18.
12. Kotb, H. R. M., El-Abd, M. A. M. and Abd El-Gawad, M. G. 2018. Effect of spraying some natural compounds on quality and marketing of “Anna” apple fruits. *Asian Journal of Advances in Agricultural Research* 23(4) 608: 635.
13. Prasad, B., Dimri, D. C. and Bora, L. 2015. Effect of preharvest foliar spray of calcium and potassium on fruit quality of pear cv. Pathernakh. *Scientific Research and Essays* 10(11): 376-380.
14. Meitei, S. B., Patel, R. K., Deka, B. C., Deshmukh, N. A. and Singh, A., 2013. Effect of chemical thinning UK. On yield and quality of peach cv. Flordasun. *African Journal of Agricultural Research* 8: 3558-3565.
15. Ezz, M., Thanaa., 1994. Effect of phenylalanine on anthocyanin pigments, fruit quality and yield of Roumi Red grapes *Alexandria Journal of Agricultural Research* 39 (1): 345-356.
16. Taiz, Z and Zeiger, E. 2004. *Plant Physiology*. Porto Alegre, Artmed 23-45.
17. Barden, J. A. and Thompson, A. H. 1962. Effect of heavy annual application of potassium on Red Delicious apple trees. *Proceedings of American Society for Horticultural Sciences* 81: 18-25.
18. Naiema, M. S. 2003. Effect of different doses of nitrogen and potassium on leaf mineral content, fruitset, yield and quality of apple grown in calcareous soils. *Alexandria Journal of Agricultural Research* 48(1): 85-92.
19. Neilson, G. H. and Neilson, D. 2006. The effect K-fertilization on apple fruit Ca concentration and quality. *Acta Horticulturae* 721: 177-183.
20. Anjum, R., Kirmani, N. A., Nageena, N. and Sameera, S. 2008. Quality of apple cv. Red Delicious as influenced by potassium. *Asian Journal of Soil Science* 3(2): 227-229.
21. Ommol, B. S., Vali, R., Farhang, R. and Gholamreza, G. 2020. Phenylalanine Alleviates Postharvest Chilling Injury of Plum Fruit by Modulating Antioxidant the Accumulation of Phenolic Compounds. *Food Technol Biotechnol* 58 (4): 433-444.
22. Fanyuk, M., Patel, M. K., Ovadia, R., Maurer, D., Feygenberg, O., Oren-Shamir, M. and Alkan, N., 2022. Preharvest applications of phenylalanine induces Red color in Mango and Apple fruit’s skin. *Antioxidants* 11: 491.
23. Gaaliche, B., Ladhari, A., Zarrelli, A. and Mimoun, M. B. 2019. Impact of foliar potassium fertilization on biochemical composition and antioxidant activity of fig (*Ficus carica* L.). *Scientia Horticulturae* 253: 111
24. El-Abd, M. A. 2011. Enhancement of “Florida prince” peach fruit quality under prince fruit quality under protected cultivation by using natural compounds. Ph. D Faculty of Agriculture, Damanshour University, Egypt.

25. Farag, K.M., and Attia, S.M. 2018. Pre-harvest treatments to reduces incidence of the soft scald and to enhance coloration of “Anna” apple fruits. Assiut Journal of Agricultural Sciences Doi: 10.21608/ajas.2018.10567
26. Nava, G., Dechen, A. R. and Nachtigall, G, R. 2008. Nitrogen and potassium fertilization affect apple fruit quality in southern Brazil. Communications in Soil Science and Plant Analysis 39(1-2): 96-107.
27. Mosa, W. F. A., EL-Megeed, N. A. and Paszt, L. S. 2015. The effect of the foliar application of potassium, calcium, boron and humic Acid on vegetative growth, fruit set, leaf mineral, yield and fruit quality of ‘Anna’ apple trees. American Journal of Experimental Agriculture 8(4): 224-234.

UNDER PEER REVIEW