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Research Paper

Physico chemical evaluation of exotic apple cultivars under high density planting systems of Kashmir

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ABSTRACT

In order to -overcome the problems of low productivity, poor fruit quality, less color and irregular bearing habits in current apple plantations in Kashmir valley, eight exotic apple cultivars introduced namely Mitch Gala, Elrosa, Wiltons Star, Golden Delicious Reinders, Red Delicious Camspur, Red Braeburn, Jonagold A and Jonagold DC Robijin, were evaluated for there performance in terms of fruit physical, chemical and organoleptic properties. All the cultivars were on M9T337 rootstock and of uniform age. Physical characteristics of fruits revealed that the highest fruit weight (190g), fruit volume (178.53cc) and lowest specific gravity (1.06) was recorded in cultivar Wiltons Star. In terms of chemical characteristics, Mitch Gala recorded the highest SSC, TSS/acid ratio and total sugar content of 14.73 ^{0}Brix, 70.03 and 12.61%, respectively and thus proved to be superior in terms of fruit quality. During sensory evaluation, Mitch Gala followed by Wiltons Star got the best scores in terms of overall acceptability.

Key words: Apple, characteristics, chemical, cultivars, evaluation, physical

Apple is the most produced fruit in temperate climate areas and is expanding into subtropical and tropical areas (Brown, 2012). More than 90 countries of the world produce apple. Total production of apple at global level is 86,142,197 MT from an area of 4,904,305 ha (FAOSTAT, 2018). The major apple producing countries in the world are China, United States, Poland, India, Turkey, Italy, Chile, Russia, Iran, France etc. India ranks 4th in apple production with the annual production of 25,03,000 MT from an area of 3,14,000 hectares (NHB, 2018).

In Jammu and Kashmir, apple is grown over an area of 1, 64,742 ha with a production of 18, 82,319 MT (Anonymous, 2019). The productivity of apple in Jammu and Kashmir is 11.43 MT/ha though it appears to be highest when compared with other apple producing states of the country, yet it is far below the productivity level achieved by the horticulturally advanced countries like Chile (47.22 MT/ha), Netherland (44.97 MT/ha) and Belgium (46.22 MT/ha), and also the proportion of A grade apple produced is very low. The reasons behind this low productivity and poor quality are old and senile orchards, low density plantings, non-availability of quality planting material, lack of irrigation facilities, high incidence of insect, pest and diseases and biennial bearing of commercial cultivars.

With stagnation in productivity, looming threat of imported fruits and land prices touching new peaks in the valley, it becomes imperative to go for high-density plantation for which change in rootstock from vigorous to size controlling rootstock is a prerequisite. Modern orchard planting systems are based on higher tree densities ranging from 1000 to 6000 trees per hectare (Robinson, 2003). Most commercial grower's world-over use size controlling dwarfing rootstocks planted at high densities that bring the grafted scion into fruit production within 2 to 3 years after planting. Greater light penetration in these high-density orchards increases tree health and precocity; return bloom, fruit size and quality. High density planting are coupled with faster returns on investment, though the initial costs tend to be somewhat on the higher side. Worldwide, the traditional apple cultivars are being gradually abandoned, enabling the new quality cultivars to take place (O'Rourke, 2003).

With the globalization of markets, it becomes imperative for any state or region to shift to new varieties having both high yield potential as well as good marketability to sustain in the competition. Varieties need to be recognized which meet our climatic requirements. In addition, in the years to come, we need to swing to zonalization of apple (i.e, identify particular variety well-matched to particular area based on suitability). All this is possible if we continue to research on the new varieties which are acceptable to the larger part of world consumer and assess their fitness in our valley conditions. Such an initiative to assess newly introduced apple varieties has been taken up by SKUAST-Kashmir, Srinagar J&K with the introduction of new exotic apple varieties in 2013 onwards. These varieties are under evaluation at the Shalimar campus under high density orcharding system. Few of these exotic cultivars of apple were studied during 2017 for different parameters to assess their feasibility for cultivation in the region.

MATERIALS AND METHODS

Eight exotic varieties of apple namely Mitch Gala, Elrosa, Wiltons Star, Golden Delicious Reinders, Red Delicious Camspur, Red Braeburn, Jonagold A and Jonagold DC Robijin grafted on M9-T337 rootstock were introduced by SKUAST-Kashmir from Holland in summer 2016. In order to access the performance of these exotic cultivars, it was proposed to conduct the study on their fruit physical, chemical and organoleptic characteristics. The plant material was two year old knip boom trees planted at a spacing of 3x1m. The experiment was laid in Randomized Complete Block Design (RCBD) with four replications and three trees per treatment as plot size.

For fruit weight, ten fruits from each treatment in each replication were weighed individually on a sensitive monopan balance and average weight was recorded in grams. The length and diameter of ten randomly selected fruits from each treatment in each replication was measured with the help of a Vernier Calliper, averaged and expressed in milimeters (mm). L/D ratio was calculated by dividing the length of fruit with the diameter of corresponding fruit and shape of fruit was determined as per the following procedure.
L/D ratio 1 = Round; L/D ratio > 1 = Oblong; L/D ratio < 1 = Flat

The volume of the fruits was determined with the help of water displacement technique and specific gravity was determined using the formula:

$$\text{Specific gravity} = \frac{\text{Mass}}{\text{Volume}}$$

Fruit firmness was measured with the help of Effegi penetrometer model Ft-3-27 having 7/16 diameter of the head with a penetration of 5/6. In case of number of seeds/fruit, fruits were cut and seeds removed from the core and number was counted. Chaffy and shriveled seeds were discarded. A hand refractrometer ranging from 0-33 ^{o}Brix (Erma make Japan) was used to determine TSS. Acidity was calculated as malic acid by using the following formula:

$$\text{Acidity (\%)} = \frac{\text{Titrate value} \times \text{normality of alkali} \times \text{dilution} \times 67}{\text{Weight of sample} \times \text{volume of aliquot taken} \times 1000} \times 100$$

Total soluble solids/acid ratio was determined using the formula:

$$\text{TSS/Acidity ratio} = \frac{\text{Total Soluble Solids (\%)}}{\text{Acidity (\%)}}$$

Total sugars were determined by taking known weight of fruit sample of 25g, crushed and mixed with distilled water and volume made to 250 ml in a volumetric flask and neutralized with 1N NaOH. To this 250 ml solution, 2 ml of 45% lead acetate was added. After 5-10 min, 2 ml of 42% potassium oxalate was added to precipitate the excess lead acetate and filtered. Fifty millileaters (50 ml) of filtrate was taken and hydrolyzed by adding 10 ml of hydrochloric acid (1:1) and was allowed to stand overnight for complete reaction. The excess hydrochloric acid was neutralized with saturated NaOH solution next day. The hydrolysed aliquot was taken in burette and titrated against boiling solution containing 5ml each of Fehling A and B using methylene blue as indicator (A.O.A.C., 1990). The end point was indicated by the appearance of brick red color.

$$\text{Total sugars (\%)} = \frac{\text{Fehling factor} \times \text{volume made up}}{\text{Titrate value} \times \text{weight of sample}} \times 100$$

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To assess the consumer acceptability (physical appearance, color, taste, flavor, texture, firmness and overall quality), the fruits were rated on a scale of 1-5 by a panel of five experts as:

(1 = Poor, 2 = Fair, 3 = Good, 4 = Excellent, 5 = Very Excellent)

RESULTS AND DISCUSSION

Physical characteristics: The data recorded in the present investigation reflects significant differences between the physical characteristics of fruits under study as revealed in Table 1. The fruits of cultivar Wiltons Star showed maximum fruit length (69.13 mm) and fruit diameter (79.59 mm) while as minimum length (54.13 mm) and diameter (69.95 mm) were recorded in Elrosa. Variations in fruit size have also been reported by several workers (Sharma and Chauhan, 2008; Singh, 2013) in different apple cultivars and is featured to be the inter-varietal differences associated with the genetic makeup of the cultivars and governed by the cell size and intercellular spaces of the flesh. According to Weber (2001), fruit size is closely related to number of fruits per tree and tree volume.

Table 1. Physical characteristics of exotic apple varieties

Variety	Fruit length (mm)	Fruit diameter (mm)	Fruit weight (g)	Length/ diameter (mm)	Specific gravity	Fruit firmness (kg/cm)	Fruit volume (ml)	Seed number
Mitch Gala	65.27	73.86	178.41	0.88	1.10	7.14	161.17	7.10
Elrosa	54.13	69.95	133.92	0.77	1.19	8.03	111.90	6.90
Wiltons Star	69.13	79.59	190.00	0.86	1.06	7.36	178.53	7.50
Golden Delicious Reinders	67.08	73.99	184.63	0.90	1.15	7.96	159.71	8.30
Red Delicious Camspur	67.71	74.15	173.01	0.91	1.13	7.97	152.26	8.85
Red Braeburn	66.28	74.29	186.33	0.89	1.05	7.92	176.92	8.85
Jonagold A	64.74	73.46	181.61	0.88	1.11	6.78	163.20	6.70
Jonagold DC Robijin	62.29	73.48	170.75	0.84	1.09	6.98	155.89	7.05
CD(p≤ 0.05)	**0.83**	**1.35**	**1.22**	**0.01**	**0.01**	**0.49**	**1.21**	**0.28**

Apple shape is a very important component of visual quality, and in different regions of the world a particular shape can fetch more than the other. Fruits of variety Elrosa showed a flat shape with L/D ratio of (0.77) while as the fruits of Red Delicious Camspur were elongated in shape with L/D ratio of (0.91). According to Currie *et al.* (2000), a very common pattern to express the fruit shape is the length/diameter ratio and more the ratio, more elongated fruit. These results were supported by the findings of Janick *et al.* (1996), who reported that apple shape can be classified from very flat, oblate to oblong.

The maximum fruit weight (190g) and volume (178.53 cc) was observed in cultivar Wiltons Star while the minimum fruit weight (133.92g) and volume (111.90 cc) was recorded in cultivar Elrosa. The variation of fruit weight and volume in different apple cultivars is attributed to the inter-varietal differences associated with the genetic makeup of the cultivars. Similar variation in fruit weight and volume have been reported by several workers (Yosef and Belal 2014 and Atashi *et al.* 2015) in different apple cultivars. Our results are in conformity with Salvador *et al.* (2006) who stated that there is a strong positive correlation between fruit size and fruit weight.

The highest fruit firmness was recorded in the cultivar Elrosa (8.03kg/cm^2) and lowest in Jonagold A (6.78kg/cm^2). The significant difference between the cultivars in the fruit flesh firmness and number of seeds per fruit may be due to difference in fruit size specific to each variety, number of fruits, number of seeds peculiar to each cultivar, stage of maturity of cultivars. The variations in fruit firmness may be due to varietal differences as reported by Magness *et al.* (1926) who found that fruit firmness of Delicious ranges between (18-16 lbs/inch^2) and in Jonathan (16-15 lbs/inch^2).

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The highest specific gravity was observed in cultivar Elrosa (1.19 g/cm³) and it was lowest in Red Braeburn (1.05 g/cm³) followed by Wiltons Star (1.06 g/cm³). Specific gravity of a fruit is governed by many factors including the mass, volume of fruit, compactness of cells and intercellular spaces between the cells. The variation can also be varietal difference, environmental factors, crop load, vigor of the tree, fruit leaf ratio and difference in both number and size of cells. The number of seeds per fruit were recorded maximum in Red Delicious Camspur and Braeburn (8.85) each while minimum number was recorded in variety Jonagold A (6.70). Our results are supported by Bozbuga and Pirlak (2012) who stated that number of seeds per fruit varied from 6.5 in Galaxy Gala to 9.3 in Granny Smith. The valid rule for triploid cultivars shows that such varieties contain less seeds per fruit (Soltesz, 1992). These cultivars, develop regular and symmetrical fruits even when containing few seeds only. The variations in physical characters among the cultivars may be due to varietal difference, environmental factors, crop load, vigor of the tree, fruit leaf ratio and difference in both number and size of cells and the findings are in agreement with the study of Daugaard and Callesen (2002).

Chemical characteristics: All the fruit biochemical parameters differed significantly as presented in Table 2. The highest value for soluble solid content was recorded in Mitch Gala (14.73 ^{o}Brix) and lowest in Red Braeburn (11.72 ^{o}Brix). The remarkable difference in the total soluble solids of fruits may be due to varietal characteristics or it could be due to size of fruits as well as number of fruits on a tree. These characters are also influenced by climatic and moisture availability during the growing season. Our results are supported by the findings of Kotiyal *et al.* (2017) who reported highest TSS in the variety Scarlet Gala (14.27^{0} Brix). Our results were also supported by the findings of Ghosh and Govind (1981), who reported that the TSS of Golden Delicious (14.30 ^{0}B) was higher than Red Delicious (12.80 ^{0}B).

Table 2: Chemical characteristics of exotic apple varieties

Variety	TSS (^{o} brix)	Acidity (%)	Total sugars (%)	TSS/Acid ratio
Mitch Gala	14.73	0.21	12.61	70.03
Elrosa	14.05	0.24	12.05	58.75
Wiltons Star	14.29	0.23	12.18	61.27
Golden Delicious Reinders	13.77	0.25	11.57	54.65
Red Delicious Camspur	13.43	0.26	11.14	50.73
Red Braeburn	11.72	0.31	9.67	37.34
Jonagold A	12.23	0.30	10.23	40.81
Jonagold DC Robijin	12.56	0.29	10.70	42.25
CD (p≤ 0.05)	**0.96**	**0.02**	**1.18**	**6.44**

In the present study, highest titrable acidity (0.31%) and total sugar (12.61%) were recorded in Red Braeburn and Mitch Gala, respectively and lowest values were observed in Mitch Gala (0.21%) and Red Braeburn (9.67%). Since all apple cultivars evaluated in this study were grown in the same location using similar horticultural practices, the variation in fruit chemical composition demonstrates that the genetic variability led to the differences in the synthesis of soluble solids, organic acids and sugars in these apple cultivars. Our results for total sugars are supported by the findings of Kotiyal *et al*, 2017 who reported that maximum mean value of total sugar in Royal Gala (11.36%) while as minimum in Jonagold (7.06%). The TSS/acid ratio is a key characteristic of determining the taste, texture and feel of fruit segments. It is sugar/acid ratio which contributes characteristic flavor to fruits. This ratio was found highest in variety Mitch Gala (70.03) and lowest in Braeburn (37.34). Our results for TSS, acidity, total sugars and TSS: acidity ratio are in conformity with the findings of Kumar *et al*. (2006) who evaluated various standard, spur type and color mutant varieties of apple for various chemical characteristics. They noticed that TSS of spur types was in the range of 11.34 to 13.5 ^{o}Brix and that of color mutants was in the range of 10.25 to 12.31^{o}Brix. Acidity ranges from 0.22 to 0.39 per cent while as total sugar ranged from 7.19 to 8.45 per cent and TSS: acid ratio ranged from 29.08 to 67.63.

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Similar variation for chemical characteristics like TSS, acidity, sugars etc. have also been reported by different workers like, Kumar and Verma (2001) under mid hill conditions of Kullu; Dwivedi *et al.*, (2005) in Ladakh region of Jammu & Kashmir; Sharma and Chauhan (2008) in dry temperate conditions of Spiti; Sharma (2011) under mid hill conditions of Sirmour and Singh (2013) under dry temperate region of Kinnaur. Our results are further supported by Verma *et al*, 2018 who recorded highest TSS and total sugars in the variety Gale Gala.

Mitch Gala

Organoleptic evaluation: All the eight exotic apple varieties as depicted in Fig. 1 were subjected to organoleptic evaluation. In order to evaluate varieties on the basis of sensory evaluation, a panel of five judges was selected and the scores were given for their color, ta ste, flavor and overall acceptability as shown in table 3. In terms of color, Wiltons Star (4.03) got the highest ratings and lowest ratings were given to Jonagold A (2.45). In case of taste and texture Mitch Gala ranked first and recorded (3.95) and (4.43) respectively. Cultivar Golden Delicious Reinders recorded the highest value in case of flavor (3.92). As far as overall acceptability is concerned cultivar Mitch Gala (3.95) ranked first followed by Wiltons Star (3.89). The apple skin color plays an important role in apple fruit trading because customers prefer red colored apples and thus the cost effectiveness of red skin apples is greater. Fruit skin color is determined by carotenoids, chlorophyll and anthocyanin (Lancaster, 1992). Besides that, fruit color intensity mostly depends on weather conditions during the ripening season (Stampar *et al*., 2002).

Elrosa

Wiltons Star

Golden Delicious Reinders

Red Delicious Camspur

Red Braeburn

Jonagold A

Jonagold DC Robijin

Paillard (1990) states that "taste is directly linked to certain constituents present in variable amounts" and goes on to say that research has suggested that the acid and sugar contents of apples can give a good indication of

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flavor. Hulme & Rhodes (1971) consider the taste of pome fruits including apples is principally based on sugar/acid balance.

Table 3. Organoleptic Rating of Exotic apple cultivars

Variety	Color	Texture	Taste	Flavor	Overall acceptability
Mitch Gala	3.55	4.43	3.95	3.87	3.95
Elrosa	3.03	2.82	3.76	2.86	3.11
Wiltons Star	4.03	4.14	3.85	3.55	3.89
Golden Delicious Reinders	3.52	3.22	3.62	3.92	3.57
Red Delicious Camspur	3.74	3.42	3.50	3.42	3.52
Red Braeburn	3.68	4.40	2.77	3.54	3.59
Jonagold A	2.45	3.22	3.18	3.30	3.03
Jonagold DC Robijin	3.05	3.62	3.38	3.53	3.39
CD (p≤ 0.05)	**0.28**	**0.08**	**0.14**	**0.14**	**0.57**

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CONCLUSION

The cultivar Mitch Gala proved superior followed by Wiltons star in terms of fruit quality and overall acceptability parameters and hence can be recommended for commercial production. The number of seeds per fruit were recorded maximum in Red Delicious Camspur and Braeburn (8.85) each while minimum number was recorded in variety Jonagold A (6.70). Furthermore, additional studies and more evaluation years are necessary to generate an apple production system under high density that is reliable under Kashmir conditions.

REFERENCES

A.O.A.C. 1990. Methods of Analysis; 14th ed. Association of official agriculture chemists. Washington, D.C; USA 957.

Anonymous. 2019. Statement showing area, production and productivity of fruits in J&K state. Department of Horticulture, Jammu and Kashmir Government, Srinagar.

Atashi, S., Mashayekhi, K., Garmakhany, A.D. and Pour, S. M. 2015. Physico-chemical characteristics of apple fruits as a function of climatic conditions and cultivars. *Minerva Biotecnologica*, **27**:37-42.

Bozbuga, F. and Pirlak, L. 2012. Determination of phenological and pomological characteristics of some apple cultivars in Nigde-Turkey ecological conditions. *The Journal of Animal and Plant Sciences*, **22**: 183-187.

Brown, S. 2012. Apple. In: Fruit Breeding (Eds. Badenes, M. L. and Byrne, D. H.) pp. 329-367, *Springer*, New York, NY, USA.

Currie, A.J., Ganeshanandan, S., Noiton, D.A., Garrick, D., Shelbourne, C.J.A. and Oraguzie, N. 2000. Quantitative evaluation of apple (*Malus* × *domestica* Borkh.) fruit shape by principal component analysis of Fourier descriptors. *Euphytica,* **111**:219-227.

Daugaard, H. and Callesen, O. 2002. The effect of rootstock on yield and quality of Mutsu apples. *Journal of Horticultural Science and Biotechnology,* **77**: 248-251.

Dwivedi, S.K., Abdul, K. and Raut, B. 2005. Some fruit characteristics of apple varieties indigenous to Ladakh, India. *Acta Horticulturae*, **696**:53-55.

FAOSTAT. 2018 Agricultural Statistical Database, available online at: http://faostat.fao.org.

Fuller, M. M. 2008. The ultrastructure of the outer tissues of cold-stored apple fruits of high and low calcium content in relation to cell breakdown. *Annals of Applied Biology*, **83**:299-304.

Ghosh, S. P. and Govind, S. 1981. Yield performance and fruit quality of different varieties of apple in Meghalaya. *Progressive Horticulture***, 13**:11-17.

Hulme, A. C. and Rhodes, M. J. C. 1971. Pome fruits. In**:** The Biochemistry of Fruits and their Products (Eds. Hulme, A. C.) **2**:333-436. London, Academic Press.

Janick, J., Cummins, J., Brown, S. and Hemmat, M. 1996. APPLES. **In**: *Fruit Breeding* .Tree and Tropical Fruits, pp 1-77 (Eds. J., Janick and J.N., Moore), Wiley, New York.

Kotiyal, A., Dimri, D.C. and Goswami, A.P. 2017. Physico-chemical evaluation of ten apple (*Malus* × *domestica* Borkh.) cultivars grown in Uttarakhand hills of India. *Plant Archives*, **17**:573-579.

Kumar, J. and Verma, H.S. 2001. Performance of apple cultivars under low altitude conditions of Kullu Valley. Haryana Journal of Horticultural Sciences **30**:139-142.

Kumar, P. Gangwar, P.M. and Dimiri, C.D. 2006. Evaluation of spur and color mutant cultivars of apple (*Malus domestica* Borkh.) for their suitability under mid hill conditions of Uttaranchal. *Journal of Horticultural Science*, **1**: 138-140.

Lancaster, J.E. 1992. Regulation of skin color in apples. *Critical Reviews in Plant Sciences*, **10**: 487-502.

Magness, J.R., Diche, H.C. and Haller, M.H. 1926. Picking maturity of apples in relation to storage. USDA Bulletin 1448:120.

NHB 2018. Horticulture statistics at a glance 2018. National Horticultural Board, Gurgaon, p. 60. National Horticulture Board Database (www.nhb.gov.in).

O'Rourke D. 2003. World production, trade, consumption and economic outlook for apples. In: Apples: Botany, Production and Uses (eds. Ferree, D.C. and Warrington, I.J.). CABI Publishing, CAB International, UK. pp: 15-28.

Paillard, N. M. R. 1990. The flavour of apples, pears and quinces. pp. 1-41 In: Food Flavours. Part C. The flavour of fruits. (Eds. Morton, I. D. and MacLeod, *A. J.*). Amsterdam, Oxford, New York, Tokyo, Elsevier.

Robinson, T.L. 2003. Apple-orchard planting system. In: Apples (eds. Ferree, D.C & Warrington, I.J), Cabi Publ., Wallingford, UK. pp: 345-407.

Salvador, F.R.D., Fisichella, M. and Fontanari, M. 2006. Correlations between fruit size and fruit quality in apple trees with high and standard crop load levels. *Journal of Fruit and Ornamental Plant Research*, 14(2).

Sharma, D.P and Chauhan, J.S. 2008. Performance of apple cultivars under cold dessert conditions of North-Western Himalayas. *Acta Horticulturae*, **772**:199-20.

Sharma, H.R. 2011. Performance of some apple cultivars under sub temperate conditions of Himachal Pradesh. Msc Thesis, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan (HP).

Singh, J. 2013. Studies on the performance of some newly introduced cultivars of apple *(Malus* × *domestica Borkh.)* under high hill conditions of Kinnaur (H.P.). M.Sc. Thesis. Department of Fruit Science, Dr YS Parmar University of Horticulture and Forestry, Solan.

Soltesz, M. 1992. The use of phenological information in determing cultivar combination in apple. D.Sc thesis. Hungarian Academy of Science, Budapest.

Stampar, F., Veberic, R., Zadravec, P., Hudina, M., Usenik, V., Solar, A. and Osterc, G. 2002. Yield and fruit quality of apples cv. 'Jonagold' under hail protection nets. *Gartenbauwissenschaft***, 67**:205-210.

Verma, P., Thakur, B.S. and Chauhan, N. 2018. Performance of some apple (*Malus* × *domestica* Borkh.) cultivars for fruit quality traits under mid hill conditions of Himachal Pradesh, India. International *Journal of Current Microbiology and Applied Science*, **7**:788-793.

Weber, M. S. 2001. Optimizing the tree density in apple orchards on dwarfing rootstocks. *Acta Horticultarae*, **557**: 229-234.

Yosef, I. and Belal, I. 2014. Regional effect on fruit physical and chemical characteristics of two apple varieties grown in Libya. International Conference on Agricultural, Biology and Environment Sciences Bali, Indonesia, pp 35-37.

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