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Advances in arid fruit crops: An overview

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ABSTRACT

Arid regions receive very little precipitation, usually less than 10 inches (25 centimeters) of rain per year. These regions, known as drylands, are characterized by semi-permanent water scarcity resulting from low soil moisture availability, ephemeral stream and river flow, and limited plant cover. There are approximately 30 plant species in arid zones that are known for their edible uses, with around 20 of these being known for their edible fruits or vegetables, such as aonla (*Phyllanthus emblica*), custard apple (*Annona squamosa*), lasora (*Cordia myxa*), ber (*Ziziphus nummularia*), phalsa (*Grewia subinaequalis*), bael (*Aegle marmelos*), karonda (*Carissa carandas*), jamun (*Syzygium cumini*), fig (*Ficus carica*), and pomegranate (*Punica granatum*) among others. Local people are already familiar with the nutritional and medicinal properties of these crops. Therefore, it is important to conduct rigorous studies on the conservation and nutritional characterization of these crops, to expand the future food basket and enhance its functional and nutritional values.

KEYWORDS

Arid Region, Dryland, Water Scarcity, Nutritional, Medicinal Properties

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India has an arid area of approximately 38.73 million hectares (Anon., 2015), with around 12 % of the total geographical area being classified as hot arid zones. Unfortunately, over 50 % of this hot arid zone is adversely affected by desertification. In view of the current and future water scarcity in these areas, growing less water-requiring crops with high application efficiency is essential. Drought hardy crops, particularly perennial fruits with deep root systems, can survive extreme radiation and temperatures while providing income, nutritional security and food security. Commercially grown fruit crops in arid regions include ber, beal, pomegranate, custard apple, date palm, aonla, fig and jamun. With their vast area, ample solar radiation, and low incidence of disease and pest population, arid regions in India have the potential to become the horticultural bowl of the country. Therefore, advanced production technologies should be implemented to increase fruit production in these regions.

What is Arid?

Arid implies prolonged dryness with respect to the climate itself and the land in such regions the ability to produce agricultural crops is restricted usually on arid lands the potential evaporation of water from the land exceeds the rainfall.

The Arid Areas are Characterized by

- Low and erratic rainfall (100-420 mm/year)
- Frequent droughts
- High summer temperatures (45-50° C)
- High wind velocity (30-40 km/h)
- High evapotranspiration (1500-2000 mm/year

Characteristics of Crops Suitable in Arid Regions

- Tolerance to drought (aonla, ber, datepalm, bael)
- Long and deep tap root system (aonla, bael, tamarind and jamun)
- Synchronization of growth period with maximum water availability
- Tolerance to salinity and alkalinity (aonla, ber, datepalm and pomegranate)
- Tolerance to high solar radiation (aonla, ber, karonda)

Advance Technologies in Arid Fruit Crop Cultivation

- Varietal improvement
- Propagation
- Micro propagation
- Planting system
- Intercropping
- Mulching
- INM
- Water management and fertigation
- Training and pruning
- Crop regulation

Table 1. Varietal improvement in fruit crops

Fruit Crop	Existing Commercial Varieties	New Varieties
Ber	Gola,Seb, Umaran, Banarsi, Kaithali	Goma Kirti, Sanaur-4, Sanaur-5
Aonla	Banarsi, Chakaya, Fransis	Gujarat Aonla-1,NA-7,NA-10, Kanchan, Krishna, Goma Aishwarya
Bael	Kagzi, Mirzapur seedling, Gonda, Ayodhya	Pant Aparna, Pant Urvashi, Pant Shivani, Pant Sujata, Goma Yashi
Pomegranate	Ganesh, Dholka, Jalore Seedless	Mridula, Jyoti, Arakta, Bhagva, G-137
Custard apple	Balanagar, Mammoth, Sindhan	Arka Sahan, GJCA-1
Fig	Poona, Dinkar	Dianna, Excel
Jamun	Paras	Goma Priyanka

Custard Apple

Anonymous (2010) found that Sindhan variety gave maximum plant height (3.72 m), number of fruit per plant (157.80) and yield per plant (18.67 kg) in custard apple. Since, the dwarf ness is the desirable character for the high density planting by accommodating more number of plants per unit area, which ultimately enhance the productivity. The variation in height among different varieties might be due to inherent characters of individual varieties and their acclimatization to varied agro-climatic conditions.

Ber

Singh and Bal (2010) recorded maximum fruit yield (133.30 kg/ plant), fruit weight (24.06 g), TSS (14.94 %), vitamin C (134.57 mg/ 100g) and minimum acidity (0.22 %) in Sanaur 4 variety of ber. Therefore, it was concluded that after nine year of rejuvenation in different ber varieties the yield and quality of ber remarkably improved.

The difference in height among different varieties might be due to their genetic difference because all the varieties grow under the same environmental conditions. The difference in yield among different cultivars may be due to individual growth pattern of the tree.

Pomegranate

Anonymous (2013) recorded significantly higher fruit weight (321.00 g) and yield (25.68 kg/ tree) in pomegranate variety G-137 was found better for yield characters. The growth habit of variety G-137 is spreading type with evergreen nature. The tree flowers throughout the year with three main flushes. The difference in fruit weight as well as yield among different varieties may be due to individual growth pattern of the tree.

Bael

Sing *et al.* (2014) reported that the maximum yield per plant (69.29 kg) was recorded in NB-9

whereas maximum fruit weight (4.25 kg), fruit girth (70.00) and pulp weight (3.67 kg) were observed in variety NB-7 in bael. Differences in the various quantitative characters of fruits of different varieties are genetic in nature rather than due to edaphic or other environmental factors.

Propagation

Plant propagation can also refer to the artificial or natural dispersal of plants. Plant propagation is the process of creating new plants from a variety of sources: seeds, cuttings, bulbs and other plant parts. All plants in this universe multiply themselves both by sexual (seeds) or asexual (vegetative) means. However, man has now developed some more techniques for speedy and better multiplication of these plants.

Plant Propagation Methods

The first and foremost objective of a propagation method should be to produce individuals that are identical to mother or original plant. Thus, a successful propagation method is one, which transmits all desirable characters of a mother plants to the offspring's.

Sexual Propagation

The plants, which multiply through seeds as a mode of perpetuation, such as Most annuals, biennials and many perennial fruit plants; vegetable crops; plantation, aromatic and medicinal plants; ornamental flowering and shade providing shrubs and trees etc. In general, seeds propagate the self-pollinated plants, which are considered homozygous. In sexual method of propagation, the sex organs of flower are involved in process like pollination and fertilization leads to the formation of seeds. Seeds are typically produced from sexual reproduction within a species may have different characteristics from its parents, such as papaya, phalsa, mangosteen, rootstocks plants of many fruit crops raised through sexual method of propagation.

Asexual / Vegetative Propagation

Apomictic seedlings are identical to their mother plants, and similar through the plants raised through other vegetative means, as it has the same genetic makeup as that of the mother plants, such as citrus, mango, apple etc.

Propagation by vegetative structure is also called as vegetative propagation as it involves only vegetative parts without any sexual plant parts. The plant parts like leaf, stem, root and other root producing plant organs are used. The new individual propagated through this method is true to type. The commercially important fruit crops are propagated by vegetative method.

Aonla

Negi *et al.* (2010) observed that one-month-old seedlings for rootstocks raised in polybags and performed chip budding at next year during last week of June had higher survival percentage (87.96 %) in aonla. Relatively less survival percentage of budlings/ grafts recorded with transplanting of ex-situ nursery bed raised budlings/ grafts could be attributed to cutting of main tap root system and damage of feeder roots at the time of digging plants from the nursery beds and the resulting stress and change of soil environment near the root system on transplanting in the field might have possibly caused failure of budlings/ grafts to survive. While in case of in-situ and polybags raised seedlings/ budlings/ grafts, the roots remain undisturbed and better uptake of nutrients and water by roots must have influenced the good survival of plants. From the results of these studies, it may be inferred that the treatment combination transplanting of one month old seedlings for rootstocks raised in polybags and performed chip budding after one year recommended for commercial use for rehabilitation of degraded pasture/grazing lands.

Jamun

Mulla *et al.* (2011) observed that softwood grafting during the month of October-November gave maximum survival percentage (93.33) in open condition in jamun. This may be due to favorable climatic conditions during these months such as moderate temperature (28^0 to 32^0) and relative humidity (74% to 78%). The temperature and relative humidity activates the cambium cells. The new callus tissue arising out of the cambial region is composed of thin walled turgid cells, which can easily desiccate and die off and RH can protect such cells in the cambial region of the graft union. The high humidity stretched for longer period in October, which prevents desiccation of the scion.

The environmental conditions for mist house grafts can be readily controlled, thereby permitting greater reliability of grafting over long period, when compared to outdoor grafting operation.

Fig

Sivaji *et al.* (2014) recorded that basal cutting with IBA 3000 ppm gave maximum rooting (79.77 %), survival percent (95.10), number of roots/cutting (36.38) and length of the longest root (28.49 cm) in fig. Better performance of basal cuttings over other types may be because increased carbohydrate storage and presence of more performed root initials in basal cuttings. Root parameters recorded highest in cuttings treated with IBA 3000 ppm. This might be because root formation process in cuttings is intensified by IBA through polysaccharide hydrolysis, which provides energy for meristematic tissues and thereby for root primordial for root formation.

Micro Propagation

What is Micro Propagation?

It is a technique of growing any part of plant in an artificially prepared nutrient medium under aseptic and control environment.

Advantages of Micro Propagation

- Rapid, large scale multiplication of true-to-type plants with uniform growth in a limited time and space is possible
- Plants are usually free from viruses and diseases
- The plants can be produced throughout the year
- Long term storage of the material in lesser space is possible
- Potential for long term transportation of propagation material

Pomegranate

Patil *et al.* (2011) studied that the nodal explants grown in MS medium containing 1 mg/l silver nitrate and 30 mg/l adenine sulphate had the highest number of shoots/explant (5.00), shoot length (2.5 cm) and more number of explants showing response (96.00 %) in pomegranate. In this experiment, proliferated shoots were subjected to in-vitro rooting and shoot elongation in MS medium containing IBA.

Therefore succeeded in the development of an efficient protocol by using PGR in combination with silver nitrate and adenine sulphate for mass scale micro propagation of pomegranate cv. Bhagava.

Planting System

The various layout systems used are the following:

Vertical Row Planting Pattern

Square System

In this system, trees are planted on each comer of a square whatever may be the planting distance. This is the most commonly followed system and is very easy to layout. The central place between four trees may be advantageously used to raise short-lived filler trees. This system permits inter cropping and cultivation in two directions.

Rectangular System

In this system, trees are planted on each corner of a rectangle. As the distance between any two rows is more than the distance between any two trees in a row, there is no equal distribution of space per tree. The wider alley spaces available between rows of trees permit easy intercultural operations and even the use of mechanical operations.

Alternate Row Planting Pattern

Hexagonal System

In this method, the trees are planted in each comer of an equilateral triangle. This way six trees form a hexagon with the seventh tree in the centre. Therefore, this system is also called as 'septule' as a seventh tree is accommodated in the centre of hexagon. This system provides equal spacing but it is difficult to layout. The perpendicular distance between any two adjacent rows is equal to the product of 0.866 x the distance between any two trees. As the perpendicular distance between any two rows is less than unity, this system accommodates 15% more trees than the square system. The limitations of this system are that it is difficult to layout and the cultivation is not so easily done as in the square system.

Diagonal or Quincunx System

This is the square method but with one, more plant in the center of the square. This will accommodate double the number of plants, but does not provide equal spacing. The central (filler) tree chosen may be a short-lived one. This system can be followed when the distance between the permanent trees is more than 10 m. As there will be competition between permanent and filler trees, the filler trees should be removed after a few years when main trees come to bearing.

Triangular System

The trees are planted as in square system but the difference being that those in the even numbered rows are midway between those in the odd rows instead of opposite to them. Triangular system is based on the principle of isolateral triangle. The distance between any two adjacent trees in a row is equal to the perpendicular distance between any two adjacent rows. However, the vertical distance, between immediate two trees in the adjacent rows, is equal to the product of (1.118 x distance between two trees in a row). When compared to square system, each tree occupies more area and hence it accommodates few trees per hectare than the square system.

Contour System

It is followed on the hills where the plants are planted along the contour across the slope. It particularly suits to land with undulated topography, where there is greater danger of erosion and irrigation of the orchard is difficult. The main purpose of this system is to minimize land erosion and to conserve soil moisture to make the slope fit for growing fruits and plantation crops. The contour line is so designed and graded in such a way that the flow of water in the irrigation channel becomes slow and thus finds time to penetrate into the, soil without causing erosion. Terrace system on the other hand refers to planting in flat strip of land formed across a sloping side of a hill, lying level along the contours.

Aonla

Singh *et al.* (2011) obtained maximum yield (4.49 t/ha) and percent increase in yield (96.44) of aonla in double hedgerow planting system.

If productivity per unit area basis is considered, yield /plot had given significantly higher yield under double hedgerow due to higher plant population / unit area. With advancement of age, productivity rise significantly in all the systems of planting. The results clearly revealed that although productivity of individual tree under different planting systems were at par, but accommodation of more plant population in double hedgerow system led to almost double the production than square system.

Intercropping

Intercropping is the practice of growing two or more crops in proximity. The most common goal of intercropping is to produce a greater yield on a given piece of land by making use of resources that would otherwise not be utilized by a single crop.

Advantages of Intercropping

- Fertility, the ability of the soil to maintain plant growth is very well maintained.
- It is one of the natural ways to control pests.
- The resources are used well.

Aonla

Das *et al.* (2011) studied that intercropping of turmeric in aonla gave maximum yield (13.30 t/ha), net return (4, 63,665) and benefit cost ratio (6.29) under agri-horti system. The reason for increase in fruit production under agri-horticultural systems may be that aonla trees, as there was no physical barrier between the root systems of intercrops and trees also utilized manure and fertilizers applied to intercrops.

Economic analyses of different systems showed that higher returns were obtained when the crops were grown in association with aonla, rather than sole cropping. Considering the total cost and monetary return from main and intercrops, it was found that turmeric with aonla earned maximum net returns.

Ber

Yaragattikar and Itnal (2003) recorded the highest net income and benefit cost ratio (3.85) in ber + bengal gram intercropping system. The ber trees were young and there was enough inter space available for growth of intercrops and light was penetrating through the canopy of ber.

The better performance of safflower and bengalgram under stored soil moisture conditions during rabi season in northern dry zone of Karnataka have been proved. The equal performance of field crops in intercropping system could be attributed to the absence of competition for moisture, light and nutrients between the ber and intercrops.

Mulching

Mulching is a widely practiced gardening technique that is beneficial for plants when done properly. It is the act of covering the soil with mulches, such as bark, wood chips, leaves, and other organic material, in order to preserve moisture and improve the condition of the soil.

What is importance of mulching?

- Mulches conserve the soil moisture, enhance the nutrients status of soil, control erosion losses, suppress weeds in crop plants and remove residual effects of pesticides, fertilizers, heavy metals.
- Mulches improve the aesthetic value of landscapes and economic value of crops.

Aonla

Singh *et al.* (2010) reported that paddy straw mulch was found better for maximum fruit weight (50.00 g), diameter (4.50 cm), TSS (8.00 %) and vitamin–C content (497.70 mg/100g) in aonla. Increased soil moisture content below the mulches in various organic mulching treatments might be due to reduction in soil surface evaporation, increased infiltration percolation capacity of soil, suppression in extreme fluctuation of soil temperature thus retaining the soil moisture in the soil for longer duration.

Ber

Bal and Singh (2011) revealed that maximum fruit size (4.37 cm, 3.21 cm length and breadth), fruit weight (22.5 g), yield (45.36 kg/tree) and TSS (12.96 %) in ber cv. Umran with black polythene had recorded maximum yield with better quality parameters. The increased fruit yield under mulched condition was mainly attributed to increase availability of soil moisture for longer duration and control of weed growth. The lowest yield was observed in control is due to lower soil moisture regimes, more weeds and higher evaporation from soil surface.

Integrated Nutrient Management

The indiscriminate use of chemical pesticides along with improper nutrient management is deleterious to the plant health, environment and human being who consume them. The quality attributes of different fruits are badly affected due to indiscriminate application of inorganic agro-chemicals which results in quality deterioration with less consumer preference and low returns to the growers. It also causes soil health deterioration and disturbs the soil microorganisms. Such practices are also common among the fruit growers. Due to these practices, the plants also become susceptible to several biotic and abiotic stresses. Therefore, it is a holistic approach based on usage of all possible sources of plant nutrients in an integrated manner is considered as alternative source to maintain soil fertility and plant nutrient supply for sustaining the desired crop productivity.

Aonla

Singh *et al.* (2012) observed that maximum yield per plant (32.15 kg), fruit weight (42.50) and fruit pulp (40.35 gm) were obtained in aonla with FYM + NPK (500:250:375 g/tree), while vitamin-C (390.40 mg/100 gm) was maximum in combination of neem cake + FYM + cow pat pit. The increased in the yield was mainly attributed to relative increase in the availability of nutrients and better solute uptake by the plants. The increased fruits quality may be explained from the fact that the different sources of nutrients enhance the nutrient availability by enhancing the capability of plants for better uptake of nutrients from rhizosphere.

Ber

Bohane and Tiwari (2014) revealed that maximum fruit diameter at harvest (3.31 cm), fruit volume (22.25 ml), pulp weight (20.06 gm) and TSS (20.85 ˚Brix) the application of 50 % RDF as VC+ 50 % RDF as NPK fertilizer + PSB + Azotobacter significantly increased all physical and quality parameters of ber var. Gola. The increase in fruit diameter and volume might be due to the increased photosynthetic ability of plants supplied with Azotobacter + vermicompost, which in turn might have favored and increased the accumulation of dry matter. Fruit diameter and volume are highly correlated with dry matter content and balanced level of hormone.

Nitrogen fixers are known for accumulation of dry matter and their translocation as well as favors synthesis of different growth regulators.

Water Management and Fertigation

Fertigation is a method of fertilizer application in which fertilizer is incorporated within the irrigation water by the drip system. In this system fertilizer, solution is distributed evenly in irrigation. The availability of nutrients is very high therefore, the efficiency is more.

Pomegranate

Shanmugasundaram and Balakrishnamurthy (2013) observed that 50% RDF *i.e.* 250: 75: 75g NPK/ plant through fertigation gave maximum no. of fruits/ plant (52.38), average fruit weight (211.43 g), fruit volume (228.75 cc), yield/ plant (11.1 kg) in pomegranate cv. Mridula. The increase in number of fruit /tree was due to the production of highest number hermaphrodite flowers per tree and due to better growth of the plant and mineral assimilation, which resulted in increased fruit volume. The increase in yield was largely as quince of higher fruit number and fruit weight. Apart from this, drip irrigation restricts the fluctuations in soil water potential within narrow range and maintained favorable water regime leading to higher yield. Haneef *et al.* (2014) noted that 125 % RDF in fertigation level and 100 % drip irrigation on PE base level resulted in more number of fruits (52.00), fruit weight (170.56 gm), higher profitable yield (8.90 kg/plant), juice percent (80.44) and TSS: acid ratio (42.44) of pomegranate cv. Bhagwa. The possible explanation for increase in yield by F_3 treatments might be due to increase in balance vegetative growth with maximum harvest of solar light. Higher levels of fertigation, *i.e.,* F_2 and F_3 maximized the growth of the plant and facilitated in accumulation of more carbohydrates into the fruit further, during the subsequent fruit development. Such metabolites (starch) will hydrolyse into sugar that increases the TSS and decrease the acidity.

Training and Pruning
Training

Judicious removal of plant part to give the plant particular shape required mainly in the initial years of crop growth to build up the strong framework.

Objectives of Training

- Establish a strong tree framework
- Facilitate management of tree and crop
- Maintain productivity
- To admit light up to centre of the tree and provide sufficient movement of air across the plant
- To increase photosynthetic activity by exposing leaves to the sun
- To provide strong scaffold system this could bear the heavy load of fruits, without limb breakage

Gill *et al.* (2011) concluded that bush training system gave maximum canopy spread (3.56 m E-W and 3.43 m N-S) and stem girth (45.78 cm) in pomegranate cv. Kandhari. The bush system represents the average girth of four scaffolds. Bush trained plants did not show ant tilting while high stem trained plants showed some tilting with heavy velocity winds. The canopies spread on both sides of E-W and N-S directions of the trees were significantly higher in plants trained as bush indication larger fruiting area for higher yields.

Pruning

Judicious removal of plant part to obtained better and qualitative yield is termed as pruning

Objectives of Pruning

- To remove surplus branches
- To obtain regular bearing
- To remove diseased, damaged, insect infected and weak shoots
- To thin out flowers and fruits
- To have a balance between vegetative and reproductive growth
- To control flowering and fruiting
- Prevent formation of weak crotches
- Regulate exposure to sunlight

What happens if you do not prune?

- Faster growth
- Less light penetration
- Poor spray coverage
- More difficult to manage

Phalsa

Abid *et al.* (2012) recorded maximum number of cone/bush (13.66), number of sprouted shoots/cone (29.26), number of fruiting nodes/shoot (29.29), number of fruits/node (9.18), yield/ha

(7080.5 kg), TSS (16.17 ºBrix) and sugars (11.20%) in pruning level at 90 cm in phalsa. This might be due to shoots were longer in plants pruned have more number of cones/bush, number of sprouted shoots/cone, number of fruiting nodes/shoots and fruiting nodes. Lakra *et al.* (2018) recorded maximum number of canes per bush (13.67), number of sprouted shoot per cane (30.30), total number of flowering per plant (2927.41), length of shoots/ cane (84.64 cm), number of fruiting nodes/ shoots (27.72), number of leaves per shoots (23.46) and leaf area per plant (240.78 cm^2) of phalsa in pruning level at 90 cm.

Pomegranate

Mishra *et al.* (2020) recorded significantly minimum days to first flowering (105.49), days taken to first fruit (147.80) with maximum number of flower/plant (95.16), number of fruits/plant (26.67) and fruit yield/plant (3.82 kg) in treatment T_4 (40 cm pruning). Whereas, maximum number of branches (7.79 and 10.24) were noted under treatment T_2 (20 cm pruning).

This might be due to pruning which remove carbon starved, exhausted flowering and fruiting and promote new growth to build up carbohydrates reserves for flowering and allows the sprouting of lateral buds which, ultimately influenced plant growth and other vegetative characteristics of the plant.

Crop Regulation

Manipulation or regulation of flowering at a desired time through bahar treatment.

Bahar Treatment Include

- Root pruning
- Root exposure
- Use of chemicals
- With holding water for about two months before flowering

Season of Flowering

- Ambe Bahar (January-February)
- Mrig Bahar (June-July)
- Hasta Bahar (September-October)

Table 2. Crop technologies and results

Technologies	Result
Varietal Improvement	▪ Ber : Sanaur-4, custard apple : Sindhan , beal : NB 9 varieties found higher production and quality fruit characters
Propagation	▪ Aonla : chip budding, jamun : soft wood grafting, Fig : basal cutting with IBA 3000ppm recorded higher survival percentage and rooting
Micropropagation	▪ Pomegranate : MS + 30 mg/l adenine sulphate found best for shoot growth and MS + 0.50 mg/l IBA found best for root growth
Planting System	▪ Aonla : Double hedge row planting system found best for maximum yield
Intercropping	▪ Aonla+turmeric, ber+bengalgram for getting highest net income and benefit cost ratio
Mulching	▪ Ber : black polythene, aonla : paddy straw mulch recorded maximum yield and better quality parameters
Inm	▪ Aonla : FYM + NPK (500:250:375 g /tree), ▪ Ber : 50% RDF as VC + 50% RDF as NPK fertilizer + PSB + Azotobacter increased all physical and quality parameters
Water Management and Fertigation	✓ Pomegranate: RDF 50% *i.e.* 250: 75: 75g NPK/plant through fertigation increased yield and save 50% dose of inorganic fertilizers
Training and Pruning	✓ Pomegranate : bush training system for better vegetative growth, Pomegranate showed significantly maximum growth with better fruit quality and yield when plants were pruned up to 20 cm (light pruning) ✓ Phalsa: Produced significantly higher vegetative growth with better fruit yield and quality when plants were pruned up to 90 cm
Crop Regulation	✓ Pomegranate : bahar treatment by withholding irrigation in February-March yielded superior quality fruits with less cracking

Pomegranate

Singh and Kingsly (2007) revealed that minimum cracking (0.73 %), acidity (0.71 %) and maximum weight of fruit (240.00 gm), TSS (17.63 °Brix) in mrig bahar treatment (February-March) gave pomegranate fruits with least cracking with better quality. Since day and night, fluctuation in advanced stages of harvesting increased the thickness of peel, which has led to maximum cracking. Hardy nature and suitability to marginal lands, farmers of arid region have taken up cultivation of pomegranate on commercial scale. The main problem for getting quality fruits suitable for table purpose and processing, under arid ecosystem is cracking of fruits at maturity stage. Goswami *et al.* (2013) reported that two spray of 200-ppm ethrel recorded significantly higher TSS (17.18 %), total sugar (12.51 %) and reducing sugar (10.83 %) in pomegranate cv. Sindhuri. The increase in total soluble solids and sugar percentage may be caused due to starch hydrolysis and early maturation of fruits.

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