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Innovative Cultivation Practices of Grape

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Abstract
Grape is the most delightful, replenishing, and nourishing fruits. Grapes are refreshing fruits because of their flavours, nutritious content, structure, and low calorific value. Fructose is the primary sugar in grape berries, followed by glucose and sucrose. Berries from *Vitis champini* and *V. doaniana* are examples of two species that contain more glucose than fructose. In the past, "grape therapy" was employed to treat cancer. Resveratrol, a molecule found in grapes that has anti-carcinogenic activity, was first identified by scientists in 1996. The grape producers utilize a variety of training strategies to train the grapevine. The Bower (Pandal System), Telephone System, Single Wire, T Trellis, Small Y, and Kniffin forms were often employed.

Key words: Grape, fructose, grape therapy, training

Introduction
Grape is a crop that has a long history in the development of human civilization. It is one of the oldest plants that man has grown. The term "viticulture" refers to the cultivation of grapes. References to this fruit and the wine that is derived from it may be found in the Bible and other reliable literary works, which shows how old they are. 5000–6000 years ago, viticulture was mentioned in Egyptian literature. Historical sources show that Middle Eastern and Mediterranean people used grapes and wine even before the advent of Christianity. Grape is the most delightful, replenishing, and nourishing fruits. Grapes are refreshing fruits because of their flavours, nutritious content, structure, and low calorific value. Despite being successfully adapted to various sub-tropical nations, it is still regarded as a fruit of the temperate zone.

Taxonomy of grape
Order : Vitales
Family : Vitaceae
Genus : *Vitis*
Species : *V. vinifera*

The American grapes, including *Vitis labirusca*, other species of Euvitis and Muscadinia originated in North American region where the largest collection of native Vitis species occurs. Euvitis has 2n=2x=38 chromosomes, while Muscadinia has 2n=2x=40 chromosomes.

Origin

Armenia in Russia is where the *vitis vinifera* grape originated. It arrived from Iran and Afghanistan to north India by Muslim invaders around 1300 AD, and it was carried to south India by French Christian missionaries in 1832.

Geographical distribution

India is one of the top 10 producers of grapes in the world. The top grape producers are Italy, France, Spain, America, Turkey, China, and Argentina. In India, this crop ranks fifth among that produce fruit. In India, the states of Maharashtra, Karnataka, Andhra Pradesh, Telangana, Tamil Nadu, and Punjab are where grapes are largely grown. With around 81% of the nation's total grape production, Maharashtra is India's top grape grower. In Maharashtra, the Sangli and Nashik districts are well recognized for their grape cultivation. Maharashtra, a western Indian state, has Nashik as its primary grape-growing region. Nashik is referred to be the "Wine Capital of India" and is well recognized for its grape growing. Significant grape production also occurs in Punjab, Andhra Pradesh, Telangana, Tamil Nadu, and Karnataka.

Composition and importance

Fruits consists of pulp, skin and seed . A further prevalent variety is seedlessnes. On average, the weight of the fruit is made up of 5–12% fruit skin and 0%–10% fruit seeds. The tannin content of seeds is 5-8%, and the oil content is 0-20%. Fruits' juice quantity is influenced by the pulpiness of the variety, the stage of ripeness, the size of the berry, the presence or absence of seeds, and the effectiveness of the process of extraction. The fruit grape is a soothing one that contains an abundance with sugars, acids, minerals, vitamins, and tannins. Nitrogenous substances (0.03-0.7%), minerals (0.2-0.6%), organic acids (0.3-1.5%), and carbohydrates (15%), calcium (0.004-0.025%), potassium (0.15–0.25%), iron (0.003-0.0017%), vitamin A (1–80 micrograms), vitamin B complex (391-636 mg/100g), and vitamin C (1–12.5 mg/100g) are the main components of fruits. Fructose is the primary sugar in grape berries, followed by glucose and sucrose. Berries from *Vitis champini* and *V. doaniana* are examples of two species that contain more glucose than fructose. The majority (90%) of the acidity in fruits comes from tartaric and malic acids.

Furthermore, the medical benefits of grapes are well documented. In the past, "grape therapy" was employed to treat cancer. Resveratrol, a molecule found in grapes that has anti-carcinogenic activity, was first identified by scientists in 1996. It has since been shown to suppress tumor growth by preventing DNA damage and slowing the transformation of normal cells into cancerous ones, both of which are known to cause cancer. Because of its anti-inflammatory qualities, resveratrol is excellent for preventing cancers of all kinds, including colon cancer.

Floral biology

There are two seasons full of flowering for *Vitis vinifera*. During the first season, there was induction, initiation, and early differentiation; in the second season, there was differentiation at budburst. A cluster that grows on the third or fifth node bears flowers. Grape blooms come in three different form: functionally staminate, functionally pistillate, and functionally hermaphrodite. The standard complement of five upright stamens in the perfect-flowered variety encircle a sizable bottle-shaped pistil. According to the most recent hypotheses, self-pollination is crucial and frequently happens before capfall (cleistogamy), however cross-pollination also happens and can enhance seed development in the berries. After successful fertilization and pollination, fruit begins to develop. Regarding increases in volume, fresh weight, dry weight, and diameter, the fruit growth is depicted by a double sigmoid growth curve. There are three stages to growth. The "lag phase" which occurs between the first and third development stages is a period of no or very little growth.

Soil

Light soils are best, grape vines can grow on any soil with adequate drainage, which is the most essential requirement. The water table should be more than two meters deep. Grape vines can tolerate salinity and alkalinity better than other horticulture crops, but too much lime can be hazardous. The availability of nutrients, water, and minerals in the soil can have an impact on the flavor, aroma, and color of the wine that is produced.

Climate

Current status of grape production in the nation. In three different agro-climatic zones in India, namely the climatic zones that are subtropical, hot and mild tropical, grape can be produced over different soil and climatic environments.

Sub-tropical Region: This area includes Delhi, the district of Meerut in Uttar Pradesh, the districts of Hissar and Jind in Haryana, the districts of Bhatinda, Ferozpur, Gurdaspur, and Ludhiana in Punjab, as well as the northwest plains between 28° and 32° N latitude. because vines go into dormancy in the first week of March, bud break begins after that week, and rains start in 1st week of June, because of that only 90–95 days occur from growing to the harvest. As a result, the only early-ripening cultivar planted in this area is "Perlette." With Thompson Seedless, rain damage is an issue in this area. Here, it is common to perform a single pruning and a single harvest.

Hot Tropical Region: This area includes the northern Karnataka districts of Bijapur, Bagalkot, Belgaum, and Gulberga, which are located between 15° and 20° N latitude, as well as the Andhra Pradesh districts of Hyderabad, Ranga Reddy, Mahbubnagar, and Medak, as well as the Maharashtra districts of Nashik, Sangli, Solapur, Pune, Satara, Latur, and Osmanabad.This is the country's primary viticulture region, with 70% of the land planted with grapes. In this area, double pruning and a single harvest are common because vines do not enter a dormant period. The temperature ranges from 8 to 42 degrees Celsius. The varieties planted here include Flame Seedless, Anab-e-Sahi, Sharad Seedless, and Thompson Seedless (TS), Tas-A-Ganesh, Sonaka (clone of TS)

Mild Tropical Region: The districts of Kolar and Banglore in Karnataka, Chitoor in Andhra Pradesh, coimbatore, madurai, and theni in Tamil Nadu, along with others are all included in this region.. It is located between 10° and 15° N latitude. . Bangalore Blue, Anab -e-Sahi, Gulabi, Muscat Hamburg, and Bhokhri are the main varieties**.**

Rootstock

Although nematode problems are more prevalent in India than phylloxera, salinity issues are more severe in the dry irrigated tract of north India as a result of these issues, making use of rootstocks is crucial. Grapevines can thrive in soils have pH value from 4.5 to 6.5, extremely acidic soils are problematic. Different *Vitis* spp. or Cultivars responded to soil with lower pH in different ways, according to vine development.

The rootstocks "SO4" and "3309C," along with the *V. labrusca* cultivars "Concord" and "Catawba," were the most resistant to highly acidic soils. The grape rootstocks *V. champini* and *V. vinifera* are regarded as salinity-tolerant. Shiraz grapes grafted on Ramsey, 140 Ru, and 1103 Paulsen exhibited higher wine potassium ion, pH, and colour than grapes grafted their own seedlings. According to research done on various grape rootstocks for levels of salt (0.40 or 2.30 dS/m). The same researchers also discovered that the rootstocks "Ramsey," "1103P," and "R2" promote significant development in the grape variety "Sultana.". Different rootstocks were characterized as sensitive (41 B, R. Lot, 110 R, 140 Ru, and 161-49), moderately tolerant (13-5 and Ramsey), and tolerant (196-17, CH-1, CH-2, and Superior) based on their tolerance to various salt concentrations. 110 R, 140 Ru, and 1103 P hybrids from the rootstocks *V. berlandieri* x *V. rupestris* can be utilized in drought-prone places have water is a limiting factor for grapevine productivity.

Field preparation

The most complex occupation is cultivating grapes through vineyard development because it combines technology and aesthetic sensibility. The field should first be marked off, cleaned, properly leveled, plowed, and laid out with waterways and bunds. According to the variety and soil fertility, planting areas should be marked, dug out to a size of 0.9-1.2 m cube, poles should be fixed at particular distances, and the dug-on top soil should be sun dried for at least 4-5 weeks. Under fertile soils, smaller pits could be formed.

Spacing

For low and medium vigor types, a spacing of 3.0×2.5 m for head systems and 3.0×3.0 m for telephone, bower, or trellis systems are usually provided. However, a spacing of 3.6×3.6 m or 3.6×3.0 m is offered for high vigor cultivars. The rectangle system of planting allows for a greater number of plants per unit area than the square system, which is used in the majority of situations. However, the distance between rows is always maintained at 3.0 m to allow for simple mechanization of various activities. In order to support the weight of the overhead network or trellis, poles are also attached to correspond with the planting strategy. To maximize the use of natural resources, rows have been laid out from east to west.

Planting

The weather at the time of planting will determine the timing. Planting can be done between October and January in semitropical climates with winter rainfall or simple irrigation. However, in northern hemisphere subtropical and temperate climes, planting begins in February and continues through April and May. The operation may be done between the months of March- May and July-October in the comparable southern hemisphere climate. Before planting, the dried-out soil from the pits should be mixed with 100–150 g of 10% BHC and an equivalent amount of organic manure, and then poured into the pits to fill up half of them. Placing disease-free rooted propagules in the center of pits that have been filled with the remaining soil mixture, pressed firmly, and then soaked with water to moisten the soil up to the root zone. In other locations, 2-5 fresh cuttings are directly put in a pit to eventually thrive under favourable atmospheric conditions. A week of initial shade and irrigation up till establishment ensure the propagules' survival.

Seed rate

Grapes can be reproduced asexually or sexually. Numerous risks, including poor germination and a lengthy seed germination phase, are associated with sexual reproduction. On the other hand, asexual or vegetative reproduction has a high success rate and guarantees genetic purity. Due to all these benefits, commercial adaptation of vegetative grape propagation methods has taken place.

Depending on the varieties utilized and the growing environment, grapes can be vegetatively propagated through cutting, grafting, layering, as well as budding.

The most common method of propagation in commercial viticulture is cutting. Mature canes with a pencil-thickness and a length of 25 to 30 cm are chosen from the vines' yearly clipped shoots, which is typically done to encourage reproductive growth. Cutting preparation is aided by making a circular cut at the lower end of the nodes, a slanting cut at the top of the cane, and leaf removal. Under mist chambers, it is also feasible to cut soft wood. Following planting, these are then allowed to grow for 4-5 weeks so that the roots can form in moist soil or sand that has received frequent irrigation for callusing. The following year, the sprouted cuttings are prepared for transplantation in the main vineyard.

Layering is additionally used in select unique circumstances. Some kinds that are challenging to root, including dogridge and salt creek, use layering. It is also standard

practice to replant the vineyard after a hiatus. Tongue and ring stacking are the techniques that are typically used in certain situations.

Under typical conditions, grafting and budding are not typically undertaken. However, some unfavorable circumstances, such as disease infestation, decreased yield, or salt in the soil, demand for the use of these vegetative propagation techniques. For the multiplication of grape varieties on various rootstocks, limited techniques such as Cleft grafting, Splice grafting, Whip Grafting, and Green Grafting are used with varying degrees of success. T- Budding and chip budding in grapes are successfully used. The major purposes of cleft grafting, T-budding, and chip budding are to top work the old or unproductive vines.

In addition to this, grapes have been successfully propagated by somatic and gametic cells (Cain et al., 1983). Large-scale totipotency plants are produced by micropropagation, which makes them ideal for commercial endeavors. Grape embryo culture was used for micropropagation, according to Emershad and Ramming (1984). However, micropropagation using soot Apex culture had already been documented. Although a very complex process, micropropagation has been standardized with many different grape varietals.

Nutrient management

Nitrogen is more required for grapes than phosphorus, and potash is more essential than both. However, phosphorus is needed when fruit buds are forming, when the need is lower. During the fruiting season, nitrogen is more necessary for shoot growth. After bud differentiation, phosphorus is needed for healthy shoot maturation and to increase the size of the fruit bud.

Magnesium deficiency is a widespread problem among nutrients. Depending on the degree of the deficit, magnesium sulphate (100–200 kg) is applied. Magnesium should be added to the soil at least a week before applying potash to improve uptake.

In black soil with lime modules, iron deficiencies are extremely prevalent. Foliar application of a chealated iron complex or 0.2% ferrous sulphate solution is advised.

Irrigation management

Different regions of India have distinct irrigation procedures, which are influenced by the timing of pruning, different growth stages, soil's ability to retain water, grown-variety, used training system, and spacing of vines. Irrigation is provided on newly planted vineyards by allowing water into a little basin with fifty centimeters radius after every 3rd days. The rapid growth causes the basin's size to increase to a two meter radius. One emitter is placed at the base of the vine when drip irrigation is used. There are eventually 2 emitters, then 4, each of which is arranged between (0.30 to 0.40) meter from the stem, based on the type as well as spacing of grapevines. Heavy irrigation is used right after pruning to properly hydrate the entire root zone and promote rapid growth in the plant. Every (10 -12) days ongoing of the winter and every (5 to7) days ongoing the summer, a light irrigation from 50 to 75 mm (5.0 to 7.5 L/ha) is applied. If it rains during that time, the irrigation that comes after is either skipped or delayed. Irrigation frequency is reduced during anthesis, fruiting, and even after berry softening in order to enhance fruit quality.

Weed management

One of the primary barriers to the cultivation of grapes has been thought to be the possibility of weeds. Although effective, hand weeding is time-consuming, expensive, and labor-intensive, making it unsuitable for extensive grapevines. This makes using herbicides for weed control in emerging nations including India necessary, whether used as a Pre-emergence as well as Post-emergence treatment, can provide longterm weed problem control in vineyards because irrigation is used to water grape vines, which keeps the soil moist all year long, allowing weeds to grow constantly.

Hand weeding: The big weeds *Euphorbia geniculate* and *Euphorbia hirta* also serve as alternative hosts for fungi and insects that are pests. Weed control is typically done manually with the help of female laborers.

Mulching: Mulching has been recommended for preserving soil moisture and promoting quick plant growth. Both organic and inorganic materials, including dried leaves, wheat and rice straw, sugar cane refuse, and black polythene film, can be employed.

Sodium 2,4-D salt Technical (containing 2-4-D acid 80% by weight) (80%Wetteble Powdwer) can manage Tridaxprocumbens and Convolvulus spp. Control of Cyperus rotundus, Cynodondactylon, Convolvulus sp., Portulaca spp., and Tridax spp.

Disease Management

Powdery Mildew (*Uncinula necator)*

Symptoms: White powdery patches appear on both leaf surfaces as the symptoms start to manifest. White powdery growths cover infected spurs, canes, tendrils, panicles, and berries. Any stage of the vines' development is susceptible to the diseases. When seriously diseased, young leaves curl and drop prematurely Infected flowers shed their petals, which leads to poor fruit development.

Management: Applying Bacillus to the soil at a rate of 1 L or kg per acre will help the vineyard's pathogen inoculum decrease. For canes wabbing in dormant buds, combine Hydrogen Cynamide (30–40 mL/L) with Mancozeb 75 WP (5 g/L).

Downy Mildew (*Plasmopara viticola*)

Symptoms: Uneven, yellowish, translucent patches appear on the upper surface of leaf as the symptoms start to develop. Likewise, a fungal growth that is dusty white and powdery emerges on the lower surface. Necrosis forces the affected leaves to turn yellow and brown and dry out.

Management: Decaying wood and sickly canes should be eliminated .Hydrogen Cynamide (30–40 mL/L) and Mancozeb 75 WP (5 g/L) should be combined to make a paste for caneswabbing.

Anthracnose (*Elsinoe ampelina*)

Symptoms: Leaves: In earlier phase, the pathogen causes infection to leaf and grow little circle spots. The leaves shrink and fall off after severe infections.

Shoots: Deep, elongated cankers with a black edge and a grayish center.

Inflorescences-Inflorescences are quite vulnerable. They may become severely infected and turn yellow, brown, and finally entirely dry out. On berries, distinctive "Birds Eye"-like circular, brown sunken marks can be spotted.

Management: Spray Thiophanate methyl 70 WP at 0.75 g/L or carbendazim 50 WP at 1.0 g/L starting at the first sign of sprouting.

Insect and pest

Thrips : *Scirtothrips dorsalis:* Thrips are sucking insects that like consume the grapevines' above-ground, squishy, and vulnerable parts, including young leaves, leaf as well as veins, stems, shoots, pre-flower stages bunches, flower and young fruit berries.

Management: Elimination of weed and substitute host plant, such as guava, bhendi, Annona and hibiscus, in and around near vineyards. To control the thrips population, spray Neem Seed of Kernal Extract 5 % @ 0.50 mL/L of water. Spraying with Cyantraniliprole, Fipronil, Spinetoram, or Spinosad (10.26 percent, 80 percent, 17 percent, or 45 percent, respectively).

Flea Beetle: *Scelodonta strigicollis* (Coleoptera: Chrysomelidae): It regularly damages grapes and results in financial losses. Flea beetles are very active when the vine is breaking

buds after pruning. Adult pests are the most devastating stage. Young buds and leaves are eaten away by adults. As a result, the growth of the shoot is stopped. This bug typically leaves behind linear and rectangular holes on the leaves as signs of its destruction.

Management: Eliminate weeds from the vineyards' inside and outside. The soil that lies between rows can be raked up with the cultivator to bring out and eradicate immature stages. They feed actively at night and remain hidden from the sun during the day. Sprayings should therefore be done at night for the best flea beetle management. When necessary, spray pesticides such as imidacloprid 17.80% Soluble Liquid or Lambda- Cyhalothrin 4.9 %.

Mealy bugs: *Maconellicoccus hirsutus* (Hemiptera: Pseudococcidae): The most significant and prevalent of the six mealybug species that infest grapes is *Maconellicoccus hirsutus*. The imbalance in the environment is what causes the mealy bugs to multiply. On various plant parts, nymphs and adult females both pierce plant sap from the phloem. The bulk of mealy bugs are still buried beneath the bark of the main trunk and cordons at the time of forward pruning. Mealy bug feeding causes the growing shoot to curl and malform during the fresh emergence stage, especially after fruit trimming, which stops the shoot's further growth.

Management: When natural enemy activities are at their peak, Broad-spectrum insecticides like Fipronil, Lambda cyhalothrin, Methomyl, and imidacloprid should be used very sparingly, if at all possible. To control mealybugs, grapes shouldn't be treated with broad-spectrum pesticides such. Buprofezin 25 Solidify Concen. @ 1.25 mL/L water should be the first choice if insecticidal application is required to control mealy bugs because it is less harmful to natural enemies. Systemic chemical soil soaking is preferred to spraying since it helps protect natural enemies and is therefore advantageous.

Interculture operation

Training of Grapevine: The grape producers utilize a variety of training strategies to train the grapevine. The following forms are frequently used: Bower (Pandal System), Small Y, Single Wire, Telephone System, Kniffin and T Trellis. But in grape-growing regions, the Y system, Extended Y and bower are mostly used.

Bower system (pergola): In this arrangement, iron rods measuring 2.4 meters high are set sparingly at a distance of 3 to 4 meters. The entire vineyard is covered in a thick iron net that is fixed over the poles. Climbers with a 3x3 meter spacing are permitted to grow straight, without any branches, up to a height of 2.4 meters in order to later distribute shoot and cane and eventually bear fruit. Strongly growing cultivars like Cheema shahebi, Anab-e-shahi, Bhokari, Black Beauty, Banglore purple, Pusa seedless, etc. are well suited for this construction. Under the training approach, high cost-benefit ratios of up to 1:2.09 have been documented with some types (Chadha, 1984).

Pruning: The following three categories broadly describe the three types of pruning that are used commonly in India.

i) **Single Pruning and single cropping:** The northern part of India frequently uses this system. Grapewine are pruned at the beginning of spring or in late winter (typically in Jan. and Feb.).The crop should be harvested before the start of monsoon season because there is only one growing season.

ii) **Double pruning and single cropping:** Maharashtra and Karnataka are the two states that use this technique most commonly. In order to assist accumulate the reserves in the mature parts of the vine, water is withheld from the vines for roughly a month after the grape harvest (which is completed in March-April). One basal node is retained after pruning back all of the fruiting canes. This is referred to as foundation pruning or back pruning. The spurs' developing shoots mature in approximately five months when the buds on those shoots separate into flower primordial. To prepare for the fruiting before

the start of winter (Sep–Oct), these mature shoots are trimmed. Forward pruning or fruit pruning are two names for this method. Fruit pruning is applied to all mature shoots. As a result, this pruning method involves a cycle of two prunings that each produce one crop.

iii) **Double pruning and double cropping:** Tamil Nadu and southern interior Karnataka both use this system. These areas grow Anab-e-Sahi and Gulabi types. Due to the warm climate in this area throughout the entire year, Fruit Bud Differentiation is not an issue. Two crops of grapes are harvested by the grape growers each year.

Regulation of Flowering: Soon after the appearance of young shoots, a flower cluster appears.In order for table grapes to produce good-sized berries, a certain number of berries must be kept. It is typical practice to use GA-3 @ 40 ppm at 50% blooming for this purpose. As a result, 50% of the berries merely set and stay away from the bunch's compact. The use of GA may be avoided if the rachis is properly extended.

Application of Hormones

1) For uniform bud sprouting: Bud sprouting is an important concern in established vineyards and can be resolved with hydrogen cyanamide. The amount of hydrogen cyanamide used varies depending on the temperature in the vineyard, cane diameter, and pruning period. Apply hydrogen cynamide 50% SL at a rate of 25 to 30 ml/L after foundation pruning and 40 to 50 ml/L after fruit pruning.

2) For Fruit Bud Differentiation (FBD): Following the foundation pruning, using plant growth regulators judiciously is necessary to achieve fruit bud differentiation. The vine possesses to have greater cytokinin in it. The sub-cane is sprayed with 6-BA at a concentration of 10 ppm for the first time at 3–4 leaves, and then again at 6-7 leaves. This stage typically occurs between 40 and 50 days after foundation pruning.

3) For Bunch Emergence : The conversion of the blossom into a tendril may occur after fruit pruning due to weather changes. this is known as Fillage. Just as the bud is budding, spray 6BA @ 10 ppm to control this problem. Potash can be used in soil and is most effective when applied in small amounts.

4) Cluster development: The formation of clusters is crucial for a bunch's export quality. The pre-bloom stage marks the beginning of the GA3 spray dosage.

Harvesting

Plants in North India begin to bear fruit two years after they are planted. Early variety berries start to ripen at the end of May. However, the majority of the types are picked once they have turned delicious and changed color at the tip. The broken, decaying, malformed, and undersized berries are taken out a day before harvest. In order to avoid temperatures rising above 20^0 C, the clusters are often picked in the morning.

Yield

Yield varies according to the variety, the climate, and other factors. India has the highest grape yields in the world, with 1 ha of vineyard producing as much as 92 tonnes of Anab-e-Shahi and 48 tonnes of Thompson seedless. Anab-e-Shahi and Bangalore blue have an average yield of 40 to 50 tonnes per hectare, compared to 20 tonnes per hectare for seedless cultivars. A acceptable yield is one of 20 to 25 tonnes per hectare.

Storage

Grapes have a one week shelf life when kept at room temperature. By using effective methods to decrease desiccation, decay caused by the growth of fungus such as *Botrytis*, *Cladosporium*, *Alternaria*, etc., and bio-chemical deterioration, the storage life of grapes can be extended. The storage life of grapes can be shortened by picking overripe grapes during the hottest hours of the day and by handling berries carelessly during harvest and packaging, which can result in bruising and other damage. The maximal storage life of the Anab-e-Sahi

variety is forty days, the Muscat variety 45 days, the Thompson seedless type 30-60 days, etc., under ideal storage conditions. Low temperature (zero degrees Celsius) and high humidity (92–96%) are the best storage conditions.

Conclusion

An important crop that has contributed to India's development is grapes. Its consumption provides health benefits like anticancer qualities and significantly contributes to farmers' ability to generate income through technical developments in vineyard management. According to Chadha (1984), the bower system has a benefit cost ratio of up to 1:2.09, making it advantageous for crops with low per-acre costs and large returns. Therefore, those crops that offer Indian farmers a greater return should be grown in the future.