ALMOND

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Introduction

Almond (*Prunus dulcis, syn. Prunus amygdalus* Batsch.) is an important temperate fruit crop. In India, it is mostly cultivated in Jammu and Kashmir and Himachal Pradesh. Almond is a small deciduous tree, growing to 3–10 m tall, with a trunk up to 30 cm diameter. The young shoots are green at first, becoming purplish where exposed to sunlight, then grey in their second year. The leaves are lanceolate, 4–13 cm long and 1.2–4 cm broad, with a serrated margin and a 2.5 cm petiole. The flowers are white or pale pink, 3–5 cm diameter with five petals, produced singly or in pairs before the leaves in early spring. The fruit is a drupe 3.5–6 cm long, with a downy outer coat. The outer covering or exocarp, fleshy in other members of *Prunus* such as the plum and cherry, is reduced to a leathery grey-green coat called the hull, which contains inside a hard shell the edible kernel, commonly called a nut in culinary terms. Generally, one kernel is present, but occasionally two. However, in botanical terms, an almond is not a true nut. In botanical parlance, the reticulated hard stony shell is called an endocarp. It is mature in the autumn, 7–8 months after flowering. The fruit of the wild forms contains the glycoside amygdalin, "which becomes transformed into deadly prussic acid (hydrogen cyanide) after crushing, chewing, or any other injury to the seed". However, domesticated almonds are not toxic. (FAO, 2013 and Verma, 2014).

Origin and distribution

Almond is native to southwest Asia, from northwestern Saudi Arabia, north through western Jordan, Israel, Lebanon, western Syria, to southern Turkey. (Verma, 2014). A well-known archaeological example of almond is the fruits found in Tutankhamen's tomb in Egypt (c. 1325 BC), probably imported from the Levant. Almond is called Lawz in Arabic, and Baadaam in Persian, Urdu and Hindi (Chadha, 2001).

Area and Production

In India almond are mainly grown at Jammu and Kashmir (5.67 thousand ha) and Himachal Pradesh (4.92 thousand ha) and 13.69 thousand MT almond are produced (Annon.,

2018).Among them 94.45 percent are produced at Jammu and Kashmir and 5.55 percent at Himachal Pradesh. The Global production of almonds is around 1.4 million metric tons during 2018 (FAO, 2019). Major producers include USA, China, Spain, Iran, Syria, Italy, and Morocco. The United States is largest producer of almond and its production is concentrated in California.

Nutritive value and uses

Almonds are the healthiest and most nutritious nuts of all, considered a well-balanced cholesterol free food. Almonds are one of the nutritious nuts and contain vitamins and anti-oxidants considered a well-balanced cholesterol free food. A 100g almond contains 575 calorie energy, good amount of fiber (12.2g), vitamin E (26mg), total fat (949g), monounsaturated fat (31g), total Omega-3 fatty acid (6mg), total Omega-6 fatty acid (12065mg), protein (21g), potassium (670mg), magnesium (268mg), phosphorus (484mg) calcium (265mg) and iron (3.5mg).(Ahmad and Verma, 2009).

Taxonomy

Almond belongs to family Rosaceae, genus Prunus, subgenus Amygdalus and has chromosome number=16. . Morphologically and taxonomically, almond is very closely related to peach. The tree characters of peach and almond are very similar. The chief differences in the two are found in matured fruits (Ball, 2002).

Climate

Almond grows from 750 to 3210 m AMSL. The blossoms become more and tenderer on opening. Blossoms with petals exposed but not yet opened are known to withstand cold at -2.2^{0}C, but blossoms at petal fall stage are killed at 0.55 to -1.1^{0}C. The blossoms can often withstand temperatures from -2.2 to -3.3^{0}C for a short time, but if low temperatures continue for many hours, they get damaged (Chadha, 2001).

Soil

The almond requires fertile, well drained and aerated soil. The site should be free from hailstorm and frost in spring. It can be grown in average soils supplemented with FYM and assured irrigation. Trees do not thrive well in heavy or poorly drained soils.

Varieties:

There are large numbers of varieties available around the world. But only few varieties dominate the export market due to superior export quality viz., Non Pareil, Texas, Ne Plus Ultra, California Paper Shell, IXL and Merced. In addition to these exotic cultivars, recently four Indian varieties have been released includes 'Shalimar', 'Makhdoom' and 'Waris' shown promise of higher yields of better nut quality.(Verma, 2012)

Exotic varieties (USA and Ukraine)

Non-Pareil: It is considered the best, alround, almond cultivar because of its high kernel quality, papery shell and high kernel to shell ratio. It is regular bearer; blooms during 3rd week of March and early maturing matures after 141 days after full bloom; bears flower and nuts on both spurs as well as on long shoots. The variety is suitable for export market as nut and kernels. The average productivity is 3-5 t/ha under irrigated conditions.

California Paper Shell: It is regular bearer; blooms during 2nd week of March and ready to harvest after 152 days from the date of full bloom. The tree is upright suitable for high density plantations. It bears flower and nuts on both spurs as well as on long shoots. The nut and kernel are longer in size with extra light colour, papery shell that gives shelling percentage of 50%. This variety is also suitable for export market. The average productivity is 2.0-3.0 t/ha under irrigated conditions.

Merced: It is regular bearer, blooms during 3rd week of March and ready to harvest after 152 days from the date of full bloom. It bears flower and nuts on both spurs as well as on long shoots. Shell colour intermediate with papery shell gives shelling percentage (56%). The average productivity is 2.0-3.0 t/ha under irrigated conditions. It cross pollinates with Mission and Non-Pareil.

Mission: It blooms late and is more likely to escape frost damage. It requires cross pollination. Harvest time is late.

IXL: It is regular bearer, blooms during 3rd week of March and ready to harvest after 151 days from the date of full bloom. The tree is spreading to intermediate vigour. Bear flowers and nuts on both spurs as well as on long shoots. The nut and kernels are medium and shell colour

intensity is intermediate. Shells are soft that gives a high shelling percentage (55%). The average productivity is 2.5-3.0 t/ha under irrigated conditions.

Pranyaj: It is regular bearer, bloom during 3rd week of March and ready to harvest after 144 days from the date of full bloom. It bears flower and nuts on long shoots and spurs. The shell colour is light, very soft shelled, nut are medium, soft shelled with, plump kernels and gave shelling percentage of 44%. The average productivity is more than 2.0-3.0 t/ha under irrigated conditions.

Indian varieties

Shalimar: It is regular bearer variety, blooms during 2nd week of March and ready to harvest after 143 days from the date of full bloom. The tree growth habit is spreading/drooping type. It bears flower and nuts on both long shoots and spurs. The shell colour is light, papery type that gives a high shelling percentage (50%). The average productivity is 2.0-4.0 t/ha under irrigated conditions in HDP.

Makhdoom: It is regular bearer, blooms during 1st week of March and ready to harvest after 141 days from the date of full bloom. The tree growth habit is spreading/drooping.

Waris: It is regular bearer, blooms during 3rd week of March and ready to harvest after 145 days from the date of full bloom. The tree growth habit is upright and is suitable to grow under high density orcharding. It bears flower and nuts on long shoots and spurs. The shell colour is medium, soft shelled, nut are medium, soft shelled with, plump kernels and gave shelling percentage of 48%. The average productivity is more than 2.0-3.0 t/ha under irrigated conditions.

Almost all cultivars of almond are self-sterile and require a pollinizer. Also a few cultivars like IXL and Non Pareil are cross sterile as well. The almond flowers are self-incompatible. Therefore, to obtain a maximum crop of almonds, essentially 100 percent of the flowers must be cross-pollinated (Chadha, 2001). The orchards are usually planted with two rows of the main cultivar and one of the pollinizer cultivars (33%). For better fruit set in almonds, ‘IXL’, ‘Jordanalo’, ‘Ne-Plus-Ultra’ and ‘Waris’ are recommended as compatible pollinizers. In addition, to this, placement of 4-6 beehives is found highly beneficial and can for increase fruit set and yield of almond by 12-15 percent. During flowering, fair weather with day

time temperatures above 12^0C is essential to permit flight of honey bees (Verma and Awasthi, 2013).

Propagation

The T-budding and tongue or cleft grafting are commercial propagation method of almond.

Rootstocks: The most commonly used rootstocks for almond in Kashmir Valley are the seedlings raised from sweet or bitter almond. Wild peach is also used in certain areas of valley. Sweet almond seedlings are being favoured more because of the reason that if the budded sprout fails, at least the tree will yield sweet almonds. In Himachal Pradesh, Behmi (*Prunus mira*) is also widely used as a rootstock for almonds.

Following are the best rootstocks for almond-

Nemaguard (Peach) (*Prunus persica x Prunus davidiana*): Most widely used rootstock; resistant to root nematodes; compatible; out yields almond-rooted trees; can be affected by crown gall, oat-root fungus, and crown rot.

Lovell (Peach): Moderately tolerant to root knot nematode and tolerance to heavy soils and higher rainfall; oak root fungus, crown rot, and crown gall.

Bitter Almond: Its seedlings are generally preferred in India, are late bearing; tolerates drought as well as soils high in lime and boron. Sensitive to nematodes, crown gall, oat-root fungus, and crown rot.

Marianna (Plum): It is able to tolerate some heavy, wet soils and soils infested with oak-root fungus; resists root knot nematodes and crown gall; incompatible with Nonpareil cultivar

Marianna 26-24: It is shallow rooted, good vigor, although tends to slightly dwarf trees. It have heavy suckering and compatibility problem with almonds.

Peach/almond Hybrids: These are nematode resistant; drought tolerant; high vigor; deep rooting; tolerance to calcareous soils; susceptible to crown and root rot; somewhat susceptible to root fungal infections, crown gall and root knot nematodes.

Nickels Peach Almond Hybrid: Deep and vigorous roots. Excellent anchorage and root formation. It is resistance to nematodes.

Titan Peach Almond Hybrid: Excellent anchorage & vigor and prefers sandy loam soil. It is vigorous trees and sensitive to wet soil conditions.

Raising of Seedlings: The almond nuts are harvested from July to September and are stored in a cool and dry place till December. Stratification of nuts is needed to break the dormancy. The nuts are stratified in sand in boxes in the end of December. In the month of February, the hard shell of the seeds breaks open by absorbing moisture and the kernels which begin to show signs of germination are exposed partly or wholly. When the shells have split partly, the nuts are taken out from the stratification box and sown in beds (Verma and Awasthi, et al., 2013).

Budding or grafting operation: When the seedling are of pencil thickness and have attained a height of 30 cm they are T-budded in the month of June. The seedlings which do not make sufficient growth so as to become fit for T-budding, are Tongue or cleft grafted in December-January.

Planting Techniques

The plants should be planted by square or hexagonal system at a distance of either 6X6m (normal farmers planting system), 4.0x 4.0m (Medium high density system), and 3.5 X 3.5-2.5m (under high density planting system) depending upon the soil fertility, vigour of the tree and availability of irrigation. Every third row should be pollinizer row. Before planting, pits of 1mx 1x1x1 M size should be dig up during the month of September-October. The plants should be planted from February to March (Verma et al., 2010).

Irrigation

Irrigation is the most important practice to survival, growth and yield of plant. For successful cultivation almond requires about 650mm rainfall. The flowering (Feb to March) and fruit development (April, May and June) are critical stages of almond. Therefore, irrigations must be provided during these stages for getting higher yield and quality nuts. The drip irrigation system is more efficient for growth and development of plants. It is also saving water.

Manures and Fertilizers

Almond is a heavy feeder and requires appropriate fertilization. For optimum production, the soil and foliar analysis must be conducted. However, the following recommendations may be adapted in J&K in absence of the analysis. Nitrogen may be split in 2-3 doses. First dose (Half the quantity) should be supplied along with phosphorus and potassium a fortnight before expected bloom, second dose (1/4th of total quantity) may be applied about 3 weeks after fruit set and third dose (1/4th of total quantity) should be applied in June/July (Ahmed and Verma, 2009).

Age of the tree in years	Urea (g/tree)	DAP (g/tree)	MOP (g/tree)
1	55	25	60
2	110	50	130
3	170	75	200
4	225	100	260
5	280	125	330
6	400	150	580
7	515	200	750
8	635	225	910
9	740	300	1080
10 & onwards	860	325	1240

Training and Pruning

The plants should be headed back about 100 cm above the ground level after planting. The first branch should be allowed 0.6 m from ground level. The plants should be trained to central modified leader system by retaining 3-4 branches 15-20 cm apart spirally in order to produce a well-balanced tree. The crotch angles of the scaffold limbs should be 45 to 60º. Almonds produce most of their fruit on short spurs which remain fruitful for about 5 years. Pruning operation should be planned in such a manner that 1/5th of fruiting wood are replaced each year. Prune only older branches that are 1.2 to 3.7cm in diameter. Thin out very little of the smaller wood, except to remove unwanted water sprouts or suckers. Trees with less than 10-12 years of age should make 22.5-25 cm of new growth a year. Trees older than this should make at least 15 cm of new shoot growth each year (Verma, 2014).

Flowering and fruit set

Almond is one of the first trees to blossom in spring and for this reason, it is very susceptible to spring frosts. The bud differentiation in almond starts in August-September and continues upto February next. The blossom becomes more and tenderer as it open. The blossoms appear before the foliage develops and the first leaves appear about the time the last petals fall depending upon the variety and season. In almond, flowers are hermaphrodite with white or pink petals, 5 sepals, a single and unicarpel pistil which usually contains 2 ovules in orthotropic position and 20-40 stamens. The almond fruit is an egg-shaped drupe with a sigmoid growth pattern (Ball, 2002).

Harvesting and handling of fruits

Generally, almonds are ready for harvest when the hull colour changes from green to yellowish with cracks or splitting at suture starting from pedicel end. Under premature harvest conditions, the hulls remain as stick-tights and it requires more energy to dislodge the nuts, resulting in damage to limbs in the form of wounds. The thin leathery hull or husk in almond is non-edible. For full recovery of nuts, orchard floor should be cleaned and tarpaulin of polyethylene sheets may be spread beneath the trees prior to knocking of the nuts. Nuts should be placed at a shady place for drying and removing of hulls and they lose 20-50 percent weight in the drying process. The dry nuts are usually graded into two categories viz. thin-shelled and hard-shelled and sent to markets. In Kashmir harvesting season starts by the end of July and lasts for 10-15 days (Bal, 2002). Fruits may be dried and fumigated against Navel Orange worm after harvest. Nuts are dried by forced hot air until their moisture content reaches 5-7%. Fumigated nuts are stored at temperatures below 4.5^{o}C.

Insects

Aphid (*Hyalopterus amygdali* and *Hyalopterus pruni*)

Aphids appear on tiny shoots and cause damage by sucking sap in early spring. These aphids reduce plant growth and fruit set.

They can be controlled with spray of imidachlorprid @ 0.5 ml per liter of water or Thiometon (0.05%) or Methyldameton (0.025%) and Dimethoate (0.04%).

SanJose scale (*Comstockaspis perniciosa*)

It attacks all above ground parts; foliage turns thin and yellow speckled; bark around scale is reddened and fruits with grey patches surrounded by inflamed red area.

Spray diesel oil Emulsion in Potash based fish oil soap (1:7) or tree spray oil during dormancy when temperature is above 4^0C during night.

Stem borer

The beetles damage stem and branches drilling big holes in the trunk & branches. Saw dust is noticed coming out from holes. Clean the holes of saw dust and plug these with cotton soaked in petrol after inserting naphthalene balls in holes & watch for any further damage. Repeat the practices.

Leaf spot/ shot hole

On leaves, twigs and fruits it causes small round to irregular, light brown to dark brown lesions. The necrotic spots on leaves form shot holes when these sloug-off. Early infected fruits exude gum from the infected sites. Spray plants with copper oxychloride 50wp (0.3%) or Mancozeb 75 WP (0.25%) or captan 50 WP (0.25%) or carbendanzim 50 WP (0.05%) at bud burst, petal fall, fruit let and 10-15 days after fruit let stage.

Diseases

Gummosis:

The disease is caused by *Pseudomonas syringae*. The bark and outer sapwood show symptoms of circular to elongated water soaked lesions. The main symptom of infection is the appearance of brownish watery ooze on the surface of the bark.

Spray Bordeaux mixture in the fall as well as in the spring to prevent infection. Mashobra paste is also found effective against this disease.

Shot hole:

It is caused due to ***Stigmina carpophila*.** Dark brown scattered lesions appear on leaves. The spots later on enlarge rapidly. Abscission of the diseased area in the leaf results in shot hole.

The disease can be controlled by spraying Captan, Ziram or Thiram at the rate of 0.2 per cent at leaf fall or bud swelling stage.

Crown Gall

It is caused by *Agrobacterium tumefaciens*. It occurs worldwide and is the main bacterium to attack almond. Symptoms and control measures are suggested under peach.

Among the diseases of foliage, leaf spot and leaf curl are quite common but these do not appear to cause much damage.

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