

Optimizing flower regulation technology for quality harvest in pomegranate

Flower regulation is a critical approach in pomegranate cultivation that modifies the natural fruiting cycle, enabling the plant to produce higher yield of quality fruits during desired season with sustainable use of resources. Pomegranate plant bears male, intermediate, and hermaphrodite flowers on both new and old branches, typically across three flowering seasons known as *ambe*, *mrig* and *hasta bahar*. In hot arid climate, however, the plant tends to flowers irregularly across all three *bahars*, resulting in low yield of inferior quality fruits with non-synchronized maturity, which is commercially disadvantageous. To address this issue, ICAR-CIAH, Bikaner has standardized flower regulation technology specifically for hot arid climate, ensuring a quality harvest.

POMEGRANATE (*Punica granatum* L.) is a highly promising fruit crop cultivated in hot arid regions of India. It possesses immense nutritional and medicinal value, and is considered one of the richest sources of antioxidants. It is commercially cultivated in Maharashtra, Karnataka, Gujarat, Andhra Pradesh, Tamil Nadu, Madhya Pradesh and Rajasthan. In India, pomegranate is cultivated over 2.23 lakh hectare area with 28.42 lakh tonnes annual production and 12.74 tonnes/ha productivity (MoA & FW, 2024). The pomegranate area is increasing very fast due to high market demand, extended storage life, tolerance to heat and drought stress, and adaptability to sandy soils. In Rajasthan, pomegranate is primarily grown in Barmer, Jalore, Jodhpur, Jaisalmer, Bikaner, Sirohi, Nagaur, Bhilwara and Jaipur districts over 17,000 hectare with 156.84 thousand tonnes production (Horticulture

Department, Govt. of Rajasthan., 2023).

Pomegranate plant bears three types of flowers namely male, intermediate and hermaphrodite on both old and new growth. It produces flowers continuously from January to December particularly in three flushes/seasons known as '*bahars*' namely *ambe*, *mrig* and *hasta bahar*. However, under the hot-arid climate of the *Thar* desert, it produce fruits continuously throughout the year, but with low yield, high fruit cracking incidence and inferior quality. Consequently, harvesting becomes staggered and difficult to manage. To overcome this challenge, pomegranate flowering and fruiting is regulated to one season in a year, allowing for a quality harvest at a specific time. The practice is commonly referred as flower regulation, crop regulation or *bahar* treatment.

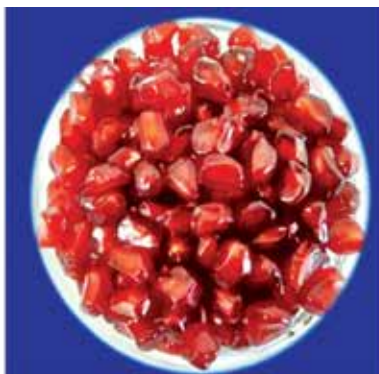
Flower regulation is influenced by availability of irrigation water/rainfall, climatic condition, rind and aril colour development, fruit-cracking, pest-diseases and market demand. However, in order to achieve profitable crop production, co-ordinations of various flowering phenomenon are essential. This coordination involves flower bud development, ensuring efficient pollination, understanding different flower types, fruit set, fruit growth and development attributes such as size, colour and aril development. By considering all these factors and coordinating flowering phenomenon effectively, pomegranate growers can achieve a lucrative quality fruit harvest (Table 1).



Hermaphrodite, intermediate and male flowers in pomegranate

Table 1. Advantages and disadvantages of different *bahars* of pomegranate under hot arid climate

<i>Bahar</i>	Flowering period	Harvesting period	Advantages	Disadvantages
<i>Ambe bahar</i>	February to March	June to August	Low fruit cracking, pest and disease incidence Good yield	Require assured irrigation Poor rind and aril colour development
<i>Mrig bahar</i>	July to August	December to February	Not much irrigation require Very good rind and aril colour development High yield	Fruit cracking incidence High incidence of fungal spot and bacterial blight disease
<i>Hasta bahar</i>	September to October	March to April	Moderate rind and aril colour Fetches high value due to limited availability	Stress cannot be given during rainy season Poor flowering and low yield

*Ambe bahar**Mrig bahar**Hasta bahar*

Pomegranate cv. Bhagwa fruits quality in different *bahars* under hot arid climate

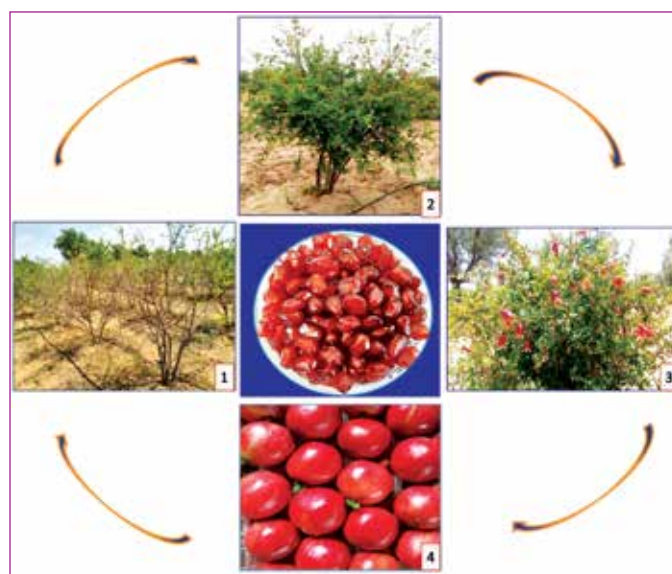
Flower regulation methods

Flower regulation plays a crucial role in determining the timing and intensity of flower induction, sex ratio and fruit quality. In flower regulation, various interventions such as water stress, pruning, defoliant applications and nutrient management are implemented. These interventions have a positive impact on flowering, fruit yield, overall quality, and the ability of orchards to withstand biotic and abiotic stresses.

Flower regulation cycle in pomegranate

The ICAR-CIAH, Bikaner conducted a series of experiment from 2015 to 2024 to standardize flower regulation technology for pomegranate cultivation under hot arid climate. The objective was to induce flowering and regulate the crop, thereby improving the quality yield and reducing the fruit-cracking. The following are the key components of flower regulation technology.

Water stress: In hot arid climate and sandy soils, plants are subjected to one month of stress by withholding irrigation during June. This intentional deprivation leads to a loss of 30-40% of leaves, depending on the prevailing climatic condition. Water stress is imposed slowly by



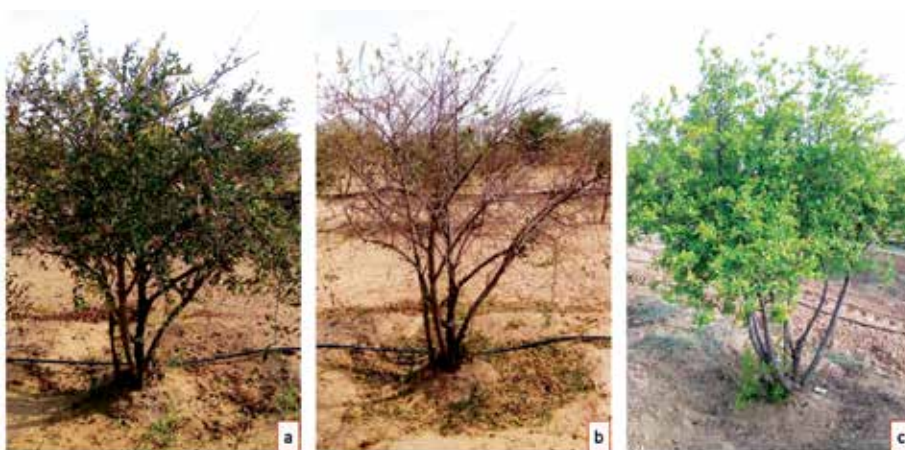
1. Imposition of water stress, *bahar* pruning and ethephon application. 2. Initiation of new growth 15-20 days after ethephon application. 3. Synchronized flowering and high fruit set after flower regulation treatment. 4. Quality fruit harvest through efficient water, nutrient and pest-disease management

gradually extending the dry period. Initially, the water is withheld for 1-2 days in a week and then increases to 3-4 days per week and finally water is completely withheld. Irrigation is gradually resumed to accommodate the recovery of the plants.

Bahar pruning: In *bahar* pruning, the terminal 20-25 cm growth is removed, and Bordeaux paste (10%) is applied to the cut ends. Pomegranate bears flowers on both old and new growth of the current year. Therefore, maintaining a balance between new and old growth is crucial for sustainable fruit production. Fruits produced on stronger, older branches (stump setting) and inside the tree canopy exhibit larger size with improved quality. These fruits are also protected from sun scald and the intense heat.

Defoliant application: After *bahar* pruning, apply defoliant ethephon (40%) 1 to 2 mL/L along with 5 g/L N:P:K (0:52:34 grade) to achieve 80-90% defoliation. If the plant bears more number of older leaves, 1 mL/L ethephon is usually sufficient. If the plant has more newer leaves, 2 mL/L ethephon is recommended. Within 10-15 days of ethephon application, the plant shed leaves and become leafless, and new growth commences after 15-20 days. Ethephon can be applied in two split doses of 500 ppm for better result if resources permit.

Nutrient management: Nutrient management is crucial for plant growth, fruit yield and quality. The fertilizer requirements vary with the *bahar* stage, from flowering and fruiting. A bearing pomegranate plant of ≥ 5 year's age requires 45 kg FYM, 625:250:250 g nitrogen,



Imposition of water stress (a), Defoliated plant after water stress and ethephon application (b) and New growth free from pest and disease (c). Effect of flower regulation treatment on biotic stress management in pomegranate

phosphorus and potassium, respectively. Micronutrients mixture (2% iron, 2% manganese, 5% zinc, 0.5% copper, 0.05% molybdenum and 0.5% boron, on w/w basis) are applied twice as foliar sprays. During flowering, avoid excess nitrogen application to maintain proper C:N ratio.

Biotic and abiotic stress management: In flower regulation, plants become almost defoliated. After defoliation, spray 1% Bordeaux mixture as prophylactic measure. The high scorching heat during June-July helps in plant and stems solarization, and reduces pest-disease inocula. After 15-20 days, new growth emerges, typically free from pest and diseases. In hot arid region, during rainy season, bacterial blight and fungal spot, and in dry dusty period, mite poses a significant threat. Fruit cracking is also a major problem which is influenced by variety, season, nutrient deficiency (boron), pest-disease incidence (blight and mite) and climatic condition (moisture

Table 2. Calendar of operations for pomegranate flower regulation under hot arid climate

Time period (Stage)	Operations to be carried out
June (Stress period)	Withheld irrigation and do light <i>bahar</i> pruning by removing terminal 20-25 cm growth. Spray 1-2 mL ethrel (40%) and 5 g NPK (0:52:34 grade) per litre water at the end of June. Collect fallen leaves/debris and burn. Spray 1% Bordeaux mixture as phytosanitary measure.
July (New leaves emergence and flowering initiation)	Apply 30 kg FYM, 500 g neem cake/plant and 1/3 rd dose of N and K and 2/3 rd dose of P should be applied as basal dose just after first irrigation. Spray salicylic acid 0.3 g/L and micronutrients mixture (1 kg/ha). Spray bronopol 0.5 g/L mixed with carbendazim (50% WP) 2 g/L, copper oxychloride (50% WP) 2.5 g/L and spiromesifen (240 SC) 0.5 mL/L for bacterial, fungal spot and mite management. Provide regular irrigation and remove suckers.
August (Full bloom and fruit setting)	Apply 1/3 rd remaining dose of N and K. Spray bronopol 0.5 g/L mixed with propiconazole (25EC) 2 mL/L, copper oxychloride (50% WP) 2.5 g/L and propargite (57% EC) 1 mL/L. Repeat the spray after 15-20 days if disease and pest symptoms appear. Spray salicylic acid 0.3 g/L and micronutrients mixture (1 kg/ha). Apply NPK (12:61:00 grade) @4 kg/ha through fertigation at weekly interval.
September (Fruit growth)	Remove suckers and provide irrigation regularly. Apply NPK (19:19:19 grade) @4 kg/ha through fertigation at weekly interval. Repeat the spray of pesticide, if disease and pest symptoms appear.
Oct.-Nov. (Fruit development)	Provide irrigation regularly and apply NPK (0:52:34 grade) @4 kg/ha through fertigation at weekly interval.
Dec.-Jan. (Fruit maturity)	Provide irrigation regularly. Apply calcium nitrate @12.5 kg/ha through fertigation and foliar spray of NPK (0:0:50 grade) @10 g/L. Harvest mature fruits after 210-230 days after full bloom.
Feb.-March (Rest period)	In main pruning, remove cris-cross, dried twigs. Apply 10% Bordeaux mixture paste on cut end. Apply 15 kg FYM and 1/3 rd recommended dose of NPK fertilizer just after pruning.
April-May (Rest period)	Provide light irrigation. Spray of Bordeaux mixture (1%) or copper oxychloride 50% WP (2.5 g/L) alternatively at 15-20 days interval. Ensure the removal of water shoots and suckers regularly.

imbalance, diurnal temperature variation and frost). To manage this, ensure proper plant health by providing proper irrigation and nutrition with effective pest-disease management.

Rest period: Pomegranate cv. Bhagwa takes 6-7 months from flowering to fruit harvest. Therefore, a rest period of three-four months is necessary to maintain the plant health and manage pest-disease inoculums for sustainable orchard life. The calendar of operations to be carried out in pomegranate flower regulation under hot arid climate are given in Table 2.

SUMMARY

In pomegranate cultivation, flower regulation is an important horticultural practice which induces synchronized and profuse flowering with improved sex

ratio (more hermaphrodite flowers) and high fruit set. Consequently, plant produce high yield (15-20 kg/plant) of quality produce (large fruit size, red rind/aril colour, high maturity index) in desired season. It is also found effective in biotic (mite, blight and fungal spot) and abiotic stress (fruit cracking and sunscald) management with sustainable production. Therefore, optimization of flower regulation technology is found highly effective in *mrig bahar* under hot arid climate.

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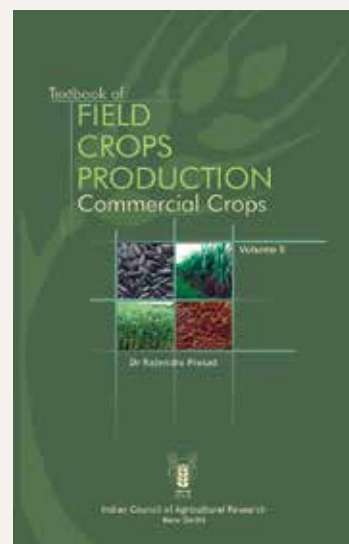
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Pages : i-xiv + 612 • Price : ₹ 800 • ISBN No. : 978-81-7164-146-8

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