CURRENT APPROACHES FOR SMART AGRICULTURE

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Chapter - 39

Post-Harvest Handling of Cut Flowers

Vimal Chaudhary, Jitendra Kumar Sahu, Abhangrao Ashwini, VK Dhangrah and Mukul Kumar

Flowers are an integral part of human civilization and culture and have always been vital in the Indian traditional way of life. Globally, more than 145 countries are involved in the cultivation of ornamental crops and the area under these crops is increasing steadily. At present area under the flower, the crop is in India 3,29,000 ha with a production of 2,26,6000 MT of loose flower and 3,39,000 MT of cut flowers. The production of flower crops has increased significantly and there is a huge demand for floricultural products in the world, resulting in the growing international flower trade. The world consumption of cut flowers and plants is increasing and there is a steady annual increase of 10 to 15 % in all importing countries. Cut flowers are fresh flowers harvested in clusters, spines, or in singles along with their stem. In our country, flower crops like roses, chrysanthemum, orchid, anthuriums, tuberose, carnation, dahlia, and gerbera are grown for cut flower production. A fresh flower is still a living specimen even though it has been cut from the plant. Its maximum potential vase life, although acceptable in the market place, is short. Many impinging forces can interact to reduce fresh-flower vase life. As an industry, we need to be more successful in preserving the potential life of fresh flowers. However, there are well-known solutions for this. Proper harvesting and care of flowers after harvest are important to maximize the vase life and ensure a high-quality product. During handling Maximizing the vase life of cut flowers is dependent on pre-harvest procedures too. Long before harvest, plant cultivar selection should be considered for postharvest longevity to provide the best possible cultivars for cutting. Post harvest factors like a method of harvest, time of harvest, maturity stage, ethylene management, vase life enhancement, and packaging. Apart from the adaptation, training for flower harvesting, handling, packing, and transportation should be given to the growers to avoid the losses of cut flowers.

The flowers of some species and varieties remain fresh only for a few hours or a day and therefore they are of no value as cut flowers. Many farmers and gardeners grow cut flowers for export decoration, gardening, floral markets, farm shares, domestic purposes, etc. The quality of the flower is dependent on the shelf life, vase life, and longevity of flowers. So, this may be influenced by genetic factors, environmental factors, and Pre-harvest and Post-harvest practices too. In India, it is estimated that there is a 20% loss of cut flowers during harvest, handling, and marketing. So, the proper harvesting and care of flowers after harvest should be taken to maximize the longevity, shelf life, and high-quality flowers and which can be reduced by effective management and careful handling of cut flowers.

Status of Post-harvest Technology of Cut Flowers: Standardization of suitable post-harvest technology is an important area to maintain the post-harvest life of cut flowers for the improvement in export potential in India. For the promotion of this cut flower as an export product, research and study must be directed towards the development of appropriate post-harvest technology (Kakade *et al.*, 2021; Malik *et al.*, 2017). The longevity of the flower has always been one of the important criteria to assess the quality of cut flowers. In this cut flower demand situation, there is a need to transport the flowers to long distances with good transportation facilities and the use of suitable packing materials and preservative chemicals. This is crucial to promote the prolonged supply of flowers. Cut flower longevity is influenced by several factors such as genetic makeup and environmental factors. India ranks23rd among world exporters of floriculture products and its share in the world exports is negligible at around 0.67%. It is estimated that fresh cut flowers worth Rs. 100 crores are being exported annually from India. On the other hand, the losses are estimated to be more than 30-35%. The quality of the cut flowers can be decreased by the following factors pre-harvest and post-harvest factors.

Pre-harvest Factors Affecting Flower Longevity

Geneticor Inherent Make-Up: Post-harvest longevity of flowers pecies and cultivars varies considerably due to differences in their genetic make-up Anthurium and orchid have longer vase life than rose and Dianthus, whereas lilies have shorter vase life than rose and gerbera (Bhattacharjee and De, 2003)' Baccara roses' have longer vase life and possess the ability to close their stomata upon cutting than 'golden wave roses, which possess short vase life (Mayak *et al.,* 1974).

Environmental Factors

Light: Light regulates several physiological processes such as photosynthesis, which determine the carbohydrate content of flowers. Flowers containing relatively higher amounts of carbohydrates especially sugars, last longer in the vase. High light intensity causes scorching of the foliage and flower buds, dropping of leaves, and petal senescence whereas low light causes blue /discoloration of petals and bent neck in roses and stem bending in gerbera (Halevyand Mayak, 1979).

Temperature: The temperature requirement of different crops varies. For example: In rose, the day temp. 20-25 °C and night temp 16 °C are required. A difference of 10 °C day and night temperature is considered ideal for growth and flower production. Low night temperature is advantageous because of low respiration rates at low temperature decreases the utilization of sugars, thereby improving the net accumulation of carbohydrate in the petals. High temperature accelerates the respiration rate and hence, reduces net carbohydrate reserves leading to poor post-harvest life. Too low temperature also causes freezing injury to buds (Halevyand Mayak, 1979).

Humidity: Optimum level of humidity is required by different crops. For example, roses are required by different crops. For example, rose to require relative humidity between 60-65%. High humidity leads to browning of leaf edges, and thin leaves. High air humidity (90 %) and a 24h photoperiod reduce the post-harvest life of several cultivars of Rose. The reduction was attributed to the increased rate of water loss from the leaves due to the failure of stomata to close (Morteneseon and Fjeld, 1998).

Season: Variation in the longevity of cut flowers due to the seasonal effects has also been reported. Chrysanthemum harvested during hot seasons showed longer vase life than those during the cold season. High light intensity is associated with higher photosynthetic activity for increased longevity of cut flowers (Singh *et al.*, 2013). The sugar content of petals increases in autumn and decreases slightly towards summer, while chlorophyll intensity increases gradually towards spring and decreases in summer (Celikel and Karacaly, 1995).

Ethylene: The longevity and quality of cut flowers also depend upon the composition of the ambient atmosphere. Ethylene caused the most adverse effects on cut flowers. In carnation, ethylene was first produced in gynoecium.

Carbon Dioxide: The atmospheric content of CO_2 is very less i.e., 0.03% (Kumar *et al.*, 2002). It is essential forphotosynthesis. CO_2 enrichment in the greenhouse is advantageous as it improves quality and increases yield and vase life.

Pest: Flower crops are attacked by various pests and affect the quality of flowers.

Stage of Maturity: A decrease in the trend of total and reducing sugar is observed in the total and reducing sugar of corolla from harvest towards senescence.

Harvest Factor Affecting Flower Longevity: The right stage method and time of harvesting flowers are of considerable importance to ensure their long vase life.

Time: Flowers should always be harvested either in the morning or evening when the temperature is moderate because high temperature leads to faster respiration and excessive water loss.

Method of Harvesting: The stem should be cut with sharp knives or secateurs. Hardwood stems should be given a slanting cut to expose the maximum surface area to ensure rapid water absorption. The flowers of dahlia and poinsettia release latex upon cutting. To overcome such a problem, the stem should be given a dip in hot water (80-90 °C) for a few seconds.

Table 1: Stage of Harvesting

Flowers	**Harvesting stage**
Rose	Tight bud stage
Marigold	Fully opens the flower
Gladiolus	1-5 lower florets show colour
chrysanthemum	When outer floret fully expands
Jasmine	Fully open flower
Orchid	3-4 days after opening flower
Carnation	Paint brush stage
Dahlia	Fully open flower
Anthurium	Spadix fully develop
Amaranthus	½ florets open on spike
Alstroemeria	4-5 florets open on spike
Lilium	Bud colour shows red
Chinaaster	Fully open flower
Tuberose	Lower pair of flower buds just burst
Gerbera	Flower open but outer 2 row show shedding of pollen
Tulip	Half colour buds' stage

Flowers should always be harvested at an optimum stage of maturity. Too immature buds do not open whereas over mature ones wither quickly.

Major Problem Post-Harvest Life in Cut Flowers

Bent Neck: It is a very common problem of roses and is due to the following reasons. Water deficiency in the neck tissue is controlled by transpiration rate, the rate of water uptake, and the ability of the different organs on the cut flower shoot to complete for water (Van Doorn, 1997). Appearing of plugging materials like pectin, cellulose, and microbes. The extreme temperature during shipping or storage.

Limp Neck: It is a type of disorder in roses caused by water stress in the area just below the flower head. The affected flower bud bends due to the weight of the top. The insufficient stored energy of the flower head may be one of the reasons

Bud Drying: It is the common problem of Asiatichy brids lilies, the apparent desiccation and shriveling of flower bud followed by abscission is a common problem. This problem is solved by STS pulsing.

Calyx Splitting: Calyx splitting is mainly found in double types of carnation. The sepals beneath the flowers are unable to form a cylindrical calyx tube, which supports based by petals. During bud opening the calyx may be split either half or completely. The reason is mainly - Genetic, High dose of Ammonium nitrate, Low dose of N2, High day and low night temperature, High-density planting, and Low boron level.

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Sleepiness: It is another disorder in carnation, it mainly occurs by high ethylene synthesis or water stress. Ethylene synthesis occurs much higher when flowers are stored for long periods or when they are kept at a high temperature.

Flower bud blasting: A disorder found in tulips that are caused by dry storage or the forcing of bulbs. It has been reported a change in the plant's hormonal status, which regulate the distribution of carbohydrates and other organic materials within the plant, is the main reason for blasting.

Topple: Topple in gladiolus is characterized by the breaking of spikes after the opening of the florets in the vase. The spikes harvested from calcium-deficient soil have a higher incidence of toppling.

Petal Discoloration: Low night and day temperatures are correlated with the accumulation of pigments and are accompanied by the blackening of petals and are often stimulated by ultraviolet radiation through the materials covering the greenhouse. Blueing duration storage is attributed to the breakdown of proteins, the release of free ammonia, and a concomitant increase in pH. The bluing of red rose petals is increased by the use of AOA but reduced by the use of STS.

Leaf Wilting: A lower rate of water uptake caused by bacterial plugging is prevalent in chrysanthemum. Placement of the stems in cold water overcomes the problem.

Post-harvest Factors Affecting Vase Life

Temperature: Opening of flower buds and rate of senescence accelerate at a higher temperature. At low temperatures, respiration comes down, the flower produces less amount of ethylene, and the multiplication of micro-organisms does not take place at a faster rate. The most important metabolic process is respiration that increases in temperature.

Humidity: Cut flowers should be kept at 90-92 % relative humidity for maintaining turgidity i.e., beneficial for prolonging the vase life of cut flowers during post-harvest (Doi *et al.,* 2000).

Water Relation: The termination of the life of the harvested flowers depends on water uptake and transport, water loss, and the capacity of the flower tissue to retain its water. Water deficit and wilting develop when the transpiration exceeds the absorption of water. Disruption of the water column in stem vessels by air embolism and resistance to water flow in stems, also develop water deficit. Acidification of water and addition of wetting agent and flower food in the holding solution markedly improve water uptake of cut flowers (Kushal *et al.,* 2013). The vase life of Gladiolus decreases when the conc. Salts in water approach 700 ppm and in chrysanthemums and carnation, 200 ppm is harmful (Waters 1968).

Conditioning: Flowers are kept loosely in a big container of water so that air circulates around the stem. The main purpose of conditioning is to restore the turgidity of cut flowers.

Pre-cooling: Remove excess field heat either by hydro-cooling or refrigeration. The time gap between harvest and pre-cooling should be as short as possible. It brings down the respiration rate For Rose, the pre-cooling temperature required is 1-3 °C, chrysanthemum -0.5 °C-4 °C, Carnation -1 °C and for Gladiolus -4 °C.

Floral Preservative: Floral preservatives are chemicals added to water to make flowers last longer. The marketability of Dutch iris (Iris x hollandica) cut flowers is limited by their short display life and frequent failure to open fully. Macnish *et al.,* (2010) tested the ability of thidiazuron, a phenylureacompound with cytokinin–like activity, to improve iris flower opening and longevity. A post harvest pulse with 0.2- 1mM thidiazuron for 6-24 h at 0 or 20 °C extended the vase life of flowers by up to 1.5days relative to control (0 mM thidiazuron) stems in water. Salicylic acid prevents ACC-oxidase activity which is the direct precursor of ethylene and decreases ROS (Reactive oxygen species) with increased enzyme antioxidant activity. Also, salicylic acid seems to act as a germicide the decrease bacteria, which block the xylem vessels in the cut region and interfere with the normal flux of water through the stem (Nowak and Rudnicki, 1990). Mei-hua *et al.,* (2008) showed that SA can extend the vase life of cut flowers with decreased ROS and ethylene in *Dianthus caryophyllus.* Kazemi *et al.,* (2011) suggested that Salicylic acid increases membrane stability by decreasing MDA content and ACC–oxidase activity, bacteria populations in vase flower preservative solution of the carnation cut flowers.

Constituents of Floral Preservatives

Water: Acidic water with low pH (3.0-3.5) decreases microbial growth (VanDoorn, 1995).

Sugar: Act as an additional food source and also improves water balance. Sugars promote microbial growth, so it is usually combined with biocide before use. Among the sugars, glucose (reducing sugar) was found most effective in extending the vase life, followed by fructose (Ichimura*et al.,* 2006).

Biocide: These are the chemical compound, used to inhibit microbial growth in vase water as well as on cut stems. Treatment with some germicides, such as silver nitrate, 8- Hydroxyquinoline Sulfate (HQS), and Sodium dichloro–isoyanurates, maintain the hydraulic conductance of the stems of cut roses and extend their vase life (Knee, 2000).

Impregnation: Sometimes, the cut ends of the flower stems are impregnated for a short time with chemicals. This treatment protects the blockage of the water vessel in the stem by microbial growth and stem decay. Impregnation of cut bases of flowers with a high concentration (1000 ppm-1500 ppm) of silver nitrate, nickel chloride, or cobalt chloride for 10-15 minutes improves the longevity of several flowers such as aster, gerbera, gladiolus, carnation, chrysanthemum, phalaenopsis, and snapdragon. In Cymbidium, $COCl_2$ (1000ppm) for 15 minutes and Phalaenopsis $COCl_2$ (1000 ppm) for 45 minutes had maximum vase life. Effective impregnation of cut stems is accomplished by immersion for 10 minutes in a 1000 ppm $AgNO_3$ solution. The upward movement of silver in the xylem tissue of the chrysanthemum ranged between 4 and 6 mm per hour depending on the stress history of the cut flowers. The effect of pre-treatment on gladiolus stems increases the percentage of florets which open; with gerbera, silver pre-treatment was only marginally beneficial. The effectiveness of the silver impregnation in part depended on the sugar status of the plant. For carnations, introducing sugar in to the solution, after stems had been impregnated with silver, just prior to or during the longevity studies enhanced the cut flower life. Tight carnation buds were opened in 10% sucrose after impregnating the stems for 1 hour in a1000 ppm $AgNO_3$ solution.

Use of Growth Regulators: Post-harvest life of flowers can be controlled by growth regulators. Water relation changes with flower senescence are also influenced by growth regulators. Auxin does not play many roles in improving vase life. Gibberellin helps in delaying senescence. It promotes the opening of immature buds in gladiolus. Outer bracts of gladiolus regulate the production of alpha-amylase Saeed *et al*., 2013 reported that the application of GA_3 at 25-50 mgl^{-1} renders the highest results for improving the vase life and quality of gladiolus cut flowers.

Cytokinins play important role in delaying senescence. The level of cytokinins decreases with aging. BAP in holding solution delays senescence of Tuberose. Dip treatment of BA increases the vase life of Anthurium. Mature coconut water is considered a rich source of sugar, electrolytes (Jayalekshmi *et al.*,1986), and growth regulators such as auxin, gibberellins, and Cytokinin (Mamaril *et al.*,1986) Agampodi and Jayawardena, 2007 observed that Anthurium cut flower variety wild pink when treated with 50 % Coconut water with 0.23% NaoCl shows longest vase life (21 days). Coconut water has been successfully used to increase the post-harvest life of Gerbera (Nair *et al.*, 2000). Ethylene: a hydrocarbon gas, commonly known as a ripening hormone induces senescence in many flowers. Some important effects of ethylene are Sleepiness of petals in carnation, epinasty in poinsettia, Abscission of petals or whole flowers, and inhibition or promotion of bud opening in roses. 1-MCP and Promalin on oriental lily and observed that 1- MCP plays an important role in preventing post-harvest deterioration of buds and flowers caused by ethylene.

Pulsing: The absorption of the chemical solution containing sugar and germicide through the lower cut base ends of flower stems is known as pulsing. Pulsing is mainly done to increase vase life, Promote, open, and improve the color and size of cut flowers. Pulsing is employed with a high concentration of sugar mainly sucrose, the percentage is very crop to crop and species to species. Chrysanthemum should be needed 2-6% sucrose

(Bhattacharjee and de, 1998) Bird of Paradise or carnation needed 10% sucrose (Crilley and Pul 1993). Gladiolus needed 20% sucrose.

Condition with Chemical Preservatives: Certain chemicals, (the effect which lasts for the entire post-harvest period even when the flowers are held outside). The main ingredients of various pulsing solutions are sucrose, which is used in higher concentrations than in preservatives formulations. Sucrose undoubtedly serves as a respiratory substrate and to a certain extent prevents desiccation and probably replaces the depleted natural carbohydrates and eliminates the breakdown of the other organic compounds.

Table 2: Extending the shelf life by using chemical preservatives

Sr. No	Cutflower	Preservatives	Vaselife
1.	Rose	3-5% sucrose 300 ppm Al_2SO_4	6-9 days
2.	Gerbera	200 mg/l of 8HQS	4-5 days
3.	Chrysanthemum	2% Sucrose and Al_2SO_4	12-20days

Vase Life of Cut Flowers: Vase life is the period during which a cut flower or cut foliage retains its appearance in a vase. This is a major consideration in identifying plant species suitable for use in floristry, plants with a long vase life being farm or desirable than those with a short vase life

Table 3: Vase life of Cut Flowers

Sr. No.	Flowers	Vase life
1.	ChinaAster	5 to 10 days
2.	Bird of Paradise	1 to 2 days
3.	Calla lily	4 to 8 days
4.	Carnation	03 weeks
5.	Chrysanthemum	1 to 2 days
6.	Dahlia	6 to 12 days
7.	Gladiolus	6 to 12 days

Storage Methods

1. Optimum levels of light, temperature, relative humidity, ethylene, and soil moisture should be maintained in the storage environment.
2. In the storage condition low metabolism in tissue, slow down respiration and transpiration rate, ethylene production, and retards the multiplication of bacteria and fungi growth (Mahajan *et al.*, 2014).
3. Some foliage plants can show some disadvantage if stored for long days under cool storage. What problems are-leaf chlorosis, flower and foliage drop, desiccation, or reduction of plant grade.

4. Storage is a different type such as cool storage, wet storage, dry storage, etc.

Gladiolus flower can be stored in polypropylene packing under cold storage for 10 days (Singh, 2007) and Dastagiri *et al.*, (2014) reported that Ornithogalum spikes can be best stored up to 3 days at 4 ºC in modified atmosphere packaging with cellophane. 6. Ex- Bulbous plants need 4-5 ˚C, Rose and carnation needs 0-1 ˚C.

Simple Refrigerated Storage: It is mostly used in cut flowers. Two types of simple refrigerated storage. In wet storage, the stems are stored with their basal portion dipping in water or preservative solution and the temperature is 2-4 °C. Wet storage holds the flower for a short duration. Modified atmospheric storage (Dry storage): sealing of flowers in plastic bags leads to a reduction in O_2 and an increase in CO_2 levels due to respiration of tissue (5-7% CO_2 and 1 to 2 % O_2). Dry storage can be used to hold the flowers for a longer duration.

Controlled Atmospheric Storage: CO_2 and O_2 level is controlled. Has a storage chamber where the air is continuously circulated and is also released. Low temperature is maintained and RH is kept high. A major limitation of CA storage of flowers: optimum levels of CO_2 and O_2 required for storage vary for different flowers and hence, different flowers cannot be stored at the same time in the same chamber.

Hypobaric Storage: Storage at low atmosphere pressure i.e., 40-60 mm Hg under continuous ventilation and high relative humidity (90-95%). Major disadvantage – High cost of installation.

Table 4: Storage methods

Storage	Crop	Storage Temperature
Dry storage	Carnation	0 to 1 °C
	Chrysanthemum	1 °C
	Gerbera	2 °C
	Gladiolus	4 °C
	Rose	0.5 to 2 °C
Wet storage	Carnation	4 °C
	Chrysanthemum	4 °C
	Gerbera	4 °C
	Rose	2 to 5
	Gladiolus	4°C

Grading: During sorting, flowers damaged, infested with pests and diseases, and defective are discarded. Good flowers are graded according to the bud size and stem length. Uniforms buds with stem length. Uniform buds with stem length. Uniform buds with a stem length of a particular grade range are bunched in 10, 15 or 20 numbers. Grading is normally done on the basis of flower quality judged by bud or bloom regularity stem length and straightness. The grades prevailing in roses and gladioli in international trade are given below. The flowers which are uniform in colour, stem length, and development are grouped together. Internationally recognized grades are as follows:

Table 5: Grading size of flowers

Varieties	Stem length (cm)	Bud size (cm)
Large flowered	60-90	3.0-3.5
Small flowered	40-50	2.0-2.5

Roses: The flowers which are uniform in colour, stem length, and development are grouped together. Internationally recognized grades are as follows:

Gladiolus: Four grades are used on the basis of overall quality, length of the spike, and the number of florets per spike (Staby *et al.*,1978). While grading care should be taken to discard the bruised, broken, diseased, and insect-damaged flowers. Same grade flowers are bunched together and wrapped with cellophane paper to improve the display value.

Packaging: The package ensures quality maintenance during transport and storage. The package should withstand shocks, drops, vibration, compression, and refrigeration during shipping and storage. Package standards vary with flower crops, cultivars, mode of transport, storage, and market outlet to meet the regulation of importing countries. The package is considered a silent salesman and it influences the consumers at a subconscious level, evoking an image of quality and stimulating the desire to buy. The inner layer of the package should also provide cushioning effect to the flowers. Some of the packaging materials commonly used are cellophane paper, news paper, fluted card board paper, poly propylene, polyethylene, craft paper, and tissue paper either in the form of sleeves, cones, cups, or simple wrapping over flowers. Corrugated cardboard boxes are commonly used for the packaging of flowers.

Packaged should be labeled mentioning the source, crop, variety, grade, and a number of flowers or bunches with a handling tip. *Singh et al.*, 2007 reported that polypropylene packing in cold storage can keep the gladiolus spike for up to 10 days. Dastagiri *et al.*, (2014) observed that Ornithogalum pikes can be best stored for upto 3 days at 4 °C in modified atmosphere packaging with cellophane.

It is necessary to study the post-harvest factors; so that we can maintain these factors according to crop demand and post-harvest life can be improved. Training for flower packing and transportation should be given to farmers. Establishing cold storage after harvesting flower senescence is a necessary evil that cannot be completely checked but can be delayed or partially controlled by using of anti –ethylene compound and several package practices.

Transportation: Flowers are short-lived and Perishable in nature and should be a delivery destination as early as possible immediately harvest. There are three methods of transportation for cut flower plants to be shipped by truck, air, and sea but air transport is the costliest of the three methods but it is fastest. Truck transportation is the main mode for foliage plant or cut flowers, must be provided like cooling system, heating system artificial light facility and also maintained relative humidity. But Desiccation is a major problem in sea transportation and to overcome this problem the following steps are recommended. Growing media should be modified to plant protection from drought conditions, and relative humidity, temperature, and artificial light should be maintained.

Market: Market means, a region or a place where consumers come here and buy their preferable or choice-able product. India has different markets in different parts of the city. Some important market is Mumbai, Kolkata, Delhi, Chennai, Hyderabad, and Bangalore.

Marketing Channels: There are three marketing channels followed by flower growers.

1. Producer-Wholesaler-Retailer Consumer.
2. Producer-Pre-harvest contractor Consumer.
3. Producer Processor.

The concept of the Agri-Export zone takes a comprehensive look at a particular produce/product located in a contiguous area for the purpose of developing and sourcing the raw materials, and their processing/ packaging, leading to final exports. The main focus boosting agricultural exports from India (Export between different states or export between different countries) in March 2001, the Government of India declared a policy of setting up Agri Export Zones across the country. The Central Government has sanctioned 60

AEZs comprising about 40 agricultural commodities. AEZs are spread across 20 states in the country.

The Agri Export Zone in India (Floriculture)

1. W.B. (Darjeeling and Kolkata)
2. Karnataka (Bangalore, Dharmapuri, Nilgiri)
3. Uttarakhand (Dehradun, Pantnagar, Nainital, Udhamsingh Nagar, and Uttarkashi)
4. Maharastra (Pune, Nasik)
5. Sikim (East Sikkim).

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