# Souvenir-Kisan Mela 2017

# किसान मेला 2017

**March 10-11, 2017**

**(Theme: Horticulture-An Enterprise for Hills)**

*Organised by*

**ICAR-National Research Centre on Orchids**
**Pakyong, Sikkim-737106, Sikkim**

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(March 10-11, 2017)

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## MESSAGE

I am happy to know that the ICAR-National Research Centre on Orchids, Sikkim is organizing the '**Kisan Mela 2017**' with a theme "*Horticulture - An Enterprise for Hills*" during March 10-11, 2017.

Orchids form the royal patronage in floriculture and Sikkim is known to harbor over 55 orchid species that have both aesthetic and medicinal values. This *mela* would help appreciating the horticultural potentials of the State and express its attributes to socio-economic development of the State and the region in totality.

I wish the Kisan Mela a great success.

( T. MOHAPATRA )

**Dated the 16th February, 2017**
**New Delhi**

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February 21, 2017

## Message

Kisan Mela is a festival for all farmers, growers and entrepreneurs for knowing perfected technologies which are simple in use and efficient in operation. It is high time that all new technologies, devices and tools need to brought at a common place for demonstration and use.

I am happy to know that ICAR-National Research Centre on Orchids, Sikkim is organizing Kisan Mela-2017 with a theme "Horticulture-An Enterprise for Hills" during March 10-11, 2017. Horticulture is a field which is expanding in right shape, presently we are producing about 10% of fruits and 14% of vegetables on global level. There is good scope for processing and value addition in this sector.

I would like to congratulate Dr. D.R. Singh, Director and his team for initiating this excellent event for the benefit of farmers and growers of the region. I wish "Kisan Mela-2017" a great success.

(N. S. Rathore)

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## MESSAGE

I am extremely happy to know that ICAR – National Research Centre on Orchids, Pakyong, Sikkim is organizing its 4thKisan Mela- 2017 on the theme *"Horticulture- An Enterprise for Hills"* on March 10-11, 2017 and on this auspicious occasion a Souvenir is being published to mark the event.

Nestling in the Himalayan Mountains, the state of Sikkim is characterized by mountainous terrain. Almost the entire state is hilly with an elevation ranging from 280 metres (920 ft) to 8,586 metres (28,169 ft). Sikkim is predominantly an agrarian state where about 80 percent the population depend upon agriculture for their livelihood. Further, the State has got a unique system of production where majority of farmers are practicing inter-cropping, such as cardamom, mandarin-based intercropping, ginger-maize, paddy-soybean, pulses-turmeric, maize-potato and vegetable crops, keeping the very scientific concept of multi-storey crops. This practice, while serving the food and nutritional security of the growers, is directly supporting in strengthening of agro-biodiversity of the state embedded with traditional tribal wisdom. Recently, Sikkim has the pride of becoming the first state of India to declare and adopt organic farming. Organic farming has numerous advantages viz., improves soil health, nutritional condition and leads to sustainable production of quality foods. Apart from these, by adoption of organic farming, growers of the state will be immensely benefitted through offering premium prices of their produce. I am well confident that the proposed event of *Kisan Mela* will provide an ample opportunity to growers of the state to know the latest developments in Agriculture, in general and Horticulture, in particular.

I convey my best wishes for a grand success of Kisan Mela- 2017

**(M. Premjit Singh)**

# উত্তরবঙ্গ কৃষি বিশ্ববিদ্যালয়

পুণ্ডিবাড়ী, কোচবিহার , পশ্চিমবঙ্গ-৭৩৬১৬৫

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Ref. No. VC/ UBKV- 1480 Date- 21 Feb 2017

**MESSAGE**

I am very pleased to learn that ICAR- NRC on Orchids, Sikkim is going to organize "Kisan Mela 2017" with a theme "Horticulture – An Enterprise for Hills" during March 10 – 11, 2017. I must congratulate the organizing team for setting up such an aim of creating mass awareness and educating orchid farmers for sustainable growth in the hill region and enabling growers become entrepreneurs.

This Kisan Mela 2017 would not only provide platform for innumerable orchid farmers to display their efficiency but would also help the farming community to come up with better solution against all the odds they are facing. Further, it is truly a proud feeling to learn that a "Souvenir of Kisan Mela 2017" is also going to be published. I hope the Kisan Mela would surely be a landmark event for the NRC and also for Sikkim.

I feel assured that the Mela would gain tremendous success thus enabling the organizing committee to achieve their goal of benefiting the farmers of the hill region.

I wish the Mela a grand success.

With best regards,

Sincerely yours

*(C. CHATTOPADHYAY)*

**Dr. D. R. Singh**
**Director**
**ICAR- National Research Centre on Orchids**
**Pakyong- 737106**
**Sikkim**

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## MESSAGE

I am indeed happy to know that ICAR-National Research Centre on Orchids, the pioneer institute in the Orchids research is organizing the "Kisan Mela 2017" with a theme "Horticulture- an Enterprise for Hills" from 10-11 March, 2017 at Pakyong, Sikkim.

The ICAR-NRC Orchids has taken a mission oriented research programme on crop improvement, crop production and post harvest management.

Extension of an opportunity to farmers through this Mela for interaction about their problems and to guide and inform farmers about the latest technologies, innovations and package of practices is praiseworthy efforts of ICAR-NRC Orchids.

The Govt. of India enacted PPV & FR Act, 2001 in compliance to our obligations under the agreement on Trade Related Aspects of Intellectual Property Rights (TRIPS) of WTO. The Act also captures the basic features of the International Conventions/Treaties like ITPGRFA, CBD and UPOV. The PPV&FR Authority has worked very closely with Centre not only for development of DUS guidelines of various species of Orchids but also for organizing awareness camps about the Farmers Rights as per PPV&FR Act, 2001 for the benefit of the farmers . This Mela shall also help PPV&FR Authority in spreading the message about the importance of registration of Farmers Varieties and to inform Farmers about their Rights under the PPV&FR Act.

I convey my best wishes for the grand success of the "Kisan Mela 2017" and to the organizers in their earnest endeavour.

**(R.C. Agrawal)**

**Dr. T. Janakiram**
Assistant Director General (Hort. Science)
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New Delhi-110012

## MESSAGE

I am extremely happy to know that ICAR-National Research Centre on Orchids, Sikkim is organizing its 4th Kisan Mela 2017 with a theme "Horticulture- an Enterprise for Hills" from 10-11 March, 2017 at Pakyong, Sikkim. I must appreciate the organizing team on preparing official document of programme as 'Souvenir – Kisan Mela 2017' for the benefit of farmers.

I am sure that the Kisan Mela would attract greater number of farmers from Sikkim and adjoining areas & benefit the farming community in hill regions.

I wish great success of Kisan Mela 2017.

With best regards,

Sd/-
**(T. Janakiram)**

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Dr. S. M. Deb, ARS
Director

Date : 21.02.2017

# MESSAGE

It gives me immense pleasure to write a message for the Souvenir to be published on the occasion of 'Kisan Mela 2017' with a theme **'Horticulture-An Enterprise for Hills'** during March 10-11, 2017 organized by ICAR-NRC on Orchids, Sikkim.

The attempt to publish one 'Souvenir of Kisan Mela 2017' is an appropriate endeavouer for creating awaremess and educating farmers and orchid growers for uplifting economy in the hill region. The Souvenir will be able to receive the attention of the planners and development/extension workers engaged in the field for enhancing horticultural productivity and will deliver its intended goal of roping in the benefits of scientific research by the farming community of the hill region of our country.

I do sincerely hope that efforts will be made by the enthusiastic researchers to use this opportunity to share their rich experiences in diversified fields to achieve the intended goal of enhancing the income of the farming community of the hill region.

I wish for the success of the event and hope the Souvenir will be a reference document.

With regards,

**( S. M. Deb )**
**Director**

*"HEALTHY SOILS FOR A HEALTHY LIFE"*

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डा. अभिजित मित्र
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**Dr. Abhijit Mitra**
Director

## MESSAGE

I am delighted to know that ICAR-NRC on Orchids, Sikkim is organizing 'Kisan Mela 2017" with a theme "Horticulture-An Enterprise for Hills".

This effort will act as a catalyst in harnessing the Horticultural potential of the region through the provision of a common platform to farmers, agriculturists, technical experts, policy makers, buyers and sellers of the North Eastern region. I trust that this Kisan Mela 2017 will have a progressive impact on the horticulture sector in the region.

I would like to congratulate the organizing committee of ICAR-NRC on Orchid, Sikkim for successfully conducting the programme and in bringing forth the souvenier of Kisan Mela 2017.

23/2/17
**(Abhijit Mitra)**

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*'Healthy Soils for a Healthy Life'*

# Salient Achievements of ICAR-NRC on Orchids, Sikkim

## (Summary of Achievements)

ICAR-NRC on Orchids, Sikkim was established in 1996 during 8th Five Year Plan with an aim to promote commercial Orchid cultivation in India. In 1997, the Darjeling campus was taken over from CPRI and acquired 8.87 ha land from Govt. of Sikkim. Genetic resources of orchids are conserved under NAGS with > 3,130 accessions (360 species, 124 genera) collected across India. Paphiopedilum variety **'Sheetal 1'** (IC 614753) registered with PPVFRA. Three varieties *viz.*, '**B. S. Basnet**' (Cymbidium), '**V. Nagaraju**' (Dendrobium, INGR 10073/ IC 574581) and '**Kung Gyatso**' (Aranda) were identified at institute level in 2013. Eight breeding lines of Paphiopedilum were registered with NBPGR (IC 614750 to 614753 & IC 617522 to 617525). Three breeding lines of Cymbidium (IC-0614747 to 0614749) and 3 putative apomictic lines of Zygopetalum (IC 617526 to 617528) were identified and registered. Novel and scented Cymbidium genetic stocks, Vanda hybrids, progenies of Dendrobium and Phalaenopsis hybrids are developed. State flower of Mizoram, *Renanthera imschootiana* known as 'Red Vanda' was registered (**INGR 10113**/IC 566525) Germplasm stock. Putative apomixis for seed production technique is developed in Zygopetalum. DUS Guidelines for seven genera of orchids developed to fulfill PPV & FR Act, 2002.

DNA bank developed for 400 species for long-term preservation and bar coding developed for native *Vanda* species & 410 NCBI sequences were deposited. Efficient method DNA extraction protocol of Orchids (No. 826/KOL/2013) was filed for patent. Chemical profiling of two fragrant orchids was done and isolated novel compounds. Technology for producing plantlets from Cymbidium back bulbs developed and propagation techniques in lillium was standardized. *In-vitro* technique for clonal propagation for orchid species and hybrids developed and method for *in-vitro* flowering developed in *Cymbidium dayanum* using hormones. More than 1,00,000 planting material developed through *in-vitro* clonal propagation and distributed in NEH under DBT project (2008 to 2014) and compiled 12 success stories completed. Concept of model floriculture, package of practices for Cymbidium, Dendrobium, Vanda, Phalaenopsis, Cattleya, Oncidium, Paphiopedilum etc were developed. Flower drying techniques, single flower packing method (Cymbidium) and packaging techniques were developed. Virus indexing technique with dip stick method developed. Pest control measures in Cymbidium, Dendrobium, Vanda, Phalaenopsis & Paphiopedilum etc were developed and bio-control measures developed for mites and aphids (reported aphelinid wasp*, Coccophagus ceroplastae* (Howard) as parasitoid of soft scales, *Coccus hesperidum* infesting Orchids and *Aphytis* sp. as parasitoid of Cymbidium Scale, *Lepidosaphes pinnaeformis* (Bouche) infesting Cymbidium). Organic methods were developed using local materials (ex: organic fertilizer) and potting media. TSP scheme was launched in 2014 Sikkim District and other parts of North-East India for direct asset transfer and demonstration of technologies & trainings. Revolving Fund Scheme (RFS) and planting material production were taken up under 'Mega Seed Project' and DBT's mission with generation of Rs. 21.30 lakh. Achieved ICAR best award '**Fakhruddin Ali Ahmad Award (2002-03)** for Teamwork in Tribal Farming System and won best stall awards in '**International Flower Show**' in 2008 & 2013 (Germplasm category). Received prestigious '**Indira Gandhi Rajbhasha Award 2012**' from the President of India at Rashrapathi Bhavan (14/09/2014) for Hindi book and 'ICAR Best Employee Award' at national level with cash prize in 2015. Received 'Pandit **Deen Dayal Upadhyay Antyoday Krishi Puraskar 2015**' (Zone VI) for woman orchid farmer in 2016. Nearly 20 external funded projects were handled by institute. Regular training programmes were conducted for farmers. Four annual stakeholder meetings and two national seminars were conducted at Sikkim.

# 1. Orchid Preparations

**D. R. Singh, R. Kishore, Raj Kumar, A. Singh and Deepak Rai**

**ICAR-National Research Centre on Orchids, Pakyong, Sikkim**

## Introduction

Orchids, one of the most fascinating creations of the nature are one of the most widely distributed groups of flowering plants on the earth. Having tremendous horticultural and medicinal value, the family Orchidaceae has been paid adequate attention in many countries throughout the world to study their biology, evolution, taxonomy, cytology, chemistry, hybridization and cultivation etc. They are abundant in tropical regions of the South East Asian countries Like India, China, Malaysia, Laos, Myanmar, Nepal, Bhutan Japan, Philippines, Australia, Europe, South & Central America and South Africa etc. The family Orchidaceae is one of the oldest known and world's largest family of flowering plants comprising of over 800 genera and between 25000 – 35,000 species.

In India, the family Orchidaceae is widely distributed from alpine to coastal regions and islands but their maximum diversity occurs in the Eastern Himalayan and Peninsular regions respectively. According to the reports (Misra, 2007) the family has about 186 genera, 1298 species, 5 subspecies and 28 varieties in India. Indians have one of the oldest, richest and most diverse cultural traditions called 'folk traditions' associated with the use medicinal herbs and it is still a living tradition in India. Oldest references to the use of medicinal herbs in India are found in the Sanskrit literatures. The Indian orchids were brought to the notice of the world by Charak, the great Indian medicine man as back as in 125 A.D, who described 'Vanada' and several other orchids in his book - 'Charak Samhita' which provides description of present known orchids like *Flickingeria, Malaxis* and *Eulophia* species (Kutumbiah, 1962).

Orchid Preparations consists of a diverse variety of products that has potential application in different fields such as herbal drugs, edible processed and non-processed food products, cosmetics, Essential Oils, Perfumery industry, dry flower products. Numerous orchid species have been and are being used in different countries for therapeutic properties. Orchids, besides their identity as commercial ornamental crop are also well known for their multipurpose uses including traditional medicines such as antibiotics, antimalarial, rejuvenating and many other purposes. Orchids contains a wide range of bioactive compounds viz. alkaloids, flavonoids, glycosides, benzyl derivatives, phenanthrenes, terpenoids etc. used for the treatment of various diseases. Nearly 145 bioactive molecules have been isolated from various orchid species, which are used for the treatment of different diseases and ailments like tuberculosis, stomach disorders, jaundice, eczema, inflammations, menstrual disorder, diahorrhea, muscular pain, rheumatism, malaria, wounds and sores etc. *Chyavanprash*, which is a well-known immune booster widely used in Indian households is prepared with various herbs including four orchid

species, viz., *Habenaria intermedia* (Riddhi), *Habenaria edgeworthi* (Vriddhi), *Malaxis muscifera* (Jivaka) and *Malaxis acuminata* (Rishbhaka) as important components. In Chinese herbal medicine industry, orchids like *Dendrobium nobile, Gastrodia elata*, and *Bletilla striata* are used in large quantities and are cultivated on commercial scale by the growers. The bioactive compounds like Dendrobine, Nobilonine, Gastrodin, Vanillin, Batatasin, Blespirol, Blestriarine, Blestrin which are available in these plants are used for preparation of commercial Chinese herbal medicines like *Shi-Hu, Tian-Ma, Bai-Ji* etc (Bulpitt et al, 2007).

The recent popularity of traditional herbal medicines in western countries is also creating a new niche market. Linking of the indigenous knowledge to the modern research activities will help to discover new drugs in addition to contemporary synthetic medicines. However, such large scale demand for medicinal orchids is posing serious threat to orchids in natural habitats due to pressure of collection and sale of whole uprooted plants. Before recommending any orchid species for medicinal use, extensive research on its bio-efficacy is essential. This will be helpful to fully exploit the potential of medicinal orchids in livelihood security of the growers.

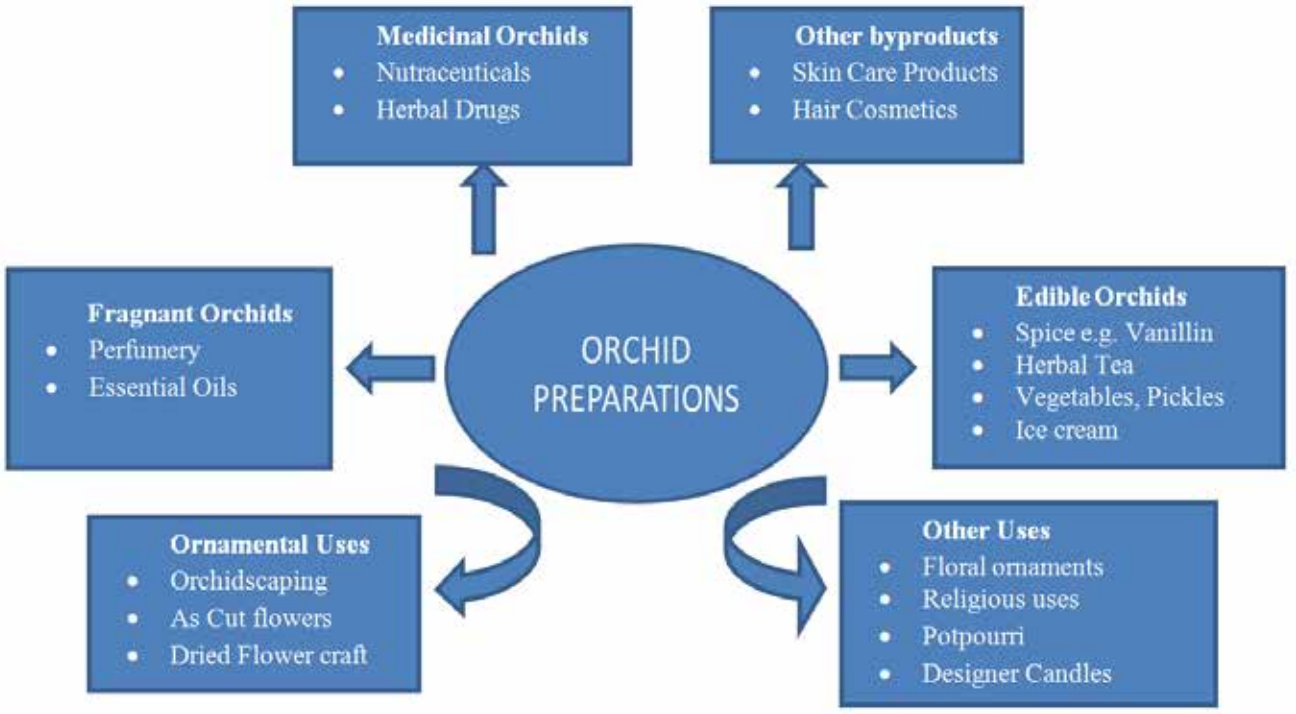


**Fig. 1.1. Pictorial Representation of different orchid preparations.**

## Edible Orchids

Orchids are used as flavouring agent in food, salad, main courses as deserts and to prepare teas. Vanilla is the most famous orchid for its flavour and has been used to flavour food & beverages and tobacco (in Cuba). There is nearly 77 species of orchids are used as food and other products.

**Orchid Ice Cream**: It is prepared from salep is called Dondurma which is also known as Turkish orchid ice cream. It is very chewy and resistance to melting and not like normal ice cream. The ice cream is very commonly seen in Turkey and Greece, where it's referred to as Dondurmas or Kaimaki.

**Fig.1.2. Preparation of Turkish Ice cream**

***Orchis mascula*→ Salep (Beverage )→Turkish Ice-cream (Dondurma) made from Salep**

**Vanilla**: Pods of the climbing orchid *Vanilla planifolia* is used for the commercial production of the prized vanilla flavour, consisting of vanillin and other numerous flavouring compounds, with the use of a curing process. It is the second most expensive flavouring spice after saffron (Sachan D., 2005).

**Fig.1.3. Vanillin from Vanilla pods**


***Vanilla planifolia* Fermented Vanilla extract from Vanilla pods**

Vanilla is chiefly used in ice creams, dairy products, biscuits, cakes, beverages, perfumery and cosmetics as flavouring agent. Vanillin is the active compound found in this orchid and has the medicinal

value. The Vanilla capsules are very cordial, cephalic, stomachic, carminative, attenuating viscous humours, provoking urine, improves food intake, reduces nausea and menstrual discharge. It is also used as blood purifier, diuretic, vermifuge, aphrodisiac, antispasmodic, stimulant and childbirth accelerator (Arditti J., 1992).

**Chikanda:** In Zambia, the tubers from the orchid genera Disa, *Habenaria* and *Satyrium* are the main ingredients of "chikanda", a popular meatless sausage, a brown jelly, also sold at roadsides in the form of slices. It is prepared by pounding the orchid tubers to remove the skins, after that grinding to produce the "yellowish flour" which is mixed peanut flour to adjust the thickness. The growing appetite for "Chikanda" had a dramatic impact on orchid populations in the whole of East Africa.

**Fig.1.4. Chikanda**

**Chikanda**

**Chinaka**: It is not only a delicacy, but also used as a medicine that protects people from various diseases and also acts as source energy. *Satyrium cursonii* is the preferred species; however, other species used are *Disa englerian, Disa robusta, Disa zombica, Habenaria clavate, Satyrium ambylosaccos, Satyrium buchanii,* etc. The tubers are cleaned, pounded in a mortar and cooked preferably with a locally produced "baking powder" called "Chidulo".

***Satyrium carsonii* Chinaka (Prepared from Tubers )**

(Source of Photographs: Internet)

**Olatshe**: It is a popular Bhutan dish, part of the local diet. The preferred orchid for this dish is *Cymbidium hookerianum*. The flowers (open or not) are removed from the flower stalk, then washed and

boiled in water until soft. The orchid flowers add bitterness and the additional spices are added to offset that bitterness. Olatshe can be served with rice, noodles or simply used as a dip.

**Olachoto**: It is another Bhutan delicacy which uses *Cymbidium* flowers. Cut into pieces boiled, strained (optional) and cooked with meat (optional),chilli & cheese or stir-fried as well.

**Fig.1.5. Preparation of Bhutanese traditional dish Olachoto**



***Cym. hookerianum*: Bhutanese traditional dish "Olachoto"**

(Source of photographs: Internet)

***Dendrobium chrysotoxum***

**Dried flowers used as herbal tea**

**Fig. 1.6 *Dendrobium chrysanthum* uses**

**Dendrobium as an edible orchid**: The genus *Dendrobium* is famous in the US as food-orchid. *Dendrobium* hybrid (bigibbum type) flowers are sold in the US as edible decorations for food. Mature canes of many "soft-cane" *Dendrobiums* are being stir fried in many Asian countries, also being used for making sauces in Japan and Singapore. In Thailand, *Dendrobium* flowers are served by dipped in butter and deep fried, while many Europeans garnish desserts and cakes by using Dendrobium flowers. *Dendrobium chrysotoxum* flowers and *Dendrobium cathenatum* canes are dried and consumed as tea. *Dendrobium longicornu* flowers are pickled by the "Tamang" community people of Nepal. In Hawaii, locals use orchids to prepare salad dishes, sugar coated candies, and main dishes orchids cooked with scallops. The fragrant leaves of *Dendrobium salaccense* are used as a condiment for rice in Malaysia. In China many *Dendrobium* species are used to prepare healing teas. *Dendrobium cathenatum* canes are boiled for tea to regain strength after sex or illness.

## Orchid Products used as Nutraceuticals/ Herbal drugs

Nutraceutical is a food that provides health benefits in addition to basic nutritional value. This term was coined by Stephen L. De Felice in 1989 by combining two words, nutrition and pharmaceutical. A Nutraceutical is any substance that may be food or part of food, which provides medical or health benefits, including the prevention and treatment of disease. Such products may range from isolated nutrients, dietary supplements, herbal products and processed foods such as cereals, soups and beverages (Prasad *et al*, 2010). Although the concept of nutraceuticals is gaining more popularity more recently, its roots can be traced to the ancient Indian system of medicine, 'Ayurveda'. The commonly used nutraceuticals in Ayurveda include Chyavanprasha (for general health and prevention of respiratory disorders) that comprises of orchid species as its vital constituents, Brahma Rasayana (for protection from mental stress), Phala Ghrita (for reproductive health), Arjuna Ksheerapaka and Rasona Ksheerapaka (for cardioprotection), Shatavari Ghrita (for general health of women during various physiological states).

## Chyawanprash

It is a very popular herbal product in India.According to Ayurvedic Pharmacopeial Index (API), Chyawanprash is a polyherbal formulation with a semisolid and sticky in nature. It is a chocolate brown coloured having sweet taste with non-specific pleasant odour. (Ayurvedic Pharmacopeia., 2007). In Ayurvedic texts, Chyawanprash is classified under the group of Rasayana, where the main purpose is to maintain the body's integrity for delaying the ageing process, enhance longevity and improves digestion (Parle M., 2003). Chyawanprash is a polyherbal formulation comprising of more than 50 medicinal plants ingredients (Parle M., 2011). Among these, four (4) of them are orchids namely **Jivak (*Malaxis muscifrea*), Rishbhaka (*Malaxis acuminata*), Riddhi (*Habenaria intermedia*) and Vriddhi (*Habernaria edgeworthii*)**. All these ingredients have been well scientifically validated individually for their health care benefits (Rastogi S *et al.*, 2004). It contains high percentage of Vitamin C, many essential fatty acids, high bioflavonoids, carotenoids and a large amount of bioactive phytochemicals that acts as an immune modulator. It is the main source for the treatment of the respiratory tract system such as bronchial spasm,


**Fig. 1.8 Chyawanprash of popular Indian brands Patanjali, Dabur & Baidyanath**

cough, asthmatic breathing, and tuberculosis and is also useful as immunomodulator and memory enhancer (Ojha J K., 1975). It is an antioxidant, blood purifier, a tonic for rejuvenation, a mild laxative, an adaptogenic, anti-aging and anti-stress tonic for old age people. It has a special effect for relieving cough and asthma, enhancing fertility, keeping menstruation regular and strengthening the immune system.

## Shi-Hu

Shi-Hu is a commonly used preparation in Chinese medicine (Chinese pharmacopoeia), which is derived from different species of *Dendrobium* but the widely used species is *Dendrobium nobile*. It is commonly used for the treatment for kidney disorders, lung diseases, stomach diseases, low grade fever, red tongue, dry mouth, swelling, hyperglycaemia, atrophic gastritis and diabetes (Bulpitt CJ *et al.*, 1977). In case of Diabetes, it reduces the level of blood glucose, promotes the secretion of insulin and increase the insulin sensitivity (Shi H *et al.*, 2004).

## Orchids as Cosmetics

Orchids are widely used as cosmetics in European and South-Asian countries for different purposes due to its antioxidants, moisturizing and emollient constituents.

**Moisturizing activity**: Orchid use in medicine was widely described a long time ago in the *Chinese Materia Medica*. Mucilaginous content of orchid makes it ideal as a moisturizing and emollient agent, due to the large number of links formed by hydrogen bonding, thus maintaining optimal water levels of the stratum corneum. Orchids are now being touted for moisturizing, fighting free radicals, increasing skin immunity and reducing the appearance of fine lines.

**Anti-oxidant activity**: The flowers of orchids are used as antioxidants and soothing agents, due to the presence of anthocyanin pigment. Scavenging activity of free radicals also leads to its inclusion in hair products, to protect hair from hair fall. Therefore the Orchid is useful in the formulation of antioxidant and soothing cosmetic products. The recommended dose ranges from 0.5-5%. They are also used in frequent-use shampoos, after-sun screen products and in treatment products for sensitive skin.

**Fragrant Orchids**: Orchid flowers exhibit high ornamental value due to variety in shapes, colors and fragrance. Even though, the economic importance of orchids lie mainly in their ornamental, a little is known about other uses like ethnic food, fragrance and flavour industry, dry flowers, jewellery and minor uses. Many orchids are known for their wonderful fragrance and it is believed that more than 75% orchids are fragrant species. Orchid fragrance ranges from warm, sweet & highly diffusive notes to stinky and offensive odour. The pleasant scented orchid flowers are often compared to fragrance of other flowers like rose, hyacinth, jasmine, freesia, lily, narcissus, sweet pea or easily identified scents like lemon, chocolate, vanilla, orange, coconut, cardamom, musk, honey, mint etc. Now-a-days fragrance in orchids is achieving a new importance as this characteristic adds to the aesthetic appeal of flower spikes besides determining the consumer choice as well as market price.

**Table.5.1. List of some popular orchid Cosmetics & Perfumery**

| S.No. | Botanical name | System(s) of Medicine | Parts used | Product Name and image | Uses |
|---|---|---|---|---|---|
| 1. | *Bletilla striata* | Traditional Chinese& Korean | Root extract | Herborist T'ai Chi Weisse Maske  | As Cleansing face mask & Moisturisor |
| 2. | *Cymbidium grandiflorum* | Not known | Flower; Root | Extrême Lift Crème Anti-Rides à l'Orchidée  | Skin-conditioning component of cosmetic products. |
| 3. | *Dendrobium nobile* | Traditional Chinese; Korean | Whole plant extract | MISA GEUMSUL SKIN TONER  | Skin conditioning component of cosmetic products. |
| 4. | *Phalaenopsis lobbii* | India, Myanmar, and Viet nam | Whole plant Extract | Manhattan Supersize Waterproof Mascara  | Bleaching (lightens the shade of hair or skin) component of cosmetic products. |
| 5. | *Vanda coerulea* Griff. ex Lindl. | Not known | Whole plant Extract | Gesichtsöl Huile Orchidée Bleue - feuchtigkeitsarme Haut  | Antioxidant component of cosmetic products. |

**Table.6.1. List of various fragrant orchid products**

| S. No. | Name | Economic parts | Brand name | Product image | Uses |
|---|---|---|---|---|---|
| 1. | *Dendrobium moniliforme* | Leaf/ Stem, Callus Culture Extract | Osafume |  | Perfume |
| 2. | *Red Cattleleya* | Floral extract | Red Cattleleya Perfume |  | Perfume |
| 3. | *Phalaenopsis javanica* | Floral extract | Javanica Perfume |  | Scent |
| 4. | *Ludisia discolour* | Jewel orchid oil | Joya- Designer candles |   | Scent candles |
| 5. | *Dendrobium species* | Flowers, leaves, seeds and roots. | Potpourri |  | Essential oils |

# 2. Diversified farming systems for improving livelihoods of mountain regions under changing climatic scenario

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The Indian Himalayas are most fragile and multifarious ecosystems in the world. Although, the region is very rich in natural resources yet it is very difficult to sustain the livelihood of the resource poors in the region due to topography. They are primarily dependent on subsistence agriculture and forest resources and struggle to raising their income and quality of life. Younger generations are migrating in large numbers to the urban and industrial regions in the plains in search of employment. Land degradation, deforestation, deterioration of natural resources and increasing poverty are threats to the livelihood. Governments have realized the urgency and importance of socio-economic development of hill people together with environmental regeneration/conservation in mountain ecosystems. It is also felt that the potential of science and technology has not been adequately and appropriately harnessed in overcoming the development constraints posed by the fragile Himalayan environment (Maikhuri *et al.,* 2007). The lack of access by marginal people to the most simple and basic technologies and knowledge needed to create sustainable livelihoods has condemned millions of people to an existence of recurrent poverty, food, nutritional and health security (Maikhuri *et al.,* 2011). Differences between conventional and new paradigms of agriculture are much more a matter of differences in farming philosophy than of farming practices or methods. The conventional model of agriculture is fundamentally an industrial development model which views farms as factories and considers fields, plants, and animals as production units. New technologies are designed to remove physical and biological constraints to production and, thus, make unlimited progress possible. Sustainable agriculture, on the other hand, is based on a holistic paradigm or model of development which views production units as organisms that consist of many complex interrelated sub-organisms, all of which have distinct physical, biological, and social limits.

## Crop production in the mountain region

The mountain agro-ecosystem is characterized by a distinctly cold winter season, terraced farm plots on steep hill slopes and complex farming systems consisting of agriculture, horticulture, animal husbandry, poultry and fishery. Despite the presence of springs and streams, lack of irrigation water is a common constraint. Similarly, trees and shrubs are found ubiquitously, but fodder availability for livestock production is limited. The key socio-economic descriptors of these farms are their small size, often managed by women and provide only a portion of the total family income. The complex nature of the hill agro-ecosystem makes it crucial for sustainability issues to be given priority for maintaining farm productivity and ensuring food and economic security.

***Intensification and Diversification:*** The present cropping intensity in hill areas is about 140 per cent and there is scope for further intensification. A multidisciplinary scientific approach is more important in the mountain areas than in the less fragile environments. The choice of crops is vast: ranging from cereals like wheat and rice to vegetables, fruit crops, spices, condiments, medicinal and aromatic species. Although current familiarity with crops and market orientation are major determinants in the choice of crops, environmental factors should also be taken into consideration. In this connection, crop with dense canopies for conserving soil by reducing runoff are preferred. Species having narrow upright leaves *e.g.*, maize are less suitable for growing on steep slopes. Small-scale diversified systems mostly depending on local resources and complex crop arrangements are reasonably productive and stable, exhibiting high return per unit of labour and energy.

***Diversified farming systems:*** It may defined as a system of agricultural production that, through a range of practices, incorporates agro biodiversity across multiple spatial and/or temporal scales (Tomich *et al.,* 2011 and Kremen *et al.,* 2012). Diversified farming systems share much in common with organic, multifunctional, sustainable, and agroecological management approaches and outcomes. The key indicators of a diversified farming system is that diversification across ecological, spatial and temporal scales serves as the mechanism for maintaining and regenerating the biotic interactions and in turn, the ecosystem services-e.g., soil quality, nitrogen fixation, pollination, and pest control that provide critical inputs to agriculture (Shennan, 2008).

## Diversification strategies

In the process of imitating nature's diversity, various strategies to restore agricultural diversity in time and space can be utilized (Altieri, 1994 and Gliessman, 1998).

1. *Crop rotations*: Time-based diversity in the form of leguminous crops and/or as a green manures are incorporated into cropping systems, providing crop nutrients and breaking the life cycles of several insect pests, diseases, and weed life cycles.

2. *Variety mixtures*: Increasing plant genetic diversity at the field level through the use of variety mixtures and/or multi-lines increases genetic heterogeneity, reducing the vulnerability of monoculture crops to diseases.

3. *Polycultures*: Complex cropping systems in which two or more crop species are planted within sufficient spatial proximity to result in competition or complementation, thus enhancing yields and minimizing risks.

4. *Agroforestry systems*: A system where trees are grown along with annual crops and/or animals, providing the benefits of perennials and resulting in enhanced, complementary relations between components while increasing multiple use of the agroecosystem.

5. *Cover crops*: The use of crop mixture stand under fruit trees to providing soil cover, improving soil fertility, enhancing biological control of pests, and modifying the orchard microclimate.

6. *Animal integration through crop-livestock mixtures*, which aids in achieving high biomass output and optimal recycling.

Research on diversified cropping systems underscores the great importance of diversity in an agricultural setting (Altieri, 1995). Diversity is of value in agroecosystems for a variety of reasons (Gliessman, 1998).

- As diversity increases, opportunities for coexistence and beneficial interactions between species may also increase that can enhance sustainability of agroecosystems.
- Greater diversity may allow improved resource-use efficiency in an agroecosystem. There is better system-level adaptation to habitat heterogeneity, leading to complementarity in crop species needs and diversification of niches.
- Ecosystems in which plant species are intermingled possess an associated resistance to herbivores as in diverse systems there is a greater abundance and diversity of natural enemies of pest insects keeping in check the populations of individual herbivore species.
- A diverse crop assemblage can create a diversity of microclimates within the cropping system that can be occupied by a range of non-crop organisms including beneficial predators, parasites, pollinators, soil fauna and antagonists that are of importance for the entire system.

## Principles for designing the diversified farming systems

- Enhance recycling of biomass and optimizing nutrient availability and balancing nutrient flow.
- Securing favorable soil conditions for plant growth, particularly by managing organic matter and enhancing soil biotic activity.
- Minimizing losses due to flows of solar radiation, air and water by way of microclimate management, water harvesting and soil management through increased soil cover.
- Species and genetic diversification of the agroecosystem in time and space.
- Enhance beneficial biological interactions and synergisms among agro biodiversity components thus resulting in the promotion of key ecological processes and services.

***Agroecology and diversified farming systems:*** Agroecology originally referred to the ecological study of agricultural systems. Much agroecological work seeks to bring western scientific knowledge into respectful dialogue with the local and indigenous knowledge that farmers use in managing ecological processes in existing agroecosystems (Altieri and Toledo, 2011). Agroecology currently holds multiple

meanings, and can refer to an interdisciplinary science, a set of sustainable farming practices, and/or a social movement. Diversified farming systems are not an alternative to agroecology. Rather, it is a framework that draws from agroecological, social and conservation sciences to focus analytical and action-oriented attention toward farming systems in which cross-scale ecological diversification is a major mechanism for generating and regenerating ecosystem services and supplying critical inputs to farming. Agroecological principles and methods can be used to evaluate diversified farming systems and to design or revive processes of diversification (Altieri, 2002).

## Agro-ecology and designing the sustainable agroecosystems

Most people involved in the promotion of sustainable agriculture aim at creating a form of agriculture that maintains productivity in the long term by (Pretty, 1994; Vandermeer, 1995) optimizing the use of locally available resources by combining the different components of the farm system, i.e. plants, animals, soil, water, climate and people, so that they complement each other and have the greatest possible synergetic effects; reducing the use of off-farm, external and non-renewable inputs with the greatest potential to damage the environment or harm the health of farmers and consumers, and a more targeted use of the remaining inputs used with a view to minimizing variable costs.

***Diversified farming systems (DFS) as a social ecological system:*** DFS are complex social-ecological systems that enable ecological diversification through the social institutions, practices, and governance processes that collectively manage food production and biodiversity (Pretty, 2003). As many political ecology scholars emphasize, ecosystems are densely interconnected with social relationships (Robbins *et al.,* 2010). Ecological variables such as soil, water, and habitat help configure an array of farming practices, exchanges of food and resources, and landscape management decisions that, in turn, influence the structure and function of the ecosystem.

## Implication of diversified farming system on mountain agriculture

***Production:*** The agriculture sector should to a larger extent satisfy the food demand of the people. In particular, it should produce adequate amounts of grains, milk and milk-products, meat, egg, potato, vegetables and fruits, etc. This "multi-product" objective can be met through diversification.

***Income:*** The farmers should attain an income as same as an industry worker. Further, the farmers should have the same economic and social status like the persons working in industries. One should have consideration on both the money income and the other means which can have an impact on their living standards.

***Environment and resource management:*** The agriculture should be practiced in a way that it should not reduce the possibility of future biological production, while satisfying the basic assumptions of the agricultural production. The resources which are utilized now should not be limited to the future

generations. Therefore, farming should be practiced as environmentally friendly, and an environmentally friendly farming is possible through farm diversification.

***Efficiency:*** In practice, the agricultural policies have so far been in favour of the income objectives than the efficiency in agriculture.

***Regional policy:*** The agriculture should provide income and build up the necessary structures to secure employment in the remote regions, where it has been a weaker sector and the only industry. One can, however, consider increase in production in the other regions while giving priorities to the remote regions. Possibility for farm diversification in the remote regions depends on the nature of the production base, can generate income and provide employment opportunities.

## Benefits of diversified farming systems:

- Better use of land, labour and capital: Better area land through adoption of crop rotations, steady employment of farm and family labour and more profitable use of equipment are obtained in diversified farming.
- The farmer and labour are engaged all the year round in different activities.
- Less risk to crop failure and market price of the product.
- The byproducts of this farm can be utilized properly as cattle, poultry, birds, etc. are reared with crop production.
- Regular and quicker return is obtained from various enterprises.
- Soil erosion can be checked as land is kept under cultivated throughout the year
- Soil fertility can be checked as land is kept under cultivated throughout the year.
- Diversified farming is less risky than specialized farming.
- Best use of all equipments.

***Conclusions:*** Diversified farming system is an opportunity to improve the rural livelihoods and soil health of mountain region under changing climatic conditions.

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# 3. Participatory approaches for quality organic seed production with inclusion of pulses in maize-based cropping system in Sikkim Himalayas

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Sikkim is a small hilly state in the Eastern Himalayas having a total geographical area of 7,096 $km^2$ with the total population is 610,577 (Census of 2011). Cultivable area in Sikkim is around 15.68 per cent out of the total geographical area of 709,600 ha. It is estimated that over 80% of the rural population depends on agriculture and allied sectors for economic, food, and nutritional security. The agriculture systems practiced in Sikkim are integrated in nature that have evolved through years of experimentation by the farmers. At the national level pulses are produced in 25.23 million hectare area with production of 19.27 million tonnes and productivity of 764 kg/ha during 2013-14. Whereas, the total cultivated area under pulse crop in Sikkim is around 6300 hectares producing 5600 tonnes with an average productivity of 929.8 kg/ha. Black gram is the most prominent pulse crop of Sikkim sown in *kharif* season. It is cultivated by the farmers in the lower, warmer parts (below 750 m msl) of the state.

The seed requirement of the State is being fulfilled to some extent from outside sources. Being an organic state the supply of requisite quantity of seeds to the farmers procured from outside sources is not feasible due to high cost and chemically treatment; hence, there is a great need for production and certification of seeds within the State to meet the domestic requirement of the State. Quality seed production of pulses is prime goal for fulfilment of pulse demand besides increasing the system productivity in terms of soil fertility restoration and economic gain to the farmers. Seed is the most vital and basic input for sustained agricultural production in enhancing crop productivity. Since the total cultivable area is decreasing due to ever growing population and urbanization, increased agricultural productivity is the only option for food and nutritional security. Hence, in modern agriculture, quality seed is of vital significance. Use of quality seeds alone could increase 20-25 % of the crop yield. Modernization of agriculture and development of modern seed industry brought about changes but more than 80% of the pulses seed planted are still farmer saved. The seed replacement rate of most of pulses has not achieved the desired level and farmers are using their own saved seed resulting in low production as well as productivity of pulses.

**Table1. Present status, deficit and requirement of seed of food grain crops in Sikkim (2013-14)**

| Crop | Total area (ha) | Total seed Requirement (t) | Seed availability* in the state (HYVs + local varieties (tonnes) | Deficit in the total seed requirement (tonnes) | Seed requirement for covering 30 % area under HYVs (tonnes) | Area required for seed production for covering 30 % area under HYVs (ha) |
|---|---|---|---|---|---|---|
| Rice | 11158.0 | 446.32 | 393.19 | -53.13 | 133.89 | 89.25 |
| Wheat | 360.0 | 36.00 | 3.85 | -32.15 | 10.80 | 8.99 |
| Maize | 39930.0 | 998.25 | 921.05 | -7.72 | 299.47 | 166.37 |
| Finger millet | 2960.0 | 44.40 | 30.80 | -13.60 | 13.32 | 12.10 |
| Barley | 580.0 | 58.00 | 5.92 | -52.08 | 17.40 | 14.49 |
| Buckwheat | 3630.0 | 254.10 | 289.69 | +35.59 | 76.23 | 84.69 |
| Urd bean | 3280.0 | 164.00 | 138.30 | -25.70 | 49.20 | 54.66 |
| Rajmash | 3020.0 | 211.40 | 140.95 | -70.45 | 63.42 | 70.46 |
| Mustard | 4070.0 | 28.49 | Nil | -28.49 | 8.55 | 10.68 |
| Soybean | 3880.0 | 232.80 | 111.03 | -121.77 | 69.84 | 87.30 |

## Constraints in quality seed production of pulses

Production of high-quality seed is fundamental pre-requisition for modern agriculture. Most of pulse crops are grown in each season from seeds, and seed quality constitutes major component for harvesting potential crop yield. Availability of quality seed of improved varieties at right time and places have been a major constraint for enhancing production and productivity of pulses in India. Lack of fine-tuned package of practices, unorganized seed production programmes, poor production of breeder seed to foundation and certified pulses seed by the state departments are some hurdles in quality seed production.

No formal seed production system exists in Sikkim. Majority of the area in the state is under traditional cultivars. The farmers follow the local seed system by procuring seeds by different methods and practices depending on the location and situation. Farmers themselves produce, disseminate and access seed directly from their own harvest. The varieties disseminated are mainly the landraces or mixed races and are heterogneous. The seeds are variable in quality and purity standards. It can be said that no distinction is made between the seed and the grain. This informal type of seed systems has some limitations in which the quality of the seed is suboptimal due to the biotic and abiotic stress and inappropriate storage problems. The seed availability depends on the harvest of the crop in the preceding season which may be insufficient, if crop fails.

## Seed production constraints

- ❖ Unavailability of Breeder seed.
- ❖ Storage conditions.

- Technical know-how of seed production.
- Seed processing facilities in the state are insufficient.
- Varietal performance varies according to the altitude and local climatic conditions; thereby one variety does not perform well at all the locations of the state.
- Considerable variation in soil fertility status.
- It is difficult to carve out extra land for seed production. Hence, it has been included in the acreage of respective crops.

## Inclusion of pulses in maize-based cropping system for enhancing the sustainability through participatory approach

Technological options for maize-based cropping system for rainfed as well as irrigated conditions are available at ICAR-NOFRI (formerly ICAR Sikkim Centre) to enhance cropping intensity (CI) by 200 to 300 per cent in the state from the existing 120 percent. Alternatively, in a long-term prespective, one of the cereal crops can also be substituted with a pulse crop which generally acts as a soil health restorer on account of its ability to fix atmospheric N and utilize soil nutrients and moisture from the lower strata of the soil through their tap root system, which in turn saves N requirement of succeeding crop (Singh, 2012) and produce quality seed as well.

***Pulses as an intercrop***: Short duration pulses such as black gram, green gram, and soybean are ideal intercrops with maize in Sikkim. The intercrop of legumes with maize crop is not only to enhance the producivity but also to cope with aberrant weather situation and enhance the soil health. However, the potential of pulses as intercrops for seed production in maize-based cropping system has not yet been fully exploited, but with advent of modern tools like bed planting, multi-crop seed drills, it may emerge as one of the promising options for the sustainability of maize-based cropping system.

***Pulses as diversification/substitute crop***: The substitution of rice largely depends on the nature of increased stress in different agroecological situations. For instance, where water stress is the serious concern, there is scope for substituting rice with short duration, low duty and deep rooted pulses which can extract soil moisture from deeper soil layers during dry spell like pigeon pea, black gram and cowpea (Singh *et al.*, 2005; Yadav *et al.*, 2003).

**Basics of breeder seed production of pulses**: Some basic and important guidelines for seed production of pulses that needs to be followed are given below:

- The agency producing breeder seed requires nucleus seed of the varieties from the concerned breeder/Institute along with a list of specific characteristic/features of the variety.
- The nucleus seed is planted in a disease-free, well-prepared and homogeneous plot that should

follow recommended isolation distance from other field having the same crop. The planting should be done as per the recommended sowing time.

- Planting is done with the required seed rate leaving sufficient space after each bed for easy monitoring of the field. The plot should be managed as per the recommended package of practices of cultivation.
- The breeder should visit the plot at regular intervals for rouging to rogue out off-type plants before flowering.
- Harvesting should be done at the proper maturity. Precautionary measures should be taken at the time of harvesting to avoid mechanical mixtures. The simultaneous threshing of the two varieties should be avoided.
- The seeds should be dried to 10% moisture level before storage, if required. Grow out test should be carried out as per the standard procedure, after taking samples from different lots to confirm the purity of the seed.
- The seed should be treated with organic pesticide to protect it from the store pests and be packed in properly labeled gunny bags.

**Isolation distance and some requirement during seed production of pulses**: Isolation distance ensures genetic purity of seed by keeping the seed separate from other varieties to prevent cross pollination. As applied to seed production, isolation means the separation of a crop from all possible sources of contamination during the growing period. An isolation distance is needed where different varieties are being grown for seed production. The objective of maintaining isolation is to minimize crossing in plants intended for seed production. If pollen from another variety fertilizes plants in a seed crop the varietal purity will decline. Isolation distance (Table 2) and some basic requirements (Table 3) for pulses are mentioned herein:

**Table 2: Isolation distance requirement for foundation and certified seed production of pulses**

| Crops | Minimum isolation distance (m) | | Other varieties and the same variety not conforming to varietal purity |
|---|---|---|---|
| | Foundation seed | Certified Seed | |
| Black gram, green gram, rice bean field pea | 20 | 10 | Other varieties and the same variety not conforming to varietal purity |
| Cow pea, rajmash, French bean, lentil, pea | 50 | 25 | -do- |
| Pigeon pea | 50 | 25 | -do- |

**Table 3: Specific requirements for seed production of pulse crops**

| Crops | Maximum permitted off type plant (%) | |
|---|---|---|
| | Foundation Seed | Certified seed |
| Black gram, Bengal gram, lentil, pea, pigeon pea | 0.10 | 0.20 |
| Green gram, cow pea, rajmash | 0.10 | 0.20 |
| Plant affected by seed borne disease | 0.10 | 0.20 |

**Conclusion**: With the rising demand of vegetarian food due to ever-increasing population and diversification for food habits, demand of pulses is increasing at a fast pace. This will be further challenged by changing climate which may manifest itself in the form of shifting rainfall pattern, untimely and erratic rains, extreme temperatures, *etc*. which may also change the cultivation pattern of pulses. Further improvement in pulses productivity is needed through conservation agriculture and diversification of cropping system so as to increase the productivity of the system and improve soil health. Above all there is a strong need to formulate a strategic plan to achieve the goal of organic seed requirement of pulses crop for breaking yield barriers through resource conservation, development of micro-irrigation techniques, mechanization and minimizing post harvest yield loss, climate risk management and efficient extension models for dissemination of pulse-based technologies for farmers to make the pulse cultivation in the state productive and remunerative. In addition, market intelligence mechanism also needs to be strengthened for the fulfillment of state demands of pulses.

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# 4. Drying Technologies in Orchids

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Dry flowers are essential export items both in Indian and International markets and Indian export basket composed of 71% dry flowers which are exported to mainly USA, Japan, Australia, Russia and Europe. The demand for dry flowers is increasing at an impressive rate of 8-10 per cent annually thus offering a lot of opportunities for the Indian entrepreneurs to enter in the global floricultural trade. A number of flowers respond well to drying techniques such as anemone, zinnia, allium, sweet william, carnation, stock, freesia, narcissus, chrysanthemum, pansy, daffodils, marigold, rose, lilies etc and foliage like ferns, aspidistra, eucalyptus, ivy, laurel, magnolia and mahonia etc. Otherwise this industry exports 500 varieties of flowers to 20 countries and export of dried flowers and plants from India is about Rs. 100 crores. Potpourri is a major segment of dry flower industry valued at Rs. 55 crores in India alone. This industry provides direct employment to around 15,000 persons and indirect employment to around 60,000 persons. In India, nearly 60% of the raw materials are sourced from natural forests and plains, only 40% of the flowers are cultivated for drying, bleaching and coloring. Orchids are beautiful elegant looking flowers that come in variety of colours and they can be used in flower arrangement or dried flower craft and other value added products.

## Harvesting of materials for drying

The flowers should be cut just as they come to maturity. Flowers harvested at half bloom stage took minimum time for drying. The collected materials should be free from surface moisture and dew. Hence it is better to collect the material in the dry season on a sunny day. Flowers or plant parts selected for drying may be sprayed with Dithane Z-78 of Neem based pesticide (0.5%).

## Moisture retention after drying

Moisture retention in the flowers after drying influences flower shape. Stronger and stiffer petal in dried flowers having low moisture content. A range of 8-11.5 per cent moisture content in the dried

flowers will ensure good quality and firmness and maintains keeping quality for more than six months. Excessive drying of flowers resulted into petal shedding during handling.

## Methods of drying

Drying is generally done under artificially produced heat and controlled temperature, humidity and airflow. For removal of water from fresh flowers and plant parts, optimum temperature to be determined, otherwise quality of the product will be affected. The different drying methods are discussed below.

**Air drying**: This is the most common method which is widely used for long lasting seasonal flowers which are crisp in texture. They are hung in an inverted position or kept in an erect manner. Air drying requires a warm clean dark and well ventilated area with low humidity. Flowers may also be spread over blotting sheets/newwspapers and kept in dark or in the sun.

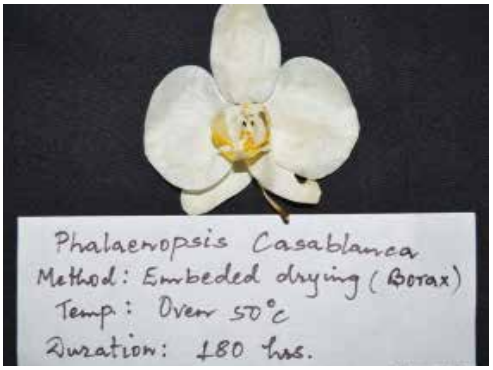
**Sun drying**: Plant material is embedded in drying medium (sand) in a container and exposed to the sun daily to facilitate rapid dehydration. In India, open sun drying is followed for drying many flowers.

**Press drying**: The flowers and leaves are placed between the folds of newspaper sheets or blotting paper. To ensure uniform pressure, flowers for press drying should be spread uniformly on blotting paper. These sheets are kept one above the other and corrugated boards of the same size are placed in between the folded sheets so as to allow the water vapour to escape. It should be given slight pressure for 24 hours and then kept in an electric hot air oven for 24 hours at 40-45°C. The press dried flowers are stored either in sheets at a dry place or in desiccators for future use. These materials can be used for composing floral craft items like greeting cards, floral designs and other art creations which may be framed for wall pin-ups.

**Embedding:** The flowers or leaves are embedded in a drying medium, namely, silica gel or borax or white sand depending upon the plant material. Embedding in silica gel is perhaps the easiest and the best method of embedded drying of flowers. These materials cover flowers in such a way that the original shape of flowers is maintained properly. Metallic or plastic or earthen containers are used for embedding at room temperature in a well ventilated room. About 5 cm layer of desiccant is poured in the bottom of the container and the flower stems are pushed into the medium. Flowers are covered and kept at room temperature. After dehydration, the containers are tilted for removing the desiccants over and around the flowers. The dried flowers are either picked up by hand or by tweezers. Embedded drying with borax at 50°C in oven was found successful in *Vanda teres*, *Dendrobium moschatum, Arundina graminifolia, Den.* 'Madam Pink', Den. 'Lervia', Den. 'A. Abraham', *Phal.* 'Casa Blanca' , Phal. 'Detroit' and *Oncidium* 'Sweet Sugar' and embedded drying with borax at 60°C was found successful in *Epidendrum* spp., *Cattleya bowringiana* and *Cattleya* hybrids, Phal. 'Ox Plum Rose x Black Jack' and Den. 'Big White' (Table 1).

**Table 1. Embedded drying of orchids in oven with borax**

| Name | Temperature | Duration |
|---|---|---|
| *Vanda teres* | 50°C | 36 hours |
| *Den.* 'Madam Pink' | 50°C | 60 hours |
| *Phal.* 'Casa Blanca' | 50°C | 180 hours |
| *Phal.* 'Detroit' | 50°C | 180 hours |
| *Den.* 'Lervia' | 50°C | 60 hours |
| Den. moschatum | 50°C | 60 hours |
| *Den.* 'A. Abraham' | 50°C | 60 hours |
| *Onc.* 'Sweet Sugar' | 50°C | 60 hours |
| Arundina graminifolia | 50°C | 60 hours |
| Epidendrum spp. | 60°C | 27 hours |
| *Blc'* ;Guanmiau City', *Cattleya bowringeana* | 60°C | 21 hours |
| *Den.* 'Big White' | 60°C | 21 hours |
| *Phal.* Ox Plum Rose × Black Jack | 60°C | 9 hours |









Embedded drying with borax and silica gel at 55°Cin oven was found successful *Coelogyne flaccida*, *Coelogyne cristata, Dendrobium nobile, Dendrobium williamsonii, Dendrobium aphyllum*, *Den,* 'Erika', *Den.* 'Big White 4N', *Den.* 'Bangkok Blue', *Paphs.'*Nagasaki' and *Cym.* 'Sungold' (Table 2).

**Table 2. Embedded drying of orchids in oven with borax and silica gel (1:1)**

| Name | Temperature | Duration |
|---|---|---|
| *Dendrobium nobile* | 55°C | 10 hours |
| *Dendrobium wiilliamsonii* | 55°C | 10 hours |
| *Dendrobium aphyllum* | 55°C | 10 hours |
| *Den.* 'Erika' | 55°C | 12 hours |
| *Den.* 'Big White 4N' | 55°C | 12 hours |
| *Den.* 'Bangkok Blue' | 55°C | 7 hours |
| *Coelogyne cristata* | 55°C | 10 hours |
| *Coelogyne flaccida* | 50°C | 7 hours |
| Paph. 'Nagasaki | 55°C | 10 hours |
| Cym.. 'Sun Gold' | 55°C | 14 hours |

**Oven drying:** The drying time can be reduced if the stalks are kept in an oven at an appropriate temperature. The embedded plant material is kept in the hot air oven at a controlled temperature for an appropriate time. But care must be taken in the drying temperature and duration of drying. Electrically operated hot air oven at a controlled temperature of 40-50°C is usually used for drying flowers in an embedded condition.

**Microwave oven drying**: The principle behind the microwave oven drying is liberating moisture by agitating water molecules in the organic substances with the help of electronically produced microwaves. This is the quickest method of drying. Embedded flowers and foliage in silica gel contained in non-metallic earthenware or glassware are kept in such an oven for a few minutes to induce effective drying. The standardized time limit should be followed. After the treatment, the containers are taken out and kept at ambient temperature for a particular period, so that the moisture of the container evaporates and the plant material gets fully dried. This process is called 'setting time'. Setting time vary from 2 to 5 hours.

**Freeze Drying:** Freeze drying is used for preserving flowers and is particularly popular for wedding bouquet preservation. Petals can also be freeze dried and used for decorations at weddings, dinner parties and other occasions, for decorating cakes and scattering on tables etc. Freeze drying flowers uses a process called lyophilization to lower the temperature of the flowers to below freezing, and then a high-pressure vacuum is applied to extract the water in the form of vapour. This process retains the original shape and structure and preserves the flowers. Flowers like Alstroemeria, Amaranthus, Aster, Bird of Paradise, Calla Lily, Carnation, Cattleya Orchid, Daffodil, Dahlia, Delphinium, Dendrobium Orchid, Dianthus, Freesia, Gardenia, Gladiolus, Gypsophilia, Hyacinth, Hydrangea, Iris, Liatris, Lily of the Valley, Lisianthus, Narcissus, Peony, Phaleonopsis Orchid, Rose (all varieties) and Snap Dragon can be freeze dried.

**Molecular sieve drying**: Molecular sieve is a material containing tiny pores of a precise and uniform size that is used as an absorbent for gases and liquids. They are metal alumino silicates which have a crystalline structure consisting of an assembly of tetrahedral. To ensure the dehydration of the fresh natural flowers the mixture of organic solvents is poured onto the hole until the level exceeds the level of the flowers by about 2 cm. The water molecules are progressively absorbed into the small cells or pores of the molecular sieve. The receptacle is closed hermetically for a few days. Once dried, the flower reabsorbs a little moisture of atmospheric origin, and this increases its suppleness and its plasticity. Flowers which are particularly suitable for such a treatment are roses, peonies, camellias, marigolds, globe flowers, orchids, dahlias, carnations, phloxes, summer chrysanthemums, hollyhocks, and the like, and other species with many petals or a fairly rigid structure.

**Cryo drying**: The fully open flowers are cut into a uniform 15cm length and placed in vials so that the basal 5 cm is immersed in solution of glycrerine, clove oil, ethylene glycol, dimethyl sulphoxide and wetting agent. After that the flower stems are recut to 5cm in length and placed in a freezing temperature at -80°C for 12 hours. Then the flowers are immediately placed in a freeze dryer at 20°C under a vacuum of less than 100 microns for 7 days. A minimum of 7 days is required for the flower and stem tissues to be totally dry.

**Drying with glycerine:** In this method, the angular cut stem ends of berries and leafy material can be dried with their lower ends dipped in a mixture of 1:4 glycerine and water for 3 to 6 days for soft stems and 6 weeks for woody stems. Many types of foliage have been successfully preserved by either immersing leaves or placing crushed stems in a 33 per cent glycerol solution. Being an osmotic agent, glycerine replaces the water content of the tissues. After treating with glycerine, the plant material can be microwaved.

**Silica gel drying**: The ground crystals of silica gel are placed in a layer, then of flowers are kept and the flowers are kept with crystals in a tin container or jar that can be covered. Within 2 to 3 days, the crystals will turn pink and the flower heads will be farm to the touch. At this point, the dried flowers are removed. The silica gel can be re-used.

**Borax drying**: Borax is best suited for dehydration of delicate flowers. These are best mixed with equal parts of sand. Borax being hygroscopic in nature might bleach flower petals if embedded for a long time. Drying through borax will take 2 to 10 days. To prevent spotting, all the desiccants should be removed from the flowers after drying. A mixture of one part of borax to one to three part of corn meal mixture is satisfactory for rapid drying. One table spoon of salt may be added to speed up drying process.

**Sand drying:** Fine sand has been found to be the best material for embedding because it is easy to handle, heavy and doesn't react with water vapour. Organic materials and salts are strained from the sand before use. Since sand is heavier, it takes a longer time for drying than the other desiccants. Drying through sand takes four days to two weeks. A mixture of two parts of borax to one part of sand may be used, adding one tablespoon salt to each quart to speed drying.

**Other drying techniques**: Other desiccants used in drying techniques are expanded clay, kitty litter, perlite, dry saw dust, rice husk and corn starch. Under room condition (24-25°C and 75-79%RH), perlite can be used for drying of spikes and florets of orchids within 15 to 20 days.


## Special Preservation Techniques

**Skeletonizing:** This treatment eliminates all tissues but the "skeleton" or veins of leaves. Skeletonized leaves lend an interesting, lacy appearance to dried arrangements. Heavy-textured leaves are the best selects for this method of preservation. Leaves are boiled for 40 minutes in 1-quart water and 2 tablespoons of lye and rinsed in cold water and scraped or brushed the green pulp from the leaves without destroying the network of veins. To lighten the color of the leaf skeletons, immersed in a 1-quart water and 2 tablespoon household bleach solution for 2 hours followed by rinsing and drying.

**Bleaching:** Bleached ornamental plant material provides a striking appearance when arranged with dried or dyed flowers. Bleaching also permits the use of dyes for colouring. Oxidative (Hypochlorite, chlorite and peroxide) and reductive bleaching chemicals (Sulphite and borohydride) are used for bleaching ornamental flowers and foliage. Sodium chlorite is an excellent bleaching agent because it is relatively selective for lignin without damaging fibre. In reductive bleaches, hydrosulphites (Sodium or zinc hydrosulphite) are cheap and have maximum bleaching power. After bleaching with oxidative or reductive chemicals, yellowing of the plant materials is the main problem. To avoid yellowing, multi -step bleaching i.e., alternating oxidative bleach with a reductive bleach create products with less yellowing. A final wash in a 2 % solution of barium hydroxide, calcium hydroxide, sodium bicarbonate or aluminium sulphate prevents yellowing.

**Coloring dried flowers:** Preserving flowers with their natural colour is essential otherwise it will be essential to improve the colour of the product by adding dyes. A dye is most often added to the glycerine preserving solution to permanently colour the decorative plant materials. Systemic dyes are available for use. They are acidic–anionic dyes, which are combined with water and glycerine to form a preservation solution that is absorbed by fresh cut flowers and foliage through the stem of the plant. Normally 1.5 ml to 5 ml dye/l of solution is prepared. Color intake and preservation will require 2-8 days.

**Sulphuring:** It is used to prevent enzymatic colour change. Traditionally, sulphur granules have been burnt for about 2 hours in a closed chamber along with dry flowers. It is very toxic and therefore, it is advised to check relevant safety instructions.

**Potpourri:** Potpourri is usually a mixture of dried, sweet-scented plant parts including flowers, leaves, seeds, stems and roots. The basis of a potpourri is the aromatic oils found within the plant. Two kinds of potpourri can be made - dry and moist. The most common, the dry method, is quicker and easier, but the potpourri does not last as long. Both methods require a "fixative", for absorbing the aromatic oils and slowly releasing them. Herbs such as Artemesia, Thyme, Sage, Rosemary, Basil, Achillea (Yarrow), Lavender, Scented Geranium, Mint, Marjoram, Verbena, Anise and Fennel can be used for scent. The herbs and fruits should be thoroughly dried to prevent mildew.

## Uses of dry flowers

Dry and pressed flowers can be used for many purposes. They can be utilised in the best manner for making decorative floral craft items, greeting cards and covers, wall hangings, floral designs, calendars, floral balls, festive decoration and other creative displays. Floral albums may be prepared with these items for identification of plants for botanical studies. A cottage or small scale industry based on floral crafts using dehydrated flowers, leaves, fruits, pods, seeds and other parts in a distinct possibility. Dehydrated plant parts may be arranged aesthetically and covered with plastic or transparent glass to protect them from atmospheric humidity, wind and dust. For interior decoration, dry flowers sealed in glass containers may be used. The dry flower industry can be associated with many subsidiary industries like cotton fabrics, terracotta, packaging, cane, basket and glass, jute, iron and brass, ribbons and laces, candles etc. by incorporating one with the other, one can have the benefit of value addition.

**Dry orchids in batches**

**Dry orchids in wall hangings**

**Dry orchids with desk calendar**

# 5. Plant Variety Protection in Orchids

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'*Patent system added the fuel of interest to the fire of genius*' - Abraham Lincoln

There is a continuing debate in science since long, whether to patent plants or not? Researchers, botanists, academicians, students and policy makers rationalize this issue and give share different opinions

across the globe. Patenting aspects on new innovations, machines, process and designs, internal circuits in industrial and pharmaceutical sector are popularly known, but the related intellectual protection measures in the fields of Agriculture and Commerce are lesser known and less popular. But, the idea of patenting plants, animals and microorganisms of biological origin was never felt before, especially in India, for the reason, **Indian Patent Act, 1970** clearly mentions to prohibit methods of agriculture and horticulture from patenting. After the implementation of new liberalized trade related policies in 1990s, it was necessitated to develop a centralized national legislative policy again for protection of our various plant genetic resources, which is our potential national wealth. The resultant is the formulation of **'Protection of Plant Variety Act & Farmers Rights, 2001'** (PPV & FR Act, 2001), which envisages the protection of commercial rights in trade to farmer's, plant breeders and companies for their new plant varieties developed. The 'Plant Variety Protection' (PVP) is the form of Intellectual Property Rights for plants or varieties developed like Patents. But, the 'Plant Patenting' is entirely different from the 'Plant Variety Protection' and at present, the 'Plant Patenting' is not operating in India.

The new legislative policy on 'protection of plant varieties' is on par with the existing patenting system in India and operates through 'Plant Breeder Rights' system (PBR system). It is implemented through an autonomous body called 'DUS Testing Authority' *i.e.*, **'Protection of Plant Varieties and Farmer's Rights Authority'** (PPV & FRA), New Delhi with support of the 'Ministry of Agriculture and Cooperation' & 'Indian Council of Agricultural Research' (ICAR) as facilitators. The licensing will be conferred to the concerned party for the protection the new candidate variety for 15 years in crops and 18 years in case of wines and trees after compulsory DUS (distinct, uniformity & stability) testing. The criteria for a normal patenting is the *novelty*, *non-obviousness* & *commercial or trade value*; whereas *novelty*, *distinctiveness*, *uniformity* & *stability* are the basis for Plant Variety Protection. Now it is the time alarming for conferring in intellectual protection to plants and plant varieties derived through hybridization.

**History**: The measures on granting protection of plant varieties is obligatory for 'World Trade Organization' (WTO) member nations as per the **'Trade Related Intellectual Property Rights'** (TRIPS) agreements. In 1994, out of 145 member countries of WTO, 125 nations signed on 'General Agreement on Trade & Tariff' (GATT) with provision of TRIPS on agriculture. The article 27.3 advocates every country to have their legislature and laws for protecting its own plant varieties either through *sui generis* system or any other method. The TRIPS Agreement part II, section 5, Art 27 to 34 deals extensively with patents. The article 22 in TRIPS gave emphasis on 'Geographical Indicators' (GI) for the protection of agricultural, natural or manufactured articles originating from specific regions. For implementation and amendments of this agreement in individual country, a span of five years for developing countries and ten years was relaxed for 'Least Developed Countries' (LDC). Hence, PVP started functioning in many developing countries from January 2001 and similarly, LDC has to implement from January, 2006. But, patenting plants is a recognized process in United States from 1930 onwards. Our country developed 'PPV & FR Rules' in 2003 for strengthening the implementation of PVP system through ICAR institutes and 'State Agricultural Universities' (SAU) of different states.

The idea of IPR on Plants in the form of plant patenting was enacted in United States of America through **'US Plant Patent Act 1930'**. This was a United States Federal Law spurred by the works of **Luther Burbank** (March 7, 1849–April 11, 1926); a botanist, horticulturist and poineer in agricultural science, who developed more than 800 strains and varieites of plants over his 55 years career. Luther Burbank's varied creations included friuts, flowers, grains, grasses and vegetables. He developed a spineless cactus, useful for cattle feed and the plum cot. A total of 16 plant patent numbers were issued to him posthumously. **Sir Thomas Alva Edison** supported the legislation and testified before US Congress on its utility. A plant patent expires 20 years from the filing date of the patent application in US.

Above legislations made it possible to patent new varieties of plants, excluding sexual and tuber propagated plants. But, the development of a new plant cultivar or variety, either by traditional breeding methods or by modern molecular breeding or gene modification, requires a lot of time and effort. In order to recover the cost of invention, the breeder/inventor may desire to obtain exclusive marketing rights for the new variety developed. Keeping it a trade secret is one way, as well as obtaining either a plant patent or plant variety protection is the other way. The method chosen depends on the specific benefits and limitations of the protection, and the costs involved for maintenance and continuation of licensing. Plant variety protection is a good choice for many breeders as plant breeding is a dynamic industry, mingling the old methods with new technology to its best advantage. In this regard, United States of America enacted the **'Plant Variety Protection Act' in 1970** (December 24).

## 'Protection of Plant Varieties and Farmer's Rights Authority', New Delhi

It is the nodal agency for implementing PPV & FR Act, 2003 and came into force in November 2005. The agency covers all plants except microbes. Therefore, plant species under food crops, oil seed, fiber and fodder crops, spices and aromatic plants, vegetables, fruits, ornamental crops, plantation crops, cash crops, bio-fuel plants, mulberry, kusum, ber, palas, forest trees, urban trees, mangroves etc are in priority. The authority has notified 114 crops that also includes seven genera of orchids *viz.*, Cymbidium (Boat orchid), Dendrobium (Spray orchid), Vanda (Blue orchid), Oncidium, Cattleya, Phalaenopsis and Paphiopedilum.

The fees levied for the registration of various material under DUS testing:

1. DUS Conducting fee: Rs. 15,000/- to Rs. 50,000/- (depending on crop)
2. Annual fee: (not yet declared by PPV & FRA)
3. Application form: Rs. 200/-
4. Registration certification charges: Rs. 5,000/-
5. Extant variety where no DUS test required: Rs. 1,000/-

6. EDV (Essentially Derived Varieties): Rs. 7,000/-

7. DUS test site visit charges: Rs. 500/-

**Farmer's Rights:** Farmer is the 1st breeder who developed many varieties. In the long tradition of agriculture, farmers conserved, improved and selected varieties out of both wild and cultivated species, that brought different land races, folk variety and local varieties in course of evolution. Hence forth, the in India, where the society and tradition is much agrarian based has given some privileges to farmers in the present act.

1. Farmers has the right to save, use, sow, re-sow exchange, share or sell his farm produce including seeds of a variety protected under the act in the same manner as before enactment of PPV & FR Act, provided farmer shall not be entitled to sell the branded seeds.

2. Breeder shall disclose to the farmer on the performance of the variety under given condition.

3. Recognition and reward to farmers for conservation of land races and development of farmer's variety.

4. Farmers are exempted from any fee for any proceeding before the PPV & FR Authority.

India is the one among the 1st country to adopt the farmer's rights in the manner of *sui generis* system to have own protection laws, apart from Breeder rights. Brazil is the next country to have similar law enacted for indigenous protection.

## Indirect Measures in India for Protection of plants & varieties

The other legislative measures were taken up after the independence in India for protection of wild life, forest flora and fauna apart from long term seed conservation. Adequate measures were also taken up for ensuring quality seed material supply to farmers.

1. **National Seed Laws**: Punjab seeds & Seedling act, 1950 and Hyderabad improved seeds & Seedling act *etc* were the models for the creation of a central legislation on seeds; the Seeds Act, 1966, Act of 54 of 1966 for an assured supply of quality seed materials to farming community. Subsequently, National Seed Corporation (NSP) came into existence and operating since 1969. State Seed Certification Agencies (SSCA) were started later in different states to ensure quality seeds to the farmers. Seeds Rules, 1968; Seeds (Control) Order, 1983; Seeds Policy, 1988 and Plants, Fruits and Seeds (Registration of import) Order, 1989 were passed in parliament for control, supply and regulation of seeds and planting material. But, these acts never emphasized the need for protection of plant varieties (patenting).

2. The Seeds Bill Act, 2004 was passed recently in parliament to bring further changes to suit our national needs in the liberalization and GATT regime to supplement 'PPV & FR Act, 2001' and 'National Seeds Policy, 2002'. The new act intended to make changes in the old seed act, where

it doesn't have provision to protect extant & denotified varieties and farmer's varieties. This new seed bill act, is proposed to bring national authority for plant variety registration, to enhance seed replacement rate (SRR), compulsory registration of horticultural nurseries & seed dealers, to have state seed committee in each state, to regulate export & import of seed material and to strengthen a viable seed industry in the country. These new acts of PVP are expected to bring revolutionary changes in seed sector of agriculture, similar to Indian Patent Act, 1970 that had brought huge change in pharmaceutical industry of Indian economy from status of importer to exporter of medicines at international level with competitive prices.

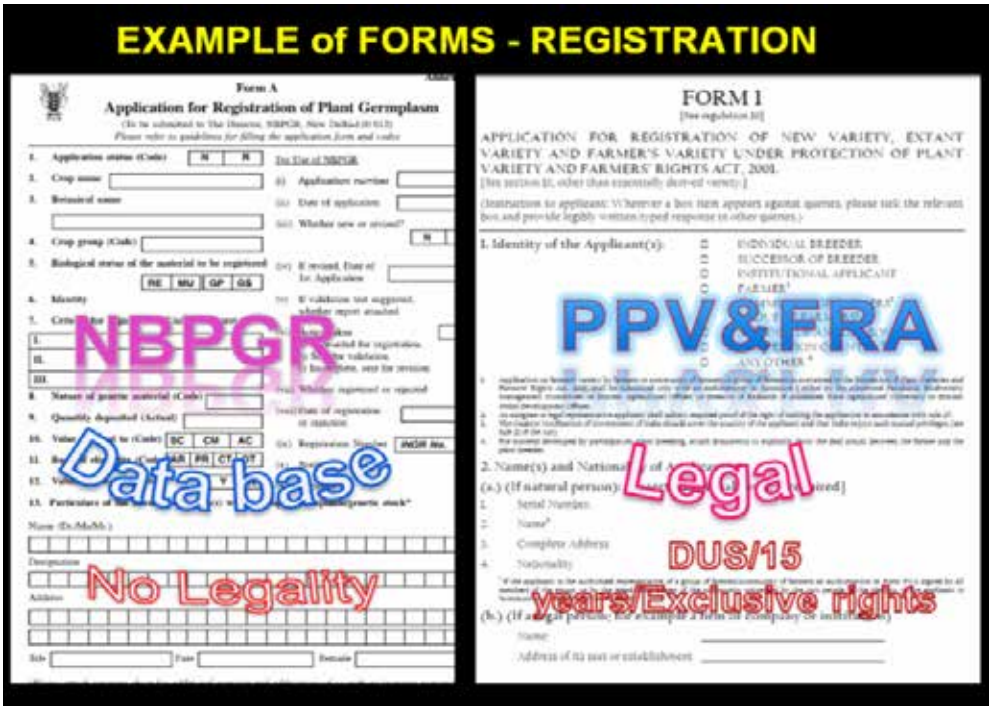
3. **Geographical Indications of Goods (Registration and protection) Act, 1999**: Apart from the above developments, Geographical Indicators of Goods (Registration & Protection), 1999 was enacted for the protection of GI in our country for protection of agricultural, natural or articles. In the context of Orchids, the advantage of proposing orchid growing areas (Sikkim, DHC & other NE states) as 'Geographical Indicator' (GI), exclusively for temperate and alpine *Cymbidium* species & varieties make these areas prosperous and get recognized all over world. The possible other geographical indicators for Sikkim are 'Timi Tea' and 'Sikkim Large Cardamom'etc., and so far 272 products were given GI status.

4. **Central Biological Act, 2002**: Following the guidelines and principles of international agreement, Convention of Biodiversity (CBD) in 1992, the act has been formulated. This act recognizes the sovereign rights of states over biological resources and gives guidelines to establish 'State biodiversity Boards' and support with exclusive rights for having 'Biodiversity Management Committee' (BMC) at grass root level. This act is much relevant to the status of Orchids to India, that comprises 184 genera with 1400 species (800 species are native to northeastern India), and as much as 150 species are endangered like *Acanthephippium sylhetense, Anoectochilus sikkimensis, Aphyllorchis montana, Arachnanthe clarkei, Arundina graminifolio, Cymbidium macrorhizon, Dendrobium densiforum, Didiciea cunninghamii, Eria crassicaulis, Galeola lindleyana, Gastrodia Exilis, Paphiopedilum fairanum, P. druryi, Pleione humilis, Renanthera imschootiana, Vanda coerulea, V. pumila and V. roxburghi etc and 18 species are extinct.* The illegal export of orchid germplasm was reported many times because of porous borders is the main threat for orchid diversity in India. The TRAFFIC board monitored jointly by WWF (World Wildlife Fund) and IUCN (International Union for Nature Conservation) for wildlife trade monitoring network has been conceptualized to restrict illegal smuggling of valuable orchid after the recommendation of CITES (Convention on International Trade in Endangered Species of Wild Fauna and Flora) convention. Further, the concept of 'Bio-sphere Reserve' in India recognized internationally under the framework of UNESCO's Man and Biosphere (MAB) Programme and Transnational Conservation and Eco-tourism for protected areas by China, India, Nepal and Bhutan for Himalayan Bio-sphere Reserve gave special attention and measures for conservation of Orchids.

## DUS Testing for Orchids in India:

The examination of a variety for DUS generates a description of the variety, using its relevant characteristics by which it can be described as a variety in terms of the Act. The DUS testing may be carried out through viz., (i) Official testing (ii) Breeder testing (iii) Official and Breeder testing & (iv) Use of test report of other countries.

**Case Study (I)**




**Example (II) in Orchids:**

# 6. Local Landraces, Underutilized and Indigenous crops for sustainable agriculture development for NE Hill Region

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Biodiversity forms the base for the crop improvement, agriculture development and food security. Despite the phenomenal growth in agriculture, there exists gap in utilization of locally available crop diversity for food production, yet only limited crop species are utilized or promoted for food production. The alarming impact of climate change on food production sought for the resilient agriculture. More diverse the farming system, more resilient they are to the climate change. The agriculture policy across the globe promoted only a few crops and varieties for combating the food insecurity. However, this modern agriculture development was at the cost of the traditional, indigenous and local landraces of the crops.

The climatic variation in terms of rising temperature, wide variation in rainfall, long dry spell during winter, extreme weather, less snowfall, shift in seasons are being experienced now. In such a case, those limited species of crop which were intensified or promoted during the last many decades are really going to be the most affected and inturn the livelihood of the agriculture dependent society.

The local landraces, underutilized and the indigenous crops are of vital importance to sustain the food production and nutritional security in the realm of changing climate. The cultivated crops or the technology used for growing these crops have been developed by continuous efforts of the associated community. These crops are adapt well to local conditions and respond well to the low inputs and are fairly tolerant to biotic and abiotic stresses.

North Eastern region of India, being listed as the mega- biodiversity hot spot of the world, is a treasure house of agro- diversity. Some of the important underutilized or local germplasm with high degree of potentiality for resilient and sustainable agriculture in the North Eastern Region are *Pyrus pashia, Prunus nepalensis, Passiflora edulis, Averrhoa carambola, Dillenia indica Phyllanthus acidus, Elaegnus latifolia and E. pyriformis, Citrus spp and Musa spp.* amongst the fruit crops. Similarly, vegetables like *Cyphomandra betacca, Sechium edule, Momordica cochinchinensis, Momordica dioca, Canavalia ensiformis, Vicia faba Psophocarpus tetragonolobus, Parkia roxburghii, Trichosanthus dioca, Coccinia grandis, Allium sativum, Amorphophallus spp., Dioscorea spp. etc.* have great potential for exploiting them for nutritional security and sustainable agriculture. Wide diversity of cereals comprising rice, maize, primitive popcorn, barley; Pseudo cereals like buckwheat, foxtail millet, finger millet. Legumes like ricebean, black gram, sword beans and oilseeds like perilla have been the major component of cropping system. Hundreds of medicinal and aromatic plants, bamboo and rattans, flowers like orchids, primulas and ferns constitute the major share of agro- biodiversity.

In the pace of development, these crops were neglected and several unadapted crops or varieties requiring high inputs and water were introduced to the region. Despite the several efforts of several agencies, small and marginal farmers especially in the hilly tract of the region showed resistance on popularization and intensification of introduced crops and varieties. Many local landraces and germplasm has rule the heart of these marginal farmers.

The fragile ecosystem of the region, fear of genetic erosions, peoples affinity to the local germplasm and the government vision are now being a factors for reviving the status of the these crops. Advocacy for adoption of organic farming system by the government to the hill zone of the country is a major steps for strategic planning in conservation and utilization of these germplasm. Sikkim Government has taken the policy decision to practice organic farming in the state since 2003. Entire cultivated land in the state is now certified. With the advent of organic farming, local landraces, underutilized and traditional crops are being promoted. Farmers have started using the local landraces or germplams owing to their higher tolerance to the biotic and abiotic stresses and prioritization of such crops for promotion. In fact, these plants are the sole alternative to sustain the organic farming system, and perform better than any other introduced crops.

The government acts like Biological Diversity Act, 2002, The Protection of Plant Varieties and Farmers Right Act'2001, Geographical Indication of Goods (Registration and Protection) Act, 1999 have been instrumental in protecting the local resources. With the formulation of standards for organic production, marketing and certification under the The National Programme for Organic Production (NPOP) in harmony with the other international standards, the organic production got the major boost.

National Project on Organic Farming implemented since 2004 in the country with National Centre for organic farming and Regional Centre for organic farming has been the major initiative of the government to promote organic farming in several ways. Paramparagat Krishi Vikas Yojana, adoption of organic village by cluster approach and Adoption of Participatory Guarantee System (PGS) certification are other recent initiative of the government that will promote the local landraces and varieties. There has been continuous efforts of agriculture scientist specially working in the NEH region for conservation of these crops. Regional Centre of ICAR, Barapani and other associated centre in NEH region have significantly contributed for germplasm promotion through awareness, research and conservation. Upgradation of ICAR centre at Gangtok Sikkim as ICAR- NOFRI (National Organic Farming Research Institute) in 2016 will be the major centre for promotion of local landraces and germplasm. There has been considerable research at department of Horticulture, Sikkim University for evaluation of nutritional values and nutraceutical potential of underutilized and local germplasms of fruits and vegetables, and the department will continuously strive to promote local resources. ICAR- National Research Centre for Orchid has been the inspiring organization. Voluminous work on conservation and utilization of local species of orchids and other flowers has been done and many species are now identified for commercialization.

The bottom line is that the indigenous varieties, underutilized crops and local landraces are the biological treasure and are the result of conscious or unconscious selection by farmers over generations; hence they are often called farmer's variety. Hence, continuous in-depth participatory studies about these species and their role in rural economy will add to the basic information for further strategic research. Some of the landraces are most acceptable by the farmers. Over the time farmers have assessed different varieties and type of the cultivable plant and the technology so developed is widely accepted and very difficult to divert the farmers to the modern varieties and technology. Any scientific fraternity and the policy makers can make the wiser decisions on improving those technologies through participatory methods. Intense work need to be carried out for more documentation and characterization using real time technology like molecular markers (DNA Fingerprinting) along with morphological markers. Some of the important indigenous crops, despite being high in nutrient content, are still not under cultivation and collected from original habitat due to lack of standardize package of practices for cultivation, which could lead to the genetic erosion. Domestication of such crop species may contributes in solving the nutritional deficiency specially the rural populace. Intense research is in demand for standardization of package of practices for the species collected from wild also for the domesticated crops for increasing the productivity. Guidelines for Good Agriculture Practice and Good Collection and Agriculture Practice for cultivated and wild medicinal and aromatic plants is also to be address. Conservation is other aspect for breeding purpose as they can be donor of many tolerant genes for biotic and abiotic factors. Crop improvement for attaining the yield without disturbing the traits for adaptation to local climatic conditions, biotic and abiotic stress is need to be focused seriously. The conservation and promotion of local land races, underutilized and indigenous species or varieties of crop and their and their commercialization can be considered as an alternative towards improving the food security, livelihood, and nutritional status of the community residing at the remotest Hills of North East India.

## 7. Climate Resilient Organic Horticulture Production System in Sikkim

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Over the years, horticulture has emerged as an indispensable part of agriculture, offering a wide range of choices to the farmers for crop diversification under changing climatic conditions. Horticultural crops occupy substantial portion of area and contribute more than 25-30% of the gross value of agricultural output of the country. The state possesses range of agro-climatic conditions, unique commodities

indigenous to the farming *viz.,* large cardamom, ginger, red cherry pepper, Sikkim mandarin *etc.* and an emerging new class of educated farmers wanting to make agriculture professionally viable vocation. For mountain states like Sikkim, this offers hopes of improving soil health of largely marginal hill farmlands, reducing cost of inputs and developing cash crops and agri-enterprises with an aim to offer opportunities of employment to a section of its people.

## A. Organic fruit production techniques

Standardization of organic nutrient management and scheduling of biopesticide and biofungicide spray has been carried out at ICAR-NOFRI. Application of well-decomposed and dried cattle manure @ 20 t/ha in two split doses (*i.e.,* dormant stage in December and active vegetative growth stage in July), neem cake @ 2 t/ha, dolomite @ 2 t/ha, and vermicompost @ 2 kg/plant showed better growth response in all the pear varieties. Spray of petroleum-oil based spray mixed with neem oil in equal concentration @ 5 ml/l during April-May and July-August is effective for control of aphids, leaf miner *etc.* and spray of copper oxychloride @ 0.25% during April-May and July-August at 15 days interval is effective for the management of blight disease in pears. Trials were also conducted to standardize the doses of foliar sprays of nano nutrients/fertilizers and their time of applications at different growth stages of Sikkim mandarin. The nano nutrient formulation encompasses five macronutrients *viz.*, phosphorus, potassium, calcium, magnesium, sulphur and seven micronutrients *viz.*, iron, manganese, zinc, copper, cobalt, boron and molybdenum loaded onto nano silica base has been sprayed on Sikkim mandarin in various concentrations at different growth stages. The results showed that the nano nutrient formulations @ 2 ml per litre sprayed at 45 days, 90 days and 135 days after fruit set reduces fruit drop per cent significantly over other treatments. The average fruit length (53.36 mm), width (64.06 mm) and fruit weight (112 g) of Sikkim mandarin increased significantly over control. The best time of spray was found to be between 9-10 am when most of the stomata were open. Kiwifruit hand pollination and its effect on per cent fruit set, fruit growth, fruit yield and fruit quality have been studied. The best time of hand pollination was observed 10-12 am to get the maximum fruit set. Pollen viability was observed up to 72 hrs for hand pollination, however, maximum (100%) fruit set was observed in hand pollination within 24 hrs after anther removal, and 90% fruit set was observed after 48 hrs of anther removal. Time of hand pollination showed significant effect on fruit weight (100-120 g) of kiwifruit variety Monty and Bruno over control (50-60 g).

## B. Organic vegetable production techniques

The vegetable farming in Sikkim varies from the valley regions to the mid-altitudes and the highlands according to climate, terrain, slope, soil contents, and availability of water. The intensified vegetable cropping systems developed at ICAR-NOFRI for varying climatic conditions shall make better and more secure use of available land, water, labor, and other resources, thus, reducing the risk of low returns from horticulture. Vegetable production techniques developed at ICAR-NOFRI are as follows:

## C. Low cost plastic tunnels

Year round production of vegetables under plastic low tunnels provides the best way to increase the productivity and quality of vegetables, especially during rainy season and severe winter season. At ICAR-NOFRI, the production technology of 14 high value vegetables have been standardized *viz.,* broccoli, cauliflower, cabbage, coriander, lettuce, fenugreek, spinach, Raya sag, pakchoi, garlic, pea, beetroot, carrot, and radish under low cost plastic tunnels. It was observed that all the 14 vegetables can be grown successfully year round in various cropping sequences under low cost plastic tunnels and have shown significant increase in earliness with higher production and productivity. This combination of earliness and greater yields can significantly increase profits for the growers. The tunnels also protect plants from unfavorable abiotic and biotic stresses like high rainfall, hail, low temperature, frost, wind, insect-pests *etc.* Plastic low tunnels are less expensive as compared with the plastic greenhouses, however, bed preparation, planting and harvesting is slightly difficult under the tunnels.

**Vegetable cropping sequences for low cost plastic tunnels**

| | |
|---|---|
| 1. | Broccoli - spinach - coriander - broccoli - coriander |
| 2. | Broccoli - coriander - cabbage - radish - coriander |
| 3. | Coriander - radish - fenugreek - spinach - coriander |
| 4. | Cabbage - Raya sāg (leafy mustard)- broccoli - coriander |
| 5. | Cabbage - spinach - broccoli - coriander |
| 6. | Coriander - radish - fenugreek - cauliflower - pakchoi |

## D. Low cost plastic rain shelters

Open cultivation of most of the summer and rainy season vegetables is not possible in Sikkim because of high rainfall during March-October months. Keeping this in view, low cost plastic shelters have been designed and experiments were conducted during 2014-15. At ICAR-NOFRI we have studied the growth and yield of determinate and indeterminate tomato varieties, capsicum, bitter gourd, bottle gourd, sponge gourd and ridge gourd under low cost plastic shelters during summer and rainy season. Results revealed that the growth and yield of tomato, capsicum, bitter gourd, bottle gourd, sponge gourd and ridge gourd was significantly higher than the open grown. Many plants also did not survive in open conditions because of heavy rainfall. Optimum spacing found for tomato is 60 cm x 45 cm and for capsicum is 40 cm x 40 cm. Spacing of bitter gourd, bottle gourd, sponge gourd and ridge gourd was optimum at 100 cm x 100 cm under the plastic shelter. The main of aim is to utilize vertical space judiciously under plastic shelter. It has been found suitable that tomato should be maintained as single stem plant by regular pinching of auxiliary side branches and train them with bamboo sticks. Pruning was done frequently in bitter gourd, bottle gourd, sponge gourd and ridge gourd at intervals of 15 days to avoid crowding of branches. Low cost plastic shelters are simple but effective in protecting wide range of crops and in various cropping systems

from high rainfall during the rainy season as well as frost during winter season. Trials for growing more types of vegetables are ongoing.

**Vegetable cropping sequences for low cost plastic rain shelters**

| | |
|---|---|
| 1. | Tomato - tomato - pea |
| 2. | Bitter gourd/Sponge gourd/Bottle gourd - tomato - pea |
| 3. | Bitter gourd/Sponge gourd/Bottle gourd - capsicum - pea |

**Advantages of low cost plastic tunnels/rain shelters**

- Vegetables can be produced year round regardless of the season to get better return.
- Provides crop diversification opportunities and supports production of high quality and clean products.
- Makes cultivation of vegetables possible in areas where it can't grow in open conditions *viz.* high altitudes.
- Used for raising healthy and early nursery.
- Maintains optimum temperature for plant growth.
- Enhances nutrients uptake by the plants.
- Increases photosynthetic activities of the plants.
- Used for cultivation during winter.
- Protection against wind, rain, frost and snow.

## Preliminary considerations prior to going into protected cultivation

Before deciding to go for the protected cultivation or plasticulture system for high value vegetable crops, one should carefully consider the following factors:

- Vegetables intended to grow suits to production under protected cultivation.
- Vegetables should be intensively managed under various cropping systems.
- Sufficient financial resources available or obtainable.
- Good market availability.
- One should establish first a successful track record growing high value crops under open conditions then plasticulture system may be profitable.

# 8. Micro irrigation technology for sustainable development of horticulture in north eastern states for maximum output per drop of water

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## Introduction

Majority of the rural population of the north eastern states of the country depends on agriculture for their livelihood. Agriculture also provides the employment to the large number of rural populations in the region. The region is blessed with the plenty of natural resources among which land and water are two most important natural resources used in the crop production system. Though the region is blessed with the plenty of rainfall but face the water scarcity during the lean period due to less or non availability water storage facility. Agriculture being the biggest consumer of water, it will face more competition from industrial and domestic water users due to constantly increasing population. Therefore, in case of shortage of water or water scarcity, water has to be used more judiciously to achieve and maintain the sustainable growth of agriculture in the region. Both its shortage and excess affect the growth and development of a plant directly and consequently, its yield and quality. Therefore, proper water management is essential for the better production and productivity of horticultural crops. Therefore, judicious use of water using water management techniques is essential and need to be adopted in the region for the horticultural development and improving the livelihood of the farmers.

Traditional methods of surface irrigation namely flood, basin, and furrow irrigation are used by the farmers in the region for growing of cereals, pulses, oil seeds and horticultural crops. But, in case of surface irrigation, crop utilize only less than one half of the water released and remaining half gets lost. But with limited and scarcity of water, modern irrigation methods namely drip and sprinkler irrigation has proved its effectiveness over traditional methods of irrigation in terms of water saving, higher yield, and higher water use efficiency. Use of these modern irrigation methods will be helpful for achieving more crop and income per drop of water.

## Efficient water management for crop production

Crop production system requires large amount of water. Therefore, management of water is essential to obtain the higher productivity per unit of water. Following factors need to be considered and studied carefully for the efficient water use planning in agriculture sector as shown in the Figure 1.

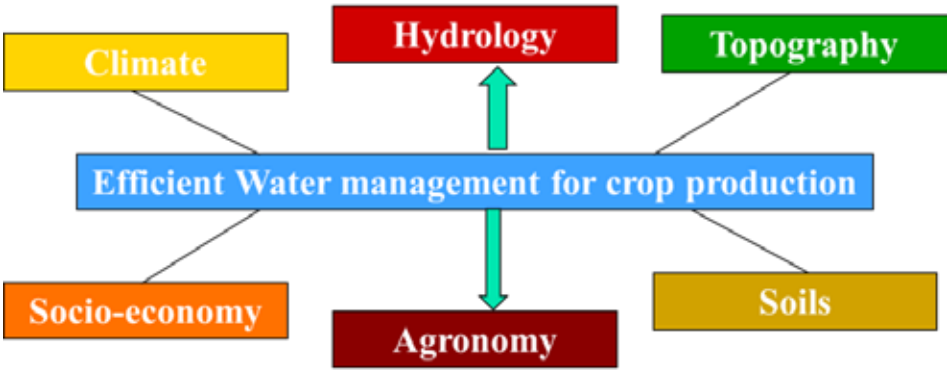


**Fig. 1 Major factors considered for water management for crop production**

## Water requirement of crops and irrigation scheduling

The crop water need (ET crop) is defined as the depth (or amount) of water needed to meet the water loss through evapotranspiration. As climatic parameters play a predominant role in governing the water needs of crops. The crop water need mainly depends on the climate of the region, the type of crop and the growth stages of a particular crop. The major climatic factors which influence the crop water needs are sunshine, temperature, humidity and wind speed. Irrigation scheduling of crops give emphasis to when to irrigate and how much to irrigate. Proper irrigation schedule helps to save water and improves the crop growth. Table 1shows typical values of crop water requirement of selected vegetable and fruit crops.

**Table 1Crop water requirement of selected vegetable and fruit crops**

| Crop | WR (mm) | Crop | WR (mm) |
|---|---|---|---|
| Tomato | 600-800 | Potato | 500-700 |
| Cabbage | 380-500 | Onion | 350-550 |
| Cauliflower | 380-450 | Broccoli | 250-400 |
| Bean | 300-500 | Citrus | 900-1200 |
| Banana | 1200-2200 | Pineapple | 700-1000 |

## Effective management of water in vegetables and fruit crops

Effective management of water for crop production in water scarce areas requires efficient approaches. Use of micro irrigation in India has played major role in terms of water saving and increasing yields and quality of the produce as compared to the conventional methods of irrigation. In conventional surface method of irrigation water use efficiency is only about 35-40%. But drip and sprinkler irrigation methods have more than 80% of water use efficiency. With limited and scarcity of water, drip irrigation has proved its effectiveness over traditional methods of irrigation in terms of water saving, higher yield, and higher water use efficiency (WUE). Various research studies conducted in India has shown 30-70 % in the water saving with 5-50 % increase in the crop yield with drip irrigation for various crops.

## Modern Irrigation Methods

- Drip
- Sprinkler
- Micro sprinkler

### Characteristics

- Low flow requires good filtration
- Reduced application losses
- Reduced runoff
- Controlled application

## Micro irrigation for water management in hill agriculture

Drip irrigation has ability to provide small and frequent water applications directly in the vicinity of the plant root zone (Fig 2). Drip irrigation system is preferred for the crops having high commercial value, and for the commercial production of vegetables flowers and fruit crops due to their high economic return. In addition to above advantage drip also reduced the weeding problem, the cost of labour and it also saves a lot of water as it is applied in the root zone only. Table 2 shows the different crops grown under drip irrigation system

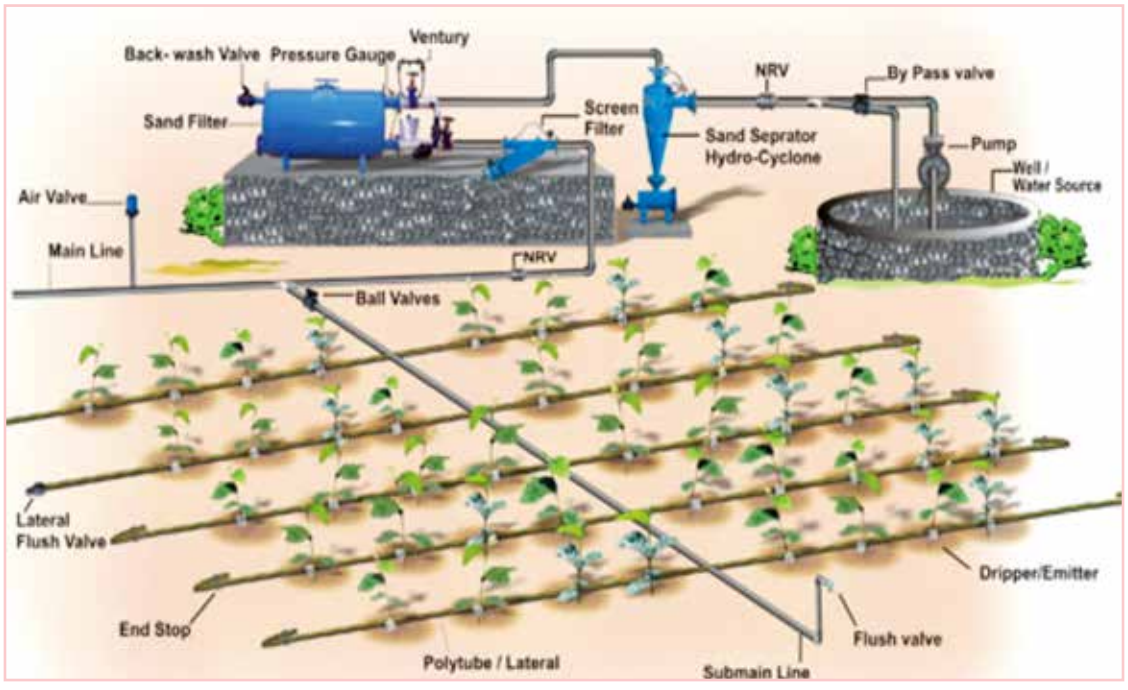


**Fig 2. Conventional drip irrigation system**

**Table 2 shows the different crops grown under drip irrigation system**

| S. No. | Particulars |
|---|---|
| 1. | **Vegetables**: Tomato, Chilly, Capsicum, Cabbage Cauliflower, Broccoli, knolkhol, Onion, Ridge gourd, Bitter gourd, Cucumber etc. |
| 2. | **Cash crops**: Arecanut, Coffee, Tea, Sugar-cane, Rubber, Strawberry, Spices, Turmeric |
| 3. | **Flowers**: Rose, Carnation, Gerbera, Anthurim, Orchids, Jasmine, Lily, Mogra, Marigold. |
| 4. | **Orchard crops**: Banana, Pomegranate, Orange, Citrus, Mango, Lemon, custard Apple, Grapes, papaya, Guava, Passion fruit etc. |
| 5. | **Oil-seeds:** Ground-nut, Sunflower, Coconut, Oil palm etc. |
| 6. | **Forest trees**: Teakwood, Bamboo, Casurina, Ucalyptus etc. |

## Water management in floriculture crops:

The north eastern states of India offers a most excellent habitat for almost all types of flowers due to extremely congenial climate. Region has the vast potential for the growth of commercial floriculture and may boost up the income of farmers by many fold in future. This region belongs to tropical to temperate climate which offers to grow traditional to non-traditional flowers and have a great opportunity for employment generation. The Horticulture Mission has played the vital role in augmenting floriculture development on these regions. Water management through micro irrigation for growing of floricultural crops can improve the yield and quality of flowers and net economic return to the farmers. Percent increase in yield and water saving in drip irrigation compared to surface irrigation for vegetable crops are shown in Table 3.

**Table 3. Percent increase in yield and water saving in drip irrigation**

| Crop | Increase in yield (%) | Water saving (%) |
|---|---|---|
| Potato | 20-30 | 0-60 |
| Tomato | 25-50 | 40-60 |
| Cauliflower | 60-80 | 30-40 |
| Cabbage | 30-40 | 50-60 |
| Okra | 25-40 | 20-30 |
| Brinjal | 20-30 | 40-60 |
| Chilli | 10-40 | 60-70 |
| Bottle gourd | 20-40 | 40-50 |
| French Bean | 55-65 | 30-40 |
| Pomegranate | 20-40 | 50-60 |

## Gravity fed drip irrigation system

Gravity drip irrigation system is the energy saving method in which the water is channelized and distributed through network of small diameter PVC pipes through gravity and directly applied in the root zone of crop, through emitting device at a low pressure. Gravity drip irrigation system resembles like conventional drip irrigation system and consist almost all components except water lifting pump and motor/engine.

## Suitability of gravity drip irrigation

- Gravity drip irrigation method is best suited in water scarcity areas
- Method is also applicable in low to marginal salty water areas
- Suitable to almost all soils & crops except rice, wheat
- Suitable to undulating topography soil, slope areas with limited depth of soil.

## Components of gravity drip irrigation

Gravity drip irrigation system can be divided into 5 parts

1. Water source and storage tank: Water is carried to the storage tank through gravity fed PVC pipes from spring or diversion of spring water and can be stored in plastic or concrete tank. From storage tank water is distributed through network of pipes
2. Water distribution system: It consists of main line, sub main and small diameter plastic tubing called laterals

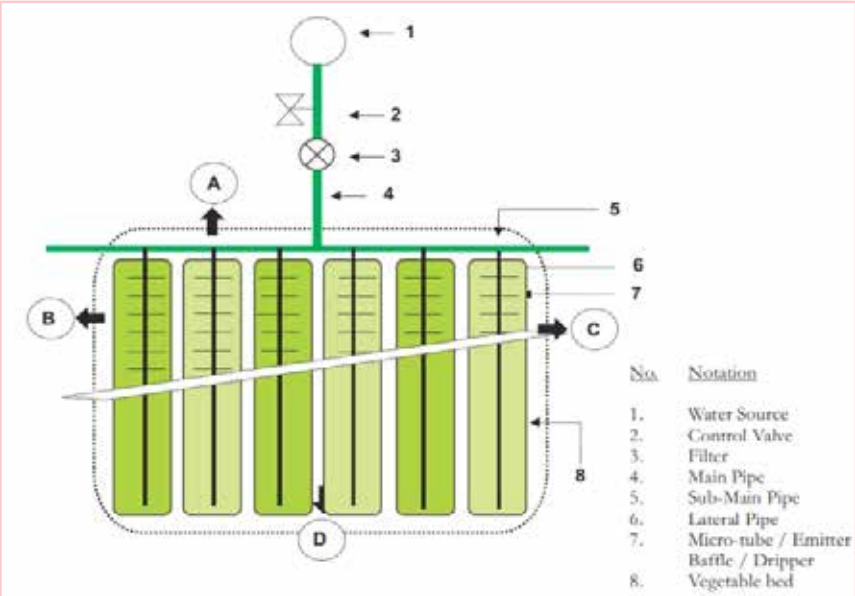


**Fig. 3. General layout of Gravity fed drip irrigation system**

3. Control valve: mostly ball valve, air release valve, flush valve

4. Filtration unit: Screen filter, Mesh filter, Disc filter etc. type and quality of filter depends the quality of water, and water flow in the system

5. Water application devices: water application devices called emitter/dripper

General field layout and various components of low cost gravity drip irrigation system are shown in figure 3 and 4.


**Fig. 4. Components of low cost gravity drip irrigation system**

**Fig. 5. Gravity Drip Irrigation on Terraces of CAEPHT, Sikkim**

## Advantages of Low Cost Micro Irrigation

- ✓ Affordability
- ✓ Improved Yield
- ✓ Water Saving
- ✓ Labor Saving
- ✓ Fertilizer Saving
- ✓ Energy Saving

- ✓ Difficult Terrain
- ✓ Tolerance to Salinity
- ✓ Improved Crop and Disease Control
- ✓ Reduced Cultivation Cost
- ✓ Application to Variety of Crops

## Conclusion

Use of micro irrigation in the hilly region of the north eastern states of India has immense potential for increasing yield and quality of the horticultural crops per unit of water. It is possible to bring more area under irrigation with less available water. Micro irrigation has proved its effectiveness over traditional methods of irrigation in terms of water saving, higher yield, and higher water use efficiency. Use of these modern water application technologies along with various water saving devices will be useful for achieving more crop and income per drop of water. Promotion and adaptation of efficient water management techniques will not only increase crop water productivity but also economic condition of the farmers of the north eastern states.

# 9. Orchids: The indicator of climate change

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Orchids belong to the angiosperm family Orchidaceae and are known for their extremely beautiful flowers with gorgeous colour, unique shape, ornamentation and prolonged self-life. The complex floral structure to facilitate biotic cross pollination makes them evolutionarily more superior from other plant families. The exchange of genetic material due to cross pollination leads to development of extreme genotypic variability which can be observed through their phenotypic expression. Presence of a modified third petal (lip/ labellum) and union of stamen and pistil (Gynostemium/ column) differentiate them from any other plant family. Their minute, non-endospermic seeds cannot germinate without external supply of nutrients.

The family Orchidaceae is amazingly diverse in forms, exhibiting incredible range of variability in vegetative structure or plant body, flower shape, colour and size etc. To survive in wide range of climatic condition, orchids possess highly specialized structures for felicitating pollination; water uptake and storage; and association with specific fungi to fulfill nutritional need (for non-endospermic seeds) during

seed germination. In spite of all the adversity, Orchids have maintained their dominance and successfully spread throughout the world. This can be attributed to the following facts:

1. More than 60 percent of Orchids are epiphytic where competition with other plants is less. The epiphytic habitat from ground to high in the tree trunk and branches provide numerous micro-climates to support the different varieties of orchids.
2. Orchids produce millions of minute, ultra-light seeds that can be dispersed to a long way by wind.
3. Cross pollination induce genetic variability and more rapid speciation.
4. Effective vegetative mode of propagation.
5. Orchids have specialized structure to attract the pollinator (even if they are few) ensuring the pollination and fruit setting.

Orchids possess immense horticultural and medicinal importance apart from being a model for study of evolutionary biology and climate change phenomenon. The phylogeny and relationship of orchids has largely been worked out because of its wider distribution, clearly expressed phenotype and adaptability to alternate habitat condition. In order to facilitate the pollination, the orchids have to offer something to the visiting pollinator to lure and invite to make the pollination happen. For this, they develop specialized structures like callus, lamellae, spur, nectarines etc. and guide the pollinator to the pollen mass. Sometimes, they mimic various animal creatures [called as spider orchid, bee orchid, pigeon orchid, moth orchid, soldier orchid etc.] to make the pollination possible. Thus, apart from the high horticultural and medicinal value, orchids are a subject of botanical research in which all experts of biology try to decode the secret of its huge diversity.

## How climate change is a threat for orchids?

Orchids inhabit fragile ecosystem; are extremely sensitive to their micro-environment and their reproduction largely depend on the availability of pollinators and suitable mycorrhiza. With the alarming scenario of global warming due to climate change, the nature is facing high ecological imbalance. The components of eco-systems (even at micro-climate level) are highly disturbed. In-spite of having all the evolutionary superiority, orchids are finding it hard to survive in this situation. To obtain the desired temperature, the orchids are gradually shifting to higher altitude or at their natural habitat getting the required temperature early to flower, thereby shifting the phenology other than the normal time. In both the situation, desired pollinators are not available, resulting in no pollination and no fruit setting. Even if the pollination is successful and fruit is set, the seed germination again depends on the availability of suitable mycorrhiza. This has a severe impact on seed reproduction and spreading of orchid species. This climate change scenario, coupled with the other threats has pushed many valuable orchid species under various degree of threat.

## Orchids as candidate for climate change studies

**An insect with pollen load visiting the flower of *Dendrobium densiflorum* Lindl.**

The impact of climate change can be clearly derived through a methodically designed study on past and present distribution of orchids. Comparative record of past and present data on distribution, altitude and phenology of orchids can provide a very good tool for climate change study. Study on Indian orchids since nearly two decades have given clearly visible effect. Many species have been observed to have shifted flowering periods and many have been observed in shifted altitude. Having the lead from such indicator species, one experiment can be designed by taking orchids as candidate group for climate change studies. The growth, survival, phenology, pollination, seed setting, pollen and seed viability etc. of orchids can be studied in simulated condition in different temperature regime and correlated to past and present climatic temperature in the natural habitats. This can prove that the changing climate has an impact on survival of species. Climate change is a continuous process and cannot be stopped, but we can save our valuable genetic resources through proper understanding and developing species specific modalities for their survival and adaptation to the changing climate.

# 10. Orchids Care: Phalaenopsis

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## Introduction

*Phalaenopsis*, also known as moth orchid, is an orchid genus of approximately 60 species. It is native to the Indo-China region, Southeast Asia, New Guinea and Australia. It is one of the most popular orchids in the trade at present and many hybrids have also been developed. Most are epiphytic, shade loving orchids while some are found to be lithophytic in nature. *Phalaenopsis* orchid possess neither pseudobulbs nor rhizome and shows a monopodial growth habit, meaning a single growing stem produces one or two alternate, thick, fleshy, elliptical leaves from the top while the older basal leaves drop off. The inflorescence of *Phalaenopsis* orchids is either a raceme or panicle and they bloom for several weeks. Under cordial conditions, flowers may last for two to three months. This orchid is commonly used as pot plants and cut flowers. The clarity and glamour of the *Phalaenopsis* flower makes it ideally special for interior adornment, bouquets, functions, birthdays, weddings, funeral etc.

## Environmental factors

### Temperature

The *Phalaenopsis* orchid is basically a tropical plant and performs best in warm and humid environment. However, they can adapt well to lower humidity and conditions found in most homes. But temperatures lower than 10˚C and higher than 35˚C should be avoided. An average temperature range of 27-29˚C during vegetative phase and 20-25˚C during flowering is ideal. If spiking plants are exposed to fluctuating temperatures or above 27˚C for extended periods, the spike can turn into a keiki or the bud may be aborted.

### Light

*Phalaenopsis* is a shade loving orchid. In nature, many are found to grow below canopies, away from direct sunlight. High light can cause sun burn. 75% shade net is ideal for cultivation. In greenhouses, 75000-15000 Lux is recommended. Good light during winter and avoidance of direct sunlight during summer should be ensured. Generally, the leaves are olive green; dark green means the plant's not getting enough light and too much light causes leaves with red tinge. Too much shading (below 75000 lux) can delay spike initiation, reduced number of spikelet and length of the spike.

### Humidity

Humidity is important for the good performance of *Phalaenopsis* orchids and 50-80% is recommended. Prolonged dry conditions causes premature bud dropping, shrivelled leaves, stunting of plants etc. In greenhouses, humidity can be regulated by watering the planting area (benches, footpath etc.), humidifier, misting or placing trays with water below or around the planting area. However the trays should be cleaned from time to time to avoid algae growth and diseases. In homes, flower pot can be placed in a tray with pebbles, partially filled with water, so that the pot doesn't sit in the water completely. Indoor foliage plants can also be placed near the *Phalaenopsis* orchid to increase the humidity.

### Air circulation

Pots/plants should not be kept congested. Circulation of air is important to dry out the leaves. Good air movement in the growing area facilitates good growth and less pests and diseases attack. If natural ventilations are restricted, ceiling or stand fans can be used to provide good air circulation, with constant changing of air flow direction and without excess leaf drying.

## Cultivation

### Planting containers

Clay or plastic pots with broader base are mostly used by growers. But plastic pots are more preferred owing to the ease of use and durability. Roots of *Phalaenopsis* orchids tend to avoid darkness and thus, transparent pots are more preferred than dark or opaque ones.

**Potting Media:** An ideal potting media/substrate for *Phalaenopsis* should not let the plant topple, ensures adequate drainage, hold enough moisture, free of pests and diseases and porous enough to facilitate good root aeration. Good potting mixture includes coconut husk chips, wood chips, charcoal, brick pieces, gravel stones, cocopeat and sphagnum moss. But the growth of roots was restricted in media which retrained excess moisture. A potting media comprising only gravel stones and brick pieces was found to perform very well for *Phalaenopsis* planting. There was more root growth, probably owing to good root aeration, less moisture stagnation and above that, *Phalaenopsis* orchids are of both epiphytic and lithophytic nature.

**Potting:** Young *Phalaenopsis* plants should be acclimatized first to the local growing conditions before planting. These orchids require shallow planting and the base of the plant should at the level of the potting media. Care should be taken that the growing tips of the young plants should not be damaged during potting.

**Irrigation:** *Phalaenopsis* orchids doesn't prefer lavish amount of water. Over watering can kill the plant. Younger plants require more watering than the older ones. Irrigation should be provided when the pots are nearly dry. Care should be taken to keep the crown dry. Accumulation of water invites diseases and may create unfavourable growing conditions. During hot and dry months, 2 times watering in a week can be done and only 1 times per week during wet months and winter. Rain water is good for irrigation.

**Nutrition:** The most common type of nutrient used for *Phalaenopsis* is the water soluble form. Diluted nutrient solutions applied frequently is better than concentrated applications. Depending on the growth phase, dose and frequency of nutrient application is managed. Plants in the vegetative phase require one application per week of 20:20:20 NPK 200ppm nutrient solution while exhausted plants, after flowering, require twice application of 100ppm nutrient solution per week. The pH of the solutions needs to be maintained 5.2-6.2. In dormant periods, nutrient should be applied 50% less than the recommended dose.

**Repotting:** Repotting should be done when the plants have outgrown the growing container, media is loose, flowering is reduced, browning of the leaf tips etc. *Phalaenopsis* are best repotted after flowering in the late spring or early summer. It should be done once a year in appropriate sized pots. The plant should be taken out of the old pot carefully, so as not to damage the actively growing root tips. Old and dried roots are cut off using sharp secateurs. Plants should be air dried before planting. It is then planted in a new pot with fresh media. Staking should be done, if required, to keep the plant stable.

# 11. Use of Plastic Mulch Laying Machine in hilly regions of Sikkim, India

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Portable Plastic Mulch Laying Machine is a manual appliance used for laying of plastic mulches in the fields or terraces in order to save the labor cost and precious time. The manual mulch laying machine was fabricated by the All India Coordinated Research Project on Plastic Engineering Technology, CAEPHT, Ranipool (Sikkim) Centre. The machine rolls a very thin mulch film with 4 feet width on a raised bed. The two furrow openers made up of mild-steel flat were attached to the machine for soil inversion on plastic mulch sheet from two ends along its length.The dimensions of the machine are as follows: Length 175 cm, width 140 cm. A metallic handle is also provided for manual pulling of the machine. The mulch film of upto 25 microns is suitable for almost all types of vegetation and horticultural crops. The approximate manufacturing cost of the mulch laying machine is about Rs 3000. The total cost of plastic mulch roll (4 feet wide and total length of plastic sheet - 400 m) is about Rs. 3200 (Three thousand two hundred) only. There is a provision of subsidy of about 90% on the use of different kinds of plastic mulches to the farmer's from the northeastern region of India. All the activities of the local centre of the AICRP on PET at Ranipool is fully funded by the Indian Council of Agricultural Research, New Delhi with the project headquarter at the ICAR-Central Institute of Post Harvest Engineering & Technology (CIPHET), Ludhiana (Punjab).

The portable mulch laying machine is recommended for use on the terraced lands of hilly regions of Northeast India. Recently, one day off-campus training was organized at the Arithang Chongrang GPU, Tashiding, West Sikkim. The use of the machine was shown to the progressive farmers of Arithang Chongrang GPU in a poly-house located in one of the farmer's field during one-day off campus training programme (see Photo 1). The famers of the Himalayan state are extensively using the plastic mulches for the cultivation of the Cherry Pepper. Therefore, the machine may be highly beneficial to the growers of the Cherry Pepper in Sikkim.

# 12. Abhishek - A high yielding variety of rice for Sikkim (success story)

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**Introduction**: The northeastern state of India, Sikkim is a tiny hilly state located at the foothills of the Himalayan range and is often referred as the 'Nature's Paradise' for its scenic beauty. Nestling in the Himalayan mountains, the state is characterized by mountainous terrain. Almost the entire state is hilly with elevation ranging from 280 m to 8586 m. For the most of the part, the land is rocky and makes it difficult for agriculture but the hill slopes have been converted into terrace for farming. The state has five seasons: winter, summer, spring, autumn, and a monsoon season. Sikkim's climate ranges from sub-tropical in the south to tundra in the north. Most of the inhabited regions of Sikkim experience a temperate climate, with temperatures seldom exceeding 28 °C in summer. The average annual temperature for most of Sikkim is around 18 °C.

Bestowed with varied agro-climatic condition, Sikkim produces some of the major crops such as cardamom, ginger, turmeric, off-seasons vegetables, flowers, kiwi, paddy, maize and millets. But the farmers of Sikkim are always inclined towards rice cultivation. The cultivation of rice has rather become like a tradition for the people and every year with the onset of monsoon marks the importance of rice cultivation for the Sikkimese people. A large number of landraces of rice both dryland and wetland was cultivated but almost all paddy landraces are now slowly disappearing. The reasons for the disappearance can be cited many like lack of conservation methods, low productivity, introduction of High Yielding varieties *etc.*

## Need of new technology

Considering the current scenario, rice is the staple food grain in Sikkim next to maize grown exclusively during kharif season. The rice productivity of Sikkim is at a very dismal figure of average 18 quintal $ha^{-1}$. In order to meet the future food demands for the teeming population of the state, it is vital to give much emphasis on enhancing rice productivity through introduction of new high yielding rice varieties.

Most of the farmers now-a-days are hesitant to take up rice cultivation as its total factor of productivity is declining and its profitability is in question with the rise in input costs. Hence new innovations and initiatives are required to make rice production system more sustainable and economically profitable. Under these circumstances, introduction of highly improved and high yielding varieties which performs well under Sikkim condition is one of the good options. Keeping view upon this, Krishi Vigyan Kendra,

North Sikkim, Mangan has taken up Front Line Demonstration (FLDs) to check the suitability of paddy variety adaptable for the local farming community and the programme was successfully demonstrated by introducing a high yielding variety of paddy "Abhishek" from CRRI, Cuttack.

## Implementation of Technology

Abhishek was selected to demonstrate its productivity potential through System of Rice Intensification (SRI) and Organic Nutrient Management to test its adaptability. Demonstration was performed at KVK farm for On Station Trial (2014) followed by FLDs at different villages of Lower Dzongu area during two consecutive seasons (2015 &16) and the seeds were also sent to other districts of the state to test for its adaptability in the third season (2016).


Unlike other varieties, with a gestation period of 135-140 days, this variety was ready for harvest by only 115-120 days. Even if there was delay in transplanting due to delay in harvest of previous crops or late release of water in the seasonal streams, the crop could be harvested with good yield. Such delay would have adverse effect on other varieties. Due to its early maturing character, its water requirement was also less, therefore can be grown even under rainfed condition.

| Name of the farm/farmers | Location and year | Planting situation | Days to maturity | Yield (q /ha) |
|---|---|---|---|---|
| KVK Farm, Mangan | Mangan /2014 | Upland | 115 | 22 |
| Mr. Pemkit Lepcha | Phidang, Dzongu / 2015 | Irrigated | 115 | 32.7 |
| Mr. Sonam Doma Bhutia | Ramthang / 2016 | Irrigated | 118 | 30 |

The taste of rice was good, bold in nature and is liked by the people. Yield was significantly higher than any other varieties used by the farmers. Being impressed by the successful trials, the farmers are interested to take up the variety in large scale and some of the farmers of North Sikkim had already started purchasing the seeds from our beneficiaries and started growing in their field owing to its high productivity.

# 13. Homemade fertilizer for orchids

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Applying fertilizer to orchids is important. It provide nutrients for the survival, flowering and overall growth of the orchid plant. A strong plant with healthy stems, shoots, foliage and roots promotes good flowering and are less susceptible to pest and disease attack. Orchids flourish well when they are given a proper balance of Nitrogen (N), Phosphorous (P) and Potassium (K), preferably fed in a water solution. These three nutrients are known as macro-nutrients (NPK). Nitrogen is essential for the vegetative growth, Phosphorus for a strong and healthy root growth and Potassium promotes flowering. Nowadays, many commercial fertilizers, with balanced nutrients, are available. But in areas or places where these commercial fertilizers are difficult for easy procurement, these homemade fertilizers might go a long way.

Some of the most common and popular homemade orchid fertilizers are tea, milk, crushed fish or chicken bones, potato, molasses, egg shells, epsom salt (Indian rock salt/sendha namak) and rice water.

### 1. Tea (Provides Nitrogen)

Used tea bags are high in nitrogen. Tea bags contain organic matter that is nontoxic and does not smell bad. To use the tea bag, open it and empty the contents into the orchid pot. Wet tea bags should be dried first. Apply once in a month in the spring and summer months.

### 2. Milk (Contains Nitrogen, Potassium, Magnesium, Calcium)

Milk is not only a wholesome food for us but surprisingly contains nitrogen-building protein that orchids require. Mix one part of milk to four parts of water and feed this to the orchids every two weeks.

### 3. Crushed fish or chicken bones (Contains Phosphorus and Calcium)

Grounded dry bones or bone meals are a good organic source of phosphorus and also provides calcium to plants. The bones should be properly dried first and crushed into powder. This can be sprinkled over the potting media.

### 4. Potato (Provides Potassium and traces of Phosphorus)

Cut potatoes into small pieces, including the skin, and boil for a few minutes. We can also add little amounts of chopped fresh bananas and sugar to this mix during boiling. This will add even more nutrients and will help the ingredients to bind together. Cool the solution and irrigate the orchids. Extra solutions can be stored in jars.

### 5. Molasses (Provides Potassium)

Dissolve about 5 grams (1 teaspoon) of molasses in water and use in the normal watering of the orchids.

### 6. Egg shells (Contains calcium)

Collecting egg shells and using them as orchid fertilizer is the cheapest and most efficient way to provide calcium in orchids. Crush the egg shells into pieces as small as possible or grind them into a powder. Sprinkle it on the medium in the pot.

### 7. Epsom salt (Contains Magnesium)

Magnesium is required for chlorophyll making in the plants. Dissolve about 2-5 grams epsom salt in a litre of water and feed the orchids.

### 8. Rice water

Water used for washing rice can be utilised for providing extra vitamins (niacin, thiamin, riboflavin, and folic acid etc.) to the orchids.

**Precaution about Nitrogen in orchids:** One thing to remember when making homemade orchid fertilizers is that orchids need a fertilizer that is higher in nitrogen, during the vegetative stages, than ordinary household plants. This is because an orchid's potting medium usually consists of tree barks, stone gravels, brick pieces etc. The bark is home to bacteria that consume a lot of the nitrogen in fertilizers, leaving very little for the orchid itself, so the orchid fertilizer needs to compensate for this.

Another important point is that, nitrogen should not be obtained from urea. Fertilizers containing urea are good for common household plants with their roots in soil because the urea is slowly broken down by bacteria in the soil, releasing nitrogen for the plants. As orchids are not grown in soil the urea is not broken down and thus the nitrogen from urea remains unavailable for the orchid.

## Important points to be noted

- Provide nutrition to your orchids with a diluted solution of fertilizer once a week or on alternate watering.
- Homemade orchid fertilizers are very easy to make but it's difficult to be certain of the precise level of nutrients that these fertilizers are providing for your orchids.
- So, if you are unsure that your orchids will thrive very well with the homemade fertilizers, give a trial run on your least favourite or very commonly available orchids.
- Watch your plants carefully and take note of the good and bad reactions.
- Flush the orchid pot thoroughly once a month, with plenty of water, to wash out any buildup of fertilizer salts that may have occurred.
- In nature, orchids are fed with whatever is dissolved in the rainwater. Harvesting rainwater all the time may or may not be an option depending on where you stay, but most of us are going to have access to milk, tea, chicken/fish bones, rice and potatoes.

# 14. Application of GIS in Orchids diversity of Sikkim

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GIS is one of the newly maturing concepts with technological developments, have been used in particular application areas in the world, but it has been used in our country only in recent years. The use of GIS is becoming more and more important in a strategic area concerning entire living beings whose lives depend on totally ecological conditions like agriculture, Hardware, map module, software including data base module and methods which provide solution for complicated planning and method problems, storing, modeling, processing, analyzing and presenting the spatial data connected to location are being developed with this system consisting of hardware, software and users on the purpose of acquiring, storing, processing, analyzing the data belonging to geographical beings and reacquiring, presenting new data from the produced information. GIS are very important in terms of determining crop pattern and parcel land and suitability of crops growing and also important for floriculture and agriculture in terms of providing characteristics of the land in advance such as climatic data, cultivated land, distance to water resources, suitability for irrigated farming, slope and soil depth of agricultural land, erosion risk depending on slope, drainage and soil salinity, risk of frost. Therefore, there may be more conscious farming and many parameters can be improved positively such as better products, more efficiency and resistance to harm and plant diseases by means of GIS.

Applying the GIS becomes much more important for the fields such as agriculture which depends on totally ecological conditions and requires people to invest through long years.

Talking about orchids, it belongs to the most highly evolved in the floral specialization and diversified form among the monocotyledons. It is estimated that at about 25,000-35,000 species with 800-1,000 genera are distributed throughout the world.[1]

Works have been carried out by Sperduto & Congalton (1996) research work on 'Predicting rare orchid (small whorled Pogonia) habitat using GIS'*in New Hampshire and Maine due to its historic and extent location of Isotria medeoloides*.GIS was used to facilitate locating potential habitat. Physical characteristics like soil, digitization of site and habitat characteristics of each site was identified using GIS. Spectral data from Landsat Thematic Mapper, USGS DEM Data are taken into consideration for the study. The study was undertaken to investigate the ecology and distribution of *Isotria medeoloides* populations in New Hampshire and Maine, and to predict potential habitat for the orchid. Three classes of restrictive

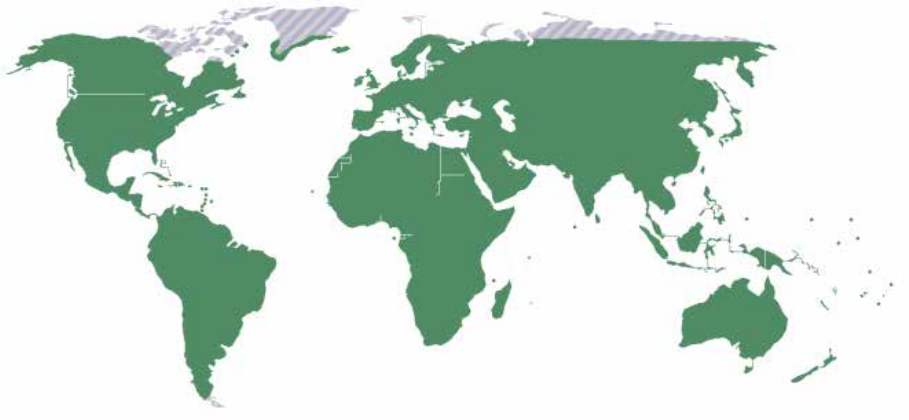

**Fig1: Worldwide distribution of Orchid**

[*Source: Wikiwind.com*]

layers were identified in soils at the 27 sites. Twenty-three percent of the sites had deep soils and lacked an impervious layer, 27 percent had shallow bedrock, and 50 percent had a pan layer.[2]

Another work has been carried out in China on Distribution and conservation of Orchid species richness by Zejin Zhang *et al* 'Distribution and conservation of orchid species richness in China', in this study they developed a database for all the 1449 orchid species in China. Using this database they explore patterns of orchid richness in relation to climate, net primary productivity and habitat heterogeneity in China. Then they evaluated the in situ conservation status of the orchids in China by overlapping the species distribution and the terrestrial national and provincial nature reserves (NNRs and PNRs) in China. Where they found that 90% of orchid species in China were distributed in 258,800 km2 (2.7% of China's landmass). Net primary productivity, elevation range, and temperature seasonality together explained 34.4% of variance in orchid richness. On average, NNRs covered 12.1%, NNRs and PNRs together covered 29.1%, of orchid distribution areas. However, there were still 154 (including 83 endemic to China) narrowly distributed orchid species not covered by NNRs; and 48 (including 28 endemic to China) were not covered by either NNRs or PNRs.[3]


**Fig2: Distribution of Orchid species in India**

[*Source: ESRI, arcgis.com*]

Work had been carried out by Jodi Goerzen *et al* (2003) on 'A Spatial analysis of rare native orchid habitat identification in Southeastern Manitoba'.The objective of the study is the potential identification of rare and native orchid sites in SE Manitoba, based on the attributes and habitat affinities of known native orchid sites within the same region, through the application of GIS software.

Benefits of this study include the possibility of finding and preserving additional populations of rare, native orchids in SE Manitoba, as well as potential refinement of existing known habitat affinities and attributes of rare, native orchid species with SE Manitoba. The project was done with the idea to prepare maps with more improved version which could make the researcher more applicable with more revised information.[4]

In India, Orchids form 9% of our flora and are the largest and highly advanced botanical family of higher plants i.e about 1300 species with 140 genera of Orchid species is found in India with temperate Himalayas as their natural home (Yonzone and Kamran, 2008)[5]. Using Satellite Remote Sensing and Geographic Information System by the Indian Institute of Remote Sensing and Department of Space (IIRS), Government of India priority sites identified in all the states of the region and accordingly, actions and strategies have been taken up. Institutions like Indian Institute of Spices Research and Indian Institute of Horticulture Research are actively involved in using DIVA-GIS for preparing biological richness maps of commercial orchid species(De & Medhi,2014)[6].

Works have been carried out in Sikkim,India by D. Barman *et al(2011)* on 'A Geospatial approach to Diversity of *Cymbidium* Swartz in Sikkim' where a research has been carried out to identify the diversity of *Cymbidium*. The majority of species of this genus in India are located in the Eastern Himalayas. Seventeen species of *Cymbidium* have been collected from the 132 sites of Sikkim. A GIS approach was taken in to consideration with keeping the environmental parameters of rainfall, temperature and altitude, and their relation to the distribution of the species in mind. The species diversity and richness was studied with point to point grid analysis of DIVA GIS. The results indicated that altitude and rainfall are the most important factors influencing the distribution of *Cymbidium* species. High richness was found in the altitude between 1500-2000 MSL. 1500-3000mm. precipitation is optimum for high concentration and diversity of the species[7].

Especially talking about Sikkim, Sikkim is one of the few states of the Republic of India that has an Orchid as its State Flower – the *Dendrobium nobile, Lindl.*

With its peculiar geographical environs, this region in the Eastern Himalayas, records more than 4000 species of flowering plants, many of which are rare and endemic to the State only. The major climatic zones in Sikkim are Tropical, Sub-Tropical, Sub-Temperate, Temperate, Dry-Alpine and Wet-Alpine. Through deep valleys the hot and moist Tropical climate penetrates right into the heart of Sikkim State, providing hotter southern and cooler northern slopes. The unique geographical features having wide range of altitudinal zonations, rich humidity percentage in the air and the high range of precipitations, makes the Sikkim state, pockets of many microclimatic niches, harboring rich flora and fauna diversity differing from one valley

to another. The orchid diversity in Sikkim is so diverse and rich that its total number of species is yet to be assessed properly and this study does not claim to have surveyed and sampled all the forest and woodland areas of Sikkim. There are still good chunks of virgin lands in Sikkim yet to be explored to unfurl the richness of its biodiversity. Most of the Sikkim orchids are beautiful but short lived. But there are species like *Cymbidium eburneum*, *C. hookerianum* and *C.irridioides* which were under exploitation since time immemorial and have been the mother plants of today's modern Cymbidium hybrids. It is needed to find out the changes in the characteristics of the short lived orchids and also to map down the different species of orchids which are easily found at Sikkim. So, it will be easy to detect the changes and to study about the orchids in future. GIS is a method to see the real world objects along with their location. GIS can easily map all the areas where orchids where are known to grow. All the species can be spatially drawn and represented. Along, with GPS instrument. GIS is needed to map the orchid blooming and its origin[8].

It is high time that one should realize the importance of our rich orchid's diversity and act sensibly, giving due thought over increasing the technology and progress according to the need. Orchids are very sensitive to ecological changes. Therefore it is very urgent to protect these valuable orchids and traditional knowledge for further study of their properties. The diversity of Orchid's in Sikkim is still needed to be explored and study[9].

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# 15. Phyto-resources of Sikkim Himalaya and their sustainable utilization - Role of IBSD, Sikkim Centre

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Sikkim is hilly state located in the western end of the Eastern Himalayas with geographical area of 7096 sq. kms. It covers just 0.2% of geographical area of country while harbouring nearly one fourth of the total flowering plants of India. Though measuring 65 km wide to 115 km length it encompasses altitudinal range from mere 230 m to as high as third highest mountain Kangchendzonga (8585m). Sikkim receives a heavy rainfall due to its closeness to the Bay of Bengal. As general trend, there is decrease in temperature with increase in altitude. The climatic conditions from cold & wet conditions provide uniqueness to Sikkim and make it rich in biological diversity mainly flora, fauna and unexploited microorganisms spread across the sub-tropical to alpine geographical regions of the state. More than 5000 species of angiosperms, 515 Orchids, 36 Rhododendrons, 23 Bamboos, 60 Primulas, 11 Oaks, 424 Medicinal Plants, 16 Conifers, 370 Pteridophytes, 150 Mammals, 552 Birds, 48 Fishes and over 690 Butterflies are found in the area.

Sikkim state being a part of inner ranges of the mountains of Himalaya is devoid of open valley and plains and remained largely unexplored due to its geographical remoteness. Sustainable utilization of phyto resources of this region provides an opportunity for local development (Purohit, 1997). Use of Sikkim's medicinal plants in Ayurvedic and Tibetan medicines their status and cultivation techniques have been studied by many workers like Rai and Sharma (1994), Nautiyal (1995), Sharma *et al.* (1995), Singh (1995), Trogawa *et al.* (1995), Tsarong (1995) and Rai *et al.* (2000). But yet research and development activities for economic development of the region largely remained low. With these objectives, the Institute of Bioresources and Sustainable Development, (IBSD) Sikkim Centre was established during March, 2009 under the aegis of Department of Biotechnology (DBT), Ministry of Science & Technology, Government of India as a regional centre of its head quarter at Imphal, Manipur. The objective of the institute is to develop and utilize the rich bioresources of Sikkim Himalayan Region through scientific intervention for socio-economic benefits of the people of Sikkim. Capacity building (human resource development) in bioresources conservation & management and biotechnology so as to generate technological packages for entrepreneurship development in biotechnology-related business and employment generation in the region is an integral objective of the institute. It is proposed to set up micro-enterprise for entrepreneurship on low-cost viable rural technology so as to generate employment from available bioresources with

other activities to bring about sustainable development of the target area. State-of-the art biotechnology research laboratories have been set up for plant tissue culture, molecular biology and microbiology with emphasis on fermentation microbiology with the procurement of essential scientific equipments for biotechnology research facilities for sustainable development and utilization of bioresources (plants and microorganisms) of the Sikkim Himalayas. A few phyto-resources specific to Sikkim have been identified and targeted with following objectives:

- Survey and collection of some selected medicinal and aromatic plants (*Panax* spp, *Swertia chirayita*, *Valeriana jatamansi*) with global importance has been started with optimization of agrotechnique for *ex-situ* cultivation of medicinal plants.
- Characterization of the *Swertia chirayita* and *Panax* spp. of the Sikkim Himalayas by ecological evaluation, adaptation during *ex-situ* cultivation and molecular techniques.
- Genomics and proteomics approaches to understand the regulation of important biosynthetic pathways of the targeted medicinal plants from Sikkim Himalaya.
- Conservation and Bioprospection of high priority medicinal and aromatics plants of the Sikkim Himalayas for sustainable utilization.

To raise the awareness on the rich bioresources of the region and the modern tools for characterization and conservation of these Bioresources, routine programs with involvement of farmers and stakeholders are being organised in the form of training program with field demonstration, etc. by organising training programme on conservation through cultivation and sustainable utilisation of local bioresources for societal upliftment program. With its initiation in March 2009 the IBSD, Sikkim Centre is slowly emerging as an important R & D institute in Sikkim and is poised to shoulder its responsibilities towards its deliverables in a more prolific way towards bioresources based research in the region.

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# 16. Prospects of indigenous microbial strains for bio-control potential and biofertilization towards sustainable and organic farming practice in Sikkim

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Agriculture is considered as the main source of economic stability and food security of sizeable native population of Sikkim. Almost 80% of rural population of the state depend on agriculture for financial and nutritional requirements [5]. Dependence of entire population of the state on agricultural output with very less cultivable area puts a tremendous pressure on the agriculture sector to produce higher amount of food products. Although, agricultural practices using inorganic fertilizers, pesticides, and other amendments, are the most preferred method to overcome specific soil constraints and increase food production, it may not be applicable to the state of Sikkim as it has recently been declared as an organic

state and use of chemicals in agriculture is strictly prohibited. Moreover, numerous reports indicate that overuse of some of the fertilizer and pesticides pose a potential risk to humans and other life forms and development of microbial resistance to conventional chemical pesticides due to selection pressure has resulted in adverse effect to the environment. Considering the negative impacts of inorganic compounds, the agriculture sector is turning towards the use of alternative and environment friendly bio-pesticide and bio-fertilizer formulations of plant and microbial origin [7]. Antimicrobial agents/compounds derived from microorganisms are effective against specific pathogens and are easily biodegradable unlike chemical compounds. Consequently, antimicrobial products of microbial origin have found a considerable interest in integrated pest management programmes [3]. Some of the commonly used bio-control agents in India are Neem, *Bacillus thuringiensis,* Nuclear *polyhedrosis virus (NPV), Beauveria, Trichogramma, Trichoderma and some other species of bacteria and fungi. On the other hand, b*io-fertilizers play a very significant role in improving soil fertility by fixing atmospheric nitrogen, solubilising insoluble soil phosphates and producing plant growth substances in the soil. Bio-fertilizers are the preparations containing cells of microorganisms which may be Nitrogen fixers, Phosphate solubilizers or organic matter decomposers. *Rhizobium*, *Azotobacter, Acetobacter, Azolla, Azospirillium,* etc. are well known for their ability to fix atmospheric Nitrogen. Phosphate-solubilizing microorganisms (PSM) include a wide range of symbiotic and non symbiotic organisms, such as *Pseudomonas*, *Bacillus*, and *Rhizobium* species; actinomycetes; and various fungi-like Aspergillus and Penicillium species [15]. Apart from these, some of the microorganisms are known for their ability to promote plant growth by producing certain hormones and siderophores [2].

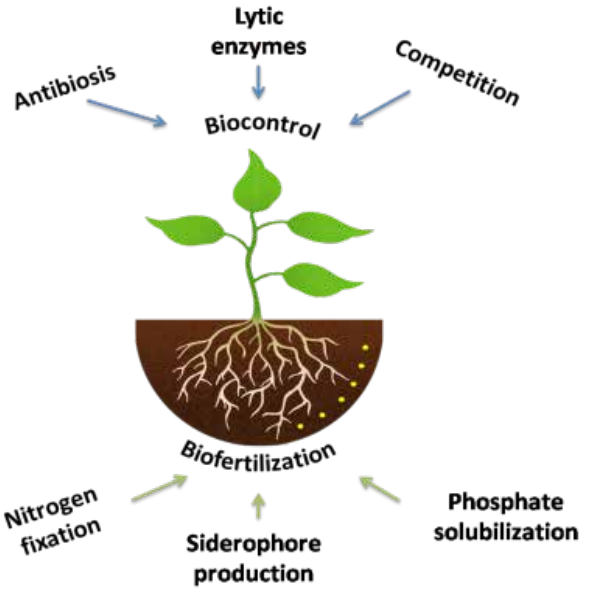


**Fig. 1 Mechanisms involved in Biocontrol and Biofertilization**

Plant growth promoting rhizobacteria (PGPR) are beneficial bacteria which have the ability to colonize the roots and either promote plant growth through direct action or via biological control of plant diseases [11]. Among these, species of *Pseudomonas* and *Bacillus* are the most extensively studied. The principal mechanisms of growth promotion include production of growth stimulating phytohormones, solubilization and mobilization of phosphate, siderophore production, antibiosis, i.e., production of antibiotics, inhibition of plant ethylene synthesis, and induction of plant systemic resistance to pathogens [15, 8, 6, 16]. It is very likely that plant growth promotion by rhizosphere bacteria may be a result of combined action of two or more of these mechanisms as illustrated in Figure 1.

Interest in biological control has been increased in the past few years partly due to change in the public concern over the use of chemicals and the need to find alternatives of chemicals used for disease control. After nitrogen, perhaps the essential mineral element that most frequently limits the growth of plants is P, which is taken up from soil solution as phosphate (Pi, $H_2PO_4^-$). Although soils generally contain a large amount of total P but only a small proportion is available for uptake by the plants. On an average, most of mineral nutrients in soil are present in millimolar amounts but P is present in micromolar or even lesser quantities [10]. However, plants are well adapted to uptake of P from low concentration soil solution [9]. Therefore, it is presumed that the supply and availability of P to the root surface is influenced by the root and microbial processes. Phosphate-solubilizing bacteria have already been applied in the agronomic practices as potential bioinoculants to increase the productivity. The unexplored pristine vegetation of this region may house numerous microorganisms with varied functionality. Antimicrobial products and bio-fertilizers derived from indigenous microorganisms of the native place has an advantage over the exotic strains introduced from outside as the latter may lose their effectiveness when introduced to a new environment. Taking this scenario into consideration, focus was given on screening of soil samples of different ecological niches of Sikkim for actinomycetes as well as *pseudomonas* to investigate their ability to: produce inhibitory effect against fungal phytopathogens, produce phosphate solubilising potentials, produce siderophores and degrade various recalcitrant organic compounds. Several indigenous actinomycetes strains were encountered with potential antifungal activity against various fungal phytopathogens. Apart from antifungal activity, some of the strains have the ability to produce siderophores too. Some of the isolates also had the ability to degrade recalcitrant molecules like cellulose. Many *Pseudomonas* strains exhibited ability to solubilise insoluble phosphate *in-vitro* using Pikovskaya medium. The Sikkim Himalayan region is bestowed with biologically diverse organisms and this region requires extensive exploration to tap the microbial flora to mitigate the ever increasing demand for natural compounds of agricultural importance and obtaining microbial strains having unique and varied functionality cannot be rule out.

## Obstacle in use of microorganism in agriculture

Several hurdles may be prevailed before innovative biocontrol studies can be transformed to practical strategies. Some of them are; first, there are technical problems in the upscale production of microbes. Formulation into viable products with a long shelf-life is sometimes relatively problematic for gram-negative than for spore forming gram-positive bacteria. However, during the last years, a lot of progress has been seen for *Azospirillum* as well as for *Pseudomonas* isolates. A big obstacle is the registration procedure, which is often expensive and time-consuming[4]; especially, the costs of registration are the principal obstacles to the development of new products. Another challenge is that plant-associated bacteria especially those from the rhizosphere play an emerging role as opportunistic human pathogens [1]. It is important to exclude potential pathogenic bacteria in the early step of product development.

## Future prospects and challenges

Microbial inputs, capable of discharging varied functions in plants, would lead to promising resolution for a sustainable, environmentally friendly agriculture. While inoculants for plant growth promotion and biocontrol capability already exist, in the future, stress-protecting agents (stress conditions like those generated by salinity, drought, water logging, heavy metals, and pathogenicity) will be of emerging importance not only due to climate change but also due to societal needs. Furthermore, to improve food quality by microbial inputs is an important task to be taken into consideration. For all kinds of inoculants, microbial mixtures as multitasking inoculants are one alternative to overcome inconsistent *in vivo* effects. Evidently, the prospect of the industry producing microbial inoculants clearly lies on innovative business management, product promotion, extension education, and advancement in research. The area of plant growth will contribute considerably to making the twenty-first century the age of biotechnology by the development of innovative biological strategies in agriculture including involvement of efficient BCAs, Biofertilization as well as microbial consortium as multitasking inoculants. By employing molecular technologies and exploring new untapped bioresources, new efficient BCAs can be detected. As such, endophytes with a specific intimate interaction with plant system could be promising bioresources to further unveil the potential of untouched microbial flora of the region.

Keeping in consideration of Sikkim being an organic state, the farming practice to employ the indigenous microbial strains as biofertilizers as well as biocontrol agents holds paramount importance towards sustainable and environment friendly agricultural practice. By employing the hitherto untapped indigenous microbial strains it would enable to extract the potential of the rich microbial resources of Sikkim for the benefit of the society.

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