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Prospects and Production Technology of Lotus: A Review

Ali Haidar Shah[1*], Priyanka Thakur[1], Pooja Sharma[1], S R Dhiman[1], Rachel Vanlalhruaii [1], B S Dilta[1], Arvinder Singh[2], Nomita Laishram[2] R K Pandey[2], I T Nazki[4], , Yogendra Singh[3], Manish Kumar[3]

[1,3] Department of Floriculture and Landscape Architecture, Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (H.P) India
[2] Division of Floriculture and Landscaping, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Jammu, Jammu and Kashmir,180009, India
[4] Division of Floriculture and Landscaping, Sher-e-Kashmir, University of Agricultural Sciences and Technology of Kashmir, Jammu and Kashmir,190025 India

ABSTRACT

According to Rigveda, The lotus is the symbol of divinity or immortality in humanity. Lotus is an aquatic plant and is a perennial herb cultivated as an ornamental Lotus. There are two basic species viz.NelumbonuciferaandNelumbolutea belonging to the family Nelumbonaceae. The attractive yellow and pink flowers are mildly scented and offered to Gods traditionally. It is being propagated through seeds and rhizomes naturally. However, micropropagation through tissue culture has also been standardized using rhizome pieces as explants. It has long been revered for its ability to remain unsullied and pure, despite of its growing environment. Lotus was introduced from China to Japan and other nations and cultivated for more than 1000 years During geological changes, particularly when temperatures were low during the Ice Age, most plants in the northern hemisphere became extinct, but lotus flowers survived. Lotus occurs naturally in almost all parts of our country. In floriculture industry, it is being used as a cut flower, loose flower, and potted plant and in landscaping of ponds and huge lakes. Besides its floricultural uses, lotus is a plant where all parts viz. roots, stems, leaves, flowers and buds are commercially being utilized in food or for traditional medicinal purposes. It can be cultivated commercially by utilizing some pond management practices, fertilizer application etc. Improvised post- harvest practices can be utilized to reduce petal blackening after harvest.

Despite of having high economic importance not much attention has been given to the commercial cultivation of this crop in our country.There is a need to carry out research on the commercial cultivation of this crop under Indian conditions combined with organization of trainings to the farmers and entrepreneurs to take up its cultivation. Floriculture business is based on novelty and hence this forgotten traditional flower has again found its way in modern decorations where lotus has become a specialty today. There is a huge potential to use this flower in modern landscaping also where eco-tourism is coming up very fast and offers a unique business opportunity to the farmers. Simultaneously, there is a unique opportunity for converting the waste and barren lands into a profitable venture.

Keywords: *Lotus, production, rhizome, cut flower, loose flower, ponds.*

LOTUS SYMBOLIZES PURITY

In the representation of Lord Vishnu as Padma-nabha (Lotus navel), a lotus issues from his navel with Brahma on it. The Goddess Sarasvati is portrayed on a pale pink lotus. The lotus is the symbol of what is divine or immortal in humanity, and also symbolizes divine perfection. In Buddhism, the lotus represents the purity of the body, speech, and mind, as if floating above the murky waters of material attachment and physical desire. Lotus has long been revered for its ability to remain unsullied and pure, despite its environment.

The flower represents spiritual enlightenment, new beginnings, detachment from materialism, purity and calm, rebirth, wisdom, being ground, and remembering one's roots."There is hardly any symbolism in Indian poetry, sculpture, and painting more extensive than that belonging to the lotus flower and other parts of the plant," writes Thomas Kintaert, on the Cultural Significance of the Leaf of the Indian Lotus. The lotus was chosen as the National flower of our country because it enjoyed a significant presence in ancient traditions, scriptures, and mythology. The 'Bhagavad Gita' considers it a metaphor for detachment: Just as the lotus remains untouched by the muddy waters in which it grows, human beings should rise above worldly attachments.

**Corresponding Author: Ali Haidar Shah*
Email Address: shahhaidar605@gmail.com

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Introduction

Lotus is an important traditional flower crop of India and is cultivated in different parts of the world. Lotus belongs to genus *Nelumbo* having only two species i.e*Nelumbonuciferia&Nelumbolutea*[1]. Earlier, lotus was placed in the waterlily family, but now lotus has its own family *Nelumbonacceae*.

Origin and History

Fossils of the genus *Nelumbo* dates to the lower cretaceous period (145.5 million years ago). Between 145.5 million years ago and 65.5 million years ago, the lotus expanded its habitat and numbers. Lotus flowers are the earliest occurring angiosperm in the world. During geological changes, particularly when temperatures were low during the Ice Age, most plants in the northern hemisphere became extinct, but lotus flowers survived[2].

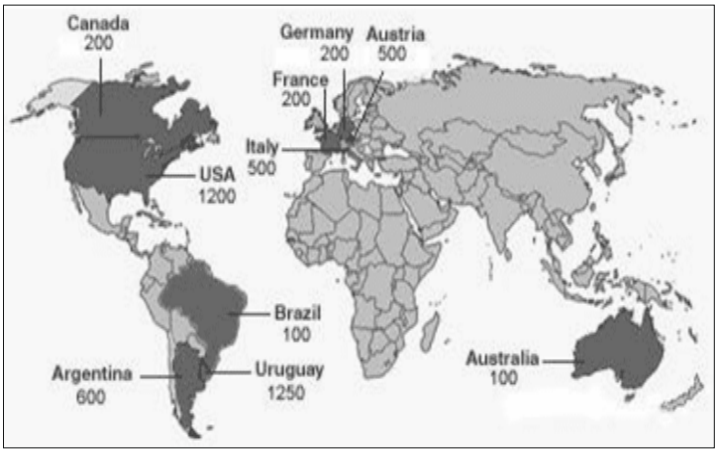
Species of Lotus

Lotus is an aquatic plant and a perennial herb cultivated principally as an ornamental. The lotus has two species:*Nelumbolutea* is indigenous to the eastern and central United States. *Nelumbonucifera* is native to Asia including the Philippines, northern Australia, Egypt and India.*Nelumbonucifera*known as Indian lotus, Sacred lotus, Bean of India, Simply lotus. It is native of South Asia and is widely distributed in Japan and china. *Nelumbolutea*, known as American lotus, Yellow lotus, Water-chinquapin, Volee. It is native to North America[3].

Status-Lotus Growing Areas of the World

The principal world regions where Lotus species are sown belong to South America, North America, and Europe, with 1.85, 1.39 and 1.38 million hectares respectively. In 2019, approximately 52.7 thousand metric tons of lotus were produced in Japan, a decrease compared to around 61.3 thousand tons in the previous year[4]

Production volume of lotus roots in Japan from 2010 to 2019 (in 1,000 metric tons)https://www.statista.com



Countries with more than 100 thousand hectare of Lotus species sown in pastures (Ling et al., 2019)

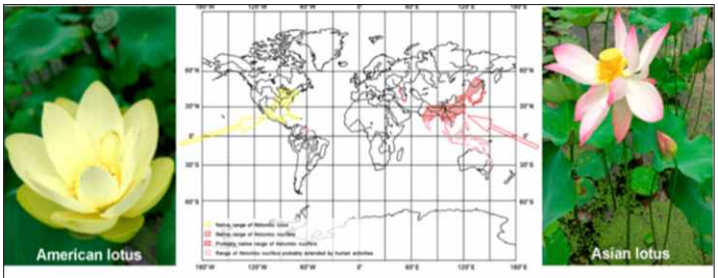


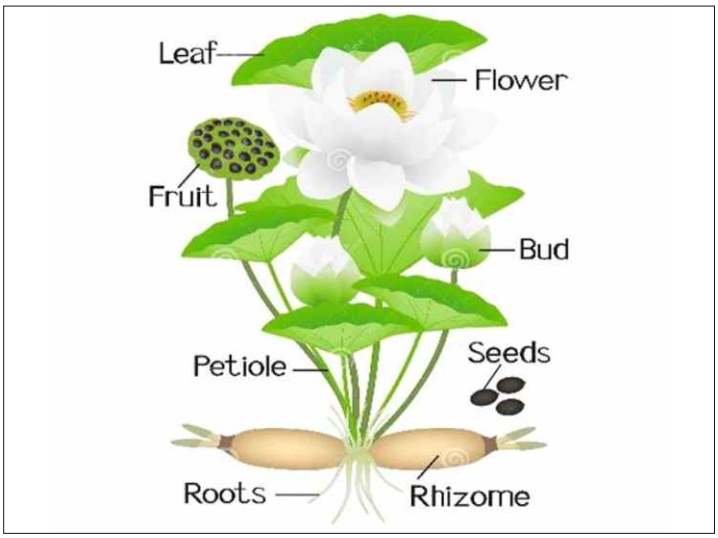
Figure 1. Overview of the lotus species and their global distribution. The left and right panels show the flowers of American and Asian lotus, respectively. The yellow and red shadow areas in the world

Indian Scenario

In India lotus is found growing in almost all the parts. Commercially it is being grown inin West Bengal, Chhattisgarh, Jharkhand, Tamil Naidu, Kerala and Kashmir. For its uses in different purposes, it is being cultivated in many regions or small pockets of the country at smaller scales.

Uses of Lotus

Each part of the lotus i.e. its flower, seed, leaf, and roots are used in many different purposes. In floriculture, it is used as a cut flower, loose flower, in landscaping and for dry flowers and its products.



Floricultural Uses of Lotus






Wedding Decoration with Lotus

Floricultural Uses of Lotus- Potted Plant (Indoors/Outdoors)



Floricultural Uses of Lotus- Dry Flowers




Medicinal Importance

Lotus seeds contain vitamin C, antioxidants, and flavonoids, which may protect one against cancer. Lotus contains chemicals that decrease swelling, kill cancer cells and bacteria, reduce blood sugar, help the breakdown of fat, and protect the heart and blood vessels. Some of the antioxidant compounds in lotus include Kaempferol, catechin, chlorogenic acid, and querctinquercetin[5].

Lotus - Edible Products

Rhizome- Lotus Rhizome is similar to sweet potatoes. The tubers can be used in a multiple of ways, sliced, pickled, cooked, candied or stir-fried.

Leaves & stems- Leaves or stems of the lotus can be eaten raw or cooked.

Flowers- Flowers are dried and used in recipes for cooking, for making tea (Kashmiri khawa).

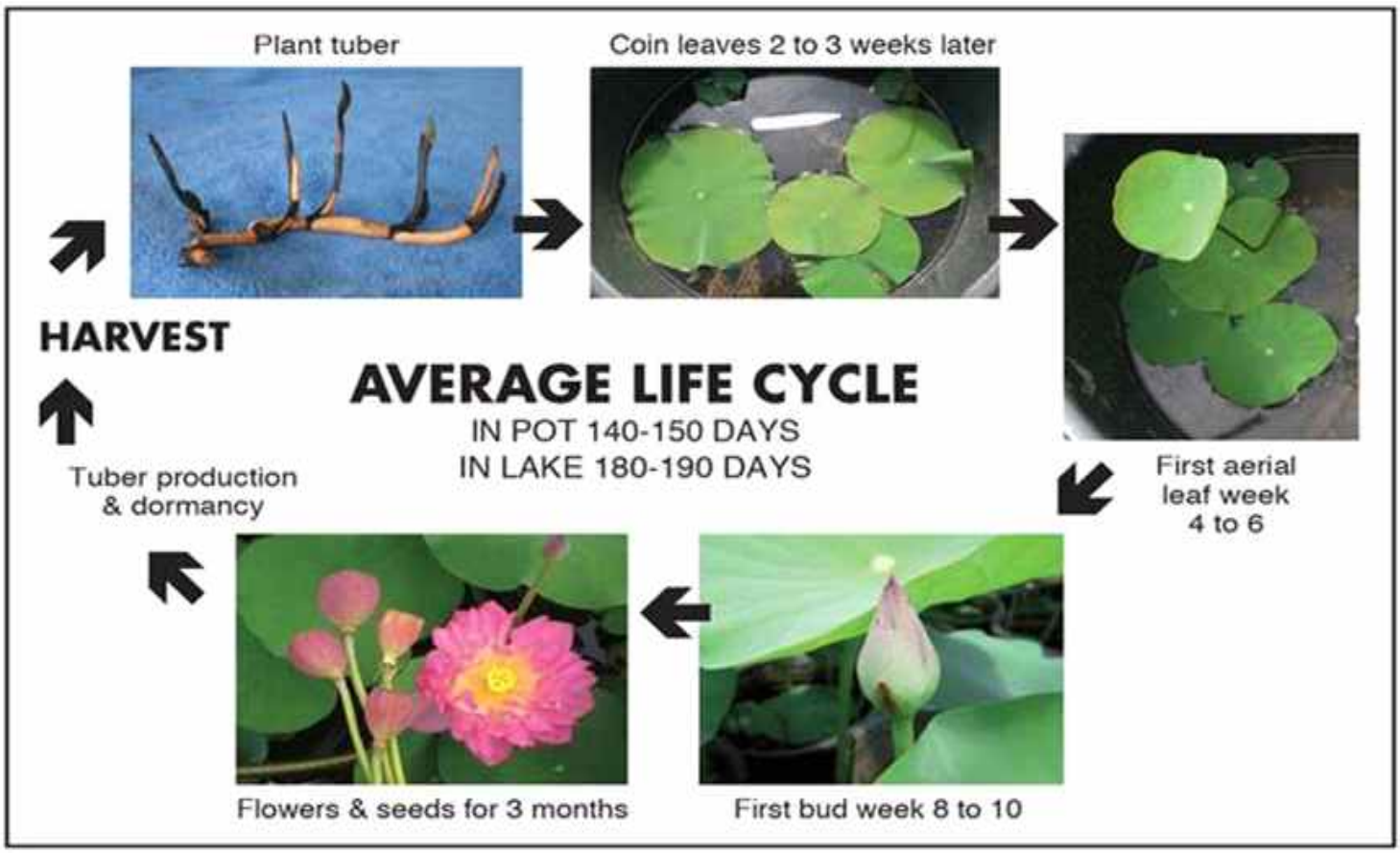
Seeds- Lotus seeds are boiled and added to dessert soups

Perfumery

Petals and stamens of lotus flower are used for scent making. Stamen of lotus flower constitute maximum for scent making. Price for 100 ml of Lotus scent is Rs 5650/-.

Cultivation

- Natural
- Man Made Ponds for Commercial Purposes



PROPAGATION

It is propagated by

- Seeds
- Rhizomes
- Tissue culture

Lotus is usually planted in ponds, rice fields, containers, and shallow lakes for different purposes. The optimal time for planting is between late March and early May depending on the local climate. Lotus can be propagated by one of the following methods: seeds, enlarged rhizomes, running rhizomes (straps), single-nodal buds, stem terminal buds, and tissue culture.

SEED: Seed has been recorded as having the longest known viability with age.

Their long life viability is due to the extra hard, impermeable seed coat. Propagation by seed can be carried out by scarifying the seed coat and then incubating at 25-30°C for 16 hrs[6]

Because of permeability barrier of the extremely rigid seed coat, lotus seeds must be treated physically or chemically before sowing to favour germination. The plants from seeds can finish a full life cycle (seed-to-seed) within one year.There is not a large difference in the plant growth between seed and rhizome propagated plants. Plant size and floral development of lotus are largely

influenced by temperature, soil or medium type, container size, and nutrition availability[7]

In fact, propagation by seed leads to plant development in a short period for a large area and saves time, labour, and large cost as compared to rhizomes. Propagation by seed also is very useful in breeding programs. In addition, propagation of lotus by seed can decrease occurrence of disease without sacrificing yield[8]. However, seeds are not encouraged for use in conservation or production of a true-to-type species or variety because of natural seedling variability. Seeds are not available for double-flower cultivars and some non flowering rhizome lotus.

The seed of Lotus can maintain viability for a very long time. American lotus seeds may remain viable for decades[9].The longevity of sacred lotus seeds is found to be extremely long under special natural conditions. Viable seeds with a life span between 100 and 1300 years have been reported[10.11.12.13] lotus, also has been produced in Japan from one of three seeds about 2000 years old based on carbon-dated wood of a prehistoric boat where the seeds were found (Godwin and

Willis, 1964). However, the average seed longevity of other plants under laboratory conditions usually ranges from 2 to 10 years[14]. The mechanism of longevity from lotus seeds remains unknown but possible explanations were given by [15]who reported that high levels of superoxide dismutase (SOD) activities in seeds might benefit the long life span of lotus seeds. [16]It was found that lotus seeds had an unusually strong heat resistance and 100% germination rate of lotus seeds was obtained after 24 hr of treatment in a 100 ºC oven. The high stability of SOD in radicles observed under high temperatures is possibly related to the longevity of lotus seeds. Biological characteristics of the centuries' seeds, germination, growth and development of the seedlings, and morphology of offspring have been studied by[17,18,19]. Metabolic activities in germinated ancient lotus seeds have been investigated by [20]

One of the most interesting phenomena in Nelumbo is its gas exchange system. The adaptability of lotus to anaerobic aquatic environments has been studied by several researchers. *N. nucifera* is able to adapt to the aquatic environment through a two-way gas transport system which may carry oxygen-rich air down to the rhizome and excess air back to the atmosphere through the leaves[21]. The thermo-osmotic gas transport existing in *N. nucifera* need not rely on a difference in humidity between two sides of a porous partition, but may be linked causally to the temperature difference and pore size[22]. The adaxial side of the leaf of Nelumbo has two distinct regions in terms of gas exchange characteristics. Air enters the leaf across the expanse of the lamina, and escapes back to the atmosphere through the highly porous region at the center of the lamina[23]. Gas canals channel air from the leaves throughout the petioles and rhizomes. Air from a leaf flows to a rhizome through one of two petiolar canal pairs, joining with the lowermost of three canal pairs in the rhizome through a chamber in the node. The lowermost canal pair links these nodal chambers along the length of a rhizome, allowing air from a node to flow both forward, toward a growing shoot, and backward, toward preceding leaves [24].

The ventilation or gas exchange system of lotus also has been investigated by [25,25,27,28,29,30,31.]

Dormancy The dormancy and growth of the American lotus, *N. lutea*, was investigated by Meyer[32]. Results showed higher temperatures from 20 to 30 ºC were found to greatly accelerate growth, while below 15 ºC, growth was very limited. Meanwhile, the development of plants also was largely influenced by pH and soil types. [33] reported high temperature and long daylength accelerated vegetable growth and short daylength rather than temperature was the main environmental factor leading to induction of dormancy in lotus plants. Phytochrome played an important role in photoperiodic response of rhizome growth [34] rhizome enlargement occurred under an 8 to 12-hr photoperiod while rhizome elongated under a 13 to 14-hr photoperiod.

The process of enlargement and elongation could be changed by a 2 hr interruption of the night with different light quality. During the formation of enlarged 11 rhizome, the dry mass, contents of starch, soluble sugar and soluble proteins showed a significant increase. Reducing sugar increased at early stage and decreased promptly at the middle stage, and then remained at a steady level until the end stage of rhizome enlargement[35]. Carbohydrate metabolism of over-wintering lotus rhizome in the field has been investigated by [36.]

Propagation- Rhizomes

Propagation through Rhizomes : This is the most easily employed and efficient method of propagation and also produces true-to-type plants. Rhizome is sourced from the current crop, or a separate mother pond is constructed to supply each consecutive season's seed rhizome-material [37]

Propagation technique -Rhizomes

The rhizome needs to be handled carefully. The tips of the tuber (or eyes) are where the leaves will grow. The rhizome needs to be kept warm about 23°C. Deep planting should be done so that they are less likely to jump over the side.

Propagation by division of running-stem (non-enlarged rhizomes or straps) is a method conducted during the growing season. This method can help to make up for died plants, save stock rhizomes and cost, and increase efficiency.

For propagation by expanded rhizomes, the farmers in Asian countries traditionally use the entire rhizome (containing the main rhizome and all branches), also called the 'parent' rhizome, as a single propagule. In fact, both the 'son'- (primary branches) and 'grandson'- (secondary or third branches) rhizomes also are suitable for propagation, and the plants from this propagation method perform as good well as from the parent-rhizome method[38].

[39]compared effect of propagation methods using whole rhizome, main rhizome, secondary rhizome, top rhizome, and terminal nodal buds. There was no significant difference in yield. Terminal nodal buds and top rhizomes can save large costs of

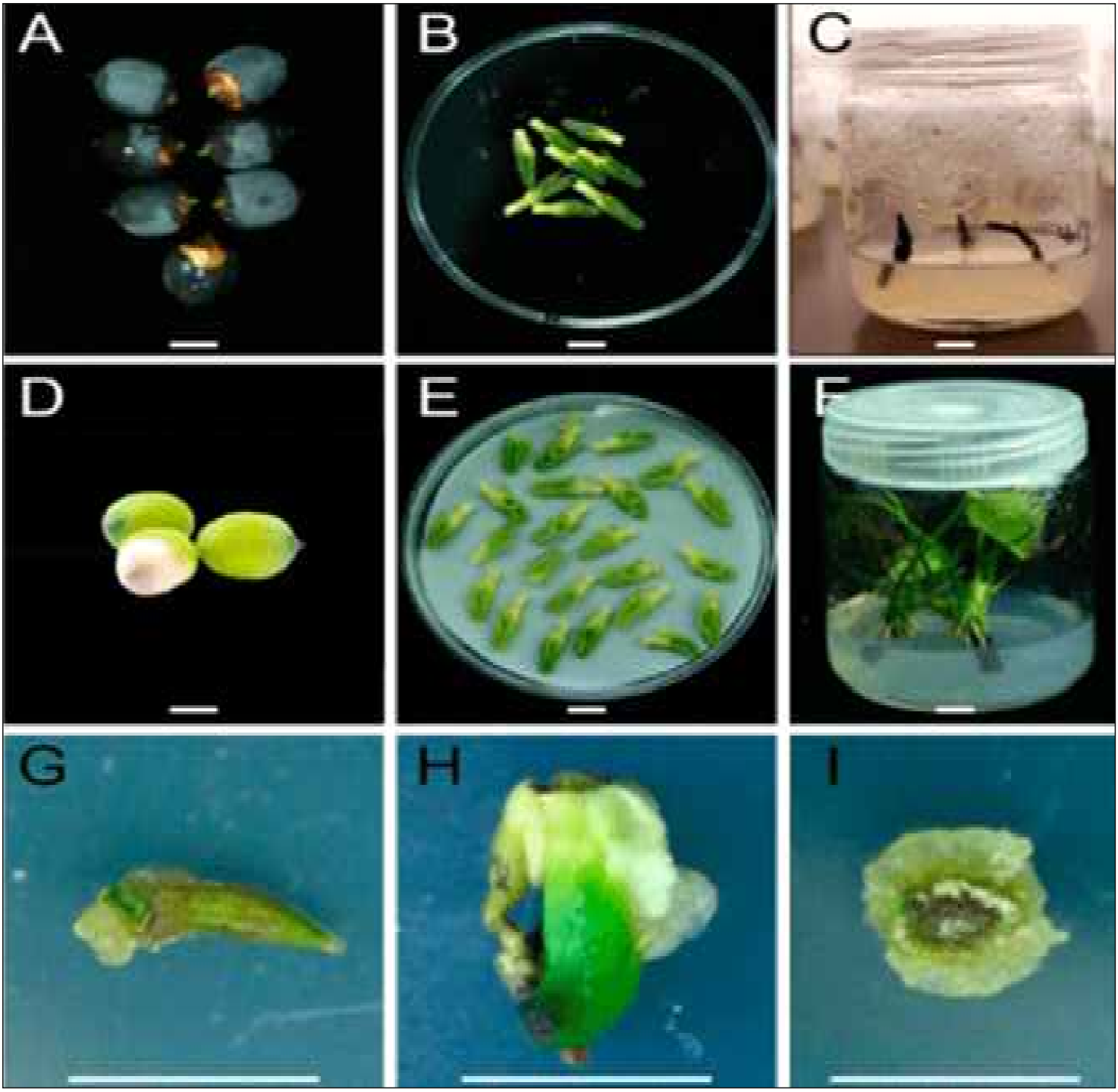
stock plants. [40]investigated effects of micro rhizomes and regular rhizomes for use as propagules on lotus growth and yield. It was found that there was no large difference in plant height, leaf number, although the highest yield of enlarged rhizomes was observed in the propagation method using large rhizome propagules. The heeling healing practice of lotus using small propagules and terminal nodal buds was discussed by [41]

Propagation via running stems can also prolong the flowering period of plants [42,43] reported that the days to flowering were significantly shorter ($P \leq 0.01$) in the strap method than in the enlarged rhizome method. However, the rhizome strap method delayed the flowering time in each cultivar and the population flowering time was cultivar dependent. Plants generated by the rhizome strap method produced larger flowers ($P \leq 0.05$). This method may prolong the availability of rhizome propagules therefore enables a more flexible scheduling of propagation tasks.

Propagation- Plant Tissue Culture

Tissue Culture: Besides traditional propagation methods, tissue culture may potentially provide an alternative approach for lotus propagation. This method holds promise for the future where an established industry sources its seed material from a seed rhizome rhizome-producing specialist. A grower would use tissue culture to produce high volumes of uniform, true-to-type, disease-free material.

This would enable growers to maximize their cropping area. Supplied seed would have to be cheaper than a grower could produce and of a higher quality standard to be a viable proposition [40]



Tissue culture of lotus has been reported by researchers mainly in China, Japan and Thailand. Liu (1948) investigated regeneration ability of excised lotus plumules. Francko (1986a) reported that a germination of 98% in inoculated seeds was obtained. The seedlings elongated and differentiated normally in sterile liquid culture.

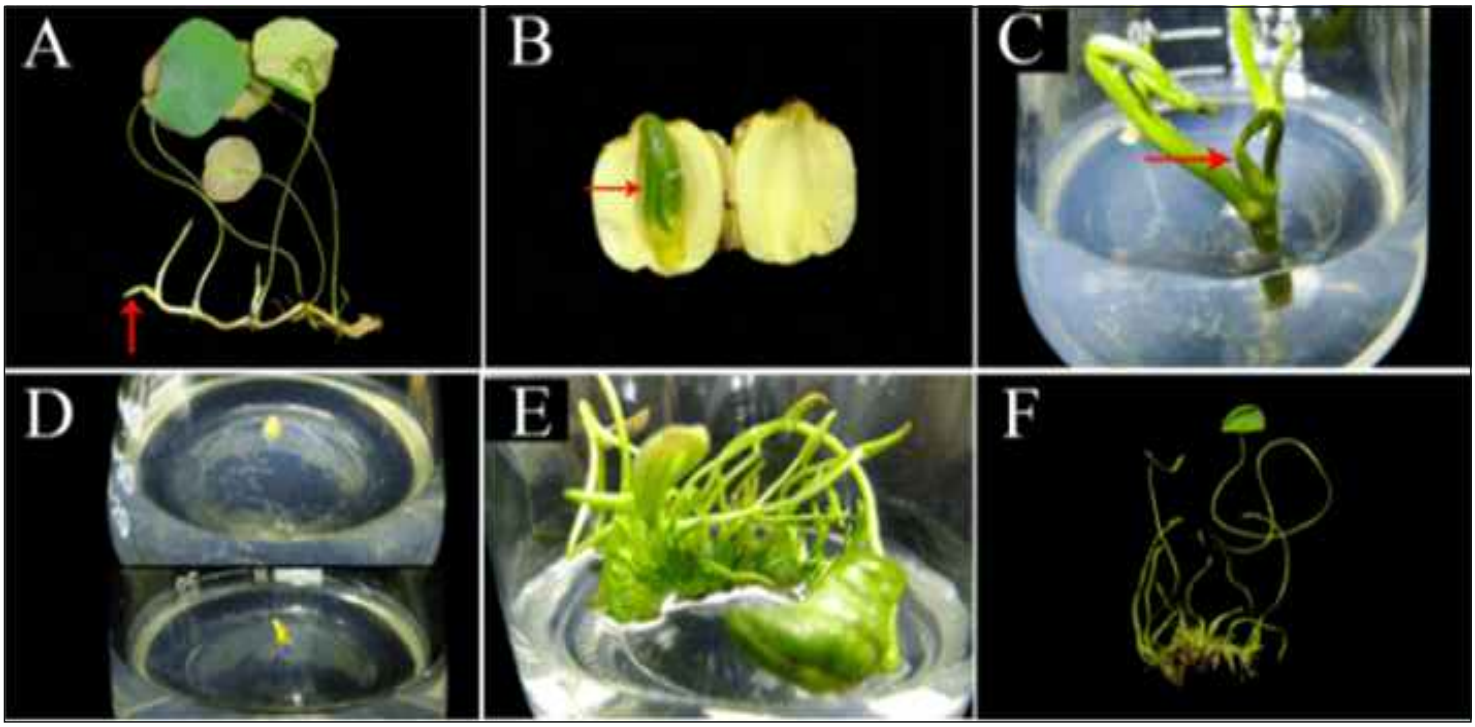
Callus was induced from buds, cotyledons and young leaf explants on Murashige and Skoog medium (1962), and somatic embryos were successfully induced from callus. [44] Shoots failed to directly generate from callus induced from immature embryos, green plumule leaves and young cotyledons, but could be directly induced from plumule leaves[45].

Terminal buds were more efficient than axillary buds for shoot induction[46]. Shoots and plantlets were successfully obtained through stem tip culture[47,48,49]. When *in vitro* plantlets were subcultured every 30 days the number of plants remarkably increased by 47-fold within 90 days of culture[50].

Acclimation The acclimation of lotus plantlets before transplanting was evaluated by[51]. After transplanting, about 75% of plantlets survived[51,52]. Genotype effect was investigated by[53,54]. Tetraploid lotus (4n = 32) was produced through in vitro culture with colchicine treatment [55.] Mutation induction of tissue tissue-cultured lotus by γ- and X-ray irradiation was investigated by Arunyanart and Soontronyatara[56]

***In vitro* Plant Regeneration of Lotus (*Nelumbonucifera*)**

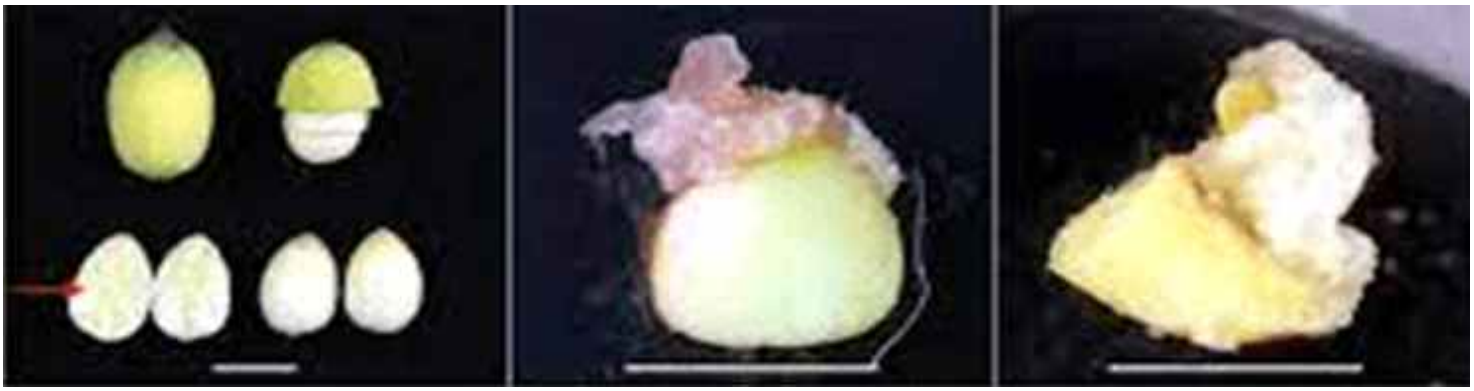
- Plant material: Lotus cultivar "Tai-Kong lotus 36"
- It was planted in lotus research centrecenter, Wuhan University



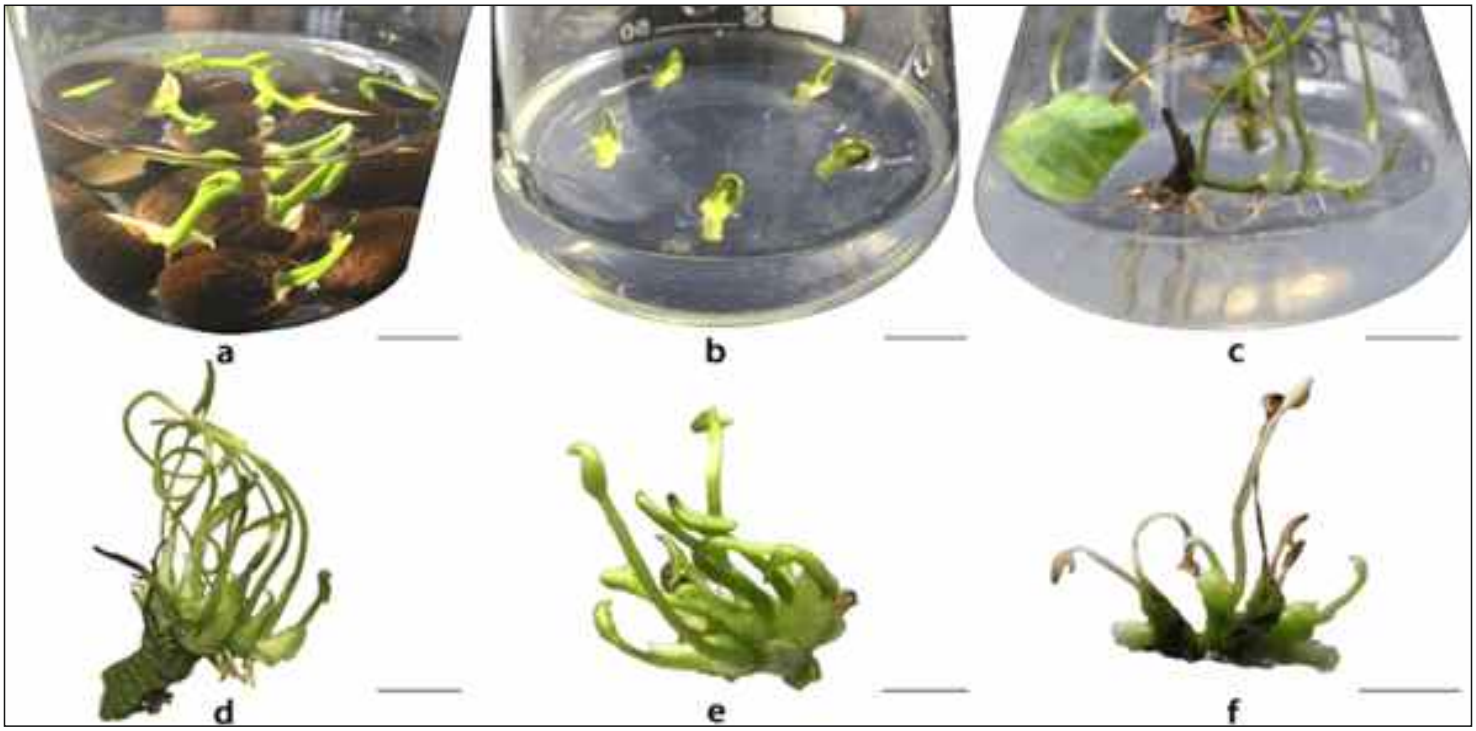
The bud from growing rhizome (arrow) (A); Dormant embryo (arrow) (B); Germinated embryos after one week on MS basal medium (arrow indicated dynamic shoot apical meristem) (C); Shoot apical meristem cultured on 16 different regeneration media (the upper from the bud and the below from germinated embryo) (D); Multiple shoot clumps developed after four weeks on MS basal medium supplemented with 2.22 µM 6-BA (E); Successfully acclimated plant prior to transplantation outdoors (F). [57.]

Explant: Shoot apical meristems from the buds and one-week-old aseptically germinated embryos as explants.

Establishment/multiplication: Multiple shoot clumps were induced on Murashige and Skoog (MS) Basal medium. Medium is supplemented with various combinations of N6-Benzylaminopurine (6-BA) and α-Naphthalene acetic acid (NAA). The maximum response was obtained with 2.22 µM 6-BA, and produced 21.33 shoots per explant after four weeks.

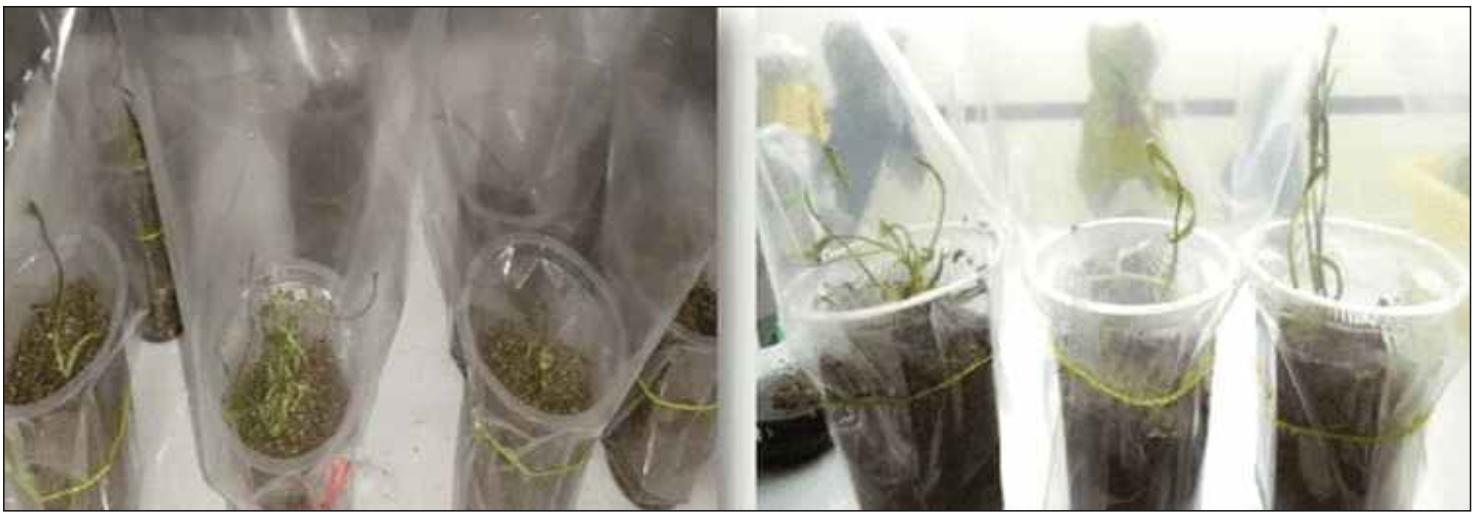


Rooting: After five subcultures, multiple shoot clumps were transferred to MS basal medium. Supplemented with various combinations of 3-Indolebutyric acid (IBA), NAA, and sucrose for root induction. After four weeks, plantlets with well-developed roots were achieved on MS basal medium supplemented with 0.54 µM NAA and 30 g/L sucrose with 100% rooting rate. [58]



Acclimatization: After four weeks, plantlets at approximately 8-15 cm in height were covered with a plastic bag. After one week of acclimation, the plantls were removed from the culture, washed carefully with tap water and transferred to pots in a green house with a 12 h photoperiod at 23°C.

Hardening: The successfully acclimated plantlets were transferred to pots with the addition of 2 g/L $KMnO_4$ into the soils. Finally, fertile plants with much bigger leaves were obtained in the greenhouse. The survival rate was 97.33%.



Lotus: Flower Production Technology

Prominent Hybrids

'Alexander The Great'

'Embolene'

Assessment of lotus (Nelumbonucifera) genotypes for growth and flowering for landscaping

Planting material (10 lotus accessions): AmiryCamelia, Amiry Peony, Almond Sunshine, Little Rain, Red Peony, Siam Ruby, Ultimate, Thousand Petals, White Peony, Yellow Peony andZhizunQianban [58]

Rhizome: Well Well-matured, freshly harvested rhizomes of uniform size (180-200g) with three nodes were taken.

Planting: Planting was done in in the plastic round tubs with a height of 10, a bottom diameter of 16 and top diameter with 21 inches. The tubs were filled up to the a three fifth of its height with potting mix (pond clay, vermicompost, neem cake + groundnut) in the ratio 3:1:1. After settling of media and water the rhizomes were planted slanted at 15^0 angle in such a way that the crown should remain above the media level.

Table: Average number of days taken for the emergence of coin leaf, floating leaf and aerial leaf

Treatments	Days taken for coin leaf	Days taken for floating leaf	Days taken for aerial leaf
T1	6.00	9.66	28.66
T2	5.66	9.33	29.66
T3	6.33	10.00	22.00
T4	6.33	16.00	23.00
T5	10.33	23.33	23.33
T6	9.00	16.00	28.33

T7	11.66	22.00	37.00
T8	10.33	14.00	25.33
To	9.33	20.66	30.33
T10	13.33	23.00	32.00
MEAN	8.33	16.39	27.96
S Ed	0.49	1.07	1.73
CD	1.03	2.24	3.61

Table: Average number of days taken for first flowering, number of flowers and field life of flowers Gokulet al., 2022)

Treatments	Days taken for first flowering	No. of flowers/plant	Field life of flowers
T_1	38.33	11.33	5.00
T_2	47.00	9.33	4.66
T_3	55.00	7.00	5.66
T_4	75.66	3.66	3.33
T_5	58.66	4.00	5.00
T_6	82.00	3.66	5.33
T_7	110.00	1.00	6.33
T_8	67.00	4.33	4.00
T_9	63.00	5.33	4.33
T_{10}	102.00	1.66	5.66
MEAN	69.86	1.16	0.39

Findings: The accessions *Nelumbonucifera* 'AmiryCamelia', *Nelumbonucifera* 'Amiry Peony', *N. Nucifera* 'Almond Sunshine', *N. Nucifera* 'White Peony' and *N. Nucifera* 'Yellow Peony' showed better performance in terms of both vegetative and flowering parameters. These accessions will be commercially exploited for container aquatic gardening in landscape and are well suited for Tamil Nadu conditions.

Cultivation and Production

American lotus is not widely planted as a crop or ornamental as is Asian lotus and it usually grows in wild areas. Asian lotus has an extremely long history in cultivation as a vegetable, medicinal, and ornamental plant in Asian countries. Recently, *N. nucifera* is becoming a potential crop in Australia[40], New Zealand ([58]), and the United States ([59]).

Lotus is usually planted in a tilled pond or rice field for vegetable production. It is also planted often in bowls, containers, small ponds, and lakes for landscape use.

Cultivar selection and cultivation techniques are dependent on where lotus is planted. Large cultivars are planted in ponds and lakes for vegetable and seed production, or for landscape uses. Medium and small cultivars are usually planted in containers and water gardens for ornamental use. China is the largest producer and consumer of lotus. Currently, the planting area of rhizome lotus is about 5 to 7 million ha in China. The total yield of edible rhizomes is about 6 million tons. Wild lotus can be naturally distributed at sites with water depths up to 2 to 3 m[60.61.62.63], which was supported by tank planting experiment [64]in that no petioles of *N. nucifera* elongated in 3 to 5 m depths of water. Most cultivated lotus generally cannot survive in pond with water depth > 1.8 m[65] and is usually grown better in water < 1.5 m deep [66.]

The survival decreased with increasing planting depth and the biomass of plants is significantly reduced from 0.5, 1.0, to 1.5 m water depth in tank experiments [67]. Lotus planted in shallow water generated higher yield [68] and the ideal water depth was approximately 10 to 20 cm[40]. However, optimum water depth is plant size dependent. Small-medium size varieties grow better in shallow water with a depth of 5 to 50 cm, so so-called shallow water lotus, while large large-size varieties grow better in water with a depth of 50 to 100 cm, so so-called deep-water lotus [69]

Climate and Soil

Growing climate: Lotus is widely adapted to varied climatic conditions. For commercial cultivation, however, a warm to tropical environment is most suitable. Temperature: 20°C - 30°C is the most ideal and should not drop below 18°C. Sunshine: At Least 6 hr Day Light is required. Intense sunlight and long day hours for successful growth.

Loam or clay soil [70] are the most suitable. Lotus germinates or sprouts at temperatures above 13 ºC[71] and prefers warm climates. Higher temperatures from 20 to 30 ºC have been found to greatly accelerate plant growth, while below 15 ºC, growth of *N. lutea* was very limited[72]. Optimal temperatures are 22 to 32 ºC for lotus growth [73]. *N. nucifera* can endure high temperatures of 41 ºC and continuous temperatures above 35 ºC for 20 days[74]. For lotus production in tunnel houses during cool seasons, 28 to 30 ºC soil temperatures were suitable. When soil temperature was below 18 ºC and ambient temperature was less than 20 ºC, plants almost stopped growth[75].

Lotus performs much better under full sun than in shady places. [76]reported that increase of light intensity improved leaf greenness, stalk thickness, and flower number of lotus in tunnel houses for winter production. Based on results from a tank-experiment, the total biomass increased significantly with increasing light, although the survival of N. lutea seedlings was high in all tested light levels [77].Soil is an extremely important ingredient for plant nutrition.

The soil type is probably the most important factor in the proper development of Nelumbo, and loam soil is much better than sandy soil [77].

Heavy garden loam containing a high percentage of clay with very small particles is best and topsoil is always good for water garden plants. A potting soil high in organic matter is not recommended because of it will float out of the containers and does not anchor the plant roots very well [78].

Lotus has a wide adaptability to soil type, but, based on the studies by Wuhan East Lake Flower and Bonsai Research Institute, lake soil (pH = 6.5) is better than mountain mud (pH = 5.6) and garbage soil (pH = 7.4) [79]. [80]compared the effects of media (peat-cobble double-layer medium, yellow sand, stone powder, pebble, and soil) and nutrient solution on a lotus and found that peat with cobble cover was the best for lotus growth.

It has also been reported that competition of *N. lutea* with other aquatic plants was high in low-salinity, fertile conditions, but decreased with increased salt and nutrient stress [81]. Lotus can tolerate a considerable pH range, from 4.5 to 9.0[82]. The plant is not much affected by pH range from 5.5 to 8.0 in water. [83] reported that suitable electrical conductivity (EC) levels for a lotus plant at the vegetative stage of growth are between 2.8 and 3.1 $mS \cdot cm^{-1}$ (Tian, 2008), which indicated that EC should not often exceed 1.0 $mS \cdot cm^{-1}$ even for large lotus plants.

A safe EC value for lotus is also dependent on plant size, growing season, and temperature. *N. lutea* may be capable of limited bicarbonate assimilation at alkaline pH, and CO2 represents the preferred dissolved carbon source in this species. Photosynthetic carbon assimilation rates in submerged shoots generated from seeds at pH 4.5 were 50-fold higher than those at pH 8.5. The pH-dependent C-assimilation curves in sections of plants grown in acidic and alkaline liquid media were statistically similar[84].

Planting Techniques

Many technologies have been developed for lotus production to obtain maximum yield and economical gain. [85] reported that discarding of terminal buds of main stock stem increased the total number of rhizome branches, rhizome yield and leaf number. Lotus is often planted with the incorporation of aquaculture to increase profits. [86]compared the effects of five models on the total yield of fish and lotus. Lotus yield can be increased by 31% by incorporating crop residue chips in the soil [87]. Lime is often used in lotus cultivation to increase yield because of its advantages on soil sterilization, pH adjustment, and nutrient provision[88]. Other new techniques, such as double-cropping lotus in spring and fall[89,90], and double cropping with other crops[91,92], have been used in China. Use The use of honeybees can markedly increase yield in seed production [93].

Lotus is usually planted between late spring and early summer, and its growth ends in the fall. Yield of lotus can be predicted through the foliar-age model [94]which benefits the lotus producer to better prepare products for the market. Recently, to meet the demands for an early market, out-season cultivation methods have been developed. The availability of vegetable rhizomes could be advanced to June by a technique of growing edible lotus in the earlier season [95]. Lotus flower generally blooms from June (May) to August, but the population flowering time can be extended to early October when plants are propagated by dividing growing plants in the middle of July [95].

It also is feasible to prolong the flowering time of lotus through winter when plants are planted in a heated greenhouse[96]. Out-of-season cultivation of lotus is reported by[97]. The time from bud occurrence above water to opening can be controlled between 10 and 15 d by changing cultivation conditions in the greenhouse[98]. If the techniques of advancing and delaying flowering are incorporated, three cycles of flowering are possible in one year[98]. Production of lotus cut flowers may be on a year-round schedule but water level should be adjusted to meet the requirements of flower quality based on growth stages[99]. The floating cultivation method provides a possibility to beautify a lake of more than 1.8 m water depth[100].

Pond Preparation

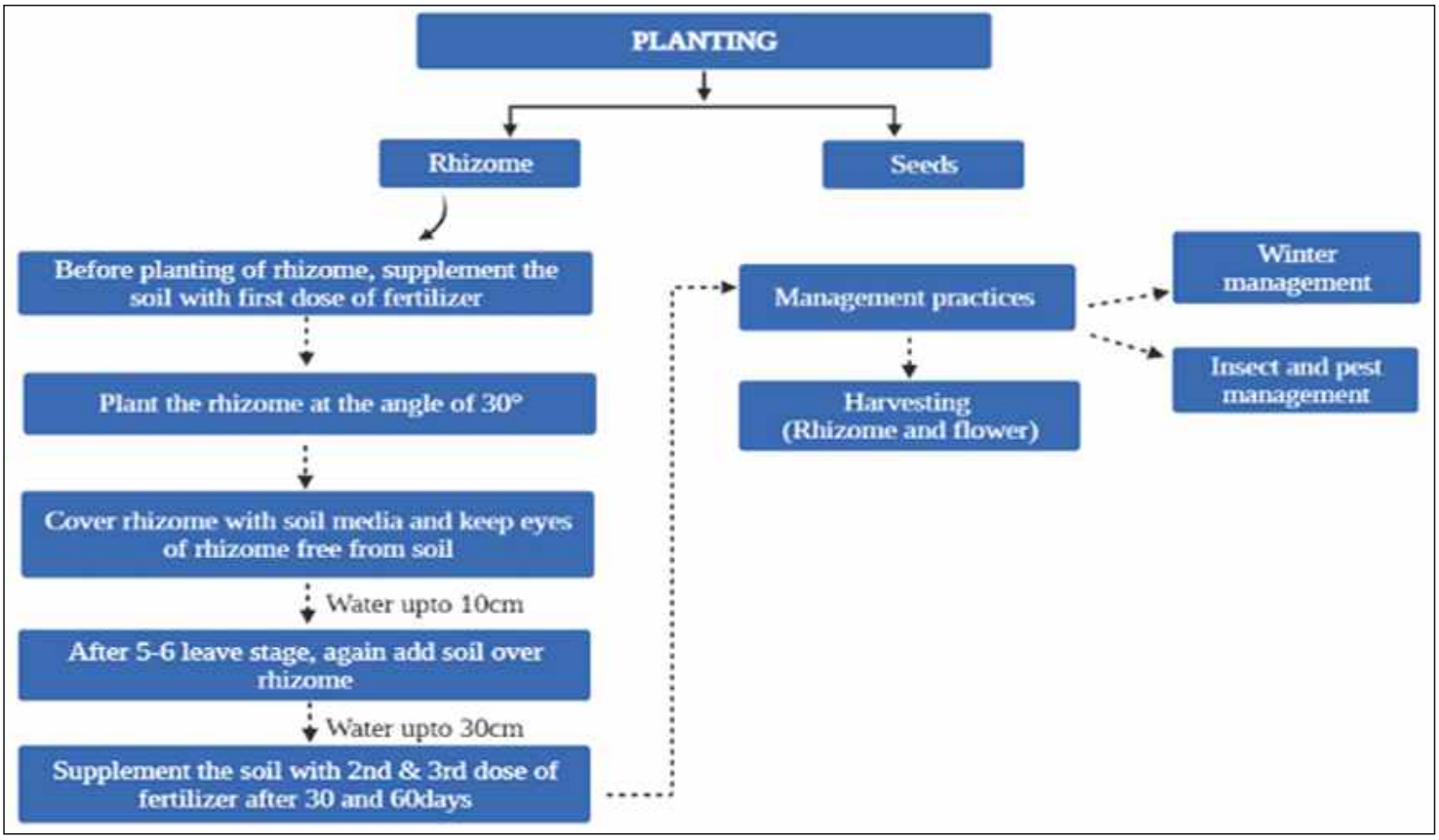




Preparation of pond: Artificially made pools of polythene, concrete or fibreglass or simple pond are dug. Depth The depth of pond should be 1m.Base The base of pond is filled with 25 to 30 cm of thick layer of soil preferably clay soil. Puddling of soil or clay should be done in newly dug ponds to make the layer impervious to water[101].

Pond management: The pond design is critical to Lotus production operations because once constructed it is difficult to change**.**

Planting Method for Commercial Scale



Seed Rhizome rate: 45 kg/ha
Planting: Rhizome are placed horizontally at angle of 30 degree in the pond base and are covered with light soil layer and fixed in position with the help of pebbles. Water is filled up to 10cm.After 5-6 leaves stage add thin layer of soil on the rhizome[102]

Seed rate: 10 kg/ha
Seeds used to raise this crop are either sown directly in pond or in a pot. Seeds are potted in pots with good loam soil at a depth of 5cm. After 5 to 6 leaf stage, seedlings are ready to be shifted in the pond.

Fertilization
Lotus is a fertilizer fertilizer-consuming plant. The seedling can normally grow up to 4-leaf stage in pure water without fertilizer. However, if no fertilizer is added after 4-leaf stage, the seedling will die soon [104]. It is recommended that fertilizer applications should be split into 4-5 applications as young plants have been observed to burn quite readily[40]. In the past, traditional organic fertilizer is usually the only choice for lotus production.
NPK: 100:60:40 kg/ha andFYM: 15t/ha is a common recommendation.It is recommended that fertilizer applications should be split into 3-4 applications fertilizer doses. For pot19:19:19 NPK 4gm/plant @30 days, 10gm/plant @60 days. Slow release fertilizer tablet may be used once a month after the plant get established i.e., Bone meal @125g/m^2.
Currently, organic fertilizer is still a major source of fertilizers for lotus production in China while chemical N-P-K fertilizers are mainly applied in Japan (Sou and Fujishige, 1995). [105] investigated the effects of balanced fertilization on lotus production and suggested that the N-P-K integrated fertilizers should be applied together with B, Cu, and Fe for lotus.
Another study revealed that the optimal dose is 18-24 kg of N, 6 kg of P2O5, 12 kg of K_2O, 1 kg of B (sodium tetraborate), 2 kg of $CuSO_4$, and 3 kg of Fe_2SO3 per 667 m^2 [106]compared the effects of nutrient solution formulations on lotus planted in soil-alternative media and found an optimal nutrient solution with 1:0.25:0.8:0.7:0.2 of N-P-K-Ca-Mg. A single basal application of coated fertilizer not only produced almost the same yield of lotus rhizome but also saved 29% nitrogen and reduced 41% effluent nitrogen fertilizer compared with conventional fertilization method[107]. Potassium-fertilizer significantly increases the yield of lotus, the highest production 1511 kg per 667 m2 is found in soggy soil when applied at 15 kg of K-fertilizer, and 1651 kg per 667 m^2 in meadow soil when applied at 10 kg of K-fertilizer [108.109] compared effects of K-fertilizers on the production of lotus. It showed that incorporated application of NPK and Fe, B fertilizers increased plant growth and yield, while K-fertilizer increased flower number, growth of leaves and rhizomes.
The suitable dose of K-fertilizer is 120 to 180 kg/ha. Comparative effects of combinations of N, P, and B-fertilizers also were investigated [110] who found the ratio of N18- K8-B1 produced the highest yield. Lotus is a Mn-loving plant, and increased Mn at the suitable levels benefited lotus growth[111]. Meanwhile, lotus is Mn tolerant and no visible toxic symptom occurred for plants with 1340 to 3200 ppm of Mn in tissue. [112] investigated the characteristics of nutrient absorption for non-flower lotus and found the absorption ratio of N-P-K in rhizomes was about 2.73: 1: 5.2 during the enlargement of rhizomes. Hicks [113]reported the effects of the major nutrients N, P, K and Ca on lotus growth.
Leaves were considered to be the most appropriate organs for field sampling and analysis, having the greatest incidence of sensitivity to nutrient variation.

Overwintering

Management in cool regions: Rhizomes of lotus can survive through a short period of low temperatures between 0 °C and -7°C, therefore nothing has to be done for winter protection in most warm regions. Cold or freeze-resistance ability of lotus is water level dependent and hence when lotus rhizomes are covered with a suitable depth of water, they can survive through winter at - 12 °C and even at -30 °C. To avoid possible damage by freezing temperature lotus propagules can be harvested: Oct-Nov Stored with mud in a container at 3 to 7 °C temperature) from December to the next

February (95% survival rate). A similar storage method with sand and water under 4 to 15 °C room temperatures results in 90% survival rate[114].

Major Insect pests /Diseases/Weeds

Insects: Caterpillars, Green peach aphids.

Diseases: Powdery mildew (*Erysiphepolygoni*), Fusarium wilt (*Fusariumoxysporum)*.

Weeds: The weeds not only compete for space, but also nutrients and, in some cases, oxygen as well [40]Lotus ponds always have the potential for invasion by aquatic weed species such as Planktonic algae. It is recommended that weeds are removed from the pond either by physical removal or the use of a herbicide during the non-crop period before they can establish.

Lotus may tolerate some herbicides at a very low dose. It was reported that N. nucifera did not show visual toxicity to the herbicide simetryn symmetry at 2.4 μg·L-1[115]. However, the lotus may be very sensitive to other herbicides even at low concentrations, therefore, the application of herbicide targeting on the weeds in the lotus's surrounding area must be done carefully otherwise it may cause damage to untargeted lotus by herbicide drifting[116]. Glyphosate isopropylamine (41%) can be used before planting lotus to control weeds.

[78] shown that after 7 to 10 days of planting, one of the following herbicides, 50% Prometryn 1500 g/ha, 60% butachlor EC 1000 ml/ha, and 12.5% Oxadiazon EC 3000 ml/ha, can kill 80% to 90% of weeds when water level remains at 3 to 5 cm for 5 to 7 days during the application

Control of *Eichorniacrassipes* and Typha sp. can be achieved using simazen (3 to 6 ppm) or monuron monaural (4 to 12 ppm) [40]Lotus is sometimes considered to be an invasive plant or weed in some countries[79]. Lotus grows very fast and *N. lutea* colony can grow 15 to 30 m each year [78.56.59] Sometimes lotus becomes a weed. The negative influence of Nelumbo-colonization is largely responsible for the decrease of both species richness and the number of other aquatic plants and invertebrates in the colonized area because of large floating leaves of Nelumbo shading the underlying zone[89]. American lotus can be cut and removed by hand or other mechanical methods but is difficult to control physically because it can reestablish from seeds and rhizomes. Excellent herbicides to kill *N. lutea* are 2,4-D butoxy ethyl ester, 2,4-D dimethylamine (DMA), and dichilobenil. Endothall dipotassium salt (K2) and endothalldimethylalkylamine salts also have good effects for the control of American lotus[69]. [78] recommended destroying the deteriorated population of seed lotus by spraying 75 to 125 g per 667 m^2 of 72% 2,4-D Butyl ester.

Nutrient Deficiency

Nitrogen (N) deficiency symptoms first appear on older leaves as an even chlorosis (yellowing) across the entire leaf blade. Lotus is very sensitive to P levels and P fertilizer must be applied with care. Potassium (K) is needed in large amounts as lotus requires K for flowering and rhizome production. Except for the limited information online available, the nutrient disorders of lotus are less reported in formal publications. The following symptoms of nutrient disorders in *N. nucifera* were evidenced under the trials at the University of Western Sydney (Hawkesbury) and accurately reflected similar disorders in other plants[40].

Lotus is very sensitive to P levels and P fertilizer must be applied with care. Plants deficient in P display a darkish green which gives way to a purplish mottling (anthocyanosis) of new leaves. The leaf will turn entirely purple under severe P stress, before an even necrosis (blackening and dehydration) of the leaf starts at the leaf margin. Growth of plants will also be appreciably slower, though often this is not as apparent as leaf symptoms. Toxicity symptoms are indicated by the deformation of new leaves which will fail to open.

Potassium (K) is needed in large amounts as lotus requires K for flowering and rhizome production as well as other regulatory and metabolic functions during growth. When K is deficient, the chlorotic patches are initially seen around the entire leaf margin of older leaves.

This yellowing then extends inwardly within the confines of the leaf veination before turning necrotic, from which comes necrosis, a curling of the leaf margin.

Symptoms of magnesium (Mg) deficiency initially exhibit a chlorotic mottling between leaf veins in older leaves, as the growing tip draws mobile Mg from mature leaves. Extensive deficiency will show an increased yellowing of the entire leaf blade, which could be easily mistaken as N deficiency. Deficient leaves will eventually become necrotic if unchecked. Calcium (Ca) deficiency in lotus is similar to Mg, where chlorotic mottling of older leaves becomes apparent giving way to a bronzed spotting. It differs in that leaves become stiff and brittle. The root system will also be affected, stunting between nodes, browning of the root hairs and necrosis of some of the growing tips has been observed.

Iron (Fe) deficient leaves will exhibit an even chlorosis interveinially interveinal on younger leaves, leaving a dark skeleton-like appearance to the veins. Deficiency may be due to an imbalance of other nutrients. It is also reported that high concentrations of chromium reduced chlorophyll, protein contents of N. nucifera, and in vitro nitrate reductase activity[110]. The toxicity of hexavalent chromium on N. lutea seedlings was investigated by[101]. The nutrition deficiency of lotus can be corrected by the application of the related fertilizers. However, foliar application will be ineffective due to the super hydrophobicicity of lotus leaves. Solutions to the nutrition toxicity of lotus have not been reported.

Harvesting

Lotus flowers are harvested at bud as well as open stage depending upon the requirement. Manual harvesting is done in different parts of the country. Lotus flowers usually have 3 to 4 days of life span under natural conditions. High transpiration, quickly increased water loss, and quick decrease in water absorption ability causes a short vase life of cut flowers [47]Application of an optimal preservative combining with low temperature 8 to 10 ºC can prolong the longevity of fresh cut flowers up to more than 9 d[58]Ethephon induces premature senescence of sacred lotus flowers and also increases water

uptake, whereas 1-MCP reduces water uptake and weight loss, delays browning and prolongs the vase-life of flowers [68]
Effects of chemical solutions, spraying thiosulfate before harvesting, precooling treatment, harvest time and other factors on the vase-life of cut lotus flower have been investigated in Thailand[67,73.39]. Shipping and storage of cut lotus flowers are usually conducted in hot summer. Darkening The darkening and dropping of lotus flower petals caused by high temperatures is a serious problem. Low temperatures at 5 to 10 ºC are effective to maintain normal appearance of lotus flowers in combination with plastic film packing[9].

Bunch Preparation, Packing and Marketing

Transportation

Transportation: Ideally, Lotus should be transported domestically by refrigerated truck. Export freight would be via sea. Airfreight is the alternative, but utilization could be a factor in prevailing markets with regard to cost.

Lotus Flowers	**:**	**1000/ha**
Average Rhizome Yield	:	50 Q/ha
Lotus Pod	:	500 Pods/ha
Lotus Seed	:	5 Kg/ha
Rate Of One Stick	:	Rs 15 - 20 INR
For Loose Flower	:	Rs 300-400/kg
Seed	:	Rs 150/100 grams

Yield from Lotus plants under natural lake farming (Rajeshwari and Chandervanshi, 2018)

Harvesting of Rhizome: Rhizomes can be harvested when shoots die off and plants go into dormancy, which occurs in autumn season. Rhizomes can be picked by hand or mechanical harvesters but due to lack of mechanical harvester's rhizomes are presently picked by hand in most of countries.The time for rhizome harvest is July-September for early season varieties and October-March for late late-season varieties[116]. In pond production, lotus is often harvested by a handy fork-like implement for a small-size production. Sometimes it is

harvested by hand, but hand harvesting is difficult and physically strenuous. In Japan, mechanic harvesting began in 1970s and it totally replaced labour harvesting in 1990s (Sou and Fujishige, 1995). In China, although a mechanical lotus digger was developed in 2000, currently manual labour harvesting is still a major method. Lotus seeds are harvested by hand when seeds or seed pods turn black then they are processed by mechanical tools for removal of the seed coat and embryos.

Lotus can survive through winter in many regions without any other protection under suitable water levels[48]. However, after harvest, enlarged edible rhizomes lose quality quickly during storage because of continued water loss, shrinkage, browning or decay[47,48]. Maintenance of freshness of *N. nucifera* rhizomes has been well well-studied in the food storage industry[34,39,45,49,51]. Low temperature is particularly important in lotus storage. Enlarged rhizomes used as vegetables can be stored up to 150 d at 6 to 8 ºC low temperatures with 95% to 100% RH[57], whereas, rhizomes usually have a shelf life of only 2 weeks at room temperature [69] and can be stored in the soil for only 10 to 30 d[99].

Lotus rhizomes keep their quality best at temperatures between 3 ºC and 7 ºC and have storage potential for up to 5 to 6 weeks. Rhizomes stored at temperatures below 3 ºC have shown evidence of surface scalding and may exhibit signs of chilling injury but this has yet to be confirmed. An acceleration of disease presence is seen at temperatures above 7 ºC, though weight loss in rhizomes is insignificant until temperatures increase above 12 ºC. Temperatures above 15 ºC break rhizome dormancy and shoots may begin growing[40]. Advances on the storage and physiology of postharvest edible lotus rhizomes are discussed by[117]. Lotus rhizomes can be stored in sand, plastic membrane covers, water, and soil. Browning is a big problem of stored lotus. Effect of mud packing on the appearance and structure of lotus rhizomes was investigated by [118]The catalytic oxidation of PPO is a the main reason causing browning and senescence of lotus rhizomes during storage [119]. The relationship of enzymatic browning and its main substrates in fresh-cut lotus rhizomes were investigated by[119].

The effects of temperature, pH, and inhibitors on PPO activity in fresh-cut lotus are discussed by[57]. Low temperature, sodium sulphite, and ascorbic acid are strong inhibitors of PPO activity, and consequently benefit the storage of lotus rhizomes[68].

Package materials also have effects on the storage of lotus, PA/PE film bags (0.06, 0.08 mm) are much better than polyethylene bags (0.08 and 0.1 mm) [54. 89] investigated the effects of oxygen, temperature, and package techniques on physiological and physical characteristics (respiration, total sugar, reducing sugar, weight loss, browning, and surface appearance) during storage. Optimal usage of amylase in pretreatment of lotus rhizomes was evaluated by [81]with Response Surface Method. [76]reported heterogeneity of lotus-rhizome starch granules under degradation of α-amylase. Effects of pressurized cooking methods on changes of chemical compositions and textures of lotus rhizomes were reported by[79]. Nutritional The nutritional quality of electron bean-irradiated lotus seeds was studied by Bhat and Sridhar[101].

Postharvest, Packaging & Storage- Rhizomes

Postharvest, Packaging & Storage: Lotus rhizomes are very easily bruised and physical damage results in an immediate purple discoloration. Lotus rhizome keeps best at temperatures between 3°C and 7°C and can potentially last in storage for up to 5-6 weeks. To avoid bruising and to maintain high humidity for the rhizomes, Thermaocol boxes with sealable lids are the size of a standard broccoli box [40.]

Table: Economic analysis of lotus cultivation under a waterlogged field in Chhattisgarh, India

Name of item	Rate per unit	Total cost
Input Cost (Rs/ha)		
Rent of land for one year	15,000	15,000.00
Field Preparation	2000.00	2000.00
Rhizome(100 kg)	5.00	5000.00
Transplanting	2000.0/acre	5000.00
Weeding (40 labours)	182.00	7280.00
Fertilizer application @NPK 100:60:40, FYM 15t/ha	-	8615.00
Insecticide and fungicide		1000.00
Digging of crop	300.00per day (140man day)	42,000.00
Transportation charges	1000.0	3000.00
Miscellaneous	2000.0	2000.00
Total cost of Input		**90,895.00**
Output		
Average Rhizome yield @ 50 q/ha	@35.00 per kg	1,75,000.00
Lotus pod (500 pod)	@1.5 Per piece*	750.00
Lotus seed (5 Kg/ha)	@500/kg*	2500.00
Lotus flower (1000/ha)	@1.5/piece*	1500.00
Net Monetory return (Rs./ha)		**88,855.00**

(Rajeshwari and Chandervanshi, 2018)

Production and Economics under Thailand

Under commercial lotus production: Production/acre: 25,000 flowers per season/acre. The average lotus price: 0.03 USD per flower (Kasikorn Thai Research Center, 2006)

Lotus flowers are an important floral product, and export to European countries, the United States and Japan (Uorasa and Thanoumnuan, 2005) is worth approximately 0.34 million USD per year.

Work Done In India and Abroad On Post Harvest Quality of Lotus

Study on harvest method and postharvest handling of lotus flowers (*Nelumbonucifera*Gaertn) variety 'Attabongkot'

Materials and methods (Plant Material): lotus flowers (*Nelumbonucifera*Gaertn) var. 'Sattabongkot'

Treatments: Six ,1Control (pulling the stem); 2The stems were cut with a sharp knife from the mother plant;3 Same as 2, but the flowers were placed and carried in plastic buckets in order to minimize bruising due to handling by hand; 4 Same as 3, but the bucket contained filtered water to prevent excessive water loss;5 Same as 4, but the flowers were wrapped in foam netting in order to minimize bruising during transport; and 6 Same as 5, but in addition, the cut ends of the flower stalks were wrapped in absorbent cotton wool soaked with filter water to prevent water loss during transport.

Results: The results showed that the prevention of bruising and water loss reduced the production of ethylene of in the cut flowers. In treatment 6, where the flowers were highly protected against bruising and water loss, ethylene production was the lowest of all the different treatments, (47.7 nl/g/h compared with 107.9 nl/g/h in the control). The average postharvest life of flowers in treatment 6 was 5.0 days compared with 3.3 days of the control [117].

Pulsing with magnesium oxide nanoparticles maintains the postharvest quality of cut lotus flowers (*Nelumbonucifera*Gaertn) 'Sattabongkot' and 'Saddhabutra'

Two main problems of cut lotus flower buds are petal blackening and petal discoloration, resulting in short vase life and loss of postharvest quality.

Material & Method: Lotus flower buds of varieties: 'Sattabongkot' and 'Saddhabutra' Cut flower buds of each cultivar were pulsed with different concentrations of an MgO NP suspension (0, 0.05, 0.1, and 0.3%), for 6 h.Followed by transfer to distilled water as the vase solution at 27°C and 80–85% RH.

Results: The longest vase life of 90.0 h was found in 'Sattabongkot' when cut flowers were pulsed with 0.1% MgO NP. 'Saddhabutra' showed the second longest vase life of 87.0 h when pulsed with 0.3% MgO NP. Increased water uptake, delayed fresh weight decrease, suppressed ethylene production, and reduced petal blackening in the cut flower buds of both cultivars were found in these treatments [119]

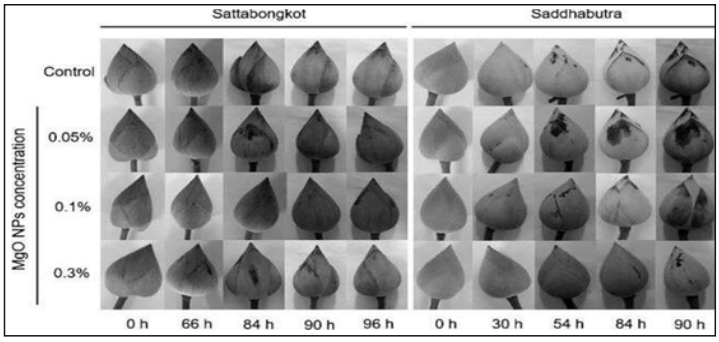


Fig. Development of petal blackening in 'Sattabongkot' and 'Saddhabutra' lotus flower buds pulsed with MgO NP suspensions119

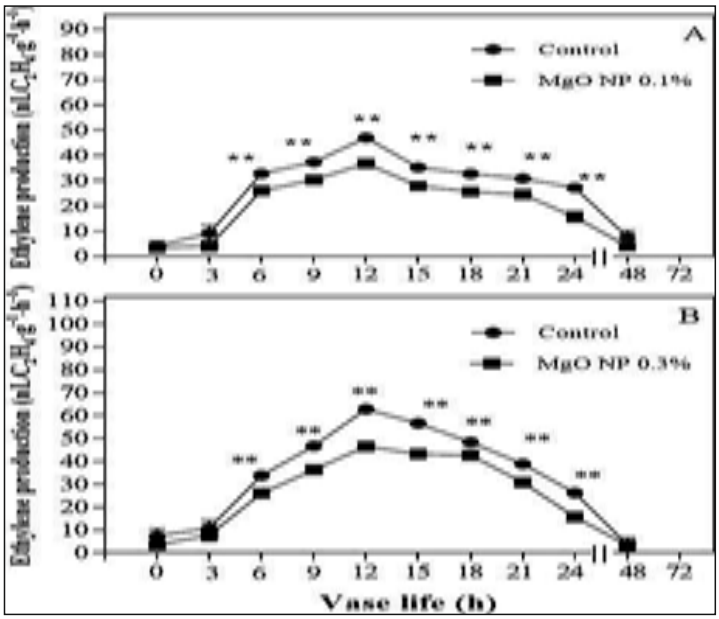


Fig: Ethylene production of in 'Sattabongkot' (A) and 'Saddhabutra' (B) lotus flower buds pulsed with MgO NP.

Research Institutes Working On Lotus

- CSIR-NBRI Lucknow(U.P)
- OUAT Bhubaneswar (Orrisa)
- SKUAST Kashmir (J&K)
- TNAU (Coimbatore)

Areas of Research: Selection of germplasm, having high nutraceutical and medicinal properties for commercial exploitation in India, analysis of genetic diversity of Indian lotus, developing agro-technologies/models for propagation and cultivation of identified elite lotus germplasm in different agro-climatic conditions of India through multi-location trials. Development of a few nutraceutical products using different plant parts of lotus targeting the global market.

Prospects

Lotus cultivation is a tradition in our country. There is huge potential to be used this crop for commercial flower and rhizome production as well as in landscaping. Some successful examples of lotus cultivation in world have been discussed here.

The Emergence of Lotus Farming as an Innovation for Adapting to Climate Change in the Upper Vietnamese Mekong Delta

The Emergence of Lotus Farming as an Innovation for Adapting to Climate Change in the Upper Vietnamese Mekong Deltabecause Delt because of local farmers' knowledge of flood-based livelihoods, such as lotus farming. Additionally, the World Wildlife Fund (WWF), seeking to promote sustainable flood-based livelihoods, entered the scene with funding from the Hong- Kong and Shanghai Banking Corporation (HSBC) to develop lotus- ecotourism in farming areas around Tram Chim[117].

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Table 1. Stakeholder Perspectives on Lotus Farming as an Emerging Innovation

Stakeholders (Relevant Social Groups)	Perceived Function of Lotus Farming as an Innovation	Claims
Farmers: lotus growers and laborers	Lotus farming is a valuable opportunity to improve incomes and deal with disadvantageous soil conditions	▪ Higher market price than rice (ten times higher in 2015) ▪ Income earned periodically, giving farmers more regular income than with rice
Scientists: academics, researchers, and students	Lotus farming is a means to adapt to climate change and cope with floods and unfavorable natural conditions	▪ An alternative to intensive rice cultivation, which has been shown to undermine resilience to climate change ▪ Resolves soil problems ▪ A good opportunity for further collaboration between stakeholders toward future sustainability
Development partners: international organizations and NGOs	Lotus farming is a way to cope with the concurrent challenges of climate change, erratic flood seasons, and unfavorable natural conditions	▪ Provides potentially environmentally friendly livelihoods and a pathway to climate change adaptation ▪ Resolves soil problems ▪ One of the best ways to achieve Sustainable Development Goals
Local officials: local authorities and farmer representatives	Lotus farming evolved from being a profitable activity for the community to being a symbol of the region's cultural identity and heritage; it is also a means of implementing the national policy of agricultural restructuring	▪ Creates jobs ▪ Provides a symbol of the region's great beauty and cultural heritage
Traders: individual traders and companies	For individual traders, lotus farming was foremost a source of monetary profit. Companies, however, viewed it as a way to achieve greater sustainability, as well as profit	▪ Excellent market potential, as lotus is an agricultural product of which all parts are used ▪ Higher market price than rice

Table 2. Profit from Crops in Study Area, i.e., Rice, Lotus and Other Products, surveyed on December 2018 (US$/ha).

Crop/Product	An Giang	Dong Thap	Average

Profit from first rice crop (winter-spring)	794.24	553.59	709.30
Lotus farming profit	911.16	62.08	495.83
Fish farming profit	168.71	354.16	175.01
Profit from second rice crop (summer-autumn)	356.34	260.80	357.05
Profits from other livelihoods (duck/frog/wild fish) in flood season	282.54	224.25	264.60

Lotus Cultivation under Wetland: A Case Study of Farmers Innovation in Chhattisgarh, India

District Dhamtari is the fertile plains of Chhattisgarh has extensive wetlands mostly belongs to paddy fields. The district experiences subtropical climate with an annual rainfall of about 1100 mm over 65 days during June to October. To evaluate economics of Lotus cultivation resource extraction pattern was estimated from field observation and discussion with user group for three different seasons – Rainy, winter and summer. The quantity of lotus part extracted was estimated through questionnaire with user group and physical verification in the field. The market prize of various parts of lotus recorded from mandi of Dhamtari, Kurud, Raipur and Durg[118]

Fig.1 Lotus Flower (A), Field View(B),Mature Field(C), Harvesting of Lotus Rhizome (D), Washing and Grading of Product (E), Bundling of Products(F), Transportation(G), Marketing of product(H)

Lotus-Ecotourism

The lotus-ecotourism model was implemented on lands with accessibility to roads. In addition to a lotus field, lotus-ecotourism required ponds in between for wild fish and other aquatic species. It brought opportunities for good jobs and better incomes for local farmers. Many tourists visited the area, attracted by the beauty of lotus, the surrounding landscape, and the local cuisine.

Conclusion

Lotus is considered as a symbol of purity and is an integral part of Indian traditions and rituals. Besides, its uses as a traditional loose flowers; it is increasingly being demanded as cut flower also in the modern decorations. A new avenue has been added in the recent past for utilizing the scenic beauty of lakes/ponds adorned with lotus flower and borrowing this into landscape. Eco-tourism is coming up very fast and offer a unique business opportunity as is evident from success story of Chhattisgarh. One of the greatest opportunities is the unique utilization of waste and barren lands of farmers converting these to profitable ventures. Presently lotus is naturally growing in ponds and lakes and is being harvested for commercial use by farmers. However, keeping the potential of crop in mind, and availability of natural growing environment in different parts of country, strengthening of research on production practices is the prime requirement.

References

1. Anonymous. 1987. *China Lotus. Wuhan Botanical Institute, Academia Sinica*, Science Publishing Association, Wuhan, Hepeh, China (in Chinese).

2. Anonymous, 1997. Horticultural Crop Production in Korea. National Horticultural Research Institute, Rural Development Administration, Seoul, Korea.

3. Anurag Sunpapaol, PrisanaWonglom, Shigeru Satoh, Seiji Takeda and SamakKaewsuksaeng. 2019. Pulsing with Magnesium Oxide Nanoparticles Maintains Postharvest Quality of Cut Lotus Flowers (*Nelumbonucifera*Gaertn) 'Sattabongkot' and 'Saddhabutra' *The Horticulture Journal* 88 (3): 420–426.

4. A.K Singh 2006. Flower crop cultivation and management. Laxmi Art Creation press ISBN 81-89422-35-9. Page no.231-238

5. Gokul, P., Rajamani, K., Ganga, M. and Vanitha, K., 2022. Assessment of lotus (*Nelumbonucifera*) genotypes for growth and flowering for landscaping.Page no.63-72.

6. Jun-ichiro Masuda, Toshihiro urakawa, Yukio Ozaki, Hiroshi okubo. 2006. Short Photoperiod Induces Dormancy in Lotus (*Nelumbonucifera*) *Annals of Botany*, Volume 97(1), 39–45.+

7. La-Ongsri, W., Trisonthi, C. and Balslev, H., 2009. Management and use of NelumbonuciferaGaertn. in Thai wetlands.Wetlands ecology and management,17, pp.279-289.

8. Lin, Z.; Damaris, R.N.; Shi, T.; Li, J.; Yang, P. 2019.Transcriptomic analysis identifies the key genes involved in stamen petaloid in lotus (*Nelumbonucifera*). BMC Genome 19, 554.

9. Q.V. Nguyen. 2001. Research report. Agriculture, Horticultural Research & Advisory Station, Gosford, NSW and D Hicks, University of Western Sydney, Hawkesbury. Pp.45-53.

10. Rajeshwari, Sahu and Chandravanshi, S. S. 2018. Lotus Cultivation under Wetland: A Case Study of Farmers Innovation in Chhattisgarh, India. *International Journal of Current Microbiology and Applied Sciences* ISSN: 2319-7706 Special Issue-7, 4635-4640.

11. Shen-Miller, J, M.B. Mudgett, J.W. Schopf, S. Clarke and R. Berger, 1995. Exceptional seed longevity and robust growth: Ancient sacred lotus from China. *American Journal of Botany* 82 (11):1367-1380.

12. Suisuwan, Chornitsiri and Pichayanonul, Kanungnit. 2005. Study on harvest method and postharvest handling of lotus flowers (*Nelumbonucifera*Gaertn) var. Sattabongkot*Thai Journal of Agricultural Science* 35 (3), 303-308.

13. Uorasa, B. and Thanoumnuan, S., 2005. A Study on Potential Market of Lotus Flowers. *Agricultural Sci. J*, *36*, pp.5-6.

14. Vo, H.T.M vanHalsema, G., Hellegers, P., Wyatt, A., Nguyen, Q.H. 2021.The Emergence of Lotus Farming as an Innovation for Adapting to Climate Change in the Upper Vietnamese Mekong Delta. *Land*, *10*, 350.

15. Xia Yu, Jiajing Sheng, Lingling Zhao, Ying Diao, Xingwen Zheng, Keqiang Xie, Mingquan Zhou, Zhongli Hu 2015 *In vitro* plant regeneration of lotus (*Nelumbonucifera*) *Open Life Sci*.10: 142–146.

16. Zhang, J., Wang, J., Zhao, Y., Xu, L., Gao, X., Zheng, Y. and Jiang, L., 2008. How does the leaf margin make the lotus surface dry as the lotus leaf floats on water? *Soft Matter*, *4*(11), 2232-2237.

17. Al-Hamdani, S. and D.A. Francko. 1992. Effect of light and temperature on photosynthesis, elongation rate and chlorophyll content of Nelumbolutea (Willd.) Pers. seedlings. *Aquatic Boany* 44(1):51-58.

18. Anonymous. 2004. Storage of lotus (*Nelumbonucifera*). Technology of storage.

19. Anonymous. 2006. Lotus seeds. Huisen Chinese Medicine Website. 20 May 2007.

20. Barthlott, W. and C. Neinhuis. 1997. Purity of the sacred lotus or escape from contamination in biological surfaces. *Planta* 202:1-8.

21. Barthlott, W. and C. Neinhuis. 1998. Lotus-effekt und autolack: die selbstreinigungsfähigkeitmikrostrukturie rteroberflächen. *BiologieUnsereZeit*. 28:314-32

22. Borsch, T. and W. Barthlott. 1994. Classification and distribution of the genus NelumboAdans. (Nelumbonaceae). *BeitragezurBiologie der Pflanzen.* 68:421-450.

23. Bosmans, R.V. 1994. Basics of planting aquatic plants. Home and Garden Mimeo. HG17a:1-4. *Maryland Coop.* Ext. Page no63-74.

24. Deng, H.Q., G.Z. Huang, and J.P. Gui. 1990. A study on the lotus propagation by cutting rhizome. *J. Wuhan Bot. Res.* 8:292-296.

25. Ding, C.M., J.X. Xu, and W.D. Shi. 1995. Several important biochemical changes during formation of enlarged lotus rhizomes. *JiansuAgr. Sci*. (6):50-51.

26. Doniger O'Flaherty, W. 1967. The post-vedic history of the soma plant. In G. Wasson, ed., Soma, divine mushroom of immortality. *Harcourt Brace Jovanovich, Inc., Italy.*

27. Fischer, H.C. (ed). 1996. Plant Fossil Record Database (version 2.2). London: InternerBiodiv. Serv., *Intl. Organ. Palaeobot*. Page no.234-48.

28. Follett, J.M. and J.A. Douglas. 2003. Lotus root: production in Asia and potential for New Zealand. Combined Proc. *Intl. Plant Prop*. Soc. 53:79-83.

29. Francko, D.A. 1986a. Studies on *Nelumbolutea* (Willd.) pers. I. Techniques for axenic liquid seed culture. *Aquat. Bot.* 26:113-117.

30. Fu, D.Z. and J.H. Wiersema. 2001. *Nelumbonaceae*. In: Flora of China 6:114.

31. Fu, C.Y., C.X. Liu, L.C. Dai, S.H. Huang, and X.L. Tang. 1994. Cultivation technology of antiseason rhizome-lotus (*Nelumbonucifera*Gaertn.). *Till. Cultiv.* (2):61-62.

32. Fukuhara, H., A. Kawakami and T. Shimogaito. 2003. Characteristics of nutrient dynamics in Lake Sagate, Japan, a shallow sand dune lake. *Hydrobiol*. 506-509:93-99.

33. Fukuhara, H., C. Satoh, T. maruyama, H. Yamagishi, and Y. Takahashi. 2006. Limnological studies of lakes in Niigata prefecture XI. Limnological studies of Lake Mitarasegata (Akatsuka, Niigata), a sand dune lake in Japan with special references to nutrient dynamics. *Nat. Sci.* 8:35-50.

34. Gandolfo, M.A., R.N. Cuneo. 2005. Fossil Nelumbonaceae from the La Colonia Formation (Campanian–Maastrichtian, Upper Cretaceous), Chubut, Patagonia, Argentina. *Review Palaeobot. Palyno*l. 133:169-178.

35. Godwin, H. and E.H. Willis. 1964. The viability of lotus seeds (*Nelumbonucifera*, Gaertn.). *New Phytologist*. 63:410-412.

36. Grodowitz M.J., S. Whitaker, L. Jeffers, and A.F. Cofrancesco. 2001. Aquatic plant information system (E version 3.0). Dept. Army, Vicksburg, MS.

37. Hall, T. F. and W. T. Penfound. 1944. The biology of the American lotus, *Nelumbolutea*(Willd.) Pers. Amer. *Midland Naturalist* 31:744-758.

38. Hayes V., E.L. Schneider, and S. Carlquist. 2000. Floral development in *Nelumbonucifera* (Nelumbonaceae*). Intl. J. Plant Sci*. 161:S183-191.

39. He, Z.S. and S.J. Liu. 1987. Culture of the shoot tip explants of lotus, *Nelumbonucifera. ActaHydrobiol. Sinica* 11:191-193.

40. He, J.J., G.Q. Xiong, L.X. Ye, J.M. Zhang, and X.Z. Liao. 1998. Technology of freshness maintenance of lotus in vacuum. *Changjiang Veg.* (7):36-37.

41. Hicks, D.J. 2005. Development and evaluation of a system for the study of mineral nutrition of sacred lotus (*Nelumbonucifera*). Univ. Western Sydney, PhD Thsis.

42. Hu, G.W., K.M. Liu, and L.G. Lei. 2003. Advances in the systematics of Nelumbo and the establishment of Nelumbonaceae. *Acta Laser Biol. Sinica* 12:416-420.

43. Ito, S. and I. Kito. 1998. Quality maintenance of cut lotus flower (NelumbonuciferaGaertn.) by low temperature. Res. Bull. Aichi. Res. Ctr. 30:221-226

44. Ji, H.W., C.Q. Tang, L.B. Li, and T.Y. Kuang. 2001. Photosystem development in darkgrown lotus (*Nelumbonucifera*) seedlings. *Acta Bot. Sinica* 43:1129-1133.

45. Kakuyama, H. and J. Ogawa. 1997. Culture condition for propagation and acclimatization of cultured plantlets in lotus (*Nelumbonucifera*Gaertn.). Bull. Tokushima Agric. Expt. Sta. 33:7-12.

46. Kasumi, M., K. Yashiro, and M. Hayashi. 2000. Effectiveness of cold stored pollen on seed formation in East Indian lotus (*Nelumbonucifera*Gaertn.) *J. Jpn. Soc. Hort. Sci.* 69:732-735.

47. Katori, M., K. Nomura, and K. Yoneda. 2002a. Propagation of flowering lotus (*Nelumbonucifera*Gaertn.) by rhizome straps, without enlarged rhizomes. *Jpn. J. Trop. Agr.* 46:195-197.

48. Ke, S.Q., S.R. Hong, X.M. Ni, R.H. Huang, and X.W. Wu. 1987a. Preliminary report of Nelumbolutea explant culture *in vitro. Acta Hort. Sinica* (3):208-212,218.

49. Lancar, L. and K. Krake. 2002. Aquatic weeds and their management. *Intl Commiss. Irr. Drainage. 112-125*

50. Lee, S.M. and T.H. Kwon. 2007. Effects of intrinsic hydrophobicity on wettability of polymer replicas of a superhydrophobic lotus leaf. *J. Micromech. Microeng.* 17:687-692.

51. Li, C.R. 2004. Study on different propagation methods of rhizome lotus. Yunnan Agr. (2):27. Li, Z.Y. and P. Qian. 1994. Effect of different culture media and nutrient solutions on lotus growth in soilless culture. *Acta Agr. Zhejiangensis*6:127-130.

52. Li, G.B., K.G. Sun, Y. Jiao, Y. Wang, and G.L. Liang. 1998. Effects of incorporative application of nitrogen, phosphorous, potassium fertilizers on lotus *(Nelumbonucifera)*. *China Veg.* (1):12-14.

53. Li, J.X., J.C. Song, Y. Liu, J. Cui, J.Y. Wang, L.X. Yang, and Y. Li. 2002. Effect of potassium fertilizer on increasing yield of rhizome lotus planted in lime-concretion black soil. *J. Anhui Agr. Sci.* 30:783.

54. Li, L.J., X.D. Zhang, K. Xie, L. Sun, L. Gu, and P.S. Cong. 2006. Study on the carbohydrate metabolism in lotus root during storage in field through the winter. *China Veg.* (4):11-13.

55. Liu, M., Y. Chen, C.B. Sun, K.D. Li, and L.J. Fan. 2002. Studies on tissue culture of several cultivars of lotus (*Nelumbonucifera*). *J. Zhejiang Agr. Sci.* (3):108-111.

56. Luo, L.P., Q.Y. Cai, B.Y. Yang, and Y.H. Guo. 2004a. Studies on the primary tissue culture of space lotus's rhizomes. *Nat. Sci.* 28:266-269.

57. Luo, L.P., Y.H. Guo, Q.Y. Cai, B.Y. Yang, and K.Q. Xie. 2004b. The tissue culture of lotus by space mutation. *Plant Physiol. Commun*. 40:201.

58. Maeda, Y., T. Minamikawa, and B.M. Xu. 1996. Metabolic activities in germinated ancient lotus seeds. *J. Expt. Bot.* 37:577-582.

59. Makthong, C. 2001. Procooling lotus flowers (*Nelumbonucifera* 'Roseum Plenum') after harvesting. Graduate School, King Mongkut's Institue of Technology Ladkrabang Bangkok, MS Thesis.

60. Mastrantuono, L. and T. Mancinelli. 1999. Long-term changes of zoobenthic fauna and submerged vegetation in the shallow Lake Monterosi (Italy). *Limnol.* 29:160-167.

61. Masuda, J.I., Y. Ozaki, and H. Okudo. 2007. Rhizome transition to storage organ is under phytochrome control in lotus (*Nelumbonucifera*). *Planta* 226:909-915.

62. Matthews, P.G.D. and R.S. Sey`mour. 2006. Anatomy of the gas canal system of *Nelumbonucifera*. *Aquat. Bot*. 85:147-154.

63. McDonald, A. 2004. A botanical perspective on the identity of Soma (*NelumboNuciferaGaertn*.) based on scriptural and iconographic records. *Econ. Bot*. 58:S147-173.

64. Meyer, W.C. 1930. Dormancy and growth studies of the American lotus, *Nelumbolutea*. *Plant Physiol*. 5:225-234.

65. Mevi-Schutz, J. and W. Grosse. 1988a. A two-way gas transport system in *Nelumbonucifera. Plant Cell Environ.* 11:27-34.

66. Nguyen, Q.V. 2001. Lotus for export to Asia - an agronomic and physiological study. *RIRDC Publ., Barton, Australia*.

67. Ohga, I. 1937. On the fertilization of Nelumbonucifera. Cytol. (FugiiJubl. Vol.):1033- 1035.

68. Orimoto, Y. and M. Takai. 2007. Influence of reducing nitrogen application rate with coated fertilizer in combination with irrigation water saving on yield of East Indian Lotus (*Nelumbonucifera*) and nitrogen effluent. Soil Sci. *Plant Nutr*. 53:819. (Abstr.)

69. Pan, D.R., L.Y. Lin, W.J. Ke, J.L. Zhang, Y.F. Zhou, X.Z. Zhang, and J.Z. Wu. 2004. The study of rapid propagation of different *NelumbonuciferaGaertn* by plant tissue culture. Proc. 2nd Natl. Symp. Plant Tissue Cult. *Rapid Production Technol*.123-127.

70. Peng, J., F. Li, X.F. Fu, W.D. Ke, and X.F. Huang. 2004. Observation on the growth of lotus (*NelumbonuciferaGaertn*.) plants propagated by micro-rhizomes. Proc. 2nd Natl. Symp. Plant Tissue Cult. *Rapid Production Technol*. 128-133.

71. Pichayanon, K. 2001. Study on harvest method and postharvest handling of NelumbonuciferaGaertn var. 'Sattabongkot'. Kin Mongkut's Inst.Technol. Ladkrabang Bangkok. MS Thesis. Porcher,

72. M.H. et al. 1995-2020, Sorting Nelumbo names. Multilingual Multiscript Plant Name Database - A work in progress. School Agr. Food Systems. Fac. *Land Food Resources.* Univ. Melbourne. Australia.

73. Priestley D. A. 1986. Seed aging. *Comstock Cornell University Press*, Ithaca, New York, USA. Priestley.

74. D.A. and M.A Posthumus. 1982. Extreme longevity of lotus seeds from *Pulantien. Nature* 299:148-149.

75. Qi, J.H. 2006. Research on *Nelumbonucifera* planting and its economic and cultural values in Ancient China. Nanjing Agr. Univ. MS Thesis.

76. Qing, Z.L. and L. Huang. 2005. Cultivation technology of high-yield double-season lotus. *Guangxi Hort.* (4):23-24.

77. Qu, X.J. and Y.W. Zhao. 1991. The preliminary study on formation of yield and characteristic of needing fertilizers of lotus rhizome without flowers. *ActaHorti. Sinica* 18:335-339.

78. Sahavacharin, O. 1998. Cut flower production in Thailand. Reg. *Office Asia Pacific*, Thailand.

79. Sanderson, M.J. and J.A. Doyle. 2001. Sources of error and confidence intervals in estimating the age of angiosperms from rbcL and 18S rDNA data. *Amer. J. Bot.* 88:1499- 1516.

80. Sang, Z.F., M.Q. Zhou, D.C. Wang, X.Z. Li, G.J. Wen, and C.Y. Fu. 1994. Comparison of lotus-fish co-culture models. *Hubei Agr. Sci*. (6):56-58.

81. Sastroutomo, S.S. 1982. Summer biomass of aquatic macrophytes in relation to sediment characteristic in lake Aino-Numa. *Jpn. J. Ecol*. 32:45-55.

82. Schneider, E.L. and L.A. Moore. 1977. Morphological studies of the *Nymphaeaceae*. VII. The floral biology of Nupharlutea subsp. macrophylla. *Brittonia* 29:88-99

83. Shao, G.Y., J.H. Cheng, W.H. Ji, Y.D. Zhang, S.L. Zhu, and X.F. Ma. 2003. Survey and control of weeds in lotus field in Baoying county of Jiangsu province. *Weed Sci.* (3):18- 19.

84. Shen-Miller, J., M.B. Mudgett, J.W. Schopf, S. Clarke, and R. Berger. 1995. Exceptional seed longevity and robust growth Ancient sacred lotus from China. *Amer. J*. Bot. 82:1367-1380.

85. Shen-Miller, J., W. Schopf, G. Harbottle, R.J. Cao, S. Ouyang, K.S. Zhou, J.R. Southon, and G.H. Liu. 2002. Long-living lotus: germination and soil γ-irradiation of centuries-old fruits, and cultivation, growth, and phenotypic abnormalities of offspring. *Amer. J. Bot*. 89:236-247.

86. Shimomura, T., A. Yamaguchi, I. Uritani, and T. Hirai. 1955. Resistance of lotus to the rhizome rot caused by FusariumbulbugenumWr. var. nelumbiculum N. et W. Ann. *Phytopathol. Soci. Jpn*. 20:43-53.

87. Slocum, P.D. 2005. Waterlilies and Lotuses: Species, Cultivars, and New Hybrids. *Timber Press, Inc. Portland*, USA.

88. Snow, J.R. 2000. Establishment and competitive ability of Nelumbolutea in relation to Myriophyllum spicatum. Univ. North Texas, MS Thesis.

89. Sohmer, S.H. and D.F. Sefton. 1978. The productive biology of Nelumbopentapetala (Nelumbonaceae) on the upper Mississippi river. II. The insects associated with the transfer of pollen. *Brittonia*30:355-364.

90. Song, J.C., J.Y. Wang, S.L. Zhao, T.Q. Yang, L.Q. Wang, and B.H. Huo. 2006. Technology of balanced fertilization for high yield in lotus rhizome. Modern Veg. (3):44.

91. Sou, S.Y. and N. Fujishige. 1995. Cultivation comparison of lotus (*Nelumbonucifera*) between China and Japan. J. *Zhejiang Agr. Sci*. (4):187-189.

92. Wang, Q.C. and X.Y. Zhang. 2004. Lotus flower cultivars in China. China Forestry *Publ. House.*

93. Beijing. Wang, C.Y., P.S. Zhang, Q.S. Xu, J. Pang, and L.Y. Luo. 2003. Study on environmental conditions of storing lotus flower. *Storage Process* (1):12-14.

94. Wangjia Lotus Plantation: Lotus.10 January 2008.

95. Watson, L. and M.J. Dallwitz. 1992 onwards. The families of flowering plants: descriptions, illustrations, identification, and information retrieval *Vers.*

96. Wei, Q.G., Z.T. Wei, J.Q. Qing, Z.G. Yu, and Z.S. Wei. 2006. Cultivation technology of lotus-arrowhead co-culture. Modern Veg. (2):27.

97. Wen, G.Y. 1987. Effect of discarding terminal buds on yield and traits of lotus rhizomes. J. Zhejiang Agr. Sci. (4):193-195. Wenzel, R.N. 1936. Resistance of solid surfaces to wetting by water. Ind. Eng. Chem. 28:988-994.

98. Xu, J.R., Q.Z. Wang, J.J. He, M.Q. Zhou, and Z.L. Hu. 2003b. Study on storage and physiology of enlarged rhizome of lotus. Amino Acids *Biotic Resources* 25:4-7.

99. Yamamoto, Y. and O. Matsumoto. 1986. Tissue culture of lotus (*NelumbonuciferaGaertn.)* from apical meristem. *Farm. Hort*. 61:87-88.

100. Yamamoto, Y. and O. Matsumoto. 1988. Tissue culture of lotus (*NelumbonuciferaGaertn*.) I. Culture media for inducing plantlet from apical meristem. Bull. Yamaguchi Agr. *Expt. Sta*. 44:44-48.

101. Yang, Z.M., P. Chen, and L.X. Luo. 2006. Antiseason lotus cultivation technology in winter in Zhuhai. Guangdong *Agr. Sci.* (7):83-84.

102. Ye, Y.Z., Z.H. Tan, and C.C. Cheng. 1975. Preliminary study on destroying deteriorative populations of seed-lotus by rust remover. *ActaHydrobiol. Sinica* 5:513-518.

103. Yi, Y., C.K. Lin a, and J.S. Diana. 2002. Recycling pond mud nutrients in integrated lotus–fish culture. *Aquacult*. 212:213-226.

104. Yuan, J.L., Y. Ding, X. Kang, and Q.J. Ai. 2004. Effect of process conditions on quality of stored clean lotus rhizomes. *Storage Process*. 25:128-131.

105. Zhan, J.F. and C.L. He. 2006. Comparison of several storage methods of lotus root. J. Shannxi Univ. Sci. Technol. 24:66-68.

106. Zhang, X.Y. 2003. Important points on cultivation of antiseason flowering lotus. *China Flr. Hort*. (16):36-37.

107. Zhang, Y. and X.H. Liu. 2005. Characteristics of postharvest water balance for cut flowers of *Nelumbonucifera*Gaertn. J. Yangtze Univ. (Nat. Sci. Ed.) 2:4-5,41,46.

108. Zhang, W.Q., Y.F. Lu, and X.L. Tong. 2004. A new insect pest of lotus flowerScirtothrips dorsalis Hood and its control strategies. J. *Chinese Landscape Architect.* (4):33-34.

109. Zhang, D.Y., M.L. Wang, J.A. Wang, and R.X. Wu. 1994. Study on fertilization of potassium to rhizome-lotus (*NelumbonuciferaGaertn*.) *Soil Fert.* (6):29-32.

110. Zhang, L.H., Y.B. Han, J. Sun, X.X. Lu, Z.X. Gu, P.Q. Chen, A.F. Liu, and Y.X. Qiu. 2005. Optimizing amylase usage in pretreatment of lotus root with response surface methodology. *Food Ferment. Ind*. (10):81-84.

111. Zheng, B.D. 2004. Study on the main quality of Chinese lotus-seed germplasm resources and its applications. Fujian Agri. Forestry Univ., PhD Diss. 56

112. Zhou, Z.P., J.X. Zhou, and P.D. Hu. 1989. Propagation of lotus (*Nelumbonucifera)* by seeds. Hubei Agr. Sci. (3):29-30.

113. Zhou, M.Q., Z.F. Sang, Z.A. Yao, and A.Y. Luo. 1994. Preliminary report on high yield technology based on foliar age model. Till. *Cultiv*. (2):2-3.

114. Zhuang, S.Q., J. Zhou, and S.H. Zhuang. 2003. Success obtained on floating cultivation of flowering lotus in reservoir. *China Flr. Hort.* (16):36-37.

115. Watson DP and Andrews PS. 1953. The effect of light intensity on the flowering of chrysanthemum variety 'Gold Coast'. *Proceedings of American Society for Horticultural Science* **61**: 551.

116. Whealy CA, Nell TA, Barrett JE and Larson RA. 1987. High temperature effects on growth and floral development of chrysanthemum. *Journal of American Society for Horticultural Science* **112**(3): 464-468.

117. Wilkins HF, Healy WF and Grueber KL. 1990. Temperature regimes at various stages of production influences growth and flowering of *Dendranthema x grandiflorum. Journal of American Society for Horticultural Science* **115**(5): 732-736

118. Wilfret GJ. 1985. Evaluation of chrysanthemum cultivars grown as centre disbudded plants in containers. *Proceedings of the Florida State Horticulture Society* **98**: 124-127.

119. Wilfret GJ and Harbaugh BK. 1979. Mini pot garden chrysanthemum cultivar characteristics and consumer preferences. *Proceedings of the Florida State Horticulture Society* **92**: 317-319