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Vertical flower farming – A smart choice

Vertical farming is a modern agricultural practice of growing crops by stacking the crops vertically in a controlled environment. Vertical farming offers numerous potential benefits, including more efficient use of vertical space, increased planting density, reduced water usage, shorter cultivation time, reduced need for plant protection chemicals, and protection from extreme weather conditions. Vertical farming is considered as an emerging smart sustainable farming solution for urban and peri-urban locations.

VERTICAL farms can help in addressing the problem of shrinking farmlands in urban and peri-urban locations. Vertical farming can be very well designed inside protected structures like naturally ventilated polyhouses, wherein the floors as well as the vertical space can be utilised for growing crops. The yield of crops per unit area is much higher in the vertical farming system as compared to conventional farming. This article reviews the recent developments in vertical farming of flower crops for smart urban agriculture including the current development of vertical farming of flower crops, state-of-the-art vertical farming practices with modern and precision technologies; and current challenges and opportunities of vertical farming for livelihood security.

Vertical farming technologies in flower crops

Vertical farming has numerous advantages, which makes it promising for the future of agriculture in general and horticulture in particular. The land requirement for vertical farming is quite low, water consumption is less, the water is recycled and utilized, and there is no real dependency on the weather fluctuations. Vertical farming is an excellent choice for increasing the plant population per unit area. There is efficient utilization of vertical space in this farming method and more crop can be produced in limited area. Higher yield can be obtained per unit area as vertical space is used effectively. A vertical farm makes farming within the limits of cities or urban areas, a reality. Vertical farming can be practiced in controlled environment to produce crops throughout the year. It makes possible to deliver the fresh produce quickly since the farms are nearby; as compared to the refrigerated produce which is usually available in supermarkets and also reduces the spoilage in transportation.

The choice of crops in vertical farming systems is currently limited, with most producers predominantly favouring exotic herbs, salad leaves and other small leafy vegetables. These types of crops are well suited for commercial cultivation in vertical farming systems for several reasons. Their compact and small size allows them to be grown in facilities such as stacked horizontal systems or tower systems or cylindrical growth units where space, particularly in the vertical dimension, is at a premium. Small plant size also allows a higher density of plants, and so potentially increased income per unit area, horizontally. These crops also tend to show fast growth rate in a short timeframe, from sowing to harvest, increasing the number of crop cycles that can be produced in a season, further maximizing profitability. However, there is a need to investigate the suitability of vertical farming practices for the production of other horticultural crops in general and flower crops in particular which may help to expand the produce range and income. Since vertical farming is known for increased planting density and requires less space, it can be efficiently utilized for the production of high value flower crops, thereby leading to high economic benefits. Vertical farming generates economic benefits not only by increasing planting density and yield but also decreasing the expenses for transportation or storage of the produce. Moreover, the growers are benefitted from reduced crop losses, improved yields and more secure supply chains as well as reduced environmental impact and improved agricultural sustainability.

Design and considerations for vertical farming of flower crops

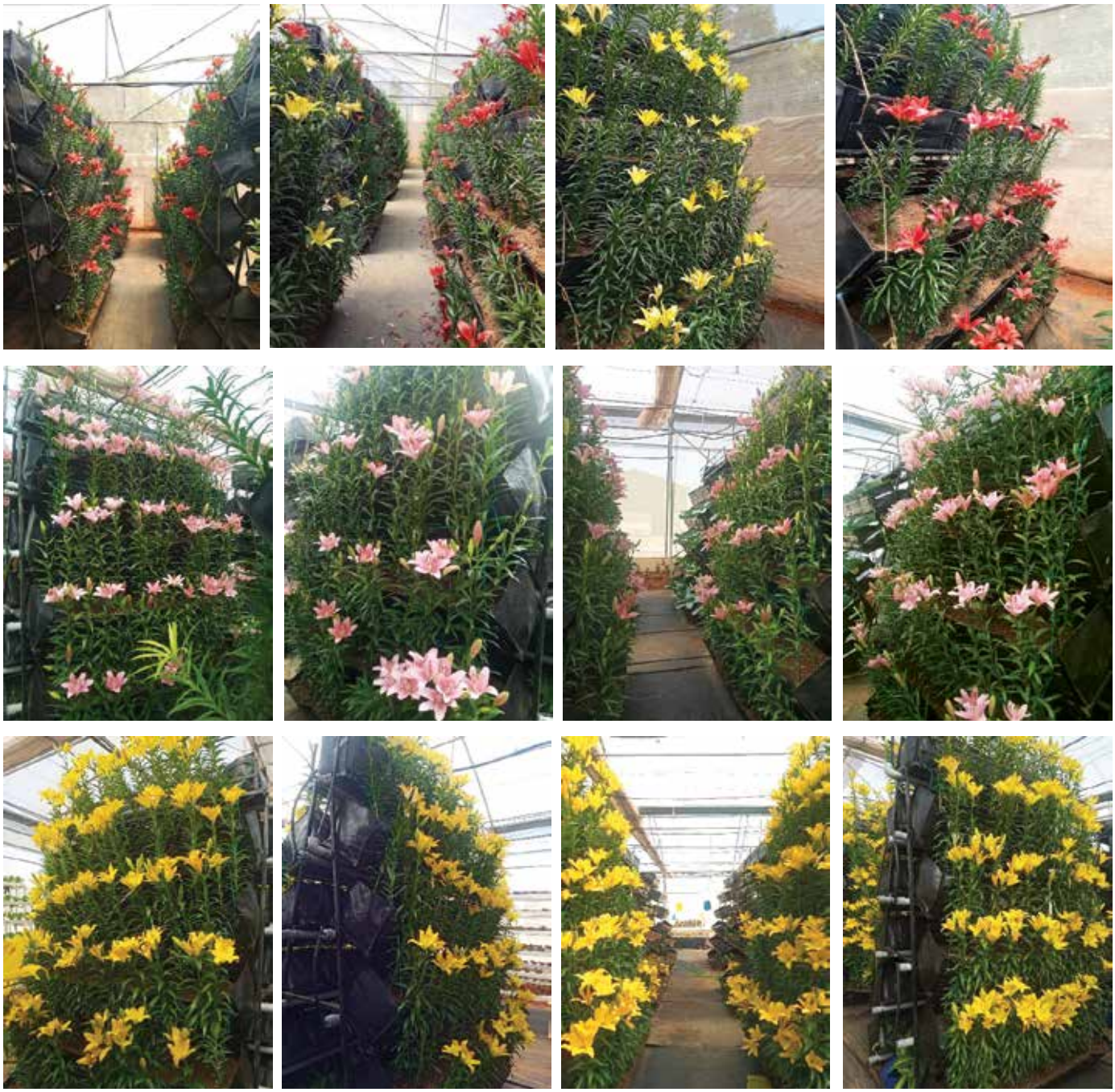
Arka vertical farming module

A vertical farming structure was designed and fabricated for commercial cultivation of high value horticultural crops at ICAR-Indian Institute of Horticultural Research, Bengaluru, Karnataka. The high value flower crop, *Lilium* was chosen as the candidate crop for conducting the preliminary research trial on vertical farming. The vertical farming structure was made of mild steel and fabricated in A shape of 12 ft height. Vertical farming structure was build with the idea of catering to the needs of urban and peri-urban farming by capitalizing on space vertically and utilizing natural light to be harvested uniformly in different tiers of the structure.

Arka vertical farming module has four major sub structures *viz*., Base/Main frame, Support frames for growbags - Vertically stacked, HDPE growbags with flaps and Irrigation system. Soil-less production system was adopted for vertical farming of *Lilium* with light weight growing media which included cocopeat, farmyard manure and rice husk (2:2:1). Only 2 growbags of dimension 6 ft × 1 ft × 1 ft can be kept in the same area (36 plants in horizontal farming) in which 1 vertical structure (198 plants in vertical farming) can be kept. Thus an increased planting density of 6 times (36 plants in horizontal farming *vs* 198 plants in vertical farming) could be attained through vertical farming. In conventional farming, water requirement for *Lilium* is 5 L/sq.m/day whereas in vertical farming, the water requirement is 952 mL/sq.m/day. This distinctive and smart farming module, aims at higher productivity in smaller spaces by making efficient use of available vertical space and uses soil-less farming. It effectively utilized 12 feet vertical space of polyhouse and an increase in planting density and yield by 6 times was attained through vertical farming. Hence, the problem of shrinking arable land in urban and peri-urban areas can be addressed through this technology and it caters to the need of smaller farms where space is a constraint.

Effective inter-space utilization in Arka vertical farming module for production of shade loving ornamental plants

The vacant floor interspace of the vertical structure as well as the upper inner tiers were utilised for production of shade loving ornamental plants which provided additional returns. To effectively utilize the vacant inter-spaces, growbags 6 ft × 4 ft × 1 ft were used for growing shade loving crops like cut foliages (*Dracaena massangeana*, Ferns,



Arka vertical farming module

Pleomele / Dracaena reflexa (Song of India / Song of Jamaica), English ivy (*Hedera helix*), *Buxus sempervirens* (Boxwood), *Ruscus hypophyllum*, Baby Eucalyptus (Baby Dollar) etc.) in the vacant floor space available in the centre of vertical farming structures. Steel flats were fabricated and kept at the top inner tiers of the vertical structures and were made suitable for placing the pots for growth and production of shade loving potted ornamentals like Anthurium/ *Spathiphyllum* etc. or shade loving indoor potted plants like *Sanseveria*, Palms, *Aglaonema*, *Dieffenbachia* etc. which require low light intensity also generated additional returns. Thus every unit space available in the polyhouse can be effectively utilised.

Orientation of vertical farming system for quality flower production of Gerbera

Vertical farming models with vertically stacked pots placed in different orientations were tested at ICAR-IIHR, Bengaluru for commercial cultivation of Gerbera. Gerbera facing the east direction possessed maximum number of leaves and flowers. Furthermore, it took fewer days to flower bud opening, harvestable maturity and first flower harvest with greater flower diameter and vase life. Plants oriented towards west had the highest stalk length and neck diameter. Thus, orienting vertical structures towards east-west direction can improve the performance of gerbera var. Arka Nesara by providing optimal natural light. Utilization of vertically stacked pots for vertical farming of Gerbera increased the utilization of unit area available in polyhouse to an extent of 5 folds. This provides immediate solution for farming in urban and peri-urban areas where arable land is a limitation besides consistent income to gerbera growers by using minimal farm inputs.

Feasibility studies of vertical farming for commercial cultivation of high value filler flower crops (*Gypsophila* and *Limonium*)

Experiments were conducted at ICAR-IIHR, Bengaluru to establish a feasible cultivation environment that can steadily produce high value filler crops *viz*., *Gypsophila* and *Limonium* on a vertical farm. The

Vertical farming system for gerbera

Shade loving ornamental plants

performance of filler flower crops *viz*., *Gypsophila* and four varieties of *Limonium viz*., Silver Pink, Sky Light, Shooting Star and Ever Snow was evaluated in Arka vertical farming module against control (Conventional farming in horizontally placed growbags). Overall, in terms of photosynthetic efficiency, no significant difference in growth, flowering and productivity was observed in *Limonium* varieties kept in lower bags and upper bags in the vertical tiers as well as control. An increase in planting density and yield by 6 times (121 plants against 20 plants in same ground area) was attained through vertical farming of filler flower crops. This practice overcome issues associated with diminishing availability of agricultural land and water. Also, there was effective utilization of inter-spaces of vertical structures (both floor space and upper inner tiers) for commercial production of shade loving ornamental crops (potted ornamental plants as well as cut foliage plants) which fetches additional income to the flower growers. This technology is beneficial for polyhouse flower growers and is a boon for urban and peri-urban horticulture where space and inputs are major constraints.

Space saving technology for propagation of ornamental crops–Use of vertical structures

The suitability of vertical structures for the nursery production of rooted cuttings of ornamental cut foliage plants like *Draceana deremensis* and commercially important loose flower crop - *Crossandra infundibuliformis* was studied at ICAR-IIHR, Bengaluru. It caters to the need of nurserymen with smaller farms where space is a constraint by making efficient use of the available vertical space for propagation purpose and evolved as a space saving technology.

Vertical farming system for *Gypsophila* and *Limonium*

Utilization of vertical structures for propagation of *Draceana deremensis*

The suitability of vertical structures for the nursery production of rooted cuttings of ornamental cut foliage plants like *Draceana deremensis* was studied at ICAR-IIHR, Bengaluru. To save the space required for nursery production, the growbags were kept vertically in tiers 6 feet long and 1 feet wide. Prior to planting of unrooted cuttings, the propagation substrate was irrigated thoroughly. The available water in the propagation substrate is sufficient to supply the moisture required by the cutting to remain turgid once the roots emerge. The unrooted cuttings were directly planted on the soilless media in the growbags of the vertical structures. To provide the moisture needed to keep propagation environment humid, the vertical structures were kept covered with tailor made tarpaulin materials with provision of zip. Acting like a greenhouse, the cover was used to warm the substrate prior to planting of cuttings. As moisture loss was controlled, it created the ideal humidity for rooting of cuttings. In a period of 45 days, 98% rooting was observed in cuttings of *Draceana* placed in all vertical tiers.

Propagation of *Dracaena deremensis*

Propagation of *Crossandra infundibuliformis* in vertical structures

The vertical structures were evaluated for their suitability for propagation of popular loose flower crop, *Crossandra infundibuliformis* belonging to the family Acanthaceae to meet the huge demand for its planting material. Five varieties of Crossandra released from the institute *viz*., Arka Chenna, Arka Amabara, Arka Kanaka, Arka Shreeya and Arka Shravya were selected for the study. Terminal cuttings of 10-15 cm length of all the five varieties were planted in seedling protrays filled with sterilized cocopeat having 50 cells. Three 50-celled portrays could be accommodated in 1 vertical tier hence

150 cuttings could be propagated in each growbags. In 1 vertical structure, 1500 unrooted cuttings could be easily accommodated for rooting. To provide the moisture needed to keep the propagation environments humid, the vertical structures were kept covered with tailor made tarpaulin materials with provision of zip. In a period of 45 days, 99% rooting could be observed in crossandra cuttings irrespective of the varieties kept in all vertical tiers.

Crossandra Infundibuliformis propagation in vertical structure

CONCLUSION

Constrains like depletion of arable land, limited water resources for irrigation, high rate of infection by soil-borne pathogens, nematode infestation, rapid conversion of fertile agriculture lands to real estate in and around the urban and peri urban areas etc. are challenges associated with farming in urban and peri-urban locations which is limiting the scope for future horizontal area expansion for horticultural crops production in general and flower crops in particular. Vertical farming practices helps growers in urban and peri-urban locations to grow different types of flower crops by using vertical designs and precision agriculture methods with minimum external inputs and energy. This technology is highly protective, conserve water and land which is necessary in present-day context of severe water shortage, degraded soils, and acute market competition. The higher planting density in vertical farming increases yield and makes it economically viable and commercially feasible in urban and peri-urban land areas.

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Success Story

Enhancing Farmers' Income via 'Strawberry Cultivation' : A Case Study from Chittorgarh District of Rajasthan

Shri Nemichand Dhakar, a 32 years old farmer, having done Post Graduation, belonging to Sripura village in Nimbahera Tehsil of Chittorgarh district of Rajasthan State, has 6.00 ha cultivable land with two tube wells as well as open well as source of irrigation, besides owning a cattle dairy unit. After completing post-graduation in the year 2014, he started lookingafter his family farms, and realized that… only growing traditional crops like maize, wheat, mustard, gram and groundnut is not profitable; and hence, some innovative enterprise is necessary for enhancement of income. Then, he contacted some agriculture scientists and extension officers, several times, while having thorough discussions regarding various innovative options to enhance farm income. In 2015, he visited KVK, Chittorgarh; and subsequently, he underwent a training on improved cultivation practices of strawberry. In the same year, he started cultivating strawberry in a small area under the technical guidance of Scientists of that KVK. After getting encouraging results, he gained confidence, and extended strawberry cultivation to 1.00 ha in the year 2020. He brought mother plants of three varieties (*Winter Down, Winter Star* and *Sweet Sensation*), imported from California; and planted the same in his field. Afterwards, he was able to produce thousands of plants from runners of mother plants, and planted on raised bed, on mulching sheet, with drip irrigation system in September. He sold strawberry fruits in the market of Delhi, Jaipur, Ahmadabad and other metropolitan cities. He earned a net income of ₹11.60 lakh per ha with 5.83 BCR. Other than strawberry production, now he has also raised 2.00 lakh plants of strawberry and earned a gross income of ₹10.00 lakh, by selling of plants to the farmers during 2021. He has branded his strawberry as '*Shiv Shakti*', and started selling with proper modern-day attractive packing.

A view of strawberry cultivation by Shri Nemichand Dhakar

A view of strawberries harvested by Shri Nemichand Dhakar

Adding an innovative enterprise to his farm has enormously increased his income. With an increased income, he not only has improved and secured his livelihood, but also has generated employment for his family members. He has also improved his social status with more acceptance, recognition and respect as an innovative young farmer, as he is the first farmer in the hilly area of Chittorgarh district to cultivate strawberry, successfully. Now more than 15 farmers from Rajasthan and adjoining state of Madhya Pradesh have been motivated to start cultivation of strawberry, and they approached him for planting materials and cultivation technology. For strawberry cultivation, several farmers visited his farm, and took technical advices regarding cultivation on large scale, on a sustainable basis.

Source: ICAR-Annual Report 2022-23