Review

Low tunnels – a tool for crop advancement in vegetable crops: a review

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ABSTRACT

Urban and peri-urban areas are economic hubs and sophisticated land markets. Vegetables are perishable in nature and can not be stored too long. The market price of vegetable crops varies day to day according to availability in the market; the earlier crops get much higher price than the main season crops. The other important factor responsible for the price determination of vegetables is quality (appearance) in the market. The protected structures like low tunnels, plastic row covers and high tunnels provide the favourable environment for the quality produce and crop advancement which fetches high price in the market. These structures also protect the plants from high wind, rain, frost and snow. Amid threat of the cold wave affecting vegetable production, the low tunnel technique is coming up as a saviour for the farmers as it not only protects their crops but also helps them get better prices for the produce by cultivating off-season. The main crops grown under these structures are namely tomato, capsicum, seedless cucumber, cucurbits etc.

Keywords: Vegetable crops; low tunnels; early harvesting

INTRODUCTION

Plastic tunnels are small greenhouse-like structures, covering the plants along the rows. These tunnels are 18" high and roughly 30" wide at the base and are erected with wire hoops and covered with clear plastic. The tunnels promote early growth by warming the air surrounding the plants, using heat from the sun. The tunnels also protect plants from frost that can destroy or damage them. Greater overall crop yields are obtained when the plants come into earlier production and continue to bear throughout the season.

Plastic tunnels, popularly known as low tunnels, are miniature structures producing greenhouse like effect. These are essentially miniature versions of high tunnels, usually two to four feet tall at their peak and four to six feet wide (Fig 1). Length varies, but less than 50 feet is recommended for windy areas. These tunnels facilitate the entrapment of carbon dioxide, thereby, enhancing the photosynthetic activities of the plant that help to increase yield. These structures also protect the plants from high wind, rain, frost and snow. Amid threat of the cold wave affecting vegetable production, the low tunnel technique is coming up as a saviour for the farmers as it not only protects their crop but also helps them get better prices for the produce (Anon 2014). Besides being inexpensive, these structures are easy to construct and dismantle.

Row covers or low tunnels

They are flexible transparent coverings that are installed over the rows or individual beds of transplanted vegetables to enhance plant growth by warming the air around the plants in the open field during winter season. They can also warm the soil and protect the plants from hail, cold wind and injury and advance the crop by 30 to 40 days than the normal season. This low cost technology for off-season cultivation of cucurbits like muskmelon, round melon, long melon, bitter gourd, bottle gourd and summer squash etc is suitable and may be quite cost effective for the growers in northern parts of the country, where the night temperature during winter season goes below 8^{o}C for a period of 30-40 days.

Major advantages of low tunnel technique are that they are used for raising healthy and early nursery,

maintain optimum temperature for plant growth, enhance nutrients uptake by the plants and increase the photosynthetic activities of the plants. They are used for cultivation during winter and give protection against wind, rain, frost and snow.

Yadav et al (2020) reported that in open field, it is not possible to cultivate summer vegetables during winter due to low temperature, cold waves and high frost levels and winter season vegetables during monsoon due to high rainfall intensity which directly damage plants or interfere with flowering and pollination. However, these crops can grow inside the protective structures like green house, low tunnel and walk in tunnel, so that proper atmosphere may be given to plants for their maximum growth and yield.

Jain et al (2020) reported that growing of vegetables under protected structures improves their quality, quantity, appearance and they provide favourable market price to farmers. By adopting few changes in crop sequence, farmers can augment their income by off-season growing in protected cultivation structures as compared to seasonal gluts leading to low prices. One of the most profitable technologies in north India is the raising of cucurbits, tomatoes, broccoli, capsicum and salad crops under low plastic tunnels.

Garg and Riar (2018) opined that low tunnel technology is helpful in management of abiotic and biotic stresses to the large extent which ultimately contributes towards its success. Cultivation under low tunnels is the practice of raising the summer vegetables like chilly, tomato, cucurbits etc during off-season, where unfavourable environment does not allow them to raise in open conditions. Small farmers are substantially increasing their income by adoption of protected cultivation of vegetables in off-season. For maximizing the income, intercropping of suitable vegetables, depending upon their growth development and fruiting period, are being practiced for utilizing the space and time resources to its fullest extent.

Shukla et al (2024) reported that protected cultivation structures such as polyhouses, low tunnels, shadow shade net houses and green houses are frequently used for crop cultivation. Vegetables grown under these structures possess better quality, decreased pesticide residue and higher yields than the ones grown under open field conditions.

Low tunnels have been used for producing healthy and high value nurseries. Use of low tunnels has been effective in crops such as tomato, cucumber, radish, beans, asparagus, strawberries, melon etc. Sikkim has produced about 80,000 metric tonnes of various organic vegetables in 2016-17 after it became a fully organic state. These vegetables were 100 per cent chemical-free and grown over farm area of 14,000 hectares out of the certified land of 76,392 hectares for organic farming in the state under the first year of the Mission Organic Value Chain Development (MOVCD) in the northeast region. However, despite this quantity of organic vegetables produced in Sikkim, there was shortfall of 1,000 metric tonnes to achieve self-sufficiency (Anon 2017) which can be achieved by growing vegetables by low tunnel technique.

The tunnels are covered with UV-stable plastic and are large enough to walk in. When low tunnels are used with a high tunnel, night time air temperature under the low tunnel can be 3 to 5ºF higher than the high tunnel air temperature and 5 to 7ºF higher than the outside air temperature (Maughan 2013).

Day time temperature increase can be significantly more than during the night. As a result, ventilation is critical when using a low tunnel. Even when outside air temperatures are relatively low on a sunny day, air temperature under the low tunnel can easily be high enough to cause damage to the plants under them. Depending on the design, low tunnel ventilation can either be done by lifting one or both sides of the tunnel up or by completely removing it. For field production, perforated plastic can be used to minimize the need to ventilate. Keeping a thermometer under the low tunnel is recommended for determining ventilation needs.

In low-tunnel cultivation technique, long and narrow strips of transparent plastic material (often polythene) are used to cover one or several adjacent rows of plants, especially vegetable crops. The polythene sheet having a thickness of 50 microns is generally used in this technique which helps in building the greenhouse effect and enables cultivation of vegetables under protected and controlled weather conditions. Vegetable growers, for getting higher prices from their off-season produce, often try to send their produce to the market early in the season and also try to extend the growing season for selected vegetable

crops for the purpose of obtaining marketing advantage of their off-season produce. For example, crops like long melon, round melon, bottle gourd, bitter gourd, muskmelon, summer squash etc, if grown early in spring or early summer, often command a greater price on the market. Producing crop when large quantities of the crop produce are not available (considered as off-season) can also command greater prices and increased demand.

Presently, river bed cultivation is in practice for production of cucurbitaceous vegetables in off-season in northern parts of the country, although area under river bed cultivation is very limited, which cannot be extended further, but with the use of protective structures such as row covers or low tunnels, vegetable crops like muskmelon, watermelon, long melon, round melon, bitter gourd, bottle gourd, summer squash etc can be grown very early in the spring or summer season.

Important factors which are considered for off-season cultivation are increased costs of using season extender production systems, potential increase in sale prices of the crop if produced either earlier or later and suitability of the crop to season extender production systems.

The use of plastic low tunnels for off-season melons and summer squash production is a common practice in Israel for export of the produce to European countries.

Kumar et al (2018) reported that protected cultivation of vegetables provides the best way to increase the productivity and quality of vegetables, especially cucurbits. The yield of some cucurbits like cucumber can be increased manifold compared to their open field cultivation. Plastic low tunnels are highly suitable and profitable for off-season cultivation of cucurbits like summer squash, bottle gourd, bitter gourd, muskmelon, watermelon, round melon and long melon in peri-urban areas of northern plains of India. It may be a useful for marginal farmers by increasing farmers income in off-season as compared to the normal season since it results in early nursery and early crop hence off-season cultivation of cucurbits is one of the most profitable technology under northern plains of India.

Tomatoes grown under low plastic tunnel and transplanted on 30 November using black polyethylene as mulch material recorded higher pericarp thickness, acidity, ascorbic acid and TSS content compared to other treatments those grown under open field condition (Duhan et al 2021).

Salman et al (1992) pointed out that mulching and tunneling applications increase the soil temperature so that vegetative development and fruit yield of tomatoes increase in the conditions of unheated greenhouse. Arin and Ankara (2001) reported that the highest early yield in tomato was obtained from the plants pruned from the 4th truss and mulched with any mulch under low tunnel.

Acharya et al (2020) observed that low tunnels covered with spun-bonded fabric (row covers) provide season extension for vegetable production and also afford a physical barrier against airborne insects and other non-soil pests. They found that low tunnels reduced insect infestation and chewing herbivory leaf injury to Brussels sprouts. Compared to an unprotected open field, infestations of lepidopteran insects and harlequin bug, *Murgantia histrionica* (Hahn) (Hemiptera: Pentatomidae) were reduced on plants under low tunnels. Fewer insect infestations and feeding injury indicated that low tunnels could be an effective management tool for sustainable vegetable production.

In their study, Anderson et al (2019) reported that low tunnels are easy to install, low cost, temporary protective structures that are well-adapted for annual day-neutral strawberry production and they are more space-efficient than high tunnels for these low-stature crops. Low tunnel systems allow for increased environmental control and improved fruit quality and are well-adapted for day-neutral organic strawberry production systems.

Mehdi et al (2014) did a comparative evaluation of low tunnel technology and traditional growing of cabbage under three different locations in Kargil district of union territory of Ladakh. Low tunnel technology increased seed germination from 75.3 to 91.0 per cent and seedling survival on transplanting from 76.3 to 96.6 per cent. Time taken for production of marketable seedling as well as attaining marketable cabbage heads was reduced from 53 to 45.6 days and 85.3 to 75.3 days respectively. Use of this technology advanced the growing period of crop by almost two months. The total cabbage yield and net profit per unit area were above normal when grown under low tunnels as the produce reached the market early, avoiding the market glut.

Lodhi et al (2024) revealed that plant height, leaf area index and dry matter accumulation in capsicum was highest in 75 cm tunnel height followed by 90 cm and 60 cm tunnel height treatments throughout the crop season.

Nursery raising for off-season cucurbits cultivation

Cucurbitaceous crop seeds require a specific temperature for germination and are unable to germinate at low temperature in northern plains during December to January. Seedlings of the desired cucurbits are raised in the nursery greenhouse in plastic pro-trays having 1.5" cell size in soil-less media in the month of December or January and 28-32 days old seedlings at four leaf stage are transplanted under row covers or plastic low tunnels in the open field from mid January to mid February, when the night temperature is very low in northern parts of the country. Nursery of these crops can also be raised even in polythene bags under very simple and low cost protected structures like walk-in tunnels or in locally available plastic trays in soilless media as per the need of the area. Crops like bottle gourd, sponge gourd, cucumber and pumpkin etc can be transplanted even in the month of December for complete off-season production and the crops are ready for harvesting in the first week of February that can fetch very high price in the market.

Preparation of beds, fixing of hoops, transplanting of seedlings and covering of plastic

Before transplanting of the seedlings in beds, flexible galvanized iron hoops are fixed manually at a distance of 1.5 m to 2.5 m. The width of two ends of hoop is kept 40-60 cm with a height of 40-60 cm above the levels of the beds for covering the plastic on the rows or beds for making low tunnels. Transplanting of the seedlings is done in a single row in each bed at a planting distance of 50 cm under drip system of irrigation. Distance between the rows is usually kept 1.5 to 1.6 m. Transparent 30 micron IR grade plastic is generally used for making low tunnels, which reflects infra-red radiation to keep the temperature of the low tunnels higher than outside field. Nowadays biodegradable plastic is available for making low tunnels and for mulching purposes. It is not only eco-friendly but it may be sustainable technology for off-season vegetable production. This biodegradable plastic is available according to the requirement of the duration one wants to cover the crop or use as mulch in the crop. After that period, the plastic, after receiving sufficient sunlight, becomes brittle. The film eventually breaks down into small flakes and finally gets completely composted in the soil.

The plastic is usually covered in the afternoon after transplanting the desired vegetables like muskmelon, summer squash, bottle gourd, bitter gourd, round melon, cucumber etc. The plastic can be vented or slitted during the growing season as the temperature increases within the tunnels during the peak day time. Generally, 3-4 cm size vents are made on eastern side of the tunnels just below the top at a distance of 2.5 to 3.0 m after transplanting and later on the size of the vents can be increased by reducing the distance between two vents with the increase in the temperature and ultimately the plastic is completely removed from the plants in the months of February or March depending upon the date of transplanting, growth of the crop and prevailing night temperature in the area.

Pollination under plastic low tunnel crops

Most of the cucurbits are monoecious and need pollination, which is usually performed by honeybees (*Apis mellifera*). When there is complete flowering, bees can work in the tunnels easily through the vents made on the plastic. For effective pollination in crops like muskmelon, summer squash etc, one beehive having 30,000-50,000 workers is sufficient for one acre area. The beehive box is always kept on the northwest side of the field for effective working of the bees.

Harvesting and crop advancement

Early harvesting in vegetable crops is a major objective since long ago as the prices of produce are much higher than the main crop in the market.

In bitter gourd, days taken to first female flower appearance and first harvest were significantly influenced by the sowing date and growing conditions. Minimum number of days was taken to first female flower and first harvest was observed when the sowing was done on 30 December under low tunnel over other dates of sowing under low tunnel. Tunnel forces the early harvest of crop which can earn high market value in off-season. The favourable effect of low tunnel on flowering and harvesting might be due to the conducive microclimatic condition (Kumar et al 2017).

If the muskmelon crop has been transplanted in first week of February, the fruits are ready for

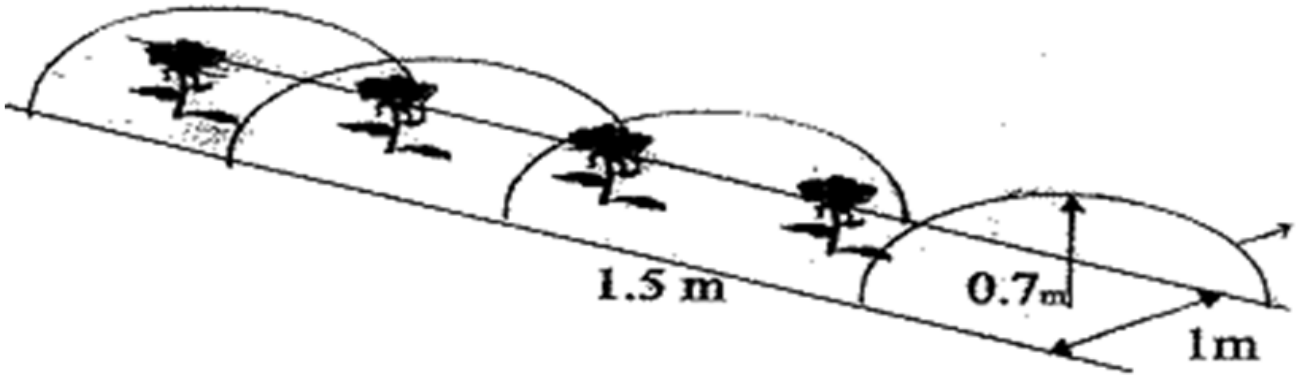

Fig 1. Low tunnel for off-season vegetable cultivation

Thakur and Devi (2013)

Table 1. Transplanting, crop advancement and expected benefit-cost ratio in cucurbits

Crop	Transplanting time	Harvesting time	Crop advancement (days)	Expected benefit-cost ratio
Summer squash	1st week of December	1st week of February	60	1:3 – 1:4
Muskmelon	3rd week of January to 1st week of February	2nd week of April to last week of April	30-40	1:2.5 – 1:3.5
Bottle gourd	3rd week of January to 1st week of February	2nd week of April to last week of April	30-40	1:2.5 – 1:3.5
Bitter gourd	3rd week of January to 1st week of February	2nd week of April to last week of April	30-40	1:3 – 1:4
Watermelon	3rd week of January to 1st week of February	2nd week of April to last week of April	30-40	1:2 – 1:2.5
Cucumber	3rd week of January to 1st week of February	1st week of February	30	1:3 – 1:4

Thakur and Devi (2013)

harvesting in the third week of April. Fruits from the mid-January transplanted crop can be harvested in the first week of April, which is normally 30-40 days early than the normal season. Similarly other cucurbitaceous crops can be advanced 40-60 days than the normal season of growing under low tunnels in northern parts of the country. Crop like summer squash can be transplanted in first week of December, which is ready for harvesting in the first week of February and can be treated as complete off-season crop. Different cucurbits can be transplanted from first week of December to first week of February and can be advanced 30-60 days over their normal season of cultivation (Table 1).

CONCLUSION

Off-season fruits produced under low tunnels can fetch very high price in the market. This technology is quite economical for growing off-season vegetables in peri-urban areas of the northern plains of the country. Urban and peri-urban areas are economic hubs and sophisticated land markets. The protected structures like low tunnels, plastic row covers and high tunnels provide favorable environment for the quality produce and crop advancement. Off-season fruits produced under low tunnels can fetch very high price in the market. This technology is quite economical for growing off-season vegetables in peri-urban areas of northern plains of the country.

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