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Adoption of Low Tunnel Technology for Vegetable Production—A Review

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Abstract

Growing vegetable by low tunnel technology (row cover technology) has many advantages with regards to increase in yield, early harvesting of vegetables, conserving soil warmth, protecting plant from wind and frost and ultimately increasing the net profit for the farmers. This review provides better understanding and facilitates optimal analysis for rational use of low tunnel technology for vegetable production and will help to identify vegetables for adoption of low tunnel technology by farmers.
Key words : Low tunnel technology, Vegetable, Yield, Row cover.

Agriculture was developed by human beings for their survival against hunger. As the time passed human beings learnt that maximum yield of the crop is achieved when they are grown in different season under favorable climatic conditions. Vegetables are rich source of vitamins, carbohydrates, salts and proteins. Increased health awareness, high population growth rate, changing dietary patterns of increasingly affluent middle class and availability of packaged vegetables, has therefore generated a year round high demand for fresh vegetables in the country in domestic and export market. But due to unfavorable climatic conditions there is a flood of vegetables in the season and high priced vegetables in off-season. Vegetables can be cultivated in off-season, with the induction of artificial techniques like geen houses, low and high poly tunnels technology, in which temperature and moisture are controlled for specific growth of vegetables. The production of vegetables all around the year enables the growers to fully utilize their resources and supplement income from vegetable growing as compared to other normal agricultural crops.

Low tunnels are miniature structures producing green house like effect. In these tunnels plastic sheets are used for roof covering of the tunnel shaped construction having low height, which is built with steel bars. These tunnels facilitate the entrapment of carbon dioxide, thereby enhancing the photosynthetic activity of the plants and hence the yield. These structures also protect the plants from the high winds, rain, frost and snow. Besides being inexpensive they are easy to construct and dismantle. Low tunnels are being used for producing high quality high valued nurseries and crops such as tomatoes, cucumber, radish, beans and capsicum. With this technology, the farmers can capture the market in the early season and may get good return of their produce. Another advantage of such technology is that low tunnels can be easily dismantled and utilized in the next year.

The use of low tunnels conserves warmth, stimulates germination and early growth, plants protects from injury and improves the quality of crops. Other beneficial effects such as maintaining soil texture and protecting crops from the attacks of birds and pests can also be expected. The objective of this paper is to review the research carried out by scientists in production of vegetables, to summarize the result and to identify the successes. A review of low tunnel effects is being presented under following sub-heads : Effect of low tunnel technology on yield of vegetable, early harvesting of vegetable—low tunnel technology, favorable climatic conditions for plant growth under low tunnels and coverage material used in low tunnel technology.

Effect of Low Tunnel Technology on Yield of Vegetable

Saini and Singh (1) conducted a research study

on growth and yield of chilly crop under low tunnel polyhouse, at research farm of soil and water engineering, PAU Ludhiana. It was found that there is no significant effect on the yield of chilli due to variation in perforations on polythene cover. Drip irrigation system with IW/CPE ratio of 0.50 and 30 cm low tunnel polythene cover gave the best yield and water saving.

Helbacka (2) conducted a study on row covers for vegetable gardens. It was reported that many cucurbits (squash, cucumber, melons) respond well under row covers with increased yield of as much as 25%.

Joublan and Vergara (3) conducted a study on vegetative and productive development of strawberry (Fragaria × ananassa Duch.), using row cover of spunbonded polyester with different densities. Row covers were placed directly over the plants as a tunnel without any support structure. Treatments comprised : A control treatment (without row covers), row covers of 20 g/m^2 and row covers of 30 g/m^2. Fruit production started 4.8 and 2.2 days earlier under 20 and 30 g/m^2 row covers, respectively, than under the control treatment. The use of row covers also increased the fruit number and weight, yield per plant and sugar concentration compared with the control treatment, with the best result obtained with 30 g/m^2 row covers.

Hernandez et al. (4) conducted studies on row covers for quality improvement of Chinese cabbage for three years in the area of Granada, Spain, under a Mediterranean continental temperate climate, on 55-day cycles with transplanting in mid-march. The mean commercial yield for the 3-years was 11.9 kg/m^2 under row cover but only 2.1 kg/m^2 in open air, owing primarily to important number of non-commercial cabbages.

Vishnuvardhana et al. (5) conducted a study on the economics of the propagation of cashew grafts in a mist chamber, naturally ventilated green house, low tunnel and shade net during the summer, monsoon and winter season of 1998—2001. The initial investment for the establishment of the propagation structure (100 m^2) reached Rs 8,500/- for the shade net, Rs 300,000 for mist chamber, Rs 36,400 for naturally ventilated green house and Rs 21,000 for the low tunnel.The highest net profit was obtained with propagation in low tunnels, followed by propagation in a naturally ventilated green house, mist chamber and shade net.

Early Harvesting of Vegetable—Low Tunnel Technology

Meesters (6) conducted a study on early cultivation of Evita under tunnels. In a study at Tongeren, Belgium, in 1995, the strawberry cultivar Evita was planted in a plastic tunnel on 6 April at densities of 3, 4 or 5 plants/m^2. The first fruits were ready on 24 May, and some 80% of the total harvest was picked on 40—50 days between late July and mid-August. The harvest finished on 19 October. Production of Evita was 20—25 days earlier under the tunnel than in the field, and it was 30—35 days earlier than that of field-grown Selva. It therefore filled the gap between field-grown Elsanta and field-grown Selva. Yields in the tunnel were good, at 2.6—3.2 kg/m^2.

Arin and Ankara (7) conducted a study to determine the effect of low tunnel, mulching and pruning treatment on yield and earliness of tomato in unheated glass house. It was observed that there is an increase of 643.42% in height (relative to height at the planting time) of the plants grown under low tunnel than those grown without tunnel (602.87%). Stem diameter increase was higher in plants tunnelled (265.63%) than plants growing without tunnel (233.83%). The number of days to first harvest was 117.97 for plants tunnelled and that for plant growing without tunnel was 119.88.

Amer (8) carried out a study on protection effect of low-temperature on some snap bean (*Phaseolus valgaris* L.) varieties green yield and some isozyme levels. It was found that protected plants recorded higher vegetative growth and total, early and exportable yields compared with those of the open field. Plants grown under plastic low tunnels recorded higher vegetative growth and total green yield compared with agrel-covered plants. All the cultivars recorded higher vegetative growth, total, early and exportable yields under plastic protection than under agrel or open field condition.

Singh et al. (9) conducted a study on effect of plastic tunnel and mulching on growth and yield of strawberry. It was found that use of plastic tunnel along with control (without tunnel) were taken as main factors and mulching materials, viz. black polyethylene, transparent polyethylene and straw mulch as

sub-factors and laid out in split-plot design replicated four times. Use of plastic tunnel resulted into significantly higher plant spread, dry matter accumulation and yield attributing characters compared to control. Further, plastic tunnel enhanced earliness by 16 days besides 19% higher yield over control. Among different mulching materials, black polyethylene mulch was found to be most suitable and resulted into 41% higher fruit yield compared to straw mulch.

Slezak et al. (10) conducted a study on enhancing earliness of sweet corn by using transplants and plastic row covers. The following technological variations were compared using transplanted plants with floating row cover; transplanted plants with no row cover; direct sown plants with floating row cover; and direct sown plants with no row cover. The application of direct sowing and floating row cover increased the earliness by 3 days for germination and by 4 days for the total growing period, compared to the treatment with no row cover. The 25—26 day transplant growing period reduced the growing period by 15—18 days. Covering the seedling in the early season was beneficial for frost protection. The combination of seedling grown plants and floating row cover resulted in a 22-day earlier harvest, compared to the traditional technology.

Favorable Climatic Conditions for Plant Growth under Low Tunnels

Libik and Siwek (11) studied the changes in soil temperature affected by the application of plastic covers in field production of lettuce and water melon. At 0800 h, the highest soil temperature was recorded under a low tunnel, where it was 3 C higher than in the open ground from 29 March to 14 April and 5.9 C higher from 9 to 14 June. However at 1400 h, the highest soil temperature was recorded under perforated plastic. By 1400 h the air temperature under the cover was between 35 and 40 C, which was 10—15 C higher than the ambient temperature. Marketable yield of lettuce was highest under low tunnel (110..9% higher than in the open field).

Lamarrel et al. (12) conducted a study on influence of nitrogen fertilization, row covers and cultivars on the production of day neutral strawberry. It was found that the use of low tunnel was beneficial during winter when the crop was protected from frost and low temperature for higher productivity.

Hochmuth et al. (13) conducted a study on row covers for commercial vegetable culture in Florida. It was found that row covers are used to enclose one or more rows of plants to enhance the crop growth and production by increasing both air and soil temperatures and reducing wind damage.

Coverage Material Used in Low Tunnel Technology

Monteiro et al. (14) carried out a study on perforated plastic film for low tunnels cultivated with lettuce. During the spring, tunnels were tested with and without lettuce, with 0, 5, 10, 15 and 20% of perforated film area and in soil without tunnel. The evaluation of the temperature inside the protected atmosphere was inversely related to the percentage of perforation contrary to the humidity loss for the external atmosphere. The production obtained under protected condition was higher and of better quality.

Fu et al. (15) conducted a study on effects of different ventilation methods on seedling growth of chilli pepper. Chilli pepper seeds were sown in beds under mini plastic tunnels. When the outside temperature dropped to below 12 C, a normal plastic tunnel was set up to cover all the mini tunnels. Different watering and ventilation methods were tested. Based upon the seedling quality and yield, it was suggested that the bed should be thoroughly irrigated before sowing, with no watering needed until the seedlings had 6 leaves. During this period, the film of miniplastic channels should be removed when 70% of the seedlings emerged and the film should be replaced to cover the mini tunnels completely when the temperature inside the normal plastic tunnel dropped to below 5 C.

Reghin et al. (16) conducted an experiment on mulching and row cover in lettuce crop. The parameters tested were total lettuce leaf number, frost-damaged leaves, plant height, stem length, plant fresh weight, plant dry matter accumulation and biomass. Weed population and dry weight were also assessed. Row cover with white polypropylene produced positive results on yield, early harvest and quality, even with the occurrence of frost. Frost damage in uncovered plots reduced the plant weight by 34.62%. Black polypropylene mulch controlled weeds and resulted

in 22.12% increase in plant weight compared to rice straw.

Shiraiwa et al. (17) conducted a study on effects of tunnel covering plastic films and fertilization methods on growth, bolting and yield in Welsh onion (*Allium fistulosum* L.) harvested in early summer. It was found that polyolefine plastic film (PO) induced the highest mean air and soil temperatures, while dripped polyethylene plastic film (DP) showed the lowest temperatures. The coefficient of variance on soil water content was higher in PO and non-dripped polyethylene plastic film (NDP). Application of an over all layer of fertilizer produced a lower bolting rate than application of fertilizer in a planting furrow when using DP. However, opposite results were demonstrated with PO and NDP. The effects of covering films and fertilizer application methods on the bolting rate and yield showed significant interaction. Higher thermo-keeping films suppressed flower initiation. When higher thermo-keeping films were used to cover tunnels, management to control nitrogen concentration is required to inhibit bolting in this culture.

Streck et al. (18) conducted a study on a system to grow lettuce inside low plastic tunnels. Four different covers were tested to obtain a system to produce vegetables throughout the year under low tunnels without ventilation management. Lettuce cv Regina was grown from October 1994 to July 1997. The winter treatments comprised low tunnel with transparent polyethylene without perforations and with conventional management according to the meteorological conditions; low tunnel with 3% perforated transparent polyethylene and without ventilation management; umbrella-like, low tunnel with transparent polyethylene with open laterals throughout the year and without ventilation management; and cropping without a tunnel throughout the year (control). The treatments in the summer were similar to the winter treatments with conventional and perforated covers replaced by a black plastic screen with a 30% reduction in solar radiation. Results showed that umbrella-like tunnels can be used instead of coventional low tunnels, which need daily management. This technique allowed lettuce to grow throughout the year and only required lateral adjustment according to the season.

Future Thrust

Considerable research work has been carried out on low tunnel technology for vegetable production during the past 15 years. However, still a lot remains to be done which is summarized below and needs to be investigated : (a) Testing of low tunnel technology for different vegetables grown under different regions of India; (b) the optimum tunnel heights for various vegetable crops; (c) the optimum polyethylene sheet thickness and effect of perforation in polysheets on vegetables crop; (d) adoption of low tunnel technology with drip irrigation; (e) working-out the economics of low tunnel; (f) constraints in the adoption of low tunnel technology for a wide variety of vegetable crops.

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