# Status and impact of protected cultivation in Himachal Pradesh, India

**R. S. Spehia**

Department of Soil Science and Water Management, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan 173 230, India

**The state of Himachal Pradesh is almost wholly mountainous with the altitude ranging from 350 to 6975 m above the mean sea level with its economy largely dependent on agriculture. Further, the state is constrained with small land holdings (avg. size 1.04 ha), as majority of the farmers belong to the marginal and small category (87%). The use of polyhouses has played a vital role not only in overcoming the vagaries of nature, but also have triggered diversification to vegetable crops of high value. In the present study, productivity of cash crops especially vegetables, employment generation, analysis of income and socio-economic status of small and marginal farmers were assessed, in addition to the saving in inputs, if any, through adoption of precision farming techniques. Considering that only 223.18 ha of area had been brought under protected cultivation, a significant increase in productivity was observed. It also created 4.95 lakh man days of employment (at farmers' and service provider's level), thereby giving additional income to the farmers and their families. The thrust on protected cultivation of vegetables in addition to use of better varieties, better management practices, etc. have played a significant role in the productivity enhancement of cash crops in Himachal Pradesh.**

**Keywords:** Employment generation, Himachal Pradesh, protected cultivation.

HIMACHAL Pradesh is almost wholly mountainous with altitude ranging from 350 to 6975 m above the mean sea level. It is situated in the Himalayan region on the northern border of the country and located between 30°22′40″N to 33°12′40″N and 75°45′55″E to 79°04′20″E. The total area of the state is 55,673 sq. km and comprises 12 districts. The total population is about 68.57 lakhs[1]. Due to the hilly terrain, density of human population in the state is low with 123 persons per sq. km. The state is predominantly rural in character with 90% of its people (61.68 lakh) residing in the rural areas. The economy is largely dependent on agriculture which occupies a significant place in the state economy. During 2010–11, 16% of the total state domestic product was contributed by agriculture and its allied sectors. The state is blessed with a wide variation of climatic conditions from sub-tropical to cold alpine, making it an appropriate place for vegetable cultivation, resulting in increasing vegetable production from 0.25 lakh tonnes in 1951–52 to 14.0 lakh tonnes in 2012–13. It has now reached a stage where production can be increased only through area expansion. The average land holding is 1.04 hectares with the marginal and small farmers (up to 2 ha) constituting about 87.03%, semi-medium and medium farmers (2–10 ha) together constitute about 12.54% and large farmers (>10 Ha) constitute hardly 0.43% of the total land holdings[2]. The gross cropped area is 8.97 lakh hectares with 3.90 lakh hectare area cultivated more than once, thus making the cropping intensity to 177%. Further, more than 80% of cultivable land is under rainfed agriculture, with limited water supply in addition to factors such as erratic rainfall, hailstorms, high velocity winds, frequent dry spells that have direct impact on crop productivity and varies from year to year. Hilly topography of the region limits the possibility of increasing cropping area and intensification of cropping systems. Therefore, polyhouses can make small holdings viable by producing maximum from limited land, overcoming vagaries of nature and diversification to high value vegetable crops. It can also stabilize production system in addition to quality improvement through utilization of vertical space and precision farming. Further, these structures can facilitate crop production in areas where vegetable production during extreme weather conditions is not possible. Keeping this in view, a survey was carried out with the objective of assessing productivity of the cash crops, especially vegetables, employment generated and income generated apart from other benefits of polyhouses. Himachal Pradesh has 223.18 ha under polyhouses[3,4]. The district wise data is presented in Table 1.

Multistage stratified random sampling technique was followed for the selection of sample units. The units were divided on the basis of polyhouse size and 16 samples per district were randomly selected for each component giving due representation to the size of the polyhouses

**Table 1.** District-wise area under protected cultivation in Himachal Pradesh

| District | Area covered |
|---|---|
| Bilaspur | 38.06 |
| Chamba | 7.70 |
| Hamirpur | 18.90 |
| Kangra | 36.02 |
| Kinnaur | 0.32 |
| Kullu | 6.57 |
| Lahaul & Spiti | 0.86 |
| Mandi | 28.53 |
| Shimla | 17.77 |
| Sirmour | 20.64 |
| Solan | 25.69 |
| Una | 22.12 |
| Total | 223.18 |

Source: refs 3 and 4.

e-mail: rss_33044@hotmail.com

**Table 2.** Effect of polyhouse on productivity of important crops as compared to open cultivation

| Crop | Open cultivation (mt/ha) | | | Protected cultivation (mt/ha) | | | Increase (%) |
|---|---|---|---|---|---|---|---|
| | Minimum | Maximum | Average | Minimum | Maximum | Average | |
| Capsicum | 25.0 | 30.0 | 27.5 | 90.0 | 150.0 | 120.0 | 336 |
| Tomato | 40.0 | 45.0 | 42.5 | 180.0 | 250.0 | 215.0 | 406 |
| Cucumber | 15.0 | 20.0 | 17.5 | 80.0 | 100.0 | 90.0 | 414 |
| Beans | 10.0 | 15.0 | 12.5 | 24.0 | 32.0 | 28.0 | 124 |
| Peas | 10.0 | 15.0 | 12.5 | 20.0 | 25.0 | 22.5 | 80 |
| Coriander | 10.0 | 12.0 | 11.0 | 15.0 | 20.0 | 17.5 | 59 |
| Spinach | 10.0 | 15.0 | 12.5 | 20.0 | 25.0 | 22.5 | 80 |

**Table 3.** Employment generated at farmer's level in polyhouses

| Particulars | Labour (man days) |
|---|---|
| Tillage, land preparation and bed preparation | 15 |
| Nursery raising | 5 |
| Transplanting | 2 |
| Fertilizer and pesticide application | 2 |
| Weeding and earthing-up | 2 |
| Training and stacking | 5 |
| Irrigation | 10 |
| Harvesting and transportation | 25 |
| Total for 500 sq. m | 66 |
| Man days required per sq. m | 0.132 |
| Employment created (man days) | 294597.6 |

(varying from 6 to 1000 sq. m). In order to study the impact, samples were randomly drawn from polyhouses setup during 2009–10 and 2010–11, wherein at least one crop cycle had been completed. The study is based on both primary and secondary sources of data. Different schedules/structured questionnaires were prepared to solicit information from both primary and secondary sources. The study team interacted with the beneficiary farmers at their farms. The broad area on which the information was collected pertained to occupation, land holding, cropping pattern, sources of irrigation, cost of cultivation, productivity, income, labour requirements, marketing channels, technology, extension, training, etc. Productivity enhancement was seen by comparing the yield data with open field of the same farmer while employment generation was calculated on the basis of information collected from the beneficiaries.

The crop-wise productivity under open and protected cultivation as reported by the beneficiaries is presented in Table 2. The data is based on the field level information collected from the beneficiaries. Data was collected for important cash crops suitable for protected cultivation, viz. capsicum, tomato, cucumber, beans, peas, coriander and spinach. Observations of the data reveal an increase in crop productivity by a minimum of 59% (coriander) to a maximum of 414% (cucumber) inside polyhouses as compared to open cultivation. Capsicum was the most dominant crop under polyhouse cultivation. Almost all beneficiaries had at one point or the other cultivated capsicum irrespective of the size of the polyhouse. It was reported that under open cultivation, the productivity ranged between 25 and 30 mt/ha as compared to 90–150 mt/ha under polyhouse cultivation. On an average, the productivity obtained under protected cultivation was 3.36 times (range 2.6 to 4.0 times) more when compared to open cultivation. As the greenhouse effect works best under polyhouses, increase in growth, crop life and production was attained which is not possible in open field cultivation.

Protected cultivation besides increasing productivity is also expected to provide employment opportunities to the unemployed youth making it an attractive agricultural option for the farmers as well as at the service provider level with the business expanding into rural areas. A total of 0.132 man days (MD) were required per sq. m (Table 3) for carrying out different operations from soil bed preparation to harvesting. A total of 2.95 lakh man days (MD) (2013) were created in the state, making it an attractive option for the youth.

As the business and the market expanded, polyhouses have helped in creating opportunities not just at the farmer's level, but also at the level of service providers. More number of local youth, both educated and un-educated, got jobs ranging from site preparation to selling of products. Apart from providing an extra source of income, this has also helped in preventing an exodus from rural areas towards cities. The total employment generated at service provider's level was 2.0 lakh MD (2013) (Table 4).

Protected cultivation helped in increasing the income generation of farmers by producing higher yields with 2–3 crops grown in a year. Of all the crops under study, capsicum was the best option for getting maximum income from polyhouses (Table 5) as it showed net income of Rs 213,830 (including self-labour) in a 500 sq. m area. This was followed by tomato (Rs 77,127) and cucumber (Rs 34,756). The net income trend indicates that income (excluding the self labour) for different crops varied from Rs 568 to Rs 1893 in polyhouse of size 40 sq. m, except for capsicum where the income generated was Rs 12,830. Thus, it is deduced that the size 40 sq. m is the optimum size for a polyhouse for subsistence cultivation of

**Table 4.** Employment generated at service provider's level for different protected structures

| Particulars | Labour (man days) 500 sq. m | 250 sq. m | 100 sq. m | 40 sq. m |
|---|---|---|---|---|
| Site preparation (farmer) | 5.00 | 2.50 | 1.00 | 0.50 |
| Planning and layout | 0.25 | 0.25 | 0.25 | 0.25 |
| Foundation | 10.00 | 7.00 | 5.00 | 3.00 |
| Erection | 15.00 | 10.00 | 7.50 | 5.00 |
| Fixing of polysheet | 2.00 | 1.00 | 1.00 | 1.00 |
| Carriage | 2.00 | 2.00 | 2.00 | 2.00 |
| Supervision | 3.00 | 2.00 | 1.00 | 1.00 |
| Total (man days) | 37.25 | 24.75 | 17.75 | 12.75 |
| No. of units | 3,216 | 1,835 | 1,019 | 1,378 |
| Man days generated | 119,796 | 45,416 | 18,087 | 17,570 |
| Total employment generated | 200,869 man days | | | |

**Table 5.** Crop-wise net income (Rs) under different polyhouse sizes

| Crop | Polyhouse size (sq. m) | Cost of cultivation: Input cost | Labour cost | Total cost | Total income | Net income (exc. self labour) | Net income (inc. self labour) |
|---|---|---|---|---|---|---|---|
| Capsicum | 500 | 71,170 | 13,200 | 84,370 | 285,000 | 200,630 | 213,830 |
| | 250 | 35,705 | 7,800 | 43,505 | 142,500 | 98,995 | 106,795 |
| | 100 | 16,765 | 4,300 | 21,065 | 57,000 | 35,935 | 40,235 |
| | 40 | 7,720 | 2,250 | 9,970 | 22,800 | 12,830 | 15,080 |
| Tomato | 500 | 84,123 | 13,200 | 97,323 | 161,250 | 63,927 | 77,127 |
| | 250 | 42,711 | 7,600 | 50,311 | 80,625 | 30,314 | 37,914 |
| | 100 | 19,356 | 4,300 | 23,656 | 32,250 | 8,594 | 12,894 |
| | 40 | 8,757 | 2,250 | 11,007 | 12,900 | 1,893 | 4,143 |
| Cucumber | 500 | 43,994 | 8,800 | 52,794 | 78,750 | 25,956 | 34,756 |
| | 250 | 22,290 | 5,000 | 27,290 | 45,000 | 17,710 | 22,710 |
| | 100 | 10,616 | 2,400 | 13,016 | 18,000 | 4,984 | 7,384 |
| | 40 | 4,810 | 1,100 | 5,910 | 7,200 | 1,290 | 2,390 |
| French beans | 250 | 4,660 | 2,600 | 7,260 | 19,250 | 11,990 | 14,590 |
| | 100 | 2,264 | 1,400 | 3,664 | 7,700 | 4,036 | 5,436 |
| | 40 | 1,036 | 600 | 1,636 | 3,080 | 1,444 | 2,044 |
| Peas | 250 | 5,950 | 2,800 | 8,750 | 16,875 | 8,125 | 10,925 |
| | 100 | 2,880 | 1,600 | 4,480 | 6,750 | 1,270 | 3,870 |
| | 40 | 1,432 | 700 | 2,132 | 2,700 | 568 | 1,268 |
| Coriander | 250 | 2,770 | 2,400 | 5,170 | 15,313 | 10,143 | 12,543 |
| | 100 | 1,298 | 1,400 | 2,698 | 6,125 | 3,427 | 4,827 |
| | 40 | 669 | 600 | 1,269 | 2,450 | 1,181 | 1,781 |
| Spinach | 250 | 2,770 | 2,200 | 4,970 | 14,063 | 9,093 | 11,293 |
| | 100 | 1,298 | 1,200 | 2,498 | 5,625 | 3,127 | 4,327 |
| | 40 | 669 | 500 | 1,169 | 2,250 | 1,081 | 1,581 |

vegetable, i.e. for fulfilling the family requirement of different vegetables rather than a commercial venture.

In terms of commercial importance, the data shows that the annual income obtained was maximum for the cultivation of capsicum followed by tomato and cucumber. Polyhouses of size 500 and 250 sq. m should mainly be devoted for capsicum and tomato cultivation. Cucumber crop is highly beneficial for polyhouse of size 100 sq. m, and as a mono-crop or as mixed crops. However, ultimately, the demand/market prices play a very important role in crop selection.

The technology as such was found very successful as it could be seen from the productivity and the income data discussed above. However, it is pertinent to mention here that in many cases, partial or complete crop failure was reported due to reasons like delay in planting season, use of spurious seeds, improper use of plant protection chemicals, lack of knowledge regarding special cultural practices and training like pruning, pinching, disbudding, timely control of temperature in polyhouses, improper maintenance of the polyhouses, sanitation, etc.

The solution lies in selecting suitable designs for different agro-climatic zones. The structure should have an adequate height of at least 5.5 m (for hot areas) and 3.5 m (for cold areas with snow) though the maximum height is debatable. Farmers should have knowledge about proper ventilation (with roll up facility), height of the side vent (30 cm from ground), double doors, fogger for maintaining humidity, drip irrigation, proper installation of shade nets (outside polyhouse), proper selection of the crop variety and the technical knowledge of growing vegetables inside polyhouses.

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2. http://hpagriculture.com/
3. http://hpagrisnet.gov.in/hpagris/Horticulture/Default.aspx?SiteID=5&PageId=1033
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# Comparative study of feed-forward neuro-computing with multiple linear regression model for milk yield prediction in dairy cattle

**Manisha Dinesh Bhosale* and T. P. Singh**

Symbiosis Institute of Geoinformatics,
Symbiosis International University, Pune 411 016, India

**The main objective of this work is to compare the accuracy of artificial neural networks (ANNs) and multiple linear regression (MLR) model for prediction of first lactation 305-day milk yield (FL305DMY) using monthly test-day milk yield records of 443 Frieswal cows. We have compared four versions of feed-forward algorithm with conventional statistical model. The performancre of ANN is found to be better than the MLR model for milk yield prediction. The Bayesian regularization neural network model was able to predict milk yield with 85.07% accuracy as early as 126th day of lactation. It has been found that $R^2$ value of the models increases with increase in the number of test-day milk yield records.**

**Keywords:** Artificial neural network, dairy cattle, milk yielded, multiple linear regression.

INDIA is the largest producer of milk in the world and it also has the world's largest dairy herd animals. The Indian dairy sector is now changing from traditional to well-organized dairies. The application of information technology-based services at all levels in this sector will improve planning and management of milk production in India. Milk production in India was around 133 million metric tonnes (MMT) in 2012–13, and it accounts for more than 13% of total milk production in the world[1,2]. The average milk yield per lactation is only 1214 kg as against the world average of 2104 kg (ref. 3). This indicates that there is a need to improve the productivity of the animals.

The analysis of first lactation 305-day milk yield is important. It is helpful to select genetically superior bulls[4,5]. Genetically superior bull identification is dependent on the high yielding ability of cows. If accurate milk yield prediction before the completion of lactation is done, it will speed up the bull identification process and lead to greater progress[6,7]. Milk yield prediction also helps in the selection of animals, which leads to optimal breeding strategies and increased annual genetic progress[8]. It also helps farmers plan the feed and fodder requirement and to sort non-productive animals from the herd. The present study has been made to predict first lactation 305-day milk yield (FL305DMY) using monthly test-day milk yield records of 443 Frieswal cows, a crossbred of indigenous Sahiwal cattle with the exotic Holstein–Friesian breed[9]. The breed is expected to produce around 4000 kg of milk in a lactation under good management practices[10].

It is well known fact that the milk yield which is normally represented in the form of lactation milk yield curve (Figure 1) follows a nonlinear pattern of milk production. Therefore, the nonlinear function should be used for the prediction of lactation milk yield[6]. The traditional multiple linear regression (MLR) does not consider nonlinearity for prediction. It also fails to address the interdependency of independent variables. Therefore, an artificial neural network (ANN) approach is used for prediction of milk yield. ANN has the ability to learn from experience to improve performance and adapt to changes in the environment[11]. In this study, monthly test-day milk yield was used as an input variable (Table 1) in ANN to

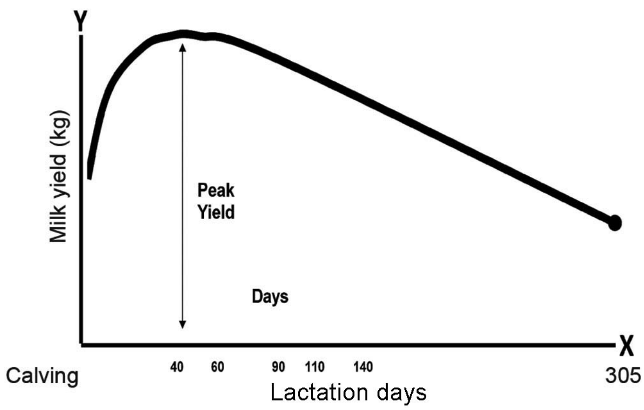


**Figure 1.** Standard lactation curve.

*For correspondence. (e-mail: manishadbhosale@gmail.com)