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# Conservation Agriculture in Punjab - Economic Implications of Technologies and Practices

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I

INTRODUCTION

Modern agriculture based on high yielding seeds, chemical using production and protection technologies and intensive use of natural resources paid rich dividends by bringing manifold increase in foodgrain productivity and production, enhancing farmers' income, reducing poverty and contributing significantly towards attainment of food self-sufficiency at the national level (Sidhu and Bhullar, 2005; Joshi, 2004; Government of India, 2006). Due to their positive impacts and institutional policy support in the form of prices, credit and input delivery, these technologies were fast and widely adopted by the farmers. However, in recent years the negative consequences of such strategies are becoming more evident in the Punjab state and have started overshadowing their economic as well as non-economic benefits. The serious fallout of this strategy is witnessed in the form of over-exploitation of groundwater resources causing faster depletion in the groundwater table and degradation of the Punjab soils due to mining of macro as well as micro nutrients (Sidhu, 2002). Even the physical properties of soils have undergone change. Rice crop is cited as the main culprit for most of the water woes in Punjab agriculture due to its huge water requirement (Sidhu, 2002; Government of Punjab, 2007; Johl, 2002). The groundwater table in central districts of the state has gone down at an annual rate of more than 80 cm during 1997 to 2007. There has been a development of hard pan in the soils, which have continuously been put under rice cultivation under nursery planting practices, preventing percolation (and hence recharge) of rain water into deeper layers and altering the physical properties of soil as well. Even the South-western districts of the state, popularly known as the cotton belt of Punjab, have experienced fall in water table due to shift of area from cotton to rice due to significant fall in cotton productivity from 1996-97 to 2002-03, owing to the increased incidence of insect-pest attack (Government of Punjab, 2007, 2009). Rice-wheat monoculture, coupled with high humidity levels, has led to increased incidence of diseases and insect-pest attack, consequently necessitating higher use of chemicals

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to maintain expected yield levels (Sidhu *et al.,* 2007). Burning of crop residue in paddy to a large extent and wheat to a limited extent is a common practice in the state, which not only increases air pollution, but also causes loss of organic matter, nutrients and soil biota (Sharma *et al.,* 2008).

Various technologies have been developed and promoted for addressing the negative outcomes of intensive agriculture. Most of these technologies aim to conserve groundwater, improve soil health, reduce use of plant protection chemicals, promote crop residue management, provide protective environment for crop cultivation (net-houses) etc. Although, there exists a large set of evidence on the extent of resource degradation and impact of such technologies, in physical terms (such as yield enhancement and extent of resource degradation), a serious effort on estimating the economic impact is lacking. Such lack of information, perhaps, is the most important reason for poor adoption of such technologies by the farmers, seriously undermining the sustainability of natural resources and economic viability of farming in the state. This investigation, therefore, attempts to examine the extent of such diverse degradation of resources in agriculture and assess the economic implications of various agricultural conservation technologies and practices aiming to achieve the long-term economic and ecological sustainability.

## II

## DATABASE AND METHODOLOGY

This paper is based on both the primary and secondary data obtained from multiple sources. Most of the information on resource conservation technologies and practices was obtained from the research experiments conducted in the Department of Agronomy, Department of Soils and Department of Farm Power and Machinery of the Punjab Agricultural University, Ludhiana and some other published sources, which are mentioned at appropriate places. The information on the use of plant protection chemicals, yield, prices and net returns in vegetable cultivation under net-house and open field cultivation was obtained from Sidhu and Vatta (2009). This study was based on the primary data collected from 155 vegetable growers (23 net-house cultivators and 132 open field cultivators). The extent of water savings for different water saving technologies has been obtained from various published sources. This water saving was converted into time-equivalents by considering the water discharge of 13 litres per second by an electric motor of 7.5 horse power. The savings of electricity were calculated by multiplying the 7.5 horse power with time equivalent for a given water saving. The economic returns from electricity saving in terms of reduction in power subsidies were estimated at Rs. 2.86 per Kwh, the price of electricity fixed by the Punjab State Electricity Regulatory Commission and was paid by the State government to the Punjab State Electricity Board in the year 2009-10.

These water conservation technologies and practices also impact yield and cost of production. The increase in returns from yield enhancement and fall in cost of production were estimated at 2009-10 input and output prices. The reduction in cost of production (Rs./ha) in case of Happy Seeder was estimated on the basis of a sample survey of 38 farmers using this technology as compared to the conventional wheat cultivation practices being followed on the same or similar farm situations. The impact of Permanent Raised Bed (PRB) practices on returns was calculated on the basis of findings of Dhaliwal *et al.,* (2008). These calculations were based on field survey conducted on these technologies/practices in comparison to conventional cultivation practices followed by farmers in wheat and rice crops. The amortised costs for use of tensiometre and laser levelling were worked on the basis of their respective costs of Rs. 300 and Rs. 1500 per ha with 3 years of economic life and 9 per cent rate of discount in each case. All the economic benefits were projected at the state level by multiplying total economic benefits per ha with total area under rice and wheat crop during the year 2008-09 (2.735 million ha under rice and 3.526 million ha under wheat).

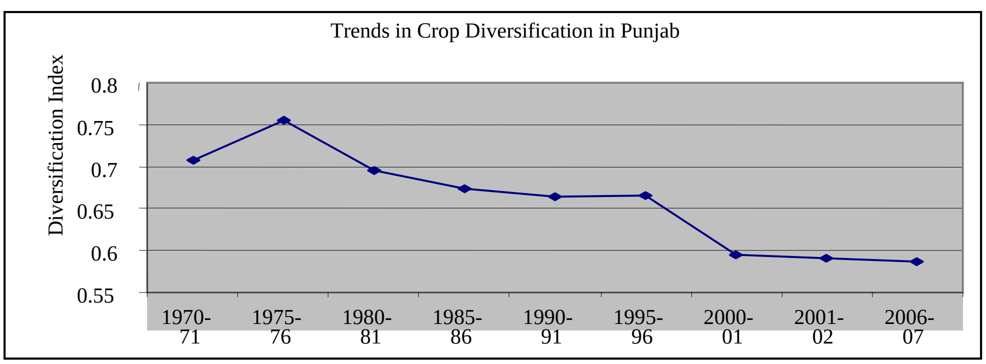
## III

## EXTENT OF DEGRADATION

The current agricultural practices, crop pattern and use of biological and mechanical inputs are resulting into degradation of soil, water and air resources. Rice is grown on an area of 2.74 million ha and is largely dependent on the groundwater resources, covering about 67 per cent of the net sown area which is irrigated. Rice is not only a water intensive crop, but the cultivation practices followed by the farmers also indiscriminately use ground water resources. Rice has been extended even to the marginal lands, not suitable for its cultivation, due to its economic advantage, assured marketing and highly stable productivity. As a consequence, the demand for water has shot up to 4.33 m ha metres, while supply from surface water and recharge is only 3.13 million ha metres, causing water deficit of 1.20 million ha metre, which is met by over-withdrawal of ground water than recharge, leading to depletion of the water table in Punjab (Government of Punjab, 2007). Out of 122 erstwhile blocks, water table is declining in 89 blocks due to over-withdrawal of water than recharge (Kaur and Sidhu, 2008). A large number of development blocks mostly falling in the central districts are categorised as dark blocks due to higher ground water exploitation than recharge capacity (ibid). Nine development blocks belonging to the South-western districts of Punjab, where ground water is unfit for irrigation and surface water is the main source of irrigation, registered rise in water table. In addition, 20 per cent of the area, representing the cotton belt of the state, is experiencing rise in soil alkalinity, salinity and water logging.

The Punjab state has the highest levels of cropping intensity in India, which has increased significantly from around 126 per cent during 1960-61 to 189 per cent during 2008-09. The area under rice and wheat crops has also increased from less than 50 per cent to almost 80 per cent of the cropped area during this period. Both these factors have severely affected the soil health in the state, endangering the sustainability of agriculture. Deficiency in major and minor nutrients is reported to be very high despite intensive use of chemical fertilisers. Seventy per cent of soil samples brought to PAU for testing were found to be deficient in nitrogen and 64 per cent were deficient in phosphorus. Even potassium deficiency has appeared in soils, in spite of the fact that Punjab soils are rich in potash (k-illite mineral). A continuous uptake of micro-nutrients has also resulted in their deficiency. Punjab soils are becoming increasingly deficient in iron, manganese and copper. Use of organic manures has declined and Punjab agriculture has transformed completely into a chemical based wheat-rice production system.

Another dimension of erosion in natural agricultural production system is higher use of agro-chemicals for controlling diseases and insect-pests. The use of pesticides in Punjab increased from 3200 kg of technical grade in 1980-81 to as high as 5760 kg of technical grade in 2008-09 (Government of Punjab, 2009). Sidhu *et al.*, (2007) reported that expenditure on the use of such chemicals increased by 69 per cent in rice and 250 per cent in wheat from 1993-94 to 2003-04 at constant prices. Decline in crop diversification has caused greater incidence of diseases and insect pest attack. The clear economic advantage of the rice-wheat rotation over other alternatives coupled with risk free production environment shifted a significant area away from other crops to these crops reducing the crop diversity. The index of crop diversification was more than 0.75 during 1975-76 but fell significantly thereafter, reaching the current level of 0.58.




Source: Calculated from the Data in Various Issues of the Statistical Abstract of Punjab

## IV

## CONSERVATION TECHNOLOGIES, PRACTICES AND THEIR ECONOMIC IMPLICATIONS

Various types of conservation technologies and practices are developed and are being promoted in Punjab agriculture. These technologies and practices tend to reduce the use of irrigation water thereby improving water use efficiency, maintain physical properties of the soil as well as enhancing soil fertility and reduce chemical load in the production system. These innovations are discussed in the following section along with their impacts on farmers' income as well as on the agrarian economy.

### 1. *Water Conservation Innovations*

Many farming techniques and technologies have been developed in recent years to address the problem of depletion of ground water resources. These innovations focus on reducing water use and improving its efficiency without any adverse impact on the income of the farmers. This issue is gaining importance due to the emergence of water scarcity in the country in general and in the Punjab state in particular.

(a) *Use of Laser Leveller*: Rice fields are irrigated in large sized plots, with no uniform levelling. These plots require relatively higher amounts of water to irrigate every corner of the plot. Laser levelling was introduced in the state about two years ago and is becoming popular among farmers in Punjab not only due to its water saving potential but also due to significant economic benefits arising out of yield enhancement. The empirical evidence has shown that laser levelling in rice brings down the water use by 36.19 cm along with the yield improvement of 0.78 tonne/ha. Though electricity is supplied free of cost to the farming sector, but such savings of water use reduce the electricity consumption by 213.35 kwh/ha bringing in the cost saving of Rs. 610 per ha of rice area to the government (Table 1). The opportunity cost of such savings in electricity is much higher in the industrial sector. The productivity of paddy was reported to have increased from 7.32 t/ha on traditionally levelled field to 8.10 t/ha on laser levelled field. Laser levelling on custom hiring basis costs around Rs 1500 per ha (2009-10) and its economic life is 3 years. The amortized cost of laser levelling thus turns out to be Rs. 593 per ha. After adjusting for such costs, the total economic benefit from laser levelling was estimated at Rs. 8207 per ha. By using the laser levelling in rice, the Punjab state can achieve 0.99 million hectare metre water saving and can save 583.51 million kwh of electricity. While the state government can achieve savings in power subsidy by Rs. 167 crores, the farming community can earn higher returns of Rs. 2078 crore per year, bringing the total economic benefits of laser levelling to Rs. 2245 crore in Punjab.

(b) *Planting on Permanent Raised Beds*: Earlier, intensive ploughings of the crop fields were recommended to realise higher productivity. Later, it was realised that intensive pulverisation of the soil was not only adding to the cost of production but was not bringing any yield improvement. Crop cultivation on permanent raised beds is being promoted to bring reduction in water use as compared to flat planting technique as water is supplied in furrows and not to the entire field. Physical characteristics of the soil also undergo favourable changes. Further, in the case of flat planting, soil has to be prepared every time before sowing the crop. Therefore, permanent raised bed planting technique was standardised and recommended in the state to save water and maintain natural texture of the soil. Permanent raised bed planting technique in comparison to flat (conventional) planting technique saves irrigation water to the tune of 8 cm/ha in case of wheat and 60 cm/ha in case of rice (Table 1). Such reduction in water use brings savings in electricity by 7.16 kwh/ha in wheat and 353.72 kwh/ha in rice. Therefore, permanent raised bed planting in rice and wheat can together reduce the annual power consumption in Punjab by 1133.71 million kwh (967.42 m kwh for rice and 166.29 m kwh for wheat) saving the state exchequer by Rs. 323.66 crore per annum through subsidy reduction. Permanent raised bed planting also affects cost of production due to savings in tillage operations. It was estimated that such bed planting reduces cost of cultivation by Rs. 2419 per ha in wheat and Rs. 2925 per ha in rice as compared with conventional tillage operations (Dhaliwal *et al.*, 2008). However, its impact on productivity is mixed. The research evidence has shown that the same yield of wheat (5.2 t/ha) is realised under permanent raised bed planting while rice productivity is reported to fall by around 14 per cent, which makes this technique un-economical for rice crop. Yet, for wheat crop it results into an economic benefit of Rs. 2,554 per ha and a total benefit of more than Rs. 900 crore to the farmers and state.

(c) *Zero Tillage (with Happy Seeder) in Wheat*: Zero tillage practice is another innovation developed for conserving rice stubbles in the soil to improve organic matter and soil fertility. It also reduces the air pollution caused by burning of paddy straw, saves water by creating straw mulch and reduces the tillage cost. Under this practice, wheat is sown in the field within standing rice stubbles without any tillage operations. Happy Seeder consists of a rotor for managing paddy residue and a zero till drill which places the wheat seed at appropriate depth, convenient for its optimal germination. Water savings of 8.5 cm/ha were reported by zero till in wheat with Happy Seeder, causing power saving of 50.11 kwh/ha and hence a cost saving of Rs.143 per ha (Table 1). All these benefits translated into 0.30 m ha m of water savings, 176.69 million kwh of power savings and reduction in power subsidies to the state by Rs. 50.53 crore per annum. Use of Happy Seeder also causes reduction in cost of cultivation due to savings in tillage operations. It was estimated that the cost of cultivation due to happy seeder falls by Rs. 2020 per ha, which can help lowering cost of production to the wheat growers by Rs. 712 crore at the state level.

TABLE 1. POTENTIAL OF WATER CONSERVATION TECHNOLOGIES FOR WATER SAVING, POWER SAVING AND COST REDUCTION IN PUNJAB AGRICULTURE

| Conservation Technology (1) | Extent of water saving (cm/ha) (2) | Extent of power saving (Kwh/ha) (3) | Reduction in power subsidy (Rs./ha) (4) | Improvement/ reduction in crop yield (t/ha) (5) | Increase in returns (Rs./ha) (6) | Total benefit (power subsidy reduction + increase in returns) (Rs./ha) (7) |
|---|---|---|---|---|---|---|
| Farm Level Estimates | | | | | | |
| 1. Laser Leveling in rice[a] | 36.19 | 213.35 | 610 | 0.78 | 7597 | 8207 |
| 2. Permanent raised bed in wheat[b] | 8 | 47.16 | 135 | - | 2419 | 2554 |
| 3. Permanent raised bed in rice[b] | 60 | 353.72 | 1012 | -0.85 | -5727 | -4715 |
| 4. Happy Seeder in wheat[c] | 8.5 | 50.11 | 143 | - | 2020 | 2163 |
| 5. Tensiometer[d] | 37 | 218.13 | 624 | - | 336 | 960 |
| 6. Delayed Transplanting of rice (15 June)[e] | | | | | | |
| - With respect to May 16 | 42 | 247.60 | 709 | - | - | 709 |
| - With respect to May 31 | 23 | 135.59 | 388 | - | - | 388 |

State Level Estimates

| Conservation Technology (1) | Extent of water saving (million ha metre) (2) | Extent of power saving (million Kwh) (3) | Reduction in power subsidy (Rs. crore) (4) | Improvement/ reduction in crop yield (million tonne) (5) | Increase in returns (Rs. crore) (6) | Total benefit (power subsidy reduction + increase in returns) (Rs. crore) (7) |
|---|---|---|---|---|---|---|
| 1. Laser Leveling in rice | 0.99 | 583.51 | 167 | 2.13 | 2078 | 2245 |
| 2. Permanent raised bed in wheat | 0.28 | 166.29 | 47.56 | - | 852.94 | 900.50 |
| 3. Permanent raised bed in rice | 1.64 | 967.42 | 276.68 | -2.32 | -1566.33 | -1289.65 |
| 4. Happy Seeder in wheat | 0.30 | 176.69 | 50.53 | - | 712.25 | 762.78 |
| 5. Tensiometer | 1.01 | 596.59 | 170.62 | - | 91.90 | 262.52 |
| 6. Delayed Transplanting of rice (15 June) | | | | | | |
| - With respect to May 16 | 0.63 | 370.84 | 106.06 | - | - | 106.06 |
| - With respect to May 31 | 1.15 | 677.19 | 193.68 | - | - | 193.68 |

*Sources*: (a) Sidhu *et al*, 2007, (b) Dhaliwal *et al*,2008, (c) Singh *et al*, 2009, (d) Singh *et al*, 2006, (e) Singh, 2009.

*Note*: The estimates of only the water savings and improvement in the crop yields have been obtained from the above sources at the farm level. The respective power savings have been estimated by converting water savings into time equivalents of a standard 7.5 HP motor and then converting these hours of use into power units. The cost savings have been calculated at Rs. 2.86 price per unit of power. The increase in returns has been calculated by multiplying the MSP with yield improvements. The state level figures have been estimated by multiplying the area under a particular crop with the per hectare benefits. However, all the benefits are not cumulative in nature.

(d) *Use of Tensiometers in Rice*: Rice nursery is transplanted and the crop is raised in standing water with flood irrigation method with complete disregard to efficient water usage practices in the state. Free power supply to the farming sector (or even the charging at flat rate) in Punjab translates into zero marginal price of water and does not provide any incentive to save water. As a result, the crop is not irrigated under optimal water use pattern. Further, the farmers are under the impression that standing water conditions in rice provide higher yields, though the empirical research and field level evidence do not support such belief. The actual water requirement of rice crop is much below the usual application of water which ranges between 180 to 200 cm. Punjab Agricultural University has developed a simple and economical device called 'tensiometer' to standardise the use of water for rice crop according to the field conditions of available soil moisture and the crop water requirement. Application of water to rice crop by using the 'tensiometer' improves the water-use efficiency, thereby saving a significant amount of water without any adverse impact on productivity. The experimental evidence has established a water saving of 37 cm per ha with the use of 'tensiometer' (Table 1). The corresponding power savings are 218.13 kwh/ha and hence power subsidy reduction of Rs. 624 per ha due to power savings. At the state level, 'tensiometer' has the potential of saving 1.01 m ha m of water, 596.59 million kwh of power and Rs. 170.62 crore of power subsidy. The amortised cost of tensiometer was Rs. 119 per ha (with the assumption that one tensiometer is installed for one ha of rice area) while tensiometer results in labour savings of Rs. 455 per ha due to less number of irrigations. Therefore, the net economic benefit due to use of tensiometer was estimated at Rs. 330/ha and Rs. 262.5 crore at the state level.

(e) *Delayed Transplanting of Rice Nursery*: For a given rice area of 2.735 million ha in Punjab, groundwater resources can be managed to their sustainable level, if rice transplanting is delayed till the first week of July, when usually the monsoon rains set in. Delayed transplantation can save a significant amount of water due to fall in the evapo-transpiration (ET) rate of rice. Keeping this in view, the Government of Punjab passed legislation known as 'Preservation of Sub-soil Water Act, 2008' (also known as Punjab Rice Nursery Act), which prohibits farmers from transplanting rice nursery before 10th June. Research evidence has established that transplantation of rice on 15th of June reduces the water use by 42 cm and 23 cm, when compared to its transplanting between 15th of May and 31st of May, respectively (Singh, 2009). It corresponds to respective power savings of 247.60 kwh/ha and 135.59 kwh/ha as well as the power subsidy reduction of Rs. 709 and Rs. 388 per ha, respectively. Translated at the state level, 1.15 m ha m of water, 677.19 million kwh of power and Rs. 193.68 crore of power subsidy can be saved by delayed transplantation when compared to that on 15th of May. The respective savings w.r.t. 31st of May are 0.63 m ha m of water, 370.84 million kwh of electricity and Rs. 106.06 crore of power subsidy. Due to the Rice Nursery Act, the rate of fall in water table in the central districts of Punjab was limited to just 37 cm during 2008 cm as compared to the previous rate of more than 80 cm fall per annum.

(f) *Direct Seeding of Rice*: Direct seeding of rice is practiced in Vietnam, Malaysia and other rice growing East-Asian economies but availability of free ground water and power has hindered its large scale adoption in the Punjab state. Owing to fast emerging threat of ground water depletion and aiming at water conservation in the state, direct seeding of rice has been recommended by the Punjab Agricultural University as it helps in reducing the water requirement of the rice crop without any adverse impact on its productivity. It is estimated that water requirement of the direct seeded rice is reduced by about 45 cm per ha with a corresponding power saving of 265.29 kwh/ha and cost reduction of Rs. 759 per ha as compared with transplanted rice. The state stands to gain 1.23 m ha m of water, 725.57 million kwh of power and Rs. 207.51 crore of power subsidy.

2. *Soil Conservation Innovations*

Soil fertility is emerging as one of the main concerns of researchers and other stakeholders for conservation agriculture in the state. Soils have become deficient not only in major nutrients but also in micro nutrients. Farmers in the state are wary in the adoption of any technology or practice, which influences their incomes adversely. Only paddy residue management is discussed in this paper as this practice does not have any adverse impact on the crop profitability.

*Paddy Residue Management*: More than 90 per cent of rice area is harvested with the use of harvest combines, which leaves paddy stubbles in the field, which are burnt causing loss of nutrients and air pollution and are detrimental to human and animal life. Happy seeder was developed for the efficient management of paddy straw while sowing wheat under zero till at the same time. Paddy residue management builds nutrients in the soil over time and improves its physical properties as well as reduces water use. Research experiments indicate that retention of rice stubble adds nutrients to the soil and would reduce N requirement of the wheat crop by 10 per cent (26.5 kg of urea/ha) in 5th year of stubble retention and by 15 per cent (40 kg of urea/ha) from 10th year onwards. Losses to the tune of 63 thousand tonnes of N and 37 thousand tonnes of K caused by burning can be saved by adopting paddy residue management practices on the rice grown area (Singh *et al.*, 2008).

3. *Diversified Farming System Approach*

The emergence of rice-wheat monoculture due to favourable agricultural price and marketing polices of the government and their higher economic returns, has resulted in loss of bio-diversity and degradation of natural resources. Some alternative farming systems are not only equally profitable to rice-wheat rotation but are also resource conserving in nature (Table 2). Definitely, the effective marketing of alternative crops is necessary for the wider adoption of these farming systems. Yet, the long-term sustainability of the agro-ecological system of the state calls for their adoption and expansion.

TABLE 2. ALTERNATIVE RESOURCE CONSERVATIVE CROPPING SYSTEMS TO RICE-WHEAT ROTATION

| Particulars (1) | Rice equivalent yield (qtl/ha) (2) | Net returns (‘000 Rs./ha) (3) | Saving in irrigation water applied compared to rice-wheat system (cm) (4) |
|---|---|---|---|
| Rice-wheat | 12.1 | 47.1 | - |
| Maize-wheat-Summer moong | 13.8 | 51.1 | 12.5 |
| Maize-potato-moong | 19.3 | 56.4 | 120 |
| Maize-potato-onion | 21.8 | 86.7 | 97 |
| Groundnut-potato-bajra fodder | 21.5 | 64.4 | 124 |

*Source*: Gill and Toor (2007).

Maize, summer moong (pulse), groundnut and summer fodder (bajra) are summer (*kharif*) crops which compete with rice for land. These crops use much less water as compared to rice and fit very well with vegetable crops in the crop rotation. The potential of vegetables, pulses, oilseeds and fodder is quite high keeping in mind their demand situation in comparison to supply and these crops can offer an important alternative to rice as well as rice-wheat rotation. Farmers opting for such farming systems can harvest higher yields (expressed in terms of rice equivalents) and earn higher profits. Maize in combination with potato and onion fetches around Rs.87,000/ha to farmers as compared with Rs. 47,000/ha from rice-wheat rotation. This farming system also saves water by 97 cm per ha due to relatively lower water requirements. Similarly, other cropping systems such as maize-wheat-summer moong, maize-potato-moong and groundnut-potato-fodder are more profitable and water conserving. These cropping systems also improve soil health by increasing levels of organic carbon and other macro nutrients. Pulses fix nitrogen in soil while maize and oilseeds are less nutrient using crops. These crop systems offer economically viable diversification options in the presence of an efficient marketing systems.

4. *Integrated Pest Management (IPM) Technologies*

Integrated Pest Management (IPM) is the use of the best possible combination of methods to reduce and maintain pest populations below that level which can cause the economic damage. It is based on the principle of optimum pest control rather than maximum pest control. It is an important constituent of an agricultural production system with an aim to achieve sustainability along with the conservation of the agrosystem, and the environment in general (Flint and Van den Bosch, 1981). The IPM technologies have demonstrated a clear economic and environmental advantage over the non-IPM technologies in cotton in Punjab. The adoption of IPM in cotton has the potential to reduce the quantity of pesticide use by 67 per cent, the number of pesticide sprays by 40 per cent, thereby reducing the cost of insecticide use by Rs.1527 per ha (22.4 per cent) when compared to the non-IPM technologies (Table 3). The adoption of IPM technologies also helped in yield enhancement of cotton by 13.6 per cent (2.79 qtl/ha). The field investigation shows an advantage of Rs. 6840 per ha in terms of gross margins with the adoption of IPM in cotton as compared to the non-IPM technologies.

TABLE 3. ADVANTAGES OF IPM TECHNOLOGIES OVER NON-IPM TECHNOLOGIES FOR COTTON IN PUNJAB

| Particulars<br>(1) | IPM technologies<br>(2) | Non-IPM technologies<br>(3) | Advantage (IPM over non-IPM)<br>(4) |
|---|---|---|---|
| Total pesticide use (kg/ha) | 3.24 | 9.83 | -6.59<br>(-67.0) |
| Number of sprays | 6 | 10 | -4.0<br>(-40.0) |
| Cost of insecticide use (Rs./ha) | 5294 | 6821 | -1527<br>(-22.4) |
| Cotton yield (qtl./ha) | 23.32 | 20.53 | 2.79<br>(13.6) |
| Gross margins (Rs./ha) | 24303 | 17463 | 6840<br>(39.2) |

*Source*: Singh and Singh (2007).
*Note*: Figures in parentheses are per cent change due to IPM technologies over the non-IPM technologies.

### 5. *Protective Technologies in Vegetable Cultivation*

The net-house cultivation is a kind of protective technology which largely aims at raising the crop under controlled conditions. This technology benefits in two ways by (i) significant reduction in the use of plant protection chemicals and (ii) increasing the crop yield due to the controlled environment and lesser incidence of insect-pest attack and diseases. Evidence from the field survey has shown that the net-house cultivation achieved 21 per cent to 33 per cent reduction in the cost of plant protection chemicals in vegetable cultivation when compared to the open field cultivation (Table 4). There was also a significant jump in the yields of tomato and cucumber by 12.5 per cent and 9.7 per cent, respectively, though the capsicum yield declined by 11.1 per cent. The consumer preference for net-house cultivated vegetables is reflected from their higher market prices, which turned all the three crops under study economically more profitable. The net returns from these crops cultivated under net-house were higher by 13.7 per cent for capsicum, 26.6 per cent for tomato and 10.8 per cent for cucumber when compared to their open field cultivation.

TABLE 4. ECONOMIC ADVANTAGE OF NET-HOUSE CULTIVATION OVER OPEN FIELD CULTIVATION OF VEGETABLES IN PUNJAB

| | Net-house cultivation | | | Open-field cultivation | | |
|---|---|---|---|---|---|---|
| Particulars (1) | Capsicum (2) | Tomato (3) | Cucumber (4) | Capsicum (5) | Tomato (6) | Cucumber (7) |
| Plant protection chemicals | 1000 (-33.3) | 2200 (-21.4) | 2200 (-26.7) | 1500 | 2800 | 3000 |
| Yield (qtl./acre) | 120 (-11.1) | 225 (12.5) | 170 (9.7) | 135 | 200 | 155 |
| Average price (Rs./qtl) | 875 (16.7) | 400 (6.7) | 775 (6.9) | 750 | 375 | 725 |
| Net returns | 52240 (13.7) | 29680 (26.6) | 65970 (10.8) | 45950 | 23440 | 59535 |

*Source*: Sidhu and Vatta (2009).
*Note*: Figures in parentheses represent per cent change over open-field cultivation in the respective category.

V

## CONCLUSIONS AND POLICY IMPLICATIONS

The negative effects of intensive agriculture in the Punjab state have started over-shadowing the positive effects such as higher productivity and production, enhanced incomes of the farmers, greater food security, etc. The sustainability of the agriculture production system appears to be under threat due to over-exploitation of natural resources, environmental degradation, fall in bio-diversity and larger exposure to production risk. Conservation agriculture has therefore assumed greater importance in recent years to meet such challenges and ensure long-term sustainability of the production system. Many technologies and farming practices are developed, which aim to use and manage natural resources (especially water and soil) more efficiently, reduce over-dependence of production on agro-chemicals and restore diversification in crop patterns. Such technologies and practices are technically feasible for adoption. This paper therefore examines the level of degradation of agriculture in the state and quantifies the contribution of such technologies and practices towards conservation of agriculture along with their economic implications for the farmers and society.

Groundwater is the highly over-exploited and inefficiently used resource in the state primarily due to cultivation of rice crop on large area (2.73 million ha). The water table has gone down drastically in central Punjab and most of the development blocks are now categorised as ‘dark’. The water application practices are grossly inefficient due to free availability of water and power to the farming sector. Water is applied through flooding method of irrigation and water is kept standing in the rice fields. Many technologies and practices such as use of laser leveller for efficient water application in the field, use of tensio-meter for regulating irrigation according to the water requirements of the crop, delay in transplanting of rice nursery and direct seeding of rice have been evolved which reduce use of water for rice crop without any adverse impact on productivity. The savings in water are estimated around 25 per cent causing significant reduction in power subsidies borne by the state. Zero-tillage with Happy Seeder in wheat results in savings in water as well as improves the health of the soil by retaining rice stubbles in the field.

Diversified cropping system is developed and tested for its economic viability and impact on soil and water resource, which can replace rice-wheat system and bring much needed crop diversification, save water and improve soil fertility in the state. This system includes pulses, oilseeds, maize, summer fodder and vegetable crops, which use less water and nutrients and at the same time ensure at least the same or higher level of income to the farmers. Similarly, protective technologies and practices such as integrated pest management in cotton and net house cultivation of vegetables help reduce chemical load in the environment besides maintaining or improving farmers' incomes. IPM in cotton advocates use of biological and chemical methods to keep the population of insect-pests below economic threshold level, thus reducing the use of chemical sprays in cotton crop.

The foregoing analysis therefore establishes that conservation agricultural technologies and practices are not only technically feasible but are economically viable also. These are not becoming popular because of the prevailing policy environment favouring rice-wheat system. Agricultural price and marketing policy for wheat and rice encourages their production and ensures their easy marketing and almost certain economic returns. Groundwater resources come under the domain of common property resources and are not managed according to sustainability principles. Free supply of power to the farming sector causes further inefficient use of ground water resources. Farmers have started using higher doses of chemical fertilisers and other agro-chemicals to maintain the current levels of food grain productivity leading to environmental degradation. What is therefore needed to conserve Punjab agriculture is to educate the farmers about the relevance of sustainable agriculture, economic impacts of conservation technologies and practices for farmers and state as well as their demonstration at farmers' fields, changes in the government policies to encourage natural resource management and environmental conservation and strengthening of supply and value chain system for maize, pulses, oilseeds, milk and milk products and other crops so that these can compete with rice-wheat system in the market. The services of costly machinery like laser leveller and happy seeder shall have to be made available to the farmers especially among small and marginal farmers on custom-hiring basis through co-operatively managed machinery service centres. Many such centres are already operating in the state under the umbrella of the Primary Agricultural Co-operative Societies, but their number needs to be increased to cover the entire state.

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