# IMPROVEMENT IN LAND AND WATER PRODUCTIVITY UPON ADOPTING PRESSURIZED IRRIGATION SYSTEMS BY THE FARMERS IN VIDARBHA REGION (INDIA) – A CASE STUDY

# AMELIORATION AU NIVEAU DE LA FERME DE LA PRODUCTIVITE DE L'EAU ET DE LA TERRE ATTRIBUEE A L'UTILISATION DU SYSTEME D'IRRIGATION A PRESSION PAR LES FERMIERS DE LA REGION DE VIDARBHA (INDE) - ÉTUDE DE CAS

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## *ABSTRACT*

*Pressurized irrigation systems were found suitable to give more yield per unit of water used. Adoption of these systems in irrigated agriculture can boost agricultural production and improve the soil ecosystem, water and fertilizer use efficiency and reduce labour requirement.*

*The present study indicated that the pressurized irrigation systems gave better results when coupled with the modern cultivation practices like cultivation across the slope, contour cultivation and cultivation on raise bed; in terms of enhanced productivity by 13 to 50 per cent, water use efficiency from 0.90 to 3.86 kg/ha/mm during kharif season (monsoon cultivation season) in cotton, soybean, green gram and pigeonpea. Similarly during rabi season (winter cultivation season) yield of chickpea was enhanced by 33 to 48 per cent and water use efficiency from 2.44 to 3.50 kg/ha/mm by providing one or two sprinkler irrigations over the traditional practice of cultivation along the slope with flow irrigation. Drip irrigation systems indicated the higher B : C ratio with net extra income in 30 to 40 per cent saving in water in high value crops viz. water melon, chilli, tomato, turmeric and ginger.*

*From these results it is concluded that on farm adoption of the pressurized irrigation systems with modern cultivation practices and adoption of drip irrigation with specific crop geometry*

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*in horticultural crops are beneficial to the farmers in terms of improved land and water productivity.*

***Key words:*** *Pressurized irrigation, Vidarbha region of India, Farmers's participation action research programme, water use efficiency*

## *RESUME*

*Il a été constaté que l'irrigation sous l'effet de pression convient mieux pour accroître le rendement agricole par unité d'eau utilisée. Ce système d'irrigation adapté au niveau des fermes s'avère être plus rentable, le rendement étant plus élevé par rapport à d'autres systèmes. Cela contribue ausi à améliorer l'écosystème du sol et l'efficience d'utilisation de l'eau et des fertilisants, l'économie en main d'oeuvre étant un autre avantage.*

*Ce système est beaucoup plus avantageux s'il est accompagné des pratiques modernes de cultivation telles que : culture sur terrasse, culture selon les courbes de niveau et cultivation sur billon élevé. Cela a rendu possible d'accroître de 13 à 50% la productivité, de 0,90 à 3,86 kg/ha/mm l'efficience d'utilisation de l'eau lors de la saison de kharif dans la cultivation du coton, du soja etc. De même façon, lors de la saison de rabi, li était possible d'accroître le rendement de pois chiche de 33 à 48% et l'efficience d'utilisation de l'eau de 2,44 à 3,50 kg/ha/mm en fournissant une ou deux irrigations par aspersion par rapport à la pratique traditionnelle de culture le long de la pente avec l'irrigation gravitaire. Les systèmes d'irrigation goutte à goutte indiquent la plus haute proportion B.C. avec le revenu supplémentaire net, l'économie d'eau de 30 à 40% dans les cultures de haute valeur telles que la pastèque, le piment, la tomate, le curcuma et le gingembre.*

*Compte tenu de ces résultats, il est constaté que l'adoptation des systèmes d'irrigation à pression sur la ferme accompagnés des pratiques modernes de culture agronomique et l'adoption du système d'irrigation goutte à goutte dans la horticulture sera avantageux aux fermiers en ce qui concerne la productivité améliorée de l'eau et de la terre.*

***Mots clés:*** *Irrigation sous l'effet de pression, région de Vidarbha en Inde, Programme de recherche d'action participatoire des fermiers, efficience d'utilisation de l'eau*

# 1. INTRODUCTION

Agriculture is the principal occupation of the majority of the Indian population. Timely availability of adequate supply of irrigation is crucial for the agricultural productivity and the country's economy. A large variation in the rainfall and its distribution pattern under the monsoon climate in India results in uncertainty of water availability and decline in the water table due to over-exploitation of groundwater in most parts of the country. While the demand for water will continue to rise rapidly in agriculture, industry and domestic sectors, the supply of water will be increasingly tightened because of the limited potential. It is also likely that presently agriculture, which utilizes about 83 percent of the exploited water resources, may have reduced share of water in the future, because of competitive demands from domestic and industrial sectors. High cost of development of water resources

is making major irrigation projects economically unsustainable. Hence, it is now very clear that major hurdle in increasing the production and productivity of food grains, high value commercial crops may be inadequate water supply, which can mainly be overcome by applying right amount of water at right time through pressurized irrigation systems to enhance water use efficiency.

Adoption of pressurized irrigation systems has not only been found suitable to improve the soil eco-system and increase crop productivity but also found effective in saving water and costs on pumping, labour and fertilizers when fertigation technology adopted. However, they are at present been used mostly for widely spaced and high value commercial crops. High initial costs in establishing the systems coupled with management problems, inadequate technical knowledge and lack of standard components have been some of the limitations in wider adoption of this technology.

## 2. ON FARM RESEARCH AND DEVELOPMENT

Adoption of pressurized irrigation systems resulted in the development of a completely new irrigation concept characterized by partial wetting of the soil area occupied by the plants. The micro irrigation methods exploit the flow of water under pressure in closed pipes to apply it through the emitters. Pressurized irrigation systems are also characterized by their ability to obtain high water use efficiencies in contrast to the efficiencies obtained by surface irrigation methods. This is a major consideration these days in view of the fact that irrigation planners and farmers in many areas of the world are faced with an increasing scarcity of quality water sources. Besides, they seek ways to minimize pollution caused by leaching of salts and fertilizers to the aquifers as a result of wasteful water application by flow irrigation. The State Governments and the Central Government have sponsored many research schemes on these aspects to the various institutions in the country from 1985.

In the present situation, it is necessary to involve farmers and motivate them to undertake more responsibilities to enhance the water use efficiency both in rainfed and irrigated farming. Working together as a group for the benefits and welfare of all, envisages changes in their attitudes, mind sets and enhancing their skill and capacities. How much water do we really need in rainfed and irrigated agriculture? Related to this question is, how should the water be managed in rainfed and irrigated agriculture in future? These questions have several answers depending on objectives of society. Yet even if we can clarify our desires, we cannot adequately answer the questions of what kind of and how much water we need in rainfed and in irrigated agriculture. A major reason for this lack of foresight is that the farmers are unaware and oblivious to the need of scientific water management in agriculture.

With the view to making the farmers water-wise, the Farmers Participatory Action Research Programme (FPARP) has been implemented. The experiments cum demonstrations were conducted with the following specific objectives.

# 3. OBJECTIVES

- Enhancing the water use efficiency
- Improving the moisture content in the soil profile
- Impact of pressurized irrigation systems under modern cultivation practices
- Suitability of pressurized irrigation systems.

# 4. MATERIALS AND METHODS

On farm experiments were conducted in participatory mode on the farmers' fields in Amravati, Akola, Buldana, Wardha and Washim district of Vidarbha region, in 13 villages during kharif and in 17 villages during rabi in the year 2008-09 and 2009-10. The farmers who participated in the on farm research study adopted modern cultivation practices like cultivation across the slope, contour cultivation and cultivation on raise bed. Drip and sprinkler irrigation systems for the respective fields were designed for providing irrigation during monsoon break in the kharif and in the rabi seasons. Drip irrigation systems were designed and installed specifically for high value horticulture and vegetable crops on farmers' fields. The following observations were recorded with the participation of farmers in order to study the suitability of the pressurized irrigation systems.

## Observations

1. Improvement in water use efficiency and crop yield.
2. Impact of pressurized irrigation system in modern cultivation practices.
3. On farm improvement in benefit cost ratio in high value crops.

## Transfer of Technologies

Following technologies were demonstrated during 2008-2010 with the participation of farmers for improvement in the land and water productivity. This required efforts and involvement of every farmer in adopting pressurized irrigation systems coupled with the improved cultivation practices like cultivation across the slope, raised bed across the slope and along contours. The following irrigation systems were installed and demonstrated on the farmers' field during kharif and rabi seasons.

## Agronomical crops

- Sprinkler
- Drip
- Flow Irrigation (Control)

## Horticultural crop :

- Drip irrigation
- Flow irrigation (control)

# 5. RESULTS AND DISCUSSION

Participatory irrigation management was done in 13 villages during kharif season and in 17 villages during rabi season by adopting the modern cultivation practices like, across the slope cultivation, contour cultivation and raised bed cultivation for better insitu moisture conservation. Irrigation was provided through drip, sprinkler and flow methods.
Impact of pressurized irrigation under modern cultivation practices

## *Kharif season*

### 1. Across the slope cultivation

Data in Table 1 reveals that by providing four irrigations to the sole cotton crop through drip system enhanced the yield by 20 per cent and water use efficiency from 3.22 to 3.86 kg/ha/mm. Two irrigations were provided to the soybean through sprinkler system enhancing the yield by 13.04 per cent and water use efficiency from 2.96 to 3.40 kg/ha/mm. In the intercrop of green gram and pigeon pea two irrigations were provided by sprinkler to the green gram and four irrigations were provided to the pigeonpea through drip irrigation enhancing the yield of green gram by 50 per cent and water use efficiency from 1.11 to 1.66 kg/ha/mm and pigeon pea by 43.75 per cent and WUE from 1.03 to 1.48 kg/ha/mm. Similarly, to the intercrop of soybean and pigeon pea, two irrigations were provided through the sprinkler system. The yield of soybean enhanced by 30 per cent and water use efficiency from 2.96 to 3.84 kg/ha/mm and four irrigation were provided to the pigeon pea through drip system. The yield of pigeonpea was enhanced by 42.85 per cent and water use efficiency from 0.90 to 1.28 kg/ha/mm over surface irrigation.

### 2. Cultivation on raise bed

Data in Table 1 indicated that four irrigations were provided to the cotton through drip system enhancing the yield by 22 per cent and water use efficiency enhanced from 3.22 to 3.93 kg/ha/mm. Two irrigations through sprinkler system were provided to the soybean which enhanced the yield by 20 per cent and water use efficiency from 2.96 to 3.55 kg/ha/mm. From the results it is inferred that pressurized irrigation systems (sprinkler and drip) had shown better results in improving the yield and water use efficiency when in modern cultivation practices were adopted.

## *Rabi Season*

During *rabi* season irrigation was provided by flow and through sprinkler system to the chickpea crop by adopting the modern cultivation practices with Green gram and Soybean based cropping systems and compared with the farmers practice of cultivation, along the slope.

### 1. Across the slope cultivation

Data in Table 2 indicated that chickpea sown across the slope after Green gram in *kharif* with one irrigation through sprinkler system enhanced the yield by 33.33 per cent and water use efficiency from 2.44 to 3.26 kg/ha-mm. Chickpea sown across the slope after Soybean in *kharif*, with two irrigations through sprinkler system enhanced the yield by 37.03 per cent and water use efficiency from 2.03 to 2.79 kg/ha-mm, respectively.

Table 1. Effect of pressurized irrigation systems under various cultivation practices during kharif season

| Crop | Type of irrigation | Total Irri. | Yield qha$^{-1}$ | | | Increase over conventional method (%) | | Water use efficiency (kg/ha/mm) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Conventional method i.e flow irrigation (control) | Across the slope | Across the slope raised bed | Across the slope | Across the slope raised bed | control | Across the slope | Across the slope raised bed |
| **Sole crop** | | | | | | | | | | |
| Cotton | Drip | 4 | 25.00 | 30.00 | 30.50 | 20.00 | 22.00 | 3.22 | 3.86 | 3.93 |
| Soybean | Sprinkler | 2 | 20.00 | 23.00 | 24.00 | 13.04 | 20.00 | 2.96 | 3.40 | 3.55 |
| **Intercrop** | | | | | | | | | | |
| Greengram + Pigeonpea | Sprinkler & drip | 2 + 4 | 7.50 | 11.25 | - | 50.00 | - | 1.11 | 1.66 | - |
| | | | 8.00 | 11.50 | - | 43.75 | - | 1.03 | 1.48 | - |
| Soybean + Pigeonpea | Sprinkler & drip | 2 + 4 | 20.00 | 26.00 | - | 30.00 | - | 2.96 | 3.84 | - |
| | | | 7.00 | 10.00 | - | 42.85 | - | 0.90 | 1.28 | - |

Av. Rainfall 575.56 mm (Karanja, Risod, Malegaon, Patur, Barshitakli and Anjangaon), per irrigation depth 50 mm.

Table 2 : Effect of sprinkler irrigation under various cultivation practices on chickpea during rabi season

| S.N. | Method of rain water management | No. of irrigations | Yield, qha-1 | Increase over conventional method, (% ) | Water use efficiency |
|---|---|---|---|---|---|
| 1. | Along the slope sowing cultivations after Green gram during kharif (control) | 01 | 15.00 | -- | (kg/ha/mm) |
| 2. | Across the slope cultivation after Green gram during kharif | 01 | 20.00 | 33.33 | 2.44 |
| 3. | Contour cultivation after Green gram during kharif | 01 | 21.50 | 43.33 | 3.26 |
| 4. | Along the slope sowing cultivations after Soybean during kharif (control) | 02 | 13.50 | -- | 3.50 |
| 5. | Across the slope cultivation after Soybean during kharif | 02 | 18.50 | 37.03 | 2.03 |
| 6. | Contour cultivation after Soybean during kharif | 02 | 20.00 | 48.14 | 2.79 |

Av. Rainfall 562.47 mm (Risod, Malegaon, Patur, Barshitakli and Anjangaon), per irrigation depth 50 mm.

### 2. Contour cultivation

Data in Table 2 indicated that chickpea sown on contour after Green gram in *kharif* with one irrigation through sprinkler system enhanced the yield by 43.33 per cent and water use efficiency from 2.44 to 3.50 kg/ha-mm. Similarly chickpea sown on contour after Soybean in *kharif* with two irrigations through sprinkler system enhanced the yield by 48.14 per cent and water use efficiency from 2.03 to 3.01 kg/ha-mm respectively.

## Horticulture / Vegetable Crops

A few pockets of Amravati, Akola, Buldana and Washim districts of Vidarbha region have a good water potential for seasonal as well as perennial irrigation. Farmers were motivated to adopt the drip irrigation system for the crops like Ginger, Turmeric, Water -melon, Chilli, Tomato. In Vidarbha region majority of farmers are still irrigating these crops by surface irrigation and usually are not willing to adopt drip irrigation. Few experiments cum demonstrations were organized and were considered as case studies. Some of the case studies are dicussed below in brief.

## Case Studies

### 1. Watermelon

The farmers cultivated Watermelon during summers of 2009 and 2010. The drip irrigation systems were designed and provided to the farmers to study the on-farm response of Watermelon to the drip irrigation system and compare the results with those with surface irrigation. The calculations were made on per hectare basis and the comparison was shown to the participating farmers. The observations are given in Table 3.

The Watermelon crop was cultivated at the spacing of 1.5 x 0.3 m in drip irrigation and at 2.10 x 0.3 m in surface irrigation. The total number of plants maintained per hectare were 22311 in drip system and 15984 in surface irrigation. In-line drippers of 4 LPH discharge were provided at every 60 cm distance in lateral. About 12 $LD^{-1}$ water per plant was applied through drip and 25 $LD^{-1}$ per plant in surface irrigation. Every day about 30 per cent water was saved by the farmer in drip irrigation over surface irrigation. Farmers received 30 t $ha^{-1}$ yield of Watermelon in drip system as against 22 t $ha^{-1}$ in surface irrigation. The net seasonal income from the selling of Watermelon was INR 65440 (US $ 1454) in drip as against INR 33600 (US $ 747) in surface irrigation. The B : C ratio was 2.19 in drip as against 1.67 in surface. The net per hectare extra income of INR 97280 (US $ 2162) was realized by the farmers due to the adoption of drip irrigation. Looking to the benefits accrued to the farmers it is observed that on-farm adoption of drip irrigation for water melon is most suitable and profitable to the farmers.

### 2. Chilli

The farmers cultivated Chilli crop during 2008-09 and 2009-10. The drip irrigation systems were designed and provided to the farmers to study the on-farm response of Chilli to the drip irrigation system over surface irrigation. The calculations were similar to those for Watermelon. The observations were given in Table 3.

Table 3 : On farm economics of Drip Irrigation for Watermelon /Chilli /Tomato /Turmeric /Ginger

| Sr. no. | Particulars | Water melon | | Chilli | | Tomato | | Turmeric | | Ginger | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Drip | Surface | Drip | Surface | Drip | Surface | Drip | Surface | Drip | Surface |
| 1. | Spacing, m | 1.50x0.3 | 2.10x0.3 | 0.9x0.3 | 0.6x0.45 | 0.9x0.3 | 0.6x0.45 | 0.60x0.225 | 0.60x0.225 | 0.6X0.225 | 0.6X0.225 |
| 2. | Cost of drip system, INR ha-1 | 52000 | | 55000 | | 50000 | | 50000 | | 50000 | |
| | a) Life 5 yrs for lateral/ drippers and 10 yrs for main, submain and filter<br>b) Depreciation, INR ha-1<br>c) Interest 12%, INR ha-1<br>d) Repair and maintenance, INR ha-1 (5%)<br>e) Total, INR ha-1 | -<br>8840<br>3120<br>2600<br>14560 | -<br>-<br>-<br>-<br>- | -<br>9350<br>3300<br>2750<br>15400 | -<br>-<br>-<br>-<br>- | -<br>8500<br>3000<br>2500<br>14000 | -<br>-<br>-<br>-<br>- | -<br>8500<br>3000<br>2500<br>14000 | -<br>-<br>-<br>-<br>- | -<br>8500<br>3000<br>2500<br>14000 | -<br>-<br>-<br>-<br>- |
| 3. | Cost of cultivation, INR ha-1 | 40,000 | 50000 | 70000 | 80000 | 72500 | 82500 | 52500 | 60000 | 45000 | 60000 |
| 4. | Seasonal total cost (3+2 e) INR ha-1 | 54560 | 50000 | 85400 | 80000 | 86500 | 82500 | 66500 | 60000 | 59000 | 60000 |
| 5. | Water used LD-1P-1 | 12 | 25 | 4 | 8 | 4 | 8 | 2 | 4 | 2 | 4 |
| 6. | Yield of produce, t/ ha-1 | 30 | 22 | 6.5 | 5.0 | 25 | 20 | 3.1 | 1.95 | 3.25 | 2.0 |
| 7. | Selling price, INR t/ha-1 | 4000 | 3800 | 30000 | 28000 | 5000 | 5000 | 40000 | 38000 | 60000 | 55000 |
| 8. | Income from produce (6x7), INR ha-1 | 120000 | 83600 | 195000 | 140000 | 125000 | 100000 | 124000 | 74100 | 195000 | 110000 |
| 9. | Net seasonal income (8-4), INR ha-1 | 65440 | 33600 | 109600 | 60000 | 38500 | 17500 | 57500 | 14100 | 136000 | 50000 |
| 10 | Additional area cultivated due to saving of water, ha | 1 | - | 0.5 | - | 0.5 | - | 0.5 | - | 0.5 | - |
| 11 | Additional expenditure due to additional area (4x10), INR ha-1 | 54560 | - | 42700 | - | 43250 | - | 33250 | - | 29500 | - |
| 12 | Additional income due to additional area (8 x10), INR ha-1 | 120000 | - | 97500 | - | 62500 | - | 62000 | - | 97500 | - |
| 13 | Additional net income (12-11), INR ha-1 | 65440 | - | 54800 | - | 19250 | - | 28750 | - | 68000 | - |
| 14 | Gross cost of production (4+11)/2, INR ha-1 | 54560 | 25000 | 64050 | 40000 | 64875 | 41250 | 49875 | 30000 | 44250 | 30000 |
| 15 | Gross income (8+12)/2, INR ha-1 | 120000 | 41800 | 146250 | 70000 | 93750 | 50000 | 93000 | 37050 | 146250 | 55000 |
| 16 | B.C. ratio (15/14) | 2.19 | 1.67 | 2.28 | 1.75 | 1.44 | 1.21 | 1.86 | 1.23 | 3.30 | 1.83 |
| 17 | Net extra income due to drip irrigation over surface irrigation INR /ha [(13+9Drip)-9Surf] (US$) | 97280 (2162) | - | 104400 (2320) | - | 40250 (895) | - | 72150 (1603) | - | 154000 (3422) | - |

Note : 1 US $ = 45 INR (Indian rupees)

The Chilli was cultivated at a spacing of 0.9 x 0.3 m in drip irrigation and at 0.6 x 0.45 m in surface irrigation. The total number of plants maintained per hectare were 36963 in drip system and 37074 in surface irrigation. In-line drippers of 4 LPH discharge were provided at every 60 cm distance in laterals. About 4 $LD^{-1}$ water per plant was applied through drip and 8 $LD^{-1}$ per plant in surface irrigation. Every day about 40 per cent water was saved by the farmer in drip irrigation over surface irrigation. Farmers received 5 t $ha^{-1}$ yield of Chilli in drip system as against 2.73 t $ha^{-1}$ in surface irrigation. The net seasonal income from the selling of Chilli was INR 109600 (US $ 2436) in drip as against INR 60000 (US $ 133) in surface irrigation. The B : C. ratio was 2.28 in drip as against 1.75 in surface irrigation. Net per hectare extra income of INR 104400 (US $ 2320) was realized by the farmers due to the adoption of drip irrigation. Looking to the benefits accrued to the farmers it is observed that on-farm adoption for chilli with drip irrigation is most suitable and profitable to the farmers.

### 3. Tomato

The farmers cultivated Tomato crop during summer 2009 and 2010. The drip irrigation systems were designed and provided to the farmers. The observations and calculations are given in Table 3.

The Tomato crop was cultivated at the spacing of 0.9 x 0.3 m in drip irrigation and at 0.6 x 0.45 m in surface irrigation. The total number of plants maintained per hectare were 36963 in drip system and 37074 in surface irrigation. In-line drippers of 4 LPH discharge were provided at every 60 cm distance in laterals. About 4 $LD^{-1}$ water per plant was applied in drip and 8 $LD^{-1}$ per plant in surface irrigation. Every day about 50 per cent water was saved by the farmer in drip irrigation over surface irrigation. Farmers received 25 t $ha^{-1}$ yield of Tomato in drip system as against 20 t $ha^{-1}$ in surface irrigation. The net seasonal income from the selling of Tomato was INR 38500 (US $ 856) in drip as against INR 17500 (US $ 389) in surface irrigation. The B : C. ratio was 1.44 in drip as against 1.21 in surface. The net extra income per hectare of INR 40250 (US $ 895) was realized by the farmers due to the adoption of drip irrigation. Thus, on-farm adoption of drip irrigation for tomato is most suitable and profitable to the farmers.

### 4. Turmeric

Turmeric was cultivated during 2008-09 and 2009-10. The drip irrigation systems were designed and provided to the farmers. The calculations were made on per hectare and the observations and calculations are given in Table 3.

The Turmeric crop was cultivated at the spacing of 0.6 x 0.225 m in drip and surface irrigation system and per hectare 74222 plants were maintained in both the cases. In-line drippers of 4 LPH discharge were provided at every 60 cm distance in laterals. Water application was about 2 $LD^{-1}$ per plant in drip and 4 $LD^{-1}$ per plant in surface irrigation. Planting was done in pair row and one lateral was provided in between two rows. Every day about 50 per cent water was saved by the farmer in drip irrigation over surface irrigation.

Farmers received 3.1 t $ha^{-1}$ yield of Turmeric in drip system as against 1.95 t $ha^{-1}$ in surface irrigation. The net seasonal income from the selling of Turmeric was INR 57500 (US $ 1278) in drip as against INR 14100 (US $ 314) in surface irrigation. The B : C ratio was 1.86 in drip as against 1.23 in surface irrigation. The net per ha extra income of INR 72150 (US $ 161) was realized by the farmers due to the adoption of drip irrigation, making it the most suitable and profitable to the farmers.

### 5. Ginger

The farmers cultivated Ginger crop during 2008-09 and 2009-10 in the same manner as the other crops. The results are given in Table 3.

The Ginger crop was cultivated at the spacing of 0.6 x 0.225 m in drip and surface irrigation system and per hectare 74222 plants were maintained. In-line drippers of 4 LPH discharge were provided at every 60 cm distance in lateral. About 2 $LD^{-1}$ per plant water was applied in drip and 4 $LD^{-1}$ per plant in surface irrigation. Planting was done in pair row and one lateral was provided in between two rows. Every day about 50 per cent water was saved by the

farmer in drip irrigation over surface irrigation. Farmers received 3.25 t $ha^{-1}$ yield of Ginger in drip system as against 2.0 t $ha^{-1}$ in surface irrigation. The net seasonal income from the selling of Ginger was INR 136000 (US $ 3022) in drip as against INR 50000 (US $ 1101) in surface. The B : C. ratio was 3.30 in drip as against 1.83 in surface irrigation. The net per hectare extra income of INR 154000 (US $ 3422) was realized by the farmers due to the adoption of drip irrigation over surface irrigation, making it the most suitable and profitable for Ginger.

From the above results it is inferred that in irrigated agriculture pressurized irrigation systems show better impact in combination with the adoption of improved cultivation practices towards enhancing the water use efficiency and the yield levels. Similarly in drip irrigation higher B : C ratio with net extra income and 30 to 40 per cent saving of water was observed in horticultural crops over surface irrigation.

# 6. CONCLUSION

From the on farm trial results it is concluded that pressurized irrigation systems (drip and sprinklers) are the most suitable irrigation methods for the on farm improvement in land and water productivity in terms of enhanced crop yields, water use efficiency, B : C. ratio with net extra income and saving in water.

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