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Annual Report 2017-18

अखिल भारतीय समन्वित अनुसंधान परियोजना (प्लास्टिक अभियांत्रिकी एवं प्रौद्योगिकी)
All India Coordinated Research Project on Plasticulture Engineering and Technology
भा.कृ.अनु.प.–केन्द्रीय कटाई–उपरान्त अभियांत्रिकी एवं प्रौद्योगिकी संस्थान (सीफेट)
ICAR-Central Institute of Post-Harvest Engineering and Technology
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P.O.: PAU, Ludhiana-141 004 (Punjab), India
(An ISO 9001:2015 Certified Institute)

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Published by:

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Citation: **AICRP on PET, ICAR-CIPHET, Ludhiana**

Printed at: Yugantar Prakashan Pvt. Ltd.
WH-23, Mayapuri Industrial Area Phase-I, New Delhi-64
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CONTENTS

PREFACE

The All India Coordinated Research Project on Plasticulture Engineering and Technology is contributing in developing technologies for overall agriculture production, intensive fish culture, animal husbandry, water management/ harvesting, farm tools and post-harvest management and other areas of agricultural development. At present the project is operational at 14 centers representing almost all major agro-climatic zones. The AICRP has five centres in mid-hills of Himalayan regions (Srinagar, Almora, Gangtok, Barapani and Dirang), two centres in northern Indo-gangetic plains (Ludhiana and Abohar), one center in coastal region (Bhubaneswar, which is mandated for fishery aspects), one centre in eastern plateau region (Ranchi), two centres in tropical wet (Mathura and Dapoli), two centre in dry climatic region (Raichur, Junagadh) and one in Aravali hills eco-systems (Udaipur).The significant achievements and results have been presented in this report for information to everybody concerned.

I express my sincere gratitude to Dr. K. Alagusundaram, DDG (Engg.) for encouragement and guidance provided from time to time to the AICRP team. I am grateful to Dr. S .N. Jha. ADG (PE) and Dr. Kanchan.K. Singh, ADG (AE) for their support and guidance in planning and carrying out research, participatory field evaluation and documentation.

I am thankful to Vice Chancellors, Directors / Director of Research, Principal Investigators and scientists of the centres of the AICRP who put their hard work to fulfill the objectives and goal of the project, providing facilities for conducting the research work.

The efforts and contributions made by Er. Indore Navnath; Scientist, Mr. Vishal Kumar; STA, Mrs. Sunita Rana; LDC, Dr. Malathi A N; SRF, Er. Harmehar Singh; SRF, and Er. Rajbir Kaur; YP-1 in the coordinating unit of the AICRP in different activities of the project are greatly appreciated.

R K Singh
Project Coordinator

1. EXECUTIVE SUMMARY

The AICRP on Plasticulture engineering & technology is operative at fourteen centres. The project has contributed in development or modification of technologies related to plasticulture in horticulture, irrigation, intensive fish culture and animal housing as per the need of the mandated area of the centres. Following are the achievements made during 2017-18 in bullet form.

- Modelling and Soil less cultivation of cucumber and tomato under naturally ventilated polyhouse in Punjab by **PAU Ludhiana**. The results showed that among three levels of fertigation (70, 85 and 100 %), fruit yield of 85 and 100 % treatments were statistically at par and were significantly higher than 70 % fertilizer dose. Among the cucumber hybrids/varieties Multistar variety (180 t/ha) gave the highest yield . Among the different tomato cultivars viz. Punjab Sartaj, Himshikhar (Syngenta) and NS 4266 (Namdhari Seeds), NS-4266 an indeterminate Tomato hybrid is performing best, with yield of 5.4 Kg/Plant. Fertigation dose up to 85 % of the dose recommended for climate controlled polyhouse is optimum for tomato production in soilless media as further increase in fertigation dose did not result significant increase in the yield.
- Yield performance of off-season okra under different type structures and mulch conditions was studied at **Junagadh centre** representing Saurashtra region in Gujrat. Performance of Hybrid variety (GJO-H4) developed by the University was evaluated inside structure. Fruit yield (22.4 t/ha) were found significantly higher inside the net-cum-polyhouse without ridge vent with silver black plastic. Water saving was the highest (28.75 %) for mulch conditions inside the structures compared to in open water saving 13.78 %. Maximum water use efficiency (71.58 kg/ha-mm) was found under silver black plastic mulch inside the Net-cum-polyhouse. Maximum net profit of Rs.8 lakh per ha could be obtained with B: C ratio of 2.61.
- The water harvesting pond is covered with 500 micron LDPE black film of capacity 1360 m^3 was designed and developed by **BAU, Ranchi centre**. Overall dimension of plastic lined pond required for irrigation of cultural command area were determined as side slope: 2:1, the bottom of pond 15 m x 15 m, depth of pond 3 m and top surface of pond 27 m x 27 m. Water storage cost is around Rs. 17.3/m^3 (considering water harvesting pond is full and life of plastic film is around 10 years). The pegeion pea and okra was sown on boundary of plastic lined pond to reduce the wind speed & eventually reduce the evaporation loss of water from pond surface. The plucking of okra was done 20 times and yield recorded is 13.5 t/ha.
- **ICAR-CIPHET, Abohar** centre designed and developed composite Solar Air-conditioning System coupled farm level cold store for hot and arid region. Solar energy based adsorption cooling system was found suitable in lowering the temperature of cooling coil by 18 °C (reduced the temperature from 38 to 20 °C).Developed system lowered the evaporator temperature by 15-18 °C. Storage capacity of the system: 1 quintal; Cooling capacity of the system under no load condition was 0.13 Tons of Refrigeration (0.44 kW). COP of the system was 0.14.
- Development of a low cost Aquaponics System in aquaculture by **ICAR-CIFA, Bhubaneshwar centre,** The system comprises of fish culture tank, submersible water pump, trickling filter, four NFT grow pipes each having length of 3 m and 9 perforations (3-inch diameter each for holding net pots) for growing plants. The system is designed to use excess nutrients from aquaculture for growing agriculture crops for having synergistic effect on both crop and fish. The combination of tilapia (Oreochromisniloticus) fish and marigold plants were shown yielding 450 marigold flowers from 36 plants in the system in 3 months
- Design and developed solar cabinet dryer for hills by **ICAR-VPKAS Almora centre**. The capacity

of dryer is 25-30 kg with lower operational cost because it is operated with solar powered exhaust fan to remove moistened air. Temperature inside solar cabinet drier rose by 11.4 °C, 24.6 °C, 33.2 °C, and 40.9 °C in basement, lower tray, middle tray and upper tray, respectively over the outside temperature (26.0 °C). it can reduce moisture content of vegetables from 90 % to 10 % safe storage in 2-3 days.

- Design, Development and Evaluation of Plastic Gadgets for Hygienic Fish Marketing by **ICAR-CIFA Bhubaneswar centre**. A mobile fish vending trolley has been designed and developed with dimension 4'x2'9"x2'6" to aid the fisher folks for vending their fish harvests in hygienic condition. The specialty of the carriage is its unibody design as all the facilities and equipments are integrated into it. An ice box of size 2'x2'9"x2'6" is integrated in the carriage box and packed with 1" thick polyurethane foam to serve the insulation factor. The icebox can store 80-100 kg of fish in ice which can be sold in a single day by the fisher folks. Cost of machine Rs. 53,000/-.
- **JAU, Junagadh centre** evaluate the effect of different types structure on off-season papaya seedling. Constructed the different types of structures like Poly-cum-shade net house covered with 200 micron UVS plastic and 50 % green shade net, naturally ventilated walk-in-type tunnel covered with 200 micron UVS plastic, black shade net house covered with the 50 %. The farmers of South Saurashtra Agro climatic Zone interested to raise papaya seedling in protected structure are advised to use poly-cum-shadenet house covered with 50 % white shade net on periphery and roof covered with 200 micron UVS polyethylene sheet for off-season papaya seedling raising.
- Impact of fertigation frequencies, operating pressure and Levels of nutrient in high density apple fruit through gravity fed drip irrigation by **SKUAST-K, Srinagar centre**. The highest average yield of 16.41 kg/plant was observed. Increase in yield could be attributed to direct effect on fertilizing timings which met the nutrient requirements at different growth stages of apples.
- Conjunctive use of runoff harvested water from plastic lined farm pond and groundwater for crop production by **UAS Raichur centre**. Total rain water harvested in the farm pond for the period was found to be 1552.63 m^3. The total quantity of groundwater utilized by different crops during period were 157.76 and 47.63 m^3. The maximum yield was recorded under the treatment of drip irrigation at 80 per cent with 100 per cent RDF (16.31 t/ha), while the minimum yield per hectare was observed in drip irrigation at 60 per cent ET with 75 per cent RDF (10.45 t/ha).
- Study on evaluation of plastic mulch for engineering properties under onion cultivation for Rajasthan region by **MPUAT Udaipur centre.** Got maximum yield of 55.32 t/ha under 30 µm mulch with drip irrigation followed by 35 µm (54.86 t/ha) over farmer practise 36.02 t/ha. Increase in yield of 53 % had been achieved over current practise. Based on this year's result it can also be concluded that 30 µm (52.13 t/ha) mulch film can be successfully reused with the help of developed machine under project i.e manual much laying cum retrieval machine.
- Evolvement of mulching technology for bunch type groundnut crop, by **JAU Junagadh centre,** pod yield and haulm yield (3469.63 kg/ha and 6876.09 kg/ha) were found for silver black plastic mulch and minimum was found in control. Minimum weed intensity (12.25 no./sq. m) was observed in silver black plastic mulch. Water saving over control was found 41.24 % under mulch condition. Maximum water use efficiency (6.77 kg/ha-mm) was found under silver black plastic mulch while it was minimum (1.74 kg/ha-mm) in control. The farmers of South Saurashtra Agro climatic Zone are advised to use silver black plastic mulch (20 µm) with drip irrigation and raised bed for water saving and to achieve higher crop yield of bunch type groundnut during summer season.

2. INTRODUCTION

2.1 Background

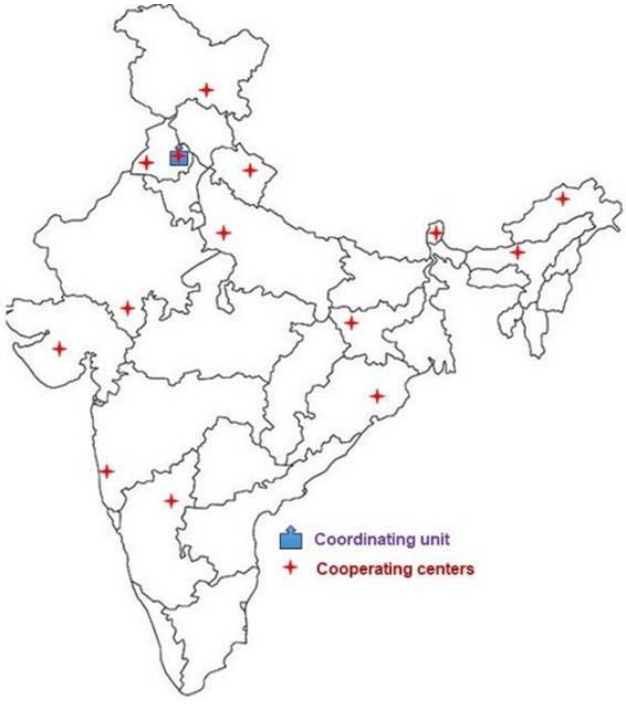
The AICRP on Plasticulture Engineering & Technology (PET) earlier known as AICRP on Application of Plastics in Agriculture (APA), was started in the year 1988 (VII Plan) with plan budget of 32.60 lakhs at 05 centres. At present the project is operational at 14 centers representing almost all major agro-climatic zones. The AICRP has five centres in mid-hills of Himalayan regions (Srinagar, Almora, Gangtok, Barapani and Dirang), two centres in northern Indo-gangetic plains (Ludhiana and Abohar), one centers in coastal regions (Bhubaneswar, which is mandated for fishery aspects), one centre in eastern plateau region (Ranchi), two centres in tropical wet (Mathura and Dapoli), two centre in dry climatic region (Raichur, Junagadh) and one in Aravali hills eco-systems (Udaipur). The AICRP on PET developed 43 most successful technologies since inception under themes viz. surface covered cultivation (14), pond lining and irrigation system (5), plastic mulching and soil solarization (6), plastic tools for farm and machinery (8), post-harvest management (5), plastic in animal shelter and aquaculture (5). The scheme had an outlay of Rs. 32.60 lakhs in the VII Plan, Rs. 80.00 lakhs during the VIII Plan, Rs. 190 lakhs during the IX plan, Rs. 353.05 lakhs during the X plan period and Rs. 1224.00 lakhs for XII Plan.

The AICRP was conferred with ICAR Prestigious Award **"Chaudhary Devi Lal Outstanding AICRP Award 2012".**

2.2 Location of cooperating centres

Coordinating Unit: Located at ICAR-Central Institute of Post-Harvest Engineering and Technology, Ludhiana- 141004 (Punjab)

1. ICAR-Central Institute of Post Harvest Engineering and Technology (CIPHET), Malout Hanumangarh Bypass Road, Abohar - 152 116, (Punjab)
2. Punjab Agricultural University (PAU), College of Agril. Engg., Ludhiana - 141 004. (Punjab)
3. ICAR-Vivekananda Parvatiya Krishi Anusandhan Sansthan (VPKAS), Almora - 263 601, (Uttarakhand)
4. ICAR-Central Institute of Freshwater Aquaculture (CIFA), PO: Kausalayaganga, Bhubaneswar - 751 002. (Orissa),
5. ICAR-ICAR Research Complex for NEH Region, Umroi Road, Umiam - 793 103. (Meghalaya).
6. Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir (SKUAST-K), Shalimar Bagh, Srinagar – 191 121. (J&K)
7. Junagarh Agricultural University (JAU), College of Agrl Engg & Tech, Junagadh – 362 001, (Gujarat)
8. Birsa Agricultural University (BAU), Department of Agricultural Engineering, PO: Kanke, Ranchi – 834 006. (Jharkhand)
9. Maharana Pratap University of Agriculture & Technology (MPUAT), College of Technology and Engineering, Udaipur – 313 001 (Rajasthan)



Location Map of centres

10. Central Agricultural University (CAU Imphal), College of Agricultural Engineering & Post Harvest Technology, Gangtok – 737135 (Sikkim).
11. Dr. Balasahab Sawant Konkan Krishi Vidyapeeth (BSKKV), Dapoli, Ratnagiri-415712 (Maharashtra)
12. ICAR-National Research Centre on Yak (NRC on Yak), Dirang, West Kameng Dist – 790101 (Arunachal Pradesh)
13. ICAR-Central Institute for Research on Goats (CIRG), Makhdoom, PO: Farah, Mathura – 281122 (UP)
14. University of Agricultural Sciences (UAS), Raichur, PB 329, Raichur – 584102 (Karnataka)

2.3 Mandate

To develop strategies for use of plastics in agriculture with major emphasis on surface covered cultivation, lining of ponds for rainwater harvesting, storage of water, micro-irrigation systems and mist formation; packaging, storage, transportation of agricultural produce and products; aquaculture, and livestock management. The Project also envisages the field evaluation and operational research of proven technologies at pilot level with an area saturation approach.

2.4 Objectives

1. To apply plastics in agriculture, both in as well as post-harvest management.
2. To identify newer areas of plastics applications in agriculture, particularly in inland fisheries, and animal shelters and environment control.
3. To carry out operational research on laboratory proven technologies at pilot level with area saturation approach.
4. To disseminate plasticulture technologies through publications, media, exposure and training programmes, workshops, developing linkages with industry, other stakeholders and catalyzing developmental programmes.

2.5 Thrust areas

For the XIII plan period, the AICRP have the following Thrust Areas:

1. Development/improvement of laying techniques and its mechanization for plastic mulch and low tunnels.
2. Standardization of location specific design of poly houses and shade net houses for round-the–year use.
3. Techniques for rainwater harvesting in plastic lined ponds and their management.
4. Development of plastic based low cost pressurized irrigation system equipped with pumping unit powered by non-conventional energy source.
5. Development of plastic devices/systems for intensive fish culture and animal shelter.
6. Application of plastics for post-harvest management (handling, storage and packaging) of important agricultural produce.
7. Development/improvement of plastic components of farm equipment.

2.6 Staff positions

The AICRP has approved staff strength for the eight centres located in State / Central Agricultural Universities in the category of Scientific- 19, Technical - 11, Administrative - 1, in XIII Plan EFC (Annexure I) including PC (Unit). In addition to surrender post of previous plan 25 RA/SRF/YP-/YP-II provided for XIII plan period

2.7 Budget

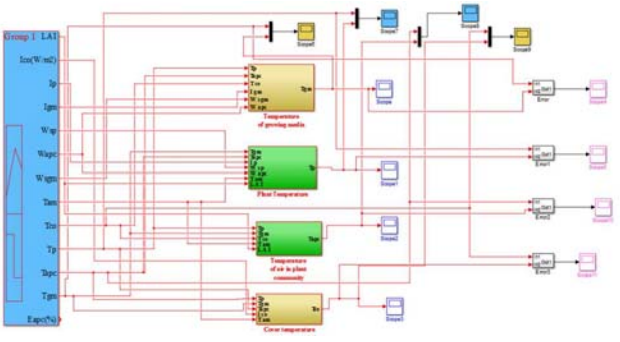
During the period 2017-18 total fund received under the scheme was Rs. 339 lakh against the approved budget of Rs. 346.10 lakh. 100 % expenditure was made.

3. RESEARCH ACHIEVEMENTS

3.1 Surface Covered Cultivation (Protected Cultivation)

3.1.1 Modelling microclimate of naturally ventilated greenhouse under cropped conditions in soilless media by PAU, Ludhiana.

The vapour pressure deficit was higher during spring compared to autumn season of crop growth which in turn directly affected the crop transpiration and ultimately the crop irrigation requirement. Transpiration formed a linear relationship with VPD even for higher values of VPD (>3.5 kPa). With an increase in rate of air exchange through natural ventilation from sides, the VPD (Vapour pressure deficit) and SVP (Saturation vapour pressure) of air in the plant community increased significantly. The cucumber yield was certainly affected with variation in VPD under fluctuating temperature and relative humidity.



Modelling temperature of air, plant, cover and growing media in Simulink

The RMSE and model efficiency were in the range of 0.004-0.023 kPa and 99.8-100 % respectively for VPD. Similarly, for SVP, the RMSE and model efficiency were in the range of 0.08-0.10 kPa and 95.6-98.6 % respectively, indicating a close agreement between predicted and calculated data. Thus, the developed model can be used to predict the VPD and SVP efficiently with or without crop from internal climate as well as from external climate in the absence of ventilation from sides. The air temperature vertically up in the plant community increased significantly from 0.5 m to 2.0 m height and the variation during two respective seasons were in the range of 2.6-14.7 % and 2.5-17.2 % with mean variation of 7.6 % and 9.6 % respectively. On an average, air temperature in plant community >leaf temperature, leaf temperature >root-zone temperature and air temperature in plant community> root-zone temperature by 8.5 %, 10.2 % and 19.0 % respectively (Fig. 3.1.1). The desirable range of air temperature, leaf temperature, root-zone temperature, relative humidity, solar radiation and VPD were 22.0-27.0 °C, 21.0-25.0 °C, 19.5-23.5 °C, 60.0-85.0 %, 10.0-169 kW/m and 0.10-1.13 kPa respectively for optimal plant growth and development.

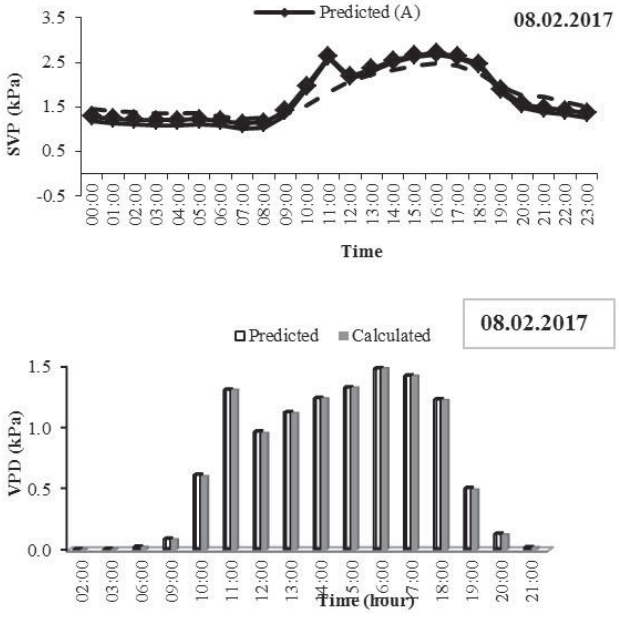


Fig. 3.1.1 Validation of developed model for predicting microclimate SVP & VPD

3.1.2 Soil less cultivation of cucumber and tomato under naturally ventilated polyhouse by PAU, Ludhiana.

The results showed that among three levels of fertigation (70, 85 and 100 %), fruit yield of 85 and 100 % treatments were statistically at par and were significantly higher than 70 percent fertilizer dose. Among the cucumber hybrids/varieties Multistar variety (180 t/ha) gave the highest yield which was statistically at par with Kafka variety but significantly superior than all other varieties PBRK4 (PAU), PBRK 3 (PAU) and Falconstar. Yield of 160 t/ha for tomato was obtained. The results showed that among the different tomato cultivars viz. Punjab Sartaj, Himshikhar (Syngenta) and NS 4266 (Namdhari Seeds), NS-4266 an indeterminate Tomato hybrid is performing best, with yield of 5.4 Kg/Plant. Fertigation dose up to 85 % of the dose recommended for climate controlled polyhouse is optimum for tomato production in soilless media as further increase in fertigation dose did not result significant increase in the yield. The nutrient solution applied and consumptive use of plant were 33.8 and 211.5 % higher during season-II as compared to season I. While, the drainage reduced by 37.3% during season-II as compared to season-I. Average irrigation water use efficiency (IWUE) and crop water use efficiency (CWUE) were highest and lowest under F1V2 (i.e 100 % RDF in GH & Multistar var.) and F3V3 (70 % RDF in GH & V3) respectively (Table 3.1.1). The average IWUE and CWUE were in the range of 25.9-36.7 kg m^{-3} and 90.5-128.6 kg m^{-3} respectively.

Table 3.1.1: Cucumber yield as influenced by different hybrids/ Varieties and fertigation level during autumn planted crop. (Kg/plant)

Cultivar	Fertigation level			
	100 %	85 %	70 %	Mean yield (kg/plant)
V1-KAFKA	3.2	2.7	2.4	2.78
V2-MULTISTAR	3.3	3.0	2.7	3.00
V3-PBRK-4	3.1	2.6	2.4	2.70
V4-PBRK-13	3.1	2.4	2.2	2.57
V5-F1-HYBRID	2.9	2.5	2.2	2.53
Mean yield (kg/plant)	3.10	2.64	2.38	

Soilless cultivation of cucumber and tomato

3.1.3 Micro climate modelling of medium sized naturally ventilated polyhouse for crop production in semi-arid region by MPUAT, Udaipur centre.

It was observed that dry bulb temperature ranges from 34.29 ^{0}C to 18.71 ^{0}C with mean value of 26.13 ^{0}C. Wet bulb temperature ranges from 28.17 ^{0}C to 16.63 ^{0}C with mean value of 22.06 ^{0}C. The maximum temperature up to 37.71 ^{0}C and minimum temperature was recorded as 7.57 ^{0}C. From 5 year data total crop evapotranspiration outside the NVPH was obtained as 537.22 mm with ranges from 1.81 mm/

day to 4.32 mm/day. It was observed that, the daily maximum reference evapotranspiration over the crop growth period is 4.24 mm/day while the minimum value is 1.83 mm/day. The combined impact of drip irrigation, mulch and naturally ventilated polyhouse resulted in to the maximum net income of Rs. 9.50 lakhs/ha, maximum tomato yield of 119.04 t/ha (Fig. 3.1.2) and maximum output- input ratio 2.14 in treatment T3 (i.e., irrigation through drip system at 80 per cent ETc with mulch) under NVPH tomato cultivation. The highest WUE 4191.89 kg/ha-cm was recorded over control 1804.37 kg/ha-cm. For tomato crop treatment T3 could be recommended to schedule irrigation for study region on the basis of greater yield benefits, higher water use efficiency and higher output input ratio.

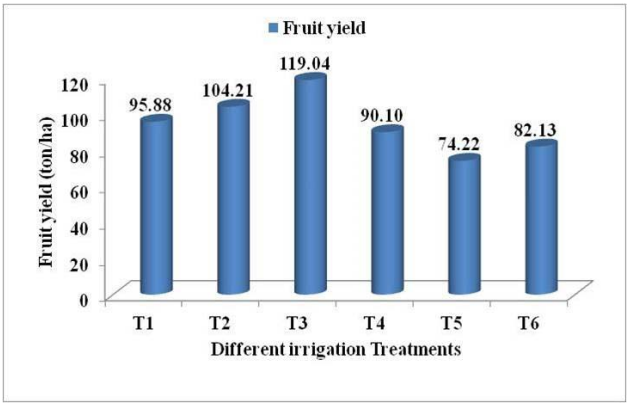


Fig. 3.1.2. Tomato fruit yield t/ha

3.1.4 Soilless cultivation of vegetables in greenhouse for enhancing water nutrient efficiency, by SKUAST-K, Srinagar centre.

The highest yield per unit area (2296.55 gm) was recorded in treatment 70 % fresh solution and 30 % leached. The yield range from 66 t/ha and there was no infestation during whole growing period in the month of August and September. Out of the four treatment 70 % fresh and 30 % leached showed better vegetative growth, yield per plant higher planting density and higher yield per unit area.

Soilless cultivation of tomato

3.1.5 Enhancing energy use efficiency of vegetable based cropping system under protected condition was studied by ICAR-VPKAS, Almora centre.

A field experiment on vegetable based cropping system (green onion-tomato-capsicum) involving four treatments was conducted under two growing conditions (polyhouse and open field). When compared across growing conditions, green onion yield under polyhouse conditions was 36.0 % higher than open field conditions (229 kg/100 m^2), tomato fruit yield under polyhouse conditions was 192.1 % higher than open field conditions (196.1 kg/100 m^2) and capsicum yield under polyhouse conditions was 103.3 % higher than open field conditions (72.1 kg/ 100 m^2). Among treatments, highest green onion, tomato and capsicum yield was obtained with recommended doses of carbendazim + carbofuran under both polyhouse as well as open field conditions followed by the treatment involving recommended dose of carbendazim. In terms of net energy return, energy profitability, energy use efficiency and energy productivity; polyhouse conditions proved better than open conditions while in case of specific energy open conditions proved better (Table 3.1.2).

Tomato and onion crop under polyhouse and open conditions

Table 3.1.2: Yield, net energy return, energy profitability, energy use efficiency, specific energy and energy productivity under polyhouse and open conditions in onion, tomato and capsicum

Particulars	Onion		Tomato		Capsicum	
	Polyhouse	Open	Polyhouse	Open	Polyhouse	Open
Green onion yield (kg/100 m^2)	311.5	2290	572.9	196.1	146.6	72.1
Net energy return (MJ/100 m^2)	2524.2	1756.2	4071.6	1253.425	879.4	189.3
Energy profitability (MJ/100^2)	4.27	3.28	2.4525	1.7575	1.50	0.36
Energy use efficiency	5.27	4.28	3.4525	2.7575	2.50	1.36
Specific energy (MJ/100 m^2)	1.92	2.36	2.955	3.83	4.05	7.52
Energy productivity (MJ/100^2)	0.53	0.43	0.3475	0.275	0.25	0.14

3.1.6 Design and development of mushroom polyhouse structure suitable for hot and arid region

ICAR-CIPHET Abohar centre developed a polyhouse structure which assists in increasing the cultivation season of button mushroom and for cultivation of *Dhingri* mushroom during summer months. Present study involves the development of mushroom polyhouse structure suitable for hot and arid regions. Preliminary cropping trials were also conducted to determine the optimum growing conditions for button and *dhingri* mushrooms. During summer months (May to early-July), average ambient air temperature during day time varied from 32-49 °C. Such high temperature was not desirable for cultivation of oyster mushroom. However, CIPHET mushroom polyhouse could provide desired temperature (28-35 °C) and RH (80 %) using evaporative cooling arrangements. Favourable temperature and RH were achieved by operating Fan-pad system for 50 min. and foggers for 40 min. During October, average ambient air temperature was 31 °C whereas structure maintained inside temperature between 23-31 °C. With evaporative cooling, inside temperature and RH were altered to 22-27 °C and ≥ 80 %, respectively (Fig. 3.1.3). These conditions were suitable for *spawn run* of button mushroom. Similarly, during November, structure could provide 20-23 °C temperature and RH ≥ 80 %. These conditions were found suitable for *spawn run* and *case run* of button mushroom. Similar results were observed in February

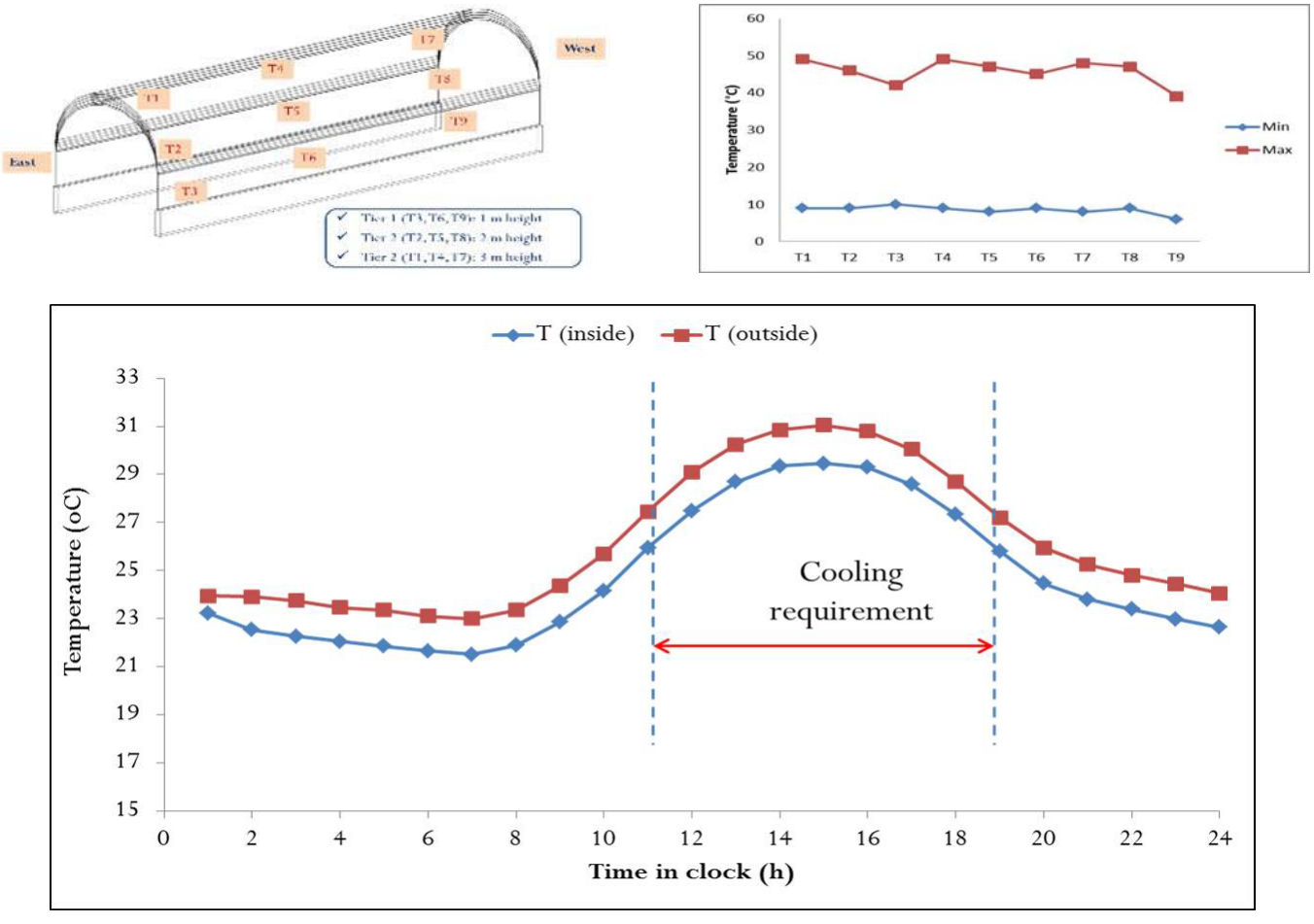


Fig. 3.1.3. Microclimate variation inside and outside structure

Table 3.1.3: Crop production and return (in Rs.) per annum from CIPHET mushroom polyhouse

Crop	Number of crops	Average production	Total production (kg)	Market price (Rs.)	Return (Rs.)
Button	2	16 kg/qt of compost	1280	100	128000
Oyster	1	14 kg/qt of compost	560	80	44800
				Total	**172800**

and early-March also. Thus, study revealed that oyster mushroom can be efficiently cultivated in hot and arid region from May to early-July in CIPHET Mushroom polyhouse. Similarly, cultivation of button mushroom can be started in October month (one month earlier) and it can be carried till early-March in hot and arid region using developed mushroom polyhouse. Probable crop production and return Rs. 1.72 lakh/ yr from CIPHET mushroom polyhouse is given in Table 3.1.3 and analysis of cost of economics such as Input costs, net return and benefit-cost ratio (B:C ratio: 1.38).

3.1.7 Performance of Asparagus (*Asparagus officinalis*) cultivation within naturally ventilated polyhouse (NVP) as compared to open field condition, was studied by CAE&PHT, Gangtok

The results of the study compared to open field condition was found to be statistically significant among all the treatments except in diameter of spear. The plants treated with Drip + mulch inside polyhouse (T_1) shows better performance for early sprouting (37 days) and harvesting (45 days) of spear. This may be due to difference in soil temperature and micro climate inside polyhouse as compared to open conditions. Number of spear harvested/ plant (28 nos.) and weight of spear/ plot (2570 g) were also observed to be highest for the T_1. Increase in plant growth and yield parameters in T_1 with drip and mulch may be attributed to the maintenance of optimum moisture level in the root zone by drip and mulch. Inferior performance was observed in T_3 (No drip No mulch in open field).The economics of cultivation of asparagus in the low cost bamboostructured NVP with gravity based drip irrigation system and blackpoly mulch was worked out. The cost of cultivation worked out to be Rs. 2,973 for an NVP of 100 sq.m. Net returns was Rs. 6,327 with B:C ratio of 3.12.

Asparagus (*Asparagus officinalis*) cultivation

3.1.8 Standardization of protected structure design for small and marginal farmers by UAS, Raichur centre

Three structures were made under this project and different cladding material mainly, the shade net with 50 % shade, 50 % shade net covered only on top (side open in all directions) and naturally ventilated polyhouse designs have been planned. The procurement and installation of the required material was done and the installation work was completed. During the successive stages of crop growth *viz*., 30, 60, 90 and 120 days after transplanting (DAT). The higher plant height (65 cm) was recorded under polyhouse conditions, followed by open field conditions (control) 30 cm. The weight of the fruits grown under polyhouse was higher (60 g) as compared to other treatments, the lowest fruit weight was observed in open field (49.50 g). Yield per plant was higher in poly house (2.28 kg) and lowest was found in open field (0.90 kg). The effect of different levels of drip irrigation *viz*., 60, 80, 100 and 120 % ET and furrow irrigation on cauliflower under shade net condition were evaluated. The highest biometric parameters were observed under drip treatment 80 % ET followed by 100, 120, 60 % and furrow irrigation. The results indicated that drip treatment at 80 % ET has highest yield of 52.27 t/ha followed by 100 % ET (42.90 t/ha), 120 % ET (38.24 t/ha), 60 % ET (34.97 t/ha) and furrow irrigation (30.76 t/ha). The highest cost benefit cost ratio of 5.07:1 was observed highest in case of drip irrigation treatment at 80 % ET followed by 3.06:1, 3.98:1, 3.44:1 and

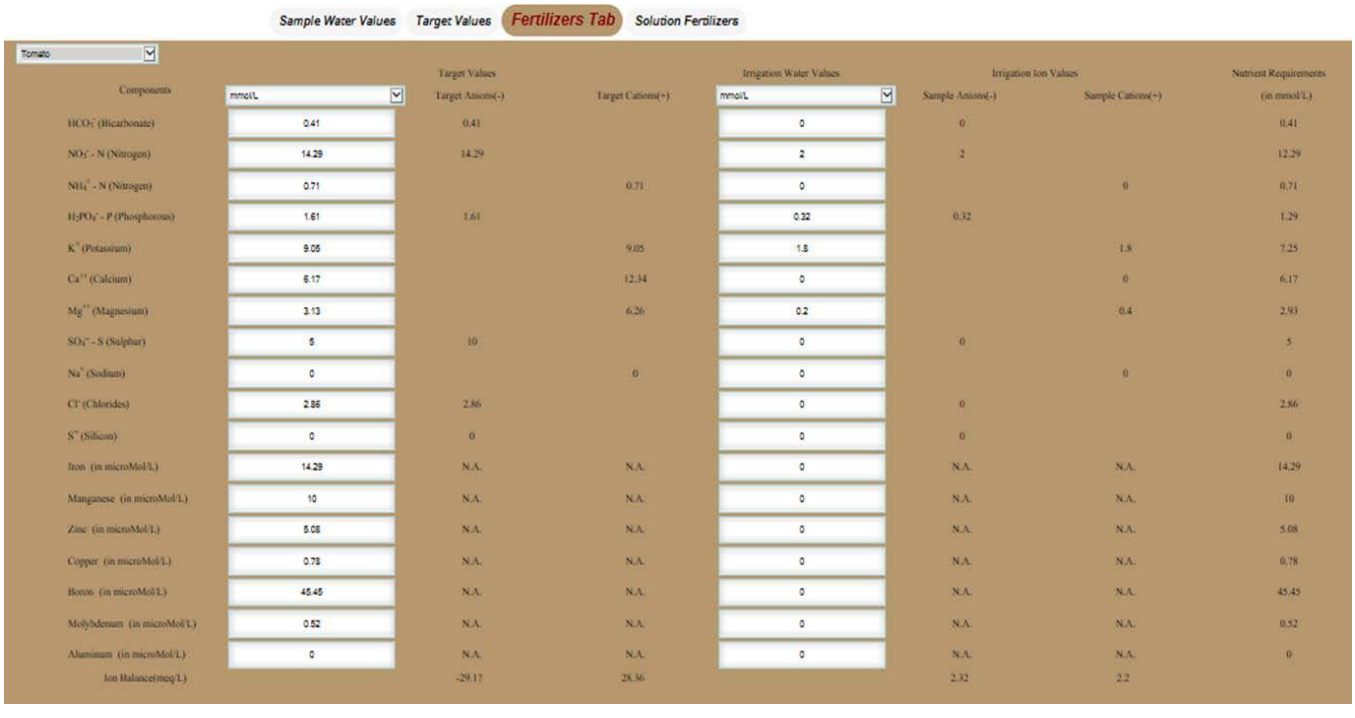
2.65:1 in case of 60, 100 and 120 % ET level and furrow irrigation respectively.

3.1.9 Computer assisted/ Web based crop nutrition program for commercial nursery and greenhouse production in soilless media by PAU, Ludhiana.

This web-based program is to assist commercial nursery and greenhouse growers with the acidification of their irrigation water and nutrient solution formulation. This computer assisted program is developed to mitigate the cumbersome calculations involved in nutrient solution formulation. The user can select from a range of available fertilizers and do adjustments for getting the perfect ion balance for formulating nutrient solutions. Even a non-specialist can compute the fertilizer and acid requirements. This program is suitable for growers who either have a two tank system (A and B tank) or a multi-nutrient injector system with or without an acid/ base injector system.

3.1.10 The low cost permanent shade net structure of size (length: 12 m & width: 5.5 m) was constructed using bamboo by BAU, Ranchi centre.

The cost of construction of permanent shade net structure was Rs. 220 m^2. Microclimate was monitored throughout the study at morning and afternoon hrs and found that the average decease in maximum temperature under shade net structure was in range of 1-3^{0}C, 50 % reduction in solar intensity and higher RH under shade net structure. The yield recorded for pea, cabbage, cauliflower & potato respectively 20.22 t/ha, 31.28 t/ha, 5.31 t/ha & 11.83 t/ha under shade net structure over open field condition for pea, cabbage, cauliflower & potato respectively 4.35 t/ha, 47.14 t/ha, 4.42 t/ha & 8.1 t/ha respectively.



Programme preview

Vegetable production under permanent shadenet

3.1.11 Yield performance of off-season okra under different type structures and mulch conditions was studied at JAU, Junagadh representing Saurashtra region in Gujrat.

Performance of Hybrid variety (GJO-H4) developed by the University was evaluated inside the structure. Internode length (18.75 cm), number of fruits/plant (38), weight of fruits/plant (416.50 gm) and fruit yield (22.4 t/ha) were found significantly higher inside the net-cum-polyhouse without ridge vent with silver black plastic. Weed intensity at 30 DAS (8.50 number/sqm), 60 DAS (8.25 number/sqm) and 90 DAS (6.50 number/sqm) was found significantly lower inside the net-cum-polyhouse without ridge vent with silver black plastic as compared to no mulch in open field. Water saving was the highest (28.75 %) for mulch conditions inside the structures while under mulch condition in open water saving was 13.78 % as compared to no mulch in open condition. Maximum water use efficiency (71.58 kg/ha-mm) was found under silver black plastic mulch inside the Net-cum-polyhouse without ridge vent while it was minimum (0.54 kg/ha-mm) in no mulch condition in open field environment. Maximum net profit of Rs. 8 lakh/ha could be obtained for off-season okra cultivation inside the net-cum-polyhouse without ridge vent under silver black plastic mulch. B: C ratio was determined and found to be 2.61.

Okra in off-season under protected environment

3.1.12 Effect of organic manures and different moisture depletion levels on off season capsicum cultivation under poly house conditions in Sikkim, by CAE & PHT, Gangtok centre.

Crop parameters were evaluated and found that the maximum number of fruits per plant (6 No.), yield of 21 t/ha and water use efficiency of (58.02 Kg/m^3) in combination of organic manure used (FYM (1 kg/m^2) + Vermicompost (500 g/m^2) + Biofertilizer (Bio NPK culture). 35- 40 % increase in yield found under organic conditions in polyhouse over open conditions.

Capsicum cultivation under polyhouse

The micro climate of the polyhouse was monitored during reporting period. The weekly average daily maximum temperature (32.88 °C) and RH (91.48 %) increased by 4.9 ^{0}C and 1.8 %, respectively inside the polyhouse compared to the outside. Similarly, the weekly average daily minimum temperature (16.04 °C) was increased by 0.07 °C inside the poly house in comparison to the outside values and the daily minimum RH (42.25 %) was decreased by 8.4 % inside the poly house compared to the outside.

3.1.13 Feasibility and Economic evaluation of heating and cooling of Poly house using earth air tube heat exchanger

ICAR Research Complex, Barapani centre designed and fabricated earth air tube heat exchanger was operated with blower speed of 12.5 m^3/h during the day time. Observed the heat/cool the polyhouse. However, the length of flow changed from 12 m to 48 m inside the heat exchanger. The performances of the heat exchanger in terms of temperature difference of inlet and outlet air have been presented in Fig. 3.1.4. The optimum length of heat exchanger for a flow rate of 12 m^3/h was found to be 36 m as at this length performance of the heat exchanger was comparable with 48 m length. High speed of air is also necessary for cooling/heating the polyhouse as total heat gain or loss will be higher as compared to low speed.

Polyhouse with Earth air tube heat exchanger (ETHE)

The average maximum and minimum temperature inside the polyhouse were 26.81 °C and 18.12 °C in comparison to outer temperature of 23.99 °C and 12.47 °C respectively. The respective relative humidity during morning and evening periods were 78.06 and 62.87 % (inside) as compared to 82.22 and 62.84 % (outside) respectively. The blower was run for 10 hrs/ day. Considering the price for electricity consumption in the Meghalaya state @Rs.2.25/kwh under agril practice, the cost comes up to Rs.9/-day and fixed charge @ Rs.50/- month. If it is considered under industrial use, the cost of operation per day @ Rs 5.2 as Rs.52/- + fixed charge @ Rs.90/- month.

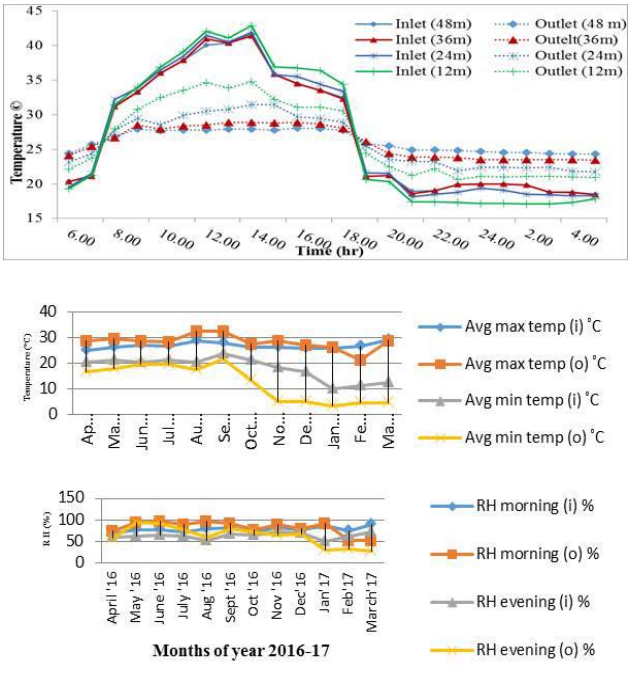


Fig. 3.1.4. Variation in microclimate inside polyhouse

3.1.14 Effect of protected environment on off-season seedling raising of Papaya, JAU, Junagadh centre

Evaluated the effect of different types structure on off-season papaya seedling. Constructed the different types of structures like Poly-cum-shade net house covered with 200 µM UVS plastic and 50 % green shade net, naturally ventilated walk-in-type tunnel covered with 200 µM UVS plastic, black shade net house covered with the 50 % black shade net were constructed at PET greenhouse complex, RE & RE Department, CAET, JAU, Junagadh. Soil, sand and FYM were used for the root media preparation and its proportion was kept as 1:1:1. Observed the climatic and morphological parameters like temperature, RH and light intensity (recorded at 3 h interval 9:00, 12:00, 15:00 and 18:00), germination percentage, seedling height, collar diameter, number of leaves and tap root length. Maximum and minimum weekly average temperature (34.1 °C) and (26.6 °C), average relative humidity (46.2 %) and (21.6 %) and average light intensity (49010 lux) and (14890 lux) were recorded in walk-in-type tunnel and black shadenet house respectively. Morphological observations of papaya seedlings viz., seedling height (34.8 cm), collar diameter (5.5 mm), number of leaves per plant (13.6), tap root length (21.1 cm) and germination percentage (93.9 %) were observed highest in poly-cum-shadenet house followed by walk-in-type tunnel. Quality parameters of papaya seedlings viz., vigour index (3266) and sturdiness (83.5) were observed highest in poly-cum-shadenet house and black shadenet house respectively. Benefit cost ratio for papaya seedling raising in different types of the structures was more or less same ie (B:C) 4.13-4.84.

Recommendation: The farmers of South Saurashtra Agro climatic Zone interested to raise papaya seedling in protected structure are advised to use poly-cum-shadenet house covered with 50 % white shade net on periphery and roof covered with 200 µM UVS polyethylene sheet for off-season papaya seedling raising.

3.1.15 Effect of different types of soil less media on growth parameters and fruits yield of strawberry in eastern Himalayan region.

The stable metallic A frame structure with three metallic supports was installed in the newly constructed polyhouse for vertical cultivation of strawberry in soilless media. The PVC pipes were fixed on the metallic A frame structure having holes of size 4 inch diameter at the spacing of one feet. About 10 numbers of holes in each pipe accommodated 10 numbers of strawberry suckers. Four media are selected for the study, viz., Perlite, cocopeat, sawdust and rice hull. Vermicompost will be used as manure. Two varieties (Chandler and Ofra) of short day plant were collected from the ICAR, Tadong.

A frame structure with soilless media

From the below Table 3.1.4, on an average the treatments T_7 – Cocopeat + Rice hull + Perlite (2:2:1) and T_9 – Soil medium (Control) observed the maximum no. of leaves/plant and plant spread at different stages of growth. Flower initiation has started at about 90 DAP in all the treatments including control but no development of fruits this may be due to unfavourable weather condition during flowering. The two selected varieties (Ofra and Chandler) were short-day variety,

Table 3.1.4: Effect of soil less media on vegetative growth parameters of strawberry

Treatments	No. of leaves				Plant spread (cm^2)			
	80 DAP	95 DAP	110 DAP	125 DAP	80 DAP	95 DAP	110 DAP	125 DAP
T_1	5.06	5.73	5.83	7.53	104.02	102.3	102.96	111.63
T_2	6.03	7.6	10.3	13.9	205.1	226.5	256.6	318.6
T_3	4.96	4.7	4.7	6.03	95.22	97.16	106.86	109.86
T_4	7.58	8.7	9	12.39	179.22	209.76	210.6	229.16
T_5	5	5.0	5.0	6.25	95.21	103.86	117.1	133.33
T_6	6.38	6.8	7.85	10.53	187.63	203.53	204.1	204.35
T_7	8.13	9.41	11.43	15.61	197.41	249.41	261.6	309.94
T_8	5.66	5.76	6.53	8.63	91.11	128.96	132.63	149.73
T_9	7.49	11.28	13.71	17.8	148.99	233.11	292.8	335.78

***T_1** – Cocopeat + Perlite (3:2), T_2 – Rice hull + Perlite (3:2), T_3 – Sawdust + Perlite (3:2), T_4 – Cocopeat + Rice hull (1:1), T_5 – Cocopeat + Sawdust (1:1), T_6 – Rice hull + Sawdust (1:1), T_7 – Cocopeat + Rice hull + Perlite (2:2:1), T_8 – Cocopeat + Sawdust + Perlite (2:2:1), T_9 – Soil medium (Control)

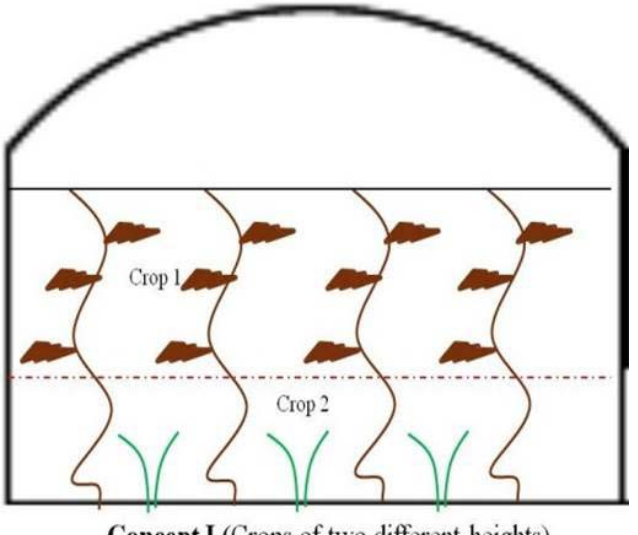
*values are averaged for 3 replications for all the nine treatments.

* DAP – days after planting

which may also be one of the reason of unfruitfulness. Short-day plants required long periods of darkness and short periods of light (less than 12 h of daylight)for flower initiation and fruit development. They are very sensitive to photo-period that any fluctuation in photo periodic requirement may not flower and sets fruit.

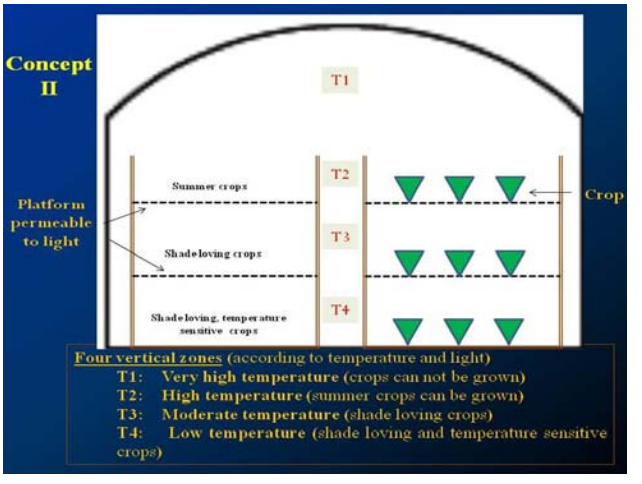
3.1.16 Strategies for maximum vertical space utilization in growing of selected vegetables inside polyhouse in hot and arid region by ICAR-CIPHET, Abohar centre

Two models of vertical farming model of A frame were designed one with multi tray and one with pipes. But the model with A frame and PVC pipe finalized and designed. The model of A frame PVC pipe has been fabricated for maximum vertical space utilization. The overall dimension of developed A frame are top width 0.15 m, bottom width 1.5 m, length 5 m and height 1.8 m. PVC pipes of size 0.10 m Dia. used and holes of 0.05 m dia made with lateral spacing of 0.25 m to accommodate media and plants. In study, bitter gourd and coriander crop were grown inside the polyhouse for maximum use of vertical space by growing of two crops of different height. In 20 m^2 area 12.5 kg coriander green leaves yield and 253 kg bitter gourd was obtained under 1st trial cropping.



Concept I (Crops of two different heights)

"A" type frame is under development for vertical farming structure for Concept 2 of the project.



3.1.17 Onion cultivation under low tunnels for restricting over winter in eastern Himalayan region.

The three varieties of onion (Minar - V1, Leader - V2& Nasik red - V3) were selected and grown under low tunnels at three different height viz. 70 cm (H1); 85 cm (H2) & 100 cm (H3) for restricting over winter. Minimum Days to harvest (63) was recorded in 85 cm low tunnel height and maximum (67) was recorded in 100 cm low tunnel height. However, minimum days to harvest (61) was recorded in the variety "Minar" and maximum (69) was recorded in in the variety "Nasik red" (Table 5). Similarly, significantly higher values for fresh weight (53.44 g) and mean diameter (35.66 mm) were also recorded at control condition and lowest fresh weight (27 g) and mean diameter (17 mm) at 75 cm low tunnel height. Similarly, significantly higher values for fresh weight (53.44 g) and mean diameter (35.66 mm) were also recorded at control condition and lowest fresh weight (30.58 g) and mean diameter (20.33) at the variety "Minar". Survival percentage was significantly affected by tunnel height on onion varieties as compared to control condition. The maximum survival percentage (89.83) was registered in control condition. However, among the low tunnel height, the minimum (21.92 %) was recorded in 75 cm low tunnel height and

Table 3.1.5: Growth and yield characteristics of onion as influenced by low tunnel height and varieties.

Treatment	PH	NOL	SP	DTH	FW	MD
Tunnel height						
H_1	24.019	2.959	21.928	64.111	27.000	17.000
H_2	22.738	2.887	23.228	63.778	31.444	20.556
H_3	23.382	3.071	33.462	66.889	43.222	28.333
Control	19.780	2.922	89.839	65.889	53.444	35.667
CD at 5%	1.59	0.35	10.72	1.47	1.40	0.95
Varieties						
V_1	22.971	2.747	39.738	60.833	30.583	20.333
V_2	22.290	3.135	47.616	69.083	47.750	31.583
V_3	22.178	2.997	38.988	65.583	38.000	24.250
Control	19.780	2.922	89.839	65.889	53.444	35.667
CD at 5%	1.38	0.30	9.28	1.28	1.21	0.82
Tunnel height x variety						
H_1V_1	24.29	2.66	19.47b	59.33b	22.67b	12.67b
H_1V_2	19.167	2.77	34.19	69.33	33.66	23.66
H_1V_3	23.64	3.55	12.11	63.66	24.66	14.66
H_2V_1	21.56	2.33	12.98	59.33	25.33	14.66
H_2V_2	23.01	3.10	31.16	67.33	41.67	28
H_2V_3	23.64	3.22	25.53	64.66	27.33	19
H_3V_1	25.24	2.88	41.12	63.66	29.67	22.67
H_3V_2	23.34	3.10	28.10	69.66	55.67	34.66
H_3V_3	21.56	3.22	31.16	67.33	44.33	27.66
Control	19.780	2.922	89.839	65.889	53.444	35.667
CD at 5%	2.76	0.60	18.57	2.55	2.43	1.64

maximum (33.46 %) at 100 cm low tunnel height. However, there is no significant difference for survival percentage on different varieties. But, the maximum (47.61 %) was recorded in the variety "Nasik Red" and lowest (38.98 %) at the variety "Leader". The interaction effect of low tunnel tunnel height and varieties were found to be significant. Plant height (25.24 cm) was maximum in H_3V_1 and minimum plant height (21.54 cm) in H_2V_1 and H_3V_3. Number of leaves (3.55) was maximum in H_1V_2 and minimum number of leaves (2.33) was recorded in H_2V_1. The maximum survival percentage (41.12) among the interaction of low tunnel height and varieties was recorded in H3V1 and minimum (12.11) at H_1V_3 but the maximum survival 89 % was recorded at control condition. Highest number of days to harvest (69.66), fresh weight (55.67 g) and Mean diameter (34.66 mm) was recorded in H_3V_2 and minimum number of days to harvest (59.33), fresh weight (22.67 g) and Mean diameter (12.67 mm) were recorded in H_1V_1 (Table 3.1.5).

3.2 Water Harvesting, Management and Irrigation Systems

3.2.1 Study on response of polytank fed drip irrigation system to pigeon pea at different planting densities carried out by ICAR-VPKAS, Almora centre.

The planting geometry of 45 cm x 20 cm (row-to-row x plant-to-plant) resulted into highest pigeon pea seed yield (2.68 t/ha) followed by 60 cm x 15 cm (2.52 t/ha) and 30 cm x 30 cm (2.49 t/ha), however the difference was non-significant (Fig. 3.1.5). Among different irrigation methods, drip irrigation resulted into highest seed yield (2.74 t/ha) followed by check basin method of irrigation (2.53 t/ha) with lowest being in control (2.41 t/ha). 15 % increase in yield obtained over control. Due to good rains during rainy season, the effect of irrigation methods was not significant.

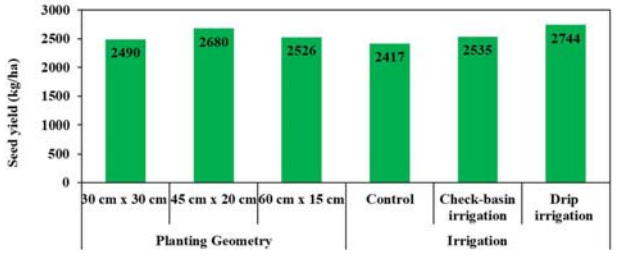
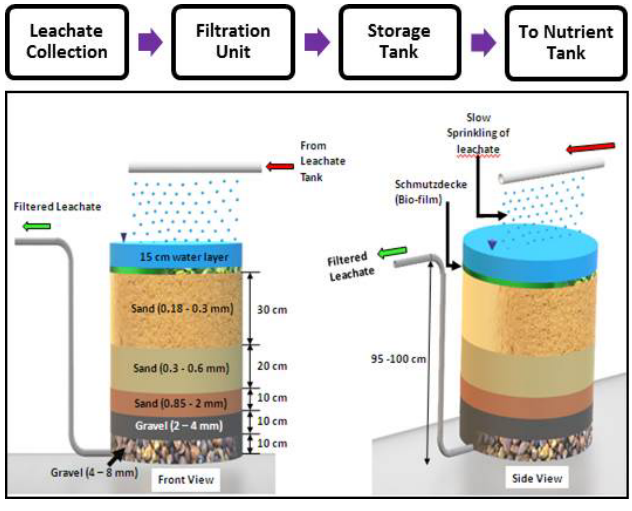


Fig. 3.1.5 Pigeon pea yield at different planting densities

3.2.2 Nutrient recycling system in soilless cultivation of vegetables under protected cultivation developed by PAU, Ludhiana.

The Bio sand filter (BSF) disinfection unit for pathogens, was made from a 125 cm diameter and 140 cm high plastic tank having 2.54 cm inlet and outlet positioned 5 cm from top and bottom respectively. The outlet of the filter was designed in such a way that there was always standing water of 10 cm above the top layer of sand. The outlet of 2.54 cm from 13 cm top was also made for overflow which was connected to the 200 liters capacity plastic tank. Layers of gravel, coarse, medium fine and fine sand of depths 10, 10, 25 and 35 cm respectively were put in the tank from the bottom of the tank. Performance of filer can be assessed from the results of the experiment. Combination of 30 % leachate and 70 % fresh solution (F1) mixed on volume basis gave fruit yield of cucumber that was statistically at par with 15 % leachate and 85 % fresh solution (F2) as well as 100 fresh solution (F3), when same volume of fertigation solution was applied in all the treatments except in variety Kafka where 100 % fresh solution gave significantly higher yield than 30 % leachate + 70 % fresh solution treatment. However, different varieties of parthenocarpic cucumber showed significant differences in cucumber fruit yield. Cucumber variety Kafka (V1) from Syngenta gave significantly higher fruit yield as compared to PBRK 3 (V3) developed by PAU, however Multistar (V2) gave fruit yield statistically at par with that obtained from Kafka (V1) but significantly superior than PBRK3 (V3).



Nutrient recycling system in soilless cultivation

3.2.3 Study the effect of drip irrigation, fertigation and mulching on the productivity of soybean by PAU, Ludhiana.

PAU Ludhiana studied soyabean cultivation under plastic mulching with fertigation scheduling based on one year data, results reveal that with each increase

Soyaben crop under silver and black polymulch and Soyaben crop under paddy straw mulch

in level of drip irrigation there was significant improvement in crop yield up to 1.0 ET crop level of drip irrigation. Similarly each higher level of fertigation resulted in significant increase in the grain yield up to 100 % of the recommended dose of fertilizer application, indicating that higher level of fertigation may increase the yield. The trend may also be attributed inherent poor fertility status of the soil. Application of paddy straw mulch and silver/black plastic mulch resulted in grain yield increase of 10.7 and 17.0 % respectively over no mulch application.

3.2.4 Design and development of low cost water lifting device for river bed cultivation in hilly region by ICAR-VPKAS, Almora centre.

A fabrication and testing of low cost water lifting device has been started. Two knap shake pumps were used to pump water from river. River current with the help turbine was used as motive power to drive the pumps. Initially eight numbers of blades were used in the turbine. The gear on the turbine drive shaft was of 14 teeth and that of pump driven shaft was of 36 teeth. It was observed that there was sufficient torque but, pump reciprocating motion was quit less. In this case the pump displacement was kept around 5 cm. it was found that the discharge was 141 lph at 1 m head and it reduced to 35 lph with head of 6 m.

Low cost water lifting device soilless cultivation

3.2.5 The water harvesting pond is covered with 500 µM LDPE black film of capacity 1360 m^3 was designed and developed by BAU, Ranchi centre.

Overall dimension of plastic lined pond required for irrigation of cultural command area were determined as side slope: 2:1, the bottom of pond 15 m x 15 m, depth of pond 3 m and top surface of pond 27 m x 27 m. Before covering the pond with plastic, the pond surface is treated with weedicide (Glycel@10 ml/liter). The plastic film is fixed with synthetic rubber based adhesive (Fevicol SR 998). Water storage cost is around Rs. 17.3/m^3 (considering water harvesting pond is full and life of plastic film is around 10 years). The peagon pea and okra was sown on boundary of plastic lined pond to reduce the wind speed & eventually reduce the evaporation loss of water from pond surface. The plucking of okra was done 20 times and yield recorded is 13.5 t/ha.

Water harvesting pond with LDPE Black film cultivation

3.2.6 The crop growth and yield parameter of peas (DDR23 & GDFPI) and chickpeas (Birsachanna 3) is studied under different irrigation systems (conventional and drip irrigation) by BAU, Ranchi.

The yield for pea (DDR23) was found 1.5 t/ha and 2.6 t/ha respectively under conventional irrigation and drip irrigation. The increase in yield is 73 % for drip irrigated peas over conventional irrigated peas. The 100 seed weight for DDR23 is 20.5 g and 22 g respectively for conventional irrigation and drip irrigated peas. The yield for pea (GDFPI) is 1.4 t/ha and 1.9 t/ha respectively under conventional irrigation and drip irrigation. The increase in yield is 35.7 % for drip irrigated peas over conventional irrigated peas. The 100 seed weight for GDFPI is 21.5 g and 22 g respectively for conventional irrigation and drip irrigated peas. The yield of chickpeas (Birsachanna 3) is found to be 5.31 q/ha and 10.65 q/ha respectively for conventional and drip irrigated chick peas. The yield recorded is slightly low due to wilting was observed in chick peas crop. Even though the increase in yield is found to be around 100 % under drip irrigated chick peas in comparison to conventional chick peas.

Chickpeas study under different irrigation system

3.2.7 Water movement in drip irrigated polyhouse under organic conditions was studied by SKUAST-K, Srinagar centre.

The water requirement for tomato crop at different stages i.e. initial stage, crop development stage, mid season stage and late season stage are 35, 142, 270.3 and 52 mm respectively. The total water requirement for tomato crop during whole growing season inside the polyhouse was 509.5 mm. The temperature range varies 15-45 ^{0}C inside poly house. The moisture movement was found maximum at upper layer 0-15 cm and uptake taken roots from this portion was 40 % of total water requirement. The water retention was found maximum in organic amended soil as compare to other treatment. The maximum yield was found (till 4th harvesting) in vermi compost treated soil as compare with other treatment. Moisture movement is faster under fertilizer applied soil and moisture retention is more in organic treated soil. Among all the treatments (Chemical fertilizer and vermi compost treatment) recorded highest plant height, canopy spread, LAI, fruit length, fruit diameter, yield per plant and crop yield .The soil water content for inorganic treated soil ranged from 22.2 to 38.2 %.The soil water content for organic (FYM) treated soil ranged from 24.9 to 39.3 %.The average max temperature range found 28-35 ^{o}C during month of August-September. The relative humidity range was found 60-80 % inside polyhouse.The tomato crop yield was found 58 t/ha in vermi compost treated soil whereas in different fertilizer treatments it was 55 t/ha.

Tomato cultivation under polyhouse

3.2.8 Impact of fertigation frequencies, operating pressure and Levels of nutrient in high density apple fruit through gravity fed drip irrigation by SKUAST-K, Srinagar centre.

The experiment has been laid in high density Apple block. Wetted depth was more as compared to wetted radius after 80 minute in 2 lph, 60 minute in 4 lph, 50 minute in 8 lph emitter discharge rate from irrigation was started. Simulation (Drip-Irrwater estimate) of volumetric water content in decreasing order form top layer to bottom layer but measured volumetric water content was found highest in 10-15 cm depth of soil layer. They may be due to evaporation or infiltration process from to upper layer to bottom layer. NO_3-N concentration was determined in different soil layers (0-15, 15-30, 30-45 cm) in vertical direction and (0-15, 15-30 cm) in lateral directions, under weekly and fortnightly fertigation frequencies. The pattern of spatial distribution of NO_3-N in different treatment was found similar. The analysis of variance of different weekly doses of nitrate content during initial stage in vertical direction revealed that the effect of treatments significantly increased NO_3-N content in soil from 67.33 to 114.11 mg kg^{-1} while as there was a significant decrease in NO3-N content at various depths from 118 to 60.42 mg kg^{-1} also effect of treatments significantly increased NO_3-N content in soil from 84.50 mg kg^{-1} to 144.50 mg kg^{-1} and decreased from 142.44 to 88.00 mg kg^{-1} in lateral distance. The optimal depth of nitrate movement was found 2.86-26.01 cm and the optimal concentration was 88.79 - 214.54 mg kg^{1} while as the optimal lateral distance was 37.20 - 65.46 cm with optimum nitrate concentration of 255.22 - 503.82 mg kg^{1} from 50 % RDF and 100 % RDF fortnightly, respectively. The results of available Nitrogen content in the surface soils varies from 240 to 265 kg/ha while as in the sub surface soils it showed variation from 145 to 195 kg /ha with a mean value of 252.5 &170 kg/ha

High density apple fruit through gravity fed drip irrigation

respectively. The available phosphorous content varies from 15 to 20 kg/ha and 7 to 17 kg/ha in surface & subsurface soils respectively with mean values 17.5 &12 kg/ha respectively. The higher contents of phosphorous in the surface soils could be due to accumulation in surface because of its low mobility. The available potassium content varies from 132 to 236 kg/ha and 118 to 165 kg/ha in surface & subsurface soils respectively with mean values 184 &141.5 kg/ha respectively. The higher contents of potassium in the surface soils could be due to weathering of potassium bearing minerals in surface soils. The highest average yield of 16.41 kg/plant was observed. Increase in yield could be attributed to direct effect on fertilizing timings which met the nutrient requirements at different growth stages of apples.

3.2.9 Standardization of protected structure design for small and marginal farmers by UAS, Raichur.

UAS Raichur Centre developed structures with shade net with 50 % shade, 50 % shade net covered only on top (side open in all directions) and naturally ventilated polyhouse designs have been planned. The procurement and installation of the required material was done and the installation work was completed. The test crop is capsicum. During the successive stages

Cultivation of capsicum crop in shdenet

of crop growth viz., 30, 60, 90 and 120 days after transplanting (DAT). The plant height of capsicum was found to be increasing and higher plant height (65 cm) was recorded under polyhouse conditions, followed by open field conditions (control) 30 cm. The weight of the fruits grown under polyhouse was higher (60 g) as compared to other treatments, the lowest fruit weight was observed in open field (49.50 g). Yield per plant was higher in poly house (2.28 kg) and lowest was found in open field (0.90 kg). During 2017-18, the effect of different levels of drip irrigation viz., 60, 80, 100 and 120 % ET and furrow irrigation on cauliflower under shade net condition were evaluated. The crop biometric parameters (plant height, number of leaves, leaf width and length, leaf area index, Root length) were recorded under all treatments at 30, 60 and 90 DAT (Days After Transplanting). The highest biometric parameters were observed under drip treatment 80 % ET followed by 100, 120, 60 % and furrow irrigation. The results indicated that drip treatment at 80 % ET has highest yield of 52.27 t/ha followed by 100 % ET (42.90 t/ha), 120 % ET (38.24 t/ha), 60 % ET (34.97 t/ha) and furrow irrigation (30.76 t/ha). The highest cost benefit cost ratio of 5.07:1 was observed highest in case of drip irrigation treatment at 80 % ET followed by 3.06:1, 3.98:1, 3.44:1 and 2.65:1 in case of 60, 100 and 120 % ET level and furrow irrigation respectively.

3.2.10 Conjunctive use of runoff harvested water from plastic lined farm pond and groundwater for crop production by UAS, Raichur centre.

UAS Raichur centre is located in North Eastern Dry Zone viz., zone-II of region-I in Karnataka state. The climate is semi-arid and average annual rainfall is 621 mm. The lining of existing farm pond was initiated by cleaning and removing of stored water. The laying of plastic lining was done with 300 micron sheet. The stored water was used to irrigate the selected crop of chilli (*Capsicum annum*.L). The variety considered for the experiment is Guntur. The experimental set up consisted of all accessories of drip irrigation. Bed preparation (7.5 m x 1m) was made and the field was laid in split-plot design with two fertilizer treatments and five different levels of irrigation *viz*., 60 %, 70 %, 80 %, 90 & and 100 %. Among the drip irrigation levels, 80 % ET had significantly higher plant height followed by 90 % ET, 100 % ET and 70 % ET. Maximum number of primary and secondary branches was recorded in 80 % ET with 100 % RDF. Fruit length and fruit diameter were observed to be highest at 80 % ET through drip irrigation with 100 % RDF through fertigation as compared to 75 % RDF through fertigation. Drip irrigation with 80 % ET produced significantly maximum yield as compared to other irrigation levels and yield was minimum at 60 % ET. Total rain water harvested in the farm pond for the period between 9th August to 16th October, 2017 was found to be 1552.63 m^3. The total water utilized for irrigating the crops from lined farm pond for the period between August, 2017 to February, 2018 was recorded as 1302.86 m^3 and total storage water loss due to evaporation through the farm pond during August, 2017 to February, 2018 was observed as 414.34 m^3. The total quantity of groundwater utilized by different crops during March and April 2018 were 157.76 and 47.63 m^3.The maximum yield was recorded under the treatment of drip irrigation at 80 % with 100 % RDF (16.31 t/ha), while the minimum yield per hectare was observed in drip irrigation at 60 % ET with 75 % RDF (10.45 t/ha).

3.3 Plastics Mulching and Soil Solarisation

3.3.1 Study on evaluation of plastic mulch for engineering properties under onion cultivation for Rajasthan region by MPUAT Udaipur centre.

Five different size (20 µm, 25 µm, 30 µm, 35 µm & 30 µm reused) of black plastic mulch were used in the experiment. Significant difference was observed in many yield influencing parameters like plant height, weed dry matter and number of roots at 30 DAT, 60 DAT and 90 DAT in mulched treatments compared to non-mulched treatments. It is evident from the tables that mulched bed has been able to maintain

Onion cultivation with plastic mulch

better soil condition for crop cultivation as evidenced by lower value of cone index, lower bulk density and higher soil moisture throughout the growing period.

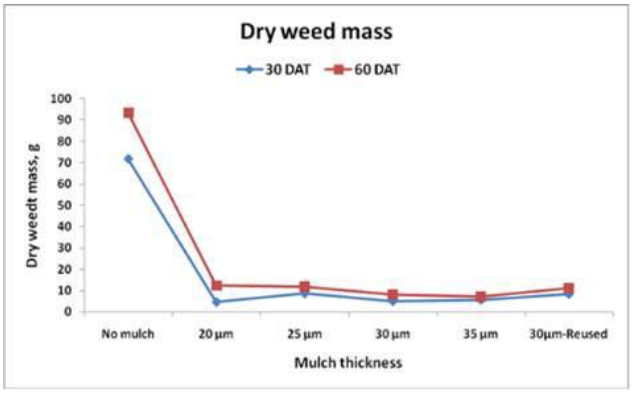


Fig. 3.1.6. Dry weed mass under different mulch thickness

Got maximum yield of 55.32 t/ha under 30 µm mulch with drip irrigation followed by 35 µm (54.86 tone/ha) over farmer practise 36.02 t/ha. Increase in yield of 53% had been achieved over current practise. Based on this year's result it can also be concluded that 30 µm (52.13 t/ha) mulch film can be successfully reused with the help of developed machine under project i.e manual much laying cum retrieval machine (Fig. 3.1.6).

3.3.2 Determination of water use efficiency for the gravity fed drip irrigation system and evaluation of the impact of this system along with plastic mulch on pulses (Black gram and chick pea) crops. Carried out by MPUAT, Udaipur.

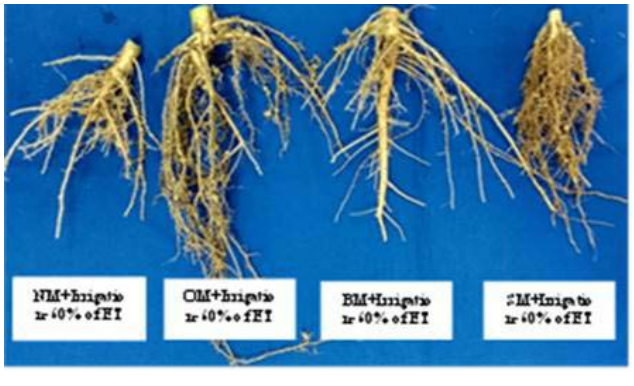
From the present study, conclusion may be drawn that mulching with one pre sowing irrigation and one irrigation at 30 DAS gave maximum yield of chick pea (3.66 t/ha) i.e. Silver black poly-mulch + Pre-sowing irrigation + One irrigation at 30 DAS. More than 100 % increase in yield achieved. One pre sowing irrigation with mulch was statistically at par, which shows that in rain fed or peta cast cultivation of pulses, if later irrigations are not available one can meet out the yield differences by using mulch. Use of mulch can save the one irrigation with equal quantum of

Plastic mulch on Black gram

produce. Similar trends in results were found in black grami.e maximum yield of 17.33 q/ha obtained under two irrigation with PPW mulch. Over 125 % increase in yield was obtained over control. Type of mulch have no significant effect on any parameter included in present study.

3.3.3 Studies on mulching on growth, yield and quality of pulse (Cowpea) under drip irrigation system by ICAR-CIPHET, Abohar centre.

During study by ICAR-CIPHET, Abohar centre, the effect of mulching on plant root length, number of secondary roots, root nodulation etc. was observed as cow pea is a legume crop. Maximum root weight, with nodule (45.63) and without nodule (38.22), was observed in organic mulch treatment while it was lowest in no mulch treatments. Among the different mulching material: Silver mulch found better for plant growth and sucking insect pests also reflected from crops.



Effect of mulching on plant root length, number of secondary roots, root nodulation

3.3.4 Effect of coloured plastic mulches on cultivation of tomato crop was studied at JAU Junagadh centre.

JAU Junagadh centre studied the effect of cloured plastic much on tomato crop and found maximum and minimum soil temperature was recorded in black and silver plastic mulch respectively. In comparison of all coloured plastic mulches, maximum soil moisture was observed in silver plastic mulch and minimum was found in black plastic mulch. Crop parameters viz., plant height (103.1 cm), no. of branches/plant (22.0), no. of fruits/plant (53.5) and weight of fruits/plant (3.9 kg) were observed highest in red plastic mulch as compared to control i.e without mulch. Weed parameters like no. of weeds and dry weight of weed was found higher in control than plastic mulches. The plastic mulches resulted in an 88-92% reduction in

Cultivation of tomato crop with plastic mulch

weed intensity as compared to control. Minimum insect/pest parameters viz., no. of thrips and no. of whitefly per three leaves per plant was observed 1.4 and 2.2, respectively in silver plastic mulch followed by white and red plastic mulch. Disease parameters like leaf curl incidence was observed minimum in silver plastic mulch (0.9 %) followed by white and red plastic mulch. The early blight severity was observed minimum in red plastic mulch (4.3 %) followed by silver plastic mulch (7.1 %). Maximum disease parameters were found in control. Yield of the tomato crop (85.6 t/ha) was found maximum in red plastic mulch followed by

silver mulch (78.8 t/ha). Minimum yield of tomato was found in control (55.2 t/ha).Maximum net profit was estimated to be Rs. 5 lakh/ha in red/black plastic mulch with B:C ratio 6.43 followed by silver/black plastic mulch Rs. 4.5 lakh/ha.

3.3.5 Assessment of soil microbial activities and post-harvest quality of tomato under plastic and organic mulches in arid regions by ICAR-CIPHET, Abohar centre.

Microbial population in the crop rhizosphere under different mulching conditions was measured (Table 3.3.1 & Table 3.3.2). Bacterial population load and fungal population in terms of (colony forming units/ gm of soil) was enumerated at 10^{-5} and 10^{-3} dilution during vegetative and fruiting stage of crop growth. During vegetative stage, highest bacterial (15.33 ± 1.52 CFU/gm) and fungal count (44.00 ± 3.09 CFU/ gm) was found in silver mulch and organic mulch respectively while lowest population count of bacteria (6.67 ± 4.28) and fungi (23.00 ± 1.15) was observed in no mulch and silver mulch conditions. Similarly, Highest population count of bacteria (40.00 ± 6.38) and fungi (28.33 ± 6.40) was found in silver and organic mulch respectively, however population count was found less comparatively to vegetative growth stage. During vegetative stage, bacterial population was 15.33 ± 1.52 CFU/gm while fungal count was found to be 44.00 ± 3.09 CFU/gm while population count of bacteria (18.67 ± 2.23) and fungi (28.33 ± 6.40) was found to have reduced during fruiting stage. The population counts of other soil microorganisms are given in the table.

Leaf samples of tomato crop grown under different cover of plastic film mulches was analyzed for its macro and micro nutrients given in the below table 3.3.3, including Phosphorous (P), Pottassium (K), Magnesium (Mg), Sulphur (S), Iron (Fe), Manganese (Mn), Zinc (Zn), Cupper (Cu), Boron (B) and Molybdenum (Mo). The tomato crop under silver mulches was found that better nutrient status as compared to the other treatments (Table 3.3.4).

Table 3.3.1: Effects of mulching on microbial population count of tomato rhizosphere soils during vegetative growth stage

Types of mulching	Population count(CFU/gm) of soil microorganisms				
Dilution factor	Bacteria 10^{-5}	Fungal 10^{-3}	Actinomycetes 10^{-3}	PSB 10^{-3}	Rhizobium 10^{-2}
Organic	15.33±1.52	44.00±3.09	59.00±46.57	289.00±40.20	481.00±5.56
Black	16.67±2.60	25.00±4.03	24.67±37.39	202.00±18.87	435.00±4.38
Silver	63.67±14.98	23.00±1.15	56.00±43.59	297.33±12.73	296.50±2.16
No	6.67±4.28	27.00±2.87	41.67±7.37	160.67±10.27	311.33±5.19

Table 3.3.2: Effects of mulching microbial population count of tomato rhizosphere soils during fruiting stage

Types of mulching	Population count(CFU/gm) of soil microorganisms				
Dilution factor	Bacteria 10^{-5}	Fungal 10^{-3}	Actinomycetes 10^{-3}	PSB 10^{-3}	Rhizobium 10^{-2}
Organic	18.67± 2.23	28.33± 6.40	424.67± 44.04	264.67± 31.35	44.33±4.28
Black	12.33±1.78	19.67± 2.45	372.00± 33.35	140.33± 14.98	24.00±7.41
Silver	40.00± 6.38	19.00± 1.15	212.50± 14.15	244.33± 22.91	47.67±3.21
No	11.33±1.66	21.33± 0.98	260.00± 8.04	147.67± 14.12	43.67±2.42

Table 3.3.3: Major and micronutrient analysis of tomato leaf sample carried out at mid-crop growth stage (All values are mg per kg of leaf samples)

Macro/micronutrient (mg kg^{-1})	Organic mulch	Black mulch	Silver mulch	No mulch
Phosphorous (P)	3429.67	3954.67	4535.67	4419.67
Pottassium (K)	11083.33	11376.67	11933.33	10716.67
Magnesium (Mg)	9809.67	9417.67	10263.33	9449.33
Sulphur (S)	29796.67	28870.00	27176.67	18786.67
Iron (Fe)	911.83	958.27	1167.67	1000.70
Manganese (Mn)	112.33	122.27	133.83	101.64
Zinc (Zn)	39.26	40.38	45.98	49.83
Cupper (Cu)	21.48	37.34	40.11	24.92
Boron (B)	163.27	231.00	206.77	167.27
Molybdenum (Mo)	0.88	0.84	1.05	1.26

Table 3.3.4. Effects of mulching on micronutrient status of tomato fruits

Micronutrient (mg kg^{-1})	Organic mulch	Black mulch	Silver mulch	No mulch
Iron (Fe)	149.67±2.92	162.77±0.76	259.23±3.50	185.43±3.06
Manganese (Mn)	21.16±0.41	24.88±0.29	25.54±0.12	21.44±0.31
Zinc (Zn)	34.70±0.70	46.88±0.65	41.16±0.20	44.03±0.70
Cupper (Cu)	11.84±0.23	32.91±0.84	14.31±0.15	12.81±0.16
Boron (B)	24.31±0.47	27.18±0.34	28.12±0.23	32.27±0.59
Molybdenum (Mo)	0.91±0.01	0.82±0.07	1.15±0.04	1.02±0.02

3.3.6 Evolvement of mulching technology for bunch type groundnut crop, by JAU Junagadh centre.

The maximum crop parameters viz., plant height (41.63 cm), numbers of pod and weight of pod per plant (25.38 number and 54.5 gm), pod yield and haulm yield (3469.63 kg/ha and 6876.09 kg/ha) were found for silver black plastic mulch and minimum was found in control. Minimum weed intensity (12.25 no./ sq. m) was observed in silver black plastic mulch. Water saving over control was found 41.24 % under mulch condition. Maximum water use efficiency (6.77 kg/ha-mm) was found under silver black plastic mulch while it was minimum (1.74 kg/ha-mm) in control. The farmers of South Saurashtra Agro climatic Zone are advised to use silver black plastic mulch (20 µm) with drip irrigation and raised bed for water saving and to achieve higher crop yield of bunch type groundnut during summer season.

3.3.7 Performance evaluation of transplanted pigeonpea under drip irrigation and plastic mulch under Raichur agro climatic conditions by UAS Raichur centre.

The crop was harvested during January, 2017. Maximum plant height at 90 days (145.47 cm) was recorded with 75 % of RDF, irrigation at 100 % of ET and use of white on black mulch. Maximum number of primary branches (16.9) and number of secondary branches at 90 DAT (34.5) were recorded at 75 % of RDF, irrigation at 80 % of ET and black colour plastic mulch, whereas minimum number of primary branches (10.1) and number of secondary branches at 90 DAT (16.5) were recorded at 100 % of RDF, irrigation at 100 % of ET without mulch. Maximum soil temperature and minimum soil moisture was recorded with black colour plastic mulch in all the irrigation levels. Maximum seed yield (32.12 q/ha) was recorded with 100 % of RDF, irrigation at 80 %

of ET and white on black plastic mulch. The yield of the pigeon pea was observed maximum with 100 % of recommended dose of fertilizers along with 100 % irrigation and white coloured plastic mulch (33.35 q/ha). The fertilizer use efficiency of pigeon pea was observed maximum with 75 % of recommended dose of fertilizers along with 60 % irrigation.

Cultivation of pigeon pea with plastic mulch

3.3.8 Development of fertigation protocol for tomato under mulch and without mulch condition by BAU, Ranchi centre.

This study was conducted to find out the economic mode of fertigation for tomato under mulch & without mulch conditions and effect of fertigation on yield & quality of tomato. The various treatments taken under this study were T1 (without fertilizer application), T2 (conventional fertilizer application), T3 (N through fertigation and P & K through conventional fertilizer application), T4 (N & P through fertigation and K through conventional fertilizer application), T5 (N & K through fertigation and P through conventional fertilizer application) and T_6 (N, P, & K through fertigation). The N, P & K fertilization &fertigation using available sources of NPK (without water soluble & water soluble) varied between Rs. 8,418 to Rs. 42,703. The cost varied widely for the same treatment condition due to fertilizer source taken for NPK. The lowest and highest yield for tomato is 13.93 t/ha and 27.68 t/ha under without mulch condition was found for T1 (without fertilizer application) and T2 (Conventional fertilizer application) respectively. But there is no significant difference in yield between T2, T3 (N through fertigation and P & K through conventional fertilizer application) and T5 (N & K through fertigation and P through conventional fertilizer application). The lowest and highest yield for tomato was 22.96 t/ha and 33.28 t/ha under mulch condition is found for T1 and T5 respectively. The corresponding yield of tomato under mulch condition for various treatments condition undertaken is higher than without mulch condition.

Tomato crop with and without plastic mulch

3.4 Farm Tools, Machinery and Post-Harvest Management

3.4.1 ICAR-CIPHET, Abohar centre designed and developed composite Solar Air-conditioning system coupled farm level cold store for hot and arid region.

It contains adsorber, condenser, evaporator, receiver, check valve, float valve and needle valve. Adsorption, alias physisorption, is the process by which molecules of a fluid (methanol) are fixed on the walls/surface of a solid material (activated charcoal). The adsorbed molecules undergo no chemical reaction; they simply lose energy when being fixed. Adsorption, the phase change from fluid to adsorbate (adsorbed phase) is reversible exothermic reaction. The adsorption cooling cycle is completed in following four steps.

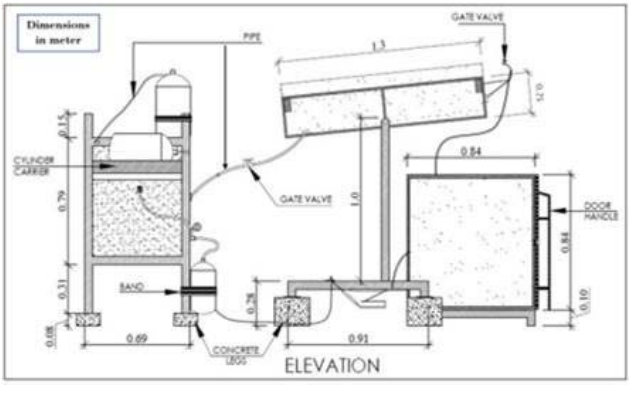
Step 1: Isosteric heating which involves increase in adsorber temperature and pressure due to the solar irradiance.

Step 2: Desorption + condensation which involves desorption of the methanol vapours contained in the activated charcoal; condensation of the vapours in the condenser; drainage of methanol in the evaporator through the receiver and float valve.

Step 3: Isosteric cooling which involves decrease of the period of sunshine; cooling of the adsorber; decrease of the pressure and the temperature in the system.

Step 4: Adsorption + evaporation which involves evaporation of methanol contained in the evaporator; cooling of the evaporator; production of cooling effect in the evaporator; re-adsorption of methanol vapours by the activated charcoal.

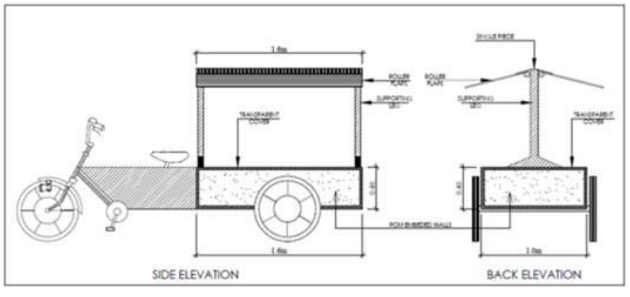
Methanol is supplied to adsorber during which it is adsorbed on the surface of activated charcoal. This process liberates considerable amount of heat. During day hours, solar energy falls on the adsorber which increases the adsorber's temperature and thus supplies enough heat to liberate methanol from the surface of the activated charcoal. Further, methanol vapours enter in to water cooled condenser through uni-directional check valve. Condensed methanol enters in to float valve through receiver and then in to evaporator coil through needle valve. Methanol receives latent heat of vaporization from evaporator coil and gets evaporated by cooling the evaporator coil. Methanol vapour then enters in to adsorber and thus completes the cooling cycle. These solar energy based adsorption cooling system was found suitable in lowering the temperature of cooling coil by 18 °C (reduced the temperature from 38 to 20 °C).Developed system lowered the evaporator temperature by 15-18 °C. Storage capacity of the system: 1 quintal; Cooling capacity of the system under no load condition was 0.13 Tons of Refrigeration (0.44 kW). COP of the system was 0.14.



Composite Solar Air-conditioning System

3.4.2 Development of phase change materials based mobile cool chamber for transportation of fruits and vegetables by ICAR-CIPHET, Abohar centre.

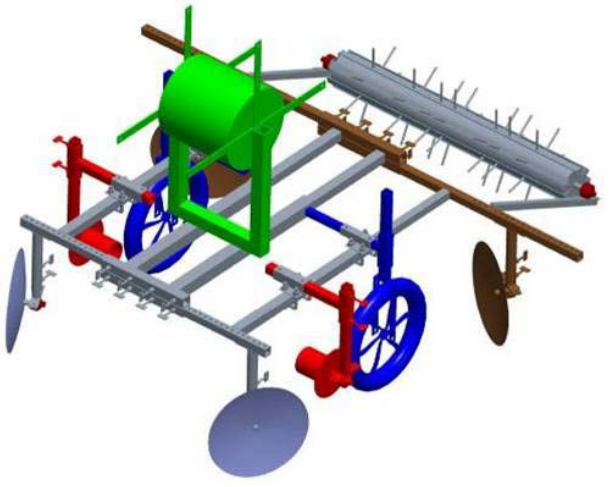
Overall Dimensions of proposed cool chamber were determined on the basis of amount of fruits and vegetables to be handled are Length= 1.6 m, breadth=1 m, height=0.4 m. Capacity of the PCM box determined to be 1.0-1.2 QT. Heat transfer rates and PCM requirements were determined. PCM requirement was calculated on the basis of certain assumptions and found to be 2.25 kg (Assumptions: outside temp–40 °C; inside temp–20 °C; PCM temp–20 °C; heat of fusion of PCM – 200 kJ/kg; thermal conductivity of insulation – 0.02 W/m °C).



PCM based mobile cool chamber

3.4.3 ICAR-VPKAS, Almora centre remodified manual plastic mulch laying machine.

Only two labours are required for operating the machine. The machine performs multiple operations in a single run. It opens furrows at one meter apart

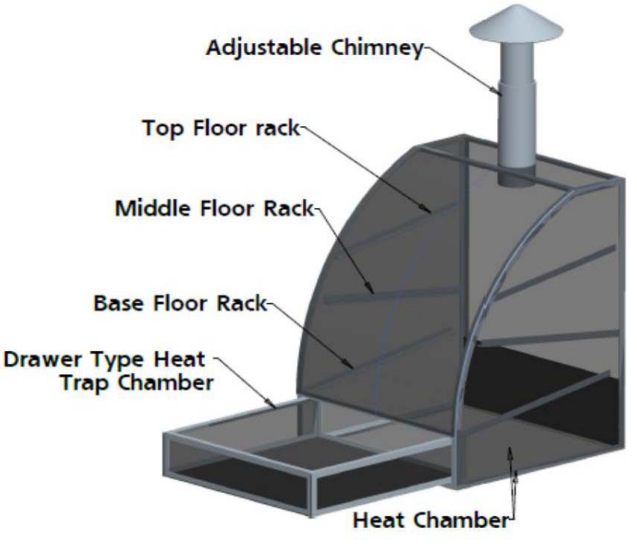


with the help of two front discs (0.30 m diameter). Lays the standard width (1.2 m) of plastic mulch in opened furrow. Plastic mulch of less than 1.2 m width can also be layed with it's the adjustable nature of frame as per the need of farmer. After laying, the mulch is covered with soil by two rear discs (0.30 m diameter). Facility of laying inline drip pipe/tape beneath the plastic mulch has also been provided in the machine. It also marks (puching) small holes on the layed plastic mulch and the marking can be done as per spacing (row to row and plant to plant) required for a crop. The overall dimension of the machine is 2.00 m × 1.70 m ×1.00 m. The theoretical field capacity of the machine is 0.29 ha/h. Actual field capacity of the machine is 0.059 ha/h which is almost 10 times faster than manually. Field efficiency was determined and found to be 20.34 % with average draft required to pull the machine was 32.2 kg.

Remodified manual plastic mulch laying machine

3.4.4 A low-cost portable plastic solar cabinet drier has been designed and fabricated for hills by ICAR-VPKAS, Almora centre.

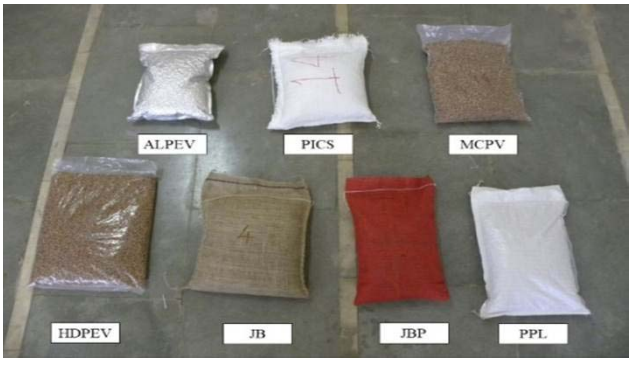
The dryer has overall dimensions of L=0.6 m, W= 0.62 m and H= 0.8 m. Dryer has three trays and provided with adjustable chimney of length 4.67 m. Performance of dryer was evaluated at no load and loading conditions. Increase in the temperature upto 37.4, 50.6, 59.2 and 66.9 °C in the basement, lower tray, middle tray and upper tray, respectively were found. Temperature inside solar cabinet drier rose by 11.4 , 24.6 , 33.2 and 40.9 °C in basement, lower tray, middle tray and upper tray, respectively over the outside temperature. Cereal crops maize and leafy vegetables successfully dried in the dryer. Two more units also developed and supplied to the farmers for field testing. Capacity of dryer ranges from 25-30 kg depending upon drying material.



Low-cost portable plastic solar cabinet drier

3.4.5 Effect of packaging on storage behaviour of chickpea grain was studied by JAU, Junagadh centre.

The insect population (46 nos./500 g), grain damage (26.33 %) and weight loss (7.51 %) was found only in chickpea grain stored in jute bag at the end of twelve months of storage period. Maximum moisture content (12.38 %) of the grain was recorded in jute bag followed by polyethylene lined jute bag and PP woven laminated bag. Minimum moisture content was observed in polyethylene laminated aluminium foil bag during entire storage period. Maximum and minimum protein content in the grain was recorded in HDPE bag (19.09 %) and in jute bag (15.32 %) respectively, at the end of storage period. Minimum cooking time of the grain was observed in jute bag (47.25 min) and maximum cooking time was recorded in vacuum packed materials i.e., polyethylene laminated aluminium foil bag (74.67 min) followed by multilayer coextruded plastic bag and HDPE bag. Maximum swelling capacity (0.248 ml/grain) was found in PP woven laminated bag and lower in vacuum packed materials like polyethylene laminated aluminium foil bag, multilayer coextruded plastic bag and HDPE bag than other treatments. Maximum germination (91.33 %) and seed vigour index (1114) was recorded in chickpea grain stored in PP woven laminated bag at the end of storage period. Seed qualities like germination and vigour index of the grain was found lower in vacuum packed bags than without vacuum



packed bags on twelve months of storage .Considering the overall aspects of the study, it may be concluded that PP woven laminated bag was observed to be best packaging material amongst all treatments for chickpea grain storage up to twelve months.

3.5 Aquaculture and Animal Husbandry

3.5.1 Six polytanks were prepared for fish rearing and four of these were covered with polyhouse by ICAR-VPKAS, Almora centre.

Overall dimensions of the each polytanks was 9.8 m × 3.0 m top, 7.4 m × 0.6 m bottom, 1.2 m depth & 1:1 side slope with capacity of approximately 20 m^3. Four of the polytanks were covered with dome shaped galvanized iron (GI) pipe polyhouse. The dimensions of the polyhouse were 11.0 m length, 4.2 m width, 10 m span with central height of 3.0 m. The size of the each polyhouse was 46.2 m^2. One ventilator of size 1.0 m × 0.8 m, one door of size 1.8 m × 1.05 m and wide opening in the two longitudinal sides fitted with insect proof net was provided. The advanced fingerlings of exotic carp and minor carp were stocked in all the six polytanks. The growth trend showed better growth of grass carp and improved strain of common carp in all ponds. The average growth was observed in the range of 270 to 600 g with highest growth in polytank having bottom sand bed of 75-100 mm and the whole polytank covered with polyhouse. Species wise maximum growth was recorded in grass carp and improved common carp. Growth of the minor carp was also encouraging with the advantage of cleaning of the excess periphyton. Comparatively better growth and survival was recorded in polythene covered polytanks due to the advantage of increasing temperature (Fig. 3.5.1 and Fig. 3.5.2).

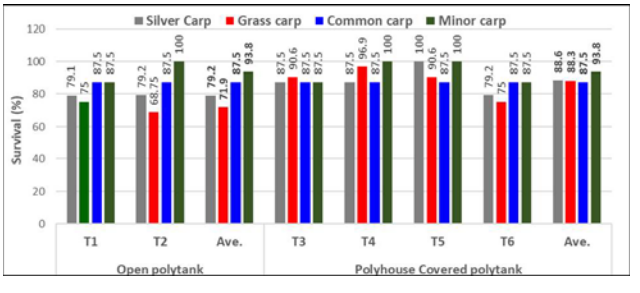


Fig. 3.5.1 Survival (%) of fish in different types of ponds (12 months)

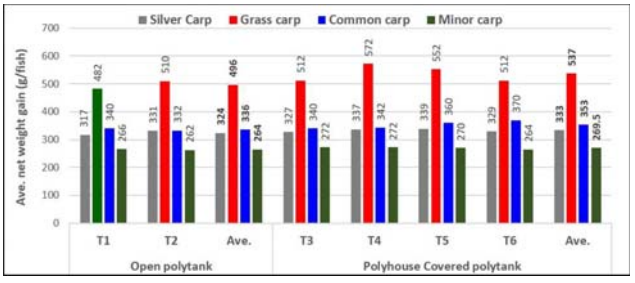


Fig. 3.5.2 Growth performance of fish in different types of ponds (12 months)

3.5.2 Pilot scale Nutrient Film Technique (NFT) aquaponics system was designed and developed by ICAR-CIFA, Bhubaneswar centre.

The system comprises of fish culture tank, submersible water pump, trickling filter, four NFT grow pipes each having length of 3 m and 9 perforations (3-inch diameter each for holding net pots) for growing plants. The system is designed to use excess nutrients from aquaculture for growing agriculture crops for having synergistic effect on both crop and fish. Using this system, various plants like poi saga (*Basella alba*), marigold (*Tagetes erecta*), bottle gourd (*Lagenaria siceraria*), lady's finger (*Abelmoschus esculentus*) and long bean (*Vigna unguiculata*) along with different fish species were grown The combination of Climbing perch (*Anabas testudineus*) fish and poi saga in the system showed 34 % higher growth in fishes in aquaponics tank compared to control tank due to improved water quality by removal of dissolved nutrients by the plants. The combination of tilapia (*Oreochromis niloticus*) fish and marigold plants were shown yielding 450 marigold flowers from 36 plants in the system in 3 months. During three month of experimental duration, 684 green chilies were produced and the tilapia production of 10.35 kg/m3 (equivalent to 103.5 t/ha) was achieved. The absolute weight gain (g) per day and FCR were 1.87 and 1.61 found respectively. Six nos of floating rafts also have been fabricated using

Chilli, marigold, beans and lady's finger rop under aquoponics system

FRP under this project. Each raft is having the capacity to hold 32 plants. The rafts have been floated in the pond.

	Cage-1	Cage-2	Cage-3	Cage-4
Initial stocking size (mg)	11.7	11.7	11.7	11.7
No. of spawn stocked (Nos.)	1000	2000	3000	4000
Final weight during harvest (mg)	68.1	59.4	35.2	31.1
Survival (%)	59.3	48.1	42	38

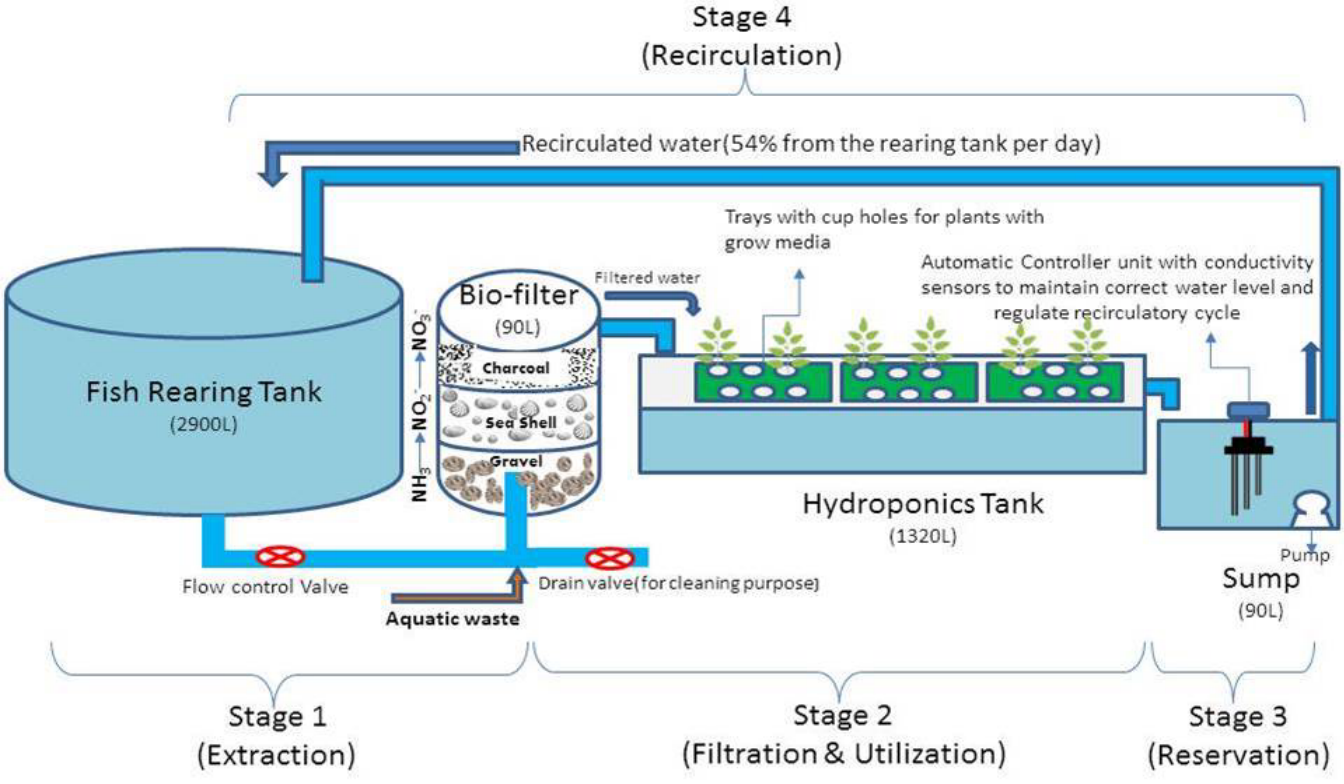
Floating cage nursery for carp fry rearing, Fabricated four net cages of size 2 m x 2 m x 1.5 m using nylon hapa supported with mild steel frames for rearing carp seed. The common carp (*Cyprinus carpio*) fry were stocked in the cages installed in the Reservoir-II of ICAR-CIFA Farm at Kausalyaganga. Normal seed rearing practices were followed. After 20 days of rearing sampling was done. It was found that the survival and growth was indirectly proportional to the stocking density of the seed. The dissolved oxygen content in water was found within the culturable limits of aquaculture.

Floating cage nursery at ICAR-CIFA farm

The system comprises of three sets of fish culture tanks (Size: 2.15 m x 1.0 m), submersible water pump, biological filter having total capacity of 100 liter and useful capacity of 85 liter, hydroponics tanks

Floating cage nursery

each having length of 4.0 m and height of 0.35 m containing 3 FRP trays each having 24 numbers of perforation (2.5 inch diameter) for holding the net pots in which plantation is done. The fish culture tank is connected to biofilter in which water flow occurs through gravitational force *via*. an outlet of 2.0 inch diameter. The biofilter contains gravels and sea-shells for colonization of nitrifying bacteria. Filtered water from biofilter trickles into the hydroponics tanks *via.* an outlet of 2.0 inch diameter and excess water from hydroponics tank is returned to a SUMP having a capacity of 200 liter through an outlet of 1.5 inch



NEW RECIRCULATORY AQUAPONICS SYSTEM DESIGNED AND DEVELOPED
By AICRP on PET at ICAR-CIFA

Aquaponics system

diameter. A conductive sensor is placed in the SUMP and when the water level comes to 180 L, it activates the submersible pump and the water is again returned to the fish culture tanks. The system is designed to use excess nutrients from aquaculture for growing agricultural crops for having synergistic effect on both crop and fish. The ammonia level in water of the fish culture tank is converted to nitrite and finally oxidized to nitrate by nitrifying microbes developed in the bio-filter and then passed through the root zone of the plant. Nitrate is not only non-toxic to fish, but also, a vital nitrogenous fertilizer for the growth of plants. The plants maintained the water quality by absorbing the dissolved nutrients from the water and make it suitable for fish production. Using this system, the experiment with various plants like Marigold (*Tagetes erecta*), Capsicum (*Capsicum frutescens),* Chilly (*Capsicum annuum*), Lettuce (*Lactuca sativa*), Broccoli (*Brassica oleracea var. italica*), Cherry tomato (*Solanum lycopersicum var. cerasiforme*) along with different fish species, such as pangas and tilapia is going on at Kausalyaganga campus of ICAR-CIFA. Pangas (Length 62-72 mm & Weight 1.5-2.81 g) with 100 nos per tank was stocked on 11 September, 2018 and tilapia stocking is going on at present. Plants were planted on 23-24 October, 2018.

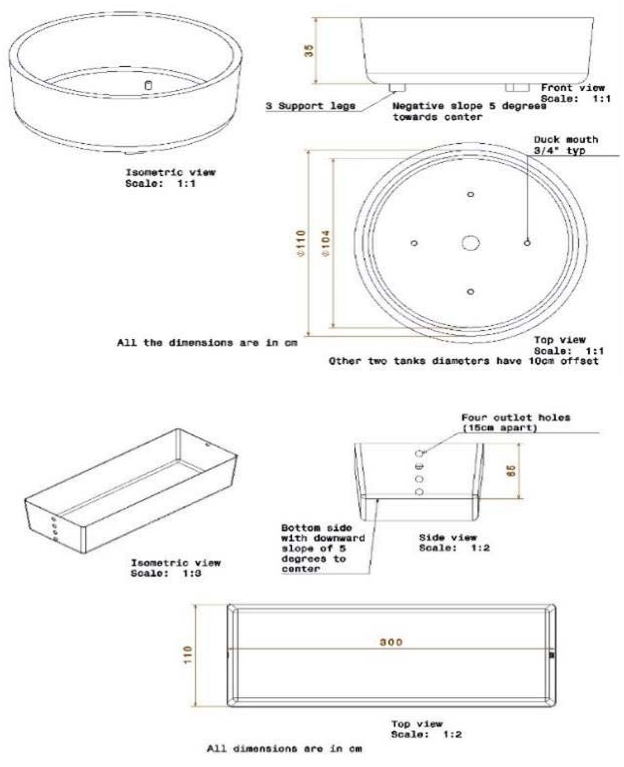
The carp seed transportation system was designed and developed by **ICAR-CIFA, Bhubaneswar** and the gadget has been fabricated using FRP. The total water holding capacity of the tank is 40 L for seed transportation. Splash breakers are placed in the tank to minimize the water slushing which help in avoiding injuries to the fish seeds during transportation. The tank bottom (inner side) is provided with oxygen supply lines and diffusers. The oxygen cylinder and supply lines are connected with regulators for oxygen supply to the tank. Fabrication and experimentation of 5 different designs of seed transportation system using splash breakers at different positions in the tank are under progress.

Carp seed transportation system

3.5.3 Development of user friendly portable pabda hatchery with tubifex culture & rainwater harvesting facilities, by ICAR-CIFA, Bhubaneswar centre.

It comprises of 3 breeding pools (rectangular tanks, the bigger one size of 3 m × 1.1 m × 0.65 m) and 3 incubation pools (circular tanks, of 1.2 m, 1.1 m and 1.0 m diameters having a water height of 0.35 m). The fabrication of other two breeding pools will be initiated shortly. The breeding pool is connected to water inlet and outlet with 1.0 inch diameter pipe. Three circular incubation pools of gradually increasing diameters are designed and fabricated to be stacked one above the other in a pyramidal structure. This is done to reduce the space needed for their installation

Portable Pabda hatchery



at farm site. This is achieved by the help of a tripod shaped MS platform (Ht 6.0 ft) with equally spaced racks to hold individual tanks. The inlet and outlet piping (1.0") are supported on the structure itself. These tanks are provided with individual valves to control flow from inlet and outlet pipes. In each of the incubation pool 4 numbers of duck mouths (0.75 inch diameter) are provided to maintain a circular flow of water. To develop brood stock 5,600 nos. of Pabda (*Ompok bimaculatus*) fingerlings were stocked in pond in two batches (1st batch during January, 2018 and second batch during June, 2018). The fingerlings procured were initially reared in cemented cistern with feed consisting of plankton, tubifex and egg yolk, in addition to commercial feed for two and half months and then released in pond provided with shelter and sufficient aeration at an average size of 7.8 – 9.8 cm / 2.1 -6.2 g. In ponds the fishes of first batch attained an average size of 13.6 ± 1.6 cm/ 24.2 ± 7.9 g in five months of rearing.

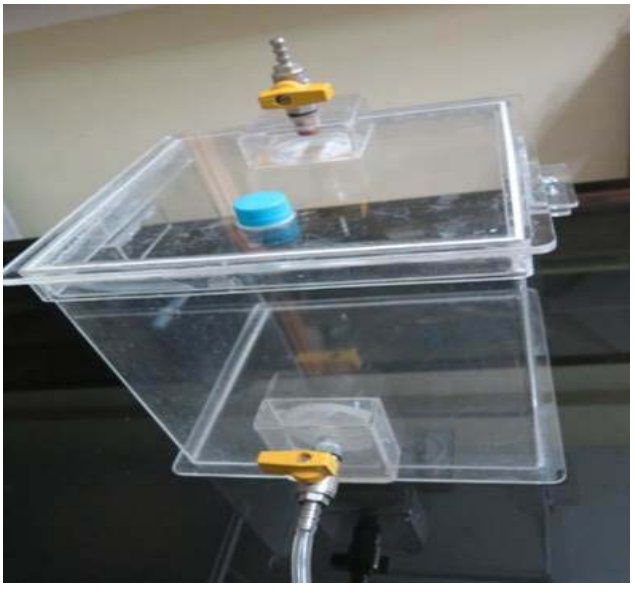
3.5.4 Design, Development and Evaluation of Plastic Gadgets for Hygienic Fish Marketing by ICAR-CIFA, Bhubaneswar centre.

A mobile fish vending trolley has been designed and developed with dimension 4'x2'9"x2'6" to aid the fisher folks for vending their fish harvests in hygienic condition. The specialty of the carriage is its unibody design as all the facilities and equipments are integrated into it. An ice box of size 2'x2'9"x2'6" is integrated in the carriage box and packed with 1" thick polyurethane foam to serve the insulation factor. The icebox can store 80-100 kg of fish in ice which can be sold in a single day by the fisher folks. The cutting tool is made removable and more than one type of cutting tool can be used. There is also provision of water storage tank of around 20 L capacity and waste collection crate chamber in the carriage. Tool box is also provided for keeping the cutting tools, money box and other items required during the marketing process. The unique selling proposition (USP) of the vending unit is its unibody design. The complete unit of mobile fish vending carriage is fabricated with fibre reinforced plastic (FRP), because of its high strength compared to other plastics, ease of fabrication and good insulation property of fiberglass. It maintained 9-12 ^{0}C less temperature in the ice box for fish storing than the outside in a sunny day. This fish vending trolley

Mobile fish vending trolley

is a boon for the marginal fish vendors, who want to sell fish in a hygienic condition. However, he appealed to the researchers to reduce the cost of the trolley and to make it self-propelled. The trolley is mounted on peddle operated cycle rickshaw and costing Rs. 52,780/-.The trolley can carry 100 kg fish. The gross weight of the gadget including fish, ice, water, rickshaw and other utilities is 320 kg. Technology was released on 1 April, 2017 by Hon'ble Union Agriculture Minister at ICAR-CIFA, Bhubaneswar.

A simple and noble respirometer in acrylic material has been designed and developed to study the oxygen consumption by fry, fingerling and advanced fingerling stages of fishes. The instrument is transparent, can be completely sealed air tight, and can store water and fish for experimentation. Water can be filled or drained manually at desired intervals, and the inlet and outlet hubs are fixed with screens to protect the fish seed to escape out of the respirometer during experimentation or water flow. Two models of respirometer were fabricated having dimensions of 10"x 10"x 10" and 11"x 11"x 11" with 18 L and 22 L water storage capacities respectively. The components of the respirometer are the transparent water tank with outlet hub containing drainage valve, transparent covering lid with inlet hub containing inlet valve and airway cap. The airway cap is provided in the lid to make a way for air to pass into the tank while draining water or out of the tank during filling of the water. The operation of the respirometer involves filling the tank with water, stocking the fishes, covering it with the lid, taking water samples for oxygen estimation in the start and end of the experiment. In all the fishes the oxygen consumption was reported to be higher in advanced fry stage than the fingerling and advanced fingerling stages. The lower critical tolerance limits of oxygen in water for survival of advanced fingerlings of catla, rohu and mrigal were found to be 0.4, 0.32 and 0.32 mg/l respectively.



Noble respirometer

Technology Release : Hon'ble Union Minister of Agriculture and Farmers Welfare, Shri Radhamohan Singh in the presence of Hon'ble Secretary, DARE & DG ICAR, Dr Trilochan Mohapatra; DDG (FY);

Release of Mobile Fish Vending Trolley

FA, DARE; Secretary, ICAR; and others, the technology of "Mobile Fish Vending Trolley" got released and dedicated to the nation.

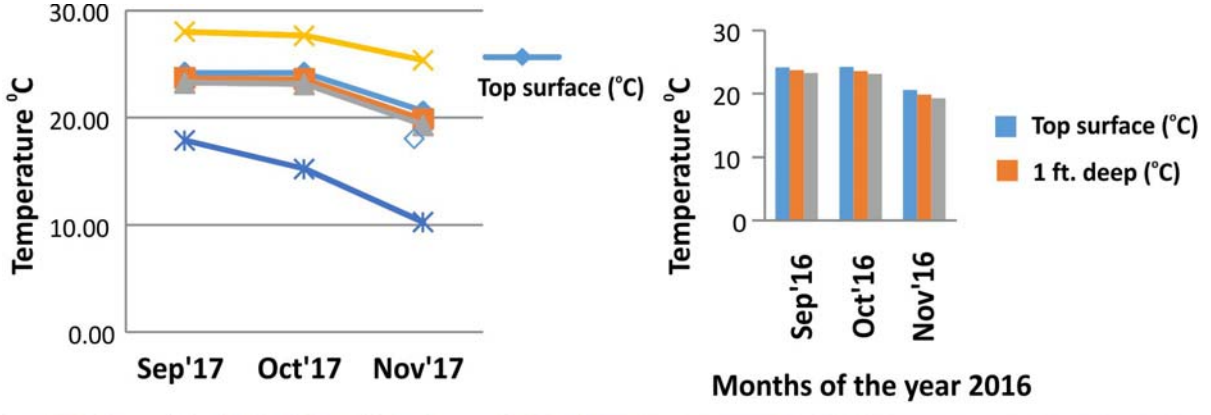
"Mobile fish vending trolley" has been recommended for release and commercialization by the ITMC, ICAR-CIFA .

3.5.5 Development of package of practices for pisciculture in poly housed – plastic lined pond for mid- hills of Meghalaya.

Two numbers of lined ponds of the division were equipped with two numbers of low cost poly houses. Fish fingerlings were procured and placed in polyhouse-plastic lined ponds. 100 nos of *Catla* are being reared in 20 m^2 capacity of pond. Variations on water and air temperature were observed inside poly housed lined pond at different depth of water are showed in fig respectively. Average water surface temperature rose by 1.3 ^{0}C during the month of July and August. During September and October, there was no significant change on average top surface temperature, 1 feet deep water temperature and bottom surface temperature. Average top surface, 1 feet deep water and bottom surface temperatures were dropped by 3.59 °C, 3.75 °C and 3.81 °C, respectively in November. Maximum and minimum air temperatures were dropped by 2.32 °C and 4.97 °C during November. However, no significant growth change detected in their growth as compared to outside.

3.5.6 Development and evaluation of polyhouse covered fish polytank for fish rearing for high hills of Uttarakhand.

ICAR-VPKAS, Almora centre has developed the technique of fish rearing in fish poly tank. Six polytanks were prepared for fish rearing and four of these were covered with polyhouse. The dimensions of the each polytanks were 9.8 m × 3.0 m top, 7.4 m × 0.6 m



Poly housed – plastic lined pond

Polyhouse covered fish polytank for fish rearing

Table 3.5.1 : Cost details and composition of fish used for stocking in different treatments

Treatment	Cost of the treatment (INR)			Type of fish (number of fingerlings)			Total	Remarks
	Tank	Polyhouse	Total	Grass carp	Silver carp	Common carp		
T_1: Polytank with covering of the polyfilm with locally made blocks.	16320	-	16320	32	24	24	80	-
T_2: Polytank (stepped inner walls) with covering of the polyfilm with soil.	13110	-	13110	32	24	24	80	-
T_3: Polytank without any covering material on the polyfilm and the whole polytank covered with polyhouse.	9600	56206	65806	32	24	24	80	-
T_4: Polytank without any covering material on the polyfilm but having bottom sand bed of 75-100 mm and the whole polytank covered with polyhouse.	9888	56206	66094	32	24	16	80	8 fingerlings of *Labeodyo cheilus*
T_5: T_1 + Polyhouse (Polytank with covering of the polyfilm with round stones and the whole polytank covered with polyhouse).	12720	56206	68926	32	24	24	80	-
T_6: T_2 + Polyhouse [Polytank (stepped inner walls) with covering of the poly film with soil and the whole polytank covered with polyhouse]	13110	56206	69316	32	24	24	80	-

Note: Grass carp (*Ctenopharyngodon idella*); **Silver carp** (*Hypophthalmichthys molitrix*); **Common carp** (*Cyprinus carpio*)

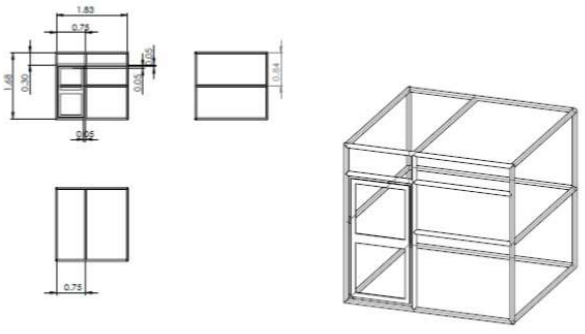
bottom, 1.2 m depth, 1:1 side slope with capacity of approximately 20 m^3. Four of the polytanks were covered with dome shaped galvanized iron (GI) pipe polyhouse. The dimensions of the polyhouse were 11.0 m length, 4.2 m width, 1.0 m span with central height of 3.0 m. The size of the each polyhouse was 46.2 m^2. There was one ventilator of size 1.0 m × 0.8 m, one door of size 1.8 m × 1.05 m and there was wide opening in the two longitudinal sides fitted with insect proof net. The fish seeding in all the six polytanks was done.

The temperature data as observed (07:12 AM and 14:12 PM) in open poly lined tanks and covered with polyhouse 0.36 to 2.49 °C higher temperature in open polytanks (Ave. of T_1 & T_2) than polytanks covered with polyhouse (Ave. of T_3 to T_6) but the difference was very less. However, in the afternoon (14:12 PM), the temperature in the polytanks covered with polyhouse (Ave. of T_3 to T_6) was about 3.72 to 9.66 °C higher than open polytanks (Ave. of T_1 & T_2). The relative humidity in the polytanks covered with polyhouse (Ave. of T_3 to T_6) was about 9.69 to 35.04 % higher than open polytanks (Ave. of T_1 & T_2) at 07:12 AM, while it was 1.54 to 10.34 % lower at 14:12 PM. However, in September the relative humidity in the polytanks covered with polyhouse (Ave. of T_3 to T_6) was lower than open polytanks (Ave. of T_1 & T_2) at 07:12 AM. The water temperature in polytanks covered with polyhouse (Ave. of T_3 to T_6) was about 2.76 to 4.19 °C higher than open polytanks (Ave. of T_1 & T_2) at 07:12 AM, while it was 0.46 to 4.37 °C higher at 14:12 AM.

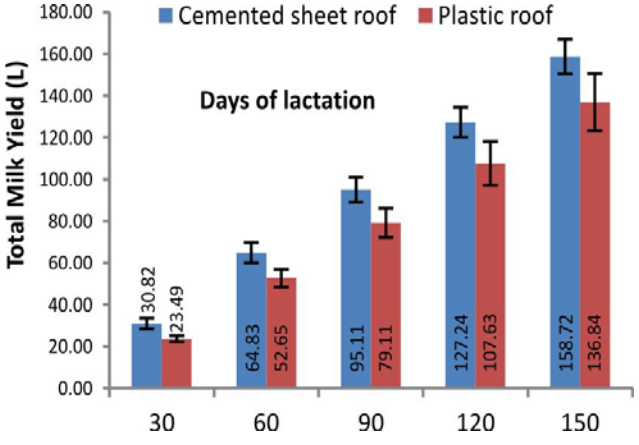
3.5.7 Assessment of Plastic Based Structures of Shelters and Appliances on Goat Production by ICAR-CIRG, Makhdoom centre.

The analysis of recorded weather data indicated that the maximum temperature (T max) during day time in plastic pen was significantly higher as compared to conventional pen and weather station at all time points. The Tmax especially during winter months was significantly higher in plastic pen. The DBT, THI also showed similar higher trend during day time in winter months except RH. Therefore, this type of plastic pen model shall be used for housing kids during day time in winter to tap the solar energy for better kids' growth. The milk yield and milk composition also showed lower trend under FRP roofed pen as compared to cemented sheets roof pen at 30, 60, 90, 120 and 150 days of lactation. The milk yield recorded under FRP and cemented roof were at 30 days (23.49 vs 30.82 lit), 60 days (52.65 vs 64.83 lit), 90 days (79.11 vs 95.11 lit), 120 days (107.63 vs 127.24 lit), 150 days (136.84 vs 158.72 lit), respectively. The morning and evening milk yield under plastic roof also showed lower trend as compared to cemented sheet roof shed. The fat, protein, lactose and SNF content of milk from does housed under FRP roof was lower up to 150 days of lactation. A total of 48 young male kids and lambs at 6 months of age, 12 each of Jamunapari, Jakhrana, Barbari breed of goat kids and Muzaffarnagari sheep lambs were equally divided and allotted randomly in plastic and soil floor. They were managed in groups and fed ad lib concentrate pellets, dry and green fodders. The body weight of animals was recorded and found good in plastic slotted floor. The portable plastic enclosure for improved kid/lamb

FRP roofed pen



Layout of goat enclosure



rearing was developed and evaluated by **ICAR-CIRG Makhdoom.** ASmall plastic enclosure of 2 m x 2 m was fabricated inside as well as outside of the kidding pen. The micro climate during winter season was recorded. Black polythene of 200 μ was used in double layer with 2" gap in between Initial observation during peak winter revealed that there was 5 ºC higher minimum temperatures inside portable plastic enclosure as compared to inside shed (8 ºC Vs 3 ºC). heat load calculation were done for the developed structure Therefore, this plastic enclosure has potential to replace conventional winter care measures for newborn kids. Under this feeder has been designed with overall dimensions (1.5 m × 0.6 m × 1.4 m). Made of material 1" PVC pipe, PVC joints, 2-3 mm FRP sheets, nut and bolts etc. This feeding device is made of plastic materials hence avoids recurring expenses like painting and wear & tear as compared to conventional feeders made of iron. Lighter in weight, hence less man power is required to handle in the goat farm i.e. easy to move in the paddock.Suitable for feeding 10 adult goats, five in each side.

3.5.8 Animal shelter for initial growth trial is fabricated by SKAUST-K, Srinagar.

SKAUST-K, Srinagar centre with overall dimensions of the structure is 9.75 m x 4.75 m x 2.59 m. The floor area of shelter to house animals is 46.31 m^2. Shelter can accommodate 25- 30 animal because floor space required to house one animal under covered area is 1.5 m^2.

Animal shelter for initial growth trial

3.6 Impact Assessment of Developed Technologies

3.6.1 Impact assessment of poyhouses.

Polyhouses established in hill states of Himalayan region, North region and Eastern region and Western region carried out by ICAR-VPKAS Almora centre, CAEPHT Gangtok centre, ICAR-CIPHET Abohar, JAU Junagadh and BAU Ranchi centre. A survey was done during May- June 2017 in the different villages of Almora, Fazilka, East Sikkim Gangtok, Junagadh Districts covering about 80 farmers/ stakeholders. The average age of the farmers under survey was in the range of 38-71 years with average family size of 5 members/family. Most of the farmers (90.9 %) were educated with 54, 28 and 10 % having high school, intermediate and above intermediate education, respectively. After survey found that farmers adopted different types of playhouses such as low-cost naturally ventilated polyhouse to high cost polyhouse/nethouse Rs. 327 – Rs. 975 per sq m size. The major crops grown by the farmers in the polyhouses included tomato, capsicum/ colour capsicum, cabbage, strawberry, beans, cucumber and cut flowers too.

In Almora district survey farmers selling their produce directly to consumer or wholesaler. Only 11.8% of the total produce was sold to consumers while remaining 88.2 % of the produce was sold to wholesalers. The income of the family from different sources (100 sq m area) showed that farmers earned Rs. 1405/- from agriculture from open field (Rs/100 sq m) as compared to income of Rs. 5221/- from agriculture using polyhouse (Rs/100 sq m) in hill state of Almora district (Table 3.6.1).

Table 3.6.1: Cost and benefits from the crops grown in polyhouse

Village	Overall Yield of all crops from one polyhouse (kg)	Overall cost of production in polyhouse (Cultivation+ polyhouse+ packaging+ transport+ others) (Rs)	Overall Gross Returns from one Polyhouse (Rs)	Overall Net Returns from one polyhouse (Rs)	BC ratio of one polyhouse
Dhudholi	817.5	11685	24969	13284	2.14
Todra	725.0	10921	21339	10419	1.92
Mean	758.6	11199	22659	11460	2.00

Table 3.6.2. Opinion of the respondents regarding acceptability of the polyhouse technology

	HA	SA	NA, ND	SD	HD
Social acceptability					
Labour friendly				√	
Reduction in women drudgery		√			
Easy farm operations in sides	√				
Off season production	√				
Increase in consumer demand	√				
Green technology					
i) Environmentally compatible	√				
ii) Higher production	√				
iii) Saving of cost of water					√
iv) Saving of cost pesticides and fertilizers		√			
v) Fresh and residue free Produce		√			

H-highly, S- Slightly, A-Agree, D- disagree, NA -Neither agree, ND- Nor disagree

3.6.2 Impact Assessment of Plastic lined pond.

Plaruc lined constructed for water harvesting hill states of Himalayan region carried out by ICAR-VPKAS, Almora centre and CAEPHT, Gangtok centre. For Dhudholi and Todara in Ranikhet tehsil of Almora district the average age of the farmers under survey was 51.3 years with family size of 5.3 members/

Table 3.6.3 Cost and benefits from the crops grown with polylined tank

Village	Overall Yield of all crops from pond (kg/100 sq m)	Overall cost of production with pond (Cultivation+ polytank+ packaging+ transport+ others) (Rs)	Overall Gross Returns from pond (Rs/100 sq m)	Overall Net Returns from from pond (Rs/100 sq m)	BC ratio with pond
Dhudholi	335.0	5688	10013	4325	1.76
Todra	300.0	6281	8633	2352	1.40
Mean	313.5	6053	9063	3110	1.54

Table 3.6.4. Opinion of the respondents regarding acceptability of the polylined tank technology

	HA	SA	NA, ND	SD	HD
Social acceptability					
Labour friendly	√				
Reduction in women drudgery	√				
Easy farm operations in sides	√				
Off season production	√				
Increase in consumer demand	√				
Green technology					
i) Environmentally compatible	√				
ii) Higher production	√				
iii) Saving of cost of water	√				
iv) Fresh and residue free Produce			√		

H-highly, S- Slightly, A-Agree, D- disagree, NA -Neither agree, ND- Nor disagree

family. The average family size comprised 4.5 adults and 0.8 children. Most of the farmers (92.3 %) were educated with 61.5, 23.1 and 7.7 % having high school, intermediate and above intermediate education, respectively. The income of the family from different sources (100 sq m area) showed that farmers earned Rs. 1,654/- from agriculture under rainfed conditions (Rs/100 sq m) as compared to income of Rs. 3,110/- from agriculture using harvested water (Rs/100 sq m). The major crops grown by the farmers with the polytanks included tomato, capsicum, cucumber and bean. The design of the polylined tank was trapezoidal using LDPE with average capacity of 67.1 m^3 and average cost of Rs. 18,203/- per polylined tank. All the farmers used polylined tanks regularly. About 84.6 % farmers also used the polylined tank for fish farming. The marketing channels used for selling the produce was directly to consumer or wholesaler. Only 12.7 % of the total produce was sold to consumers while remaining 87.3 % of the produce was sold to wholesalers. The questionaire used during survey and their responses shown in Tables 3.6.2 to 3.6.5.

Table 3.6.5: Opinion of the respondents regarding Acceptability and sustainability of the technology

	Opinion	Frequency
Do you feel polyhouse cultivation is better than open field?	Yes	11
Cost of cultivation is less	No	11
Less insect-pest attack than open field	Yes	11
Impact on nutrition and food intake	Yes	11
Better quality and premium price of produce	Yes	11
Social acceptability		
Labour friendly	Slightly agree	11
Reduction in women drudgery	Slightly agree	11
Easy farm operations inside	Highly Agree	11
Off season production	Highly Agree	11
Increase in consumer demand	Moderate agree	11
Green Technology		
Environmentally compatible	Highly Agree	11
Saving of cost of pesticides and fertilizers	Slightly agree	11
Saving of water	Highly Agree	11
Residue free produce	Slightly agree	11

Table 3.6.6: Economics of vegetable cultivation in polyhouse

Particulars	Polyhouse (low cost)	Open field	Crops	Benefits of polyhouse over open cultivation
Cost (Rs/ha)	95035	76500	Tomato, Capsicum,	• High yield
Gross returns (Rs/ha)	273950	145734	French bean,	• Less insect pest attack
Net returns (Rs/ha)	178915	69234	Cauliflower, Cucumber	• Better quality and premium price
B:C Ratio	2.89	1.89	GEB=	• Opportunity of off season market

The economics fo polyhouse/greenhouse cultivation shown in Table 3.6.6 and its B:C ratio found more than 2.5, which and overall impact on livelihood and income.

4. TRAINING AND EXTENSION ACTIVITY

ICAR-CIPHET, Abohar

1. Dr. Sakharam Kale, PI (PET) participated in a 21 days CAFT training program on "Design and manufacturing of agro-processing machines" held from 1st - 21st August 2017 at CIAE, Bhopal
2. Sh. Narender Bhati and Sh. Vikas Kumar, resident of village Amarapura (Abohar) were guided for mushroom cultivation. Their farms were visited thrice by PI and Co-PI of PET centre during cropping period. Spawn of button mushroom was provided to them from funds of AICRP on PET.
3. Sh. Ankur Sharma, resident of Abohar was guided for mushroom cultivation. His farm was visited several times on regular basis during cropping period (December 2017 to February 2018).

4. Farmers' visit to PET centre: Sh. Santosh Kale and Sh. Rahul Lambe, Nashik, Maharashtra visited PET centre on 01 March 2018. They took guidance about NADEP compost unit and vermiwash unit constructed under PET project. After receiving guidance, Sh. Santosh Kale has started construction of NADEP unit and vermiwash unit at his place.
5. More than 35 farmers from Fazilka district visited PET centre individually and learnt about protected cultivation of mushrooms and other vegetable
6. Constructed four low-cost polyhouse structures at farmer's field and also provided technical guidance to them

ICAR-RC NEH, Barapani

1. Farmers from Assam, Arunachal Pradesh (Anjaw) and Meghalaya were exposed to Soil and water conservation technologies, water harvesting techniques, protected cultivation methods suitable for hill agriculture in April 2017.
2. Students of College of Post Graduate Studies (CAU), Umiam, students of Kendriya Vidyalaya, Umroi Cantonment and Shillong were exposed to Soil and water conservation technologies, water harvesting techniques, protected cultivation methods suitable for hill agriculture in April 2017.
3. Plasticulture technologies, water harvesting techniques, protected cultivation methods suitable for hill agriculture were demonstrated to 26 numbers of Soil Conservation trainees of Byrnihat, Govt. of Meghalaya in July 2017.
4. Plasticulture technologies, water harvesting techniques, protected cultivation methods suitable for hill agriculture were demonstrated to 30 numbers of Soil Conservation trainees of West Khasdihills, Nongstoin, Meghalaya in August 2017.
5. 35 numbers of students from Nagaland University were exposed to poly house, net house and pond lining water harvesting structures in October 2017.
6. 25 numbers of farmers of Nongthymwi Shillong were exposed to poly house, net house and pond lining water harvesting structures.

7. Students from Aurangabad were trained on polyhouse, net house and pond lining water harvesting structures.

8. Plasticulture technologies, water harvesting techniques, protected cultivation methods suitable for hill agriculture were demonstrated to the 27 nos of trainees of South- Garho hills deputed by NIRD &PR, Guwahati.

9. Honourable DG ICAR and Secretary DARE, Govt of India visited the site of ploy lined water harvesting structure and poly house of the division with Financial advisor of ICAR on 14th May 2017.

10. Er. S.S. Chaliha. Asst. Soil Conservation Officer, Sonitpur Soil Conservation Division, Govt. of Assam visited on 09th Feb. 2017 and inspected the site of *Jalkund* and poly house structures in the division of Agril. Engg. Division with 17 members of WDT, farmers and beneficiaries.

11. 25 nos. of SMS, Asst. Professor of Meghalaya, Manipur, Mizoram and Nagaland state were exposed to poly house technique in hilly area on 18th March 2017.

ICAR-CIFA, Bhubaneswar

1. Dr B.C. Mohapatra, PI (PET) as Project Leader of DST (TSP), Govt. of India Project operating at ICAR-CIFA and in collaboration with State Fisheries Department, Ganjam organized the Tribal Fish Farmers – Scientists – Interaction Meet and Training Programme at PNB, Farmer's Training Centre, Korapalli, Ganjam District on 5 July 2017. The fisheries officials from all CD Blocks of Ganjam District and more than 150 farmers of Kukudakhandi, Sanakhemundi, Digapahandi and Khallikote Blocks participated in the programme.

2. B.F.Sc. students (15 nos) of College of Fisheries (AAU), Raha, Assam were trained in the breeding and hatchery operation of rohu during 7-10 August, 2017 at the centre under In-Plant training programme.

3. In-Plant Training of B.F.Sc. students of College of Fisheries, Kawardha, Chhattisgarh were conducted in breeding and hatchery operation of carp on 17 October, 2017 at the centre.

4. Dr B.C. Mohapatra, PI (PET) as Chairman of the TSP (Tribal Sub Plan Programme), ICAR-CIFAorganized the "Scientists - Tribal Farmers' Interaction Meet" at Wildlife Protection Society of India Centre at Bali Island, Sunderban, West Bengal on 22 October 2017. Total 50 tribal farmers from the Island participated in the programme.

5. Dr B.C. Mohapatra, PI (PET) as Organizing Secretary organized the National Consultation Meet on "Faster reach of innovations from aquaculture research through media: A science communication perspective" at ICAR-CIFA, Bhubaneswar on 27 October 2017. Total 120 participants from all over India participated in the meet.

6. Dr B.C. Mohapatra, PI (PET) as Convener and Chairman of the TSP (Tribal Sub Plan Programme), ICAR-CIFA andin collaboration with State Fisheries Department, Ganjam Zone, Berhampur and Gram Vikas organised the Tribal School Students' Meet on "Fish as Health Food" at Gram Vikas School, Gayaganda, Ganjam District, Odisha on 24 March, 2018. Total 416 students from four schools namely Gram Vikas Vidya Vihar, UP School and Saraswati Sisu Mandir of Gayaganda, and Ashram School of Rudhapadar; and 100 officials from ICAR-CIFA, Schools, State Fisheries Department, District Administration and Gram Vikas attended the meet.

7. ICAR-CIFA, Bhubaneswar centre organized 4th National Training programme on "Installation and operation of FRP carp hatchery" during 7-10 August, 2017. 23 nos were participated

8. Dr B.C. Mohapatra, PI (PET) participated in National Fish Farmers' Day celebration held at RRC of ICAR-CIFA at Vijayawada, Andhra Pradesh during 10 July 2017

9. Dr B.C. Mohapatra, PI (PET) participated in National Fisheries Development Board (NFDB), Hyderabad sponsored training programme held at Kalinga Institute of Social Sciences (KISS), Bhubaneswar during 11 August 2017

10. Dr B.C. Mohapatra, PI (PET) participated in National Fisheries Development Board (NFDB), Hyderabad sponsored training programme at Kalinga Institute of Social Sciences (KISS), Bhubaneswar during 5 September, 2017

11. Dr B.C. Mohapatra, PI (PET) participated in Zonal Workshop on "Development of tanks/ ponds for intensive aquaculture under RKVY 2016-17" at Korapalli, Ganjam, Odisha during 10 October, 2017

12. Dr B.C. Mohapatra, PI (PET) & Mr. K. Anantharaja, CoPI (PET) participated in Annual Workshop of AICRP on PET at Birsa Agricultural University, Ranchi, Jharkhand during 6-7 December 2017

13. Dr B.C. Mohapatra, PI (PET) participated in Quinquincial Review Team Meeting of AICRP on PET at Punjab Agricultural University, Ludhiana, Punjab during 13 December 2017

14. Dr B.C. Mohapatra, PI (PET) participated in Skill Development Programme on "Freshwater carp culture" at State Fisheries, Kausalyagangaduring 27 December 2017

15. Dr B.C. Mohapatra, PI (PET) & Mr. K. Anantharaja, CoPI (PET) participated in National Conference on Improving income of farmers through agriculture and aquaculture development interventions at ICAR-CIFA, Bhubaneswar during 5-7 January, 2018

16. Dr B.C. Mohapatra, PI (PET) & Mr. Ajmal Hussan participated in 4th International Conference on Environment and Ecology at Gauhati University, Assam during 11-14 February, 2018

17. Dr B.C. Mohapatra, PI (PET) as Course Director and Co-Chairman of ICAR-CIFA-NEH programme of ICAR-CIFA in collaboration with Department of Fisheries and Assam Fisheries Development Corporation, Govt. of Assam organized the training and demonstration programme on "Scientific fish farming practices and operation of FRP carp hatchery" at Majuli, the largest River Island of the world in Assam during 28-30 April, 2017. Total of 55 participants attended the training program.

18. Dr B.C. Mohapatra, PI (PET) as Organizing Secretary and Co-Chairman of ICAR-CIFA-NEH programme of ICAR-CIFA conducted one-day Workshop on "Technological interventions of ICAR-CIFA towards blue revolution in Arunachal Pradesh" in collaboration with State Fisheries Department of Arunachal Pradesh at Itanagar on 16 May, 2017. It was attended by all District Fisheries Officers, FEOs, Director and Commissioner of Fisheries of the state.

19. Dr B.C. Mohapatra, PI (PET) as Co-convener and Chairman of the TSP (Tribal Sub Plan Programme), ICAR-CIFA organized One-day Workshop on "Sustainable aquaculture by tribal fish farmers of Gujarat" at Jambusar, Bharuch District of Gujarat on 2 June, 2017. More than 130 participants including scientists, academicians, extension officials, development officers and progressive tribal fish farmers attended the event.

20. The AICRP on PET centre conducted 4th National Training programme on "Installation and operation of FRP carp hatchery" at ICAR-CIFA, Bhubaneswar, Odisha during 7-10 August, 2017. Twenty three persons participated in the programme.

21. Dr B.C. Mohapatra as Chairman of the TSP (Tribal Sub Plan of Planning Commission), ICAR-CIFA and Course Director organized the Training Programme on "Freshwater aquaculture as a livelihood option for tribal youths of Assam" held at CIFA, Bhubaneswar, Odisha during 6-

10 November, 2017. The programme was sponsored by 21 Battalion, the Mahar Regiment, Indian Army, Nalabari, Assam. 19 tribal youths from Assam and 4 military personnel took the training.

ICAR-CIRG, Makdhoom

1. International conference on climate change adaptation and biodiversity: ecological sustainability and resource management for livelihood security held during 8-10 December, 2016 at CIARI, Portblair, A&N Islands, India.
2. Attended 9th Livestock Championship and Agri & Livestock Expo-2016 from 2nd-5th December, 2016 at Mukatsar Sahib, Punjab organized by Department of AH, Fisheries and Diary Development, Punjab.
3. Dr N. Ramachandran, PI (PET) and Dr S. P. Singh as Recourse person in programmes Delivered lectures and demonstrated the farmers during various training programmes organised at our Institute during the period.
4. Three 10 days National training on "Scientific Goat Farming" held at CIRG, Makhdoom Since January 2017.
5. Four 3-7 days sponsored training on "Scientific Goat Farming" held at CIRG, Makhdoom since January 2017.

CAEPHT, Gangtok

1. Dr. Deepak Jhajharia, Assoc. Prof. & PI, AICRP-PET and Mrs. Kh. Lily Devi, Jr. Scientist, AICRP-PET attended three days training programme on "Integrated Farming System for Sustainable Hill Agriculture" (September 18-20, 2017) and delivered lectures on Protected cultivation of high value crops and demonstration of different polyhouse structures suitable for NEH region for round the year cultivation of fruits, vegetables and flowers for higher productivity.
2. Dr. D. Jhajharia, PI (AICRP on PET) and Mrs. Kh. Lily Devi, Junior Research Scientist (Hort.), AICRP on PET attended QRT (2012-17) Meeting, AICRP on PET held at CAU, Imphal, Manipur during November 29-30, 2017.
3. Mrs. Kh. Lily Devi attended the National seminar on Floriculture for rural and urban prosperity in the scenario of climate change (16-18 Feb, 2018) organized by NRC for Orchids held at CAEPHT, Ranipool and presented a paper entitled "Performance of Asparagus (*Asparagus officinalis*) cultivation within naturally ventilated polyhouse as compared to open field condition.
4. The construction work of the Naturally ventilated polyhouse (NVP) along with the plastic mulch was completed with the financial and technical support of both the College of Agricultural Engineering & Post Harvest Technology (CAU,Imphal), Ranipool, Gangtok (Sikkim) and the AICRP on PET, Gangtok Centre (CAEPHT), Sikkim at Soureni village, Ward No. 1, Assam Lingzey, East Sikkim in the month of November 2017. The farmer arranged the bamboo materials from the near-by forest area on his own.
5. Technology and Machinery Demonstration Mela 2018 jointly organized by AICRPs on FIM, ESA, UAE and PET Centre of CAEPHT held at CAEPHT, Ranipool on 20th Feb, 2018.
6. Demonstrations of polyhouses/research activities under AICRP-PET in the campus/off-campus (outreach activities in farmers field) to 18 numbers of farmers during Exposure visit of farmers under Kisan Business School (KBS), Bishnupur District, Manipur at CAEPHT, CAU during March 7-15, 2018.
7. The construction of one more NVP was completed with the financial and technical

support from both the College of Agricultural Engineering & Post Harvest Technology (CAU, Imphal), Ranipool, Gangtok (Sikkim) and the AICRP on PET, Gangtok Centre (CAEPHT), Sikkim in the month of March 2018 at the farmer's field of Mr. PratapThatal, Soureni village, Assam Linzey, East Sikkim of area (80 ft X 16 ft) and crop plan to take up is capsicum.

8. Dr. D. Jhajharia, PI (AICRP on PET) and Mrs. Kh. Lily Devi, Junior Research Scientist (Hort.), AICRP on PET attended the XIII Annual workshop of the AICRP on PET held at Birsa Agricultural University, Ranchi, Jharkhand during December 6-7, 2017.

9. Two-days training on "Low-cost Greenhouse Technology" was organized at Soureni Village, Assam Lingzey, East Sikkim by Dr. D. Jhajharia, Associate Professor (SWCE) & PI of the AICRP-PET Organized the program at Assam Lingzey. About 200 "Tagar" (medicinal) plants were also distributed by Dr. R. P. Misra, Chief Guest of Programme, and Dr. J K Shukla, Scientist i/c of the IBSD Imphal (Gangtok Centre).Dr. S K Sharma, Dean CoH (Bermiok), Dr. M. S. Seveda, Prof. &HoD (REE), Dr. A K Vashisht (Assoc. Prof.), Dr. Rakesh Kumar (Assist. Profe.) and staff members of the AICRP on PET were present as distinguished guests and experts. Training on the use of the plastic mulch and drip irrigation in the polyhouse was completed with the financial and technical support of both the College of Agricultural Engineering & Post Harvest Technology (CAUImphal), Ranipool, Gangtok (Sikkim) and the AICRP on PET, Gangtok Centre (CAEPHT), Sikkim at Soureni village, Ward No. 1, Assam Lingzey, East Sikkim.

10. Mrs. Kh. Lily Devi attended the National seminar on Floriculture for rural and urban prosperity in the scenario of climate change (16-18 Feb, 2018) organized by NRC for Orchids held at CAEPHT, Ranipool and presented a paper entitled "Performance of Asparagus (*Asparagus officinalis*) cultivation within naturally ventilated polyhouse as compared to open field condition.

11. Dr. D. Jhajharia, PI (AICRP on PET) attended Brainstorming workshop held at ICAR, CIPHET, Ludhiana during November 9, 2017.

BAU, Ranchi

1. Dr. R. C. Srivastava, Hon'ble VC, Dr. Rajendra Prasad Central Agricultural University, Pusa, Samastipur& Dr. S.K. Jain, Professor, College of Agricultural Engineering, Dr. Rajendra Prasad Central Agricultural Univesity, Pusa, Samastipur visited the Department of Agricultural Engineering, BAU, Ranchi on 10.04.2017.

2. The Research & Budget Committee meeting for Kharif 2017 of the Department of Agricultural Engineering, BAU, Ranchi was conducted on 29.04.17. During meeting progress report of Kharif 2016 and technical programme of Kharif 2017 was presented for PET, Ranchi centre.

3. The Ms. Rasha Omar, Country Programme Manager, IFAD India, Sri BhujendraBaski, State project Director, JTDS, Jharkhand, Sri. Manoj Sinha, Additional project Director, JTDS, Jharkhand and Dr. P. Kaushal, Hon'ble VC, BAU visited the Plasticulture Technology Information Centre (PTIC) on 08.05.17.

4. Er. D. K. Rusia, RE (PET) & Dr. Pramod Rai participated in 37th Kharif Research Council Meeting organized by Directorate of Research, BAU, Kanke, Ranchi from 04-05, July 2017.

Er. D. K. Rusia presented the work done in kharif 2016 and presented the work plan for kharif 2017.

5. Er. D. K. Rusia, RE (PET) & Dr. Pramod Rai participated in QRT (2012-17) review meet of AICRP on PET held at AGFE, IIT, Kharagpur from 25-26 September 2017. Dr. Pramod Rai presented the QRT report for 2012-17.

6. Dr. Pramod Rai attended the short term course on "Recent Advances in Utilization of Renewable Energy and Energy Conservation" from November 1–10, 2017 at Department of Unconventional Energy Sources & Electrical Engineering, Dr. PanjabraoDeshmukh Krishi Vidyapeeth, Akol.

7. Er. D. K. Rusia, RE (PET) & Dr. Pramod Rai participated in 37th Rabi Research Council Meeting organized by Directorate of Research, BAU, Kanke, Ranchi on 20th November 2017.

Er. D. K. Rusia presented the work done in Rabi 2016 and presented the work plan for Rabi 2017 for PET Ranchi centre.

8. Dr. Pramod Rai delivered lecture on "Overview of Application of Plasticulture Technology" and exhibited the Plasticulture Technology Information Centre (PTIC) & field visit on 26.2.18 during one day orientation programme for Fifty Three farmers sponsored by SPWD (NGO), Ranchi, Jharkhand.

9. Dr. Pramod Rai delivered lecture on "Overview of Application of Plasticulture Technology" and exhibited the Plasticulture Technology Information Centre (PTIC) & field visit on 10.03.18 during one day orientation programme for thirty trainees of PMKVY course of Micro irrigation Technician organized by Punjab Regimental Centre, Ramgarh Cantt., Jharkhand.

10. Dr. Pramod Rai delivered lecture on "Post Harvest Technology" dated 12.1.18 to Agricultural graduates during two months training programme under Agri Clinics and Agri Business Centre Scheme (ACABC).
11. Dr. Pramod Rai delivered lecture on "Overview of application of Plastic Technology in Jharkhand" dated 24.01.18 during Skill Development training on Greenhouse Operator (15.01.2018 – 13.02.2018) under Agriculture Skill Council of India conducted by PFDC, Department of Agricultural Engineering, Ranchi.
12. Dr. Pramod Rai delivered lecture on "Operation and management of different protected cultivation technologies" dated 31.01.18 during Skill Development training on Greenhouse Operator (15.01.2018 – 13.02.2018) under Agriculture Skill Council of India conducted by PFDC, Department of Agricultural Engineering, Ranchi.
13. Dr. Pramod Rai delivered lecture on "Vegetable cultivation under greenhouse and shade net" dated 01.02.18 during Skill Development training on Greenhouse Operator (15.01.2018 – 13.02.2018) under Agriculture Skill Council of India conducted by PFDC, Department of Agricultural Engineering, Ranchi.
14. Dr. Pramod Rai delivered lecture on "Role of water in agriculture framing & its management using different method & technology" dated 16.03.18 during Diploma in Agriculture Extension Services for Input Dealers (DAESI) organized by SAMETI, Ranchi, Jharkhand.
15. The one day training programme for sixteen farmers on "Overview of Application of Plasticulture Technology" was organized by PET Ranchi centre on 24.03.18 and it was sponsored by Chotanagpur Sanskritik Sangh (NGO), Ranchi. The lecture, exhibition of the Plasticulture Technology Information Centre (PTIC) & field visit was done during training programme.
16. Dr. Pramod Rai delivered lecture on "Introduction and importance of different types of micro irrigation systems" dated 28.05.18 during DAESI training organized by ATMA, Ranchi and sponsored by MANAGE, Hydrabad.
17. The AICRP on PET Ranchi centre participated in Agrotech 2018 held at BAU from 03.02.18 to 05.02.18. The entire plasticulture technology models desired for Jharkhand were shown.
18. The AICRP on PET, Ranchi centre participated in Technology and Machinery Demonstration Mela on 16.02.18 at Department of Agricultural Engineering, BAU, Ranchi.

UAS, Raichur

1. Dr. B. Maheshwara Babu, RE (PET) participated in 12th Biennial Workshop of

AICRP on Plasticulture Engineering And Technology held at MPUAT, Udaipur during 15-16 Dec, 2016

2. Dr. B. Maheshwara Babu, RE (PET) participated in National Seminar on Trends in Farm Mechanization & Engineering Interventions for Sustainable Agriculture held at ANGRAU, Tirupati, A.P 19-20th, January, 2017.

3. Maheshwara Babu, RE (PET) and Kavita Kandpal participated in KSTA National conference on Science and technology Education, Karnataka Science and Technology Academy (KSTA) held at University of Agricultural Sciences, Raichur during 21-22, July, 2017

4. Dr. B. Maheshwara Babu, RE (PET) participated in 7th National conference on novel polymeric materials (NPM) synthesis, processing and characterization, held at Sri Jayachamarajendra College of Engineering, JSS Science and Technology University, Mysore during 15-16, September, 2017

5. Dr. B. Maheshwara Babu, RE (PET) participated and demonstrated the use of different types of plastic mulches during different programmes held at UAS, Raichur. The benefits of mulching in terms of water conservation, reducing weed problems, moisture conservation, temperature maintenance of soil in both open filed and polyhouse were explained to farmers during Krishi Mela 2016 held on 5.11.2016 to 8.11.2016 at UAS, Raichur.

6. Dr. B. Maheshwara Babu, RE (PET) has given training on use of plastics in agriculture and green house structure and its maintenance to 20 farmers of Raichur, Bijapur, Bagalkot, Koppal on 14-2-2017 at CAE, Raichur.

7. Dr. B. Maheshwara Babu, RE (PET) gave training on use of plastics in agriculture to 80 input dealers or fresh candidates who were willing to start input dealership under one year "Diploma in Agriculture Extension Service for Input dealers (DAESI)" conducted by the University of Agricultural Sciences, Raichur in

collaboration with MANAGE, Hyderabad and SAMETI (North), UAS, Dharwad on 19-2-2017 and 26-2-2017 at KVK, Raichur.

8. All the AICRPs at CAE, UAS, Raichur i.e. AICRP on FIM, PHET, UAE, RAE and PET joined hands and conducted and organised a "Technology Machinery Demonstration Mela" with different types of agricultural technologies available such as use of plastics in agriculture. Machineries used from cultivation to harvesting were exhibited. Regarding Plasticulture scheme, different type of plastic mulches, mole plough and drip laying machines were exhibited and the benefits of mulching in terms of water conservation, reducing weed problems, moisture conservation, temperature maintenance of soil were explained to farmers during mela.

9. Dr R. K. Singh, Project Coordinator, AICRP on PET, CIPHET, Ludhiana visited the UAS, Raichurcentre on 17.3.2017 and 18.3.2017.

10. Technology and Farm Machinery Demonstration Mela -2017was organized jointly by AICPR on Farm Implements and Machinery, AICRP on Energy in Agriculture and Agro – based Industries, AICRP on Utilization of Animal Energy, AICRP on Post Harvest Engineering and Technology and AICRP on Plasticulture Engineering and Technology on 10-02-2017 from 10 am to 6 pm at College of Agricultural Engineering, University of Agricultural Science, Raichur.

11. Dr. B. Maheshwara Babu, RE (PET) given a training on use of plastics in agriculture to 40 input dealers or fresh candidates who were willing to start input dealership under one year "Diploma in Agriculture Extension service for input dealers (DAESI)" conducted by the University of Agriculture Science, Raichur in collaboration with MANAGE, Hyderabad and SAMETI (North), UAS, Dharwad on 23-3-2017 at Agricultural College, Raichur.

JAU, Junagadh Centre

1. Junagadh had organized a "Technology & Machinery Demonstration Mela" on January 22-23, 2018 in collaboration with all AICRPs and CRP on EA of the college. On January 22, 2018 the farmers visited the Mela and on Jan 23, 2018 the exhibition was visited by the scientists participating in the 33rd Annual Workshop of AICRP on Post Harvest Engineering and Technology held at the College. Main aim of this mela was to popularize the technologies / machineries developed under About 1000 farmers (men and women), 200 Scientists of JAU, Junagadh, 100 scientists of ICAR & from various University of India of AICRP on Post Harvest Engineering & Technology and 200 staff and students and media persons etc. (Total 1500 participants) participated in this Technology and Machinery Demonstration Mela during these two days.

2. Participated in Krushimela at Junagadh on May 09, 2017 during the KrushiMahotsava – 2017 organized by Govt. of Gujarat. Live demonstration of poly-cum-shadenet house, Mulching and drip irrigation was made at mela site and technical information was provided to the farmers. Technical information and literature on plasticulture were provided to the farmers at the stall of College.
3. Team, JAU, Junagadh Centre participated in Krushimela at Jam-khambhaliya (Dist. Jamnagar) on May 13, 2017 during the KrushiMahotsava – 2017 organized by Govt. of Gujarat. Technical information and literature on plasticulture were provided to the farmers at the stall of College.
4. Team, JAU, Junagadh Centre participated in Krushimela at Tadkapipaliya (Dist. Junagadh) during May 14-16, 2017 and technical information and literature on plasticulture were provided to the farmers at the stall of College.
5. Team, JAU, Junagadh Centre participated in Krushimela at Gondal on May 19, 2017 during the KrushiMahotsava – 2017 organized by Govt. of Gujarat. Live demonstration of poly-cum-shadenet house, Mulching and drip irrigation was made at mela site and technical information was provided to the farmers. Technical information and literature on plasticulture were provided to the farmers at the stall of College.
6. Team, JAU, Junagadh Centre participated in Krushimela at Surendranagar on May 23, 2017 during the KrushiMahotsava – 2017 organized by Govt. of Gujarat. Technical information and literature on plasticulture were provided to the farmers at the stall of College.

7. Team, JAU, Junagadh Centre participated in Krushimela at Swaminarayan Gurukul, Rajkot during December 21-25, 2017.
8. Four lectures on (1) Micro irrigation systems and (2) Greenhouse / net house technology (3) Mulching technology and (4) Packaging and transportation of fruits and vegetables' were delivered to BRS students (30) at Farmer training centre Junagadh during October 03-05, 2017.
9. A lecture on "Automization in net house/ greenhouse" was delivered to progressive farmers (30) during training organized by Director of Extension Education, JAU, Junagadh on November 14, 2017.
10. A lecture on "Temperature and relative humidity control in net house/greenhouse for fruits and vegetable cultivation" was delivered to progressive farmers (30) during training organized by Director of Extension Education, JAU, Junagadh on November 23, 2017.
11. A lecture on "Advanced packaging technology for fruits and vegetable" was delivered in farmer training organized by ATMA project, Junagadh on January 10, 2018.
12. Sixth semester B.Tech. (Agril. Engg.) students (105) have visited PET laboratory and MAP technology and transportation container were demonstrated on April 04, 2017.
13. Ladies farmers from ATMA of different villages like Vadal, Kathrota and Choki from Junagadh district were guided for greenhouse/nethouse, low tunnel and mulching technology in fruits and vegetables on September 4, 2017.

14. Officers from Africa visited PET laboratory and PET nursery on September 18, 2017
15. ICAR accreditation team visited PET laboratory and PET nursery on September 29, 2017.
16. BRS students (30) at Farmer training centre, Junagadh were demonstrated transportation box, packaging in PET lab as well as Poly-cum-shadenet house and green house at nursery on October 05, 2017.
17. Dr. A.R. Pathak, VC, Dr. V.P. Chovatia, DR, Dr. A.M. Parakhiya, DEE, Dr. P.V. Patel, DSW and Dr. N.K. Gontia, Principal & Dean, CAET visited PET nursery on October 17, 2017.
18. ME (Electronics & Communication) students (03) from Atmiya Institute of Technology and Science, Rajkot guided for scope of their discipline in automation of greenhouse on November 17, 2017.
19. Dr. I.U. Druj, Associate Director of Research, JAU, Junagadh visited field experiment on off-season okra cultivation under protected environment on November 18, 2017. Benefits of of protected environment for off-season okra cultivation were discussed with him
20. Seventh semester B.Sc. (Agri) students (25) from College of Agriculture, Mota Bhandariya, Amreli were demonstrated transportation box, packaging in PET lab as well as Poly-cum-shadenet house and green house at nursery on December 14, 2017.
21. Seventh semester B.Sc. (Agri) students (02) from College of Agriculture, JAU, Junagadh guided for project preparation on greenhouse on December 14, 2017.
22. A field visit at farmers field was carried out with Dr. R.K. Singh, PC-PET, CIPHET, Ludhiana to visualize the adoption level and experience of

mulching technology for water melon, tomato and other vegetable crops to a progressive farmer named 1) Ranjitbhai Barad at Village: Chamada, 2) Bhimashibhai Merashibhai Solanki, Village: Ambaliala, Ta: Veraval, Dist: Gir-somnath on February 08, 2018.

23. Visit of field experiments on drip irrigation in different crops like sweet corn, wheat, brinjal under AICRP on IWM at RTTC farm was carried out with Dr. R.K. Singh, PC-PET, CIPHET, Ludhiana on February 09, 2018.

24. A field visit at Fisheries Research station, Okha was carried out with Dr. R.K. Singh, PC-PET, CIPHET, Ludhiana to discuss the use plastic in fisheries on February 10, 2018.

25. An Industrial visit at Parth Polywoven, Junagadh (a manufacturer of plastic mulch film) was carried out with Dr. R.K. Singh, PC-PET, CIPHET, Ludhiana on February 11, 2018.

26. Visit of experiments under AICRP on PET 1) Off-season okra cultivation under protected environment, 2) chickpea packaging for storage was carried out with Dr. R.K. Singh, PC-PET, CIPHET, Ludhiana on February 09, 2018.

27. Visit of Dr. A.R. Pathak, Hon'ble Vice chancellor, JAU, Junagadh with Dr. R.K. Singh, PC-PET, CIPHET, Ludhiana for discussion of AIRP on PET on February 09, 2018.

28. A Farmer (Punabhai Posiya) Village: Khajurada, Ta. : Jam-kandorna, Dist. : Rajkot was guided for mulching technology in water melon and vegetables on March 30, 2017.

29. Ph.D. student of horticulture faculty was guided for recording of environmental parameters inside the fan & pad greenhouse for his research project.

30. A field visit was carried out for providing technical guidance for mulching technology of groundnut and other fruits and vegetables to a progressive farmer named Hiteshbhai Domadiya at Village: Vadal Ta & Dist: Junagadh on June 09, 2017.

31. A field visit was carried out for providing technical guidance for mulching technology of cotton, groundnut and other fruits and vegetables to the progressive farmers named 1) Dineshbhai Bhikhabhai Dhorajiya Village: Majevadi, Ta & Dist.: Junagadh and 2) Hiteshbhai Domadiya at Village: Vadal, Ta & Dist.: Junagadh on July 29, 2017.

32. Ph.D. student of horticulture faculty was guided for cost of construction of Fan & Pad type greenhouse on August 02, 2017.

33. Fortune Multipack, Junagadh, a manufacturing company of plastic mulch was visited on August 03, 2017. Importance and requirement of plastic mulching for crop cultivation were discussed with the manufacturer.

34. Shri Dipesh sanchla, Kutch district was guided through e-mal for soil less farming on August 09, 2017.

35. A field visit was carried out for providing technical guidance for greenhouse/nethouse and mulching technology in fruits and vegetables to the progressive farmer named Kanubhai Shilpi, Village: Bamangam, Ta: & Dist.: Junagadh on August 28, 2017.

36. A field visit was carried out for providing technical guidance for nethouse of rose cultivation and mulching technology in tomato (2 acre) and drip irrigation in flowers like marigold, rose and vegetables like bean and bottle gourd (9 acre) to the progressive farmers named 1) Chandubhai Mahadevbhai Hirapara, Village: Bhutvad, Ta: Dhoraji, Dist.: Rajkot and 2) Jentibhai Bavnjibhai Jograjiya, Village: Bhutvad, Ta: Dhoraji , Dist.: Rajkot on September 07, 2017.

37. A field visit was carried out for providing technical guidance for sprinkler irrigation in groundnut crop to the progressive farmer named Ramji Bhanji Khunt, Village: Mendarda, Dist.: Junagadh on October 13, 2017.

38. A farmer (Denish Mavani) Village & Taluka: Dhoraji, Dist.: Rajkot was guided for construction of greenhose on January 20, 2018
39. A farmer (Raghubhai Popatbhai Bhesaniya) Village: Tadaka-pipaliya, Taluka: Bhesan, Dist.: Junagadh was guided for mulching technology for water melon cultivation on January 25, 2018.
40. A field visit was carried out for providing technical guidance for drip irrigation in vegetable crop to the farmers Village: Trakuda, Dist.: Rajkot on February 03, 2018.
41. Cotton Research station, JAU, Junagadh was guided for plastic requirement for soil solarization.
42. M.Tech. students visited the off-season okra cultivation under protected environment on March 03, 2018.

VPKAS, Almora

1. Dr. Sher Singh, PI (PET) participated in the 47th Annual Group Meeting of AICRP on Soybean held at GBPUA&T, Pantnagar from 02 to 04 May 2017.
2. Dr. Sher Singh, PI (PET) attended 4th Meeting of "Indian Grain Storage Working Group (IGSWG)" at New Delhi from 11 to 12 Jun 2017.
3. Dr. Sher Singh, PI (PET) attended the ICAR-IFAD Interaction Workshop on "Integrating Renewable Energy Technology for Smallholder Agriculture in India" at NASC Complex New Delhi on 03 Aug 2017.
4. Dr. Sher Singh, PI (PET) participated in the "Kaushal Vikas Se KrishiVikas" – National Workshop on Skill Development in Agriculture at Chandigarh on 15 Sep 2017.
5. Dr. Sher Singh, PI (PET) and Er. Shyam Nath participated in the QRT meeting of AICRP on PHET and AICRP of PET held at MPUA&T, Udaipur from 26 to 27 Oct 2017.
6. Dr. Sher Singh, PI (PET) and Er. Jitendra Kumar attended the Interaction meeting with members of World Bank Implementation Review and Support Mission to Gramya – II project area at Almora on 30th Nov 2017
7. Dr. Sher Singh, PI (PET) and Er. Shyam Nath attended the 13th Annual Workshop of AICRP on PET at BAU, Ranchi during 06-07 December 2017.
8. Dr. Sher Singh, PI (PET) and Er. Shyam Nath attended the 33rd Annual Workshop of AICRP on PHET at JAU, Junagarh during 23-25 January 2018.
9. Dr. Sher Singh, PI (PET), Er. Shyam Nath and Er. Jitendra Kumar attended the National Agronomy Congress at GBPUA&T, Pantnagar held during 20-22 Feb 2018.

10. Dr. Sher Singh, PI (PET) and Er. Shyam Nath International Conference held at CSAUA&T, Kanpur during 14-17 February 2018
11. Dr. Sher Singh, PI (PET) attended the seminar on "Emerging Trends in Hi-tech Hill Horticulture in Changing Climate" at ICAR-CITH Regional Station, Mukteshwar and made lead paper presentation on 6th Mar 2018.
12. Dr. Sher Singh, PI (PET) attended National conference on "Promoting entrepreneurial growth through innovative approaches in food processing sector", ICAR-CIPHET, Ludhiana on March 16-17, 2018.
13. Dr. Sher Singh, PI (PET), Er. Shyam Nath and Er. D.C. Mishra participated in the Kisan Mela organized at ICAR-VPKAS, Almora on 07 Oct 2017.
14. Dr. Sher Singh, PI (PET) organized and pparticipated in the Field Day on Soybean at village Raun-Daal (Almora) on 09 Oct 2017.
15. Dr. Sher Singh, PI (PET), Er. Shyam Nath, Er. Jitendra Kumar and Er. D.C. Mishra participated in the Kisan Mela organized at ICAR-VPKAS, Almora on 23 Mar 2018 as well as Technology and Machinery Demonstration Mela.
16. Er. D.C. Mishra participated in All India 103rd farmers' festival during Feb 24-27, 2018 at GBPUA&T, Pantnagar.
17. Dr. R.K. Singh, Project Co-ordinator, AICRP on PET, ICAR-CIPHET, Ludhiana visited the centre and project sites (Bhagartola and Mukteshwar) during 03 to 05 May 2017.

PAU, Ludhiana

1. Dr. K.G. Singh, RE (PET) and Angrej Singh, attended Research & Extension specialist's workshop for Vegetables, Floriculture and Sericulture along with post harvest management, Farm machinery, Food technology and Agricultural economics at PAU, Ludhiana on 31 May & 1 June 2017.
2. Dr. K.G. Singh, RE (PET) delivered lecture during technical session III of Research & Extension specialist's workshop for Vegetables, Floriculture and Sericulture along with post harvest management, Farm machinery, Food technology and Agricultural economics on the topic **Soil less cultivation of vegetables in polyhouse** at PAU, Ludhiana on 01 June, 2017.
3. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh, Asstt Agronomist attended Brain storming workshop on standardization of Design specifications of Greenhouse structureson 9November, 2017 at, CIPHET Ludhiana.
4. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh participated in 13th Annual Workshop of All India Coordinated Research Project on Plasticulture Engineering and Technology at Birsa Agricultural University, Ranchi on 6-7 December, 2017.
5. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh, Asstt Agronomist, attended Research & Extension specialist's workshop for Fruits, Mushroom, and Agroforestry along with post harvest management, Farm machinery & Food technology and Agricultural economics on 11-12 January, 2018 at PAU, Ludhiana.
6. Dr. K.G. Singh, RE (PET) and Angrej Singh, attended Research & Extension specialist's workshop for *Kharif*crops at PAU, Ludhiana on 21-22 February, 2018.
7. Dr. K.G. Singh, RE (PET) and Angrej Singh, attended Research & Extension specialist's workshop for Vegetables, Floriculture and Sericulture along with post harvest management, Farm machinery, Food technology and Agricultural economics at PAU, Ludhiana on 31 May & 1 June 2017.
8. Dr. K.G. Singh, RE (PET) delivered lecture during technical session III of Research & Extension specialist's workshop for Vegetables,

Floriculture and Sericulture along with post harvest management, Farm machinery, Food technology and Agricultural economics on the topic **Soil less cultivation of vegetables in polyhouse** at PAU, Ludhiana on 01 June, 2017.

9. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh, Asstt Agronomist attended Brain storming workshop on standardization of Design specifications of Greenhouse structureson 9November, 2017 at, CIPHET Ludhiana.

10. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh participated in 13th Annual Workshop of All India Coordinated Research Project on Plasticulture Engineering and Technology at Birsa Agricultural University, Ranchi on 6-7 December, 2017.

11. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh, Asstt Agronomist, attended Research & Extension specialist's workshop for Fruits, Mushroom, and Agroforestry along with post harvest management, Farm machinery & Food technology and Agricultural economics on 11-12 January, 2018 at PAU, Ludhiana.

12. Dr. K.G. Singh, RE (PET) and Angrej Singh, attended Research & Extension specialist's workshop for *Kharif*crops at PAU, Ludhiana on 21-22 February, 2018.

13. Dr. K.G. Singh, RE (PET) organized Skill development programme for Green house operator, from 12.02.2018 to 13.03.2018 under the Skill Council of India.

14. Dr. K.G. Singh, RE (PET) delivered lecture on topic, "Introduction to Soilless cultivation in protected structures" in a training programme on Drip irrigation, fertigation and protected cultivation from 24-28 July, 2017 organized in the department of Soil and Water Engineering.

15. Dr. K.G. Singh, RE (PET) delivered lecture on topic, "Construction of shade nets/polynet houses for cultivation of vegetables" in a training programme on Drip irrigation, fertigation and protected cultivation from 24-28 July, 2017.
16. Dr. K.G. Singh, RE (PET) participated in Regional KisanMela at Gurdaspur on 08 September, 2017, guided farmers for adopting drip irrigation, fertigation and protected cultivation using soilless media in nethouse/ polynet house or naturally ventilated polyhouse.
17. Dr. Angrej Singh, Co-PI (PET) participated in Kisan Divas at Nag Kalan (Amritsar) on 12 September, 2017, guided farmers for adopting drip irrigation, fertigation and protected cultivation of different vegetables.
18. Dr. Angrej Singh, Co-PI (PET) delivered lecture and demonstrated micro-irrigation, soil less cultivation, rainwater harvesting from polyhouse rooftop system for young farmers of training programme on integrated crop production on 19 September, 2017 at the research Farm department of Soil and Water Engineering, PAU, Ludhiana.
19. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh, Co-PI (PET) participated in KisanMela at PAU, Ludhiana on 22-23 September, 2017, guided farmers for adopting Drip irrigation, fertigation and protected cultivation using soilless media in nethouse/polynet house or naturally ventilated polyhouse
20. Dr. Angrej Singh, Co-PI (PET) participated in KisanMela at Regional Station Bathinda on 27 September, 2017, guided farmers for adopting Drip irrigation, fertigation and protected cultivation of different vegetables in polyhouse/ nethouse.
21. Dr. Angrej Singh, Co-PI (PET) delivered lecture on basics of crop cultivation in training a training programme organized for skill development programme on micro irrigation Technician from 1-30 January, 2018 in the department of Soil and Water, Engineering, PAU, Ludhiana.
22. Dr Angrej Singh, Co-PI (PET) Delivered Lecture on use of different kinds of mulch and year round utilization of micro irrigation system on 30.01.2018 during the training programme on micro irrigation under Pradhan Mantri Krishi Sinchai Yojana organized by PAMETI, Ludhiana from 29-30 January, 2018.
23. Dr. K.G. Singh, RE (PET) delivered lecture on design of drip irrigation system for orchard and Vegetable crops on 30.0.1.2018 during the training programme on Micro irrigation Under Pradhan MantriKrishiSinchaiYojana organized by PAMETI, Ludhiana from 29-30 January, 2018.
24. Dr. K.G. Singh, RE (PET) delivered lecture on construction of shade nets/poly net house on 08.02.2018 during the training programme on Micro irrigation, fertigation and protected cultivation of flowers from 5-9 February, 2018.
25. Dr. Angrej Singh, Co-PI (PET) delivered lecture and demonstrated Micro irrigation systems at the research farm department of Soil and Water Engineering, PAU Ludhiana on 05.02.2018 during the training programme on Micro irrigation, fertigation and protected cultivation of flowers from 5-9 February, 2018.
26. Dr. Angrej Singh, Co-PI (PET) delivered lecture on techniques for nursery raising for protected cultivation and training pruning of poly house crops in Skill development training programme on Greenhouse Operator on 17.02.2018 organized in the department of Soil and Water Engineering.
27. Dr. Angrej Singh, Co-PI (PET) delivered lecture and demonstrated the protected cultivation of vegetables in soilless media for students of B.Sc. third year students of MCM, DAV, College Chandigarh on 23.02.2018 (Forenoon)

28. Dr. Angrej Singh, Co-PI (PET) delivered lecture on harvesting and grading of greenhouse crop produce (Capsicum, Tomato and Cucumber) in a training programme of greenhouse operator on 28.02.2018

29. Dr. Angrej Singh, Co-PI (PET) participated in Kisan Divas at BallowalSaunkhari (Shaheed Bhagat Singh Nagar) on 6 March, 2018, guided farmers for adopting drip irrigation, fertigation and protected cultivation of different vegetables.

30. Dr. K.G. Singh, RE (PET) participated in Kisan Divas at Faridkot on 08 March,2018 guided farmers for adopting drip irrigation, fertigation and protected cultivation using soilless media in nethouse/polynet house or naturally ventilated polyhouse.

31. Dr. K.G. Singh, RE (PET) and Dr. Angrej Singh, Co-PI (PET) participated in Kisan Mela at PAU, Ludhiana on 23-24 March, 2018, guided farmers for adopting Drip irrigation, fertigation and protected cultivation using soilless media in net house/poly net house or naturally ventilated poly house

32. Dr. Angrej Singh, Co-PI (PET) delivered lecture on harvesting and grading of greenhouse crops (Capsicum, Tomato and Cucumber) as per requirement to trainees of Greenhouse operator on 28.02.2018

33. Dr. Angrej Singh, Co-PI (PET) delivered lecture and demonstrated protected cultivation in soilless media, rooftop rain water harvesting from poly house and recharging structures in training course on protected cultivation of Vegetables in the department of Soil and Water, Engineering, PAU, Ludhiana on 28.03.2018.

5. PUBLICATIONS

Research paper

1. Kale SJ, Prerna Nath. 2018. Kinetics of Quality Changes in Tomatoes Stored in Evaporative Cooled Room in Hot Region. *International Journal of Current Microbiology and Applied Sciences*, 7(06): doi: https: //doi.org/10.20546/ijcmas.2018.706.xx.
2. Ajinath Dukare, Sakharam Kale, Pankaj Kannaujia, Navnath Indore, Manoj Kumar Mahawar, R.K. Singh, R.K. Gupta. 2017. Root development and nodulation in cowpea as affected by application of organic and different types of inorganic/plastic mulches. *International Journal of Current Microbiology and Applied Sciences*, 6(11): 1728-1738. doi: /10.20546/ijcmas.2017.611.209.
3. Kale SJ, Prerna Nath, Meena VS. 2018. Semi-permanent shadenet house for reducing sunburn in pomegranates (Punica granatum) produced in hot region. *Scientia Horticulturae* (Short communication, under review).
4. Kale SJ, Prerna Nath, Meena VS, Indore NS, Singh RK. 2018. Innovative polyhouse for button mushroom (*Agaricus Bisporus*) farming in hot region. *Indian Journal of Agricultural Sciences* (Communicated).
5. Ngachan S.V., Sethy, B.K. 2017. Land and water management for livelihood improvement of small and marginal farmers in north eastern hill region. Farmers First for Conservation Soil and Water Resources in North Eastern Region (FFCSWR-2017)" Published by Indian Association of Soil and Water Conservationist, Dehradun, Uttarakhand. pp: 4-21.
6. Sethy, B.K., Kumar, A., and Ngachan, S.V.2016.Farm Mechanization in Hill Ecosystem: Issues, Challenges and Strategies. Agriculture Development and Agromet Advisory Services of Nagaland.51-60.
7. Anantharaja, K., B.C. Mohapatra, B.R. Pillai, R. Kumar, C. Devaraj and D. Majhi, 2017. Growth and survival of climbing perch, *Anabas testudineus* in Nutrient Film Technique (NFT) aquaponics systems. *International Journal of Fisheries and Aquatic Studies,* **5**(4): 24-29.
8. Ramachandran N., Singh S. P. and Rai B (2016). Goat housing and appliances. P54-59. In: Kharche, S.D., Dige, M.S., Singh, K. Scientific goat production. Compendium of training lectures in the Training Course organised during 14-18th June, 2016 at ICAR-CIRG, Makhdoom. pp 1-208.
9. Ramachandran N. and Singh S. P. (2016). Sawtch Bakri prabandha, avas evam upkaran. P14-18. In: Training manual on Scientific goat rearing organized during 30 August to 08 September, 2016 at ICAR-CIRG, Makhdoom. pp 1-60.
10. Ramachandran N. and Singh S. P. (2017). Housing of goats for different age groups with special reference to different management systems. P66-70. In: Chauhan, M S., Singh, M K., Dixit, A.K., Dige, M.S., Paul, S., Agrawal, N.D. Scientific goat production. Compendium of training lectures in the Training Course organised during 01-07 March., 2017. at ICAR-CIRG, Makhdoom. pp 1-208.
11. Ramachandran N. and Singh S. P. (2017). Shelter management of goats in different animal production systems. P46-59. In: Pawaiya, RVS., Gururaj, K., Misra, AK and Chauhan, MS., Scientific goat production. Compendium of training lectures in the Training Course organised during 19-25 January., 2017. at ICAR-CIRG, Makhdoom. pp 1-125.

12. Ramachandran N. and Singh S. P. (2017). Modern approaches in goat shelter management. P46-59. In: Pawaiya, RVS., Gururaj, K., Paul, S and Chauhan, MS., Scientific goat farming. Compendium of training lectures in the Training Course organised during 31 January-02 February., 2017. at ICAR-CIRG, Makhdoom

13. Thakur AK, Ansari Md IA and Rai Pramod (2017). Drying Kinetics of Unripe Jackfruit under Convection. Trends in Biosciences 10 (18): 3327-3331.

14. Ansari Md IA, Prasad G and Rai Pramod (2017). Study on Reduction of Soaking Time of Paddy during Parboiling. Trends in Biosciences 10 (27): 5790-5793.

15. Prasad G, Ansari Md IA and Rai Pramod (2017). Optimization of Drying and Tempering Process during Parboiling of Paddy. Trends in Biosciences 10 (32): 6771-6774.

16. Ansari Md IA and Rai Pramod (2017). Optimization of Operating Conditions for Sterilization of Aseptic Food Packaging Material. International Journal of Agriculture, Environment and Biotechnology 10 (4): 1-6.

17. Rai Pramod and Ansari Md IA (2018). Development of Low Cost Plastic Ripening Chamber for Ripening of Mango. Agriculture Engineering Today, 42(1): 20-25.

18. Rai Pramod, Singh VK and Dinmani (2017). Application of plastic mulches for vegetables cultivation: a review. HortFlora Research Spectrum, 6(4): 221-227.

19. Rai Pramod (2018). A concept note on implementation of plasticulture technology in Jharkhand. *HortFlora Research Spectrum*, 7(1):1-10.

20. Rai Pramod and Dinmani (2018). Off season bottle gourd cultivation using plastic mulch and low tunnel. *HortFlora Research Spectrum*, 7(1):19-23.

21. Gottam Kishore, **B. MaheshwaraBabu, Kavita Kandpal**, U. Sathishkumar and M. S. Ayyanagowdar, 2017, Performance of tomato as influenced by plastic mulching and irrigation levels under drip irrigation, Paper presented: *National Seminar on Trends in Farm Mechanization & Engineering Interventions for Sustainable Agriculture at RARS, ANGRAU, Tirupati, January 19-20.*

22. Md Majeed Pasha, Ashwini, S. C, Megha, B. H., Shivukumar, E. G., and **B. Maheshwara Babu**, 2017, Status of micro irrigation in zone-I and zone-II of Karnataka, Paper presented: *National Seminar on Trends in Farm Mechanization & Engineering Interventions for Sustainable Agriculture at RARS, ANGRAU, Tirupati, January 19-20.* p.22.

23. Sreedevi S., **B. Maheshwara Babu**, U. Satishkumar, P.S. Kanannavar, **Kavita Kandpal,** 2017, Effect of colour plastic mulching on brinjal crop (*Solanum melongena* L.) at different drip irrigation levels. National Conference on Science and Technology Education, Karnataka Science and Technology Academy (KSTA) University of Agricultural Sciences, Raichur.

24. Biradar Praveen, Kavitha, Laxmikanth, Mallikarjun, Rubeena Tarranum, **B. Maheshwara Babu and Kavita Kandpal,** 2017, Effect of plastic mulching and irrigation levels on okra (*Abelmoschus esculentus*) crop. National conference on Science and Technology Education, Karnataka Science and Technology Academy (KSTA) University of Agricultural Sciences, Raichur.

25. Gottam Kishore, **B. MaheshwaraBabu**, **Kavita Kandpal**, U. Sathishkumar and M. S. Ayyanagowdar, 2017, Effect of colour plastic mulching and drip irrigation levels on performance of tomato, Paper presented in ***7th National conference on novel polymeric materials (NPM) synthesis, processing and***

characterization"(Polycon 2017) at Sri Jayachamarajendra College of Engineering, JSS Science and Technology University, Mysore on September 15-16, 2017, p.39.

26. Rajput Jitendra, Mahesh Kothari, **SR Bhakar**, R Choudhary (2017) Performance Assessment of Bhimsagar Irrigation Project using Technical and Maintenance Performance Indicators. International Journal of Agriculture Innovations and Research. 6(2):2319-1473.

27. Maheshwari B, T Shah, S. Prathapar, P Chinnasamy, S Oza, M Sharma, D Nagar, Y Jadeja, B Thakar, H Grewal, R Packham, M Varua, P Dillon, R Kookana, J Ward, R.C. Purohit, P.K. Singh, K.K. Yadav, **S.R. Bhakar**, P.S. Rao, S.S. Sisodia, H.K. Mittal and Y Dashora, A.S. Jodha, Hakimuddin, P Soni and P Bhatnagar (2017) Improved village scale groundwater recharge and management for agriculture and livelihood development in India. Final report submitted to Australian Centre for International Agricultural Research (ACIAR) pp 73.

28. Lakhawat SS, Rao PS and Bhakar SR (2017). Economic feasibility and identification of suitable crop okra under different types of plastic mulch in Udaipur District of Rajasthan – A Case study. Journal of Progressive Agriculture 8(1):158-162.

29. Basamma KA, RC Purohit, **SR Bhakar**, Mahesh Kothari, RR Joshi, Deepak Sharma, PK Singh, HK Mittal (2017). Analysis of Short-Term Droughts in the Mewar Region of Rajasthan by Standard Precipitation Index. Int. J. Curr. Microbiol. App. Sci. 6(6):182-192.

30. Ingle PM, RC Purohit, **SR Bhakar** and HK Mittal (2016). Forecasting short crop reference evapotranspiration using Autoregressive Modelling for Alibagh station. Institution of Engineers (India) Pune Centre. 40:1-8.

31. Purohit RC, PM Ingle, **SR Bhakar**, HK Mittal, HK Jain and PK Singh (2016). Impact of different meterological parameters and rrelationship with short crop reference evapotranspiration for Humid Climatic conditions. International Research Journal of Earth Sciences. 4(8):1-4.

32. Ingle, PM, RC Purohit, **SR Bhakar**, HK Mittal, HK Jain and PK Singh (2016) Trend analysis of reference evapotranspiration using Maan Kendall for South Knkan Region. International Research Journal of Environmental Sciences. 5(10):35-39.

33. Ingle PM, RC Purohit, **SR Bhakar**, HK Mittal, HK Jain and PK Singh, (2016). Artificial Neural Network for Predicting reference evapotranspiration under Humid region. International Jouranl of Recent Sciences. 5(1):25-31.

34. Job, M., **S.R. Bhakar**, P.K. Singh, G.S. Tiwari, R.K. Sharma, S.S. Lakhawat and D. Sharma (2016) Water requirement and soil moisture distribution studies of drip irrigated onion crop under plastic mulched and non mulched condition. International Journal of Science, Environment and Technology, 5 (1):176-184.

35. Job, M, **S.R. Bhakar**, P.K. Singh, G.S. Tiwari, R.K. Sharma, S.S. Lakhawat and D. Sharma (2016) Evaluation of Plastic mulch for changes in mechanical properties during onion cultivation. International Journal of Science, Environment and Technology, 5(2): 575-584.

36. Dahipale P, PK Singh, **SR Bhakar**, M Kothari and KK Yadav. 2016. Morphometric analysis and prioritization of sub-watersheds in Jaisamand catchment using Geographical Information System. Indian Journal of Soil Conservation. 44(1):79-86.

37. Shukla Chitra, **SR Bhakar,** and SS Lakhawat (2016). Development of crop coefficient for Capsicum (Capsicum annum L.) under protected

structures. Journal of Agrometerology. 18(2):258-260.

38. Trupti K, D machiwal and **SR Bhakar** (2016). Seasonal changes in groundwater quality and suitability for drinking and irrigation uses. Indian Journal of Soil Conservation. 44(3):266-275.

Abstracts

39. Mohapatra, B.C., K. Anantharaja, D. Majhi, A. Behera, A.K. Shetty, A.D. Sahu, B.R. Pillai and J.K. Sundaray, 2018. A new concept of reservoir stocking with Asiatic carp fingerlings by using portable FRP carp hatchery and floating nursery. National Conference on Improving income of farmers through agriculture and aquaculture development interventions, ICAR-CIFA, Bhubaneswar, 5-7 January, 2018: AQ 25, p 155.

40. Anantharaja, K., B.C. Mohapatra, B.R. Pillai, P. Routray, J.K. Sundaray, D. Majhi, A.D. Sahu, A. Behera and A.K. Shetty, 2018. Evaluation of fish and plant production in the NFT aquaponics system. In: *Ibid*. AQ 24, p 154.

41. Anantharaja, K., B.C. Mohapatra, B.R. Pillai, J.K. Sundaray, D. Majhi, A.D. Sahu, M. Mahapatra and S.K. Jena, 2018. Floating raft aquaponic system reduces total ammonia nitrogen level in freshwater pawn pond. In: *Ibid*. AQ 26, p 156.Mohapatra, B.C., P.P. Chakrabarti, N.K. Barik, B. R. Pillai and J. K. Sundaray, 2018. FRP carp hatchery: A tool for supplying quality seed for aquaculture in North-East Region of India. 4th International Conference on Environment and Ecology, Gauhati University, Assam, 11-14 February, 2018, pp 315-318.

42. Ramachandran, N., Singh, S. P., Jindal, S.K., Rai, B, Ravi Ranjan, Deepak Dwivedi, Saket Bhusan and Gupta D L (2017). Effect of fibre reinforced plastic sheets as alternate roofing materials on lactation performance of Jakhrana goats. Accepted for oral presentation in National seminar of ISSGPU 2017 on "Small Ruminants: National scope on up scaling production to products value addition and their safety" to be held at ICAR-CIRG, Makhdoom on 9-10 November, 2017.

Seminar proceedings

43. SJ Kale, VS Meena, Prerna Nath, RK Vishwakarma, RK Singh, RK Gupta. 2018. Semi-permanent shadenet house for reducing the sunburn in pomegranate fruits. **Oral presentation** in "National Conference on Promoting Entrepreneurial Growth through Innovative Approaches in Food Processing Sector" held during March 16-17, 2018 at ICAR-CIPHET, Ludhiana. Pp: 211.

44. SJ Kale, Prerna Nath, NS Indore, RK Singh. 2018. Solar energy based adsorption coling system for storage of fruits and vegetables. **Oral presentation** in National Conference on 'Emerging and sustainable technologies in food processing' (ESTFP- 2018) held during March 15-16, 2018 at Sant Longowal Institute of Engineering and Technology, Longowal, Punjab.

45. Dukare A**,** Kale S, Kannaujia P. Indore N, Gupta R.K. 2018. Impact of organic and plastic film mulching on root development and nodulation in cowpea (*Vigna unguiculata* L. Walp.) cultivated under different levels of drip irrigation. **Oral presentation in** International Conference on "Microbial Technology for Better Tomorrow" held at Department of Microbiology, Dr. D.Y. Patil Vidyapeeth in association with Microbiologists Society (India), Pune (MH)-411018 from 17-19 February, 2018.

Popular Articles

46. Sethy, B.K., Singh, R.K., Singh, H.J., Singh, H. Dayananda and Ngachan, S.V. 2017. Evaluation of Heating Feasibility of Poly House Environment using Earth Air Tube Heat Exchange .Indian Journal of Hill Farming. Umiam. 65-76.

47. Published article in Hindi on "Application of Palsticulture Technology in Jharkhand", Pathari Krishi 18, vol (1-2), 2017 published by Directorate of Extension Education, Birsa Agricultural University, Kake, Ranchi.

48. Published article in Hindi on "Ployhouse mai tomato ki kheti" in Training Manual on Greenhouse published by PFDc, Ranchi centre.

49. S.R. Bhakar, S.S. Lakhawat and M. Job (2016) Modern technique for cultivation of onion in Southern Rajasthan. Pp 36.

50. S.R. Bhakar, S.S. Lakhawat and M. Job (2016) Manually operated mulch and lateral laying machine. Pp 36.

51. S.R. Bhakar, S.S. Lakhawat and M. Job (2016) Plastic Palwar tatha fertigation hs pyaj utpadan avam laabh. Krishi main Navachar. MPUAT, Udaipur. Pp 21-23.

52. S.R. Bhakar, S.S. Lakhawat and M. Job (2016) Drip avam plastic Palwar Bichana aor pune aktrit karne ka liea manav shakti chalit trally. Krishi main Navachar. MPUAT, Udaipur. Pp 24-26.

53. Mohapatra, B.C. and K. Anantharaja, 2017. FRP carp hatchery for seed rearing in village front (In Hindi). *Neelitima,* Vol. 1, September 2017, ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar: pp 68-69.

Paper presented in seminars/symposium/ congress

54. Participated and presented a paper (oral presentation) in National Conference on Promoting Entrepreneurial Growth through Innovative Approaches in Food Processing Sector" held during March 16-17, 2018 at ICAR-CIPHET, Ludhiana.

55. Participated and presented a paper (oral presentation) in National Conference on 'Emerging and sustainable technologies in food processing' (ESTFP- 2018) held during March 15-16, 2018 at Sant Longowal Institute of Engineering and Technology, Longowal, Punjab.

56. Participated and presented a paper (oral presentation) in International Conference on "Microbial Technology for Better Tomorrow" held at Department of Microbiology, Dr. D.Y. Patil Vidyapeeth in association with Microbiologists Society (India), Pune (MH)-411018 from 17-19 February, 2018.

57. Dr. B. K Sethy, PI attended a Brainstorming Workshop on "Standardization of Design and specification of Greenhouse structures" of AICRP on PET on 9th November,2017 at CIPHET, Ludhiana.

58. Dr. B.K. Sethy, PI attended and presented progress and achievement report of AICRP on PET, Umiam infront of QRT of AICRP on PET during 29-30th November,2017.

59. Dr. B.K. Sethy and Er. H. Dayananda Singh attended XIII Annual Workshop of AICRP on PET organized at Birsa Agricultural University, Ranchi during 6-8th December, 2017.

60. Ramachandran, N., Singh, S. P., Tripathi, M. K., Paul, S., Bhusan, S. and Jindal, S. K. (2016). Effect of floor on growth, feed conversion efficiency, nutrient intake and worm load Jakhrana kids reared under semi-arid conditions. P 84. In: Abstract No. PLF 60. Compiled Research Abstracts souvenir of International Conference and Expo and 23rd Annual convention of ISAPM on "Innovative Designs, Implements for Global Environment & entrepreneurial Needs Optimizing Utilitarian

Sources, INDIGENOUS " held during 28 – 31 January, 2016 at Hyderabad, India, edited by Sreekumar D., Ninan Jacob., Mahender M and N Rajanna. pp 1-352.

Research Note

- Mohapatra, B.C., Lasky Das, S.K. Mahanta, H. Sahu, P. Sahoo, S. Lenka and K. Anantharaja, 2017. Oxygen consumption in fry and fingerling stages of Indian major carps analysed using indigenously developed respirometer. *Indian Journal of Fisheries*, **64**(1): 91-94.

Book

- Mohapatra, B.C., N.K. Barik, P.P. Chakrabarti, B.R. Pillai and J.K. Sundaray, 2017. FRP carp hatchery in India: Adoption, impact and issues. ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar: Pp 1-66.

Book chapter

- Mohapatra, B.C., 2017. Preliminary review of Indian freshwater aquaculture: Production enhancement through use of different gadgets and systems (A.S. Ninawe, J.R. Dhanze and R. Dhanze eds) *Aquaculture for nutritional and livelihood security*. Narendra Publishing House. Delhi, pp: 3-39.

NOTES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