SCOPE AND ADOPTION OF PLASTICULTURE TECHNOLOGIES FOR ENHANCING PRODUCTION IN NORTH EAST HILL REGION

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INTRODUCTION

The North Eastern hill region of India falls under high rainfall zone and the climate ranges from subtropical to alpine. It has a total geographical area of 19.9 million hectares and a population of 13.4 million representing about 6% and 1.3% of the total area and population of the country, respectively. However, food grain production in the region is merely 1.5% of the national production. Majority of the population is dependent on agriculture, horticulture and allied land based activities. The agricultural production system in the region is mostly rainfed, mono-cropped, and at subsistence level. Besides food grains and oilseeds, the region is known for the production of fruits, vegetables, flowers, cacti of large varieties, forest produce, rare varieties of condiments, medicinal and aromatics plants. Productivity of the fruits and vegetables is much less than the national average. Though the area under horticultural crops in the region is 6% of the country's area under horticultural crops but production is only 4% of the national production (Annon, 2002). The reason for this low productivity may be attributed to the prevalence of the traditional method of cultivation, excess rainwater during kharif season, scarcity of water for rabi crop cultivation, and low adoption rate of new technologies. The indiscriminate cutting of forest to bring more area under crop cultivation to feed increasing population has posed environmental problem. As the rural economy of the region is mainly based on forest produce and agriculture, therefore, the challenges before policy makers, implementers, and agricultural scientists are:

1. To enhance total crop production and productivity
2. To keep the forests cover and rich biodiversity intact
3. To minimise the soil erosion induced due to traditional food production system
4. To manage rainwater in better way for life saving irrigation to rabi crop
5. To uplift the economic status of the farmers

To tackle these problems, application of plastics in agriculture may play a significant role.

1. APPLICATION OF PLASTIC IN AGRICULTURE

If any material, which has affected the human population most, it is plastic. Plastics are polymer of high molecular weight, which can be processed and moulded to required shape with ease and less energy consumption. Plastics are becoming indispensable in area of agriculture, horticulture, industries, household as they are light, have higher strength per unit weight, resistant to chemical and weather, and have low production and transportation cost. Despite the rapid growth in production and use of plastics in our country, the per capita consumption of plastics is only 2.2 kg which is very very low as compared to consumption in developed countries like USA, Germany and Japan where per capita consumption is above 60 kg. World average of per capita consumption of plastic is 16.2 kg (Ilyas, 2001).

The use of plastics in agriculture is termed as plasticulture. This is recent and major development in the field of agriculture, which has been acknowledged world over for enhancing

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the agricultural production and the quality of produce besides conserving natural resources (Ashwani Kumar, 1996). Plastics can be used in agriculture for greenhouse cultivation, mulching for water saving by evaporation and for reducing weed infestation, drip and sprinkler irrigation, flexible pipes for conveyance of irrigation water, canal and pond lining, sleeves for nursery raising, and post harvest handling and packaging.

2. STATUS OF PLASTICULTURE IN THE REGION

Plasiculture in the northeastern hill (NEH) region is in infant stage although its utility in enhancing production and productivity, improving quality of produce, saving precious water resources has been proved in other parts of the country. State Governments and research organizations like ICAR Research Complex for North East Hill Region, Barapani (Meghalaya) and Assam Agricultural University, Jorhat are actively engaged in research and popularisation of plasticulture in the region.

2.1 Greenhouse/polyhouse

Many greenhouse designs are put forward suitable for varied geographical and climatic conditions. As NEH region is having varied geographical and climatic conditions, one design for whole region will not be suitable. Considering economic condition of the farmers of the region, high cost structure with iron/aluminium frame and auto control may not have good acceptability among the farmers of the region. Low cost polyhouse made of locally available materials like bamboo and timber should be preferred. Generally, transparent low density polyethylene (LDPE) ultra violet (UV) stabilised film of 200 μ thickness is suitable for use as cladding material (Kale and Mahorkar, 2001). As high humidity prevails in entire region fan pad cooling system will not work satisfactorily. Therefore, natural ventilation should be provided. This will also help reduce the initial cost and maintenance cost. Government assistance under plasticulture scheme in VIII and IX Plan has aroused the interest in the farmers of the region for the greenhouse cultivation of vegetables and flowers. In VIII Plan 29.05 ha area had been covered under greenhouse in the region and coverage rose to 83.4 ha by the end of 1999–2000 as compared to all India figures of 211.12 and 525.05 ha, respectively (Samuel and Singh, 2003).

In Sikkim more than 15 ha area has been brought under greenhouse cultivation for growing off season vegetables, raising seedlings, cultivation of flowers etc. Mainly four types of design for construction of greenhouse are being used by the cultivators.

a) **Roof type:** Farmers of high altitudes, where snowfalls and frost occur, are adopting this design. Slope of roof allows snow and frost slide down.
b) **Tunnel type:** This design is very popular among farmers of mid altitudes where snow and frost are not a problem but high rain and wind. Round roof allows wind waves to cross over the structure without damaging it. Further uniform sunlight is maintained inside the structure.
c) **Flat sloppy roof:** This type of structural design is followed by the farmers when motive is to raise seedling in larger area. This type of structure is easy to construct.
d) **Rainshelter:** Rainshelters are mainly constructed to protect the delicate crops like tomato and chilli from rain.

Department of Agriculture, Government of Nagaland has developed low cost greenhouse–cum–rainshelter. Structure was made of locally available bamboo and timber. LDPE UV film of 200 μ thickness was used for cladding. Cultivation of tomato, chilli and cucumber in greenhouse was demonstrated to the farmers (Keitzar and Tiameren, 2003). To raise the inside temperature during winter, the structure was kept fully covered and during summer season the sides of the greenhouse were kept open to avoid excessive heating. Sides were provided with nylon netting to protect the crops from light intensity, birds and insects damages. Three crops namely; cucumber, tomato and chilli were cultivated inside the greenhouse and round–the–year–cultivation–approach was adopted. Yields as effected by different planting time are given below (Table 1).

Table 1: Yield of crops grown in low cost greenhouse–cum–rainshelter

Crops	Yield in kg/100 m^2 (average of three years)		
	Planting time		
	Feb - Mar	June - July	Oct - Nov
Cucumber	227	222	212
Tomato	228	277	285
Chilli	96	98	103

Table 2: Crops grown in low cost green house and their benefits

Sl. No.	Crop	Month of planting	Area under crop (m^2)	Yield (kg)	Productivity (tonne ha^{-1})
Crops in terrace					
1.	Capsicum	May	32.31	26	8.05
2.	Tomato	April	32.31	24	7.43
3.	Brinjal	May	35.0	38	10.86
4.	French Bean	June(1st week)	19.38	12	6.19
5.	Cabbage	July	62.70	63	10.05
6.	Cauliflower	August	32.31	22	6.81
7.	Pea	December	32.31	23	7.12
8.	French Bean	January	35.0	25	7.14
9.	Tomato	March	62.70	35	5.58
Crops on riser					
10.	Bitter Gourd	June	10.16	9.2	9.06
11.	Bottle Gourd	June	20.23	35	17.30
12.	Cucumber	July	10.16	12	11.81
13.	Bitter Gourd	November	10.16	4.6	4.53
14	Cucumber	February	30.31	26	8.58

ICAR Research complex for NEH Region, Umiam, Meghalaya has developed low cost polyhouse made of locally available materials for terraced land on hillslope (Agrawal *et. al*, 2003). The structure was made in terraced land with vertical interval of 0.8 m between two consecutive terraces. The basic structure was made by using the net of split bamboos with a grid of 9 x 12 inch. The roof of the polyhouse was made in the form of two hemispheres (one hemisphere to cover one terrace) in such a manner that height of the roof from ground remains constant for each terrace. Each hemisphere was also made with grid of bamboo split supported on trusses made of bamboos. A drop equal to the vertical interval of the terrace, in height of successive hemisphere, was provided to compensate the drop between two successive terraces. The covering was provided by UV stabilized LDPE film of 200 µ thickness. The nylon rope was wrapped over the roof covering to resist the blowing action of high speed wind. The provision for natural ventilation to avoid excessive heating was kept by providing two openings of the size 1.0 x 2.0 m each in each side of the two opposite sides of polyhouse. The yield of vegetables grown under the polyhouse is very encouraging (Table 2). The riser area was also put under the cultivation to maximize the land utilization. The cost of construction of low cost polyhouse was ascertained to be Rs 133.25 compared to the steel framed, auto controlled greenhouse cost of Rs 2000–2500 m^{-2} of covered area (Annon, 2003). Farmers of Meghalaya are using polyhouse for raising the seedlings of vegetable crops, cultivation of tomato and chilli. But other high–valued vegetables can also be grown successfully inside the polyhouse.

2.2 Drip irrigation

Though the region falls under high rainfall zone and receives more than 2000 mm of rain every year but still the region faces scarcity of water during winter season (Satapathy, 1996). As a result agriculture in entire region is mono-cropped. Farmers of the region are well versed with the concept of drip irrigation. Farmers of Meghalaya are using bamboo drip irrigation for irrigating the crops of beetle vine, arecanut and black pepper. This traditional system of drip irrigation is practiced in the area where soil has low water holding capacity, irrigation requirement of the crop is low and water is scarce (Singh, 1979). The area under horticultural crops in the region is about 1 M ha accounting for 6% of the national area under horticultural crops but production is only 4% (6.17 M tonne) of the national production (Annon, 2002). To enhance the production in the region, scarcity of irrigation water during winter season is the limiting factor. This problem could be tackled through efficient management of rainwater. Excess rainwater during monsoon season may be stored in the water harvesting pond and recycled back in the field through drip / sprinkler irrigation during winter season to boost the production.

2.2.1 Coverage of area under drip irrigation

Recognizing the importance of the drip irrigation in saving precious water resources and enhancing the productivity, Government of India had given subsidy till 1999–2000 for installation of drip irrigation system. Due to this policy area under drip irrigation in the country increased from 1500 ha in 1985 to 3 lakh ha in 2000–01 with an average growth rate of 30,000 ha yr^{-1} (Samuel and Singh, 2003)(Fig 1). However, the adoption of drip irrigation in the region is very low as compared to the other parts of the country in spite of best efforts from the Central as well as state Governments. As per the records of the Government of India schemes, so far 1592 ha area has been brought under drip irrigation in the region (Table 3).

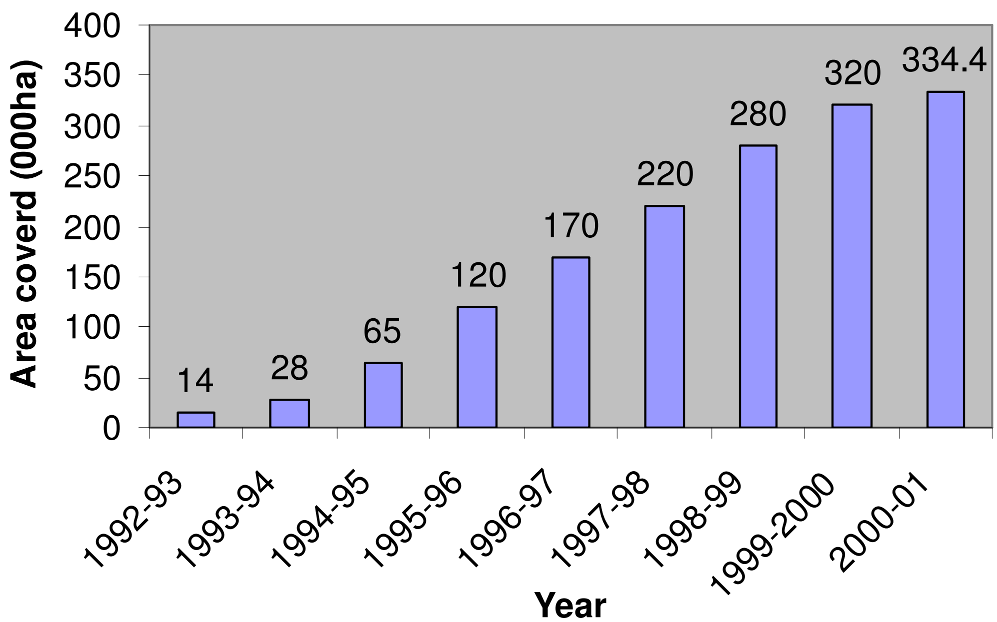

Fig 1: Growth of drip irrigation in India

Table 3: Area covered under drip irrigation in NEH Region

Sl. No.	State	Area covered (ha)
1.	Arunachal Preadesh	295
2.	Manipur	341
3.	Meghalaya	16
4.	Mizoram	124
5.	Nagaland	816
6.	Tripura	0
	Total	**1592**

The region has drip irrigation potential for 1 M ha (Table 4). As compared to this, the area covered in the region is negligible.

Table 4: Area and production of horticultural crops (1999 – 2000) (Area in M ha and Production in M tonnes)

Sl. No.	Crop	All India		North East Hill Region	
		Area	Production	Area	Production
1.	Fruits	3.78	45.50	0.61	2.00
2.	Vegetables	5.99	90.83	0.37	4.05
3.	Spices	2.52	2.91	-	-
4.	Coconut	1.78	8.42	0.02	0.12
5.	Cashew	0.69	0.52	-	-
6.	Others	2.78	1.75	-	-
	Total	17.54	149.93	1.00	6.17

Table 5: Benefits of plastic mulch for different crops

Crops	Yield increase (%)	Water saving (%)	Weed Control (%)
Banana	10	53	90
Tomato	56	78	55
Grapes	54	78	-
Groundnut	49	-	-
Okra	116	-	114
Cabbage	71	-	-
Pineapple	124	-	-
Mustard	110	-	82
French Bean	64	-	75
Rajmash	126	-	85

2.3 Plastic mulching

Mulching is a practice of covering the soil surface around the plants to make conditions more conducive for plant growth through *in-situ* moisture conservation, enhanced microbial activities in the root zone, and weed control. Mulching is in practice in the region since ages in one or another form. Generally farmers use dry leaves, straw, hay, stones as mulching materials. This implies that farmers of the region are aware of the benefits of mulching. However, introduction of the LDPE film as mulch increases the efficiency of water use by improved moisture conservation, soil temperature, and elimination of weed growth thereby increase in crop yield. Generally for mulching, thickness of LDPE film varies from 10 to 50 µ (Annon, 2003). Outcome of the research conducted by various research organizations in the region confirm the efficacy of plastic mulch in enhancing the yield, water saving and weed control (Table 5).

Government of India is promoting plastic mulching by providing 50% subsidy to a maximum limit of Rs.7000/- in IX Plan. It was proposed to cover 5700 ha during IX Plan period with an outlay of Rs. 3.17 crore (Singh and Samuel, 1999). In spite of this effort, there is no significant coverage under plastic mulching in the region.

2.4 Plastic lining of water harvesting pond

Rainwater can be harvested in a dugout-cum-embankment pond at the mid or lower reaches of the hillslope for multiple uses including drinking water supply, livestock and other domestic uses, recycling in winter season for crop production and fish production. Probability analysis of weekly rainfall data from 1983 to 2003 at Barapani (Meghalaya) revealed that except 44th and 46th week, all the standard weeks falling during the period from November to mid March, are expected to receive rainfall less than the weekly evaporation at 50, 60, 75 and 90% probabilities (Satapathy, 1996). This situation calls for an urgent need to harvest rainwater or to intercept base flow from hillslope in a water harvesting pond. The soil in the entire region except at few places, have extremely low water holding capacity and seepage losses are very high. Seepage losses from pond could be as high as about 55 l m^{-2}day^{-1}. Owing to the high rate of seepage loss, harvested water will be lost within 1-2 months of recession of rain (Singh *et al*., 2006). An unlined water harvesting pond was monitored for fluctuations in the water table in the ponds. The ponds were filled to their maximum capacity from 21st to 43rd weeks. In the remaining period the water table fluctuated. The minimum ponding of about 40 cm in the ponds were observed during the period ranging from 50th to 7th week. This ponding was mainly due to interflow from upper reaches. Therefore, lining of pond with black coloured LDPE agrifilm is very much essential for retention of harvested water in the pond at a relatively low cost for the entire dry season i.e. from November to March.

2.4.1 Procedure for plastic lining

For successful LDPE lining of pond certain procedure is to be followed. After the pond is dug as per the design, pond bed and sides should be made weed and stone free. Steps at 50 cm vertical interval are made on sides of the pond to hold the agrifilm at its place. On top of the sides continuous trench of 50x50 cm is dug for the purpose of anchoring the agrifilm to prevent it from sliding down. Pre-emergent weedicide should also be sprayed on sides and bed to arrest the weed growth. After the sides and bed are dressed properly, 10 cm thick layer of sieved sand is spread uniformly on bed and sides to provide cushion to the agrifilm. After that, agrifim is laid properly in the pond. Black coloured LDPE agrifilm of 250 µ is generally used for lining. Utmost care should be taken in joining the agrifilm to suit the shape and size of the pond. For joining, bitumen of 85/25 and 80/100 grade in the ratio of 2:1 is used. While laying the agrifilm, too much stretching or tightness of the agrifilm should be avoided, particularly on sides. Over agrifilm, soil cover of 15 cm is provided. Then stone pitching may be done on sides only to safeguard the sides of the pond against erosion and any other external forces. Study of storage behaviour of the pond revealed that seepage loss from agrifilm lined pond was reduced from 55 to 2.9 l m^{-2}day^{-1} i.e. by 94.7% (Singh et al, 2006). Cost of lining of a pond at ICAR Research Complex for NEH Region, Meghalaya varied from Rs. 20.63 to 44.29 m^{-3}of stored water.

CONCLUSION

It is now an established fact that plasticulture intervention is capable of enhancing production and productivity of horticultural crops. There is tremendous scope of adoption of plasticulture technology in the region. But the adoption rate is very slow in spite of Government efforts and assistance. The reason for this low adoption rate should be looked into and addressed. Only some headway is made in greenhouse and drip irrigation technology. Rainwater can be successfully harvested and stored in LDPE lined pond. The agrifilm lining of pond will reduce the seepage loss by 94%. The harvested rainwater can be used to irrigate winter season vegetable crops through micro irrigation system to enhance productivity and profitability. More intensive efforts in form of demonstrations and sensitization are needed to popularize these technologies. Owing to the poor economic condition of farmers of the region, more assistance and low cost technologies may find favour with farmers. Plasticulture intervention in the region in cultivation of high–valued crops like fruits, vegetables, and medicinal plants may contribute significantly in achieving the higher growth rate in agriculture sector.

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