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A CONCEPT NOTE ON IMPLEMENTATION OF PLASTICULTURE TECHNOLOGY IN JHARKHAND

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ABSTRACT : The plasticulture technology plays very important role in cultivation and post harvest management of horticultural crops. It helps in improving the crop yield and quality, growing off season crops and enhancing the shelf life of fresh and process food product. But to take the full advantage of plasticulture technology its proper implementation is very important. Here a process flow chart has been discussed to implement the various plasticulture technologies in Jharkhand such as rain water harvesting, plastic protray, low tunnel technology, drip irrigation, plastic mulching, fertigation, temporary shadenet structure, insect net proof house, multipurpose green house, detachable roof green house, shrink wrapping technology, tent type ripening chamber and medium cost protected structure.

Keywords : *Plasticulture technology, cultivation, off season crops, yield, quality, shelf life.*

Plasticulture is the art of using plastic materials to modify the production environment in crop production. It has developed into management systems that allow growers to achieve higher quality produce, superior yields and extended production cycles. It has also wider application in post harvest management of fresh/cut fruits and vegetables. The major constraints in successful application of plasticulture technology in Jharkhand are hilly terrain, small holder's farmer, small farm size, technical knowhow of farmers, availability of irrigation water, availability of quality input material, marketing facilities etc. The average land holding of farmers in Jharkhand are around less than 0.4 ha (60% farmers), between 0.4 ha^{-1} ha (22% farmers) and more than 1 ha (18% farmers) (Mishra, 12).

The All India Coordinated Research Project (AICRP) on Plasticulture Engineering & Technology (earlier Application of Plastics in Agriculture) is running in Department of Agricultural Engineering, Birsa Agricultural University, Kanke, Ranchi, Jharkhand since 2005. The Ministry of Agriculture Cooperation and Farmers welfare, GOI is promoting plasticulture technology through various programme such as Mission for Integrated Development of Horticulture (MIDH), Pradhan Mantri Krishi Sinchayee Yojna (PMKSY) etc. and these programme are running in Jharkhand also. Based on the feedback from farmers, survey of farmer's field, interaction with various stake holders (government line department, ATMA, KVKs, NGO etc.) involved in promotion of plasticulture technology, report through media and work done since inception of this project, it was felt that though the plasticulture technology can play a vital role in crop production and post harvest management but the farmers in Jharkhand have not taken full benefits of plasticulture technology due to poor implementation at farm and low technical knowhow. The need was felt that there is need to properly implement the plasticulture technology in Jharkhand. So based on the work done at AICRP on PET, Ranchi, Jharkhand a process flow chart is prepared for successful application of plasticulture technologies (rain water harvesting, plastic protray, low tunnel technology, drip irrigation, plastic mulching, fertigation, temporary shadenet structure, insect net proof house, multipurpose green house, detachable roof green house, shrink wrapping technology, tent type ripening chamber & medium cost protected structure) in Jharkhand. Once the farmers have resources and well acquainted with technology discussed at serial number 1 then he can move to other technologies discussed at serial number 2, serial number 3 and so on.

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1. Rain water harvesting : The average annual rainfall of the state is about 1300 mm but due to its inadequate distribution more than 80% of rainfall water is lost as surface runoff. About 75% area covered under rice production during kharif (rainy) season in Jharkhand remains fallow in the subsequent rabi season due to a number of biotic, abiotic and socio-economic constraints (Pandey, 14).

Water harvesting has been used for centuries and considerable work has been reported on farm ponds (Helweg and Sharma, 8; Singh and Kumar, 21). Water harvesting and storage is a major challenge for

Jharkhand as there is huge seepage losses from the pond as a result of which enough water is not available for cultivation during Rabi (winter) season. The seepage losses not only mean loss of useful water but it also leads to other problems such as trench in the embankments, water logging or increased salinity in the adjacent area. The plastics can be used very effectively in lining the ponds but lining the ponds with plastics as a barrier material, sufficient care is required in selecting the proper material, lying of plastics material, joining of plastic film and saving it from the damage.

The use of plastic films as a lining material has offered tremendous scope as lining material which provides an impervious lining thus prevent water losses due to seepage (Anony, 1). It is the cheapest among all the lining materials, which are conventionally being used (Kumar *et al.,* 11). The various losses including seepage, percolation and evaporation account for as high as 60% of the gross storage. Several researchers have shown that on-farm runoff collection into dugout farm ponds and supplemental irrigation can increase and stabilize the crop production (Krishna *et al.,* 10).

The rain water harvesting is well established technology which can be used to harvest the water in farm pond. The farm pond can be constructed using plastic lined or without plastic lined depending upon the location of farm pond. The plastic lining is very essential for farm pond at upland and midland location to reduce the seepage losses in Jharkhand.

The design consideration for plastic lined pond was considered in details with calculation of runoff water from the catchment area and water requirement in cultural command area (PET field and PFDC field). The minimum volume of runoff water from catchment area (QI = Runoff under antecedent moisture condition I, Land cover: small grain, treatment or practice: straight row, hydrological condition: good) was 20840.8 m3 and water required for cultural command area is 1294.9 m^3 for the round the year cultivation of vegetables. The volume of runoff water is 16 times of water required for irrigation, so the size of pond was decided based on the volume of water required for irrigation i.e. 1249.9 m^3. The actual size of pond (volume of water) was calculated after considering 5% buffer volume (for margin of safety in irrigation water requirement) which will be 1359 m^3. The plastic lined pond of volume 1359 m^3 can be easily filled with runoff water if we will be able to harvest only 6.5% of potential runoff from the catchment area (Rai and Rusia, 16).

The soil at pond site was found to be sandy loam, so side slope of pond is taken as 2:1. The bottom of pond is assumed to be 15 m x 15 m and depth which is usually taken between 3-5 m, is taken 3 m. The top surface of pond is 27 m $\times$ 27 m and the volume of pond will be 1359 m^3. The calculated length and width of plastic film required is equal and it is 30.42 m including 1 m length for bunging in soil and 1 m for shrinkage of plastic film. The volume of water which can be stored in the pond will be 1359 m3 (1359000 liter). The water harvesting pond is covered with 500 micron LDPE black film (Fig. 1). 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).

Fig. 1 : Plastic lined water harvesting pond.

2. Pro tray nursery raising : The virus free healthy vegetable seedling can be grown in plastic pro-tray. But there is need to provide suitable environment for growing nursery under pro-trays. It has been found that there is need to enhance the temperature during winter season, reduce the temperature & light intensity during summer season and protect the seedling from rain water during rainy season. The plastic low tunnel with different cladding materials can be used to cover the wire hoops are UV stabilized plastic film (50 micron), insect net proof material (40 mesh) and shade net material (Green & 50%). These cladding materials can be used to make the environment suitable for round the year raising of seedlings.

The production of good quality seedlings is very much essential for getting higher yield and quality of any crop. In the past, the farmers themselves used to produce the seedlings required for transplanting at a lower cost, as most of the vegetable varieties were of open pollinated types. Now days, intensive vegetable cultivation using high yielding F_1 hybrids is being taken up by many progressive farmers to augment productivity. As the seeds of hybrids are sold at very

high price, converting every individual seed into a healthy seedling becomes essential and this requires intensive nursery management. The vegetable seedling production is taken up by specialized companies or as a specialized activity in most of the advanced countries (Singh, 20). But presently the farmers in Jharkhand growing vegetable seedlings in open field under raise bed system. If farmers have availability of quality vegetable seedling round the year, they can grow off season vegetable that will fetch him higher price of vegetables. But presently there is no concept of vegetable seedling production in Jharkhand by government, private company or any other agencies.

Protrays are shallow plugs in which germination media remains warm & provides better aeration and seed are sown directly into plugs. The weeding and thinning is easily carried out in such protrays. Coco peat, a by-product of coir industry having high water holding capacity is commonly used as media in protrays. It has 6 times water holding capacity to its weight and should be supplemented with nutrients. The sterilization the growing media is essential to reduce diseases and pest introduction & attack. Other recommended media are Coco peat + vermicompost or vermicompost + sand or soil loam + FYM in equal proportion.

The farmers cannot grow the quality vegetable seedling only using protray for round the year because there is need to provide suitable environment to grow the seedling round the year i.e. winter, summer & rainy season. If the farmers can grow vegetable seedling round the year using protray under plastic low tunnel as discussed above, he can grow offseason vegetables even in open field (Fig. 2).

Fig. 2 : Protray nursery raising under plastic low tunnel.

3. Low tunnel technology : Production of vegetables under protected structures such as low tunnel provides the best way to increase the productivity and quality of vegetables, especially cucurbits. The low tunnels represent the standard method for using plastics to enhance the growth of most vegetable crops (Wells and Loy, 24). A low arch (typically less than 0.75 m centre height) of perforated clear polyethylene or non-woven fibre is supported above the crop using wire hoops. Typically, a single row of the crop is protected by each cover. By increasing air and soil temperatures, reducing wind damage and by providing a degree of frost protection, the low tunnels accelerate crop development and extend the growing season (Waterer, 23).

The cladding material which can be used to cover the wire hoops are UV stabilized plastic film (50 micron), insect net proof material (40 mesh) and shade net material (Green & 50%). The most important parameters which affect the crop yield & its quality are soil temperature, air temperature & light intensity and it does vary round the year. During winter season the soil and air temperature is low, so the UV stabilized plastic film (up to 50 micron) alone or both plastic film & insect net proof material (40 mesh) can be used to increase the soil temperature and air temperature. But during summer season the soil temperature, air temperature & light intensity are very high, so shade net material (Green & 50%) alone or both the shade net material & insect net proof material (40 mesh) can be used to reduce soil temperature, air temperature & light intensity. In rainy season soil temperature, air temperature & light intensity are more or less under suitable range but there is need to protect the crops from high rainfall, so plastic film & insect net proof material can be used.

The low tunnels technology is mainly suitable for off season cultivation of cucurbits like muskmelon, round melon, long melon, bitter grand, bottle gourd and summer squash etc (Fig. 3). Apart from off season cultivation of cucurbits it can be also be used for

Fig. 3 : Plastic low tunnel.

cultivation of cabbage/cauliflower during summer, leafy vegetables such as coriander/ spinach etc. during rainy season.

The black plastic mulch (25 micron) for winter & rainy season and silver-black/white-black plastic (25 micron) mulch for summer season can be used to enhance and reduce the soil temperature respectively. This plastic mulch is usually used in combination with plastic low tunnel (Ibarra *et al.,* 9).

4. Drip irrigation : Drip irrigation is the best available technology for the efficient use of water for growing horticultural crops in large scale on sustainable basis. Drip irrigation is a low labour intensive and highly efficient system of irrigation, which is also amenable to use in difficult situations and problematic soils, even with poor quality water. Irrigation water savings range from 36-79% by adopting a suitable drip irrigation system. Drip irrigation is designed to supply filtered water directly to the root zone of the plant so as to maintain the soil moisture near to field capacity level for most of the time, which is found to be ideal for efficient growing of horticultural crops. This is due to the fact at this level the plant gets ideal mixture of water and air for its development.

The low pressure drip irrigation system (gravity system) requires comparatively less pressure than normal pressurized drip irrigation system (Fig. 4). It is suitable for small land holdings, green houses, nursery and hilly areas. This system does not require regular

Fig. 4 : Low pressure drop irrigation system.

supply of electrical energy and the hydraulic head of about 2 m is sufficient for irrigating an area of 500 m^2. This system has very high irrigation efficiency (>90%) and is easy to install, operate and maintain (Hasan *et al.,* 7).

Fertigation becomes very easy in low pressure drip irrigation system as no additional pump or any other device is required in this system. The same tank can be used for mixing of water and water soluble fertilizers. The use of low pressure drip irrigation system (gravity system) can be used for area up to one acre. Once the farmers are well acquainted with the low pressure drip irrigation system (gravity system) and if further need arises then he can use pressurized drip irrigation system using the rain water harvested in pond/ plastic lined pond (Sabir and Singh, 17).

5. Plastic mulching : Mulch is a protective cover placed over the soil, primarily to modify the effects of local climate. It is well established technology in vegetables cultivation but the success of mulching depends on the selection of right mulching material. The various factors affect the mulch selection but most important is season of cultivation. Depending upon the month of cultivation, the purpose of mulching will change, in winter there is need to increase the soil temperature but in summer reduction in the soil temperature, apart from other benefit of mulching. The best utilization of mulch can be done with drip irrigation or drip irrigation with fertigation facility.

The beneficial effect of most plastic mulches is an increase in temperature which has shown to be beneficial to most plants. There are numerous other advantages to plastic mulches such as improved fruit quality, reduced weed problems, reduced water evaporation, increased yield, reduced fertilizer leaching, reduced soil compaction, improved phytochrome response, and other benefits.

Plastic mulches can reflect, absorb and transmit incoming sunlight, the extent of which depends on the type of mulch. The soil temperature under plastic mulch depends on the thermal properties (reflectivity, absorbitivity, or transmittancy) of particular mulch in relation to incoming solar radiation. The soil temperature has direct dramatic effects on microbial growth and development, organic matter decay, seed germination, root development, and water & nutrient absorption by roots (Decoteau, 3).

The black mulch (25 micron) was found to be effective during winter but in summer Silver-Black mulch (25 micron)/ white-black (25 micron) was found effective in cultivation of tomato and capsicum (Fig. 5). The black mulch (25 micron) is found to be effective during winter because it increases the soil temperature by 1-3°C in comparison to open field condition. The silver-black mulch (25 micron)/ white-black (25 micron) is found effective during summer because it decreases the soil temperature by 1-3°C in comparison to open field condition (Ham *et al.,* 5).

Fig. 5 : Okra under plastic mulch.

The cost involved in application of mulch is around ₹ 6-7/m^2. The expected financial benefit will be ₹ 20-35/m^2/ 4 months (Depending upon season of mulching) (Rai, 15).

6. Fertigation : Fertigation is the process in which fertilizers can be applied through the system with the irrigation water directly to the region where most of the plant roots develop. It is done with the aid of special fertilizer apparatus (injectors) installed at the head control unit of the system, before the filter. The element most commonly applied is nitrogen. However, application of phosphorous, potassium and other micro-nutrients are common for different horticultural crops.

The fertigation is essential because irrigation & fertilizers are the most important management factors through which farmers control plant development and yield, water & fertilizers have important synergism which is very well used in fertigation and timely application of water and fertilizers can be controlled through fertigation (Hasan *et al.,* 7).

The fertigation plays very important role in successful cultivation of horticultural crops (Fig. 6).

Fig. 6 : Drip irrigation with fertigation system.

Though there are many factors which affect the performance of fertigation but the cost of fertilizer and its availability plays important role in making fertigation successful (Hartz and Hochmuth, 6). Initially for using the fertigation system urea can be used for N requirement and P & K can be given as basal dose by using DAP and MOP. Subsequently fertigation of N & K can be done by urea and MOP (white) and P can be given as basal dose by using DAP.

7. Temporary shade net structure : The high temperature and light intensity are major hindrance in cultivation of tomato/capsicum during summer season. The low cost tent type temporary shade net structure (green, 50%) can be used for growing tomato/ capsicum during summer season.

The cultivation of tomato and capsicum during summer months (March-May) is problematic due to high solar intensity (Garuda, 4). It is more than required for its successful cultivation & it affects the crops productivity & quality. The major quality concern is sun burns which affect more than 50% of fruit produced. This problem can be reduced by cultivation of tomato and capsicum in permanent structure shade net (green, 50%) during summer months. But light intensity in remaining months of year (June-February) is less than the optimal level required for its cultivation. So by using tent type temporary shade net structure only during summer months (March-May) enhances its utilization and cost economics.

The bamboo is used for erection of tent type temporary shade net (green, 50%) structure at 2 meter above the ground surface and 0.5 m drop down from top around structure. It increases the marketable quality by minimum 50% and productivity by 30-40% in comparison to open field cultivation under same agronomical practices.

The suitable light intensity required for cultivation of tomato & capsicum is between 50000-60000 lux. This technology can be used any place where light intensity is more than between 50000-60000 lux. The construction cost of temporary tent type temporary shade net (50%) are around ₹ 50-55/m^2 in comparison to low cost permanent structure of ₹ 250-300/m^2. The same shade net material can be used for at least 6-7 years in comparison to permanent structure for 3 years only (Fig. 7). The expected financial benefit will be ₹ 35/ m^2/ 4 months (Narayan *et al.,* 13).

8. Insect net proof house : The low cost insect net proof house (40 mesh) can be used successfully for round the year cultivation of vegetables. Although the natural ventilated polyhouse is best for cultivation of

Fig. 7 : Low cost temporary shadenet structure.

Fig. 8 : Low cost insect net proof house.

vegetables but the temperature recorded during summer months (March-May) was found to in the range of 5-10°C more than open field condition, so it is not suitable for vegetable cultivation during these months. The permanent shade net structure is also not suitable for round the year cultivation of vegetables (tomato & capsicum).

The low cost natural insect net proof house can be constructed by using bamboo and cladding material of UV stabilized insect net (40 mesh). The specification of structure, length: 12 m, width: 6 m, side height: 2 m and central height: 3 m (Inside door: - width: 1 m, height: 2.2 m) and compartment for double door structure: width: 2 m, length: 2 m and height: 2.2 m (outside door: width: 1 m, height: 2.2 m). The temperature inside the insect net proof house is more than 1-3°C in comparison to open field condition, which is very favourable during winter season. The insect net structure performs well throughout the year but during summer season (March-May) there is marginal increase in temperature (1-3°C) from the open field condition. The environmental parameters like temperature, light intensity, relative humidity, CO_2 and air movement affect the plant growth. The air movement inside the insect net proof house is more favorable than natural ventilated polyhouse (Tanny *et al.,* 22). The performance of low cost insect net proof house was better than natural ventilated polyhouse during summer (Fig. 8). The observation of plant growth and environment proved that low cost insect net proof can be used successfully for round the year cultivation of vegetables. It can be used any place where winter and summer is not very severe. The construction cost of low cost insect net proof house is around ₹ 250-300/m^2 (Narayan *et al.,* 13).

9. Multi-purpose green house : The low cost multi-purpose green house can be used for growing vegetables during rainy & winter season and one can take the advantage of high temperature in green house during summer season for dehydration of cauliflower/ cabbage/tomato/mahua etc. and soil solarization.

The polyhouse technology is well established in the cultivation of vegetables (especially tomato and capsicum) but the cost of construction of polyhouse comes in range of ₹ 700-1000 m^2 is major deterrence in adoption of this technology by farmers. So there is need of low cost natural ventilated polyhouse which can be used by farmers. The low cost natural ventilated polyhouse can be constructed by using bamboo and cladding material of UV stabilized plastic film (200 micron). The side height of structure is covered by insect net proof material (40 mesh) accompanied by plastic film at foldable height which can be used to regulate temperature and relative humidity as per requirement. But the major challenges occur during summer months when temperature and light intensity is very high. It is very difficult to reduce the temperature for cultivation purpose, so it is better to utilize high temperature for drying (Sahdev, 18) and soil solarization. The constructed polyhouse can be effectively used for vegetable cultivation during June-February and can be used for solar drying as well as soil solarization during March-May.

The specification of structure, length: 12 m, width: 6 m, side height: 2 m and central height: 3 m (Inside door: - width: 1 m, height: 2.2 m) and compartment for double door structure: width: 2 m, length: 2 m and height: 2.2 m (outside door: width: 1 m, height: 2.2 m). The good quality tomato and capsicum were produced with productivity of 120 t/ha and 80 t/ha respectively. The temperature inside the greenhouse was more than 5-10°C in comparison to open field condition, which is very favorable during winter season. The temperature recorded during summer months (March-May) was found to in the range of 42-52°C and it can be effectively utilized for solar drying and soil solarization.

It can be used by small farmers where low cost natural ventilated polyhouse structure is used for cultivation and where summer temperature is very high (Fig. 9). The construction cost of multipurpose low cost natural ventilated polyhouse structure is around ₹ 300-350/m^2 (Narayan *et al.,* 13).

Fig. 9 : Low cost multi purpose green house.

10. Detachable roof green house : If farmers want to grow vegetables round the year then he can use low cost detachable roof green house. The favorable environment for cultivation of tomato/ capsicum can be provided by greenhouse (GH), insect net proof house and shade net structure depending upon season of cultivation. The greenhouse can be used successfully for round the year cultivation of tomato and capsicum by providing desirable environmental condition. But the major challenge is cost of construction of greenhouse and its running cost. Due to greenhouse effect the temperature inside the GH is always higher than open field and it is very much beneficial during winter season (November-February) but major problem arises during summer season (March-June). The maximum temperature inside the GH will be always higher than 5-10°C in comparison to open field conditions during summer season. The temperature is not only challenge in GH but higher light intensity is also a problem during summer season. So to utilize the GH during summer season, there is need to reduce the temperature and light intensity both during summer to make it suitable for cultivation (Sethi and Sharma, 19).

The low cost detachable roof greenhouse can be constructed using bamboo and cladding material. The whole structure (except roof) was covered with UV stabilized insect net proof material (40 mesh) but the roof was covered with UV stabilized film (200 micron), so the developed structure will be act as greenhouse (November-February), rain shelter (June-October) and shade net (March-May). The specification of structure, length: 12 m, width: 6 m, side height: 2 m and central height: 3 m (Inside door:- width: 1 m, height: 2.2 m) and compartment for double door structure: width: 2 m, length: 2 m and height: 2.2 m (outside door: width: 1 m, height: 2.2 m). The temperature inside the greenhouse is more than 5-10°C in comparison to open field condition, which is very favorable during winter time. The structure is covered with shade net material (Green & 50%) during summer due to which there is marginal decease in temperature in comparison to open field temperature (Fig. 10). The cladding materials [UV stabilized film (200 micron) and shade net material (Green & 50%)] is fixed using aluminum profile and gripper system due to which replacement of it is very simple and easy. The light intensity was found to be suitable for cultivation of tomato and capsicum. It can be used at any place by small farmers where winter and summer is not very severe. The construction cost of low cost detachable roof greenhouse is around ₹ 300-350/m^2 (Narayan *et al.,* 13).

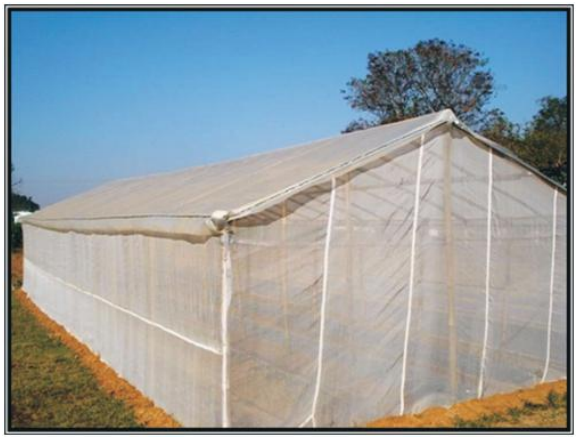

Fig. 10 : Low cost dettachable roof green house.

11. Shrink wrapping technology : Apart from the usual challenges in maintaining the shelf life of fresh produce, the water loss plays important role in enhancing the shelf life and maintaining its quality (Ben-Yehoshua, 2). The farmers can do shrink wrapping/cling film packaging of cabbage/ cauliflower to enhance its shelf life even at room temperature.

The technology used to enhance the shelf life of cabbage are refrigerated storage with temperature control, refrigerated storage with temperature and RH control and modified atmosphere storage. These technologies are not usually used by farmer because these facilities are not available and even though it is available high cost is hindrance in using it. The water

loss is major concern in enhancing the shelf life of cabbage. The major strength of Individual seal packaging (ISP) is that the packaged product can be stored even at room temperature. Apart from cabbage, cauliflower it can be used for papaya, cucumber etc.

The shrink wrapping film of 20 micron was used and it was found that the shelf life of cabbage at room temperature was 4 days and 12 days respectively for unpacked and packed cabbage (Fig. 11). The ISP was found to be very effective in reducing the moisture loss even at room temperature and ultimately helps in increasing the shelf life by eight days for cabbage. It can be used at any place for fruits and vegetables of bigger size to reduce the water loss at room temperature and enhance the shelf life. The cost involved in ISP is found to be between ₹ 0.20 to 0.50/ kg depending upon vegetables (Narayan *et al.,* 13).

Fig. 11 : Plastic shrink wrapped cabbage.

12. Tent type ripening chamber : The farmers can use low cost tent type ripening chamber for ripening of mango at farm level. Mango is often harvested in a mature but unripe condition, and is subsequently allowed to ripen further. In natural conditions, they ripen slowly, leading to high weight loss, desiccation, and ripening is also uneven. The ripening chamber is commercially used for ripening of mango, banana etc. and ethylene is used as ripening agent. Calcium carbide is banned in India for ripening of fruit under the Prevention of Food Adulteration (PFA) Act, 1954 and Prevention of Food Adulteration Rules, 1955. Usually ethrel spraying or dipping of fruits in ethrel is recommended for enhancing ripening, but it is a cumbersome process, and may cause some problems if commercially available ethrel is with chemical impurities. To overcome this, ethylene gas has been commercially used in modern ripening chambers, which require huge investments and are not economically viable option for farmers and small traders. An alternative, simple economical method is standardized for enhancing ripening of fruits by exposing fruits to ethylene gas in the plastic tents.

A ripening chamber can be constructed by using frame of iron wire and it had been covered with plastic film (200 micron). To make it air tight the bottom of the ripening camber was welded with 20 gauge mild iron sheet and a profile with gripper arrangement was fixed on the sides of the chamber to fasten the plastic sheet. The low cost ripening chamber is designed and tested for ripening of mango successfully (Fig. 12). The ratio of chemicals (ethrel and sodium hydroxide) and water required for ripening chamber were calculated. The mango was exposed for 24 hour in the ripening chamber.

Fig. 12 : Low cost plastic ripening chamber.

It can use at any place by farmers/traders for on farm ripening of mango. It can also be tried for banana and papaya. The cost of ripening for mango using low cost ripening chamber (cost of ripening mixture) comes out to be less than five paisa per kilogram (Narayan *et al.,* 13).

13. Medium cost protected structure : This type of protected structure is constructed using galvanized iron (G.I.) pipes and depending upon the type of structures cladding material will vary. The UV stablised plastic film of 200 micron can be used for polyhouse/ greenhouse, shade net material for shade net structure and insect net proof material for insect net proof structure. The major factors affecting the crop yield and quality are genetic material, agronomical management and environment management. The major environmental factor affecting yield and quality are air temperature, relative humidity, light intensity, carbon dioxide and soil temperature.

The selection of crop to be cultivated in the protected structure play very important role in viability of constructed protected structure. There are two basic options available to farmers are (i) choose a species for its high economic potential and develop the most

suitable protection, growing systems and technology. (ii) choose a crop suitable for existing structures within the farm and capitalize on those. It has been found in Jharkhand that farmers/ entrepreneurs are choosing approach (ii) discussed above are following in their farm, which results in failure of their enterprise.

There is need to follow the approach discussed at serial number (i) to be successful in cultivating crops in protected structure. Normally in case of polyhouse/ greenhouse natural ventilated protected structure are constructed. The polyhouse/greenhouse is very advantageous during winter and rainy season but the major problem arise during summer season due to high temperature and light intensity in structure. There is need to reduce the temperature and light intensity during summer season to make structure suitable for cultivation otherwise the effective period during which these structures can be utilized is only eight months (July-February) during the year. The ventilation and shading technology can be used for reducing the temperature and light intensity but it is effective only when the maximum ambient temperature is less than 33°C (Sethi and Sharma, 19). In Jharkhand during summer season the ambient temperature is normally more than 33°C for which evaporative cooling is required to reduce the air temperature inside the polyhouse but the cost of construction and running cost of evaporative cooling system is very high.

Once the farmers are well acquainted with all the above low cost technology then he can use GI based medium cost protected structure for cultivation of vegetables/ flowers (Fig. 13).

Fig. 13 : Medium cost green house.

CONCLUSION

It has been found by discussion with various stake holders involved in implementation of plasticulture technology, they are not able to take full advantage of plasticulture technology. Keeping the various constraints in cultivation of crops and condition of farmer community in Jharkhand a process flow chart has been discussed for proper utilization of various plasticulture technologies by which farmers can take full benefits of plasticulture technologies to improve their crop yield, quality and shelf life. The proper implementation can improve the income of farmer community and will help in improving their livelihood.

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