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Plasticulture: An emerging picture in Indian farming

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Abstract

Farming contributes to the largest livelihood provider in India. Agriculture makes most of the Indian economy. It has to be reformed with modern agricultural practices. Use of plastic is one of the recent approaches followed in several agriculture activities. It is used in the form of films with the constituent of polyethylene, polypropylene, polyvinyl chloride, polycarbonate, poly esters. The plastics/polymers used in soil preparation as soil solarisation or soil fumigation, raising of seedlings in seedling bags or pro-trays, in propagation-layering, budding, grafting, as mulch, in greenhouse and shade net, in irrigation, as crop protection measure, at the time of harvesting and packaging. The physical, chemical, mechanical and thermal properties of plastic have enhanced its use in farming. The increase in the production as well as productivity has been seen in these few years with the adoption of polymers as part of farming.

Keywords: Plastic, farming, uses, plastic materials, properties

Introduction

India is the home of multiple plant species widely spread all over the area due to the wide range of climate, soil and habitat. The cultivation of crop began as early as 9000 BC in India (Mulage, 2017) ^[1]. Today about 58% of India's population is engaged in farming (Indian agriculture and allied Industries Report, 2020) ^[2]. The plant species included in agriculture is classified into two broad categories such as agronomic crops and horticultural crops (Balasubramaniam, 2014) ^[3]. Emphasis is be given for the agriculture sector in India to make it healthy which helps to increase the Indian economic through GDP against 14% GDP presently. The introduction of plastic to India during 1957 paved the steps of Indian farming (DGCIS-2020) ^[4]. The term plasticulture refers to the application of plastic in farming (Singh *et al.* 2018) ^[5]. Plastics are used in various forms and structures in different activities of farming.

Importance of Plastic

Long years ago, before the invention of plastic the farmers were limited to traditional knowledge. The use of plastic over traditional knowledge helps to check the soil erosion, conserving water loss, checking the unwanted weed growth, checks the amount of pathogens and insects, increases the shelf-life, increase yield. Plastic materials such as polyethylene (PE), polypropylene (PP), ethylene-vinyl acetate copolymer (EVA), polyvinyl chloride (PVC), polycarbonate (PC), poly methyl 1-methacrylate (PMMA), glass fiber reinforced polyester are widely used in agriculture (Plastics Europe, Mugnozo *et al.*, 2011, Picuno, 2018) ^[6, 7, 8]. Use of biobased plastic nets-poly amino acids, polysaccharide derivatives, polyhydroxybutyrate, polycaprolactone, polyhydroxylalkanoate, polylactic acids which are biodegradable in nature are the more advanced and safer polymers (Maraveas, 2020) ^[9]. Fibre/polymers have physical, chemical, mechanical and thermal properties which have enabled it to its widespread use in agriculture field. They have good tensile strength and elongation property, heat preservation behaviour, good water permeability, good photopermeability, good thermal stability, reusable nature (Tan *et al.*, 2016; Espi *et al.*, 2006; Ebel, 1973; Sica *et al.* 2015) ^[10-13]. The films used in mono, double, triple and five layers depending upon the application and need (Dehbi *et al.*, 2017) ^[14]. Their use have occupied space in various agricultural activities, in soil solarisation, raising seedlings/seed, propagation methods, as covering material, greenhouses, irrigation, crop protection. The applications of plastic have converted several unproductive areas into agriculture developments.

Uses in Agricultural activities

Soil Preparation: Soil is the source of nutrients and water necessary for plant growth (Passioura 1991) ^[15]. It is the storehouse of several micro-organism which may be beneficial and harmful (Swami *et al.*, 2017) ^[16].

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To protect the plant from the attack of pathogens and to kill weed seeds by soil sterilisation is used which consists of two methods either soil solarisation or soil fumigation (Katan *et al*, 1976 and Merfield, 2019) ^[17, 18]. Soil solarisation involves the disinfection of soil through solar heating and covering it with transparent sheet. For soil solarisation very important is the thickness of polythene sheet which checks the lethal growth of weed species, micro-organisms during plant growth development stage (Saresh *et al*, 2013) ^[19]. Soil solarisation involves use of plastic film for 1-2 months which helps to eradicate against pathogens and pests (Stapleton *et al*, 1986) ^[20]. Soil fumigation is a therapeutic treatment of soil before planting to get rid of diseases, pest and nematode (Chellani *et al*, 2014) ^[21]. It involves the use of minimal residual inputs to obtain a comparable reduction of soil borne pathogens. For the fumigation technique transparent polyethylene film is needed (Patel *et al*, 2017) ^[22].

Nursery management

Nursery is a place where seedlings and saplings are raised. It involves various activities such as raising of seedlings in nursery bags/seedling bags, pro-trays, propagation, etc. (Rathakrishnan *et al* 2014) ^[23]. These operations involves the use of plastic. Raising of seeds in container or plug trays or portrays gives pest and disease free with good root developed healthy seedlings, amount of seed required is also less (Bharathi *et al*, 2014 and Pandiyaraj *et al*, 2017) ^[24, 25]. Tomato seedlings when raised in multi-celled plastic plug trays of round cell with volume 68.2 cm³ gave good quality seedlings than inverted pyramid cell volume of 18.4 cm³ and 8.6 cm³ (Singh *et al*, 2007) ^[26]. Bioplastic additives can be used as mulch film and seedling bags in agriculture. Low density polyethylene bags are used for seedling production (Blick *et al*, 2014) ^[27]. The propagation methods like layering, grafting, budding have proved successful in formation of various hybrid variety of many crops which gives higher yield. Wrapping materials occupy an important place in propagation which helps in gaining successful compatibility between different varieties or different species. These are available in different colour and thickness. Wrapping material such as coloured polythene sheet (black and transparent) used in air-layering showed profuse rooting (Rane *et al* 2011) ^[28]. The use of white polythene wrapping material is found for better rooting than black polythene and aluminium foil in air-layering in litchi (Mishra *et al*, 2017) ^[29]. In guava cv. Allahabad safeda, the use of black poly wrapper (200 gauge) proved better than transparent poly wrapper (200 gauge) in terms of rooting and survival percentage of rooted layers (Chaudhari *et al* 2018) ^[30]. Plastic has occupied a good space in softwood grafting, veneer grafting, cleft grafting. White transparent polythene tape of 20 x 6 cm used for various grafting techniques such as cleft and veneer grafting in mango (Islam *et al* 2004) ^[31]. Number of leaves found to be maximum when degradable tape (elastic tying, 25 mm) was used as wrapping material than polythene strip (200 gauge) in softwood grafting in mango (Gohil *et al*, 2019) ^[32]. The use of wrapping materials such as grating tape and normal plastic proved beneficial in success percentage and sprouting percentage of grafting in royal delicious apple (Devkota *et al*, 2020) ^[33]. Soft plastic wrapping material results highest bud success in kiwi fruit budding (Zenginbal *et al*, 2006) ^[34].

Mulching

It is the covering of soil with natural or synthetic materials to improve the soil health, maintain soil temperature, suppress

weed growth, maintain soil water, nutrient availability, increase biomass production (Sharma and Bharadwaj, 2017) ^[35]. It helps to increase productivity and crop yield by conserving water (Ingam *et al*, 2015) ^[36]. Plastic mulch in various colours, black, white, reflective are used to control the micro-climate in the soil around plant (Tarara, 2000) ^[37]. Polyethylene film mulch was the most effective method of mulching (Waggoner *et al*, 1960) ^[38]. It has also seen that the use of plastic mulch (red, black, silver) proved better than organic mulch in terms of plant growth, yield and increasing soil temperature (Rao *et al*, 2016) ^[39]. The availability of phosphorus and potassium are good enough in plastic mulch as compared to non-mulched soil. Higher C: N ratio for plant growth in black plastic mulch. Use of plastic mulch and drip-irrigation was found to remain soft and well aerated for plant growth (Tiwari *et al*, 2014) ^[40].

Controlled environment agriculture

This approach involves the manipulation of environment to provide protection throughout the growing season of crop and increase yield, quality and productivity. This involves technology like greenhouse, shade net house, poly tunnels (Singh *et al*, 2018) ^[5]. Greenhouse structure provides a modifying natural environment for the farmers to fetch an income in offseason (Nair and Barche, 2014) ^[41]. The covering material used in greenhouse mostly consist of various plastic in various forms such as single layer plastic, double-wall plastic, polythene film, polyvinyl chloride, copolymers (Shamshiri *et al*, 2018) ^[42]. The use of various covering materials like polyethylene, polycarbonate (2mm and 4 mm) maintains temperature and relative humidity in greenhouse required for plant growth (Subin *et al*, 2019) ^[43]. Plastic nets (coloured HDPE) are used in shade-net houses of varying colours and shading rates which supports agricultural applications as shading, anti-hail, anti-insects, wind break, anti-birds (Castellano *et al*, 2008) ^[44]. Nets have different colours like white, green, black, blue, orange, dark-green (Al-Helal and Abdel-Ghany, 2010) ^[45]. Plastic used in poly tunnel help in increasing yield by increase of soil temperature and air temperature (Ranjan *et al*, 2019) ^[46].

Water Management

New method of irrigation, Micro-irrigation is an efficient method of irrigation used in agriculture. This includes drip and sprinkler method which saves water, increases the water use efficiency, reduce energy requirement, reduces weed growth and checks soil erosion (Narayanswamy and Anandakumar, 2016) ^[47]. Mostly, polyvinylchloride, polyethylene, high density polyethylene, low density polyethylenes are used in main and lateral pipes in drip irrigation (Javed *et al*, 2015) ^[48].

Crop protection

Plastics have complete or partial absorption of solar UV radiation, which interrupted the lifecycle of pathogens and insects and control the insect transmitted plant viruses (Raviv and Antignus, 2004) ^[49]. The infestation of aphids, whitefly, leaf hoppers were less in UV blocking films (Doukas and Payne, 2007) ^[50]. The use of plastic film or large mesh insect nets helps to lower the insect-pest population in tomato and increase the productivity (Nordey, 2020) ^[51]. Coloured plastic mulch-black, white, red repel insect pest and decrease insect vectored virus incidences (Greer, 2003) ^[52]. Some species of insects such as whitefly, thrips, aphids are dependent on UV light. Anti-insect net (50 mesh) with plastic film and UV

blocking used to control the above (Kumar and Poehling, 2006) [53].

Harvesting and packaging

Harvesting involves the gathering of ripened crops or economic parts after maturity. The produce has to be transferred from field to storage or to be packaged for future use. For bulk produce, plastics such as sacks, bags, crates, wraps (Franklin Associates, 2018) [54]. Plastics used in packaging should be free from contamination, water-proof, non-degradable, recyclable (Geucke, 2018) [55]. Plastics are made of LDPE, HDPE, PVC (American plastic council, 1997; Raheem, 2012) [56, 57]. Sack as woven synthetic material of polypropylene is used. Polyethylene film bags are also used. For plastic crates, HDPE is used (Rapusas and Rolle, 2009) [58].

Conclusion

Plastics are proving a blessed to the agriculture field. In India, farming is regarded as backbone of our country. With the application of plastic in farming both the production and productivity have increased by minimising pest, disease and weed population. Emphasis has to be given to improve the plastic techniques to make it efficient and economic among the farmers to implement that in their field. Plastics are gaining importance in agriculture. Its implementation benefited agriculture one way or the other. The use has been spread from preparation of soil up to harvesting of crop. Soil sterilisation, sowing of the seeds, propagation techniques, soil covering, irrigation, growing crops in controlled environment, insect-pest management, collection of mature crop from field requires the plastic in the form of film, net or crates. The shape of the farming in India is to be changed with the emerging importance of plastic with its versatile nature.

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