POSSIBLE BREAKTHROUGHS BIODEGRADABLE PLASTIC MULCHES

Mulching is common practice in agriculture aimed at reducing water loss through evaporation, controlling weed growth and increasing soil temperature. The development of bio-based and biodegradable variants of mulches adds to the above-mentioned benefits as it reduces disposal costs for farmers.

ANNEX K

Description

Plastic mulching is a technique by which plastic sheets are applied as a skin over the soil surface. This second layer creates a microclimate that allows for better control of crop growth factors, such as water, temperature and nutrients. It is especially applied in the horticultural sector to optimize production and the quality of vegetables and fruits. The vast variety of plastics allows the grower to select the right plastic according to the specific crop conditions. The performance of the plastic mulch in controlling the range of crop growth factors is determined by its material, thickness and color. Common materials used for the production of petrol-based sheets are linear low-density polyethylene (LLDPE), low-density polyethylene (LDPE), ethylene vinyl acetate (EVA) and polyvinyl chloride (PVC). The material used for bio-based mulch is polymerized lactic acid (PLA). The sheets have a typical thickness of 10 to 50 microns and a width of (up to) three meters.[1] The colors used the most are transparent, white, black and green, each having different features that impact crop growth factors. Box I provides a short overview of the performance of the different sheet colors.

Box 1

Specific uses of different types of plastic sheets

Transparent (clear) sheets

- Encourage early season plant growth and cropping as sunlight shines through the sheets and increases the temperature between the sheet and topsoil. Dickerson[2] mentions increases of 4.4-7.8° C and 3.3-7.8° C at 5 and 10 cm soil depth respectively.

Black sheets

- Used to control weed growth as sunlight is unable to penetrate the sheet; thus photosynthesis, required for plant and weed growth, does not occur, which ultimately reduces weeding costs.

White, silver and aluminum

- Used to redirect sunlight that has penetrated the leaf canopy toward the leaves, allowing greater photosynthesis and yields. Simultaneously, it cools down the soil, allowing crop cultivation during high temperatures.[3]

[1]Dow Chemical Company n.d. [2]Dickerson 2002, [3]Lamont 2005; Dickerson 2002

Geography

The adoption of plastic mulching has seen exponential growth. While in 1991 the agricultural area covered amounted to 1.8 million hectares, in 1999 it grew to 12 million hectares, a six-fold increase.[4] This growth is almost completely attributed to the increasing adoption of plastic mulching in China, which expanded by 8 million hectares between 1991 and 2006.[5] In China, farmers, especially those in the drought prone provinces in the northwest, such as Xinjiang and Yunnan, are familiar with this technique as it prevents unproductive evapotranspiration of water.[6] "The mulching extends the growing season and contributes to higher yields and quality compared to open-field cultivation".[7] In some areas, entire valleys glisten as they are partly wrapped up in plastic mulch.

Table 1
Area covered by plastic mulching in 2006

Estimates (ha)	Greenhouse (glass)	Greenhouse (plastic) and large tunnels	Small plastic tunnels	Plastic mulching
Asia	2,476	926,000	665,000	10,000,000
Europe	28,922	171,500	92,000	400,000
Africa/ Middle East	6,682	50,600	112,000	80,000
North America	1,350	11,050	20,000	260,000
Central and South America		9,510	11,000	6,000
World total	**39,430**	**1,168,660**	**900,000**	**10,746,000**

Source: Rabobank 2006

[4]Brown 2004, [5]Brown 2004; Rabobank 2006, [6]Li et al. 2003 [7]Rabobank 2006

Impact on yields

Plastic mulches exercise multiple functions that ultimately lead to higher yields. They improve water and nutrient use by the crops, regulate soil temperature, control weed growth, reduce soil compaction by equipment and people, reduce erosive forces, reduce diseases from splash and reduce rot through contact between plant and soil.[8] Table 2 provides an overview of reported yield increases using the mulch technique.

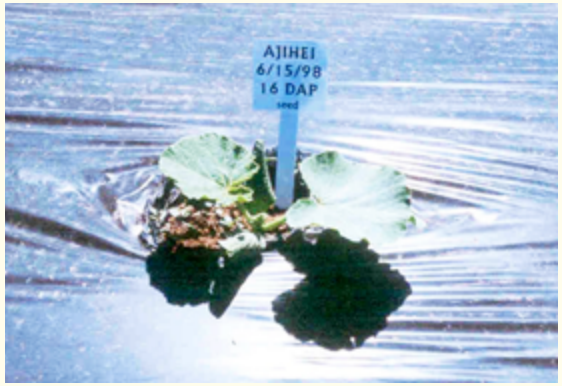

Figure 1
Kabocha squash plant in black plastic mulch 16 days after seeding[9]

Table 2
Yield response to mulching technique

Crop	Region	Yield increase (%)	Reference
Tomato	India	45-50	NCPAH 2011
Tomato	U.S. (North Carolina)	300	Sanders 2001
Pepper (Chile)	India	50-60	NCPAH 2011
Pepper (Chile)	U.S. (North Carolina)	400	Sanders 2001
Pepper (Chile)	Chile	63	Ashrafuzzaman et al. 2010
Potato	India	35-40	NCPAH 2011
White Yam	Nigeria	10-36	Osiru and Hahn 1994

[8]Osiru and Hahn 1994; Sanders 2001; Ashrafuzzaman et al. 2011; NCPAH 2011, [9]Alam and Zimmerman 2002

Energy

- The production of bio-based plastics (such as polymerized lactic acid – PLA) requires between 1 and 5 GJ/t, while petroleum-based plastics (such as low-density polyethylene – LDPE) require more than 75 GJ/t.[10]
- Biodegradable plastic mulch does not have to be removed and transported to a disposal site because the sheets decompose, saving farmers the additional use of machines and fuel.

Water

- Plastic mulch prevents unproductive evapotranspiration of water. Instead, water is kept within the reach of the crop roots.
- Drip irrigation, widely used in combination with plastic mulch, allows for water savings – up to 50% compared to furrow or overhead sprinklers.[11]
- Biodegradable mulches have the same impact on soil moisture content at 15 cm and 46 cm depths compared to black plastic mulch.

Health

- Plastic mulches are oil based and the inner side is often impregnated with fertilizers, pesticides and insecticides.[12] High disposal costs cause farmers to dump sheets uncontrolled into the environment. Besides the fact that it is unaesthetic, the inert substances are able to enter the environmental cycle.
- Biodegradable mulch, composed of biological starting materials, such as starch, decomposes by abiotic and microbial processes into carbon dioxide, methane, water, inorganic compounds and microbial biomass.[13]

[10]Bos et al. 2011, [11]Feibert et al. 1992; Kovach et al. 1999, [12]Kapanen et al. 2008, [13]Song et al. 2009

Climate change

- Production of bio-based plastics sequestrates carbon, ranging from 0.5 t CO_2 per tonne of corn/wheat and 1.8 t CO_2 per tonne of sugarcane.[14]
- Polyethylene (PE) is the most used plastic globally, totaling 80 million tonnes produced per year. It is, however, based on fossil fuels. PE can be also produced from ethanol.[15]
- Bioplastic (PLA) production based on sugar beets reduces fossil fuel use by 65% compared to LDPE plastic mulches.[16]

Costs and benefits

The price of plastic mulch is high at approximately US$ 0.14 per square meter or US$ 700 per hectare; removal and disposal costs are about US$ 250 per hectare.[17]

Bio-based and biodegradable mulches, such as PLA and polyhydroxyalkanoate (PHA) are able to compete with the petrol-based ones and have good potential as agricultural mulches.[18]

- PLA mulch production is increasing and costs are more competitive with PE mulch (currently only approximately 15% higher).[19]
- Global PLA production capacity is 140,000 tonnes/year, at an average cost of US$ 2.1-3.4 per kg.[20]
- PHA is produced by bacteria and is three times more expensive than PLA.

[14]Bos et al. 2011, [15]Ibid, [16]Wageningen UR 2011, [17]Schonbeck 1995, Olsen and Gounder 2001, [18]Vroman and Tighzert 2009, [19]Cup Depot n.d., [20]Bos and Bolck 2008

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