PLASTIC MULCHING FOR CROP PRODUCTION

Introduction

Mulching is the process or practice of covering the soil/ground to make more favourable conditions for plant growth, development and efficient crop production. Mulch technical term means 'covering of soil'. While natural mulches such as leaf, straw, dead leaves and compost have been used for centuries, during the last 60 years the advent of synthetic materials has altered the methods and benefits of mulching. The research as well as field data available on effect of synthetic mulches make a vast volume of useful literature. When compared to other mulches plastic mulches are completely impermeable to water; it therefore prevents direct evaporation of moisture from the soil and thus limits the water losses and soil erosion over the surface. In this manner it plays a positive role in water conservation. The suppression of evaporation also has a supplementary effect; it prevents the rise of water containing salt, which is important in countries with high salt content water resources.

Advantages of plastic mulching

1. It is completely impermeable to water.
2. It prevents the direct evaporation of moisture form the soil and thus limits the water losses and conserves moisture.
3. By evaporation suppression, it prevents the rise of water containing salts.
4. Mulch can facilitate fertilizer placement and reduce the loss of plant nutrient through leaching.
5. Mulches can also provide a barrier to soil pathogens
6. Opaque mulches prevent germination of annual weeds from receiving light
7. Reflective mulches will repel certain insects
8. Mulches maintain a warm temperature even during nighttime which enables seeds to germinate quickly and for young plants to rapidly establish a strong root growth system.
9. Synthetic mulches play a major role in soil solarisation process.
10. Mulches develop a microclimatic underside of the sheet, which is higher in carbon-di-oxide due to the higher level of microbial activity.

11. Under mulch, the soil structure is maintained during cropping period
12. Early germination almost 2-3 days.
13. Better nodulation in crops like Groundnut.
14. Less nematodes population.
15. Water erosion is completely averted since soil is completely covered form bearing action of rain drops.
16. When compared to organic mulches, it serves for a longer period.

Moisture conservation

- Plastic film with its moisture barrier properties does not allow the soil moisture to escape Water that evaporates from the soil surface under mulch film, condenses on the lower surface of the film and falls back as droplets.
- Thus moisture is preserved for several days and increases the period between two irrigations.
- The irrigation water or rainfall either moves into the soil thru holes on the mulch around the plant area or through the un-mulched area.

Weed control

- Black plastic film does not allow the sunlight to pass through on to the soil
- Photosynthesis does not take place in the absence of sunlight below black film hence, it arrests weed growth

Limitations

- They are costly to use in commercial production when compared to organic mulches.
- Probability of 'burning' or 'scorching' of the young pants due to high temperature of black film.
- Difficulty in application of top dressed fertilizer
- Reptile movement and rodent activities are experienced in some places.
- More runoff
- Environmental pollution
- Difficult in machinery movement
- Can not be used for more than one season using thin mulches
- Weed penetration with thin films
- Toxic to livestock

Areas of application

Mulching is mainly employed for

a. Moisture conservation in rainfed areas
b. Reduction of irrigation frequency and water saving in irrigated areas
c. Soil temperature moderation in greenhouse cultivation
d. Soil solorisation for control of soil borne diseases
e. Reduce the rain impact, prevent soil erosion and maintain soil structure
f. In places where high value crops only to be cultivated

Types of mulch film

A wide range of plastic films based on different types of polymers have all been evaluated for mulching at various periods in the 1960s. LDPE, HDPE and flexible PVC have all been used and although there were some technical performance differences between them, they were of minor nature. Owing to its greater permeability to long wave radiation which can increase the temperature around plants during the night times, polyethylene is preferred. Today the vast majority of plastic mulch is based on LLDPE because it is more economic in use.

Basic properties of mulch film

a. Air proof so as not to permit any moisture vapour to escape.

b. Thermal proof for preservation of temperature and prevention of evaporation

c. Durable at least for one crop season

Importance of parameters of the plastic film

a) Thickness

Normally the thickness of the film does not affect the mulching effect except when it is used for solorisation. But some of the recent references do indicate the impact of film thickness on crop yield. Since it is sold by weight it is advantageous to use as thin a film as possible but at the same time due consideration should be given for the longevity of the film. The early mulch film used were of 60-75 micron (240-300 gauge) thickness, and today it is possible to have 15 micron thick film due to advent of film extrusion technology. These films are mechanically weak, as shown by their easy tearing when pulled tension.

b) Width

This depends upon the inter row spacing. Normally a one to one and half meter width film can be easily adopted to different conditions.

c) Perforations

The perforations may be advantageous under some situations and disadvantageous for some other situation. The capillary movement of water and fertilizer distribution will be better and more uniform under unperforated condition. But for prevention of water stagnation around the plants, perforation is better. But it has got the disadvantages of encouraging weed growth.

d) Mulch colour

The colour of the mulch affects

i. Soil temperature

ii. Temperature of air around the plants

iii. Soil salinity

a. Due to lesser quantity of water used

b. Due to reduction in evaporation and prevention of upward movement of water.

Transparant film	-	Deposits more salt on soil surface
Black film	-	Restricts water movement and upward movement of salt is reduced.
iv. Weed flora	-	Black film
v. Insect control	-	Opaque while film acts as golden colour and attracts insects

Selection of mulch

The selection of mulches depends upon the ecological situations and primary and secondary aspects of mulching

Rainy season	-	Perforated mulch
Orchard and plantation	-	Thicker mulch
Soil solarisation	-	Thin transparent film
Weed control through solarisation	-	Transparent film
Weed control in cropped land	-	Black film
Sandy soil	-	Black film
Saline water use	-	Black film
Summer cropped land	-	White film
Insect repellent	-	Silver colour film
Early germination	-	Thinner film

Methods of mulching

- Orchard/Fruit/Established trees
- Mulching area should preferably be equivalent to the canopy of the plant.
- Required size of mulch film is cut from the main roll.
- Clean the required area by removing the stones, pebbles, weeds etc.
- Till the soil well and apply a little quantity of water before mulching
- Small trench could be made around the periphery of the mulching area to facilitate anchoring of the mulch film.
- Cover the film to the entire area around the tree and the end should be buried in the ground.
- Semi circular holes could be made at four corners of the film in order to facilitate water movement.
- The position of the slit/opening should be parallel to the wind direction

- Cover the corners of the film with 4-6 inches of soil on all sides to keep the film in position.
- In hard soil, make a trench of 1'x1'x2' depth on four corners of the mulching area and fill it up with gravel or stones, cover the trenches with the mulch film and allow the water to pass through the mulch to the trenches via semi circular holes on the film

Mulch Laying Techniques

i. Mulch should be laid on a non-windy condition

ii. The mulch material should be held tight without any crease and laid on the bed

iii. The borders (10 cm) should be anchored inside the soil in about 7-10 cm deep in small furrows at an angle of 45°.

Pre planting mulch:

The mulch material should be punctured at the required distances as per crop spacing and laid on the bed. The seeds/seedlings should be sown/transplanted in the holes.

Mulching techniques for Vegetables /close space crop

- Very thin film is used for short duration crops like vegetables.
- Required length of film for one row of crop is taken and folded in 'thaan' form at every one metre along the length of the film.
- Round holes are made at the center of the film using a punch or a bigger diameter pipe and a hammer or a heated pipe end could be used.
- One end of the mulch film (along width) is anchored in the soil and the film is unrolled along the length of the row of planting.
- Till the soil well and apply the required quantity of FYM and fertilizer before mulching.
- Mulch film is then inserted (4-6") into the soil on all sides to keep it intact
- Seeds are sown directly through the holes made on the mulch film.
- In case of transplanted crops, the seedlings could be planted directly into the hole.
- For mulching established seedlings, the process of punching the hole is the same. One end of the film along the width is burried in the soil and the mulch film is then unrolled over the saplings. During the process of unrolling, the saplings are

held in the hand and inserted into the holes on the mulch film from the bottom side, so that it could spread on the topside.

Precautions for Mulch Laying

- Do not stretch the film very tightly. It should be loose enough to overcome the expansion and shrinkage conditions caused by temperature and the impacts of cultural operation.
- The slackness for black film should be more as the expansion, shrinkage phenomenon is maximum in this color.
- The film should not be laid on the hottest time of the day, when the film will be in expanded condition.

Removal of mulch

In case the mulch film needs to be used for more than one season (thicker film) the plant is cut at its base near the film and the film is removed and used.

By compounding appropriate additives into the plastics it is possible to produce a film, which, after exposure to light (solar radiation) will start to breakup at a pre determined time and eventually disintegrated into very small friable fragments. The time period can be 60, 90, 120 or 150 days and for maize a 60-day photodegradable mulch is used. However there are still some further problems to resolve. It has been observed that the edges of the mulch, which are buried to secure the mulch to the soil, remain intact and become a litter problem when brought to the surface during the post-harvest ploughing. Currently much development effort is being made to find a satisfactory solution to this problem.

In direct contrast in developing countries which have agricultural labour available a different approach can be made. Fro example in the people Republic of China trials have been made using a plastic mulch of 15 micron thickness on a sugarcane crop. After the cuttings have been planted through the mulch they are left to grow for a period of one month. Then the mulch is removed by hand and wound up so that it can be utilized for a second season. A yield increase of 26% was obtained.

These two examples not only demonstrated the diversity of mechanisms available for resolving the problems of mulch removed, but also illustrate the different technique, which have been developed in different countries. It also indicates the necessity for each country to adapt and develop mulching technique to meet its own specific requirements

of climate, resources and economics. To undertake such technology development there is a specific requirement that both plastics and agricultural development facilities are available.

Irrigation practices under mulching

- In drip irrigation the lateral pipelines are laid under the mulch film
- In case inter-cultivation need to be carried out, it is better to keep the laterals and drippers on top of the mulch film and regulate the flow of water through a small pipe or through the holes made on the mulch film

- In flooding the irrigation water passes through the semi circular holes on the mulch sheet.

Cost economics of mulching

The cost economic of mulching is an important aspect. In a leveled field if mulching is to be done, then the film area required will be almost equal to that of field itself. In fields with ridges and furrows mulching material required will be sizably more than the field area. However mulching is carried out in strips covering 50-60% of field area. In the present era of minimizing rainfall conserving moisture with mulching transgresses the plan of economic analysis in the sense that the real cost analysis would be even meaningless in the case of a precious commodity like water. A typical calculation has been given for working out cost economics of mulching in Bhendi crop.

Assumptions made in cost estimation

- Power and source of water are available.
- Price of synthetic film of black LLDPE is taken as Rs. 120 per Kg.
- PVC film is assumed to last for 2 seasons only. However in practice, black PVC film may well last longer than two seasons, if handled properly, in that case savings could be correspondingly larger.

Cost Economics of mulching

Sl. No.	Particulars	Black LLDPE film	Control
1	Cost of cultivation (Rs. / ha)	16000	21000
2	Cost of mulch film per season	16600	--
3	Total seasonal cost (2+1)	32600	21000
4	Yield of produce (kg/ha)	11660	7770
5	Market price (Rs./kg)	6.00	6.00
6	Revenue (Rs./ha)	69960	46620
7	Total expenditure	32600	*21000
8	Net income	37360	25620
9	Difference in net seasonal income	11740	25620
10	Benefit cost ratio	1.45: 1	

*** 60% area covered with film, 50 micron film of 1 kg cover 22 sq. m**

Case studies

Effect of mulching on groundnut

An experiment on mulching with plastic films was conducted for groundnut Aliyarnagar Research Station. The film was LLDPE black and the thickness were 15 micron (T10, 20 micron (T2), 25 micron (T3), coir pith at the rate of 20 t/ha (T4) and fifth plot was control (T5). Each plot was 2m x 1m and experiments were replicated four times. For sampling purpose, 5 plants in each of the experimental plots were considered for rot length on 60^{th} day. The crop was harvested on 110^{th} day since sowing. Parameters like soil moisture, soil temperature, germination; weed, root and yield were observed.

Plastic mulching in groundnut

Treatment	Available moisture at harvest (%)	Wet weed wt. (g)/plot at 45th day	No. of pods/plant	Pod yield (kg/ha)
T_1 – 15 micron LLDPE (black)	7.69	150	9.00	1337
T_2 – 20 micron LLDPE (black)	7.62	156	7.75	1118
T_3 – 25	7.05	179	7.50	1275
T_4 – Coir pith 20 t/ha	6.50	257	6.75	1012
T_5 Control – no mulch	5.90	370	6.75	850

Mulching with 15 micron LLDPE film was found to give higher pod yield due to better moisture conservation, reduced weed growth, when compared to coirpith mulch and control. From the results it was also seen that the thickness of film did not matter much in conserving moisture.

Effect of mulching on cotton crop

Experiments were conducted at TNAU, by PDC, CAE for dry land cotton, covering 50% of land area by 25 micron LLDPE black polyethylene film. The replicated trial was repeated for 3 seasons from 1992-93 for LRA 5166 cotton variety. For comparative study purpose coir pith at a rate of 12.5 t/ha and organic mulch of 12.5 t/ha were also taken. Plot size was 5 m x 4 m.

Effect of mean yield of cotton over 3 years

Treatments	Mean kapas yield (kg/ha)	Wet weed wt./plot (gm) at 45th day
Black LLDPE (20 micron)	673	303
Coir pith	565	575
Organic mulch	509	510
No mulch	436	1121

Effect of mulch on root length and plant height in castor and redgram

To study the effect of mulching on plant height and root length under dryland conditions plants like redgram and castor crop were selected and trials were conducted at TNAU campus. The results are as shown below:

Effect of mulch on plant height and root length

Treatment	Red gram (SAI)			Castor (CO 1)		
	Plant height (cm)	Root length (cm)	Root No.	Plant height (cm)	Root length (cm)	Root No.
30 mic. LLDPE black	45.0	25.3	5	50.1	38.3	8
40 mic. LLDPE black	41.6	20.7	3	48.7	35.8	5
50 mic. LLDPE black	41.9	23.0	3	48.0	34.3	5
No mulch	22.1	20.9	4	30.1	28.6	6

Effect of mulching on vegetable crops

From the year 1986 onwards, Coimbatore PDC is continuously conducting experiments on mulching for principal vegetable crops like Bhendi, Tomato and Chilli. Replicated trials were conducted with three irrigation levels and two type of mulches as follows.

I_1 – Irrigation at 0.41 IW/CPE M_o – Control – no mulch

I_2 – Irrigation at 0.61 IW/CPE M_1 – Control – no mulch

I_3 – Irrigation at 0.61 IW/CPE M_2 – Control – no mulch

The plot size was 5.5 m x 2.5 m/each

Each experiment was repeated thrice in different season for the same variety of crop for confirming the results. The mean values of yields of each crop are tabulated below.

1. Bhendi

Effect of mulching on Bhendi yield (4 year average) in kg/ha

Treatment	M_0	M_1	M_2	Mean
I_1	6593	8249	11292	8698
I_2	8145	9156	12173	9825
I_3	8571	8686	11555	9604
Mean	77770	8697	11660	

2. Tomato

Effect of mulching on tomato yield

Mean yield data over three years

Treatment	M_0	M_1	M_2	Mean
I_1	8322	10260	11767	10116
I_2	9527	11415	13012	11318
I_3	11916	12326	13427	12556
Mean	9922	11334	12735	
		(14.2)*	(28.4)*	

*Percentage of yield increase over unmulched control / plot

3. Chilli

Effect of mulching on Chilli yield

Mean yield data over three years

Treatment	M_0	M_1	M_2	Mean
I_1	3972	4353	4916	4414
I_2	4732	5115	5475	5107
I_3	4940	5359	5872	5390
Mean	4548	4942	5421	

Effect of mulching on maize crop

Experiments conducted in TNAU main campus showed that evaporation loss from the maize crop field can be arrested by covering the soil either with plastic film of 20 micron (80 gauge) of black sheet or with organic farm waste like cumbu straw. Due to this water economizing to the level of 12-20% was achieved. Hence it is a viable technology under moisture stress condition.

Effect of mulching on maize yield and WUE

Treatment	Seasonal total water (mm)	Yield in kg/ha	WUE (kg/ha mm)
1. Control	463	5562	11.90
2. Plastic mulch with 20 micron	373	5650	15.10
3. Cumbu straw	401	5594	13.90
4. Coir pith	403	5466	13.86

Conclusions on basis of experiments conducted so for

1. Flexible PVC film is suitable for mulching. PVC film shows the expected over all advantages of mulch irrigation such as conservation of moisture and control of weed growth.
2. Savings in water appear to be the main advantage and such savings are found to vary from 20% to as high as 75%. The savings in water are more pronounced in arid areas. These experiments clearly established that such savings could be of critical importance in arid areas. Areas having elaborate irrigation do not appear to show considerable advantage. Mulching, therefore, would appear and promising for arid lands.
3. Yields of crops may not necessarily be substantially increased directly by usage of mulching, but more land can be cultivated with the available amount of water and thus overall cultivation of crops can be increased. However, it is significant to not that in both experiments conducted in arid areas increased yields were reported.

4. 150-200 gauge PVC film based on normal compositions would withstand weathering for 2 seasons. However, the life of film could be increased by covering the film with the soil and thus preventing direct exposure of the film to sunlight. PVC film based on special compositions would certainly have better weather resistance and would last for several seasons. Black as well as completely opaque, white film would be better than natural semi-transparent film in respect of weather resistance. Black film would appear to be better for colder climates while opaque white film would show some advantages for warm climates.
5. Black PVC film shows better control on weed growth than completely opaque white and natural translucent film.

Conclusion

Plasticulture is crucial to Indian agriculture in view of the changing technological scenario for boosting crop yields and productivity. Introduction of linear low density polyethylene (LLDPE) as a mulch film has brought a revolution in agricultural water management. It is actually a boon to dryland farmers. This is one of the fastest growing plasticultural applications in the world. The cost of LLDPE film is also lesser than one third of LDPE mulch film. Moreover for mulch activity lower thickness (15 to 20 microns) are highly suitable. However due to ever increasing cost of raw materials the films are costlier now. Hence Government should take all possible measures to produce the film in a mass scale and make it available to the farmers at a reasonable price. Subsidy may also be given through banks to encourage the farmer to adoption soil mulching. Low cost machines may be developed for spreading and rolling down the film in the field. PFDC's may be geared up for large scale demonstration in farmer's field to give a wide publicity.

Studies on mulching at various centres of PFDC's all over India

Sl. No.	Crop	Location of PFDC	Mulch material	Increase in yield (%)	Additional income (Rs./ha)
1.	Chilli	Navasari (Gujarat)	Black plastic (50 micron)	60.1	10140.00
2.	Brinjal	Navasari (Gujarat)	Black plastic (50 micron)	27.1	7400.00
3.	Sugarcane	Navasari (Gujarat)	Black plastic (50 micron)	50.2	25000.00
4.	Chilli	Navasari (Gujarat)	Green plastic (50 micron)	59.0	22190.00
5.	Cauliflower	Hisar	Black plastic (50 micron)	31.9	6751.00
6.	Potato	Pantnagar (UP)	Black plastic (50 micron)	35.5	8700.00
7.	Cauliflower	Pantnagar (UP)	Black plastic (50 micron)	71.0	16120.00
8.	Tomato	Pantnagar (UP)	Plastic film (25 micron)	46.5	11250.00
9.	Okra	Pantnagar (UP)	Plastic film (25 micron)	47.85	9250.00
10.	Tomato	Pantnagar (UP)	Plastic film (25 micron)	79.2	22764.00
11.	Tomato	Kharagpur (WB)	Plastic film (25 micron)	65.4	43210.00
12.	Okra	Kharagpur (WB)	Plastic film (25 micron)	55.1	19625.00
13.	Guava	Delhi	Plastic film (100 micron)	26.0	--
14.	Lemon	Delhi	Plastic film (100 micron)	21.6	--
15.	Kinnow	Delhi	Plastic film (100 micron)	46.8	--
16.	Pomogranate	Delhi	Plastic film (100 micron)	33.3	
17.	Brinjal	Coimbatore	Plastic film (25 micron)	33.3	12062.00
18.	Bhendi	Coimbatore	Plastic film (25 micron)	46.7	9770.00
19.	Bhendi	Coimbatore	Plastic film (25 micron)	54.0	6400.00
20.	Chilli	Coimbatore	Plastic film (25 micron)	18.6	6800.00
21.	Groundnut	Coimbatore	Plastic film (15 micron)	20.5	7300.00
22.	Banana	Travacore (Kerala)	Plastic film (50 micron)	12.6	13906.00
23.	Arecanut	Travacore (Kerala)	Plastic film (50 micron)	28.4	--
24.	Bhendi	Travacore (Kerala)	Plastic film (50 micron)	25.0	18885.00
25.	Maize	Rajendranagar (AP)	Plastic film (25 micron)	44.6	9800.00
26.	Brinjal	Rajendranagar (AP)	Plastic film (25 micron)	10.0	15100.00
27.	Bhendi	Rajendranagar (AP)	Plastic film (25 micron)	67.0	18300.00
28.	Tomato	Rajendranagar (AP)	Plastic film (25 micron)	65.3	13800.00
29.	Plum	Solan (HP)	Plastic film (50 micron)	9.2	12000.00
30.	Tomato	Solan (HP)	Plastic film (50 micron)	85.6	18250.00
31.	Pea	Solan (HP)	Plastic film (50 micron)	66.6	25960.00
32.	Apricot	Solan (HP)	Plastic film (50 micron)	33.3	18320.00
33.	Peach	Solan (HP)		31.2	13890.00