Effects of Polyethylene Film Mulch on Growth and Yield of Mulberry

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Based on results of field experiments conducted at the Chubu Branch Station (in Matsumoto City) of Sericultural Experiment Station on the mulching of mulberry fields with polyethylene film (hereafter referred to poly-mulch), a cooperative study has been carried out since 1970 in newly planted mulberry fields at 9 field stations to examine regional differences in the effect of poly-mulch.

As a result, it was made clear that the mulching with various kinds of polyethylene films was effective not only in saving labor for field management but also in raising soil temperature and retaining soil moisture, so that vigorous growth, early development of tree shape, and high yield can be expected. In this paper, methods and the effectiveness of poly-mulch in mulberry cultivation will be presented, based on these results.

Use of poly-mulch in mulberry cultivation

Mulberry fields are classified into two groups: one for spring pruning, and the other for summer pruning, depending on seasons of silkworm rearing. As the latter accounts for 75% of the total mulberry area in this country, the following description is mainly related to it.

Mulberry fields are usually planted with 666–833 mulberry saplings per 10a, and from the third year after the planting onward they are regarded as mature fields, producing about 2,000 kg of leaves/10a by three times of harvesting a year. Mulberry trees are cultivated for a period of about 15 years with a fixed plant shape, supplying a stable quantity of leaves with a constant quality as the feed for silkworm. For that purpose, mulberry shoots are cut for harvest at the upper portion of the trunks in the spring rearing seasons in May, and new shoots sprouted after that are cut at their middle portion in the autumn and late-autumn rearing seasons in August and September.

Thus, the mulberry cultivation has a specific problem, not observed with other crops, that the cultural practice for promoting growth and at the same time for removing leaves, the photosynthetic organ, is required. To solve this problem, many studies have been made so far in relation to time and methods of harvesting.

For the harvesting, so-called shoot harvesting method, by which shoots with leaves are cut, is generally adopted. By this method, an early harvesting with high yield has been developed. It is not a rare case to have the first harvest for the late rearing season (September) in the year of planting.

Thus, it becomes desirable to promote the plant shaping and the thickening growth of trunks as soon as possible after planting. The poly-mulch has come to be recommended as a new technique under such background.

Method of mulching and field management

1) Materials

Films with the thickness of 0.03–0.05 mm are generally used. As to the mulching width, it can hardly be said that the wider the better in its effect on number of branches, due to regional differences, but the total length of

branches and leaf yield were increased by wider mulching (Table 1). As the rate of mulch coverage on soil surface is related to the mulching width, increases in the total length of branches as effected by the rates of mulch coverage are shown separately for temperate areas and for cold areas (Table 2). In temperate areas, the increase in the total branch length as expressed by percentage to that of 100% coverage was almost similar to the percentage of coverage, while the former was greater than the latter in cold areas. At the same rate of coverage, the mulching around mulberry trunks was more effective than the mulching made on inter-row soil surface.

As to the kinds of films, transparent films are used, but green- or black-colored films can also be used. In temperate areas, colored films give a relatively higher effect in suppressing weeds.

Table 1. Relation between growth of newly planted mulberry trees and the mulching width of polyethylene film

Locality	Interrow distance (cm)	Width of polyethylene film*(cm)	Components of branches			Leaf yield	
			number	mean length (cm)	total length (m)	fresh Weight (kg/10a)	index
Shinjoh	250	0	1.8	102	1.83		
		90	2.0	191	3.75		
		250	2.0	214	4.27		
Kobuchizawa	200	0	2.9	92	2.63		
		90	2.8	158	4.36		
		200	2.9	179	5.26		
Matsumoto	250	0	7.7	102	7.85	406	100
		135	8.5	115	9.77	506	124
		250	7.6	137	10.41	592	146
Iizaka	250	0	3.0	152	4.56		
		90	3.0	169	5.06	218	
		250	3.2	185	5.85	217	
Hino	250	0	3.8	116	4.37	197	100
		180	4.2	153	6.44	273	138
		250	4.4	165	7.16	353	179
Maebashi	250	0	5.7	141	8.06	513	100
		50	5.9	161	9.53	627	122
		100	6.5	155	10.09	615	120
		200	6.4	187	11.98	853	167
		250	7.4	188	13.92	739	155
Ayabe	250	0	6.5	104	6.86		
		135	8.1	78	6.36		
		180	7.9	107	8.44		
		250	7.1	184	13.13		

* Polyethylene film was applied to cover around main trunks

Table 2. Relation between soil area covered with polyethylene film and rate of increase in total branch length

District	Percentage of covered surface to field area				
	20	36	40–45	54	72–80
Cold district (Shinjoh, Kobuchizawa, Matsumoto)	—	62	66	80	—
Temperate district (Iizaka, Maebashi, Hino)	25	39	35	—	71

Note: Rates of increase in total branch length are expressed by percentages to the increase shown in the entirely mulched plot.

2) Time and duration of mulching

Poly-mulch is usually applied before the sprouting of mulberry in the year of planting. For example, it is applied in March–April in temperate areas, while in middle to late May in cold areas. According to the experiment conducted at Hino (in Tokyo-to), the earlier the time of application the more was the effectiveness, showing the best growth by the application 15 days prior to sprouting. As to the duration of mulching, the longer the better, although a considerable effectiveness was observed by a 3 month duration.

3) Method of mulching

At first the top portion of mulberry plants, newly planted, is cut off at the height of 15 cm above ground. Then, stones and wood pieces on the field are removed, and the field is tilled with a rotary tiller. After that, CAT (Shimazine) is applied at the rate of 200 g/10a to the soil surface to be covered by the poly-mulch. By doing so, the film comes in close contact with the soil surface, and inhibits weed emergence.

The mulch application is made by a set of two workers in a windless day, preferably after rainy day, but not in drought time. In case of mulching the inter-plant space in a row, the film of 135 cm in width is spread above the row with its central portion oriented just along the row, and, using a sharp knife, holes are made in the film to permit the pass of plants through the film. Then, the film is lowered, starting from one end, to come in contact with soil surface with a care not to injure mulberry buds, and the both sides of the film are fixed by covering soil. This practice is continued up to the other end of the film.

The mulching for inter-plant space requires 6–8 hrs/10a by a set of two workers, but the use of mulcher (Plate 1) saves labor considerably. The mulcher, which was developed in the Sericulture Division of Sericultural Experiment Station, is attached to a riding type tractor, and operated by two workers, an operator and his assistant. It requires about 7 hrs/ha, about 10 times of the efficiency of manual work.

Plate 1. A mulcher operating in mulberry field

4) Management of poly-mulched fields

As the application of chemical fertilizers to the entire inter-row space can not be made in poly-mulched fields, 50–70% of the standard rate (30 kg N, 15 kg P_2O_5 and 17 kg K_2O) was applied as the basal dressing at plantin time, and, as a rule, no more application is made in that year.

For weed control, a herbicide is applied to the bare soil surface immediately after mulching. However, rotary tillage by small cultivator is made instead of herbicide use after the sprouting of mulberry. Pest control by agricultural chemicals must be done carefully, not to damage the film.

Effects of poly-mulch to newly planted mulberry

Effects of poly-mulch on soils, such as soil temperature rise and soil water retention, have been proved not only with mulberry fields but also with many other crop fields. Therefore, discussions will be made here only on its effects on growth and yield of mulberry.

1) Elongation and components of branches

The Robertson's equation can be applied to the elongation of mulberry branches which shows a S-shaped pattern. Therefore, the growth rate at t_1 was calculated by measuring

Table 3. Effect of the mulch with polyethylene film on growth rate of mulberry shoots

Locality	Interrow distance (cm)	Width of Polyethylene film (cm)	$\log \frac{X}{A-X} = k(t-t_1)$ A	k	t_1**	Growth rate at t_1* cm/day	index
Shinjoh	250	0	102	0.0192	118.4	0.66	100
		90	191	0.0227	103.8	2.46	373
		250	214	0.0256	102.0	3.06	464
Kobuchizawa	200	0	103	0.0210	109.7	1.23	100
		90	173	0.0220	100.4	2.16	176
		200	200	0.0232	98.0	2.64	214
Matsumoto	250	0	143	0.0169	89.8	1.39	100
		250	180	0.0212	94.2	2.16	155
Iizaka	250	0	166	0.0212	91.5	2.17	100
		90	178	0.0225	87.9	2.53	117
		250	204	0.0223	83.4	2.82	130
Hino	250	0	130	0.0208	81.0	1.45	100
		180	177	0.0200	72.0	1.99	137
		250	195	0.0200	71.7	2.20	152

* Growth rate was obtained by calculation. It's values are almost equal to actually measured values.
** t_1 and t represent number of days from the lst of May.

Table 4. Effect of the mulch with polyethylene film on growth of main trunk (in the first year)

Locality	Variety of mulberry tree	Interrow distance (cm)	Width of film (cm)	Kind of film	Diameter of main trunk at leaf-fall stage (A) (mm)	Increase of trunk diameter during a year (B) (mm)	Rate of increase in volume $\frac{A^2}{(A-B)^2}$	index	r*
Maebashi	Kairyo-nezumigaeshi	250	0	Colorless, transparent polyethylene	26.9	13.4	3.97	100	0.766
			50		29.3	16.1	4.93	124	0.886
			100		30.7	17.4	5.33	134	0.929
			200		33.0	20.8	7.32	184	1.106
			250		31.7	20.9	8.62	217	1.207
Hino	Ichinose	250	0		22.6	11.5	4.34	100	0.822
			95	Transparent vinyl	28.1	17.5	6.99	161	1.069
			95	Black polyethylene	27.7	16.1	5.69	131	0.963

* $r = \frac{100}{t} \log_e \frac{A^2}{a^2}$ ($a = A - B$, $t = 180$ days)

the final length, A, of branches, a constant, K, and the time, t_1, when 1/2 of A is attained. As given in Table 3, values of A were greater in mulched plots than in control plots in all experimental sites. Values of K and t_1 showed differences among plots, and K showed also regional differences. The promotion of elongation rate was more in cold sites, and the length of branches reached the same level as in temperate areas.

A high correlation between the number of branches and total branch length was observed in all sites, showing that the latter increased with increasing number of branches (Fig. 1).

2) Thickening growth of main trunks

Growth rates in diameter(mm) and volume of main trunks were examined at Maebashi and Hino. Rates of thickening, r, was calculated as percentage/day by the following equation, by taking growth period, t, as 180 days:

$$r = \frac{100}{t} \log_e \frac{A^2}{a^2}$$

where a=trunk diameter before sprouting,

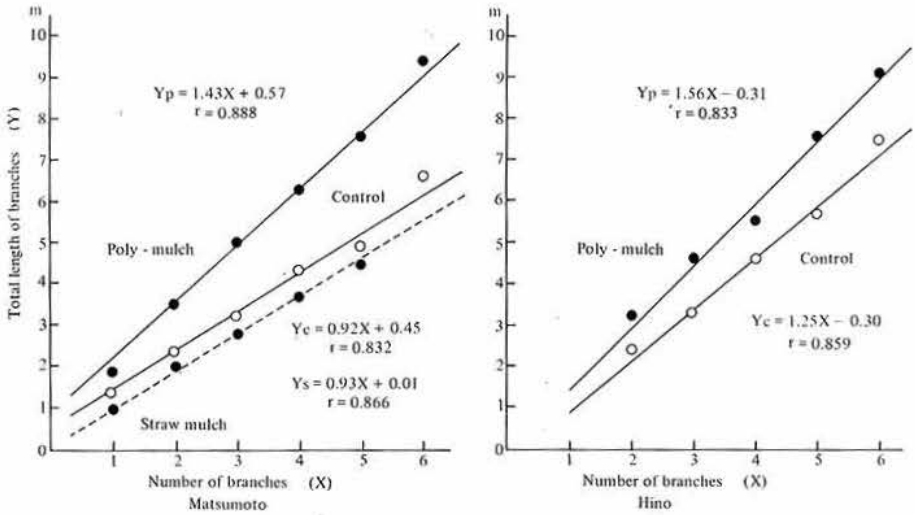

Fig. 1. Relation between number of branches (X) and total length of branches (Yp for poly-mulch, Ys for straw-mulch, and Yc for control plot).

and A=trunk diameter at the time of leaf fall. As a result, it was proved that the trunk diameter was increased very much by the mulching, and an early development of plant shape was made possible (Table 4).

3) Leaf yields

It has been known that leaf yields are closely correlated with the total branch length. In the present experiment also, it was found that the mulching increased the leaf yield as well as total branch length, although some differences in the response were observed between different mulching methods and regions. The mulching on inter-plant space resulted in the leaf yield increase by 20–67%. An example showing 50% yield increase was observed with the mulching practiced in the second year after planting.

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