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Weed control through degradable, herbicidal plastics and organic mulches and their effect on crop growth and yield of winter rapeseed (*Brassica napus*)

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ABSTRACT

Field experiments were conducted during winter (*rabi*) of 2004 and 2005 to control weed intensity in winter rapeseed (*Brassica napus*) using different types of mulches, viz black polyethylene, transparent polyethylene, herbicidal polyethylene film (herbicide coated), degradable polypropylene, straw mulch and non-mulched control. The results indicated that irrespective of the colours and types, plastic film mulches significantly reduced the weed density and weed dry weight at all stages. In general, the weed density and weed dry weight was lowest with black polyethylene film mulch at all the stages. Similarly, the weed-control efficiency and weed index were also highest with black polyethylene film mulches. However, the weed control efficiency did not differ much between the black and herbicidal polyethylene film mulch in the later stages. Though black polyethylene film mulch excelled the other treatments in weed control, the same was not reflected in the growth and yield parameters due to its poor soil-warming efficiency. Leaf chlorophyll concentration was higher with black polyethylene mulch though it was at par with other plastic mulches at all the stages. The increased number of pods/plant, number of seeds/pod and seed yield with herbicidal plastic mulches indicated that herbicidal plastic mulch could improve the rapeseed production through better weed control.

Key words: Degradable, Mulch, Polyethylene films, Rapeseed, Weed control

Weed management is one of the important areas in rapeseed production as the yield loss up to 90% weeds in rapeseed production was reported (Song *et al*. 2006). Rapeseed growers adopt different weed control methods which include cultural (Lanini *et al.* 2002), mechanical, hand weeding (Kroonen-Backbeir and Zwart-Roodzant 1998) and mowing (Zaragoza 2003). However, weeding during the critical growth stages is impossible due to wet soil conditions and intermittent rains during the winter season. Hand weeding is very laborious, expensive and inefficient (Brault *et al.* 2002). Manual weeding may cause injuries to the root system and reduce both yield and quality. Chemical weed control has changed cultural practices to save weeding labour. But at the same time, continuous use of the same herbicides has caused weed shift problems and weed resistance to herbicides (Zhang and Ze Pu 2003).

Plastic mulches provide weed control while minimizing root damage and maintaining soil temperatures favourable for crop growth and development. Transparent polyethylene mulch had been recommended for many years as a method of warming soil to promote crop maturity. Transparent film had no effect on weed control unless the film was coated with herbicides (Toshio Hanada 1991). An alternative to transparent polyethylene was black polyethylene mulch, which suppressed weed growth but did not have the soil warming and yield improvement capabilities of transparent polyethylene (Matheke *et al*. l989). Kuang Lesheng (1996) reported that herbicidal transparent polyethylene film mulch reduced the weed density by more than 90% and thereby increased the cane yield by 15–22.5 tonnes/ha when compared with the non-mulched control and plastic film mulch plus herbicide application in sugarcane. Organic mulches were reported to reduce soil temperature and evaporation, but did not increase the crop yield (Kwon 1988).

The use of plastic mulch in crop production has increased dramatically in the last 10 years throughout the world. However, the problem of disposing of used plastic films, which cause pollution, is also increasing with time (Johnson 1989). Degradable mulch was developed to help with disposal problems, which have not been totally resolved through research. Introduction of different colours of plastic films for mulch challenged the growers to new heights; which crops respond to different coloured mulch. Unfortunately, there is

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very little research work published, which might help growers to resolves this problem (Orzolek *et al.* 2003). With this background, this present study was conducted to explore the possibilities of achieving weed control in rapeseed by using herbicidal polyethylene films and degradable polypropylene films and its effect on crop biomass, physiological activities and yield of rapeseed.

MATERIALS AND METHODS

Field experiments were conducted for two years at college of Agriculture and Biotechnology, Zhejiang University, Hangzhou, P R China (30° 10' N latitude and 120° 12' E longitude with an altitude of 41.52 m above mean sea level) during winter (*rabi*) of 2004 and 2005 to study the effect of different degradable and non-degradable plastic mulches on weed control and growth and yield of winter rapeseed. The experiment was conducted with six mulches (black polyethylene, transparent polyethylene, degradable polypropylene, herbicidal polyethylene film, straw mulch and non-mulched control) and each treatment was replicated four times.

The soils was the clayey loam type. The available nutrient status field was medium in N (297 kg/ha), P (13.5 kg/ha) and K (260 kg/ha). The 'Zheshuang 758' rapeseed variety was used as test crop in the experiments. A seed rate of 10 kg/ha was adopted. After the bed preparation and fertilizer application, farm compost dissolved in water was sprayed over the bed in all the treatments. In addition, a fertilizer schedule of 40:30:60 kg N: P_2O_5 and K_2O/ha were kept constant for all the treatments and the entire quantity was applied at sowing. The herbicidal plastic film was made by blending the herbicide butachlor in the polymer of plastic films. Polyethylene sheets (10–15 micron thickness) with holes made at the required spacing of 35 cm×25 cm were spread over the soil and straw 5tonnes/ha was applied as per treatment. Since all the treatments were covered with plastic film and straw mulches, no after cultivation was done for any treatment studied including non-mulched control.

Weed counts and weed dry weight was recorded for 1m^2 and converted into hectare. To work out the weed control efficiency and weed index, the non-mulched treatment was taken as control. The chlorophyll content was estimated in fully expanded third leaf from top of the main stem at 40, 80, 120, 150 and 180 days after sowing. The chlorophyll content as chlorophyll 'a', and chlorophyll 'b' were estimated by following the method suggested by Yoshida *et al*. (1971) and expressed as mg/g fresh weight of leaf. To determine effect of treatments on yield, data on number of pods/plant, number of seeds/plant, 1000-grain weight, and seed yield were recorded after the harvest of crop from the whole plot of 27 m^2 in each treatment. Analysis of Variance (ANOVA) was used to detect the significance of treatment effects on the different variables measured. Whenever the treatment means were significantly different, LSD was used to separate the mean. In general, differences are reported at 5% probability level. Since the trend of results was similar in both years, pooled mean of the data of two years are presented here.

RESULTS AND DISCUSSION

Weed dynamics

The weed density of both mono and dicotyledonous weeds was obviously more at 120 days after sowing when compared to 30 and at 60 days after sowing (Table 1). A minimal number of monocot and dicot weeds were observed with black polyethylene mulch at 30 days after sowing and significant differences were noted among the different mulch treatments. Although very few monocot and dicot weeds were visible under black polyethylene mulch at 30 days after sowing, no new weeds emerged at the subsequent observations on 60 and 120 days after sowing. The early-emerged weeds were also etiolated under black polyethylene film mulch. Monocotyledon and dicotyledonous weeds were found under herbicidal film mulch to a notable level in the later stages (60 and 120 days after sowing). However, these weeds did not develop beyond the cotyledonary and 2-leaf stages. The weeds under degradable polypropylene film mulch grew freely due to the transparent nature of degradable polypropylene film, which allows the sunlight to pass inside. However, the weed density under degradable polypropylene film was lesser than the transparent polyethylene film mulch. The total weed density under straw mulch was significantly lower than the transparent and degradable plastic mulches

Table 1 Monocots, dicots and total weeds/m^2 as influenced by different plastic film mulches at 30, 60 and 120 DAS

Treatment	30 DAS			60 DAS			120 DAS		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
Black	3.0	4.0	7.0	2.0	2.0	4.0	2.0	2.0	4.0
Transparent	66.0	52.0	118.0	62.0	22.0	84.0	41.0	16.0	57.0
Degradable	61.0	47.0	108.0	47.0	22.0	69.0	31.0	14.0	45.0
Herbicidal film	8.0	13.0	21.0	18.0	14.0	3.0	17.0	10.0	27.0
Straw mulch	62.0	29.0	92.0	73.0	18.0	91.0	49.0	16.0	65.0
Control	83.0	58.0	142.0	110.0	56.0	167.0	86.0	66.0	152.0
SEd±	2.56	2.88	7.05	4.11	4.87	9.111	4.45	4.18	8.22
LSD (*P*=0.05)	5.46	6.14	15.02	8.76	10.38	9.41	9.48	8.91	17.52

at 30 days after sowing, while the weed growth was drastically reduced under transparent and degradable plastic mulches at 60 and 120 days after sowing and the weed density was lower than straw mulch. The weed growth was exorbitant in non-mulched control at all the stages of observation.

Weed dry weight

Similar to weed density, the weed dry weight (g/m^2) was lowest with black polyethylene film mulch (Table 2). However, the weed dry weight observed under black polyethylene mulch was proportionately higher than the herbicidal mulches in relation to weed density. The weed dry weight under degradable polypropylene mulch showed a decline trend as the days after sowing increases. Similar to weed density the weed dry weight under straw mulch was significantly lower than the degradable plastic mulches at 30 days after sowing. However, the weed dry weight under transparent and degradable plastic mulches at 120 days after sowing was significantly lower than the straw mulch. The reason for lowest weed dry weight in black polyethylene film mulch was due to poor transmittance of light in the black polyethylene film mulch which resulted in reduced the photosynthetic activity of the weeds. This would have also resulted in poor germination and growth of weed seeds. This is in line with the findings of Shrivastava *et al*. (1994) who reported that black plastic mulch reduced weed infestation by 95%. The rice straw mulch provided good control of weeds at the initial stage as compared to transparent and degradable plastic mulches, but in the later stages of crop growth, heavy weed infestation resulted in increased dry weight of weeds. Similarly Gulshan Mahajan *et al.* (2007) reported that plastic mulch resulted in significant reduction of weed dry weight by 37.4 and 63.8% over rice straw mulch and non mulched soil condition, respectively.

Weed control efficiency (per cent)

Though the weed control efficiency under herbicidal mulch was significantly lesser than black polyethylene mulch at 30 days after sowing, its efficiency has been improved remarkably at 60 and 120 days after sowing (Table 3). Though the weed density and weed dry weight were higher under straw mulch as compared to both transparent and degradable film mulch, the efficiency of transparent and degradable film mulch was dramatically increased at 60 and 120 days after sowing.

Growth parameters

Biomass accumulation: In general, the dry matter accumulation between polyethylene film mulches and non-mulched control differed markedly at all the stages (Fig 1). The crop dry matter production differed significantly in relation to weed density at 30, 60 and 120 days after sowing. However, the variation in weed control efficiency of different mulches did not reflect on the biomass accumulation at 180 days after sowing. Herbicidal film mulch registered the highest crop dry weight at 180 days after sowing though it was at par with black film mulch. Invariably non-mulched control registered significantly the lowest dry matter at all the stages. The reduced weed competition under black polyethylene film mulch might have triggered the plant to use the available resources

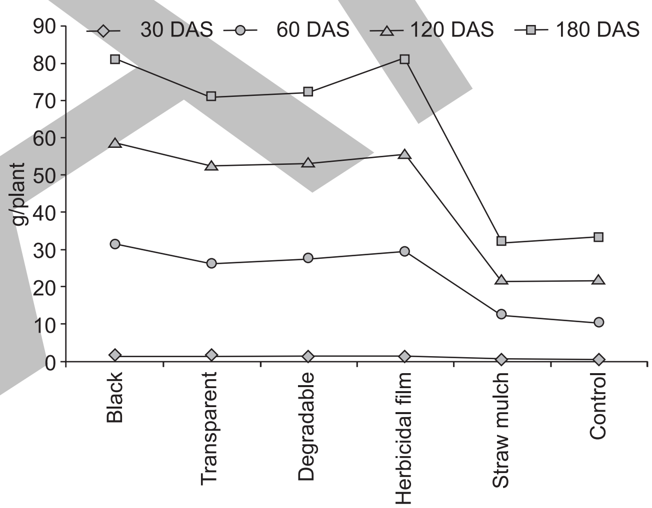

Fig 1 Crop dry weight (g/plant) as influenced by different mulches

Table 2 Dry weight of monocots, dicots and total weeds (g/m^2) as influenced by different plastic film mulches at 30, 60 and 120 DAS

Treatment	30 DAS			60 DAS			120 DAS		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
Black	0.20	0.04	0.24	0.17	0.07	0.24	0.16	0.07	0.23
Transparent	1.11	0.89	2.00	3.45	0.92	4.37	2.09	0.64	2.73
Degradable	1.02	1.05	2.07	2.99	0.92	3.90	1.85	0.63	2.48
Herbicidal film	0.24	0.34	0.58	1.08	1.05	2.13	0.65	0.49	1.14
Straw mulch	0.62	0.51	1.13	6.33	1.83	8.16	4.43	2.41	0.84
Control	1.14	1.98	3.12	23.40	6.40	29.79	17.48	6.99	24.47
SEd±	0.08	0.07	0.11	0.21	0.20	0.22	0.45	0.48	0.88
LSD (*P*=0.05)	0.17	0.15	0.23	0.45	0.43	0.47	0.96	1.02	1.88

Table 3 Weed control efficiency as influenced by different plastic film mulches at 30, 60 and 120 DAS

Treatment	30 DAS			60 DAS			120 DAS		
	Monocot	Dicot	Total	Monocot	Dicot	Total	Monocot	Dicot	Total
Black	82.4	97.9	92.3	99.2	98.9	99.2	99.0	99.0	99.0
Transparent	2.6	54.9	35.7	85.2	85.7	85.3	88.0	90.8	88.8
Degradable	10.5	46.7	33.4	87.2	85.7	86.9	89.4	90.9	89.8
Herbicidal film	78.9	82.7	81.3	95.3	83.6	92.8	96.2	92.9	95.3
Straw mulch	45.6	74.4	63.8	72.9	71.4	72.6	74.6	65.5	72.0
Control	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SEd	3.56	2.88	7.05	4.11	4.87	9.111	4.45	4.18	8.2
LSD (0.05)	7.59	6.14	15.02	8.76	10.38	9.41	9.48	8.91	17.5

effectively resulting in biomass advantage in the early stages of the crop. However, due to smothering effect of rapeseed in the later stages of the crop, herbicidal polyethylene film much produced biomass equivalent to black polyethylene mulch. This indicated that utilization of plastic mulch to develop sufficient heat and to produce early season biomass accumulation and maximize yield potential of rapeseed might be useful at low temperature conditions besides weed control. Research on microclimate modification induced by plastic mulch has largely focused on effects on dry matter yield and quality of field corn (Kwabiah 2003).

Chlorophyll content: Plastic film mulch had a significant influence on total chlorophyll content at all the stages of observation (Fig 2). Similar to crop dry matter production, black polyethylene film mulch registered significantly higher content of chlorophyll at 30, 60 and 120 days after sowing, while at 180 days after sowing, the content was higher with herbicidal polyethylene film mulch. However, at all the stages of observations, all the plastic film mulches were at par. More number of functional leaves/plant and larger leaf area would have increased the chlorophyll content of the leaves and

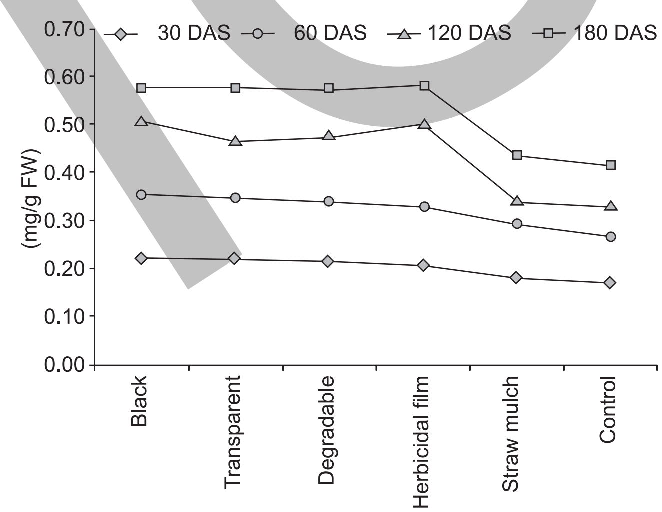

Fig 2 Total chlorophyll (mg/gFW) content of leaves as influenced by different mulches

ultimately resulted in higher biomass production under plastic mulch. Our chlorophyll results are very similar to the findings of Setter and Greenway (1988).

Yield components and yield

Between different mulches studied, herbicidal film mulch had higher number of pods/plant (Table 4). The number of seeds/plant was significantly more with transparent polyethylene film mulch when compared to straw mulch and non-mulched control. However, it was at par with other plastic mulches. No significant increase in 1000-grain weight was observed due to different mulches. A remarkable increase in the seed yield was achieved through different plastic mulches. Among the different treatments, herbicidal film mulch registered significant higher seed yield (4 425 kg/ha) as compared to straw mulch (1 637 kg/ha) and non-mulched control (1 993 kg/ha). The review of seed yield obtained indicated the significant superiority of herbicidal polyethylene film mulch. In general vigorous crops with large plants will be less affected by weeds than less vigorous ones with small plants. In the case of rapeseed, the crop under plastic mulches grew aggressively and the crop had smothered the weeds. But weeds become much more damaging in the case of straw mulch and non-mulched control, where the crop was slow growing and weak at all the stages of the crop growth. Though black polyethylene film mulch excelled herbicidal polyethylene mulch in terms of weed control efficiency, the yield parameters and pod yield were in the favour of herbicidal polyethylene film mulch. Enhancement in growth characters and yield attributes might contribute a greater extent in enhancing the pod yield. In respect of rapeseed due to higher dry matter production and increase in yield parameters, higher seed yield was reported earlier by Leul and Zhou (1998).

The yield registered under non mulched control was higher than that of straw mulch, which clearly indicated the yield reduction due to straw mulch in winter season. Similarly, Wicks *et al*. (1994) reported yield reduction in corn under straw mulch due to cool and rainy weather and the yield variations resulted from delayed plant development under

Table 4 Yield attributes and yield of rapeseed as influenced by different plastic mulches and herbicides

Treatment	Days to first flowering	Days to 50% flowering	Pods/ plant	Seeds/pod	1000-grain weight (g)	Days to maturity	Seed yield (kg/ha)
Black	120	140	386	22	3.61	200	4120
Transparent	118	138	384	23	3.51	198	4032
Degradable	120	140	388	22	3.57	200	4046
Herbicidal film	121	141	405	23	3.73	198	4425
Straw mulch	126	151	163	18	3.48	214	1637
Control	126	151	182	18	3.48	214	1993
SEd	3.26	0.04	12.60	1.21	0.91	2.80	88.06
LSD (*P*=0.05)	6.68	0.82	25.83	2.48	NS	5.95	180.52

straw mulch. These results clearly indicated in addition to weed control, soil warming efficiency of the plastic mulches would have played a major role in determining the yield. Though the transparent polyethylene film mulch and degradable polypropylene mulch were known for its soil-warming efficiency, their poor ability in weed control due to transmittance of light resulted in reduced yield when compared to black polyethylene film mulch. Though black polyethylene film mulch had highest weed control efficiency, its relatively lower soil-warming efficiency resulted in lesser yield than herbicidal film mulch. Hence, optimum weed control coupled with better soil warming efficiency achieved under herbicidal film mulch had enhanced the seed yield of winter rapeseed.

Summarizing the results, the biomass accumulation, chlorophyll content, yield parameters and yield of winter rapeseed were increased through better weed control under plastic mulch, especially during the early growth period of the crop.

REFERENCES

Brault D, Stewart K A and Jenni S. 2002. Growth, development and yield of lettuce cultivated on paper and polyethylene mulch. *Horticultural Science* **37**: 92–4.

Gulshan Mahajan, Rakesh Sharda, Ashwani Kumar and Singh K G. 2007. Effect of plastic mulch on economizing irrigation water and weed control in baby corn sown by different methods. *African Journal of Agricultural Research* **2**: 19–26.

Johnson H. 1989. Plastigone photodegradable film performance in California. Proceedings, National Agricultural Plastics Congress **21**: 1–6.

Kroonen-Backbeir B M and Zwart-Roodzant M H. 1998. Integrated cultivation of cabbage is competitive. *PAV Bull Akkerbouw* **5**: 23–6.

Kuang Lesheng, Chen Mingzhou, Deng Haihua, Zeng Lianqiang and Pan Dongying. 1996. *Spreading of the sugarcane herbicidal plastic film and the method to improve the weed killing results*. Tsinghua Tongfang Optical Dis Co.ltd., 10–16.

Kwon. 1988. The effect of different mulching materials on soil conditions with refernce to red pepper production. ASPAC, Food Fertilizer technology centre, *Extn bulletin* **277**: 11–24.

Lanini W T, Bell C E, Smith R F, LeStrange M and Cudney DW. 2002. Weeds. University of California, Pest Management Guidelines: Cole Crops. Division of Agriculture and Natural Resources Publication No. 3442. Available at: http://www.ipm.ucdavis.edu.

Leul M and Zhou W J. 1998. Allevation of water-logging damage in water rape by application of uniconazole: Effect on morphological activities, hormones and photosynthesis activities. *Field Crop Research* **59**: 121–7.

Matheke G E M, Wagner P and Holloway P. 1989. Effect of different mulches on ever bearing strawberry production,- *Proceedings of 8th Annual Alaska Greenhouse and Nursery Conference*, pp 100–3, 1989.

Orzolek M D, Murphy J and Ciardi J. 2003. The Effect of Coloured Polyethylene Mulch on the Yield of Squash Tomato and Cauliflower. *Final Report.* Pennsylvania Vegetable Marketing and Research Commodity Board.

Setter T L and Greenway H. 1988. Growth reductions of rice at low temperature: decreases in nutrient uptake and development of chlorosis. *Journal of Experimental Botany* **39**: 811–29.

Shrivastava P K, Parikh M M, Sawani N G and Raman S. 1994. Effect of drip irrigation and mulching on tomato yield. *Agricultural Water Management* **25**: 179–84.

Song W J, Zhou W J, Jin Z L, Zhang D, Yoneyama K, Takeuchi Y and Joel D M. 2006. Growth regulators restore germination of *Orobanche* seeds that are conditioned under water stress and suboptimal temperature. *Australian Journal of Agricultural Research* **57**: 1195–201.

Toshio Hanada. 1991. The effect of mulching and row covers on vegetable prodcution. *Extension Bulletin*, Food and Fertilizer Technology Centre, Taiwan.

Wicks G A, Crutchfield D A and Burnside O C. 1994. Influence of wheat (*Triticum aestivum*) straw mulch and metalachlor on corn (*Zea mays*) growth and yield. *Weed Science* **42**: 141–7.

Yoshida S, Farno D A, Cock J H and Gomez K A. 1971. Laboratory manual for physiological studies of rice. *International Rice Research Newsletter***,** 70 pp.

Zaragoza C. 2003. Weed management in vegetables. In: Labrada R (ed) Weed Management for Developing Countries (Addendum 1), *FAO Document Repository*. FAO Plant Production and Protection paper 120 Add. 1. Agriculture Department, Food and Agriculture Organization of the United Nations, Rome, Italy.

Zhang, Ze Pu. 2003. Development of chemical weed control and integrated weed management in China. *Weed Biology and Management* **3**:197–203.