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RESEARCH ARTICLE

Poly-Coated Brown Wrapping Paper Sheet as an Alternative to Black Plastic Film Mulch in Bhendi

Manidurai Manoharan David, P* and Mathan Kumar, G.

Mother Terasa College of Agriculture, Illuppur, Pudukkottai – 622 102

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ABSTRACT

Black plastic film mulching is widely practiced in crop production, especially in horticultural systems, because of its multiple benefits. However, its post-usage polluting residues and limited availability to farmers at all places cause concern. The objective of this study was to evaluate in a field experiment the potential of the commonly available stationery-purpose poly-coated brown wrapping sheet mulching in bhendi [*Abelmoschus esculentus* (L.) Moench] in comparison with black plastic film mulching. Observations made on plant height and fruit yield, soil temperature and soil microbial population revealed that the less-polluting poly-coated brown wrapping sheet mulching was as good as the black plastic film mulching in performance which is discussed in the light of increase in plant growth and yield, moisture conservation and weed suppression, root-zone temperature moderation and termite activity.

Keywords: *Mulching; Plastic film; Poly-coated wrapping-paper; Bhendi*

INTRODUCTION

Though various materials are used for mulching (the process of covering the soil around the root area) in crop production, the black plastic film mulching has revolutionized the mulching technique worldwide with huge benefits (Iyengar *et al*., 2011; Kasirajan and Ngouajio, 2012). The benefits of plasticulture, include early maturity (7-30 days earlier), higher yields (up to 4 times), higher quality produce, water saving by conserving soil moisture (up to 80%), efficient fertilizer use (savings up to 50%), more wetting in light soils, suppression of weeds (reduction up to 100%), moderation of temperature, reduced soil compaction, increased microbial activity, management of insect pests and pathogens, and reduction in soil erosion (Ham *et al*., 1993; Schrader, 2000). Even though photodegradable, the residues of the black plastic film have become a pollutant, detrimental to the agricultural environment, especially soil structure, water and nutrient transport, and crop growth (Liu *et al*., 2014). It is also not easily available to all farmers in rural settings in India. The stationery-purpose poly-coated brown wrapping sheet with its very thin polyethylene film coating and biodegradable brown paper (kraft paper) may serve as an alternative to the black plastic film. The objective of this paper was to evaluate the performance of this poly-coated brown wrapping sheet mulching in comparison with the regular black plastic film mulching in bhendi.

MATERIAL AND METHODS

A field experiment with two treatments was conducted in 2019-20 at Mother Terasa College of Agriculture, Pudukkottai, Tamil Nadu wherein the thin poly-coated brown wrapping paper sheet was compared with the black plastic film in bhendi, *Abelmoschus esculentus* (L.) Moench. Tractor-made beds (1.0 m wide, 25.0 m long) were formed and drip irrigation laterals were laid over the beds before spreading the black plastic film (30-micron, 1.2 m wide, black bottom-silver top) and the poly-coated brown wrapping paper (by joining together with cellophane tape three 0.5 m wide sheets to form 1.2 m wide sheets) (Plate 1) in two sets of 17 beds for each treatment. In all, there were 34 beds for each treatment. The poly-coated brown wrapping paper sheet roll was laid with the paper side at bottom facing the soil (Plate 2). Hybrid Co 4 seeds were sown after punching holes at 50 x 50 cm spacing, and regular horticultural practices followed. Observations were made on plant height 70 days after sowing. Fruit yield from the treatment beds

*Corresponding author's e-mail: ememdavid2012@gmail.com

was recorded on alternate days to record the yield on the basis of weight and number per plant from 10 plants in each treatment 60 days after sowing. The soil temperature at root zone was recorded for a day with a digital thermometer at 2-hour interval from under each treatment mulch at 15.0 – 20.0 cm depth at three places in each treatment, starting at 6.0 am and ending at 6.0 pm 62 days after sowing. The soil microbial populations were enumerated by collecting samples from 15 – 20 cm depth using an auger before serial dilution technique to isolate the bacteria and fungi grown on the Nutrient Agar and Rose Bengal Agar medium. The data on plant height, fruit yield and soil temperature were subjected to unpaired t-test analysis.

RESULTS AND DISCUSSION

The results indicated that the poly-coated brown wrapping paper mulch was as efficient as the black plastic film in performance in terms of fruit yield on both weight basis (136.7-164.5 g/plant/picking/day) and number basis (5.0–5.4/plant/picking/day) without any significant difference between them (Table 1). However, the plants grew significantly taller by 15.6 cm ($P < 0.05$) in the poly-coated wrapping paper mulching beds than in the black plastic film mulching beds, indicating more vigour. The soil root-zone temperature was significantly lower by 3.0°C ($P < 0.05$) in the poly-coated wrapping paper mulching beds than in the black plastic film mulching beds (Fig. 1). The soil bacterial populations were low in the poly-coated wrapping paper mulching beds (3.0×10^6 cfu/g of soil) than in the black plastic film mulching beds (10.0×10^6 cfu/g of soil), whereas the fungal load was higher in the poly-coated wrapping paper mulching beds (22.0×10^6 cfu/g of soil) than in the black plastic film mulching beds (20.0×10^6 cfu/g of soil) (Table 1).

It has been well established in agriculture that the black plastic film mulching improves crop yield from different factors. Made from polyethylene, they are available in 0.015 – 0.020 mm thickness. The black plastic film used in this study was 30 micron (0.0012” or 0.030 mm) which is more difficult to degrade. On the one hand, the paper-removed poly-coating layer of the brown wrapping paper sheet is much thinner (11.0 g/m^2 by weight) while the water-separable brown paper (40.0 g/m^2 by weight) is totally biodegradable (Table 1). Comparatively, even though the separated poly-coated brown wrapping paper is much heavier (51.0 g/m^2) than the total weight of the black plastic film (27.0 g/m^2), its poly-coating layer is less than twice (59.2%) lighter in weight when compared to the black plastic film. However, according to the results, the poly-coated wrapping paper mulch is capable of acting as the black plastic film in mulching characters and in effect as discussed earlier. On the one hand, the brown opaque poly-coated wrapping paper mulch were able to cut the light and suppresses the weeds, even though the pure paper mulch was considered as a failure in early 1920s because of its shorter life and higher cost (Kasirajan and Ngouajio, 2012). Similarly, though very thin, the poly-coating layer causes the evaporation to condense inside the mulch itself (Plate 3), thus conserving moisture which causes the brown wrapping paper to get wet, inviting arthropods, especially the termites. In this study, the previously rain-exposed experimental field did not receive any exclusive fertilization, either organic or inorganic as basal or through fertigation, except for the drip irrigation given only three times at weekly interval immediately after sowing. Thus the moisture conserved by both the mulches sustained not only the microbial activity, more fungi in poly-coated wrapping paper mulch and more bacteria in black plastic film mulch, but also the termite activity, especially under the former that served as a source of moist cellulose for the termites to feed even visible from above as scrapings at random (Plate 4).

Generally, the root-zone temperature is 1.0-5.0°C warmer than the air temperature after mulching, highest at midday under the black plastic film mulch, with the degree of soil warming correlated with the reflectivity of the mulch, black colour having the lowest light reflectance (Diaz-Perez and Batal, 2002). Teasdale1 and Abdul-Baki (1995) observed the soil temperatures under tomato foliage to reduce by an average of 2.2-5.2°C and at 5-15 cm deep after the canopy closure. In this investigation, the midday root-zone temperature was 2.0-5.0°C lower in the poly-coated wrapping paper mulch beds than that in the black plastic film mulch beds. This probably caused these plants to grow more vigorously and taller than those in the black plastic mulch beds which also lacked the cellulose layer attractive to the soil termites. However, the termite activity needs to be quantified in future studies. Evans *et al*. (2011) have demonstrated that ants and termites, which function similar to earthworms by providing valuable ecosystem services in arid regions, increased the wheat yield by 36 per cent from increased soil water

infiltration. Considered to be 'ecosystem engineers' (Jones *et al*., 1994), earthworms improve soil health in agricultural systems due to their tunnels and improved soil nitrogen, especially in temperate and humid tropical conditions. Similarly, termites, especially fungus-growing termites, act as the soil engineers in arid and sub-arid ecosystems (Jouquet *et al*., 2017). In this investigation, termites fed on the poly-coated brown wrapping paper sheet by irregular gnawings, leaving the thin transparent lamination intact (Plate 4). These termites are probably likely to improve the soil health from enhanced tunneling and water dynamics, microbial activity and nitrogen mineralization more than that in the black plastic mulching system wherein usually the soil arthropods are least abundant (Summers *et al*., 2010). Though weeds tended to grow in patches under the termite-eaten now-transparent poly-coat lamination, they were chlorotic and etiolated, unable to push through the poly-coat layer, partly owing to the vigorously established crop canopy. This technology could drastically reduce the quantum and cost of the plastic used for mulching in agrosystems. Incidentally, the biodegradable poly-coated brown wrapping paper, with obviously little trace of mulch residues soon after the crop was harvested, can augment the role played by the ecosystem service providers, especially termites. This paper opens up more scope for further research in these lines.

Table 1. Comparative performance of the poly-coated brown wrapping paper mulching and of the black plastic film mulching in bhendi *A. esculentus*.

Parameters	Poly-coated brown wrapping paper mulching	Black plastic film mulching	t-value
Mean plant height (n = 20)	143.2 cm	127.6 cm	15.67 (P < 0.05)
Mean fruit yield / picking / day (n = 20)	164.5 g/ plant	136.7 g / plant	NS
Mean fruit number / picking / day (n = 20)	5.0/ plant	5.4/ plant	NS
Mean soil temperature (n = 20)	31.3 ºC	34.3 ºC	6.65 (P < 0.05)
Mean soil bacterial population (n = 3)	3.0 x 10^6 cfu / g of soil	10.0 x 10^6 cfu / g of soil	-
Mean soil fungal population (n = 3)	22.0 x 10^4 cfu /g of soil	20.0 x 10^4 cfu / g of soil	-
Total weight (paper roll or plastic film)	51.0 g / m^2	27.0 g / m^2	-
Poly-coating film weight alone	11.0 g / m^2	-	
Paper weight minus poly-coating film	40.0 g / m^2	-	-

NS, Not significant; cfu, Colony forming units

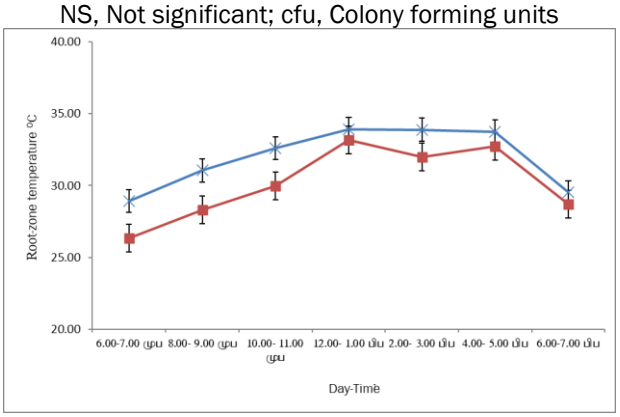

Figure 1. Day-time soil root-zone temperature in black plastic film mulch beds and in poly-coated brown wrapping paper mulch beds. Vertical bars indicate the standard error. Mean of 3 observations.

Plate 1. An experimental bed showing the poly-coated brown wrapping paper sheet mulch

Plate 2. Experimental beds showing the poly-coated brown wrapping paper sheet facing the soil with plants at close.

Plate 3. Moisture trapped inside the transparent poly-coated layer.

Plate 4. An experimental bed showing the brown paper layer being eaten away by the termites inside the now-transparent poly-coated layer left intact.

Conclusion

The outcome of this study indicates that the stationery-purpose poly-coated brown wrapping sheet commonly available at all places can be effectively used as mulch in crop production in place of the black plastic film mulch in order to reduce pollution to the crop environment. More studies are needed in the future with 1.5 m wide single-sheet poly-coated paper rolls made especially for this purpose to reduce the overall cost and practicability of this technology on a larger scale.

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REFERENCES

Diaz-Perez, J. C. and Batal, K. D. 2002. Coloured plastic film mulches affect tomato growth and yield via changes in root-zone temperature. *J. Amer. Soc.. Hort. Sci.,* **127(1)**: 127-136.

Evans, T. A., Dawes, T. Z., Ward, P. R. and Lo, N. 2011. Ants and termites increase crop yield in a dry climate. *Nature Communic.*, **2**: **262** (7 pp). DOI: 10.1038/ncomms1257.

Ham, J. M., Kluitenberg, G. J. and Lamont, W. J. 1993. Optical properties of plastic mulches affect the field temperature regime. *J. Amer. Soc. Hort. Sci.,* **118(2)**: 188-193.

Iyengar, K. S., Gahrotra, A., Mishra, A., Kaushal, K. K. and Dutt, M. 2011. *Practical Manual on Plastic Mulching.* National Committee on Plasticulture Applications in Horticulture (NCPAH), Department of Agriculture & Cooperation, Ministry of Agriculture, Government of India, New Delhi. 16 pp.

Jones, C. G., Lawton, J. H. and Shachak, M. 1994. Organisms as ecosystem engineers. *Oikos*, **69:** 373–386.

Jouquet, P., Chaudhary, E.and Kumar, A. R. V. 2018. Sustainable use of termite activity in agro-ecosystems with reference to earthworms. A review. *Agron. Sustain. Dev.*, **38: 3** (11 pp).

Liu, E. K., He, W. Q. and Yan, C. R. 2014. 'White revolution' to 'white pollution' - agricultural plastic film mulch in China. *Environ. Res. Lett.* **9:** 091001, 3 pp.

Schrader, W. L. 2000. Plasticulture in California vegetable production. University of California, California. Publication: 8016, 9 pp. http://anrcatalog.ucdavis.edu.

Summers, C. G., Mitchell, J. P. and J. J. Stapleton. 2010. Population dynamics of arthropods associated with early-season tomato plants as influenced by soil surface microenvironment. *Crop Protection,* **29(3)**: 249-254.

Teasdale1 J. R. and Abdul-Baki, A. A. 1995. Soil temperature and tomato growth associated with black polyethylene and hairy vetch mulches. *J. amer. Soc. Hort. Sci.*, **120(5)**: 848-853.