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Effect of mulches on weed suppression and yield of ginger (Zingiber officinale Roscoe)

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ABSTRACT

Ginger (*Zingiber officinale* Roscoe) is grown in tropical and subtropical regions of the world for its spice and medicinal values. The emergence and early growth of ginger is inherently slow and weed growth can impact on yield. A field experiment comprising different organic mulch viz., paddy straw, coir pith compost, dried coconut leaves, *Glycosmis pentaphylla* leaves (farmer's practice), *Lantana camara* leaves, cowpea plants and plastic mulch black, ash and white colour were compared with non mulched ginger grown under rainfed condition. The experiment was conducted to identify an alternative to suppress weeds, enhance yield and income of small-holder ginger farmer. Maximum height (43.2 cm) and weed control efficiency (72%) was recorded by the treatment application of one season old paddy straw along with green leaf mulch followed by application of Lanthana camara leaves. Application of dried coconut leaves alone at the time of planting recorded maximum benefit cost (B: C) ratio (2.04) followed by the application of one season old paddy straw. White coloured polythene mulch recorded maximum yield (7.52 t ha^{-1}) that was similar with ash coloured polythene mulch and income obtained was less compared to other organic mulches. Application of dried coconut leaves as a mulch for suppressing weeds in ginger is a viable technology which can be practiced in places where coconut is being grown in India. Monocot weeds were less in number and among dicots most predominant weed species were *Spermacoce latifolia*, *Ageratum conyzoides*, *Oldenlandia auricularia*, *Cleome rutidosperma* and *Oxalis corniculata*.

1. Introduction

Ginger (*Zingiber officinale* Roscoe) is a rhizomatous crop belonging to the family Zingiberaceae and is one of the most important and most widely used spices worldwide. It is believed to have originated in Southeast Asia, but was under cultivation from ancient times in India as well as in China. Though the plant is an herbaceous perennial, it is usually grown as an annual for its pungent aromatic rhizome. In Ayurvedic medical system ginger is considered to be carminative, stimulant, aphrodisiac, anti-flatulent, appetizer and good for heart and it reduces Cough and Rheumatism (Pruthi, 1998). India is a leading producer of ginger in the world and during 2012–2013 the country produced 745,000 tons of the spice from an area of 157,839 ha. Ginger is cultivated in most of the states in India. During 2013–2014 23,300 tons of ginger valued US$38.6 million was exported to foreign countries from India.

Initial growth of ginger is slow and if weeds are not controlled properly it will result in considerable yield reduction (Lee et al., 1981). Bhowmick and Doll (1982) reported that weed compete with the crop for nutrients, light and space and weed competition is one of the major production constraints which leads to low productivity of rainfed ginger. Organic mulch adds nutrients to the soil due to microbial activity and helps in carbon sequestration (Mukherjee et al., 1991), provides better soil environment by conserving soil moisture, inhibit weed growth in crop fields (Jodaugiene et al., 2006). Mulching is essential for weed control, moisture conservation and to protect the ginger beds from erosion during high rainfall and this is an important and essential component in ginger cultivation (Mohanty, 1977). Mulching was proved to increase of soil moisture content, to improve the soil structure and to decrease weed growth, and thereby enhanced yield in vegetable crops reported (Govindappa and Pallavi Seenappa, 2014). Mulching the crop with 30 t ha^{-1} green leaves of trees such as *Garuga pinnata Roxb.*, *Ailanthus malabarica* Candolle., *Terminalia paniculata* Roth., Swietenia mahagani (L.), *Glyricidia sepium* Jacq has been recommended in Kerala (Nybe and Miniraj, 2005). It also adds organic matter to the soil during the later part of the cropping season after

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the southwest monsoon. Since the decomposition rate of mulches is faster, two or three weedings is a common practice, but it is less efficient, labour intensive, expensive, and often not done due to adverse weather conditions. With the impending shortage of labour and their rising wages the use of herbicides appears to be promising alternative practice for controlling weeds (Ravindran et al., 2010), but use of herbicides is not advised due to health hazards and environmental problems. Plastic mulch also helps to protect the soil from erosion and helps to create a microclimate favourable for the growth of crops (Otsuki et al., 2000). However use of plastic mulch is more beneficial to cool season crops to enhance the temperature in the soil (Subrahmaniyan and Weijun Zhou, 2014). Non-availability of labour for weeding and lack of green leaf mulch coupled with high labour wages are great concern in ginger production hence an efficient alternate method to control weeds is essential. Hence this study was carried out with the objective to identify the best weed management practice for weed control during ginger cultivation to enhance yield and improve income of small-holder farmers.

2. Materials and methods

2.1. Site characterization

Field experiment was conducted at the ICAR-IISR experimental farm of Peruvannamuzhi of ICAR-Indian Institute of Spices Research (ICAR-IISR), Calicut District, Kerala state, India (geographical coordinates 11°34′N, 75°48′E and 60 m MSL). The area falls under warm humid climate with bimodal distribution of rainfall in which 75% of rainfall is received during the southwest monsoon. The weed management study reported here was conducted for a period of three years from 2011 to 2014. Average temperature and rainfall recorded during the year 2011 was 31.92 °C and 4907 mm respectively. During 2012 rainfall received was less 3763.6 mm compared to previous year and average temperature recorded was 32.08 °C. During 2013 more rainfall 5316.5 mm was received and the temperature recorded was 31.83 °C. The soil of Peruvannamuzhi was clay loam with nitrogen 300 kg ha^{-1}, phosphorus 24 kg ha^{-1}, potassium 202 kg ha^{-1}, calcium 600 kg ha^{-1}, magnesium 136 kg ha^{-1}, zinc 1.4 kg ha^{-1} and classified under Ustic humitropept (Lekha, 1997).

After land preparation raised beds of 3 × 1 m size was prepared to a height of 30 cm and shallow pits of 5 cm depth were taken at a spacing of 25 × 25 cm in the beds. An improved ginger variety 'Varada' known for its dry recovery and essential oil content, was used in the study. Rhizome bits of 'Varada' weighing 25 g was sown in the beds in all the three years at a spacing of 25 × 25 cm after applying cowdung @30 t ha^{-1} in the beds (IISR, 2014).

2.2. Experimental design

The experiment was laid out in Randomised Block Design (RBD) with 15 treatments and four replications (Table 1). The treatments were various organic mulching materials as well as plastic mulch as follows:

In unweeded check, mulching, fertilizer application and no intercultural operation were carried out throughout the growth period of ginger. In all other treatments hand weeding was done at 45 and 90 days after planting (DAP). After sowing the ginger rhizomes, green leaves of the tree *Glycosmis pentaphylla was* applied to a thickness of 5 cm at the time of planting and later at 45 & 90 (DAP) which was the Farmer's practice (T2). Required quantity of dried paddy straw was collected locally from farmers plot and applied as per the treatment T2 in the ginger beds. Coir pith compost was prepared using the mushroom fungus *Plerotus* sp. collected from Kerala Agricultural University, Mannuthy, Trichur, Kerala, India (KAU, 2011). Twenty days old dried coconut leaves were collected from IISR farm, removed the petiole, split into two at midrib and in total three coconut leaves were used for mulching in a single bed 3 × 1 m^2 (5.4 t ha^{-1}). At 45 and 90 DAP green leaves @7.5 t ha^{-1} each was also applied along with this treatment. Regarding T7 treatment cowpea seeds were sown in between two ginger rows (3 × 1 m beds) one week after sowing the ginger. At 45 DAP all the cowpea plants were uprooted, and incorporated (0.4 t ha^{-1}) as mulch in ginger beds. At 90 DAP green leaves @7.5 t ha^{-1} was applied in the beds in which cowpea plants were grown as per treatment. Leaves of *Lantana camara* was collected from the farm and applied at the rate of 30 t ha^{-1} to ginger plants as per the treatment. In mixed tree leaves mulch leaves of *Garuga pinnata Roxb.*, *Ailanthus malabarica* Candolle., *Terminalia paniculata* Roth., and *Glyricidia sepium* Jacq. were mixed in equal proportion and applied @30 t ha at 45 & 90 DAP (T9).

Three colors of polythene mulch (ash, white and black) having a thickness of 25 μ (micron) was used in the study. Holes of 10 × 10 cm were provided in the polythene mulch at a spacing 25 × 25 cm irrespective of the colors for the emergence of ginger shoots. In other treatments holes of 15 × 10 cm was provided at a spacing 25 × 25 cm in all the three colored polythene mulches. Each colored polythene mulch was spread on the beds of 3 × 1 m ginger beds and fixed at four corners of the bed using soil.

The recommended package of practices of IISR was given to the crop during the growing period. At the time of planting, well decomposed farm yard manure 30 tons ha^{-1} was broadcasted in ginger beds (IISR, 2014). The average elemental composition of FYM is 0.4% N, 0.3% P and 0.2% K, respectively. The recommended dose of fertilizer for ginger is 75 kg N, 50 kg P_2O_5 and 50 kg K_2O per ha was applied as follows. Entire P and 50% K as basal dose, half the quantity of N at 45 days after planting and the remaining N and K at 120 days after planting.

Recommended dose of FYM, full P and half K was applied as basal doze to the beds in which polythene mulch was applied. Remaining recommended quantity of fertilizer was applied in the holes provided for emerging shoots of ginger at 45 & 90 DAP and covered with soil. Weeding, fertilizer application and earthing up was done in each bed in the experiment.

2.3. Measurements and statistical analysis

The biometric observations were recorded at five months after planting. Yield of ginger was recorded at harvest in a plot size of 3 × 1 m and projected the yield into tons ha^{-1}. Data was statistically analyzed for variance. In order to make weed counts a quadrate of 100 cm was used. The quadrate was randomly thrown into the beds, individual weed species were collected inside the quadrate and species per unit area was identified with the help of a taxonomist. Weeds in quadrate were identified and classified into monocotyledons and dicotyledons. Weeds in individual beds were taken replication wise from each treatment, dried and weighed. The weed control efficiency (WCE) was calculated by using the formula WCE = (DMC-DMT)/DMC × 100 Where, DMC is dry matter of weeds in control (unweeded) and DMT is dry matter of weeds in a particular treatment (Singh et al., 2000).

The prevailing market prices of inputs and farm gate prize of output were taken into account for economic analysis of different weed control treatments. Basic parameters to calculate the cost of cultivation per hectare included: the cost of ginger seed rhizome US$ 2252.9, land preparation US$ 11715, labour for planting US$ 45.05, manures and fertilizers US$ 45.05, intercultivation US$ 360.47, plant protection US$ 60.08, harvest US$ 45.05, cleaning and transportation US$ 270.35. Application charges for weeding at 45 & 90 days after planting including material cost for each treatment worked out separately and added with the basic parameters. The

Table 1
Details of treatments used in the experiment.

Treatment		At the time of planting t ha $^{-1}$	45th Day of planting (*G. pentaphylla*) t ha $^{-1}$	60th Day of planting (*G. pentaphylla*) t ha^{-1}	Short Title
T1	Control	No mulch	–	–	Control
T2	Application of Green leaves *Glycosmis pentaphylla*)	15	7.5	7.5	Farmer's practice
T3	One season old paddy straw	6	7.5	7.5	Paddy straw
T4	Coir pith compost	4	7.5	7.5	Coir pith compost
T5	Dried coconut leaves + green leaf mulch	5.4	7.5	7.5	Coconut leaves along with green leaf mulch
T6	Dried coconut leaves alone	5.4	–	–	Coconut leaves alone
T7	Incorporation of cowpea plant mulch	0.4	7.5	7.5	Cowpea mulch
T8	Mulching of *Lantana camara leaves*	15	7.5	7.5	*Lantana camara* mulch
T9	Leaves other than *Glycosmis pentaphylla*	15	7.5	7.5	Mixed tree leaves mulch
T10	Plastic mulch ash colour 10 × 10 cm	3 m^2	–	–	Ash colour plastic mulch I
T11	Plastic mulch ash colour 15 × 10 cm	3 m^2	–	–	Ash colour plastic mulch II
T12	Plastic mulch white colour 10 × 10 cm	3 m^2	–	–	White colour plastic mulch I
T13	Plastic mulch white colour 15 × 10 cm	3 m^2	–	–	White colour plastic mulch II
T14	Plastic mulch black colour 10 × 10 cm	3 m^2	–	–	Black colour plastic mulch I
T15	Plastic mulch black colour 15 × 10 cm	3 m^2	–	–	Black colour plastic mulch II

wages of labour was taken as per US$ 45.05 day^{-1}. The farm gate price of fresh rhizome was US$ 1.35 kg $^{-1.}$

3. Results

3.1. Effect of mulches on dry weight of weeds

At 45 days after planting significantly less dry weight of weeds (66.18 kg ha^{-1}) was recorded by the application of paddy straw (T3) that was similar with application of coconut leaves along with green leaf mulch (T5) and farmer's practice (T2). Maximum weed control efficiency (72%) was recorded by the same treatments. Regarding dry weight of weeds, application of mixed tree leaves (T9) and application of *Lantana camara* mulch was similar (T8). Maximum dry weight of weeds was recorded by unweeded control (735 kg ha^{-1}). Regarding plastic mulch ash coloured I, recorded less dry weight of weeds 44.18 kg ha^{-1} and same treatment recorded maximum weed control efficiency (76.9%). At 90 DAP application of paddy straw (T3) (185 kg ha^{-1}) and ash coloured plastic mulch II recorded less dry weight of weeds and weed control efficiency noticed was 55.9 and 50.8, respectively (Table 2).

3.2. Identification of weeds

In total 71 weed species including 58 monocotledons and 13 dicotledons were identified. Monocots were less in number and among dicots most predominant weed species were *Spermacoce latifolia* Aubl, *Mimosa pudica* (L.), *Ageratum conyzoides* (L.), *Oldenlandia auricularia* (L.) F. Muell, *Cleome rutidosperma* DC, *Oxalis corniculata* (L.) and *Ludwigia hyssopifolia* (L.). Among monocotyledons major weeds identified were *Kyllinga monocephala* Rottb, *Mollugo pentaphylla* (L.) and *Cyperus rotundus* (L.).

3.3. Effect of mulches on yield and yield attributing characters

Results of the study indicated that all the treatments significantly influenced height, leaf area except number of tillers produced by the plant. Maximum height (43.2 cm) was recorded by the application of paddy straw (T3) that was similar with all the treatments except application of coconut leaves alone (T6), cowpea mulch (T7), and application of plastic mulch in ginger beds. Less height was recorded by control (T1) (29.0 cm). Maximum leaf area was recorded by the application of coconut leaves along with green leaf mulch (T5) (966.55 cm^2) that was similar with application of paddy straw (T3), coconut leaves alone (T6) and application of *Lantana camara* (T8) in ginger beds. Maximum yield was recorded by application of paddy straw (T3) (13.3 t ha^{-1}) that was similar with application of coir pith compost along with green leaf mulch (T4), application of coconut leaves along with green leaf mulch (T5) and application of coconut leaves alone (T6) which was significantly superior than Farmer's practice (T2) and control (T1). White coloured plastic mulch recorded significantly higher yield (7.52 t ha^{-1}) which was significantly lesser than Farmer's practice (T2). Lowest yield was recorded by control (T1) (3.3 t ha^{-1}) that was on comparable with beds mulched with black coloured plastic mulch (T15) (5.5 t ha^{-1}) (Table 2).

3.4. Economics of weed management practices

The cost of cultivation varied from US$ 4082–12350. Among organic mulches maximum cost was recorded by the application of *Lantana camara* leaves (T3) and lowest cost of was registered for the application of coconut leaves alone (T5) (Table 3). The cost of cultivation of polythene mulch was comparatively lower compared to other green leaf mulch. Application of paddy straw (T3) recorded the highest net returns per hectare (US$ 8615.1) followed by application of coconut leaves along with green leaf mulch (T5) US$ 7843.9 and the lowest net return was noticed under the control (T1). Maximum benefit cost ratio (B:C) was recorded by the application of coconut leaves alone (T6) and application of paddy straw (T3). Lowest B: C ratio (0.86) was noticed in beds mulched with black color polythene mulch (T15) and control (T1) (Table 3).

Table 2
The effect of weed management practices on growth and yield of ginger.

Treatments	Height (cm)	Tiller (nos)	Dry weight of weeds 45 DAP (kg ha^{-1}) WCE*	Dry weight of weeds 90 DAP (kg ha^{-1}) WCE*	Leaf area (cm^2)	Yield (t ha^{-1})
Control	29.14^{f}	4.02	735.08^{a}	700.8^{a}	328.0^{c}	3.00^{g}
(Farmer's practice)	38.97^{abc}	5.33	68.798^{def} (71.5)	241.94^{cde} (49.9)	642.75^{b}	9.56^{bc}
Coir pith compost	39.88^{abc}	5.26	159.68^{b} (62.7)	268.04^{bcde} (52.5)	672.60^{b}	11.14^{ab}
Paddy straw	43.22^{a}	5.50	66.18^{def} (72.8)	185^{e} (55.9)	647.47^{ab}	13.03^{a}
Coconut Leaves + mulch	39.33^{abc}	5.24	69.72^{def} (72.5)	367.08^{bcd} (50.09)	966.55^{a}	11.24^{ab}
Coconut leaves alone	37.44^{bcd}	5.53	99.20^{cde} (68.4)	316.54^{bcde} (47.7)	745.15^{ab}	10.58^{ab}
Cowpea mulch	37.90^{bcd}	5.43	150.30^{b} (62.6)	407.32^{b} (35.9)	554.32^{bc}	7.63^{cd}
Lantana Camara mulch	40.66^{ab}	5.44	125.55^{bc} (65.2)	415.70^{b} (42.2)	714.73^{ab}	10.10^{b}
Mixed tree leaves	39.18^{abc}	5.58	111.70^{bcd} (66.3)	389.19^{bc} (38.6)	709.38^{b}	9.49^{bc}
Plastic mulch Ash I	37.02^{bcd}	4.70	44.8^{f} (76.2)	328.3^{bcde} (42.1)	664.22^{b}	7.30^{de}
Plastic mulch Ash II	36.61^{bcd}	4.48	38.9^{f} (76.9)	235de (50.8)	614.48^{b}	6.74^{de}
Plastic mulch White I	37.88^{bcd}	4.91	77.43^{cdef} (70.7)	382.07^{bcd} (45.0)	689.65^{b}	7.52^{cde}
Plastic mulch White II	37.58^{bcd}	4.98	96.67^{cde} (67.7)	318.46^{bcde} (44.7)	770.05^{ab}	6.60^{de}
Plastic mulch Black I	35.61^{cde}	4.59	49.07^{ef} (59.75)	324.64^{bcde} (47.0)	647.47^{b}	5.61^{def}
Plastic mulch Black II	34.14^{e}	4.54	56.36^{ef} (77.1)	374.77^{bcd} (41.0)	562.80^{bc}	5.40^{efg}

F-Farmers practice, DAP-Days after planting.
* Values in bracket indicate weed control efficiency (WCE).

Table 3
Economics in ginger cultivation using various organic and plastic mulches.

Item	Yield (t ha^{-1})	Cost (US$)	Total return (US$)	Net return (US$)	B:C ratio
Control	3.00	4082.0	4055.2	27.0	0.99
Farmer's Practice	9.56	11539.5	12922.7	1383.2	1.12
Coir pith compost	11.14	8093.2	15058.5	6965.3	1.86
Paddy straw	13.03	8615.1	17613.3	8998.1	2.04
Coconut leaves + mulch	11.24	7843.9	15193.7	7342.29	1.94
Coconut leaves alone	10.58	7016.4	14301.5	7261.9	2.04
Cowpea mulch	7.63	7816.8	10313.9	2497.2	1.32
Mixed tree leaves	10.10	12059.1	13652.7	1593.5	1.13
Lantana camara	9.49	12350.5	12828.1	477.6	1.03
Plastic mulch Ash1	7.30	8324.09	9867.8	1543.7	1.19
Plastic mulch Ash II	6.74	8324.0	9110.8	783.74	1.09
Plastic mulch White I	7.52	8477.29	10165.2	1884.9	1.19
Plastic mulch White II	6.80	8481.7	8921.5	439.8	1.05
Plastic mulch Black I	5.61	8427.7	7583.3	844.36	0.90
Plastic mulch Black II	5.40	8522.3	7299.4	1222.8	0.86

4. Discussion

Plant height (43.2 cm), leaf area (647.47 cm^2) less dry weight of weeds, 66.18 kg ha^{-1}, maximum weed control efficiency (72.8) and yield (13 t ha^{-1}) was recorded by application of paddy straw (T3) compared to control (Table 2). Better performance of the ginger in the beds in which paddy straw applied was due to increased yield attributing characters, the optimized soil temperature, controlled evaporation losses, increased soil moisture conservation, due to suppression of weeds and uptake of major, secondary and minor nutrients. Rair et al. (2011) reported that relatively more height in mulched plot with straw over plastic in turmeric. Lal et al. (1996) reported decreased bulk density under straw mulch (1.42) compared to bare soil (1.50 g cm^3). This result corroborates with the findings of Ghosh et al. (2006) who observed lower bulk density due to application of paddy straw (T3) in ginger beds. Ram Chandra and Sheo Govind (2001) observed increased yield and weed control in ginger due to application of straw mulch, Similar result was reported in hot pepper and tomato. The surface residue mulch generate more favorable habitats for soil and surface dwelling earthworm, microorganisms, insects and pathogens (Acharya and Kapur, 2000) which might have contributed to low bulk density. Plant residue mulches are capable of reducing soil water evaporation by 35–50% (Hatfield et al., 2001). The reduced bulk density due to application of paddy straw might have helped in reducing the mechanical resistance to growing roots, resulted in better aeration and helped for rhizome development and yield. Similar results were reported by Anikwe et al. (2003) in groundnut.

The total dry weight of weeds was high in control plots compared to the mulched plots indicating that different organic mulches have suppressed the growth of weeds in mulched plots. Increased yield and weed control efficiency due to application of paddy straw in ginger (Roy and Wamanan, 1988; Ram Chandra and Sheo Govind 2001; Kushwah et al., 2013) and in turmeric (Kumar et al., 2003; Hossain, 2005; Rair et al., 2011) and in pepper and tomato (Amati et al., 1989; Dzomeku et al., 2009) was reported.

Yield was also more in the plots in which composted coir pith was applied (T4). Composted coir pith acts as an important soil ameliorant to improve the physical condition and moisture status, thus it can be used as effective mulch (Savithri and Khan, 1994). The composted coir pith improved productivity in turmeric (Thankamani et al., 2005).

The higher rhizome yield obtained with application of coconut leaves along with green leaf mulch (T5) may be due to improved growth attributes, reduced competition by weeds and improved soil conditions. It was reported that mulching with coconut fronds increased germination and yield of *Phaseolus vulgaris* (Reynolds, 1975), weed control efficiency in *Colocasia esculenta* (Fatuesi et al., 1991), productivity in pine apple (Guinto and Inciong, 2012), leaf N, P and K content and yield in chilli (Siti Aishah Hassan et al., 1994).

The yield was high in the plots in which coconut leaves alone was applied (T6). Less soft rot incidence (8.70%) over control (33%), high content of N 2666 mg kg^{-1}, K 202 mg kg^{-1}, Mg 127 mg kg^{-1}, might have contributed better health to the plants which have resulted in good yield. According to Liebman and Mohler (2001) coconut leaves as organic mulch act as a physical barrier because it decreases light

penetration and soil temperature, thereby resulting in inhibition of weed shoot emergence.

In general yield was more in the mulched beds compared to non-mulched beds. This may be due to retention of moisture, reduced vapour loss, erosion, modified temperature, addition of nutrients to the soil, less weed problems and nutrient loss. Bhardwaj (2013) reported that soil under the mulch remains loose, friable and leading to suitable environment for root penetration and conserve more moisture. By providing a physical barrier mulching reduces the germination and nourishment of many weeds (Van Derwerken and Wilcox, 1988). Early and greater sprouting of rhizomes in the mulched plots gave dominance of the crop over weeds as a result crop utilized higher amount of nutrients from the soil and produced more leaf area more yield compared to non mulch plots. Similar result was reported in turmeric grown under rainfed condition in Orissa by Mohanty et al. (1991).

Yield was less in the plots in which polythene mulch was used compared to control. Yield was comparatively more in white and ash coloured mulch compared to black coloured one. Bhardwaj, (2013) reported that white coloured polythene mulch decreased soil temperature while clear transparent plastic mulch increased soil temperature. Black mulch applied to the planting bed prior to planting will warm the soil (Lamont, 2005). Increased temperature in soil due to use of black colour polythene mulch might have resulted in poor root growth, absorption of water and nutrients, shrinking of rhizomes and poor yield. This result corroborates the finding in turmeric by Hussain et al. (1969), Kumar et al. (2003) and Ghosh et al. (2006) in groundnut.

The decreased yield in beds in which plastic mulch was applied was due to reduced growth parameters like height and leaf area of ginger grown in beds. Application of black coloured polythene mulch was more suited to cool season vegetables to enhance the temperature and yield (Subramaniyan and Weijun Zhou, 2014). The present study was conducted in rainfed humid tropics and increased temperature and poor aeration in the soil would have resulted less yield of the ginger observed in the experiment due to application of plastic mulch.

Regarding economics, application of paddy straw 6 t ha^{-1} along with green leaf mulch at 45 & 90 DAP increased the yield by 36%, and received a net income (US$ 8998.1) compared to Farmer's practice. This may be due to better weed control efficiency and reduced labour requirement. Sutagundhi (2000) observed that application of straw mulch (T3) recorded significantly higher net returns (US$ 464.01 ha $^{-1)}$ and B:C ratio 1.8:1 compared to control as a result of soil water conservation and weed suppression in chilli.

Application of coconut leaves alone, increased the yield by 11%, and recorded higher B:C ratio 2.04 and net income obtained was US$ 7261.9 ha^{-1}. Lesser cost of dried coconut leaves would have helped in reducing cost of cultivation, better economic performance of coconut leaf mulch. Elimination of green leaf mulch at 45 & 90 days in ginger cultivation is an added advantage and can be adopted in ginger as well as coconut growing areas of the country.

5. Conclusion

The study has shown that application of paddy straw 6 t ha^{-1} along with green leaf mulch 7.5 t ha^{-1} at 45 & 90 DAP and application of dried coconut leaves at the time of planting 5.4 t ha^{-1} recorded higher weed control efficiency, higher economic returns compared to application of *Glycosmis pentaphylla* leaf mulch (Farmers practice). Both the technologies are environment friendly and can be used depending on resource availability and can be recommended for organic cultivation of ginger.

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