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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