Utilization of water hyacinth as mulch in turmeric

V.P. Indulekha and C. George Thomas*

College of Horticulture, Kerala Agricultural University, Vellanikkara,Thrissur 680 656, Kerala, India.

Received 31 May 2018; received in revised form 4 June 2018; accepted 24 June 2018

Abstract

Water hyacinth (*Eichhornia crassipes* (Mart.) Solms), considered as the world's worst aquatic weed, was evaluated for its mulch value as a part of its control strategies. A field experiment comprising of three mulch materials viz., jack fruit leaves, green water hyacinth, and coconut leaves, were compared with no mulching in turmeric. The study was carried out at the Department of Agronomy, College of Horticulture, Vellanikkara during 2014-15 and 2015-16. All the mulch materials including water hyacinth had positive effects on most morphological and physiological parameters like plant height, number of leaves, leaf area index, leaf area ratio, and dry matter production of turmeric. In 2014-15, rhizome yield was higher in plots mulched with jack leaves (22.45t/ha), but it was on par with mulching by water hyacinth (20.52 t/ha) and mulching by coconut leaves (20.12 t/ha) compared to non-mulch control (15.91 t/ha). In 2015-16 too, the same trend in rhizome yield was observed. Nutrient uptake by the crop was also higher with mulching compared to non-mulched control. All the mulch materials substantially reduced weed density, weed dry weight, and turmeric-weed competition for different growth factors.

Keywords: Aquatic weeds, Mulching, Turmeric, Utilization, Water hyacinth.

Introduction

Water hyacinth (*Eichhornia crassipes* (Mart.) Solms) is considered as the world's worst aquatic weed. It is estimated that 20-25 per cent of the total utilizable water in India is infested with water hyacinth alone (Varshney *et al*., 2008). It adversely affects water sources by blocking canals and water ways, providing convenient breeding sites for mosquito, and interfering with fishing and fish culture. In the past, several chemical, biological, and mechanical methods were tried to prevent its proliferation and spread, but all these have not been very successful because of the weed's survival strategies. The initial clearance of the weed followed by regular, periodic removal of the regrown weeds, coupled with proper utilization of the harvested weeds as fibre, animal feed, manure, and mulch seem to be viable solutions to this weed menace. Utilizing the high productivity in better ways can be a part of integrated management of water hyacinth.

An experiment was planned to utilize water hyacinth as a mulch material taking turmeric, which requires heavy mulching, as a test crop. In turmeric, mulching is an important cultural practice, and mulching immediately after planting with green leaves and subsequently, after 50 days is recommended (KAU, 2011). Initial growth of turmeric is slow, and if weeds are not controlled properly, it may cause considerable yield reduction. The commonly used mulch materials in turmeric are jack leaves and coconut leaves but during the planting time of turmeric, shortage of mulch materials is common. It is hoped that using water hyacinth as a mulch will be a blessing for the farmers as well as the public because of the conversion of a menace for a good cause.

*Author for correspondences: Phone: 91-9349759355; Email: gtcgthomas@gmail.com

Materials and methods

Field experiments were conducted during May 2014 to Jan. 2015 and May 2015 to Jan. 2016 at the Department of Agronomy, College of Horticulture, Vellanikkara. The area enjoys warm humid climate with bimodal distribution of rainfall in which 75 per cent of rainfall is received during the southwest monsoon. In 2014-15, 2428.9 mm rainfall was received during the cropping season (May-Jan.) and the mean temperature recorded was 31.86 ^{0}C. In 2015-16, the rainfall received was less (1695.3 mm) compared to previous year and the mean temperature recorded was 31.7 ^{0}C. The soil of the experimental site was sandy clay loam in texture belonging to the order Ultisol containing organic carbon 1.24 per cent, available nitrogen 493.43 kg/ha, available phosphorus 22.25 kg/ha, and exchangeable potassium 396.27 kg/ha.

The experiment was laid out in Randomized Block Design (RBD) with five replications. By the receipt of summer showers, the field was ploughed, stubbles removed, and levelled. Each plot included 4 raised beds of 2m length and 1m width, leaving 40cm gap in between beds on all sides. Planting was done during the month of May after the receipt of three pre-monsoon showers. Small pits were taken in beds at a spacing of 25 cm x 25 cm. Rhizome bits were planted with a viable healthy bud facing upwards at a depth of 4 cm to 5 cm, then covered with dry powdered cattle manure and soil.

The treatments included water hyacinth, jackfruit leaves, coconut leaves, and no mulch control. The mulch materials (green) were applied at the rate of 15 tonnes per hectare (20.16kg/plot) at the time of planting and repeated after 50 days. All the cultural operations were carried out as per the Package of Practices Recommendations (KAU, 2011).

The fertilizer recommendation followed was 30:30:60 kg N, P_2O_5 and K_2O per hectare. Cattle manure at the rate of 40t/ha was applied as basal dose along with the full dose of P_2O_5 (30kg/ha) and half the dose of K_2O (30kg/ha). Two-third of the dose of nitrogen (20 kg/ha) was applied at 30 days after planting. The remaining quantities of N (10 kg/ha) and K_2O (30 kg/ha) were applied 60 days after planting. Manual weeding was done thrice at 45, 90, and 150 days after planting. Earthing up was done at 60 days after planting.

For recording various biometric observations, five turmeric plants were selected at random as observation plants. Pre-harvest observations were recorded at monthly intervals starting from 90 days after planting. The crop was harvested during the first week of January in both years (2015 and 2016), when the plants completely dried. Harvesting was done leaving one border row from all the sides from each plot, and the net plot yield was projected into tonnes per hectare. Leaf area index (LAI) was calculated by multiplying the leaf length, width, and number of leaves with a conversion factor 0.72 (Rao and Swamy, 1984). LAI was measured at 90 and 120 DAP. Leaf area ratio (LAR) was also calculated from the values of area of leaf lamina and whole plant dry weight at 90 and 120 DAP.

Weed density was counted using 50 cm (0.25m^2) quadrat at 45, 90, and 150 days after planting and reported as numbers/m^2. For estimating, weed dry weight, the uprooted weeds were cleaned, air dried, and then oven dried at 80±5°C for 48 hours till constant weight was obtained.

Nitrogen, phosphorus and potassium contents of plant samples were determined using standard methods, and their uptake was also calculated. After the harvest, soil analysis was done for organic carbon, available nitrogen, available phosphorus, and exchangeable potassium employing standard procedures.

Results and Discussion

Effect of mulching on various biometric parameters of turmeric

All the mulch materials including water hyacinth significantly improved the height of turmeric throughout the crop growth period compared to no mulch control (Table 1). In all the treatments, plant height increased progressively with time, reaching 123.98 cm to 144.64 cm in 2014-15 and 99.38 cm to 123.80 cm in 2015-16 by 210 days after planting. However, there was no significant difference in plant height between mulching materials (water hyacinth, jack leaves, and coconut leaves).

Mulching affected the number of leaves produced per clump of turmeric and the results were similar in both years. Goswami and Saha (2006) observed that mulched plants grew taller and had more number of branches. Mulching enhances plant height by influencing soil environment by maintaining favourable temperature, soil moisture status, and increased nutrient availability. In ginger, Ghosh (2008) noted significant differences in growth and yield parameters when mulched with paddy straw followed by water hyacinth.

Number of tillers per plant did not show any significant variation due to the treatments at any stage of the crop in both years (Table 1.). However, mulching improved the number of leaves per plant in both years. As turmeric is a shy tillering plant, it may compensate its tillers with the enhanced number of leaves (Sanghamithre, 2014). Presence of weeds also affects yield and yield attributing factors. It is obvious that absence of mulches in non-mulched plots encouraged weed growth resulting in higher competition.

Effect of mulching on physiological parameters of turmeric

Leaf area index (LAI) at 90 DAP and 120 DAP is presented in Table 2. Leaf area index in both years was higher in plots mulched with jack leaves and was on par with mulching by water hyacinth and mulching by coconut leaves. Variations in leaf number (Table1) and leaf area ratio (Table 2) were reflected in LAI, indicating better coverage of the crop canopy due to mulching. Early and greater sprouting of rhizomes in the mulched plots gave dominance of the crop over weeds, and as a result, the crop utilized higher amount of nutrients from the soil and produced more leaf area compared to non- mulched plots.

*Table 1.*Effect of mulching on important biometric parameters of turmeric

Treatments	Plant height at 210 DAP (cm)		Number of tillers per plant at 210 DAP		Number of leaves per plant at 210 DAP	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Mulching with water hyacinth	142.78	123.80	2.20	2.00	10.92	10.34
Mulching with jack leaves	144.64	123.26	2.24	2.04	11.40	11.00
Mulching with coconut leaves	135.20	121.16	2.12	1.92	10.80	10.28
No mulch	123.98	99.38	1.96	1.76	8.08	7.72
SEm ±	4.91	3.67	0.12	0.09	0.38	0.24
LSD (5%)	15.31	11.42	NS	NS	1.17	0.76

*Table 2.*Effect of mulching on important physiological parameters of turmeric

Treatments	Leaf Area Index				Leaf Area Ratio (cm^2/g)			
	90 DAP		120 DAP		90 DAP		120 DAP	
	2014-15	2015-16	2014-15	2014-15	2014-15	2015-16	2014-15	2015-16
Mulching with water hyacinth	3.868	3.686	5.844	4.968	36.540	33.000	49.020	45.000
Mulching with jack leaves	3.996	3.712	5.914	5.098	41.020	36.800	54.200	52.600
Mulching with coconut leaves	3.428	3.364	5.530	4.696	35.600	31.800	47.620	43.800
No mulch	2.526	2.402	3.970	3.496	29.800	27.800	40.200	37.600
SEm ±	0.20	0.122	0.171	0.302	0.452	0.600	0.444	0.824
LSD (5%)	0.625	0.379	0.531	0.940	1.409	1.869	1.383	2.566

*Table 3.*Effect of mulching on drymatter production and rhizome yield of turmeric

Treatments	Drymatter production (kg/ha)		Rhizome yield (t/ha)	
	2014-15	2015-16	2014-15	2015-16
Mulching with water hyacinth	8260.00	7440.00	20.12	16.91
Mulching with jack leaves	8491.20	7645.60	22.45	18.65
Mulching with coconut leaves	8017.80	7382.00	20.52	17.00
No mulch	7089.00	6122.00	15.91	13.71
SEm ±	168.44	135.06	1.17	0.93
LSD (5%)	524.75	420.76	3.63	2.89

Leaf area ratio (LAR), a measure of relative leafiness of the plant, was higher in plots mulched with jack leaves at 90 DAP in both years. However, water hyacinth and coconut leaves were similar in LAR values. LAR of plants mulched with jack leaves was significantly higher at 120 DAP in 2014-15, followed by water hyacinth mulch and coconut leaves. Non-mulched plants showed lower LAR values at both stages. In 2015-16 too, LAR was higher in plants mulched with jack leaves. However, there was no significant differences between plants mulched with water hyacinth or coconut leaves.

Effect of mulching on drymatter production and yield of turmeric

Total drymatter production of turmeric at harvest was significantly higher in plots mulched with jack leaves, water hyacinth, and coconut leaves than non-mulched plots (Table 3). It is obvious that higher plant height, number of tillers, and leaf area production as reported earlier caused higher drymatter production in mulched plants. Chakravarti *et al*. (2010) reported that mulching by water hyacinth improved drymatter production and yield of groundnut by altering the thermal environment through reduction of air and canopy temperatures.

Rhizome yield was higher in mulched plots compared to non-mulched plots. Water hyacinth performed well on par with other mulched materials in both years of study. Higher weed growth and competition in non-mulched plots might have influenced crop growth thus reducing yield. Nutrients and improved soil physical characters also may have contributed. In 2014-2015, as given in Table 3, rhizome yield was higher in plots mulched with jack leaves (22.45 t/ha), which was on par with mulching by water hyacinth (20.52 t/ha) and mulching by coconut leaves (20.12 t/ha). In 2015-2016 also, no significant differences in rhizome yield was observed between different mulches but the yield was lower in non-mulched plots. In general, rhizome yield was comparatively less during the second year, which can be attributed to the receipt of less rainfall during the crop growth period.

Effect of mulching on nutrient uptake by the crop

In 2014-15, the nitrogen uptake by the crop was higher in plots mulched with jack leaves (109.56 kg/ha), and was on par with mulching by water hyacinth and coconut leaves (Table 4). Nitrogen uptake was significantly lower in non-mulched plots (74.19 kg/ha). The same trend was observed in 2015-2016 also.

In 2014-15, P uptake by the crop was higher in plots mulched with jack leaves (17.18 kg/ha), and was on par with mulching by water hyacinth or coconut leaves. Phosphorus uptake was lower in non-mulched plots. The trend in 2015-16 in terms of P uptake was similar to that of 2014-15. In both years, K uptake was lower in non-mulched plots (108.20 and 98.20 kg/ha) respectively. There was no significant difference in K uptake between plots with different mulches. Mulching produced higher available soil nutrients and this might have resulted in higher uptake leading to higher dry matter production.

Table 4. Effect of mulching on uptake of different nutrients (kg/ha) by the plant

Treatments	N (kg/ha)		P (kg/ha)		K (kg/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Mulching with water hyacinth	107.35	97.59	16.24	15.55	137.61	125.60
Mulching with jack leaves	109.65	102.63	17.18	16.62	138.83	126.54
Mulching with coconut leaves	103.75	91.70	15.83	14.29	129.70	119.44
No mulch	74.19	72.90	12.72	10.56	108.20	98.20
SEm ±	6.08	3.78	1.11	0.71	7.37	7.02
LSD (5%)	18.95	11.79	3.46	2.22	22.95	21.87

Efficacy of mulches for weed management

In 2014-15, density of weeds at 45 DAP was higher in non-mulched plots (35.20/m^2). Compared to mulched plots, there was no significant difference in weed density between mulches (Table 5). In 2015-16, higher weed density was observed in non-mulched plots (34.80/m^2) followed by mulching by water hyacinth (14/m^2). Weed density was lower in plots mulched with jack leaves (7.20/m^2) on par with mulching by coconut leaves (8.80/m^2).

In 2014-15, weed density at 90 DAP was higher in non-mulched plots (21.20/ m^2) followed by mulching by water hyacinth (11.60/m^2). Weed density was lesser in plots mulched with jack leaves (6.80/m^2), which was on par with mulching by coconut leaves (8.40/m^2). The same trend was observed in 2015-2016 also. Thankamani *et al.* (2016) compared different mulch materials such as paddy straw, coir pith compost, dried coconut leaves, *Glycosmis pentaphylla* leaves, *Lantana camara* leaves, cowpea plants, and plastic mulch and reported that application of paddy straw at 6 t/ha along with green leaf mulch 7.5 t/ha at 45 and 90 days after planting and application of dried coconut leaves at 5.4t/ha at the time of planting showed higher weed control efficiency and higher economic returns from ginger crop.

In the case of number of weeds germinated, jack leaves and coconut leaves had a slight edge over water hyacinth probably because of their slow decaying rate. However, this is not reflected in growth characters or rhizome yield of turmeric (Table 3).

In the case of crop-weed competition, dry matter production is a deciding factor rather than number of weeds. Dry matter production by the weeds at 45 DAP in both years was higher in non-mulched plots (535.20 kg/ha and 289.56 kg/ha respectively). There was no significant difference in weed dry weight between mulching treatments. The same trend was observed at 90 DAP in both years.

Table 5. Effect of mulching on total weed density and weed dry weight

Treatments	Weed density (No./m^2)				Weed dry weight (kg/ha)			
	45 DAP		90 DAP		45 DAP		90 DAP	
	2014-15	2015-16	2014-15	2014-15	2014-15	2015-16	2014-15	2015-16
Mulching with water hyacinth	4.33*	3.84	3.51	3.36	15.77	12.42	12.06	11.87
	(18.00)	(14.00)	(11.60)	(10.60)	(263.04)	(155.04)	(146.16)	(141.90)
Mulching with jack leaves	3.35	2.78	2.77	2.58	10.90	9.54	10.52	10.63
	(10.80)	(7.20)	(6.80)	(5.80)	(132.96)	(95.04)	(112.14)	(116.96)
Mulching with coconut leaves	3.89	3.03	3.04	2.87	14.03	11.20	11.21	10.85
	(14.80)	(8.80)	(8.40)	(7.40)	(214.56)	(129.83)	(126.42)	(119.11)
No mulch	5.99	5.95	4.65	4.25	25.58	17.25	17.42	16.33
	(35.20)	(34.80)	(21.20)	(17.40)	(535.20)	(289.56)	(313.74)	(273.05)
SEm ±	0.36	0.33	0.22	0.17	1.82	1.04	1.08	1.10
LSD (5%)	1.11	1.02	0.68	0.52	5.68	3.24	3.38	3.44

*$\sqrt{x+1}$ transformed values. Original values are given in parentheses.

Table 6. Effect of mulching on nutrient status of the soil after the experiment

Treatments	Organic carbon (%)		Available N (kg/ha)		Available P (kg/ha)		Exchangeable K (kg/ha)	
	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16	2014-15	2015-16
Mulching with water hyacinth	1.31	1.32	455.58	468.07	18.82	20.03	370.40	373.19
Mulching with jack leaves	1.27	1.29	440.528	458.34	18.62	18.67	364.52	368.70
Mulching with coconut leaves	1.25	1.26	435.510	449.10	18.60	18.80	363.89	368.06
No mulch	1.14	1.15	427.984	427.47	17.42	17.00	351.86	349.20
SEm ±	0.031	0.033	4.77	4.79	0.72	0.43	1.39	1.42
LSD (5%)	0.096	0.10	14.85	14.93	NS	NS	4.32	4.43

Effect of mulching on nutrient status of soil

The nutrient status of the soil after the experiment is shown in Table 6. Organic carbon content of the soil in both years varied significantly among treatments. After the experiment, soil organic carbon significantly improved because of mulching, but all the mulches were on par in plots with water hyacinth in both years of study. According to Sarora and Lal (2003), continuous addition of plant residues like water hyacinth increases soil organic carbon.

In 2014-15, available nitrogen content was maximum in plots mulched with water hyacinth and the minimum was in non-mulched plots. In 2015-16, available N content of the soil was higher in plots mulched with water hyacinth which was on par with that of jack leaves. Increase in soil N content with water hyacinth mulching due to lower C/N ratio of green water hyacinth was reported earlier by Balasubramanian *et al*. (2013).

Available phosphorus content of soil did not differ significantly among the treatments in both years. However, exchangeable potassium content of soil was the highest in plots mulched with water hyacinth in 2014-15 and the least was recorded in non-mulched plots. In 2015-16 also, exchangeable potassium content of soil was higher in plots mulched with water hyacinth. However, no significant differences were observed in potassium content of soils mulched with jack leaves or coconut leaves.

From the results reported, it can be concluded that mulching turmeric crop with plant materials including water hyacinth significantly improved its growth and yield attributes. Water hyacinth when applied as mulch contributed more available nitrogen and exchangeable potassium content to soil compared to other mulch materials like jack and coconut leaves. All the mulch materials reduced weed density and weed dry weight at different stages of crop. The efficacy of water hyacinth as mulch in turmeric is thus evident and can be recommended as an alternative to jack and coconut leaves.

References

Balasubramanian, D., Arunachalam, K., Arunachalam, A., and Das, A. K. 2013. Water hyacinth [*Eichhorniacrassipes* (Mart.) Solms.] engineered soil nutrient availability in a low-land rain-fed rice farming system of north-east India. *Ecol. Eng*., 58:3-12.

Chakravarti, A. K., Moitra, R., Asis M., Dey, P., and Chakraborty, P. K. 2010. Effect of planting methods and mulching on the thermal environment and biological productivity of groundnut. *J. Agrometeorol,*. 12(1): 77-80.

Ghosh, D. K. 2008. Performance of ginger as intercrop in coconut plantation with organic mulches and the effect of intercropping on the main crop. *Indian Coconut J.,* 51(4): 20-24.

Goswami, S. B and Saha, S. 2006. Effect of organic and inorganic mulches on soil moisture conservation, weed suppression andyield of elephant-foot yam (*Amorphophallus paeoniifolius*). *Indian J. Agron.,* 51(2): 154-156.

KAU [Kerala Agricultural University] 2011. Package of Practices Recommendations: Crops (14^{th}Ed.).

Kerala Agricultural University, Thrissur, 360 p.

Rao, D. V and Swamy, G. S. 1984. Studies on the effect of N, P and K on growth, yield and quality of turmeric. *South Indian Hortic*., 32:288-291.

Sanghamithre, V. K. 2014. Effect of secondary nutrients on yield and quality of turmeric (*Curcuma longa* L.). M.Sc. (Ag) thesis, Kerala Agricultural University, Thrissur, 100p.

Sarora, G.S and Lal, R. 2003. Soil restorative effects of mulching on aggregation and carbon sequestration in a Miamian soil in central Ohio. *Land Degrad. Dev*., 14: 481-493.

Thankamani, C.K., Kandiannan, K., Hamza, S., and Saji, K.V. 2016. Effect of mulches on weed suppression and yield of ginger (*Zingiber officinale* Roscoe). *Sci. Hortic.,* 207: 125–130

Varshney, J. G., Sushilkumar, and Mishra, J. S. 2008. Current status of aquatic weeds and their management in India. In: Sengupta, M. and Dalwani, R. (eds.), *Proceedings of TAAL 2007, the 12th World Lake Conference*, 28th Oct. to 2nd Nov. 2007, Jaipur, pp.1093-1045.