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HORTICULTURE

Effect of Various Mulching Materials on Crop Production and Soil Health in Acid Lime (*Citrus aurantifolia* Swingle)

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ABSTRACT

An experiment was conducted to study the effects of mulching on acid lime during 2014-2015 in Randomized Block Design with 9 treatments and 3 replications. The highest increase on plant height (6.63 %), canopy spread in E-W (9.90 %) and N-S (7.60 %) direction was recorded by polythene mulch with black side facing upward (T_8). The treatment also had a significant influence on yield and yield attributing parameters where T_8 recorded the highest number of fruits per plant (163.0), fruit weight (50.22 g) and fruit yield per plant (7.81 kg) while dry grasses mulch (T_2) recorded highest number of fruits per branch (7.50) and fruit retention (44.71 %). With respect to quality parameters of fruit, T_8 recorded highest total sugar (0.40 %) and reducing sugar (0.61 %) while significant increase on titratable acidity (6.93 %) and ascorbic acid content (33.46 mg/100g) was observed in T_2. Among soil parameters, maximum moisture content (36.06 %) was observed in T_8 while maximum organic carbon (3.11 %), available nitrogen (428.47 kg/ha), phosphorus (45.17 kg/ha) and potassium (575.06 kg/ha) content were recorded by saw dust mulch (T_7). The treatment recorded highest microbial population of bacteria (83.45×10^5) in paddy straw mulch (T_4) and fungi (119.34×10^5) in rice husk mulch (T_5). The study revealed that T_8 was the most effective with respect to plant growth, fruit yield and quality while T_4 also proves to be the best ideal treatment for improving soil health in acid lime.

Highlights

- Polythene mulch with black side facing upward is the most effective for improving plant growth, fruit yield and quality
- Paddy straw mulch proves to be the best ideal treatment for improving soil health

Keywords: Acid lime, mulching materials, plant growth, yield, fruit quality, soil health

Acid lime (*Citrus aurantifolia* Swingle) is the third important citrus fruit crop in India next to mandarin and sweet orange (Chadha 2002). The quality production of citrus fruits is highly dependent on the soil moisture availability. In North Eastern Region, rainfall increase gradually from the month of March and continues up to last week of October wherein maximum rainfall is observed during the month of June to September from South-West monsoon. The months of November to March, however, are deprived of rainfall thus producing a dry period. Proper management of available irrigation water and conservation of moisture for longer duration in the root zone of the tree canopy plays an important role in enhancing the yield and quality of acid lime, besides sustaining the orchard life (Shirgure 2012). Mulching plays an important role in conservation of soil moisture during dry periods, as well as improves physical, biological and chemical properties of soil. It is a practice, which helps in proper growth and development of the plants by modifying soil temperature, providing better nutrient availability and by better moisture conservation (Kher *et al.* 2010). Organic mulches derived from plant and animal materials such as straw, hay, husks, compost, sawdust, wood chips,

etc. are efficient in reduction of nitrates leaching, improve soil physical properties, prevent erosion, supply organic matter, regulate temperature and water retention, improve nitrogen balance, take part in nutrient cycle as well as increase the biological activity (Muhammad *et al.* 2009; Sarolia and Bhardwaj 2012). The effective use of polyethylene and organic mulches was evaluated for improving the growth, yield and quality of the Coorg mandarin (Mustaff*a* 1989), Assam lemon (Nath and Sharma 1993), Nagpur mandarin (Shirgure *et al.* 2003) and acid lime (Shirgure 2012). The information on mulching materials and its effect on soil health in acid lime suitable for North Eastern conditions were not known. Therefore, an investigation was done to find out the effect of various mulching materials on plant growth, fruit yield, quality and soil health parameters in acid lime.

MATERIALS AND METHODS

The experiment was carried out on 6 years old of acid lime var. PKM 1 planted at spacing of 3m × 3m, these plants were treated with different mulches at Fruit Research Farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, Arunachal Pradesh in the year 2014 to 2015. The experiment consisted of nine treatments in a Randomized Block design with three replications. The treatments were T_1 = No mulch (Control), T_2 = Dry grasses, T_3 = Banana leaves, T_4 = Paddy straw, T_5 = Rice husk, T_6 = Wood shavings, T_7 = Saw dust, T_8 = Polythene mulch with black side facing upward and T_9 = Polythene mulch with silver side facing upward. The dry grasses mulch and banana leaves mulch materials were imposed on 3 kg/ basin around the tree trunk, while the remaining organic mulch materials *viz*. paddy straw, rice husk, wood shavings and saw dust were applied as 6 cm/ thickness around the canopy during the study period. Standard procedures were followed for the estimation of yield attributing and fruit quality parameters. The fruit quality analysis was done after extraction of juice using different quality analysis method. The standard method (AOAC 2002) was followed to determine the titratable acidity of fruit juice and ascorbic acid content was estimated as per the method of Jagota and Dani (1982). The reducing sugar was estimated by spectrophotometric method (Somogyi 1952), total sugar determined by Anthrone method (Hodge and Hofreiter 1962) and non-reducing sugar by traditional method (Kumar 2002). The yield was calculated as the product of average fruit weight and the number of fruits per plant. The shelf life of the fruits was determined by visual observation and continued till the fruits became yellow and no longer marketable. The surface (0-15 cm) soil samples were used for analyzing the soil properties. The soil properties were determined using soil analytical methods given by Jackson (1973) as organic carbon content was determined by wet digestion method of Walkley and Black, available nitrogen (N) by Kjeldahl's method, available phosphorous (P) by Bray and Kurtz method and available potassium (K) by flame photometric method. The microbial population of the soil was estimated using serial dilution agar plating method or viable plate count method. The Cost Benefit Ratio (CBR) was calculated based on the benefit obtained per rupees invested on different treatments. The data collected on various parameters have been statistically analysed as per the method of Panse and Sukhatme (1978).

RESULTS AND DISCUSSION

Growth parameters

The experimental results showed that the growth of acid lime was significantly influenced by the different types of mulching materials in terms of plant height and canopy spread (Table 1). The highest increase in plant height (6.63 %) as well as canopy spread in both East-West direction (9.90 %) and North- South direction (7.60 %) were recorded by polythene mulch with black side facing upward (T_8), which were observed to be at par with polythene mulch with silver side facing upward (T_9), dry grasses mulch (T_2) and saw dust mulch (T_7). The increase in these plant growth parameters might have attributed due to ideal soil moisture and better water conservation along with lower weed intensity due to the mulching materials. There was no significant increase in plant girth. Highest percentage increase in plant girth was recorded in rice husk mulch (6.85 %). However, there was no significant variation in flowering time with respect to the effect of mulching as all the plants of different treatments were flowering around the same time. Studies conducted by Shirgure (2012) observed similar findings of significant increase on growth

Table 1: Effect of mulching on growth and yield attributing parameters

Treatments	Percent increase (%)				Time of flowering (in days)	Number of fruits per plant	Number of fruits per branch	Fruit set (%)	Fruit retention (%)	Fruit length (cm)	Fruit girth (cm)	Fruit volume (cc)	Fruit weight (g)	Fruit yield per plant (kg)
	Plant height	Plant girth	Canopy spread (E-W)	Canopy spread (N-S)										
T_1	3.74	5.46	5.49	3.37	95.66	102.63	5.52	26.74	30.99	3.73	3.57	36.03	39.83	4.02
T_2	5.55	6.33	6.50	7.44	96.66	149.33	7.50	32.55	42.98	4.33	4.04	43.24	46.80	6.91
T_3	3.93	4.95	4.17	3.29	95.66	106.61	5.97	28.83	32.65	3.82	3.72	35.09	41.69	4.37
T_4	4.68	5.99	8.88	4.42	96.00	129.28	6.17	33.70	42.18	4.01	3.77	40.20	45.66	5.90
T_5	5.91	6.85	8.43	4.42	94.66	131.52	6.87	34.18	44.71	4.07	3.86	41.66	45.21	5.93
T_6	4.35	3.96	4.71	3.20	96.33	116.30	5.60	28.76	33.35	3.85	3.82	39.41	42.16	4.71
T_7	5.85	6.24	8.60	6.25	97.33	126.46	6.88	31.90	38.74	4.10	3.99	41.25	44.60	5.60
T_8	6.63	6.67	9.90	7.60	95.00	161.85	7.21	36.34	36.85	4.41	4.15	43.86	50.22	7.81
T_9	6.35	5.63	9.28	5.82	95.66	135.14	7.15	35.36	36.50	4.21	4.10	42.57	48.33	7.76
S.Ed±	0.53	—	0.65	0.43	—	8.67	0.56	—	3.70	—	—	—	2.49	0.50
C.D at 5%	1.14	N.S	1.39	0.91	N.S	18.39	1.20	N.S	7.86	N.S	N.S	N.S	5.28	1.07

parameters of acid lime under different mulching materials treatments.

Yield and yield attributing characters

The yield and yield attributing characters of acid lime were found to be greatly influenced by different mulching materials (Table 1). Highest number of fruits per plant (161.85), fruit weight (50.22 g) and fruit yield per plant (7.81 kg) were recorded in polythene mulch with black side facing upward (T_8). However, polythene mulch with silver side facing upward (T_9) and dry grasses mulch (T_2) also showed significant results wherein the above mentioned yield attributing parameters under (T_8) were at par with (T_9) and (T_2). The highest number of fruits per branch (7.50) was recorded in dry grasses mulch (T_2) and highest fruit retention (44.71 %) was recorded in rice husk mulch (T_5). Similar results were also concurred by Nath and Sharma (1994) in Assam lemon and Ghosh *et al*. (2009) in sweet orange. There was no significant effect with respect to fruit set (%), fruit length (cm), fruit girth (cm) and fruit volume (cc). The improvement maybe attributed to the suppression of weed growth which leads to less competition between the weeds and crop for nutrients and moisture which may have led to better nutrient use efficiency by the crop.

Quality parameters

The quality parameters of acid lime were also significantly influenced by the treatments. The use of polythene mulch with black side facing upward (T_8) led to improvement in total sugars (0.61 %) and reducing sugars (0.40 %) while dry grasses mulch (T_2) recorded highest titratable acidity (6.93 %) and ascorbic acid content (33.46 mg/100g). However, the rind thickness, fruit juice content and non-reducing sugar were not significantly influenced by the treatments (Table 2). Enhanced total sugar content of citrus fruit under the effect of mulching may be due to the increased activity of sucrose synthase (SS). Similar findings were also reported by Zhang and Xie (2014) in Satsuma mandarin (*Citrus unshiu*) with an increase in total sugars, reducing sugars and vitamin C content was observed in trees mulched with black polythene.

Shelf-life

Shelf life was not significantly influenced by the effect of the mulching materials (Table 2). The shortest shelf life was recorded by rice husk mulch (7.22 days) while in saw dust mulch treatment, the longest shelf life (7.77 days) was recorded. Ritenour *et al*. (2003) opined that as fruit quality usually improves soil moisture and nutrients increase from deficient to optimum, levels that produce maximum yield may not always correspond to those that result in the highest fruit quality and maximum quality retention.

Soil parameters

The effect of various mulching materials on soil moisture content, organic carbon, available nitrogen, phosphorus, potassium content and microbial population have been observed showing a significant observation although there was no significant impact on the soil pH. The maximum soil moisture content (36.06%) was observed in polythene mulch with black side facing upward (T_8) while maximum organic carbon (3.11 %), available nitrogen (428.47 kg/ha), available phosphorus (45.17 kg/ha) and potassium (575.06 kg/ha) were observed in saw dust mulch (T_7) (Table 2). The mulching materials especially paddy straw and rice husk mulch imparted significance increase on the soil microbial population (Table 3).

Paddy straw mulch (T_4) recorded highest microbial population of bacteria at 83.45×10^5 followed by rice husk mulch (T_5) at 74.88×10^5 while highest population of fungi was observed in rice husk mulch (T_5) at 119.34×10^5 followed by paddy straw mulch (T_4) at 54.77×10^5. The available nitrogen in post harvest soils increased successively with increasing nitrogen levels which was due to integration of organic and inorganic sources and also due to increased microbial activity which could have stimulated the nitrification process. Among the organic mulches, saw dust mulch (T_7) proves to have a profound beneficial effect on the soil properties although the other treatments were in par with T_7.

Economics of cultivation

The highest cost benefit ratio (CBR) was observed in dry grasses mulch (1:2.67) followed by polythene mulch with black side facing upward (1:2.62) while lowest was observed in banana leaves mulch (1:1.05) (Table 3). The cost of treatment and higher yield

Table 2: Effect of mulching on fruit quality and soil parameters

Treatments	Rind thickness (cm)	Fruit juice content (ml)	Titratable acidity (%)	Total soluble solid (°Brix)	Reducing sugar (%)	Total sugar (%)	Non reducing sugar (%)	Ascorbic acid content (mg/100g)	Shelf-life (in days)	Soil pH	Soil moisture content (%)	Organic carbon (%)	Available nitrogen (kg/ha)	Available phosphorus (kg/ha)	Available potassium (kg/ha)
T_1	0.23	15.61	6.17	6.73	0.24	0.46	0.21	29.38	7.55	5.45	24.20	2.19	296.83	24.27	440.83
T_2	0.24	16.93	6.93	7.06	0.36	0.61	0.24	33.46	7.44	5.37	33.66	2.85	388.80	44.80	511.46
T_3	0.22	15.53	6.23	6.33	0.23	0.48	0.21	29.41	7.55	5.41	29.11	2.49	347.10	31.73	482.16
T_4	0.22	16.80	6.40	6.80	0.32	0.55	0.21	32.20	7.55	5.53	30.26	3.03	367.63	41.81	556.92
T_5	0.24	16.57	6.36	6.56	0.32	0.54	0.22	32.88	7.22	5.32	28.66	2.94	376.27	42.93	559.35
T_6	0.22	15.82	6.34	6.16	0.26	0.50	0.22	29.10	7.66	5.97	26.73	2.76	409.73	38.08	527.86
T_7	0.25	15.73	6.41	6.63	0.36	0.57	0.22	30.33	7.77	5.90	29.66	3.11	428.47	45.17	575.06
T_8	0.23	17.47	6.71	7.06	0.40	0.61	0.25	31.46	7.40	5.33	36.06	2.60	355.77	36.21	520.43
T_9	0.23	17.43	6.49	6.95	0.34	0.59	0.24	31.18	7.36	5.32	35.25	2.56	334.70	34.34	514.13
S.Ed±	—	—	0.20	—	0.02	0.02	—	1.04	—	—	2.99	0.21	33.98	5.96	32.17
C.D at 5%	N.S	N.S	0.44	N.S	0.03	0.05	N.S	2.20	N.S	N.S	6.34	0.44	72.03	12.65	68.21

from the fruits sold attributes to the cost benefit ratio by selling the fruits at ₹ 20/kg.

Table 3: Effect of mulching on soil microbial population and Cost Benefit Ratio

Treatments	Microbial population (cfu/g)		C:B ratio
	Bacteria ($\times 10^5$)	Fungi ($\times 10^5$)	
T_1	14.06	0	1:1.90
T_2	29.42	0.10	1:2.67
T_3	27.36	0	1:1.05
T_4	83.45	54.77	1:1.86
T_5	74.88	119.34	1:2.23
T_6	31.89	0.25	1:1.60
T_7	34.77	0.03	1:2.05
T_8	47.71	22.71	1:2.62
T_9	21.07	12.30	1:2.59
S.Ed±	1.14	0.18	
C.D at 5%	2.43	0.38	

The experimental study concluded that mulching materials had significantly influenced moisture conservation, growth, fruit quality and soil health in acid lime as compared to control (no mulch). The moisture regulation is of utmost importance and needs to be emphasized as a priority at critical stages of growth. The polythene mulch with black side facing upward (T_8) proves to have a profound beneficial effect on the plant growth, fruit quality and yield which could be recommended for commercial cultivation of acid lime although the significance of various other treatments were at par with T_8. The study revealed that the organic mulches such as paddy straw (T_4), rice husk (T_5) and saw dust mulches (T_7) gave the best results for improving soil health status of acid lime. The dry grasses mulch (T_2) produced the highest cost benefit ratio. The mulching with polythene mulch (50 μ) exhibited good result but organic mulches such as rice husk, paddy straw and saw dust mulches are more recommended as compared to the inorganic mulch since they are readily available raw material resulting high cost benefit ratio.

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