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Effect of Mulching: A Best Practice of Soil Management in the Litchi Orchard

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Abstract: Litchi is one of the main fruit crops of North Bihar (India). It is of high export potential due to its nutritional and pharmaceutical properties. Litchi production is highly dependent on its soil fertility status, which is declining due to the lack of proper agronomic practices and changing climatic conditions. The aim of the study is to observe the effect of mulching on soil nutritional content of litchi plant, its quality and yield. The study was conducted in a litchi orchard situated at Harsidhi block, East Champaran (Bihar), during litchi growing season. The Organic and inorganic mulching treatment was applied on the soil of litchi trees covering its basin. Mulching treatment increased the N, P, K content, soil moisture content, organic carbon and diversity of rhizobacteria in the soil as compared to control. Soil moisture content increased from 11.9% to 20.67% (inorganic mulch). Available Nitrogen (252kgha^{-1}), phosphate (53kgha^{-1}) was found maximum in inorganic mulch as compared to control. Organic carbon (0.95%) and rhizobacterial diversity (2.5 X 10^{-8}) was high in organic mulch. Physical characteristics of fruit were also enhanced in mulched trees. Fruit yield/ tree was maximum in inorganic mulch (97.56 kg), followed by organic mulch (85.64kg) and least in control (74.82 kg). Both organic and inorganic mulching treatment is fruitful for soil health and litchi production. Thus it can be effectively applied as a good agronomic practice in modern agriculture system.

Keywords: Mulching, litchi, rhizobacteria

Introduction

Mulches have a good impact on enhancing yield and quality of fruits. It improves physiochemical properties and nutrient pool availability of the soil for the growth of soil beneficial microbes [1]. The term “Mulch” means ‘covering of soil’. The covering may be organic or inorganic. Mulches

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impart many beneficial effects, like stabilized soil temperature, and reduced water loss through evaporation resulting increased soil moisture content, which is used by crop plants especially during dry conditions [2]. Mulches also check weed density, apart from conserving soil moisture content or stabilizing soil temperature [3] which ultimately enhances the total and early yield [4]. The practice of applying dead vegetable waste as mulch is being used since long years all over the world as a source of organic fertilizer. The mulches of organic origin contribute to plant nutrition. Various materials of plant origin such as straw, leaves increase soil agreeability and stability. It also adds nutrients and humus to the soil as they decompose improving its tilt and water holding capacity [5].

Litchi being an evergreen plant, the maintenance of optimum soil moisture is essential for growth, development and fruit production. Irrigation is essential at the fruit development stage to get better yield and quality of fruits. For young plants, mulching with dry leaves or plant residues present in the soil help in better moisture conservation. Physiological disorders such as poor fruit set, heavy fruit drop and high fruit cracking, sunburn can be minimized with proper water management. Moisture conservation through mulching using dried leaves, plant parts or black polythene sheet has been found useful. Frequency of irrigation is reduced by adopting mulching. Thus the present investigation was carried out to observe the effect of mulching using dry leaves and black polythene on nutritional content of litchi soil and its rhizobacterial diversity with respect to unmulched litchi plant.

Materials and Method

Experimental site

To observe the effect of mulching, a litchi orchard farm of Harsiddhi block, East Champaran district, Bihar was selected as the experimental site during the year 2018-2019. Soil of the experimental site is sandy and loamy with pH 7.95 .The site was selected to conduct the experiment as it is more than 25 yrs old litchi orchard in 35 acres land, containing 1700 litchi trees and is well managed.

Experimental design

Nine fruiting trees of litchi were selected at the experimental site from the central region of the plot. The mulching treatment was applied to observe the effects of mulching on the fruit crop and its production. Mulching method was applied to selected litchi trees from (November 2018 to May 2019).The mulching was carried out by two distinct methods, organic and inorganic method The area of approximately 28.27 m^2 of soil, holding the 3 selected Litchi trees were covered with dead and dry leaves (organic mulching method) of mix plants like mango, litchi, guava, banana etc. and of other 3 selected Litchi trees with black polythene sheet (inorganic mulching method). The covering occupied the area of circumference of litchi trees in the soil. Three out of nine trees were selected as control in which no mulching treatment was performed. Experimental set up shown in fig 5.

During mulching, the sides of plastic used to cover the soil surface of the selected trees, was bounded by the moist soil all around, to avoid removal of the applied material by wind blow. The dried leaves covering the top soil surface of the selected fruiting trees were made moist by sprinkling water and putting cow- manure above the dried leaves surface. The whole process of mulching carried out in the selected area provided extra moisture and favourable physical condition to the rhizobacteria to grow and flourish in the soil.

Uniform agricultural practices and plant protection measures were applied to all 9 selected trees. The samples of soil and harvested fruits of mulched and unmulched trees were brought to the laboratory for further studies on different parameters.

Physio-chemical analysis of soil

Moisture content of all the treated (mulched) and non- treated (unmulched) soil samples at a depth of 10-30 cm was measured by gravimetric method. For estimation of physio-chemical contents and nutrients of soil, soil samples were sent to Central soil testing laboratory (CSTL), Mithapur, Patna.

Microbial analysis of soil

For estimation of microbial content of mulched and unmulched soil, soil samples were taken from 10-15 cm depth and bacterial counts were calculated on the basis of serial 10 fold dilution technique, using Pour plate method. Soil bacterial population was calculated using the equation of James (1978). It has been expressed as Colony forming units per g of soil (CFU/g). Colony forming unit CFU/gm soil= No. of colonies x dilution factor/ volume of inoculums.

Physical estimation of harvested fruits

The physical parameters of fruit, like fruit size (length and diameter) were measured by Vernier Calipers. The weight of fruit was measured by digital weighing balance **(**A&D manufacturer) based on random 10 fruit samples.

Result

Physio-chemical analysis of soil

Basic Physio-chemical properties of the control trees were at the lower level. Experimental data revealed that maximum soil moisture content was observed in plastic mulch (inorganic method) followed by dry leaves mulch (organic method) and then in the unmulched tree. Marked increment in moisture content of the soil was recorded in plastic mulch before and after the mulching treatment. Moisture content increases from 11.9 % to 20.67% in inorganic mulch. The soil mineral contents (N, P, and K) were also influenced by the application of different mulches. Black polythene mulch proved very effective and had the highest available soil mineral contents i.e. Nitrogen (252Kgha$^{-1)}$, Phosphorus (53 Kg ha^{-1}) and Potassium (166 Kgha^{-1}) in comparison to organic mulch and least in unmulched litchi plant (N: 195 kg ha^{-1}, P_2O_5: 30 Kgha^{-1} and K_2O:94 Kgha^{-1}) shown in table 1, Fig 1.

Table 1: Effect of different mulching on soil and microbial properties

Mulching material	Pre & post mulching	Soil moisture content (%)	Organic carbon content (%)	Available nitrogen (kg/ha)	Available phosphate (kg/ha)	Available potash (kg/ha)	Microbial count (Cfu/gm) soil
Plastic Mulch	Pre	11.9%	0.6	200	24	126	$1.8x\ 10^{-6}$
	Post	20.67%	0.9	252	53	166	$2.2x10^{-6}$
Dry leaves mulch	Pre	10.4%	0.54	190	28	114	$1.1\ X\ 10^{-6}$
	Post	18.50%	0.95	226	31	189	$2.5x10^{-6}$
Unmulched (control)	Pre	13.4%	0.48	179	29	87	$1.4\ x\ 10^{-6}$
	Post	9.9%	0.57	195	30	94	$1.6x10^{-6}$

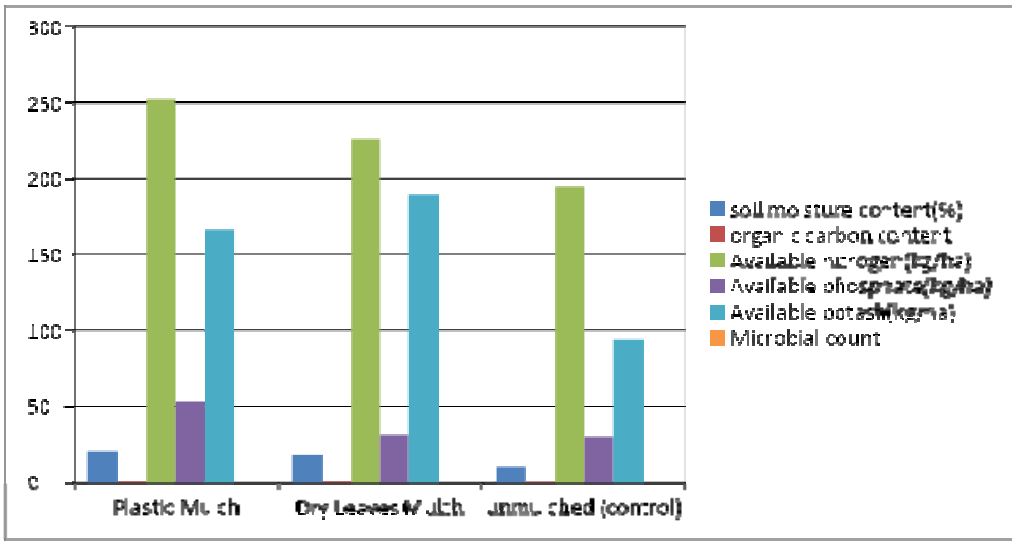

Fig 1: Effect of different mulching on soil and microbial properties

Microbial analysis of soil

Soil microbial population was observed to be different, which was influenced by different mulches. Highest soil microbial population was observed in dry leaf mulch (2.5×10^{6} Cfu/g soil

bacteria) followed by black polythene mulch (2.2 x 10^6cfu/g soil bacteria) while least recorded as $1.6x10^6$ in unmulched. Highest increase in CFU count/gm was recorded in organic mulch before (1.1 X 10^{-6}) and after ($2.5x10^{-6}$) the treatment. Rhizobacterial diversity of soil samples from mulched and unmulched trees were shown in fig2.

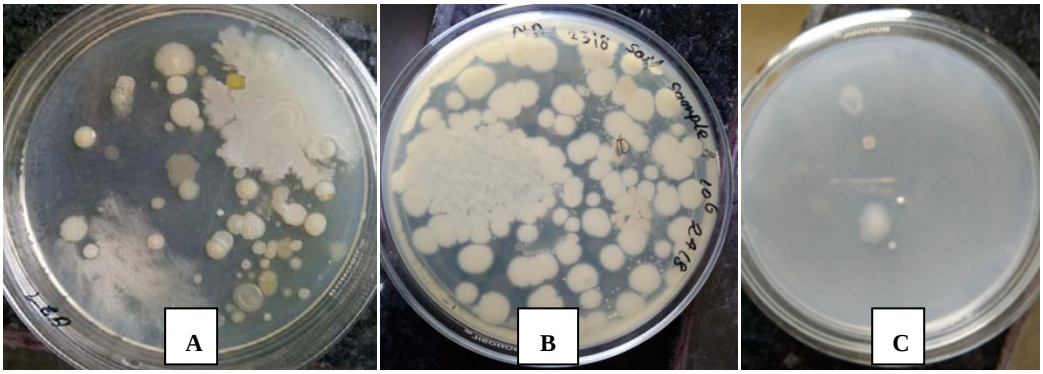

Fig 2: Rhizobacterial diversity in inorganic (A), organic (B) & unmulched soil sample(C)

Physical estimation of harvested fruits

In physical estimation of the fruit, the weight(23.5g), diameter(3.2 cm), length(3.8 cm) and yield per tree(97.56kg/tree) was found maximum in plastic mulched trees followed by dry leaves mulched trees having fruit weight (21.8g), diameter(2.8 cm), length(2.9cm), yield/tree(85.64kg/tree)and least in control (18.5g weight, 2.1 cm diameter, 2.2cm length , 74.82 kg/tree yield) (Table 2; Fig 3& Fig 4).

Table 2: Effect of mulching on physical qualities of fruit

Mulching material	Pre and post mulching	Fruit weight (gm)	Fruit diameter(cm)	Fruit length (cm)	Yield/tree
Plastic mulch	Pre	17.6 g	1.9 cm	2.3 cm	72.11 kg/tree
	Post	23.5g	3.2 cm	3.8 cm	97.56kg/tree
Dry leaves mulch	Pre	18.0 g	1.87 cm	2.2 cm	69.98 kg/tree
	Post	21.8g	2.8 cm	2.9cm	85.64kg/tree
Un mulched (control)	Pre	18.1 g	1.97 cm	1.9 cm	73.1 kg/tree
	Post	18.5g	2.1 cm	2.2cm	74.82 kg/tree

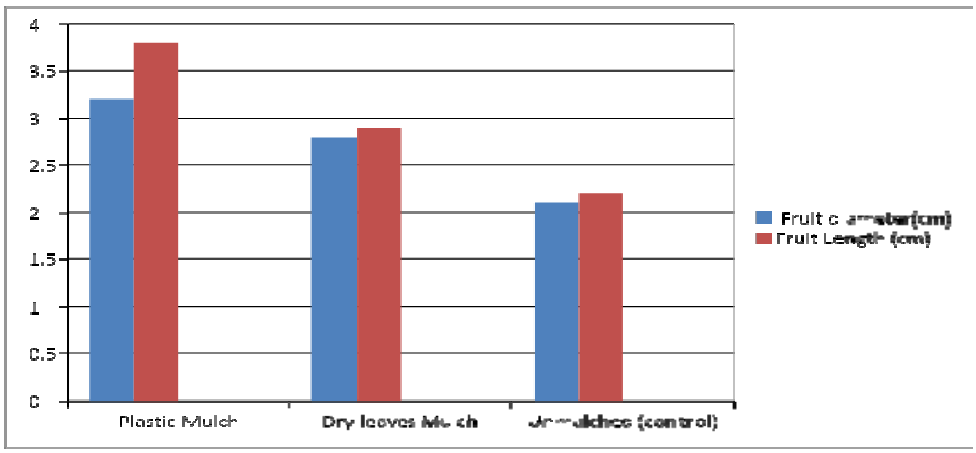

Fig 3: Effect of mulching on fruit length and diameter

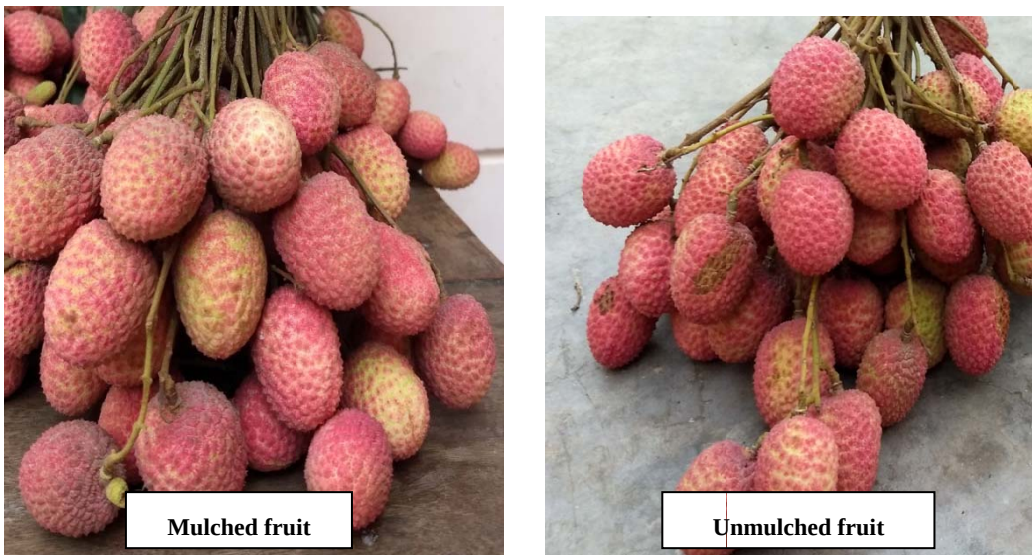

Fig 4: showing physical characteristics of litchi fruits in mulched and control treatment

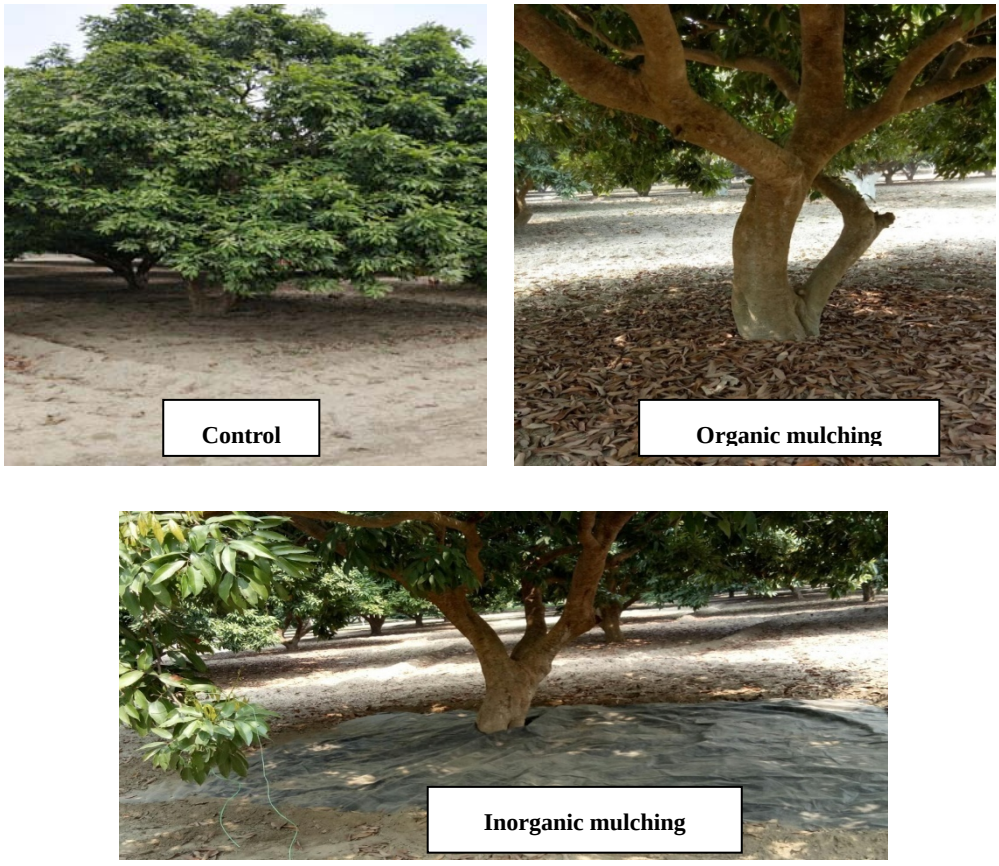

Fig 5: Experimental design for mulching

Discussion

High moisture retention ability of plastic mulches could be due to less evaporation from soil. The water vapors that evaporate from the soil surface gets trapped in the plastic and dropped back into the upper soil surface which increases the soil moisture content in the root zone [6]. The availability of nutrient pool in the soil under polythene mulch was the result of mineralization of organic matter. Same conclusion was also obtained by Dutta and Majumder [1] in the guava orchard.

Microorganisms are a vital component of soil environment [7]. Better soil health, improved nutrient availability to plants and the yield of healthy fruits indicate the presence of microbes in larger number [8]. Organic mulch helps in reduction of nitrate leaching, improve soil physical properties, prevent soil erosion, supply organic matter, regulate temperature and water retention, improve nitrogen balance, take part in nutrient cycle and enhanced biological activity [9, 10, 11].

Organic matter plays a vital role especially in Sandy soils, by creating adsorption surfaces and chelating effect on various micronutrients such as iron, zinc, copper and manganese. The organic inputs create a favourable environment for beneficial soil microorganisms, which utilize the organic material as a source of energy and it often compete harmful microbes [12]. Soil under plastic mulch remains loose and friable and roots get adequate amount of oxygen and microbial activity is enhanced [13]. Enhanced macronutrient uptake with the application of bio fertilizer and mulching was reported in Mango [14] and Litchi [15]. Effect of mulching is also reported by Borthakur and Bhattacharya [5] in guava.

Conclusion

The litchi cultivation is highly sensitive to water deficiency [16] which results in fruit cracking and shortens the post harvest life. Mulching treatment helps to overcome such problems by minimizing the water loss through evaporation and maintaining the moisture content of the soil. The study clearly shows that mulching, both organic and inorganic are effective in improving the physio-chemical and microbial properties of soil. It also enhances the soil fertility and fruit quality of litchi. Litchi cultivation is highly dependent on its nutrient content of the soil. Inorganic mulching (plastic) showed significant increase in carbon, moisture, available NPK content and rhizobacterial count of the soil as compared to control, showing enhanced nutrient status of soil. Fruit yield/tree was also highest in plastic mulching. Organic mulch also proved better than control in all respect. Polythene mulching proved best for improving the soil, microbial and fruit quality of litchi trees. A good mulch layer saves many hours of manual weeding as they provide unfavorable conditions for seed germination of weeds and provide a physical barrier for emerging weeds.

Mulching is also being practiced in other crops since along years. Plastic mulching increased total plant growth, rate of branching and early flowering in tomato [17]. [18] Reported beneficial impact on chilli production. [19] Reported higher no. of leaves and plant height in cucumber than the control. Plastic mulches increased crop growth, dry root mass, nitrogen fixing ability, leaf chlorophyll content, more reproductive buds and early flowering in groundnut than the unmulched control [20]. Besides fruit crops, mulching has proved very effective in overall growth of other crops also.

Polythene being the non-biodegradable material can be used as an effective mulching tool in modern agricultural practices, instead of throwing it as a waste, which can adversely affect the environment. Thus, both organic and inorganic mulching technique should be practiced for achieving sustainable agriculture.

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Conflict of Interest: NIL

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