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Evaluation of mulching techniques in the context of weed management in citrus crop cultivation on Hills

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ABSTRACT

An experiment was conducted on hill slope in Khagrachari hill district during in 2021 to observe the effect of different mulching techniques on weed infestation and performance of Binalebu-1 on hill slope. The experiment was laid out in RCBD, where the treatments, i.e. mulching with straw, mulching with Jute Geo-bag, mulching with bamboo leaves and control were imposed in plots. From year round observation most of the weeds were grasses, a few were broadleaf and only one sedge species was found. Mulching with jute geo-bag exhibited the highest weed control efficiency (84.45%) at 270 DAT. The tallest plants (137.9cm) were found from the plots receiving the jute geo-bag at 360 DAT. The mulching with jute geo-bag treatment incurred the lowest (6.5 gm-2) weed biomass at 360 DAT. The highest number of branches/ plant (35.1) was recorded in the plots receiving mulches with jute geo-bag at 360 DAT. The highest number of flowers/plant (7.7) was produced in the plots receiving mulches with jute geo-bag at 360 DAT. The highest number of fruits/plant (6.7) was produced in the plots receiving mulches with jute geo-bag at 360 DAT. Weed biomass was negatively correlated with WCE whereas positive correlation existed between plant height and number fruits and flowers. Moreover, similar relation was observed between number of branches and number of flowers.

INTRODUCTION

Citrus production in Bangladesh has been gradually increasing over the years. In 2019, Bangladesh's citrus fruit production was 165.327 tons. Citrus fruit in Bangladesh grew from 23,513 tonnes, in 1970, to 165,327 tonnes, in 2019, with an annual average growth rate of 5.06% (Knoema, 2019). According to FAO, Bangladesh ranked 52nd in the world, contributing about 0.1% of total citrus production (FAO, 2016). High demand for citrus fruits exists in both the domestic and overseas markets. In Bangladesh, the Sylhet region is famous for citrus cultivation. The atmospheric and soil conditions of the Sylhet division are congenial for the growth and development of citrus fruits and have a similarity with the hill tracts of Chattogram. Chattogram Hill Tracts (CHTs) comprise 10% of country's landmass, is located at southeastern parts of Bangladesh. Bandarban, Khagrachari and Rangamati districts are called together Chattogram Hill Tracts. The CHTs' comprises 70% of the hilly areas of Bangladesh. Agriculture is the main source of livelihood of the majority of CHTs dwellers (BBS, 2017). Agricultural activities include shifting cultivation, fruit gardening, paid wage labor, timber production, livestock and poultry rearing, and etc. Crop agriculture including fruits and trees provide both subsistence needs and cash incomes of both Bengali and ethnic communities in hilly areas. Therefore a small study is carried out to encourage the production and indicate other contradictions with the cultivation of citrus in Chittagong hills.

Citrus represents several wild and cultivated species and is believed to originate in Southeast Asia (Janick et al., 1981; Whiteside et al., 1988), which has greater varietal diversity than anywhere in the world (Mcphee et al., 1966). In Bangladesh, several important species are growing in wild and

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semi-wild states, alongside a number of commercially farmed species. These wild and semi-wild Citrus species are also major sources of agricultural characteristics and have a vast socioeconomic, cultural, religious and medical importance. Genetic resources are the backbone of any crop development program and their value is extraordinary for a variety of fruit such as citrus. The management of genetic resources for citrus therefore takes on importance in the national setting. However, because of the large-scale deforestation and farmers' preferences for higher paid crops, the natural diversity of citrus is diminishing at an alarming rate.

Crop productivity is significantly influenced by several biotic and abiotic factors (Hussain et al., 2018; Farooq et al., 2017; Farooq et al., 2015). Weeds are among the major constraints in crop production, which significantly reduce yield and quality of the produce (Kanatas et al., 2020). Weeds compete with crop plants for nutrients, water, light and space, which ultimately result in reduced crop yield (Zimdahl, 2018). Weed infestation also exerts negative impacts on economy and causes environmental and health issues in terrestrial ecosystems (Lee and Thierfelder, 2017). Maize crop (like all crops) had a specific critical period during which weed control is necessary to reduce yield losses (Iqbal et al., 2017; Khaliq et al., 2019). Weeds can be controlled by depleting soil seed bank through integrated weed management methods comprising of herbicides, mulching, and tillage operations, sowing methods, and hand weeding (Iqbal et al., 2014).

In the CHT farmers traditionally do not control weeds on hill slope. However, in monocrop they apply 4-5 weeding. The practice, however, is very laborious, time consuming and costly. In recent years herbicide application has been gaining momentum as a cheap and effective alternative to manual weeding in the CHT. Farmers usually apply non-selective herbicide at pre-planting and then sow crop seeds 3-5 days after herbicide application. But, herbicide application alone is not effective to combat diverse weed problems effectively (Sultana et al., 2021). Again, herbicides are also blamed to cause several environmental and health hazards. Therefore, an effective as well as appropriate weed management system seems essential to combat increasing weed problem along with ensuring of crop productivity and also ecosystem health Mulching can be effective and easiest techniques among others to control weeds on hills, also it can serve as conserving moisture and nutrients in the soils. Therefore, an effective as well as appropriate weed management system seems essential to combat increasing weed problem along with ensuring of crop productivity and also ecosystem health.

Mulching is an important technology widely used in orchards and agricultural system to conserve soil moisture and improve weed control in row crops (Biswas et al., 2022; Sportelli et al., 2022). Furthermore, mulching is also aimed at reducing soil erosion (Nzeyimana et al., 2017). Different mulch materials, i.e., organic (e.g. straw or wood chips), polyethylene foils, polypropylene nonwoven fabrics, gravels, biodegradable plastic foils are used to serve these purposes (Yang et al., 2020; Abed Gatea et al., 2020). Plastic mulching plays an important role in crop growth and development as it conserves soil moisture and decreases weed infestation (Briassoulis and Giannoulis, 2018; Akhir and Mustapha, 2022; Hamed et al., 2022). Furthermore, plastic mulching adjusts soil temperature, improves crop yield, and decreases costs incurred on herbicides and fertilizers (Chen et al., 2018). Similarly, paper mulching conserves soil moisture through reduced water evaporation. Furthermore, it improves soil quality when returned to field after harvesting in the following season (Saglam et al., 2017).

Weeds can be managed by exploiting allelopathic potential of crops using mulches (Riaz Marral et al., 2020), residues' incorporation (Kumar et al., 2022), intercropping (Law et al., 2022), crop rotation (Naeem et al., 2022; Naeem et al., 2021), cover crops and allelopathic crop water extracts (Khan et al., 2012; Jabran et al., 2015). Different types of phenolics, i.e., protocatechuic acid, syringic acid, chlorogenic acid, p-hydroxybenzoic acid, vanillic acid, ferulic acid, p-coumaric acid, gallic acid, caffeic acid and benzoic acid have been recognized from sorghum crop (Hassan et al., 2012). Owing to existence of these phenolics, sorghum water extracts and sorghum mulch may help in decreasing weed infestation (Naeem et al.,

2022; Farooq et al., 2017). Therefore, using mulches of allelopathic crops could provide significant control over weed flora. However, mulch materials obtained from allelopathic crops like sorghum has not been tested on large scale.

Weed management in citrus crops is highly reliant on herbicides, although several cultural and mechanical methods are also used. Mulching has been used in different countries to suppress weed flora in this crop. Mulching is an important technique to suppress weed flora and improve crop yield. However, the role of different mulches in suppressing weed flora and improving the productivity of citrus crop has rarely been tested. Therefore, this field study was conducted to evaluate the role of different mulch materials in improving yield of citrus and suppressing weed flora present in this crop. It was hypothesized that mulch materials will significantly differ from each other in their ability to suppress weed flora and improve crop productivity. It was further hypothesized that jute geo-bag mulch will provide better weed control compared to straw and bamboo leaf mulches. The results of the study will help to improve weed control in citrus crops. Furthermore, the results will help to reduce the herbicide use and associated negative impacts on environment and human health. In short it can be disclosed that primary objectives of the study were determining the effect of selected mulching techniques on weed management of the crop and evaluating the yield performance of crop as affected by mulching techniques.

MATERIALS AND METHODS

Experimental site and soil

The study was carried out in the farmer's field on hill slope in Satvaiya Para, Khagrachari district under the observation of Institute of Nuclear Agriculture (BINA) Sub-station, Khagrachari. The geographic position of the study area was 23.11^0 N latitudes and 92.01^0 E longitudes with an elevation of 47 meters above the sea level. This area is situated in AEZ: Northern and Eastern Hills Agro-ecological Zone (AEZ 29) with soils being yellow brown to strong brown, permeable, friable loamy, and low in moisture holding capacity. The soil is strongly acidic having a pH of 5.0-5.5.

Experimental details

The experiment was started with the transplantation of seedlings of Binalebu-1 in 20th July of 2021. It was a year round experiment which planned to be executed for three years. On account of citrus fruit the popular variety of Binalebu-1 was used as the representative. It was an experiment based on RCBD design with three replications. Unit plot size was $3m^2$ with maintained plant to plant distance of 3m. Total number of four treatments was used as depicted below.

T_0= Control
T_1= Mulching with straw
T_2= Mulching with Jute Geo-bag
T_3= Mulching with bamboo leaves

Collection of data

Data was collected based on following parameters at a certain interval of 90, 180, 270 and 360 Days after transplanting (DAT)

Crop Growth Parameters
1. Plant height (cm)
2. Number of branches/ plant
3. Number of Flowers/ plant
4. Number of Fruits/ plant

Weed Parameters
1. Weed biomass (g m^{-2})
2. Weed control efficiency (%)

Weed control efficiency (WCE) = $\frac{DMT}{DMC} \times 100$

Where,
DMC = Weed dry matter production in unweeded treatment
DMT = Weed dry matter production in weed control treatment.

Statistical Analysis

All data were processed with analysis of variance (ANOVA) by. SPSS (version 17.0; SPSS, Chicago, IL) was used. Means were separated by Duncan's multiple range test at $P \leq 0.05$ level of significance.

RESULTS AND DISCUSSION

Weed identification

The results of this study were carried out with the identification of total number of 10 common weed species were inventoried at the study site. Among them 7 were broadleaf, 2 were grass and 1 was in the sedge category. Names and their scientific distinctions were tabulated (Table 1) respectively.

Plant height affected by weed control

Plant height was increased progressively up to 360 DAT. Weed control treatments put considerable effects on plant height. At 360 DAT, the tallest plants (137.9 cm) were produced in the plots receiving mulches with jute geo-bag (T_2), while the shortest (112.8cm) were recorded in the plots receiving mulches with bamboo leaf (T_3).

Branch development affected by weed control

Branch development was low at early crop growth stage, which started to increase progressively after 270 DAT up to 360 DAT. At 360 DAT, the highest number of branches/plant (35.1) were recorded in the plots receiving mulches with jute geo-bag (T_2), while the lowest (27.3) were recorded in T_1 treatment receiving mulches with straw.

Flower development affected by weed control

Flower development was monitored at three sampling dates, i.e. 180 DAT, 270 DAT and 360 DAT. Number of flowers/plant was the highest at 360 DAT. At3 60DAT, the highest number of flowers (7.7/plant) were produced in the plots receiving Mulches with Jute Geo-bag (T_2), while the lowest (3/plant) were recorded in T_1 treatment Mulches with straw.

Fruit development affected by weed control

Fruit development was monitored at two Sampling dates, i.e. 270 DAT and 360 DAT. Number of fruits/plant was the highest at 360 DAT. At 360DAT, the highest number of fruits (6.7/plant) was produced in the plots receiving Mulches with Jute Geo-bag (T_2), while the lowest (3/plant) were recorded in T_3 treatment -Mulching with bamboo leaves.

Weed biomass affected by weed control

Weed control treatments caused considerable variations in weed infestation, hence weed biomass in the experimental field. Weed biomass increased in all the treatments up to 360 DAT. At 360 DAT, control treatment (T_0) contributed to the highest weed biomass. Apart from control situation T_1 treatment incurred the highest weed biomass, while the lowest was recorded in T_2 treatment during the same sampling date.

Weed control efficiency affected by weed control

Weed control efficiency (WCE) is inversely proportional to weed biomass, i.e. lower the weed biomass, the higher the WCE when compared to control (T_0). It seemed all three treatments were effective to control weeds. At 270 DAT the highest WCE (84.45%) was observed in T_2 treatment (mulching with Jute Geo-Bag), being followed by WCE (66.28%) in T_3 treatment (mulching with bamboo leaves). The lowest WCE (60.86%) was observed in T_1 treatment (mulching with straw) Data indicated that, mulching with Jute Geo-Bag inhibited weed germination and growth which contributed to better WCE in citrus field.

Correlation of parameters

A strong positive relationship was found between plant height and number of flowers/plant and between plant height and number of fruits/plant. Moreover, number of branches/plant and number of flowers/plant are also correlated with each other. However, the relationship was weak at early crop growth stage, and increased progressively with the advancement of the season. The closest relationship was observed between WCE and wee biomass. It was a strong negative correlation.

Result further indicated that, weed control efficiency were more critical to fruit setting in Lemon.

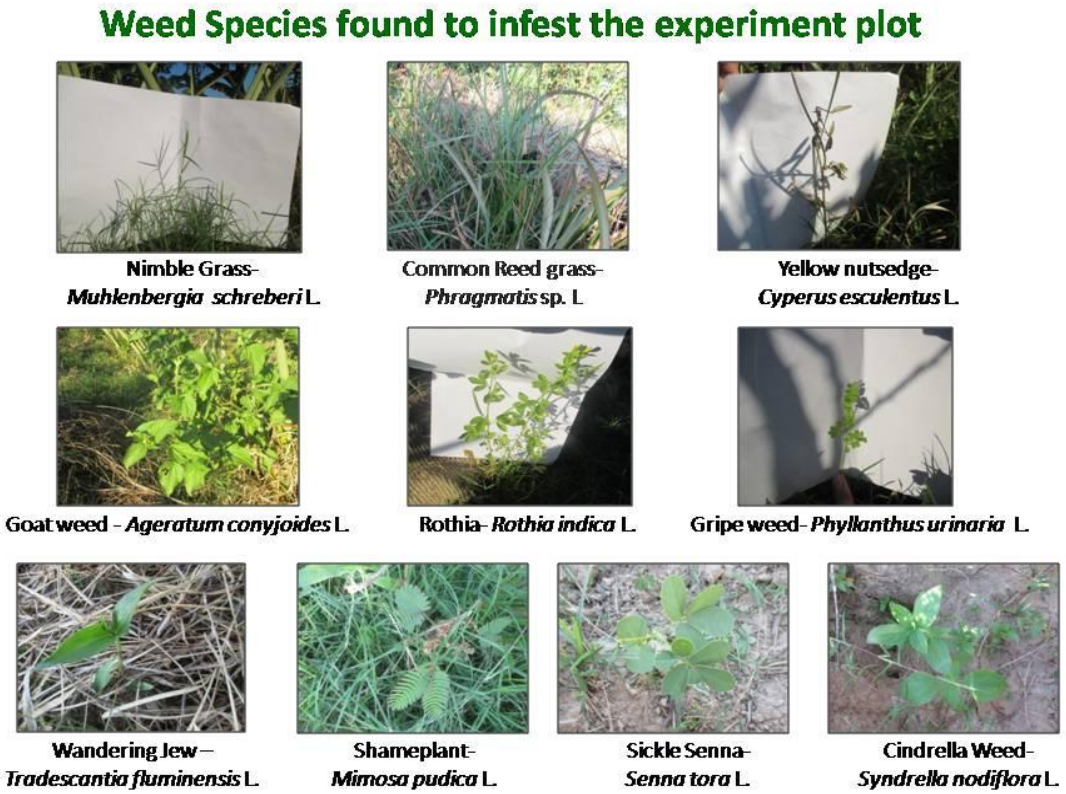

Figure 1: Identified weed from different study areas

Table 1: Weed Identified in the study

Name	Scientific name	Category
Goat weed	*Ageratum conyjoides L.*	Broadleaf
Rothia	*Rothia indica L.*	Broadleaf
Gripe weed	*Phyllanthus urinaria L.*	Broadleaf
Wandering Jew	*Tradescantia fluminensis L.*	Broadleaf
Shameplant	*Mimosa pudica L.*	Broadleaf
Sickle Senna	*Senna tora L.*	Broadleaf
Cindrella Weed	*Syndrella nodiflora L.*	Broadleaf
Nimble Grass	*Muhlenbergia schreberi L.*	Grass
Common Reed grass	*Phragmatis sp. L.*	Grass
Yellow nutsedge	*Cyperus esculentus L.*	Sedge

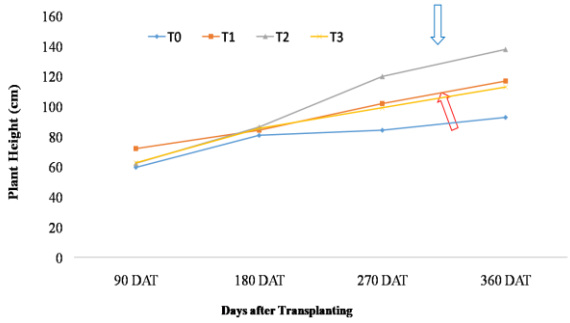

Figure 2: Plant height as affected by weed control treatment on hill slope

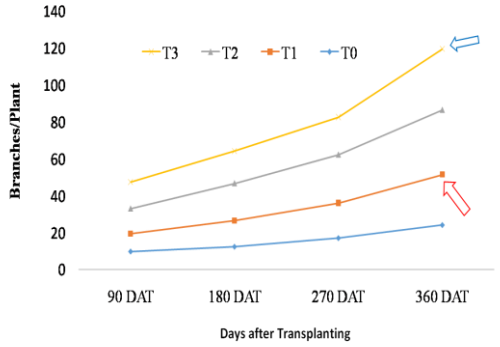

Figure 3: Branch development in lemon as affected by weed control treatment on hill slope

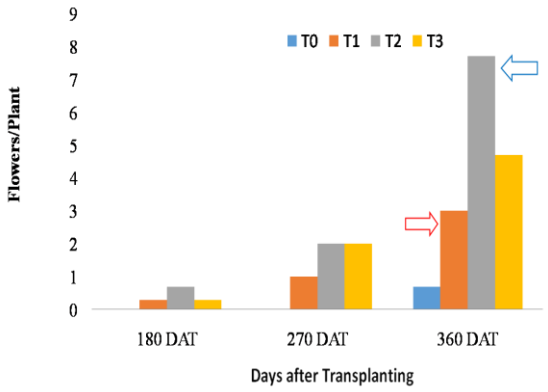

Figure 4: Flower development in lemon as affected by weed control treatment on hill slope

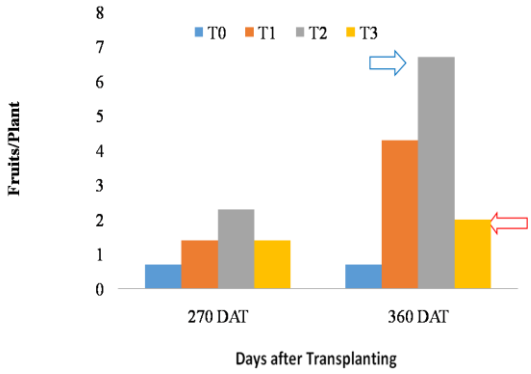

Figure 5: Fruit development in lemon as affected by weed control treatment on hill slope

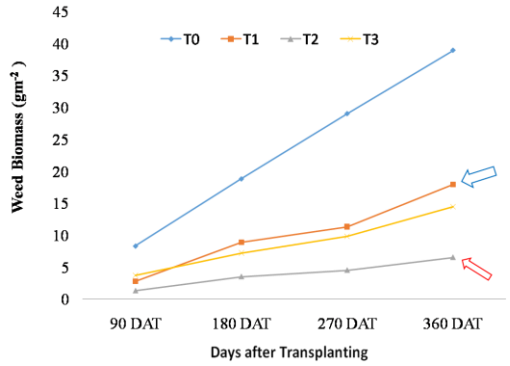

Figure 6: Weed biomass as affected by weed control treatment on hill slope

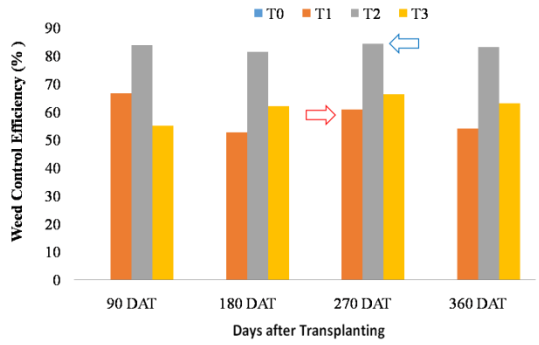

Figure 7: Weed control efficiency (%) as affected by weed control treatment on hill slope

Table 2: Effect of Mulching Techniques on crop growth and weed growth

Treatments	Plant Height (cm)				Weed Biomass (gm^{-2})			
	90 DAT	180 DAT	270 DAT	360 DAT	90 DAT	180 DAT	270 DAT	360 DAT
T_0	59.7a	80.9a	84.3b	92.8b	8.3a	18.8a	29a	38.9a
T_1	63.4a	84.4a	102ab	116.9ab	2.8bc	8.9b	11.3b	17.9b
T_2	62.3a	86.4a	120a	137.9a	1.3c	3.5c	4.5c	6.5c
T_3	62.7a	85.4a	99ab	112.8ab	3.7b	7.2b	9.8b	14.4b
CV (%)	16.2	13.12	17.27	18.34	70.22	62.73	71.13	65.44
SE	2.90	3.19	5.05	6.09	0.82	1.74	2.80	3.67

T_0= Control, T_1= Mulching with straw, T_2= Mulching with Jute Geo-bag , T_3= Mulching with bamboo leaves.
Within each column followed by the same letter are not significantly different (P ≤0.05) according to Duncan's multiple range test.

Table: 3: Effect of Mulching Techniques at different stages and yield attributes in Lemon

Treat	Number of Branches/plant				Number of flowers/plant			Number of fruits/plant	
ments	90 DAT	180 DAT	270 DAT	360 DAT	180 DAT	270 DAT	360 DAT	270 DAT	360 DAT
T0	9.7a	12.3c	17b	24.1b	0a	0c	0.7c	0.7b	0.7c
T1	9.7a	14.1bc	19b	27.3ab	0.3a	1.1ab	3b	1.4b	4.3b
T2	13.7a	20.4a	26.3a	35.1a	0.7a	2.2a	7.7a	2.3a	6.7a
T3	14.3a	17.3ab	20.3b	28.6ab	0.3a	1.5ab	4.7b	1.4b	2c
CV	24.189a	23.56	20.15	19.86	147.71	73.639	71.51	50.49	73.26
SE	0.79	1.09	1.20	1.65	0.14	0.26	0.83	0.21	0.72

T_0= Control, T_1= Mulching with straw, T_2= Mulching with Jute Geo-bag , T_3= Mulching with bamboo leaves.
Within each column followed by the same letter are not significantly different (P ≤0.05) according to Duncan's multiple range test.

Table 4: Correlation of weed control efficiency with different growth parameters

Characters	Plant height	No. of Branch	No. of flowers	No. of fruits	Weed Biomass
No. of Branch	0.8398				
No. of flowers	0.9451*	0.9629*			
No. of fruits	0.9571*	0.6507	0.8233		
Weed Biomass	-0.9387	-0.912	-0.9327	-0.8169	
Weed control efficiency	0.9381	0.912	0.9324	0.8161	-0.972**

* indicates significant at 5% level of significance.
** indicates significant at 1% level of significance.

DISCUSSION

In the present study, the weed flora reported was common in all treatments applied. The results show a dominance of the broadleaf category. Among ten of the weed seven were found as broadleaf. This dominance can be justified as the soil and environmental differences existing in this particular region.

All treatments applied were very effective in reducing the weed density and dry biomass compared to the control. Growth parameters like plant height and branch development were affected by the treatments applied compared to the control. Both were positively moved by the jute geo-bag treatment. On the other hand yield contributing characters like flower development and fruit development were also affected by the treatments applied. In this case the result was also the same. Jute geo-bag treatment showed its efficiency. It affected the most. Weed biomass production was very much effectively affected by the treatments. Jute geo-bag reduced the weed production the most. So weed control efficiency was found the most by the Jute geo-bag treatment.
A strong positive relationship was found between plant height and number of flowers/plant and between plant height and number of fruits/plant. Moreover, number of branches/plant and number of flowers/plant are also correlated with each other. However, the relationship was weak at early crop growth stage, and increased progressively with the advancement of the season. The closest relationship was observed between WCE and wee biomass. It was a strong negative correlation. Results further indicated that, weed control efficiency were more critical to fruit setting in Lemon.

CONCLUSION

The result of the present study highlighted the importance of use of mulching on weed control and also the effect of weed growth on citrus crops. Application of mulching with jute-geo bag provided better weed control efficiency compared to the other weed management techniques on hill slope. It also provided superior growth and development on citrus plants. As the citrus crops have long term productivity the study should be carried on for a certain period of time. Further in-depth trial in different locations on hill slopes might be needed to reach more precise conclusion.

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