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EFFECTS OF MULCHING ON GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus*) CV. HARITHA

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ABSTRACT
Mulch has a great role in soil moisture conservation through modification of microclimatic soil conditions. It helps to prevent weed growth, reduce evaporation, and increase infiltration of rainwater during the growing season. Different types of mulches have been used to obtain good crop growth and yield. Hence considering this a field experiment was laid out at the Sri Lanka School of Agriculture – Palamunai to evaluate the effect of different types of Mulching materials in the growth and yield performances of Okra (Abelmoschus esculentus L.) under field conditions. There were five treatments (T1- Control, T2-Paddy straw, T3-Mango leaves, T4-Polythene, T5-Paddy husk) with four block and the experimental units were arranged in the Randomized Complete Block Design (RCBD) manner. Growth parameters those were plant height, stem girth, number of leaves, days for 50% flowering, yield components and total yield were evaluated for the ability of the different mulching materials in Okra cultivation. Collected data were analyzed using ANOVA procedures by SAS statistical software. Plant height showed significant difference on later days of crop growth. Higher plant heights were observed in T3 and T4 and the lowest was found where no any mulching material applied. Stem girth showed not significant ($p>0.05$) during the entire growth period for all the mulching materials used. No. of leaves showed significant ($p<0.05$) values except 2nd week. It was found that, highest number of leaves observed in T4 where polythene mulch applied and the lowest number of leaves found in control treatment where no any mulch applied. Early days of harvesting, yield and yield components showed significant ($p<0.05$) differences between the treatments. On the basis of yield, application of polythene mulch showed not significant with application of paddy straw on 4th harvesting. Paddy straw and paddy husk showed similar performances with T4. Even though polythene mulches showed better performances in most of the tested parameters, it can be concluded that, paddy straw and paddy husk were the viable options next to polythene mulch as an environmental friendly strategy.

Keywords: Abelmoschus esculentus, Environmental friendly, Growth, Mulch, Weeds

INTRODUCTION
Mulching is the process or a field practice for covering the soil to make the more favourable condition for plant growths, development, and thus it is for the sustain the crop production. Commonly farmers are using natural mulches such as leaf, stray, dead leaves, paddy straw, paddy husk and compost have been used for centuries, still in the recent advancement of technology, synthetic materials have altered the method and benefit of mulching such as plastic covering the soil. It has several merits in the soil rejuvenation process (Park et al., 2004; Roh and Pyon, 2004; Willis, 1962). Commonly, it prevents directs evaporation of moisture from the soil and reduces the water losses and soil erosion over the surface. While, it prevents the rise of water containing salt in the field and causes the easy absorption plant available water and nutrients for easy growth and development. In case of soil temperature controls of soil, plastic mulching will provide the higher temperature than other mulching, it means organic sources of mulching will provide the ambient soil temperature in all part of soil and it causes the smooth transfer of water and nutrients Tarara, (2000). Soil temperature was lowest with the use of sorghum straw mulch as the organic mulching practices, which is best for agronomic practices (Abdalla, 1969)

Application of mulch had significant effect on the number of leaves of okra which causes for the high level of leaf area development and increment of photosynthetic production for the translocation process. In crop production, mulching is one of the most beneficial and simplest agronomic practices used to aid water retention as it is sensing the economic benefits in the water conservation practices, increase soil nutrition and usage efficiency, improve seed germination and seedling growth, development and survival, suppress weed growth and kill the weed seeds for further destruction process, enhance pest and disease protection by removing the weeds because it is the host plant for the most of the pest life cycle completion, enhance root establishment by having the micro climate production among the soil, transplant survival and increase the plant growth and harvest (Mugalla et al., 1996; Iqbal, et al., 2009; Mochiah et al., 2012). Amoroso et al., (2010) reported that the mulched plants have been shown to have higher shoot dry weight than non-mulched plants.

Okra is cultivated in tropics, subtropics and some warmer temperate region (Farinde et al., 2007) but In Sri Lanka, Dry zone and intermediate zone are the possible leaders of the production. By concerning the health

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important of Okra, the crop production is the indeed one and it has the export scope in the earning of foreign exchange for country. So that the efficient production is the viable requirement and profitable way of cultivation is the prominent concept we have to test here. In Sri Lanka, in Dry zone and intermediate zone, there is lack of re-searches and scientific articles in the usage of different types of mulching practices in the field level and there is no scientifically proven data to go for the field level practices to the usage of organic mulching in the field level especially in the Okra Cultivation. This study aims that to evaluate effect on growth and yield on usage of the mulching in the cultivation of Okra in field level by using different mulching; polythene, paddy straw, paddy husk and mango leaves with the objective of to evaluate the influence of different mulching materials on growth and yield of *Abelmoschus esculentus* (cv. Haritha).

MATERIALS AND METHODS

The experiment was conducted in the field of Sri Lanka School of Agriculture, Palamunai. The land was prepared well manually and using two-wheel tractor up to the depth of 15 – 30 cm. and planting 3-4 seeds per hole at depth of 1-2cm. The land was ploughed well and raised from the land level. The Haritha variety of Okra seeds were used for this study. About 40 gram of pure seed was collected from Sri Lanka School of Agriculture, Palamunai. The seeds were sown at the rate of two seeds per hill and two weeks after germination thinning out was done and a single plant was allowed for the growth and development. Seeds were planted with the spacing of 90 cm x 60 cm. Watering was done twice a day by basin irrigation method except on rainy days after germination for one week and after that days went to once in a day till five weeks then once in two days till eight weeks and followed 3-4 days' interval- As recommended by DOA, Sri Lanka, this all was done according to the climatic pattern. Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP) were applied as recommended by DOA, Sri Lanka.

There were five treatments and four replications. Each replication contained 10 Plants. The treatments were as follows; T1 –Control, T2 –Paddy straw, T3 –Mango leaves, T4-Polythene and T5 –Paddy husk. This experiment was laid out in a Randomized Complete Block Design (RCBD) manner. Growth and yield of Okra (Haritha variety) were evaluated by measuring growth and yield parameters. Plant height was measured in (mm) from surface of the soil to the top of the terminal bud in each plant at once in two weeks' intervals. Stem girth was measured with using Vernier scale from bottom level, intermediate level, top level each plant per each pot measure for finally average stem girth was calculated. Number of fully expanded leaves was recorded at once in two weeks' interval. Days taken to 50% of flowering was measured by observing manually through naked eye. Pod length was measured with using a measuring tape from bottom level, intermediate level, top level per each pod per measure for finally average pod length calculated.

Pod weight was measured by using a top loading balance. Pod girth was measured with using Vernier scale from bottom level, intermediate level, top level each pod measure for finally average pod girth calculated. Pods were harvested in alternative days up to eight harvests and total yield was calculated. Collected data were analyzed using ANOVA procedures by SAS 9.1.3 statistical programme and Difference between the treatments were compared using Duncan's Multiple Range Test (DMRT) at 5% significance interval.

RESULTS AND DISCUSSION

Plant Height

Results revealed that there were significant ($p<0.05$) differences among the treatments on plant height throughout the experiment except 2nd week after sowing (2WAS). Data regarding plant height are given in Table 1.

Table 1: Effects of different mulching materials on Plant Height of Okra in 2nd, 4th, 6th and 8th week

Treatment	2nd week	4th week	6th week	8th week
T1	7.61 ± 0.02^{b}	20.23 ± 0.09^{c}	45.32 ± 1.43^{c}	57.63 ± 3.61^{c}
T2	8.37 ± 0.06^{ab}	22.19 ± 0.25^{b}	59.66 ± 0.84^{ab}	78.12 ± 0.91^{ab}
T3	7.80 ± 0.07^{ab}	25.87 ± 0.22^{a}	64.57 ± 1.91^{a}	75.86 ± 3.34^{ab}
T4	7.68 ± 0.08^{ab}	27.22 ± 0.10^{a}	69.72 ± 0.43^{a}	88.16 ± 1.75^{a}
T5	8.43 ± 0.16^{a}	21.05 ± 0.25^{bc}	50.75 ± 2.65^{bc}	70.57 ± 3.43^{bc}
Sig	**ns**	*	*	*

Values represent mean± standard error of ten replicates. Means followed by the same superscripts in a same column are not significantly different at 0.05 probability level according to DMRT. '*' and 'ns' represents significant at $P<0.05$ and not significant, respectively.

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In the 2nd week, there were no any significant differences between treatments. But in 4th week onwards, it showed significant differences among treatments. T3 and T4 showed similar performances. Meantime, T5 and T2 were statistically similar and the performances followed to T3 and T4. But the scenario got different in 6th WAS, it showed T2, T3 and T4 were in similar performances and did not show any differences among them. This phenomenon also been followed in 8th WAS too. But from 6th WAS to 8th WAS, T2 and T5 were not significantly differ among them, it shows that paddy husk started to work in the field level.

This finding holds the close conformity to the several findings. different mulching types on the growth performance of Okra (Abelmoschus esculentus) which shows that plant height, weed count in polythene mulch, and low soil temperature was recorded in sawdust and sorghum straw mulch (Dalorima et al., 2014).

Stem Girth

Stem girth is the prominent parameter which holds the xylem and phloem vessels in which all the transport is occurred. Data regarding the stem girth is presented in the table 2. It was revealed that, there were no any significant differences between the mulch applications on stem girth of Okra plants. It showed that mulching materials not influenced the stem girth.

Table 2: Effects of different mulching materials on stem girth of Okra in 2nd, 4th, 6th and 8th week

Treatment	2nd week	4th week	6th week	8th week
T1	1.96±0.02^{a}	7.64±0.17^{a}	8.57±0.29^{a}	9.13±0.26^{a}
T2	2.32±0.09^{a}	8.80±0.13^{a}	10.04±0.08^{a}	13.94±1.51^{a}
T3	2.16±0.02^{a}	8.17±0.20^{a}	10.57±0.18^{a}	10.35±0.17^{a}
T4	2.20±0.03^{a}	9.13±0.06^{a}	11.15±0.12^{a}	11.87±0.20^{a}
T5	2.23±0.02^{a}	8.63±0.20^{a}	9.98±0.12^{a}	9.85±0.18^{a}
Sig	ns	ns	ns	ns

Values represent mean± standard error of ten replicates. Means followed by the same superscripts in a same column are not significantly different at 0.05 probability level according to DMRT. '*' and 'ns' represents significant at P<0.05 and not significant, respectively.

Number of Leaves

Number of leaves is the most important aspects as it is the relative proportional to the photosynthetic rate of plant. The data regarding the number of leaves in each treatment is expressed in the table 3. in 2nd WAS, there were any significant differences among tested treatments. In 4th WAS, T2 and T4 showed statistically similar performances and T2 and T5 showed same performances among them but these all four treatments showed significant difference over T1.

In 6th WAS, the scenario slightly differs. T2, T3 and T4 were statistically similar in their performances, meantime, T2, T3 and T5 were not significantly differ among them. But T4 takes highest performances among all other tested treatments.

Table 3: Effects of different mulching materials on no. of leaves of Okra in 2nd, 4th, 6th and 8th week

Treatment	2nd week	4th week	6th week	8th week
T1	5.00±0.00^{a}	8.00±0.00^{c}	9.00±0.00^{c}	10.25±0.09^{c}
T2	5.00±0.00^{a}	9.00±0.00^{ab}	10.25±0.09^{ab}	11.25±0.09^{bc}
T3	5.00±0.00^{a}	8.25±0.09^{c}	10.25±0.09^{ab}	12.25±0.09^{ab}
T4	5.50±0.11^{a}	9.25±0.09^{a}	11.00±0.00^{a}	13.00±0.21^{a}
T5	5.25±0.09^{a}	8.50±0.11^{bc}	10.00±0.21^{b}	11.75±0.31^{b}
Sig	**ns**	*	*	*

Values represent mean± standard error of ten replicates. Means followed by the same superscripts in a same column are not significantly different at 0.05 probability level according to DMRT. '*' and 'ns' represents significant at P<0.05 and not significant, respectively.

In 8th WAS, T3 and T4 showed statistically (P<0.05) similar performances among them. But T2, T3 and T5 were not significantly differ among them. In this case also, T4 holds the higher performances over all other tested treatments. These findings have the close conformity to the several findings. The leaves number was significantly increased by the influence of organic manure (El-Kader et al., 2010), and under black plastic, the mulch plant gave the maximum number of leaves also observed (Olabode et al., 2007).

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Days For 50% Flowering

Flowering is the prominent factor which will determine the harvest and early flowering and late flowering will determine the path of the yield increment. The data related with the flowering is presented in the table 4.

Table 4: Effects of different mulching materials on days to 50% flowering of Okra

Treatment	Days
T1	37.50 ± 0.11^{a}
T2	34.75 ± 0.09^{c}
T3	35.00 ± 0.15^{b}
T4	34.50 ± 0.11^{c}
T5	36.50 ± 0.11^{b}
Sig	*

Values represent mean± standard error of ten replicates. Means followed by the same superscripts in a same column are not significantly different at 0.05 probability level according to DMRT. '*' and 'ns' represents significant at P<0.05 and not significant, respectively.

It shows highly significant (P<0.05) to the treatments T2 and T3. The maximum value is recorded in T2 (37.75). T4 and T1 showed statistically similar performances and T3 and T5 also did not significantly differ among them.

Pod Length

Length of the pod is the direct proportional to the numbers of seeds while other parameters show the cumulative effect on them. The data regarding the Pod length of Okra is presented in the Table 5. in 1st WAS, T4 significantly differed among all other tested treatments. T1, T2, T3 and T5 were statistically similar in their performances and followed by T4. In the 2nd WAS, the same phenomenon observed as it is in the 1st WAS. T4 showed significant difference among the tested treatments. But rest of the treatments did not show significant differences among them and it was followed to T4. In the 3rd WAS, there were not any significant differences among the treatments except T5. T5 showed lower performances. In the 4th WAS onwards, all treatments did not show significant differences among them.

Pod Girth

Pod Girth is the factor related with the size of the seeds. The data regarding the pod Girth is presented in the table 6. in 1st WAS, T4 showed significant differences (P<0.05) with all other tested treatments. T1, T2, T3 and T5 remained same in their pod girth sizes. In the 2nd WAS, T2, T3 and T4 were statistically similar in their effect on the pod girth and showed significant differences with T5. T1 still remain in lower performances than all other tested treatments.

In 3rd WAS, T4 showed highest effect on pod girth and significantly differed with all other treatments. T1, T2, T3 and T5 remained statistically similar performances in pod girth size development. In 4th WAS, T4 significantly differed with all other tested treatments and the maximum value recorded for it. But T2, T3 and T5 showed statistically similar in the performances and followed to T4. In the 5th WAS, T1, T2, T3 and T5 were statistically similar in their performances. In T4 and T5, there were no significant differences among them and the maximum value was recorded in the T4 (15.52 mm).

In 6th WAS, there were no significant differences among the tested treatments. In 7th WAS, T3, T4 and T5 were statistically similar in their performances and maximum value was recorded to T4 (16.65 mm). but T1, T2, T3 and T5 showed statistically similar performances in the pod girth increment. In the 8th WAS, there were no significant differences among the tested treatments.

Total Yield

Effect of mulching materials will be determined by this parameter in most cases. The aim of the re-search is defined by this aspect. The yield data recorded in this experiment is presented in the table 7. in the 1st WAS, T4 showed significant differences among all other tested treatments and the maximum value (148.65 g) was recorded. T1, T2 and T5 were statistically similar in their performances. In 2nd WAS, T4 showed highest value (132.60 g) and significantly differed with all other treatments. T2, T3 and T5 were statistically similar in their performances. In 3rd WAS, T2,T3 and T4 were statistically similar in their effect on the Yield performances and T5 and T1 did not show significant differences (P<0.05) among them.

In 4th WAS, T2 and T4 showed statistically similar performances and maximum value is recorded in T4 (126.75 g). meantime T1, T3 and T5, showed similar performances and it was followed by T4. In the 5th WAS, there were no any significant differences among the tested treatments. In the 6th WAS, T2, T3 and T4 showed similar

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performances and maximum value was recorded T4 (148.20 g). meanwhile T1 and T5 were statistically similar in their performances.

In 7th WAS and 8th WAS, there were no any significant differences among the tested treatments. These findings have the close conformity with several researches. plastic on lettuce plants was effective in controlling weed growth and thus increased marketable yield to 7% compared to the control or unmulched plants (Zenaida et al., 2017). Superior plastic mulch shows relevant fruit size, number and weight of marketable okra fruits, with lesser weeds, as Poffley (1997). Meantime, the rice straw mulch was effective in minimizing weeds (Devasinghe et al 2011). Most of the experiments on mulching materials were primarily to determine their effect in soil water conservation, reduction of salt accumulation in the soil, soil temperature amelioration, weed suppression and the resultant effect on crop yield (Jamil et al., 2005; Awodoyin et al., 2007; Al- Rawahy et al., 2011; Mochiah et al., 2012).

CONCLUSIONS

Highest plant height was observed during 4th and 6th weeks mango leaves and polythene mulch showed higher not significant values meanwhile 8th polythene mulch showed maximum plant height and lowest was found where no any mulches applied. Stem girth not showed any significant differences among them. It could be concluded that stem girth was not influenced. While taking the account on the numbers of leaves, in 6th WAS, T2, T3 and T4 were statistically similar in their performances, meantime, T2, T3 and T5 were not significantly differ among them. But T4 takes highest performances among all other tested treatments. In case of yield and yield components, early days of harvesting showed significant values in pod length, pod weight, pod girth and total yield. But later days no any significant differences were found in tested treatments. Finally, it could be concluded that the performances of T4 (Polythene) showed significant differences to all other treatments. Optimum days for flowering, maximum yield increment also observed. T2 (Paddy straw), T5 (Paddy husk) showed better performances next to T4. Despite the fact that polythene mulches outperformed polythene mulches in the majority of the studied metrics, it can be stated that paddy straw and paddy husk were feasible alternatives to polythene mulch as an environmentally friendly method.

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Table 5: Effects of different mulching materials on pod length of Okra up to eight harvestings

Treatment	1st harvesting	2nd harvesting	3rd harvesting	4th harvesting	5th harvesting	6th harvesting	7th harvesting	8th harvesting
T1	16.41±0.22^{b}	16.56±0.14^{b}	16.17±0.32^{ab}	18.00±0.43^{a}	14.65±0.55^{a}	15.08±0.71^{a}	17.41±0.26^{a}	16.86±0.17^{a}
T2	14.90±0.28^{b}	17.87±0.21^{b}	17.00±0.36^{ab}	18.55±0.66^{a}	17.65±0.14^{a}	16.20±0.39^{a}	18.38±0.40^{a}	17.61±0.26^{a}
T3	17.17±0.24^{b}	16.98±0.27^{b}	17.46±0.22^{ab}	18.97±0.10^{a}	17.34±0.23^{a}	16.25±0.37^{a}	18.79±0.32^{a}	17.60±0.36^{a}
T4	20.09±0.14^{a}	19.70±0.19^{a}	18.61±0.27^{a}	18.66±0.39^{a}	17.27±0.83^{a}	16.08±0.48^{a}	19.47±0.17^{a}	19.20±0.27^{a}
T5	17.07±0.39^{b}	17.15±0.18^{b}	14.88±0.56^{b}	20.33±0.51^{a}	16.89±0.30^{a}	15.78±0.24^{a}	20.06±1.01^{a}	17.29±0.29^{a}
Sig	*	*	ns	ns	ns	ns	ns	ns

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Table 6: Effects of different mulching materials on pod girth of Okra up to eight harvestings

Treatment	1st harvesting	2nd harvesting	3rd harvesting	4th harvesting	5th harvesting	6th harvesting	7th harvesting	8th harvesting
T1	12.18±0.03^{b}	10.93±0.26c	12.53±0.10^{b}	12.07±0.15^{c}	12.38±0.26^{b}	13.76±0.22^{a}	14.03±0.27^{b}	13.88±0.17^{a}
T2	13.34±0.28^{b}	13.13±0.14ab	13.71±0.22^{b}	12.99±0.16^{bc}	13.02±0.14^{b}	14.39±0.24^{a}	13.12±0.17^{b}	13.93±0.19^{a}
T3	13.34±0.22^{b}	12.95±0.12ab	13.70±0.27^{b}	13.92±0.12^{b}	13.37±0.12^{b}	14.91±o.22^{a}	14.44±0.12^{ab}	13.83±0.30^{a}
T4	14.83±0.17^{a}	14.46±0.08a	16.35±0.23^{a}	15.67±0.18^{a}	15.52±0.08^{a}	14.84±017^{a}	16.65±0.29^{a}	15.25±0.48^{a}
T5	12.93±0.25^{b}	12.75±0.33^{b}	13.70±0.24^{b}	13.75±0.18^{b}	14.01±0.33^{ab}	14.66±0.25^{a}	14.81±0.46^{ab}	14.01±0.24^{a}
Sig	*	*	*	*	ns	ns	ns	ns

Table 7: Effects of different mulching materials on total yield of Okra up to eight harvestings

Treatment	1st harvesting	2nd harvesting	3rd harvesting	4th harvesting	5th harvesting	6th harvesting	7th harvesting	8th harvesting
T1	125.10±2.83^{b}	87.10±4.73^{c}	103.28±4.89^{b}	87.00±3.32^{b}	131.25±6.56^{a}	112.50±3.02^{b}	119.70±6.34^{a}	132.30±6.24^{a}
T2	123.60±1.73^{b}	104.47±4.35^{b}	152.10±5.67^{a}	123.92±0.60^{a}	152.10±5.67^{a}	127.50±4.04^{ab}	146.25±4.43^{a}	132.75±3.25^{a}
T3	97.80±5.66^{c}	100.70±4.36^{bc}	145.50±5.40^{a}	103.65±1.45^{b}	142.50±5.40^{a}	130.80±5.28^{ab}	142.50±7.04^{a}	133.35±6.35^{a}
T4	148.65±3.83^{a}	132.60±3.17^{a}	165.00±1.31^{a}	126.75±1.33^{a}	165.00±1.31^{a}	148.20±7.38^{a}	144.85±4.53^{a}	132.15±1.41^{a}
T5	117.30±2.19^{bc}	115.00±4.21^{b}	105.75±2.58^{b}	101.10±2.49^{b}	44.15±3.64^{a}	115.35±1.14^{b}	134.53±7.24^{a}	121.05±3.30^{a}
Sig	*	*	*	*	ns	ns	ns	ns

Values represent mean± standard error of ten replicates. Means followed by the same superscripts in a same column are not significantly different at 0.05 probability level according to DMRT. '*' and 'ns' represents significant at P<0.05 and not significant, respectively.