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Research Article

The Response of Okra (*Abelmoschus esculentus* L. Var Arka Namika) to Different Mulching Techniques Under the Organic Condition at Udayapur, Nepal

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Abstract

The yield of okra is primarily limited due to the weed problem. The study "The Response of Okra (*Abelmoschus esculentus* L. Var Arka Anamika) to Different Mulching Techniques under Organic Condition at Udayapur, Nepal" was conducted to reveal the efficiency of different weed controlling mulching measurement/management for increasing the yield. The experiment was conducted in Sungava Training Centre WOREC, Udayapur district. WOREC has been working in the field of women's human rights and sustainable livelihood programs for a long time ago. The treatments consist of 3 different mulching practices and one weed-checked control plot. The three different treatment practices were plastic mulching, organic and leaf mulching. The experiment was divided into three replication and done under a complete randomized block design (RCBD). The result of the experiment revealed a significant reduction in weed density and an increase in yield due to mulching practices for weed control. The organic matter mulching practice effectively controlled the weed and increased the yield (13.26t/ha). Also, the organic matter added to the soil because of mulching increased the yield. It was statistically different from other treatments. The organic mulch was followed by the plastic mulch and a yield of 7.6t/ha was recorded which was statistically like other remaining treatments.

Keywords: Mulch; Okra; Weed; Yield

Introduction

Nepal has extremely varied and diverse physiography and agro-climatic condition, so there is wide variation in the types of vegetables that are grown in different seasons and parts of the country. More than 200 indigenous and exotic plants species are used as vegetables in Nepal, and 42 of these are commercially grown in kitchen gardens or on a commercial scale [1]. The main vegetable crop includes cauliflower, cabbage, radish, okra, chilli, eggplants, carrots, turnips, broad leaf mustard, swiss chard, spinach, sweet pepper, cucurbits, beans, peas, onion and garlic. Out of the total population of 26,494,504, the total population involved in agriculture in Nepal is 65.7% with the contribution of the agriculture sector in the country's GDP by 31.3%. Significant variation in weed diversity and crop-weed competition from Terai to high mountains is one of the major constraints of Vegetable cultivation. Though vegetable demand and production in Nepal are increasing as a result of a growing population, rapid urbanization, and the export potential of vegetable and vegetable seeds, and people's awareness of the nutritional value of vegetables. Vegetables are now considered a high-value crop and vegetable growing is becoming a sustainable source of income for farmers [2].

Okra (*Abelmoschus esculentus* L.) is a fast-growing annual herb; tender fruits called capsules are used as a common vegetable. It is one of the important fruit vegetable crops of the tropical and subtropical regions of the world as all classes of the people of the world popularly consume it. It is commonly grown throughout the warmer parts of temperate Asia, southern Europe, northern Africa, the United States, and all parts of the tropics. According to [3]. okra is believed to have originated in the Hindustan Center of Origin, chiefly India, Pakistan, and Burma. However, according to some other authors, *A. esculentus* originated in Ethiopia [4], and Nepal [5]. The main cause of poor pollination is excessively high or low temperature, water-soaked spot on leaves; spot becoming circular with grey centers, plant stunted, leaves yellowing, root decayed, leaves turning yellow and then brown from the bottom up; plant loss of

vigor which is caused by root-knot nematodes, leaves are yellowish, curl under and become deformed; shiny speech on leaves due to aphid, hole in a pod, deformed pods and pods are woody and tough due to late picking of pods [6].

According to [7] the prevalent weeds on the okra field included *Cyperus rotundus, Talinum triangulare, Paspalum conjugatum, Digitaria horizontalis*, 4 *Mollugo nudiculis, Euphorbia heterophylla, Dactyloctenium aegyptium*, and *Cleome viscosa*. In general, weeds like *Cyperus rotundus, Cynodon dactylon and Echinochloa crusgalli* shared 75% of weed flora in okra [8]. Crop weed competition is maximum before a particular stage of crop growth. Thus, removal of weeds before this critical stage is essential to prevent damage to crop plants. Generally, morphologically similar weeds are more competitive than morphologically dissimilar weeds and depending upon their intensity and type of crop, these weeds can trap 30-60 percent of the applied nutrients due to their quick growing habits [9]. The critical stage of the crop-weed competition in vegetable okra (15-30) days after sowing respectively [10]. The presence of weeds throughout the crop season reduced the 26.5% in seed yield of mustard [11].

Mulching is a practice of covering the surface of the soil with plastics, organic and non-organic materials like straw, grasses, sands and stones to reduce evaporation and to moderate wide fluctuations in diurnal soil temperature, especially in the root zone environment. Mulching increases the growth and yield of crops, and improves soil moisture status, nutrient utilization, weed suppression, disease control and temperature regulation of upper layers of soil [12]. Mulching reduces the deterioration of soil by way of preventing runoff and soil loss, minimizes weed infestation and reduces water evaporation. Thus, it facilitates more retention of soil moisture and helps in the control of temperature fluctuations, improves physical, chemical and biological properties of soil and ultimately enhances the growth and yield of crops [13]. Mulch is used to cover the soil surface around the plants to create congenial conditions for growth; it may include temperature moderation, salinity reduction and weed control. It exerts decisive effects on earliness, yield and quality of the crop [14]. The mulching operation favours the reduction of weed seed germination, weed growth and overall control of weeds [15,16]. opined that mulch can effectively minimize water vapour loss, soil erosion, weed problems and nutrient lose [17]. reported that weed growth was checked, and soil moisture losses through evaporation were arrested when mulches were applied to the crops. Mulching reduced the population and dry weight of broad-leaf weeds significantly as compared to grass weeds [18]. Mulches modify the microenvironment surrounding crops differently depending on mulch properties, environmental conditions, and management 13 practices; however, in general, organic mulches result in cooler and moister soil compared with bare ground [19].

Organic mulches are materials of plant or animal origin, and they have several important effects on soil and plant growth. Organic mulches improve soil physical properties, prevent erosion, supply organic matter, regulate temperature and water retention, improve nitrogen balance, reduce nitrate leaching and take part in the nutrient cycle as well as increase biological activity [14,20,21]. To achieve optimum advantage from organic mulches, they should be applied immediately after germination of crop or transplanting of vegetable seedling @ 5 t/ha [14].

The emergence of weeds is hindered due to the presence of crop residues over the soil surface. The organic mulches proved more suitable for soil moisture conservation and temperature regulation from the excess summer heat and saved the crop from early-stage weed infestation [22]. Loose materials such as straw, bark and composted municipal green waste can provide effective weed control [23]. Straw mulch decreases weed 15 emergence and growth [24]. Rye straw residue can inhibit early season germination of some weeds like *Chenopodium album, Portulaca oleracea* and *Amaranthus retroflexus* [25]. The weed dry weight decreased significantly by 70-75% and 60-66% under okra and tomato, respectively with the application of *Gliricidia sepium* pruning as mulch under *G. sepium* alley cropping system with higher fruit yield [26]. Weed suppression due to mulching with wood shavings in okra was reported by [27]. Increased soil organic carbon and decreased bulk density due to straw mulching was observed by [28]. The presence of straw on the soil surface reduced the maximum temperature and increased the minimum diurnal soil temperature. It also increased the concentration of nitrate-N and available P in the upper soil layer significantly and improved water use efficiency in alfalfa [29].

Plastic mulches have been used commercially for vegetable production since the early 1960s in the United States and several European countries and the advantages of using plastic mulches to produce high-value vegetable crops have been recognized since the late 1950s. The benefits associated with the use of plastic mulches include higher yield, earlier harvest, improved weed control and increased water and fertilizer use efficiency [30,31]. reported that mulching with polythene sheet had a significant positive effect on soil temperature, seed germination, fruit production and plant growth patterns, mainly during the first two months of growth.

Black or non-light-transmitting plastic is preferred, eliminating the light required for weed germination and growth. Weed growth requires light to drive photosynthesis. Black pigments used in mulch significantly reduce light transmission to very low levels, restricting photosynthesis under the sheet and hence weed growth. Plastics can be used as mulches which are available in different colours and thicknesses. Recommended thickness for seasonal crops is 20-25 microns. Plastic mulching significantly controlled weed growth but many of the monocotyledonous plants in the field grew in soil under clear plastic [32].

The effect of soil solarization on weeds appears to be based on a combination of high soil temperature in the topsoil layers and the factors such as the toxic products resulting from rapid organic matter decomposition. Higher temperatures of 50.10C and 42.80C at 5 and 10 cm depths under solarization compared to 43.60C and 39.80C in the uncovered plots in Bangalore [33]. Observed that white cabbage, cauliflower and tomato when grown with rye, hairy vetch and crimson clover as cover crops resulted in increased organic matter in the soil, reduced soil erosion, improved soil structure and suppressed weed growth [26]. Studied the weed control ability of okra in both monoculture and intercropping with cassava. Okra sown at 50,000 plants per hectare was the best weed control as compared to 25,000 and 35,000 plants per hectare, intercropping with cassava significantly reduced weed growth by 25-45 percent. The goal of this research was to identify a suitable mulching technique for the weed control and productivity due to different mulching technique in Udayapur.

Materials and Methods

Experimental site

The field experiment was conducted at Sungava Training Centre, WOREC of Rajabas, Udayapur. The research site is located just 5 km northwest of Gaighat, Nepal. The experiment site is situated at 26.8998° N latitude and 86.7014° E longitude with an altitude of 430 m above sea level. The experiment was done under total organic conditions.

Layout

The layout was carried out to fit the experiment into RCBD with 4 treatments and 3 replications as shown in the figure. The total experimental area was 57.35m^2. The space between the replication and plot was 50 cm and 45cm respectively. The individual plot size was 3.0375m^2. There were 15 plants in each plot with 3 rows and 5 columns and total 180 plants. So, the plant population of the total plot was 0.3186 plants perm^2.

Selection of Variety

Akra anamika

It is a Yellow Vein Mosaic (YVM) resistant variety developed at the Indian Institute of Horticulture Research, Bangalore [34]. The plants are tall (175 cm), erect and well-branched, fruits are medium long(20cm) with 5-6 ridges, spineless, tender, and lush green in color, fruit stalk is long and easy to snap. It gives 20-25 t/ha yield under improved management conditions and can be cultivated in kharif and summer season (NHRDF,2000).

Field preparation, composting

The experimental plot was ploughed 15 days before sowing the seeds. The soil was well solarized after ploughed. The composting with well-decomposed FYM 50 kg per plot was applied during the ploughing. The chemical fertilizers were not applied before, during and after the experiment in the field.

Seed treatment and sowing

Seeds were soaked overnight in clean water. Then seeding was done at 45cm row to row and 45 cm plant to plant distance in each plot. Two to three seeds were placed in each hill [1]. One seedling per hill was maintained by thinning out all the remaining seedlings 15 days after germination.

Intercultural operation

The field was inspected on the daily basis. First irrigation was provided just after the seed sowing. Irrigation was done 3-4 days a week until the monsoon started. For weed control, different mulching practices were done.

Treatments

The different techniques of mulching were taken as the treatments for weed control.

The organic matter (compost+ decomposed weed) was added every 15 days according to the doses mentioned in the above table. The mango leaves were added every 15 days according to the doses mentioned in the above table.

Growth parameters

Seed germination and field stand

360 seeds of the variety *Arka anamika* was sown to the experimental plot for the different treatments. Germination % was recorded by counting the number of emerged seeds. After 15 days, the total number of seedlings that survived from emergence was counted to determine the field stand.

	Treatments
T_1	Mulching with mulch plastic
T_2	Mulching with organic matter (compost+ decomposed weed) @ 5 t/ha (1.5 kg/3m^2)
T_3	Mulching with mango leaf @ 5 t/ha (1.5 kg/3m^2)
T_4	Control

Table 1: Different Treatments applied to the experimental Study.

Plant height

The plant height (cm) of each plant of the plot was measured. It was measured from the base of the plant to the highest point of the plant. It was measured at 15 days intervals at 15 DAS, 30 DAS and 45 DAS.

Number of leaves per plant

The number of leaves per plant was recorded from each plant of the plots. It was counted at 15 days intervals at 15 DAS, 30 DAS and 45 DAS.

Reproductive parameter

Days to flowering

The days to first flowering was monitored in all plant within the plot area. The day when the first flower appeared was considered the day of the first flowering.

Days to 80% flowering

Plants within the net plot area were considered as 100% and the day when twelve out of fifteen plants flowered was recorded as days to 80% flowering.

Yield and yield parameter

Days to the first harvest

The days of the first fruit picking were recorded from all the plants within the plot area. The day of the first crop harvest was considered the day of the first harvest.

Crop duration (days)

The duration from seed sowing to final harvest was recorded which was termed duration.

Harvest duration (days)

The duration from the fruit picking to the final fruit picking was considered as fruit harvest duration. Observation of all the plants within the net area was considered for this parameter.

Yield per plot (gm)

The yield per plot was recorded by taking four different harvesting at different times.

Productivity (t/ha)

The net plot yield was converted to the hectare and the unit was converted to metric tons to determine the productivity of the given variety with treatment.

Weed parameters

Weed count

The different weed species found in the field were identified, counted and recorded.

Weed Biomass

The weed biomass of individual plot was also taken accordingly. Weed from three treatments of plastic mulch, Organic mulch and leaf mulch were picked and weighed before and after drying and recorded respectively.

Insect pest management

The biological and cultural methods of insect pest control were applied in the field. Cow urine and neem extract were sprayed throughout the field and were found to be effective to control the insect and pest.

Disease observed and Management

Any disease that occurred in the field crop during the cropping period was monitored and controlled.

Data entry and analysis

The recorded data on various observed parameters were compiled and arranged treatment–wise systematically in three replications. MS Excel was used for simple statistical analysis, construction of graphs, tables and Microsoft office-word for word processing. Compiled data were subjected to analysis of variance (ANOVA). GenStat Statistical package was used for data analysis. ANOVA was constructed and significant data were subjected to DMRT for mean separation regarding [35].

Results and Discussion

Growth Parameters

Days to Germination

The germination of the seeds of the given variety was influenced by the different mulching materials. As plastic mulching took the highest number of days followed by organic matter mulching. The plot without mulching took the least time to get germinated.

Treatment means followed by common letters are not significantly different from each other based on DMRT at a 5% level of significance.

Treatments	Days to Germination
Plastic mulching	9.3 a
Organic matter	3.8 b
Mango leaf	3.6 bc
Control	3.3 c
Grand Mean	5.017
SEm (±)	0.121
CV	16.2
LSD (0.05)	0.3381**

Table 2: Germination of seeds of okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

In the experiment, the germination of the seed in the control took less time while the plastic mulching took much time followed by organic mulching and leaf mulching respectively. Seeds under the plastic mulching became hotter because of sunlight so the germination could become delayed. The same thing might happen to the organic matter and the leaf mulch.

Plant height

Plant height on each date of observation was significantly influenced by weed management practice i.e., different mulching techniques. At every observation, treatment with the plant height of the organic mulching was found to be higher. While the height of the plant with leaf mulching is also following the height of the plant in organic mulching.

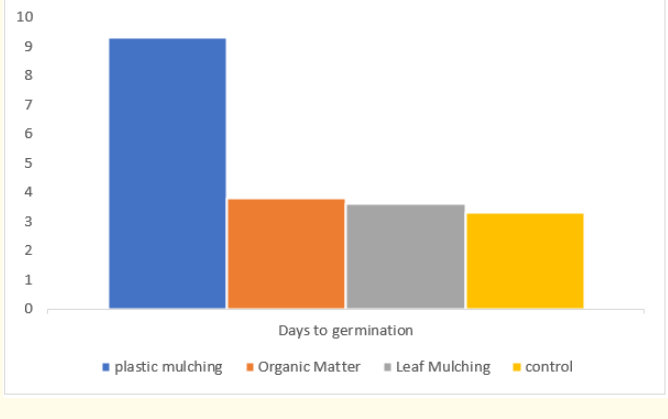

Figure 1: Day to germination in okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

The plant height of the organic mulched plot was found to be the tallest while the lower most was under the control plot. The supplement of nutrients, appropriate soil moisture along with controlling the weed might be the reason for this. The leaf also provides nutrient in comparison to plastic and control so that it also gains height than other. Organic mulching had a highly significant difference in soil moisture content in all soil depths. So, the plant growth in enough organic matter supports the plant growth [36]. Also, a reduction in plant height of okra due to crop weed competition was reported by [37].

Treatments	Plant Height (cm)		
	30 DAS	45 DAS	60 DAS
Plastic Mulching	23.50b	34.02c	63.36c
Organic Matter	29.89a	41.49a	76.69a
Leaf Mulching	28.82a	39.93ab	67.66b
Control	28.07b	38.23b	60.56d
Grand Mean	27.57	38.42	67.06
SEm (±)	0.839	0.760	0.93
CV	20.4	13.3	9.3
LSD (0.05)	2.34**	2.121**	2. 604**

Table 3: Plant height of okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

Note: DAS, days after sowing.

- Highly significant, treatment means followed by common letters are not significantly different among each other based on DMRT at a 5% level of significance.

Number of leaves per plant

The number of leaves per plant was also significantly influenced by the mulching techniques. The number of leaves within the organic mulching plot is higher as compared to other followed by the mulched with leaf only.

The number of leaves under the organic mulching has a higher leaf count. While the leaf count of the plants under control has the lowest count. The microclimate condition improved by the mulches might have provided suitable conditions for producing a higher number of leaves per plant. According to [22] mulched plants grew taller and had more leaves. Conversely, the lowest plant height and number of leaves were noticed in unweeded control. Severe infestation of weeds might have reduced the vegetative growth of plants.

Reproductive parameters

Days to flowering in 80% of plants within the plot

The days to flower in 80% of plants within a plot have significantly influenced by the mulching. The flowering in the organic

Treatments	Number of leaves per plant		
	30 DAS	45 DAS	60 DAS
Plastic Mulching	7.82c	17.11b	32.13a
Organic Matter	10.62a	20.49a	33.13a
Leaf Mulching	9.31b	18.13b	29.56b
Control	7.62c	15.04c	27.49b
Grand Mean	8.84	17.69	30.58
SEm (±)	0.304	1.678	0.769
CV %	23.1	22.8	16.9
LSD (0.05)	0.848**	0.601**	2.147**

Table 4: Number of leaves per plant of okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

Note: DAS, days after sowing.

**- Highly significant, treatment means followed by common letters are not significantly different among each other based on DMRT at a 5% level of significance.

mulching took the least time to get bloom 80% of the flower. Statistically, the other mulching techniques (leaf mulching and plastic mulching) took the quite same time to bloom following organic mulching. While the weed unchecked/controlled took more time to bloom.

Here the Organic mulches leaves mulches and plastic recorded early flowering than the control. Meanwhile, the organic mulches became the earlier ones. The earliness in mulches may be attributed to the high heat unit efficiency of mulching materials [38].

Treatments	Days to Flowering 80% of plant within the plot
Plastic Mulching	63.33ab
Organic Mulching	61.00ab
leaf mulching	63.33abc
control	64.00a
Grand Mean	62.92
SEm	0.674
CV%	1.9
LSD	2.331**

Table 5: Days to flowering in 80% of plants within the plot of okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

Weed parameters

Weed biomass

The weed biomass recorded from three plots only has significantly influenced by the mulching techniques. The weed biomass in the plastic mulching has a lower value. While the weed biomass in mulches leaf and organic matter has higher values.

Because of the control treatment, it was unable to take the record of the weed biomass. The biomass recorded in other treatments secured the least value in the plastic mulching while weed biomass in the leaf and organic mulching remained quite similar

Treatments	Weed Biomass	
	30 DAS	60 DAS
Plastic Mulching	2.17c	15.80c
Organic Matter	32.24b	49.96b
Leaf Mulching	32.24b	61.96a
Control	NR	NR
Grand Mean	19.39	31.93
SEm (±)	1.169	1.944
CV %	10.4	6.727
LSD (0.05)	4.045**	6.727**

Table 6: Weed Biomass in okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

Note: DAS: Days After Sowing; NR: Not Recorded

**- Highly significant, treatment means followed by common letters are not significantly different among each other based on DMRT at a 5% level of significance.

statistically at 30 DAS and the weed biomass in the leaf became higher at 60 DAS while others remained as it was. The plastic prevented the soil surface from the proper growth of the weed and checked the number. Also, the lack of light under the plastic could have prevented the process of weed growth.

Weed count of major weeds

The weed count of major weeds (*Cynadon dactylon*, Echinochola, Coinzoides, Amaranthus spp.) was significantly influenced by the mulching techniques. The weed count in the control plot was recorded at the highest value while the plastic mulching was recorded at the least value.

In the weed count recorded in different treatments, the plastic mulches were recorded with the least count while the leaf and organic mulches remained almost the same statistically and the highest weed count was recorded in the control plot. The plastic

Treatments	Weed Count
Plastic Mulching	5.0c
Organic Matter	136.0b
Leaf Mulching	149.0b
Control	237.3a
Grand Mean	131.8
SEm (±)	4.11
CV %	5.4
LSD (0.05)	14.23**

Table 7: Weed Count in okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

Note: DAS: Days After Sowing

****-** Highly significant, treatment means followed by common letters are not significantly different among each other based on DMRT at a 5% level of significance.

prevented the soil surface from the proper growth of the weed and checked the number. Also, lack of light under the plastic could have prevented the process of weed growth.

Yield Parameter

Yield (t/ha)

Mulching significantly influenced the yield of okra highest yield of Organic mulching was recorded. While mulches with plastic and leaf were almost the same statistically. Unweeded control recorded the lowest yield.

The highest yield was recorded in the organic mulch followed by leaf and plastic mulches. The higher yield in the organic mulches was recorded as higher, least plant weed competition, soil moisture content and the nutrition supplement from organic matter (in organic mulches and leaves), which might be the reason behind this. Organic mulches proved to be better when compared to plastic mulches because in the case of plastics, the cost of production is high and disposal of plastic debris after cropping is difficult [39].

TRTS	Yield				
	1st	2nd	3rd	4th	Final
Plastic mulching	0.949b	2.083b	3.00a	1.667b	7.6b
Organic mulching	2.331a	3.917a	2.5a	3.667a	12.414a
Leaf mulching	0.546b	1.833b	3.17a	1.917b	6.046b
Control	0.32b	1.417b	1.50a	2.100a	5.338b
Grand Mean	1.04	2.31	2.19	2.34	7.87
SEm	0.216	0.216	0.509	0.378	1.069
CV	36.0	28.3	40.3	29.8	23.5
LSD%	0.747**	1.308**	1.760 **	1.392**	3.699**

Table 8: Yield of okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

Note: DAS: Days After Sowing; NR: Not Recorded; TRT: Treatment

****-** Highly significant, treatment means followed by common letters are not significantly different among each other based on DMRT at a 5% level of significance.

[40] observed higher okra production with black polyethylene mulch and suggested that the least competition from weeds and uniform moisture conservation throughout the growing season might be responsible for better performance of okra under black polythene sheet. Fruit yield in plots with mango mulch, newspaper mulch and pre-emergence herbicides were similar, indicating the option of replacing herbicides in vegetable production systems. The possibility of replacing herbicides in citrus orchards with organic mulches was reported by [41].

Relationship between total weed count and yield

The regression equation shows the relationship between the total yield with different weeds and yield attributes like plant height, days to flowering, weed biomass and total weed count. All these parameters show a positive correlation with total yield. Plant height was found to have a 47.37% determination on total yield, days to flowering had a 78.08% determination, weed biomass at 60 days after sowing had an 8.23% determination and total weed count was found to have a 10.27% determination over total yield.

Conclusions

The assessment of the response of different mulching treatments in okra revealed that the mulching with the organic matter significantly contributed to increased growth and yield of the crop

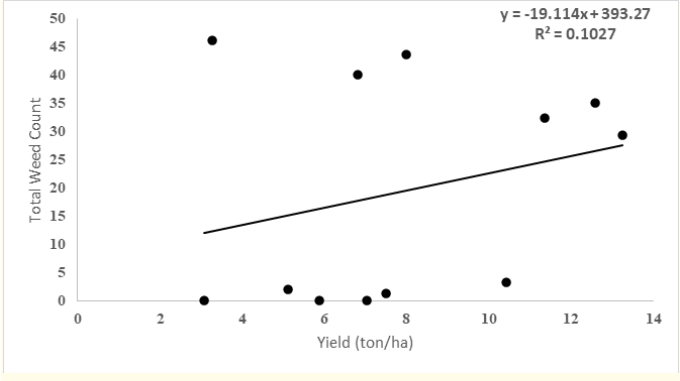

Figure 2: Relationship between total weed count and yield in okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

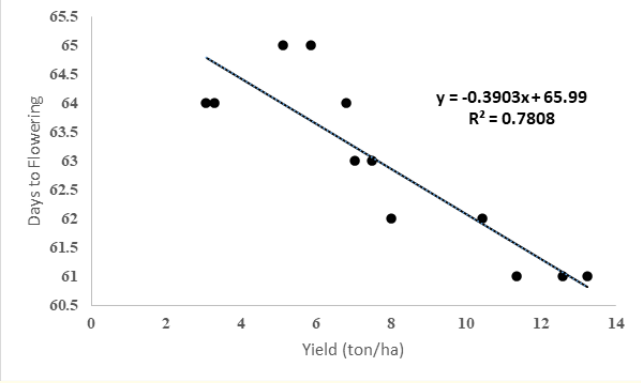

Figure 3: Relationship between days to flowering and yield in okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

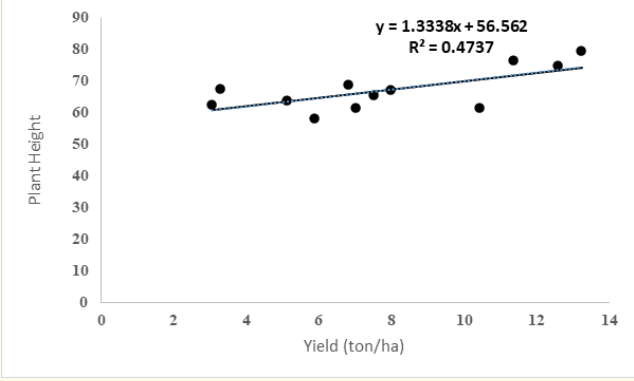

Figure 4: Relationship between Plant height and yield in okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

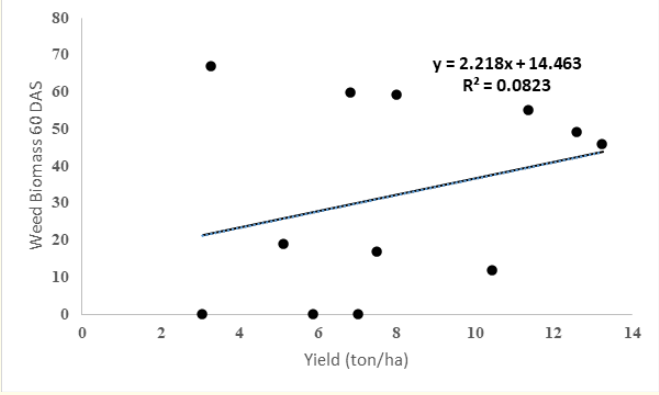

Figure 5: Relationship between weed biomass and yield in okra under different mulching techniques at Sungava Training Center, WOREC Udayapur, Nepal.

by providing adequate weed control and adding nutrition supply and hence, reducing the competition that occurred by dense weed growth. Leaf mulching was effective for controlling the weed as they block seed germination stimuli by intercepting light, reducing soil temperature, and greatly dampening day-night temperature fluctuations. The experiment concluded that the organic mulched practice was found to have a higher yield among all treatments. Rice straw and rice husk mulch are also can be effective for better production of okra. The experiment also concludes that there was more yield with organic mulch than mulched with plastic because of increasing soil organic matter in the organic mulched plot.

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