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# Effect of conservation agriculture practices on weed management in okra under rice- okra-green manure cropping system

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**ABSTRACT**

A field experiment was carried out at Agronomy Farm, College of Agriculture, Vellanikkara in, Kerala, India a randomized block design consisted of ten treatments having three replicates during the years 2019 to 2021 to develop a conservation agricultural practices for upland rice-vegetable-green manure cropping system. It has been found that different conservation treatments had a significant effect on weed density, weed dry matter production, weed control efficiency, yield and economics in okra (lady finger). The results revealed that the lowest density and dry matter of weeds were recorded in direct-seeded rice in flat bed + green manuring followed by okra with crop residue mulch at 30,60,90 DAS and at harvest. Highest weed control efficiency (59-67%) and yield (16.47 t/ha) in okra was registered in direct-seeded rice in flat bed + green manuring followed by okra with crop residue mulch. The highest weed density and weed dry matter production was noticed in direct-seeded rice in flat bed-okra. While considering the whole cropping system the highest B:C was found in direct-seeded rice in flat bed + green manuring followed by okra-green manure based cropping system (3.31).

## INTRODUCTION

Rice is major crop in Kerala and it grows both as transplanted wetland rice and also upland rice. Weeds are the main constraints in upland rice. Chemical herbicides are generally used for weed control but the excessive use of herbicides causes ecological imbalance (Liu *et al.*,2015). In this situation, conservation agriculture practices are gaining importance for environmental sustainability. Conservation agriculture (CA) is an approach to manage agro-ecosystems for improved and sustained productivity, increased profits and food security while preserving and enhancing the resource base, and which emphasize minimum soil disturbance, permanent soil cover and diversified crop rotation. CA techniques like green manuring, mulching *etc*. can effectively control the weeds (Navas *et al.* 2017). Yadav *et al.* (2018) reported that among two types of tillage in rice field, conventional tillage with 100% residue incorporation registered higher total weed density of 89-168 weeds/m$^2$ and weed biomass of 9.6–183 g/m$^2$ on dry weight basis over no-tillage with 100% residue retention which recorded 75-161 weed/m$^2$ and 8-155 g/m$^2$ on dry weight basis. So minimum soil disturbance can reduce the weed population. Crop diversification reduces the weeds than monocropping so a rice - vegetable based cropping systems helps the farmers to diverse the weed population. But the impact studies on conservation agriculture-based resource conserving techniques on weed management in the said cropping systems are lacking. So the study is proposed with an objective for developing cost effective, eco-friendly resource conservation technologies for upland rice based cropping system. Therefore, in the present study the effect of conservation agriculture practices on weed management in okra (lady finger) in rice-okra-green manure cropping system was carried out.

## MATERIALS AND METHODS

The field experiment was conducted at Agronomy Farm, College of Agriculture, Vellanikkara, Kerala, India (10°31' N latitude and 76°13' E) from May, 2019 to March, 2021. The soil of the experimental site was sandy loam with pH4.91, EC0.71dS/m, OC (1.22%), available N (144.4 kg/ha), available P (23.29 kg/ha) and available K (291.36 kg/ ha). Rice crop was raised during May as first crop followed by okra in September as second crop and cowpea was raised in January as the third crop for

green manuring with ten treatments and each replicated thrice in a randomised block design.Crops were raised in flat bed (5 x 4 m) and in raised beds *i.e.* 3 raised beds (5m x 1m x 30 cm) adjusted in the area of 5 x 4 m. Treatments consists of direct-seeded rice (DSR) in flat bed + brown manuring (BM)-okra + green manuring (GM), DSR in flat bed + BM-okra + crop residue mulch, DSR info at bed + GM-okra +GM, DSR in flat bed + GM-okra + crop residue mulch, DSR in raised bed + BM-okra + GM, DSR in raised bed + BM-okra + crop residue mulch, DSR in raised bed + GM -okra + GM, DSR in raised bed + GM-okra + crop residue mulch, DSR in flat bed-okra, DSR in raised bed-okra.

Okra variety '*Arka Anamika*' was used for this study. The previous crop rice was a direct-seeded one. Initially the field was ploughed at the start of experiment and sowing of rice was done manually. In second year minimum land preparation was done for rice crop. Crop residue which is left in the above ground portion after harvest of rice was cleaned by using brush cutter. Brown manuring in rice was done at 25 DAS by applying 2,4-D 1.25 kg/ha. Field was made weed free before sowing with minimum soil disturbance using brush cutter after harvest of rice. After rice harvest, the okra seeds at the rate of 8.5 kg/ha was dibbled in planting holes at a spacing of 60 x 30 cm without disturbing the rest of the area and earthing up was given at the time of fertilizer application with minimum disturbance by piling soil up just as a support around base of the plant. Fertilizers were applied as urea, phosphate and potash at the rate of 55:35:70 N, P and K kg/ha at the time of sowing. Another 55 kg N/ha was applied one month after sowing.

Cowpea seeds were also dibbled in alternate rows along with okra for in situ green manuring for only the treatments where green manuring is specified. The cowpea was uprooted and spread as mulch at 25 DAS in those treatments (1-1.5 t/ha). For crop residue mulching, 50% straw of previous rice crop (5-6 t/ha) was retained at the time of harvest and it was cut and spread in the field using brush cutter for crop residue mulching before planting of okra. After harvest of okra, the field was cleaned by brush cutter and cowpea seeds was sown as sole green manure crop. Cowpea was grown in between rows of okra only in the treatments were the insitu green manuring was specified as mentioned above it was cut and spreaded as mulch in those treatments at 25 DAS. After harvest of okra the field was cleaned by brush cutter and cowpea seeds were sowed as green manure as third crop in sequence of this cropping system. A quadrat of 1 $m^2$ was used and different weed species present within the quadrat were collected. Weeds were categorized into grasses, broad-leaf weeds and sedges and counted separately. Weeds collected were oven dried at 70 °C to attain constant dry weight. Data were tabulated and subjected to statistical analysis 'WASP 2' (Statistical package, ICAR Goa) and the significance among the treatments was estimated at 5 per cent of probability and pooling was done for two years data and the data on weed density was subjected to square root transformation before analysis.

## RESULTS AND DISCUSSION

### Weed flora

Weed flora of the experimental field consisted of grasses, broad-leaf weeds (BLW) and sedges. Among grassy weeds in okra *Setaria* spp., *Digitaria sanguinalis, Panicum maximum, Oryza sativa* and *Brachiaria* spp. were dominant. The broad-leaf weeds identified were *Alternanthera bettzickiana, Ageratum conyzoides, Euphorbia hirta, Euphorbia geniculata, Mollugo disticha, Mitracarpus hirtus, Ludwigia perennis, Hemidesmus indicus Phyllanthus niruri, Lindernia crustacean, Commelina benghalensis* and *Trianthema portulacastrum*. *Cyperus iria* was the only sedge identified in the field.

### Weed density

The conservation treatments had a significant effect on weed density in okra (lady finger) (was sown during both the years of study at 30, 60 DAS and at harvest (**Table 1**). Minimum grasses, broad-leaf weeds and sedges density after 30 days (7.19,5.91, 1.28 no./$m^2$), 60 days (4.22, 6.47, 1.21 no./$m^2$) and harvest (3.24, 4.62, 1.00 no./$m^2$) was observed in direct-seeded rice in flat bed + green manuring-okra + crop residue mulching. Residual effect of previous crop might have influenced the weed population of subsequent crop. Rotation with green manure crop in a cropping system reduces the soil weed seed bank and it can mitigate the weed problems in succeeding crops (Melander *et al*. 2020). The highest weed density was recorded in direct-seeded rice in flat bed –okra where no conservation practice was followed. Crop mulching practice in okra caused more weed reduction compared to insitu green manuring. This might be due to the covering of soil surface right from the planting onwards and hence preventing/restricting the emergence of weeds. Similar findings were reported by Rehmann 2017 that crop rotation helps for breaking the life-cycle of weeds than mono cropping and the soil cover (mulches) inhibit the weed seed germination by preventing the sunlight or by the exudation of allelopathic substances.

**Table 1. Effect of treatments on weed density (no./m$^2$) at 30 , 60 DAS and at harvest of okra (pooled data 2 years)**

| Treatment | Grasses* | | | Broad-leaf weeds* | | | Sedges* | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | Harvest | 30 DAS | 60 DAS | Harvest | 30 DAS | 60 DAS | Harvest |
| Direct-seeded rice in flat bed + brown manuring - okra+ green manuring | 10.16 (103.3) | 5.75 (33.2) | 4.86 (23.7) | 7.59 (58.0) | 8.07 (65.2) | 6.65 (44.2) | 3.11 (9.7) | 2.67 (7.2) | 1.87 (3.5) |
| Direct-seeded rice in flat bed + brown manuring - okra + crop residue mulch | 8.33 (69.5) | 4.81 (23.2) | 4.14 (17.2) | 6.82 (46.5) | 7.29 (53.2) | 5.64 (31.8) | 1.92 (3.8) | 1.79 (3.3) | 1.41 (2.0) |
| Direct-seeded rice in flat bed + green manuring - okra + green manuring | 9.85 (97.2) | 5.40 (29.2) | 4.58 (21.0) | 6.93 (48.0) | 8.17 (66.7) | 6.78 (46.0) | 2.76 (7.7) | 2.37 (5.7) | 1.72 (3.00 |
| Direct-seeded rice in flat bed + green manuring - okra + crop residue mulch | 7.19 (52.3) | 4.22 (17.8) | 3.24 (10.5) | 5.91 (35.0) | 6.47 (41.8) | 4.62 (21.3) | 1.28 (1.7) | 1.21 (1.5) | 1.00 (1.0) |
| Direct-seeded rice in raised bed + brown manuring - okra + green manuring | 10.86 (118.3) | 6.35 (40.3) | 5.60 (31.3) | 9.83 (96.8) | 9.91 (98.3) | 8.92 (79.8) | 3.29 (10.8) | 3.37 (11.3) | 2.19 (4.8) |
| Direct-seeded rice in raised bed + brown manuring -okra+ crop residue mulch | 11.18 (125.2) | 6.47 (41.8) | 5.43 (29.5) | 10.13 (102.8) | 9.96 (99.3) | 8.94 (80.2) | 3.31 (11.0) | 3.00 (9.0) | 2.44 (6.0) |
| Direct-seeded rice in raised bed + green manuring - okra + green manuring | 10.93 (119.5) | 6.23 (38.8) | 5.20 (27.0) | 11.35 (128.8) | 9.15 (84.0) | 7.99 (64.2) | 3.78 (14.3) | 2.83 (8.0) | 2.88 (8.3) |
| Direct-seeded rice in raised bed + green manuring - okra+ crop residue mulch | 10.05 (101.0) | 5.87 (34.5) | 5.10 (26.0) | 8.02 (64.3) | 8.40 (70.5) | 7.23 (52.3) | 3.21 (10.3) | 2.76 (7.7) | 1.76 (3.2) |
| Direct-seeded rice in flat bed – okra | 15.82 (250.3) | 8.28 (68.7) | 7.10 (50.5) | 15.55 (242.0) | 11.36 (129.2) | 10.49 (110.0) | 4.58 (21.0) | 4.62 (21.3) | 4.20 (17.7) |
| Direct-seeded rice in raised bed – okra | 13.14 (172.8) | 6.98 (48.7) | 6.10 (37.3) | 13.38 (179.0) | 10.65 (113.3) | 9.62 (92.7) | 4.40 (19.3) | 4.24 (18.0) | 3.34 (11.2) |
| LSD (p=0.05) | 0.83 | 0.44 | 0.40 | 0.83 | 0.61 | 0.71 | 0.44 | 0.41 | 0.37 |

*$\sqrt{x+0.5}$ transformed values, original values in parentheses

**Total weed count and weed dry matter production**

The conservation treatments significantly influenced in total weed density and weed dry matter production (**Table 2**). Among all treatments, direct-seeded rice in flat bed-green manuring-okra + crop residue mulching recorded lowest total weed density (9.41, 7.82, 5.73 no/m$^2$) and weed dry matter production (22.75, 23.58, 17.50 g/m$^2$) at 30,60 DAS and at harvest respectively. The low weed density might be the reason for lowering the dry matter production of weeds. The result of the present study was in consonance with the findings of Sharma and Sharma, (2019) who also reported the less weed density in mulched plot and which was responsible for reduction of weed dry matter production. The highest weed density and weed dry matter production was reported in direct-seeded rice in flat bed–okra without conservation practices. The less weed density and dry matter production were reported in crops inter-cropped with green manure due to less competition of weeds to nutrients, space, water and light in early stage (Barla *et al*. 2016). Minimum tillage and crop cover might have helped in reducing weed seed germination and thereby reduction in weed infestation in treatments with conservation agriculture practices than without conservation practices.

**Weed control efficiency**

Among all the conservation treatments, direct-seeded rice in flat bed + green manuring - okra + crop residue mulch showed maximum weed control efficiency of 60-67% compared to all other treatments (**Table 2**). High weed control efficiency under this might be due to their mulching property which suppressed the weed growth. This result was also in accordance with the findings of Baghel *et al.* (2018) that who reported higher weed control efficiency where conservation principles for rice-based cropping system were followed.

**Yield and yield attributes**

The number of fruit plant (21.50), length of fruit (18.48 cm), yield plant (138.95 g) and a total yield of 16.49 t/ha was recorded in direct-seeded rice in flat bed – okra + crop residue mulching (**Table 3**). The lowest weed population might be the reason for improving the yield. Das *et al.* (2019) assessed the effect of conservation tillage and four rice residue management practices on lentil in India, and reported that lentil can be cultivated after rice by retaining the stubbles of rice which has a significant difference in yield than other treatments. The lowest yield of 7.71 t/ha was registered in direct-seeded rice in raised bed + brown manuring – okra + green manuring. Due to

**Table 2. Effect of treatments on total weed density (no./m2) and weed dry matter production (g/m$^2$) and weed control efficiency (WCE) of okra (pooled data 2 years)**

| Treatment | 30 DAS | | 60 DAS* | | Harvest* | | WCE 30 DAS | WCE 60 DAS | WCE Harvest |
|---|---|---|---|---|---|---|---|---|---|
| | *Total weed density | Weed dry matter production | *Total weed density | Weed dry matter production | *Total weed density | Weed dry matter production | | | |
| Direct-seeded rice in flat bed + brown manuring - okra+ green manuring | 13.08 (171.0) | 37.83 | 10.27 (105.5) | 34.50 | 8.45 (71.3) | 23.67 | 45.64 | 41.46 | 52.12 |
| Direct-seeded rice in flat bed + brown manuring - okra + crop residue mulch | 10.94 (119.8) | 28.85 | 8.92 (79.7) | 29.42 | 7.14 (51.0) | 22.21 | 58.63 | 49.99 | 55.010 |
| Direct-seeded rice in flat bed + green manuring - okra + green manuring | 12.36 (152.8) | 34.87 | 10.08 (101.5) | 33.25 | 8.37 (70.0) | 25.00 | 49.97 | 43.57 | 49.49[c] |
| Direct-seeded rice in flat bed + green manuring - okra + crop residue mulch | 9.41 (89.0) | 22.75 | 7.82 (61.2) | 23.58 | 5.73 (32.8) | 17.50 | 67.26 | 59.8 | 64.58 |
| Direct-seeded rice in raised bed + brown manuring - okra + green manuring | 15.02 (226.0) | 44.96 | 12.24 (150.0) | 43.50 | 10.76 (116.0) | 35.75 | 35.28 | 26.04 | 27.62 |
| Direct-seeded rice in raised bed + brown manuring -okra+ crop residue mulch | 15.45 (239.0) | 46.69 | 12.24 (150.2) | 37.83 | 10.74 (115.7) | 28.50 | 32.87 | 35.57 | 42.18 |
| Direct-seeded rice in raised bed + green manuring - okra + green manuring | 16.21 (262.7) | 45.58 | 11.43 (130.8) | 38.42 | 9.97 (99.5) | 31.25 | 34.37 | 34.80 | 36.67 |
| Direct-seeded rice in raised bed + green manuring - okra+ crop residue mulch | 13.25 (175.7) | 39.92 | 10.61 (112.7) | 35.17 | 9.03 (81.5) | 26.58 | 42.77 | 40.40 | 46.08 |
| Direct-seeded rice in flat bed – okra | 22.65 (513.3) | 69.83 | 14.80 (219.2) | 58.92 | 13.35 (178.2) | 49.42 | 0.00 | 0.00 | 0.00 |
| Direct-seeded rice in raised bed – okra | 19.26 (371.2) | 55.26 | 13.42 (180.0) | 52.08 | 11.88 (141.2) | 41.92 | 20.58 | 11.55 | 15.12 |
| LSD (p=0.05) | 0.97 | 6.74 | 0.60 | 4.68 | 0.64 | 6.50 | 6.77 | 7.80 | 6.77 |

*$\sqrt{x+0.5}$ transformed values, original values in parentheses

**Table 3. Effect of treatments on yield, yield attributes and economics of okra (pooled data 2 years)**

| Treatment | No. of fruits / plant | Length of the fruit (cm) | Yield g/ plant) | Yield First year (t/ha) | Yield second year (t/ha) | Yield pooled (t/ha) | Cost of cultivation (x10$^3$ `/ha) | Gross return (x10$^3$ `/ha) | Net return (x10$^3$ `/ha) | B:C ratio |
|---|---|---|---|---|---|---|---|---|---|---|
| Direct-seeded rice in flat bed + brown manuring - okra+ green manuring | 18.57 | 15.68 | 262.1 | 14.73 | 14.35 | 14.55 | 160.30 | 510.10 | 349.79 | 3.17 |
| Direct-seeded rice in flat bed + brown manuring - okra + crop residue mulch | 20.87 | 17.18 | 286.7 | 15.98 | 15.84 | 15.91 | 159.63 | 557.22 | 397.59 | 3.47 |
| Direct-seeded rice in flat bed + green manuring - okra + green manuring | 19.22 | 16.93 | 270.2 | 14.99 | 15.00 | 14.99 | 160.30 | 524.75 | 364.45 | 3.26 |
| Direct-seeded rice in flat bed + green manuring - okra + crop residue mulch | 21.50 | 18.48 | 296.8 | 16.24 | 16.70 | 16.47 | 159.85 | 575.44 | 415.58 | 3.59 |
| Direct-seeded rice in raised bed + brown manuring - okra + green manuring | 12.25 | 13.33 | 138.9 | 76.77 | 7.75 | 7.71 | 152.38 | 269.74 | 117.35 | 1.76 |
| Direct-seeded rice in raised bed + brown manuring -okra+ crop residue mulch | 15.50 | 14.07 | 183.0 | 10.05 | 10.27 | 10.15 | 150.38 | 354.89 | 204.51 | 2.35 |
| Direct-seeded rice in raised bed + green manuring - okra + green manuring | 14.88 | 15.03 | 160.3 | 8.45 | 9.34 | 8.90 | 150.38 | 309.25 | 158.87 | 2.05 |
| Direct-seeded rice in raised bed + green manuring - okra+ crop residue mulch | 16.83 | 15.15 | 203.9 | 11.56 | 11.07 | 11.31 | 152.98 | 397.28 | 244.29 | 2.58 |
| Direct-seeded rice in flat bed – okra | 19.08 | 15.63 | 254.2 | 14.26 | 13.94 | 14.11 | 183.63 | 494.50 | 310.87 | 2.68 |
| Direct-seeded rice in raised bed – okra | 16.17 | 14.07 | 195.7 | 10.80 | 10.91 | 10.86 | 157.88 | 379.80 | 221.92 | 2.41 |
| LSD (p=0.05) | 1.09 | 0.68 | 11.4 | 0.97 | 0.90 | 0.63 | - | - | - | - |

continuous cropping in same field the compactness of bed caused water deficit and reduced the water intake by the crop. So, there might be a competition between the crop and green manure for water which might have reduced the yield. Similar finding was reported by Hasanuzzaman (2019).

## Economics

The highest B:C ratio of 3.59 was recorded in direct-seeded rice in flat bed + green manuring-okra + crop residue mulching (**Table 3**) due to higher fruit yield and maximum net return. Similar findings were also reported by Pandey *et al.*2013 that the straw mulching increases fruit yield in tomato and thereby it improved the net return.

## Conclusion

Conservation agriculture practices followed in rice-okra cropping system has significant influence on weed management in okra. Direct-seeded of rice in flat bed + green manuring followed by planting of okra with minimum soil disturbance and crop residue mulch maybe recommended as an effective weed management practice for okra in a rice- okra cropping system.

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