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Efficacy of rice straw mulch for the sustainable production and insect pest management in okra (*Abelmoschus esculentus*)

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ABSTRACT

With an aim to utilize rice straw for crop mulching purpose and prevent environmental damage caused due to its burning, the efficacy of rice straw mulching was compared with the standard practice of silver colored polyethylene mulch and without mulch in okra (*Abelmoschus esculentus* (L.) Moench) for the crop growth, yield and for the reduction of insect pest population. The trials were performed during the *rabi* season with two sprays each of neem (Agroneem®@ 2 ml/l), imidacloprid (Confidor®@ 0.5 ml/l) and their combination. Plant growth and yield was significantly higher in silver mulch and straw mulch compared to the control. The yield of okra was maximum in silver colored polythene mulch along with the application of insecticide imidacloprid. The yield were 23.89, 16.08 and 15.80 t/ha respectively during the years, 2015-16, 2016-17 and 2017-18. The yield observed in straw mulch was slightly lower than silver colored polythene mulch, but higher than control. The straw mulch was found at par with silver colored polythene mulch in reducing population of sap sucking insect, pests, aphids, thrips, leafhoppers and whiteflies. Among the treatments, spray of imidacloprid (@ 0.5 ml/l) was found best for reducing pest population. The results indicated the utility of rice straw mulching as an organic option for the okra cultivation, which is otherwise burnt every year creating huge environmental problem in India.

Key words: Rice straw, Mulching, Okra cultivation, Crop growth, Pest management

Okra (*Abelmoschus esculentus* (L.) Moench), is an important fruit vegetable grown throughout the tropical and sub-tropical regions of the world for its tender, green fruits. The practice of mulching has been widely followed as a management tool in many parts of the world. Large quantity of straw produced as a byproduct due to cultivation of paddy and wheat. About 122.6 million tonnes of rice straw and 110 million tonnes of wheat straw generated every year in India. Farmers usually dispose of the straw by burning which created huge environmental problem every year in India (Devi *et al.* 2017). Several studies have demonstrated mulching as a management practice for okra cultivation for its yield and growth attributes. Use of silver colored polythene mulch is now a regular practice in almost all the crops mainly due to its repellant nature for the different insects-pests. In spite of its several benefits, there are few serious drawbacks. First being the difficulty in disposal of used plastic mulches and secondly the cost factor. Left over polyethylene mulches are often disposed of by burning after crop cultivation. Burning of left over polyethylene well as crop residues results in release of harmful gases like carbon monoxide, chlorine, etc which causes respiratory problems (Nisar *et al.* 2011). Organic mulches on the other hand proved to be better when compared to plastic mulches as it contributes to the soil nutrients upon its decomposition. Instead of burning the rice straw may be used for mulching in the cultivation of different vegetable crops. The use of straw mulch has shown to be effective for increasing crop yield and reducing insect vector-virus incidence (Doring *et al.* 2005). Till date paddy straw mulching has not been exploited for okra cultivation, it can be from an organic option in pest management in the okra cultivation practice. Excess use of pesticides for crop management is hazardous as exposure to these pesticides residues in primary and derived agricultural products results in serious human health concerns. Thus, an effective strategy could be developed by utilizing rice straw for mulching purpose wherein insect-pests, diseases are well managed and at the same time environmental damage caused due to its burning could be prevented. Keeping above points in view, a trial was conducted to study the impact of rice straw mulching in combination with the minimum sprays of recommended pesticides on growth, yield and population of pests in okra.

MATERIALS AND METHODS

The trial was conducted during the *rabi* season under drip irrigation for three consecutive years at the Regional Station (ICAR-IARI), Pune (2015-16, 2016-17 and 2017-18). The experiment was conducted in split plot design where the main treatments were silver plastic mulch (25

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micron), rice straw mulch and control (No mulch) and four sub-treatments which includes the spray of different insecticides (T_1- Control/No Spray; T_2-Agroneem®@ 2 ml/l; T_3-Confidor® 0.5ml/l; T_4-Agroneem®/Confidor® (First spray of Agroneem® followed by the second spray of Confidor). Agroneem® (0.2%) which is a botanical with active ingredient azadirachtin, while Confidor® is a chemical pesticide which is a formulation of imidachloprid. The first spray was done at 30 days after sowing and the second spray was done after fifteen days of the first spray. Insect pests population was recorded before spray and seventh day after spray of pesticide. Observation on population of whiteflies (*Bemisia tabaci*), aphids (*Aphis gossypii*), leafhoppers (*Amarasca biguttula*) and thrips (*Thrips palmi*) were recorded. Whiteflies and leafhoppers population were calculated by counting their number per leaf from upper, middle and lower tire of each plant, from randomly selected (10/replicate) plants in the morning hours. Thrips population was estimated by gently beating plants against thermacol cup and counting their numbers collected in the cup (Chavan *et al*. 2015). The data thus recorded were statistically analyzed to compare the efficacy of different treatments. The okra variety Phule Utkarsh was used for the experiment. In organic mulching, rice straw was used which is readily available. In synthetic mulch, standard practice of silver colored polythene mulch (25 micron and width 1.2 m) was used. The straw mulch was also placed on the ridges with a uniform layer and the sides are tightly anchored with the soil. Seeds were sown in the first week of January with the spacing of row to row- five feet and plant to plant one foot.

The statistical analyses of the data were carried following the analysis of variance for split-plot design (Gomez and Gomez 1984).

RESULTS AND DISCUSSION

Higher and early fruiting was observed in silver coloured polythene mulch and straw mulch compared to control (Table 1). Among the main treatments, highest yield was observed in silver coloured polythene mulch followed by rice straw mulch over the years (Table 1).The yield increase in mulched plots may be due to conservation of soil moisture and increased availability of phosphorus, potassium and organic carbon in comparison to non-mulched plots (Ramakrishna *et al.* 2006). This signifies that mulching increases yield. Similar results was reported by Hutton *et al.* (2005) who observed the effect of reflective mulch in increasing yields of bell pepper. Iqbal *et al.* (2009) also reported that the fruit yield per plant in hot pepper hybrid was higher in plastic mulch than in un-mulched treatment. Mulching helps in repelling the sucking insect pests from landing in the plants resulted in increased yield. Thus, mulching along with the spray of safe pesticides is good management practice for insect-pest control. Among the four sub-treatments two sprays of Confidor® (T_3) had considerably increased yields in all the three years followed

Table 1 Effect of mulch and pesticides on okra yield (2015-18)

Treatment	Yield of okra in t/ha								
	Silver mulch			Straw mulch			No mulch		
	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18	2015-16	2016-17	2017-18
T_1	21.65	11.09	9.41	16.40	6.95	4.74	13.95	3.11	1.63
T_2	21.41	13.66	13.97	18.74	7.21	5.26	15.85	3.28	1.90
T_3	23.89	16.08	15.80	19.97	9.27	6.01	18.03	4.09	2.02
T_4	22.04	13.78	14.15	19.73	7.49	5.40	16.24	3.29	2.08
CD (P=0.05)	2015-16	2016-17	2017-18						
M × S treatment	5.43	4.64	2.35						
Main treatment	2015-16	2016-17	2017-18						
Silver mulch	66.74	40.94	39.99						
Straw mulch	56.14	23.18	16.05						
No mulch	48.05	10.32	5.72						
CD (P=0.05)	5.35	3.05	3.45						
Sub treatment	2015-16	2016-17	2017-18						
T_1	52.00	21.14	15.77						
T_2	55.99	24.15	21.13						
T_3	61.90	29.43	23.82						
T_4	58.01	24.54	21.63						
CD (P=0.05)	3.13	2.68	1.36						
CV (M)	24.85	32.53	44.34						
CV (S)	16.67	32.75	20.00						

by the combination spray of Agroneem® and Confidor (Table 1). Significant differences in yield was observed in the interaction between mulch and pesticides. The treatment of confidor @ 0.5 ml/l (T_3) recorded highest yield of 23.89 t/ha 16.08 t/ha 15.80 t/ha in silver mulch; 19.97 t/ha, 9.27 t/ha, 6.01 tonnes/ha in straw mulch and 18.03 t/ha, 4.09 t/ha and 2.02 t/ha in control (without mulch) respectively during the year 2015-16, 2016-17 and 2017-18.

Spray of Imidacloprid (T_3) has considerably increased yield which might be due to reduction of pest population. Kumar *et al.* (2016) reported that spray of Imidacloprid was the most effective insecticide against whitefly and leafhoppers. T_4 was the next best treatment followed T_2. The overall yield was quite low in the third year due to severe infestation of leafhopper as high population of leaf hoppers recorded in all the treatments during 2017-18 (Fig 1D).

Pest population before and after spray

Whitefly population was found comparatively less in mulched plots than in control. The whitefly population before spray of pesticides in silver colored polythene mulch and rice straw mulch ranged between 2 to 5/leaf, while the population was slightly higher in un-mulched one ranging between 3- 6/leaf (Fig 1A). This shows that mulch is effective in reduction of whiteflies population. Silver colored polythene mulch resulted in a lower incidence of whiteflies in water-melon (Alvin *et al*. 2010). The whitefly population was more than economic threshold level in un-mulched than in mulched ones in all the three years. The economic threshold level (ETL) for whitefly in okra is 4 adults/leaf (Anonymous 2001). Pesticide spraying had considerably reduced the whitefly population in all the treatments. Overall, the population of whiteflies in all the treatments which ranged from 2-6/leaf before spray has reduced to 0.11-3.66/leaf over the respective years (Fig 2) which below ETL.

Several studies have demonstrated a reduction in infestation by insect pests and incidence of insect-vectored viral infection in vegetable crops by the use of reflective mulch (Wolfenbarger and Moore 1968; Kring and Schuster 1992; Smith *et al*. 2000; Stapleton and Summers 2002; Summers *et al.* 2004; Frank and Liburd 2005; Kousik *et al*. 2008; Nyoike *et al*. 2008). Maximum number of whiteflies (before and after spray) was observed in control (T_1) among the main treatments and in all the respective years. Lowest whiteflies numbers recorded in T_3 treatment in silver mulch ranging from 0.11-0.33/leaf while in straw mulch it was 0.11-0.56/leaf. The population of whiteflies before spray in T_3 treatment in silver mulch and straw mulch was between 2-4/leaf, which reduced to 0.11-0.56/leaf, while in un-mulched it was between 3-4/leaf before spray which was reduced to 0.22-0.67/leaf. The next best treatment is T_4 (alternate spray of Agroneem® and Confidor®) followed by T_2 treatment. Although silver mulch was best in reducing the population of whitefly by deterring adult insects from landing on plants, but organic rice straw mulch can be the next best mulch in controlling whiteflies. It was suggested that the use of reflective mulch alone or in combination with imidacloprid, can be used to reduce whitefly populations and reduce the incidence of CuLCrV-infected squash plants (Teresia and Oscar 2008).

Number of thrips before spray ranged from 7-11/ sample in silver mulch, 9-12 in straw mulch and maximum of 12-17 in no mulch in the respective years (Fig 1). Silver coloured polythene mulch and rice straw mulch were almost at par. Overall positive effect of plastic mulch was observed on crop health which has contributed to improved crop production (Vos *et al.* 1995). In onion, adults and larvae populations of thrips were significantly reduced by the use of straw mulch without compromising overall yield (Larentzaki *et al*. 2008). The thrips number reduced to 0.33-4/sample in silver colored polythene mulch, 0.99-8 in straw mulch and 2-10/sample in control (Fig 2). This 0shows that mulching has a positive effect in reduction of insect pest population. The number was quite high in without mulch in comparison to the mulched treatments. Among the treatments, T_3 had minimum thrips population. The thrips population before spray in T_3 treatment was between 7-9, 9-10 and 12-13/ sample before spray which reduced to 0.33-0.77, 0.99-1.50 and 2-4/sample in silver mulch, rice straw mulch and control in the respective years. It was also observed that T_4 treatment (an alternate spray of Agroneem followed by Confidor) was the next best treatment for controlling the thrips. Absence of mulch leads to the increase in population. Both mulch and systemic insecticides can simultaneously reduce secondary virus spread in the field by preventing the buildup of vectors on primary virus sources (Chalfant *et al.*1977).

Aphids are the sucking pests which considerably reduces yield by sucking the plant sap. Feeding results in an overall loss of plant vigor. Aphid numbers on leaves of okra plants growing over mulches were consistently lower than on those growing over bare soil or un-mulched ones. Overall, the aphid number ranged from 7-141/leaf. Due to the reflective nature of silver colored polythene mulch the aphids' population was quite low ranging from 7-52/ leaf while in rice straw mulch it ranged from 9-92/leaf. Maximum number was recorded in un-mulched ranging from 9-141/leaf, which was quite high. Severe infestation of aphids results in yield loss. The lowest infestation of aphids was observed in silver-black polyethylene mulch (Dattatraya 2014). Mulch had a great impact in reducing aphid population. The number was reduced after spray which ranged from 1.67-43/leaf in silver colored polythene mulch and 1-88/leaf in rice straw mulch (Fig 2).

Maximum number of aphids before and after spray were observed in un-mulched plots ranging from 9-141/ leaf and 4-137/leaf respectively. The population before and after spray were recorded more in control (T_1) in all the main treatments. The comparative number less in mulched than in un-mulched plots for T_1 treatment. This reflects that combination of both mulch and sprays were found effective in the management of aphids and other insect-pests. Silver mulch reported to considerably reduces the

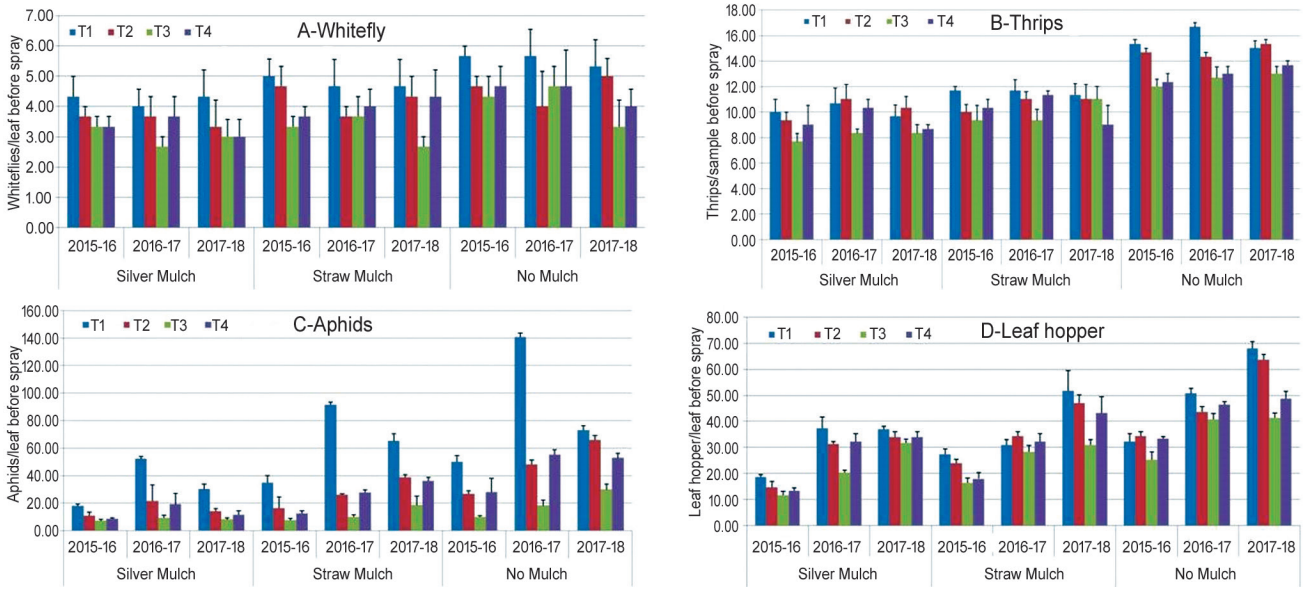

Fig 1 Insect-pest population in okra before spray in *rabi* season.

incidence of virus disease by confusing the aphids (Zalom and Cranshaw 1981). The thresholds level for treatment of aphids in vegetable crops was reported by Cami *et al.* (2017). When plants are young and aphid populations are increasing with 50-60% of the leaves infested or aphid populations remain at 8 to 10 or more per leaf for two or more consecutive week's spray of insecticides is essential to control the damage (Cami *et al.* 2017).

Among sub-treatments, T_3 had considerably less aphid population over all the years. In silver coloured polythene mulch, the aphid count reduced from 7-9/leaf to 1-5/leaf; 7-19/leaf to 1-7/leaf in straw mulch and 9-30/leaf to 4-15/leaf in un-mulched ones in the T_3 treatment (Fig 1 and 2). This reflects that even under un-mulched conditions T_3 treatment is best in the management of aphids. Spraying of Imidacloprid has resulted in considerable reduction of aphids. The above results illustrate that use of mulch along with pesticides is a good management practice for controlling aphid's infestation.

Leafhopper population was comparatively less in the mulch plots than in the un-mulched plots. The number ranged from 11-38/leaf in silver colored polythene mulch while in straw mulch it was between 16-52/leaf. In un-mulched the population was quite high and it ranged from 25-68/leaf (Fig 1). The leafhopper is an important pestiferous insect that sucks the cell sap and injects toxic saliva into leaves resulting in yield loss (Singh *et al.* 2008). Reflective mulches were more effective in reducing leafhopper numbers than

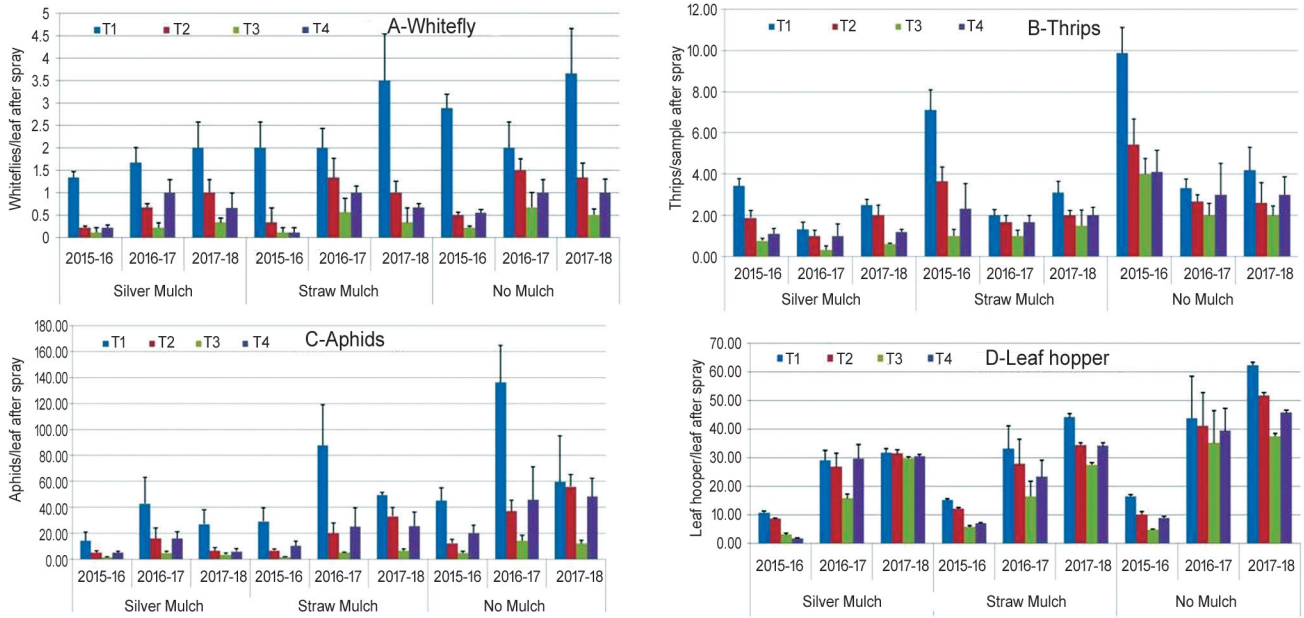

Fig 2 Insect-pest populationin okra after spray in *rabi* season.

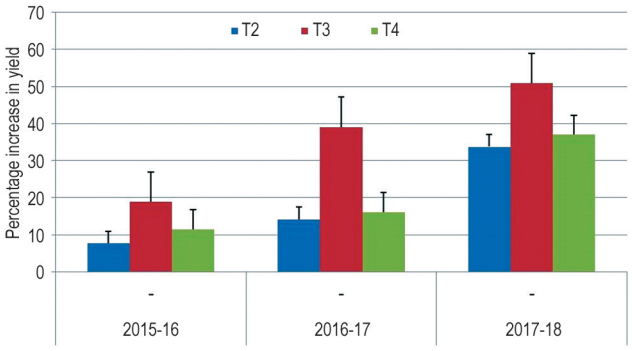

Fig 3 Percentage increase in yield with respect to Control.

were insecticides (Setiawan and Ragsdale 1987, Wells *et al.* 1984).

Maximum number of leafhopper was observed in un-mulched both before and after spray. Overall the number ranged between 11-68/leaf before spray which got reduced to 3-63/leaf after spray. The economic threshold level for leafhopper in okra is 2.5 nymphs/leaf as reported by Directorate of Plant Protection, Quarantine and Storage, India in 2001. Throughout the experiment, the leafhopper count was recorded more than the threshold level. The leafhopper count varied from 11-38/leaf, 16-52/leaf and 25-68/leaf before spray which got reduced to 3-32/leaf, 5-44/leaf and 4-63/leaf after spray in silver mulch, rice straw mulch and un-mulched respectively. Both the mulched treatments were almost at par. Spraying of pesticides had drastically reduced the leafhopper number. T_3 treatment recorded the minimum leafhopper number varying from 3-30/leaf in silver mulch, 5-28/leaf in straw mulch and 4-38/leaf in no mulch for the respective years 2015-2018. T_1 treatment recorded leafhoppers count 10-32/leaf in silver mulch; 15-44/leaf in straw mulch and 16- 63/leaf in no mulch for the respective years 2015-2018. The leafhopper number was also more in the year 2017-18 with respect to the other years. This may be one of the reasons for lower yield in that year. Among the environmental factors, maximum temperature had a positive correlation with the density of leafhopper on okra (Srinivasan *et al.* 1988). Overall, the mulched treatments along with spray of Imidacloprid were found best in the okra insect-pest management in the *rabi* season in comparison to un-mulched and without spray, i.e. control (T_1).

The percentage increase in yield varied from 19.04% in 2015-16 to 50.95% in 2017-18 compared to control. The percentage increase in yield for T_4 treatment ranged from 11.59% in 2015-16 to 37.07% in 2017-18 (Fig 3). The percentage yield for the main treatments was more in silver coloured polythene mulch as well as in T_3 treatment among the sub treatments over the years. T_3 treatment and silver mulch was found best and effective in management of vector–virus in okra. The performance of organic rice straw mulch was almost at par in all the respects and can be an alternative to the silver colored polythene mulch. T_4 treatment which is a combination of spray of neem based pesticide (Agroneem®) and Imidacloprid can be the next best option after T_3 treatment.

Problems of crop residues burning leading to environmental pollution may be partially reduced by using organic rice straw as mulch for crop cultivation. Besides reducing problem associated with its disposal, straw mulching can reduce cost of production and benefit the environment by adding nutrients to soil. Straw mulching when used along with safe chemicals like azadirachitin not only increases crop yield of okra, it can also be beneficial to natural enemies and minimizes human health hazards associated with straw burning. Hence this study suggests incorporating straw mulching in IPM programme for okra cultivation.

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