Journal of Sciences and Multidisciplinary Research
Volume 12, Number 3, 2020
ISSN: 2277-0135
http://www.cenresinjournals.com

EFFECTIVENESS OF MULCHING AND INTER-ROW SPACING ON WEED SUPPRESSION AND YIELD OF UPLAND RICE

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ABSTRACT

Weed infestation is one of the major constraints in rice production, hence the need to evaluate integrated weed control in its production. Field experiments were carried out at Teaching and Research Farm of Taraba state college of Agriculture Jalingo (8° 54′ N 110 22′ E) to evaluate the effect of mulching and inter-row spacing on weed control and yield of upland rice during 2018 and 2019 farming seasons. Two sets of factors were considered in the experiments, first factor consisted of three mulching treatments (no mulch, maize straw mulch and rice straw mulch) while the second factor were three inter-row spacing (25 cm, 30 cm and 35 cm) were laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were collected on weed density, weed biomass, grain yield and yield components of rice. On the average, rice straw mulch reduced significantly weed density (42.18 no/m^2 and 25.34 no/m^2) and weed biomass (25.42 g/m^2 and 13.21 g/m^2) than weed density (289.88 no/m^2 and 94.74 no/m^2) and weed biomass (88.55 g/m^2 and 49.84 g/m^2) at 3 and 7 WAP, besides, rice straw mulch also recorded significantly higher average grain yield (4.19 t/ha) than no-mulch treated plots (1.587 t/ha). Although 25 cm inter-row spacing recorded significantly lower average weed density (62.86 no/m^2 and 40.14 no/m^2) and weed biomass (23.32 g/m^2 and 16.08 g/m^2) than average weed density (90.22 no/m^2 and 69.06 no/m^2) and weed biomass (45.40 g/m^2 and 33.67 g/m^2) in 30 cm inter-row spacing, the average grain yield was significantly higher (5.099 t/ha) in 30 cm inter-row spacing.

Key words: weed control, rice straw, maize straw, inter-row spacing, mulching.

INTRODUCTION

Rice production in Nigeria is constrained by weed infestation (Dada *et al.*, 2017). Weeds affect rice by competing for nutrients, water, space and light (Alam *et al.*, 2012) which account for up to 68-100% yield losses in rice (Babar et at., 2012); therefore, timely weeding is crucial to increasing the yield of the crop (Toure *et al.*, 2013).

In general, hand weeding is the most popular method of weed control in rice in Nigeria (Kolo *et al.*, 2013), however, it is laborious due to significant human work hours needed (Gaire *et al.*, 2013). Besides hand weeding, a number of herbicides have been developed and tested for rice production (Johnson et al., 2005), however, there are concerns over the escalating problems of herbicides resistance and weed shift in weeds in rice (Bhurer *et al.* 2013; Bhagirath *et al*; 2012).

Mulching is another technique for reducing weed problems in rice. It is simple and valuable technique that can be used to control weeds, save time and reduce labour (Nwosisi *et al.*, 2019). Organic mulches remain popular due to their availability and low cost (Bird et al., 2002). Organic mulches such as rice straw, maize straw, dry sugarcane leaves, saw dust and bark dust provides stronger mechanical barriers to all kinds of germinating weeds (Gaire *et al.*, 2013). Organic mulch cut off weed seed germination stimuli, hinders weed emergence, conserve soil moisture, adds organic matter and nutrients to soil (Schonbeck *et al.*, 2011).

El-shahawy *et al.*, (2006) and Kato-Noguchi (2000) reported that rice straw and maize straw contains number of allelopathic compounds, when used as mulch can release these chemical substances to the soil during their decomposition process which has potentials to suppress weed growth and influence positive plant growth.Results of findings showed that four (4) tonnes of rice straw can be used as soil cover in one hectare of land (Devasinghe *et al*; 2011) straw has been identified as future natural herbicides because during its degradation it releases phenolic compounds to the soil which can hinder weed seeds germination and growth (El-shahawy *et al.*, 2006). Rice vegetative parts at maturity stage contains about 40% of nitrogen, 30-35% phosphorus, 80-85% potassium and 40-45% Sulphur (Hanafi *et al.*, 2012), when used as mulch will increase the fertility of the soil especially potassium and nitrogen besides its weed suppressive abilities (Bird *et al*; 2002), leading to less application of nitrogen, potassium as well as low cost of production and low water pollution potential (Bird *et al*; 2002).

Similarly, vegetative growth, yield and yield components as well as weed density and weed biomass were greatly influenced by plant spacing in rice production (Wang *et al*; 2002). Alam *et al.* (2012) reported that adjustment of spacing is necessary for effective weed management and maximum grain yield of rice. Close spacing reduce weed infestation (Krupnik *et al*; 2012) but hampers vegetative growth and yield of rice (Singh *et al*; 2012), similarly, wide spacing increase weed infestation (Alam *et al*; 2012), but promote higher grain yield of rice (Singh *et al*; 2012). Therefore, it is necessary to identify the optimum spacing and suitable mulching material that will reduce weed infestation in rice, thereby, leading to higher yield. The objective of this research is to evaluate the effect of mulching and inter-row spacing on weed suppression and yield of upland rice.

Materials and Methods

Field experiments were carried out at Teaching and Research Farm of Taraba State College of Agriculture, Jalingo (8° 54′ N 11° 22′ E) in the northern guinea savannah zone of Nigeria during the cropping seasons of 2018 and 2019. The land was ploughed and levelled manually with hoe. The plots were demarcated and pegged. Two sets of factors included in the experiment; first factor comprised of three mulching treatments (no-mulch, maize straw at 4 t/ha and rice straw at 4 t/ha), whereas, the second factor consisted of three inter-row spacing (25 cm, 30 cm and 35 cm), making a total of nine treatments were laid out following a Randomized Complete Block Design (RCBD) with three replications, in plot size of 4m x 3m. The rice variety (FARO 65) used in this experiment was sourced from IITA Ibadan. Mulches (maize and rice straws) were obtained from farms along Nukai river. The seeds were soaked in a container for 24 hours, then removed and kept in dark corner of room and cover with jute bag, started sprouting after 48 hours and were sown after 72 hours to the field. Four pre-germinated seeds were sown per hill with inter-row spacing specified in the treatments. Mulching materials were applied to the respective plots immediately after sowing. Seedlings were later thinned to 2 per hill, two weeks after planting. Weeds were managed manually with hoe at 2 weekly interval beginning from three weeks after planting (WAP).

Birds were controlled by covering the entire farm with fishing net. The crop was harvested at its full maturity, then threshed, winnowed, bagged and labeled. According to plot, data were collected on weed density and weed biomass at 3 and 7 weeks after planting. Yield data were collected from plants within net plot of 1m^2 at harvest on panicle length, number of grains/panicle, 1000-grain weight, grain yield, panicles/m^2 and panicle weight. Data collected were subjected to analysis of variance (ANOVA) using Genstat Package version 8.1. Significant differences among the treatment means were compared suing Duncan Multiple Range Test at 5% level of probability.

RESULTS/DISCUSSION

Mulch treatments significantly influenced weed density and weed biomass as presented in Table 1. The application of rice straw mulch effectively smothered weeds, which was reflected in terms of lower average weed density (42.18 no/m^2), (25.36 no/m^2) and weed biomass (25.42 g/m^2), (13.21g/m^2) than average weed density (315.29 no/m^2), (95.74 no/m^2) and weed biomass (88.55 g/m^2), (49.39 g/m^2) where mulch covering was absent (no-mulch treatment) at 3 and 7 WAP in both years.

This finding showed that rice straw mulch significantly reduced weed density and dry weight compared to maize straw and no-mulch treatments. This support previous studies that the most effective way for suppressing problematic weeds in rice farming is by using rice straw mulch (Chung *et al*; 2003). The results of this study also indicated that rice straw and maize straw mulches were effective in reducing weed density and weed biomass than no-mulch treatment. This is in agreement with El-Shahawy *et al.* (2006) and Kato-Noguchi, (2000) who reported that rice and maize straw mulches contains number of allelopathic compounds. These compounds are release during decomposition process and have potential to suppress the growth of weeds.

No-mulch treatment significantly enhanced weed density and weed biomass over mulch treatments (rice and maize straw). This result support previous studies that plots without soil cover in terms of mulch gave significantly higher weed density and dry weight, simply because when no mulch covering was applied more weed seeds germinated and grow better without restrain (Wayayok *et al*; 2014).

Inter-row spacing had significant effect on weed density and weed biomass as presented in table 1. The inter-row spacing of 25 cm significantly lower average weed density (62.86 no/m^2), (40.14 no/m^2) and weed biomass (28.32 g/m^2), (16.08 g/m^2) compared to average weed density (87.72 no/m^2), (69.06 no/m^2) and weed biomass (49.40 g/m^2), (33.67 g/m^2) in inter-row spacing of 35 cm at 3 and 7 WAP in both years.

This study showed that weed density and weed biomass were significantly reduced in narrow inter-row spacing of 25 cm than wider inter-row spacing of 35 cm. Similar results were obtained by these researchers. Adigun *et al*. (2016) reported reduced weed density and weed biomass with increased groundnut density. Gorgy, (2010) observed that wider spacing of rice resulted in sparse stands and encouraged weed growth, while narrower row spacing provided earlier overlapping canopy, hence effective weed suppression. Dalley *et al*. (2014) observed that narrow spacing led to earlier canopy closure consequently reduced weed infestation in crops. Interaction between mulching and inter-row spacing had significant effect on weed density and weed biomass as revealed in table 1.FARO 65 planted in no-mulch plots using inter-row spacing of 35 cm recorded significantly higher average weed density (302.15 no/m^2), (110.25 no/m^2) and weed biomass (92.91g/m^2), (49.26 g/m^2), while FARO 65 planted in plots covered with using 25 cm rice straw inter-row spacing recorded significantly lower average weed density (31.72 no/m^2), (23.72 no/m^2) and weed biomass (14.31 g/m^2), (10.71 g/m^2) at 3 and 7 WAP in both years.

All mulch treatments significantly influenced yield and yield components of rice (Table 2 and 3). Among the mulch treatments, rice straw mulch significantly increased panicle length (27.84 cm) (26.17 cm), panicle weight (6.83 g) (5.20 g), number of panicles/m^2 (205.19) (186.07), number of grains/panicle (126.22) (149.60), 1000-grain weight

(26.14g) (25.83g) and grain yield (4.040 t/ha) (4.340 t/ha) compared to panicle length (19.88 cm) (21.85 cm), panicle weight (1.82g) (1.34 g), number of panicles/m^2 (112.14) (118.81), number of grains/panicles (95.82) (110.11), 1000-grain weight (20.06g) (19.50 g) and grain yield (1.637 t/ha) (1.538 t/ha) in no-mulch treatment in both years. The results of these studies revealed that rice straw mulch recorded significantly maximum grain yield and yield components of rice in both years. The results support previous studies that rice straw contains about 40% nitrogen, 30-35% phosphorus, 80- 85% potassium and 40-80% Sulphur (Hanafi *et al*; 2012), Thus when use as mulch, these nutrients are release to the soil during decomposition process (Nader et al; 2010), hence increasing organic matter content and fertility of the soil, leading to better vegetative growth and yield of crops (rice).

Inter-row spacing significantly impacted on grain yield and yield contributing parameters of rice as shown in Tables 2 and 3. The inter-row spacing of 35 cm recorded significantly higher panicle length (28.42 cm) (27.91 cm), panicle weight (5.58g) (4.58g) number of panicles/m^2 (201.43) (161.30), number of grains/panicle (146.30) (137.20), 1000-grain weight (27.85 g) (26.11 g) and grain yield (5.170 t/ha) (5.028 t/ha) compared to panicle length (22.57 cm) (20.42 cm), panicle weight (2.00g) (1.78 g), panicles/m^2 (138.47) (122.14), grains/panicle (102.00) (94.80), 1000-grain weight (22.36g) (21.16g) and grain yield (2.188 t/ha) (2.288 t/ha) in inter-row spacing of 25 cm in both years.

The results of these trials indicated that higher grain yield and yield components of rice were recorded in wider inter-row spacing of 35 cm apart. This is in agreement with Mohammadian *et al*. (2011) and Ang *et al*. (2002) who reported significantly higher rice grain yield in wider inter-row spacing (Wang *et al*. 2002) which might be due to the fact that in wider spacing plants were able to exploit maximum food materials which eventually led to significant higher grain yield.

There was significant interactive effect of mulching and inter-row spacing on yield and yield components of rice during 2018 and 2019 farming seasons. FARO 65 planted in no-mulch cover plots using 25 cm inter-row spacing recorded significantly lower panicle length (17.20 cm) (18.25 cm), panicle weight (1.40g) (1.33g), number of panicles/m2 (102.28) (104.21), number of grains/panicle (98.54) (96.84), 1000-grain weight (19.15g) (20.17g) and grain yield (1.334 t/ha) (1.297 t/ha) compared to panicle length (26.46 cm) (25.24 cm), panicle weight (4.58g) (4.10g), panicles/m2 (202.32) (178.28), grains/panicle (170.00) (160.00), 1000-grains weight (27.32g) (28.57g) and grain yield (5.233 t/ha) (4.748 t/ha) in rice straw mulch plots planted with FARO 65 using 35 cm inter-row spacing during 2018 and 2019 farming seasons.

CONCLUSION

Rice straw mulch reduced significantly fresh weed and dry weed weight, hence higher grain yield. Narrower inter-row spacing of 25 cm reduced weed infestation, whereas significantly higher grain yield and yield components were found in wider inter-row spacing of 35 cm. It is concluded that, although application of rice straw mulch and narrow inter-row spacing of (25 cm) reduced weed infestation, higher grain yield were recorded in rice straw mulch and wider inter-row spacing of (35 cm).

Table 1: Impact of mulching and inter-row spacing on weed density and weed biomass during 2018 and 2019 farming seasons.

Treatment		Weed density (no/m²)	Weed biomass (g/m²)	Weed density (no/m²)	Weed biomass (g/m²)	Weed density (no/m²)	Weed biomass (g/m²)	Weed density (no/m²)	Weed biomass (g/m²)
			2018 WAP				2019 WAP		
		3	3	7	7	3	3	7	7
Mulching									
No-mulch		284.77	84.13	89.27	46.51	345.82	92.98	102.21	52.217
Maize straw		45.13	32.07	27.88	22.85	61.85	47.90	35.94	18.21
Rice straw		37.65 *	24.65 *	21.42 *	14.19 *	46.71 *	26.18 *	29.30 *	12.22 *
Spacing									
25cm		58.11	26.53	32.64	18.22	67.62	20.11	47.63	13.95
30cm		62.22	43.84	35.25	22.64	81.70	32.83	68.54	20.19
35cm		83.10 *	51.16 *	61.78 *	37.00 *	92.33 *	39.64 *	76.35 *	30.35 *
Interaction									
mulching x	spacing								
No-mulch	25cm	218..00c	72.83a	76.92c	38.12c	246.68c	85.00c	62.18cd	27.67cd
	30cm	260.82b	81.60b	82.10b	43.44b	306.75b	91.53b	78.73b	38.13b
	35cm	286.75a	87.10c	111.25a	51.52a	317.56a	98.72a	109.28a	47.00a
Maize straw	25cm	38.82g	21.03g	26.88h	18.29f	52.84f	32.33f	48.44f	18.17f
	30cm	47.58e	25.13e	32.13f	22.55e	62.11e	40.15e	54.92e	21.82e
	35cm	52.14d	31.41d	37.28e	26.60d	70.49d	46.10d	63.18l	28.41c
Rice straw	25cm	31.25i	17.25h	18.27j	12.14h	32.19i	11.37i	29.28i	9.29i
	30cm	36.52h	21.42g	20.29i	15.47g	39.77h	14.72h	32.55h	12.40h
	35cm	43.76f	24.11f	28.21g	18.16f	43.06g	17.85g	47.92fg	15.11g

There are no significant differences among means with same letters in the same column (DMRT=0.05)

* = Significant

Table 2: Effects of mulching and inter-row spacing on yield and yield contributing characters of rice during 2018 farming season.

Treatment		Panicle length (cm)	Panicle weight (g)	No. of Panicles/m² 2018	No. of grains/ panicle	1000-grain weight (g)	Grain yield(t/ha)
Mulching							
No-mulch		19.88	1.82	112.14	95.82	20.06	1.637
Maize straw		25.42	3.22	172.50	108.75	23.45	2.025
Rice straw		27.84 *	6.83 *	205.19 *	126.22 *	26.14 *	4.040 *
Spacing							
25cm		22.57	2.00	138.47	102.00	22.36	2.188
30cm		25.30	3.82	180.15	132.65	25.10	3.0128
35cm		28.42 *	5.58 *	201.43 *	146.30 *	27.85 *	5.170 *
Interaction							
mulching x	spacing						
No-mulch	25cm	15.20g	1.40h	106.82i	98.54i	19.15f	1.334i
	30cm	19.17bcde	1.73g	114.32h	103.18g	22.73bcd	1.572efgh
	35cm	22.18bcd	1.98e	117.11g	107.82f	23.33bc	1.877ef
Maize straw	25cm	18.24bcdef	1.80ef	122.68f	102.13gh	21.44bcde	1.634efg
	30cm	22.13bcd	2.03bcd	158.12d	135.66d	23.68bc	2.762bcd
	35cm	24.80b	2.94b	162.31c	157.16b	24.82b	2.895bc
Rice straw	25cm	20.10bcde	1.97e	140.84e	110.38e	22.41bcd	1.872e
	30cm	23.32bc	2.41bc	183.70b	145.22c	24.07b	3.812b
	35cm	26.46a	4a.58	202.32a	170.00a	27.32a	5.233a

There are no significant differences among means with same letters in the same column (DMRT=0.05)

Table 2: Influence of mulching and inter-row spacing on yield and yield contributing characters of rice during 2019 farming season.

Treatment		Panicle length (cm)	Panicle weight (g)	No. of Panicles/ m²	No. of grains/ panicle	1000-grain weight (g)	Grain yield(t/ha)
				2019			
Mulching							
No-mulch		21.85	1.34	118.81	110.11	19.50	1.538
Maize straw		23.38	3.50	168.08	122.26	22.99	2.025
Rice straw		26.17*	5.20*	186.07*	149.60*	25.83*	4.340*
Spacing							
25cm		20.42	1.78	122.14	94.80	21.16	2.288
30cm		23.70	2.08	143.70	126.10	23.20	3.028
35cm		27.91*	4.58*	161.30*	137.20*	26.11*	5.113*
Interaction							
mulching x	spacing						
No-mulch	25cm	18.25g	1.13def	104.21i	96.84i	20.17f	1.297f
	30cm	21.30abcde	1.68de	112.85h	100.28h	22.88bcde	1.421d
	35cm	23.14abcd	1.99d	115.27f	108.20g	23.09bcd	1.900e
Maize straw	25cm	20.76f	1.87d	113.51g	118.48f	22.53bcde	1.584
	30cm	24.80abc	2.11bc	143.83d	146.70c	24.17bc	2.306d
	35cm	25.84ab	2.88b	151.00c	152.22b	25.48b	2.633c
Rice straw	25cm	21.81abcd	1.94d	137.88e	126.56e	23.12bcd	1.900e
	30cm	23.11abcd	2.22bc	158.90b	139.40d	25.17b	2.879b
	35cm	27.24a	4.10a	178.28a	160.00a	28.57a	4.748a

There are no significant differences among means with same letters in the same column (DMRT=0.05)

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