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EVALUATION OF MULCHING MATERIALS AS INTEGRATED WEED MANAGEMENT COMPONENT IN MAIZE CROP

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ABSTRACT:- Yield losses by weeds in maize crop and demonstrated efficacy of various mulches in weed management led to check the efficacy of various available mulches for suppressing weeds in maize crop at National Agricultural Research Centre (NARC), Islamabad during *kharif* (autumn) season 2011. The experiment was laid in Randomized Complete Block Design, (RBCD) having eight treatments and four replications. The treatments were black plastic, white plastic, sugarcane straw, wheat straw, live mulch, weeds as mulch, hand weeding and weedy check. Weed data included weed density m^{-2}, fresh and dry weight g m^{-2}, while crop data included crop density m^{-2}, fresh and dry weight g m^{-2}, number of plant $plot^{-1}$, stover yield (g), plant height (cm), number of cobs $plant^{-1}$, number of leaves $plant^{-1}$, average grain number of five cobs and grain yield (t ha^{-1}). With the exception of hand weeding, minimum number of weeds 128 m^{-2} and 164 m^{-2} were recorded in black plastic and weeds as mulch, respectively, compared to 595 m^{-2} in weedy check. Similarly, maximum grain yields (1.91 and 1.85 t ha^{-1}) were recorded in black plastic and weeds as mulch, while minimum grain yield (0.64 t ha^{-1}) was recorded in weedy check plots. The economic net returns of black plastic mulch and weeds as mulch were Rs. 39,824 and Rs. 38,291, respectively as compared to Rs. 21431 for weedy check. Yield increased by 21.1 and 16.5% over hand weeding by plastic mulch and weeds as mulch, respectively. Black plastic followed by weeds as mulch, are recommended to control weeds and get maximum yield as well as net economic return.

Key Words: Maize; Mulching; Weeds; Crop Yield; Pakistan.

INTRODUCTION

Maize, the third major cereal crop in the world and also in Pakistan after wheat and rice is the highest yielding cereal crop in the world. It has great importance in Pakistan because the rapidly increasing population is already fearing the low availability of food. Maize is used as a staple food especially in the rural areas of developing countries including Pakistan (Arif et al., 2011). Rehman et al. (2008), reported that maize is grown twice a year in spring and autumn both for grain and fodder purposes due to short growing season. During 2012 maize was grown on 1,085,000 ha with an annual production of 4,631,000 ton (Anonymous, 2013).

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The two leading provinces for maize production in Pakistan are Khyber Pakhtunkhwa and Punjab, contributing 51 and 48% of the total production, respectively.

Maize is used for three main purposes as food, feed for poultry and livestock (Memon et al., 2011). It is used by a million of people in the form of bread, cake and porridge (Bukhsh et al., 2008; Sasson, 2010). In the total food grains production in the country, maize contributes 6.4 % (Rehman et al., 2008). It is used in various ways like as a food, fodder, used in industries to make corn oil, corn starch, corn flakes, corn syrups, lactic acid, alcohol etc. (Khan et al., 2011). Moreover, the biomass of plant above the ground minus grain (Mupangwa et al., 2007), is regarded as valuable forage stalks for the cattle feeding in dry season. Whereas, the maize, cut into pieces is commonly used for roasting purposes (Romney et al., 2003). Maize oil is used in cooking, bakery products, oleomargarine, salad dressing and pharmaceutical. It is also used in making plastics, cellophane, photographic films, dying of clothes, tanning of hides, soaps, varnishes, paints, etc. (Bukhsh et al., 2008).

High weed infestation in rainfed areas causes significant yield losses (Hussain et al., 2011). The main reasons for low yield of crops are high weeds infestation and poor weed management practices (Munsif et al., 2009). Weeds reduce the crop yield by competing for light, water and nutrients, carbon dioxide; besides they can play a role as alternative host for insect pests. Weeds not only impure the qualities of crop market value but also reduce the yield of a crop. Therefore, weed control is the best tool for a profitable agriculture (Din et al., 2011).

Maize is sensitive crop with more risks due to climatic conditions and poor management practices including weed control which reduce the yield significantly (Munsif et al., 2009). In Pakistan, the production of maize is comparatively low related to other countries of the world, due to infestation of weeds, improper weed management practices and poor planting methods. About 20-40% crop yield is lowered by weeds depending upon its density and species (Najafi and Tollenaar, 2005). Dalley et al. (2006) also concluded that the season-long weed competition reduced the maize yield considerably. The late growing weeds reduce the crop yield by competition, remain green to interfere and produce a large number of seeds that may produce future infestation in crop (Clay et al., 2005).

Weeds can be controlled effectively by integrated weed management (IWM) including biological, cultural, mechanical, chemical and genetic methods (Mahmoodi and Rahimi, 2009). High yielding agriculture mostly depends on using herbicides. But there are negative effects of herbicides, including deteriorated environment and contaminated food (Coble, 1994). Hand weeding and cultivation are the most important physical methods for weed control (Ulloa et al., 2011), but not considered the best options (Wszelaki et al., 2007). Legumes as cover crops are reported to be essential for the improvement of soil nutrient status (Kaizzi et al., 2006). The legumes-cereals mixed cropping system increases soil fertility and give best yield compared to crop alone (Abdullah and Chaudhry, 1996).

Mulching is a cultural method for

weed control in maize. Mulch is material that covers the soil to impede weed growth & support crop plants growth. It reduces the need for chemical sprays. This is important for agricultural land as it causes conservation of soil and water, improves soil organic matter contents and soil structure, regulating soil temperature and restoring the productivity of degraded land (Srivastava et al., 1993). Sugarcane dry leaves are used for mulching purposes and these are more effective for the control of weeds in field (Lorenzi et al., 1989). Plastic mulch is used by placing on the ridges with crop seeds beneath with perforations (Fisher, 1995). By using plastic mulch and returning crop residues had significantly affected the rainfed environment for several years. Transparent plastics are more effective for heating the soil, mainly for the soil solarization (Stapleton, 2000). On the other hand, black plastic mulches can increase soil temperature more than clear plastic in some cases when plastic mulches are narrowly in contact with the soil, increasing heat transmission at the mulch and soil interspaces (Ham and Kluitenberg, 1994).

The experiment was conducted to evaluate few types of mulch in rainfed environmental condition of Islamabad to evaluate weed suppression ability of various mulching materials and to determine cost effectiveness of integrated weed management in maize.

MATERIALS AND METHOD

The materials for experiment were; seeds of maize and black gram, mulching materials like black plastic, transparent plastic, wheat straw, sugarcane leaves and weeds. The maize variety (Agaiti 2000) and black gram [*Vigna mungo* (L.) Hepper] were used for the experiment. The experiment was conducted at NARC, Islamabad during *kharif* (autumn) season 2011. The maize was sown during August, 2011 in Randomized Complete Block (RCB) design with eight treatments and four replications (3.5 m × 4 m) keeping 25 cm plant to plant and 75 cm row to row distance. In each row of live mulch treatment, black gram (*Vigna mungo*) was planted as live mulch, with 10 cm plant to plant distance. Maize was sown with the help of dibbler (Table 1). Data were recorded on plant height, fresh and dry weights (g), weed flora composition, weed density (m^{-2}), crop plant population, and number of cobs per plant, number of grains per cob, grain yield and stover yield was performed at crop harvest. A quadrate measuring 25 cm × 25 cm was used to sample weeds in each plot. Data was collected at 40 and 70 days after sowing for weeds and maize

Table 1. Treatments of the experiment

T_1 = Control (weedy check)
T_2 = Hand weeding (HW) at 30 and 45 DAS
T_3 = Black plastic + HW 45 DAS
T_4 = Transparent plastic + HW 45 DAS
T_5 = Live mulch (black gram) + HW 45 DAS
T_6 = Wheat straw (thin mulch) + HW 45 DAS
T_7 = Sugarcane (thick mulch) + HW 45 DAS
T_8 = Weeds were removed by hoeing and laid in the same plot as mulch + HW

DAS: Days after sowing

plant at harvest. The average data recorded for each treatment was subjected to the Analysis of Variance (ANOVA), using Statistix-8.1 computer software and the significance was tested by using Least Significant Differences (LSD) at P = 0.05 (Steel et al., 1997). To determine the costs of weed control, the calculation was done on the basis of variable costs and current local and market prices of plastics, straws, man-hours spent in hand weeding and seed of maize and live mulch etc.

RESULTS AND DISCUSSION

In general, data recorded at 40 and 70 DAS showed the lowest weed density as well as fresh and dry biomasses in hand weeding treatments.

Weed Density (m^{-2})

The density of weeds was taken twice (40 and 70 DAS) and it was found that mulches showed its effectiveness for weeds suppression. In both data hand weeding (78 m^{-2} and 71.5 m^{-2}) followed by black plastic (128 m^{-2}) followed by wheat straw (289 m^{-2}) in first and weeds as mulch (164 m^{-2}) in the next data (Table 2), as compared to weedy check plots (595 m^{-2} and 494 m^{-2}) affected weeds negatively in the consecutive data and the same results were reported by Gul et al. (2009) that weeds failed to germinate due to high temperature and lack of light under black plastic. So the results of different types of mulches indicated best control of grasses as well as broad leaf weeds.

Table 2. Weed density (WD), weed fresh weight (FW) and weed dry weight (DW) as affected by different mulches in maize crop

	40 DAS			70 DAS		
Treatment	WD (m^{-2})	FW (g m^{-2})	DW (g m^{-2})	WD (g m^{-2})	FW (g m^{-2})	DW (g m^{-2})
T_1	595.00 e	1419.8	396.23 a	494.50 a	606.16 a	178.93 a
T_2	78.00 d	76.3	27.25 c	71.50 e	82.00 f	25.75 c
T_3	128.00 e	64.3	23.62 c	123.00 d	178.73 e	71.56 d
T_4	309.00 d	351.3	243.38 b	246.00 c	327.16 cde	151.34 ab
T_5	448.75 bc	347.1	223.74 b	306.00 b	443.76 bc	171.70 a
T_6	289.00 d	332.9	204.72 b	234.00 c	564.09 ab	159.10 ab
T_7	351.00 cd	318.6	49.24 bc	171.00 d	296.20 cde	106.87 cd
T_8	309.00 d	331.0	192.10 b	164.00 d	268.44 de	92.53 cd
LSD (0.05)	122.67	931.3	109.02	62.12	158.17	41.60

Means followed by same letters do not differ significantly at 5% probability level.

Fresh Weight of Weeds (g m^{-2})

The fresh weights of weeds taken at 40 and 70 DAS was significantly affected by applying different types of mulches. The lowest values for fresh weights of weeds in both data were with black plastic (64.8 gm^{-2}) followed by hand weeding (76.3 gm^{-2}) at 40 DAS and hand weeding (82 m^{-2}) and black plastic (178.7 m^{-2}) at 70 DAS as compared to weedy check plots (1419.8 m^{-2} and 606.2 m^{-2}). Our results are in line with those reported by Khan and Pervej (2010) (Table 2).

Dry Weight of Weeds (g m^{-2})

The minimum dry weights of weeds were recorded in hand weeding (27.25 g m^{-2}) followed by black plastic (60.77 g m^{-2}) at 40 DAS and hand weeding (15.75 g m^{-2}) and black plastic (71.56 g m^{-2}) at 70 DAS as compared to weedy check plots. Our results are parallel to the work of Khaliq et al. (2010). They reported that dry weights of weeds from weedy check plots were significantly greater than the mulches applied plots and hand weeding plots (396.23 g m^{-2} and 178.93 g m^{-2}) (Table 2).

Crop Density (m^{-2})

The data was recorded only for maize crop as frequently heavy rains caused plant damage to live mulch. Both the data (40 DAS and 70 DAS) showed that the crop density was not affected by applying mulches. Our

Table 3. Crop density (CD), fresh weight (FW) and dry weight (DW) at 40 and 70 DAS, as affected by different mulches in maize crop

	40 DAS			70 DAS		
Treatment	CD (m^{-2})	FW (g m^{-2})	DW (g m^{-2})	CD (g m^{-2})	FW (g m^{-2})	DW (g m^{-2})
T_1	8.00	310.66	50.80	8.00	384.3^{c}	105.67^{d}
T_2	9.00	292.08	80.73	7.00	1489.5^{a}	534.05^{ab}
T_3	4.00	418.81	55.19	8.00	1069.9^{ab}	535.13^{a}
T_4	7.00	384.83	101.06	6.00	1111.9^{ab}	392.82^{bc}
T_5	7.00	68.45	90.25	8.00	1217.4^{ab}	354.15^{bc}
T_6	6.00	396.60	86.38	8.00	963.8^{ab}	293.18^{cd}
T_7	7.00	267.89	37.26	6.00	868.3^{bc}	320.77^{c}
T_8	5.00	364.18	73.52	4.00	899.7^{bc}	320.75^{c}
LSD (0.05)	3.8840 (NS)	264.06 (NS)	54.52 (NS)	3.55 (NS)	508.9	207.10

Means followed by same letters do not differ significantly at 5% probability level; NS = Non-significant results are in contrast with the work of Gul et al. (2009) who reported that the plant density increased with the use of mulching materials. This may be due to the fact that we used dibbler and seed with high germination rate (Table 3).

Crop Fresh Weight (g m^{-2})

The data on 40 DAS showed that mulching gave no significant effects on the crop plants (Table 3). Whereas, the data on 70 DAS indicated that maximum crop fresh weight was recorded in hand weeding (1489.5 g m^{-2}) followed by live mulch (1217.4 g m^{-2}) due to two time weeding and suppression of weeds due to weed suppression ability of live mulch as compared to weedy check plots (384.3 g m^{-2}). Our results are in line with the work of Gul et al. (2009).

Crop Dry Weight (g m^{-2})

Data on 40 DAS showed that mulching gave no significant effects on the crop plant's dry weight (Table 3). However, 70 DAS dry weight of maize plants was differently affected by various mulches (Table 3). The maximum dry weight was found in black plastic (535.1 g m^{-2}) followed by hand weeding (534.1 g m^{-2}) compared to weedy check plots (105.7 g m^{-2}). This was because the crop plants collected from black plastic possessed large cobs as compared to other treatments. Our results are in conformity with that of Gul et al. (2009).

Plant Population per Plot

The number of crop plants from each subplot for all the treatments was non-significantly affected by mulches (Table 4); contradictory to the work of Gul et al. (2009) who reported that mulches increased the plant population.

Stover Weight (kg)

The number of plants and plant height of the crop linearly contributed in increasing the stover yield of maize crop. Maximum stover yield was recorded in black plastic (3.77 kg) and weeds as mulch plots (3.4 kg) as compared to weedy check plots (1.5 kg). These results are in line with the work of Nawab et al. (1999) who reported that mulching significantly increased stover yield (Table 4).

Plant Height (cm)

Plant height of each individual selected crop plant showed significant variation. Maximum plant height was recorded in weeds as mulch (144.9 cm) followed by black plastic (142.2 cm) as compared to weedy check plots (100.6 cm). Our results are in agreement with those of Pervaiz et al. (2009). They reported that plant height was increased in those plots in which weeds were controlled as compared to weedy check at the time of harvest. In the present study the live mulch also competed with crop and reduced the plant height (Table 4).

Number of Cobs Plant^{-1}

Black plastic treatment possessed maximum value for cobs plant^{-1} (1.15) followed by both of hand weeding and weeds as mulch (1.07) (Table 4). Similar results were reported by Easson and Fearnehough (2000) who reported that cob yield increased with the use of plastic and other mulch treatments as compared to weedy check plots (0.87).

Table 4. Maize crop data at harvest as affected by different mulches in maize crop

Treatment	# P Plot^{-1}	SW (kg)	PH (cm)	# Cobs Plant^{-1}	# Leaves Plant^{-1}
T_1	49.25	1.50^{c}	100.60^{d}	0.87^{c}	9.95
T_2	53.75	3.35^{ab}	135.92^{a}	1.07^{ab}	10.97
T_3	48.25	3.77^{a}	142.18^{a}	1.15^{a}	10.82
T_4	45.25	2.95^{ab}	127.60^{ab}	1.02^{abc}	10.60
T_5	47.50	2.62^{bc}	122.75^{ab}	1.02^{abc}	10.22
T_6	45.25	2.77^{ab}	124.90^{ab}	1.05^{ab}	10.60
T_7	48.50	3.35^{ab}	128.38^{ab}	0.97^{bc}	10.80
T_8	50.50	3.40^{ab}	144.93^{a}	1.07^{ab}	10.87
LSD (0.05)	6.56 (NS)	1.13	18.43	0.13	0.98 (NS)

Means followed by same letters do not differ significantly at 5% probability level. NS = Non-significant. #P Plot-¹; = No. of plants Plot-¹; SW = Stover weight; PH = Plant Height; # Cobs Plant-¹ = No. of Cobs Plant-¹; # Leaves Plant-¹ = No of Leaves Plant-¹ .

Number of Leaves Plant^{-1}

The results showed that the number of leaves per maize plant was not significant and all the treatments indicated almost same number of leaves per plant (Table 4). As the experiment was performed in view of integrated weed management (IWM), no spray was applied for insect control; to evaluate mulch effect on insect damage. At harvest it was noted that leaves in all treatments were damaged equally by insects.

Number of Grains Cob^{-1}

The data recorded for the number of grains per cob was significantly affected by applying mulches (Table 5). Data indicated that black plastic (196.6) and weeds as mulch (177.9) were the best treatments for the number of grain per cob of the maize crop as compared with weedy check plots (67.65). Our results are in line with Arif et al. (2011) who reported

Table 5. No. of grains cob^{-1} and grain yield as affected by different mulches in maize crop

Treatment	No. of grains*	Grain yield (t ha^{-1})
T_1	67.65^{c}	0.64^{b}
T_2	163.55^{ab}	1.59^{a}
T_3	196.60^{a}	1.91^{a}
T_4	150.30^{ab}	1.48^{a}
T_5	162.25^{ab}	1.61^{a}
T_6	141.90^{b}	1.40^{a}
T_7	155.05^{ab}	1.51^{a}
T_8	177.90^{ab}	1.85^{a}
LSD (0.05)	52.01	0.60

Means followed by same letters do not differ significantly at 5% probability level.
** Average number of grain/five cobs.*

Table 6. Cost benefits of various treatments in maize crop

(Rs.)

Treatment	HW ha^{-1}	Mulch ha^{-1}	IWMº Total costs ha^{-1}	Total earning (tha^{-1})	Net return (tha^{-1})
T_1	0	0	0	21431*****	21431******
T_2 **	7500	0	7500	47940	37940
T_3 *	2500	25000	27500 ****	67324	39824
T_4 *	2500	26000	28500 ****	54565	26065
T_5 *	2500	10000	12500	48477	35977
T_6 *	2500	30000	32,000	56033	24033
T_7 *	2500	32000	34500	57522	23022
T_8 *	2500	0	7500 ***	45791	38291

** One hand weeding cost.;*
*** Three hand weeding cost.*
**** Cost of hand weeding to obtain mulch (1 HW in same plot).*
***** Can be used for two seasons; this may enhance economic benefit by cost sharing over two seasons.*
****** Maize price was taken Rs.40 kg^{-1}.*
******* Small plots values were extrapolated to tons ha^{-1}.*
º Integrated Weed Management.

that number of grains increased significantly by using mulch residues.

Grain Yield (t ha^{-1})

The grain yield was influenced by various treatments, however, remained at par to each other. In this study due to frequent rains, there was no competition for moisture and results did not differ significantly. The results showed that maximum grain was recorded from black plastic (1.91 t ha^{-1}) and weeds as mulch (1.85 t ha^{-1}) (Table 5). Our results are in line with the work of Easson and Fearnehough (2000) who reported that grain yield increased with the use of plastic and other mulch treatments as compared to weedy check plots. Similar results specifically for the mulch residues were also reported by Larbi et al. (2002).

The economic net returns of black plastic mulch and weeds as mulch are Rs. 39824 and Rs. 38291 respectively as compared to Rs. 21431 of weedy check (Table 6). Similarly, minimum grain yield (0.65t ha^{-1}) was recorded in weedy check plots as compared to other treatments. It is thus concluded that black plastic followed by weeds as mulch, are best to control weeds and get maximum yield.

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