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DEVELOPING A SUSTAINABLE AND ECO-FRIENDLY WEED MANAGEMENT SYSTEM USING ORGANIC AND INORGANIC MULCHING TECHNIQUES

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Abstract

To determine the effect of different mulching treatments against weeds in maize, an experiment was laid out in RCB Design during summer 2011. The mulching treatments consisted of farmyard manure, chicken manure, black plastic, white plastic, hand weeding, eucalyptus (chopped) and weedy check. The data were recorded on nitrogen content in weed (%), weed frequency (%), fresh weed biomass (kg ha^{-1}), dry weed biomass (kg ha^{-1}), plant height (cm), biological yield (kg ha^{-1}), harvest index (%) and cost benefit ratio. Higher nitrogen content in weeds were observed in chicken manure which was statistically at par with farmyard manure, while lower nitrogen content were recorded in hand weeded plots. Maximum weed frequency (71.61%) was recorded for *Cyperus rotundus* L., while the minimum weed frequency was observed for *Convolvulus arvensis* L. (9.52%). The highest fresh weed biomass was recorded in weedy check (389.90 kg ha^{-1}) and the lowest fresh weed biomass was recorded in hand weeding (35.10 kg ha^{-1}) followed by black plastic (92.93 kg ha^{-1}) and white plastic (128.70 kg ha^{-1}). Different mulching treatments did not significantly affect plant height. The highest biological yield (8979 kg ha^{-1}) was recorded in hand weeding plots however, it was statistically at par with black plastic producing biological yield of (8671.7 kg ha^{-1}), while minimum biological yield (7363.7 kg ha^{-1}) was recorded in weedy check plots. Maximum cost-benefit ratio was observed for farmyard manure plots (4.9) followed by chicken manure (4.6), while the minimum cost-benefit ratio was observed for hand weeding (3.5). The results showed that it is necessary to cover the soil surface with different materials to obtain high biological activity, retain soil moisture and to achieve a good control of weeds.

Introduction

Maize belongs to family Poaceae and is grown in spring as well as summer season in Pakistan. It is high yielding crop and has great importance for developing countries like Pakistan where population is continuously increasing. In Pakistan, it is the third important cereal crop after wheat and rice and 2nd important cereal crop in Khyber Pakhtunkhwa after wheat (PARC, 2007; Asim *et al*., 2012). In Pakistan maize is grown as a multipurpose food and forage crop, therefore the economic potential of this important crop is overwhelming (Khan *et al*., 2008). Maize grains have great importance and are used for food, fodder, pharmaceutical and industrial purpose. Maize grains have starch, protein, fiber, oil and ash with a percentage of 72, 10, 8.5, 4.8 and 17, respectively (Ahmad *et al*., 2007). Weeds are unwanted and undesirable plants, which compete for light, water, nutrients, carbon dioxide and space (Anderson, 1996). Maize crop is highly infested with weeds and causes yield loss of 20-40 % in maize (Ashique *et al*., 1997). Many weed species are high consumer of nitrogen (Hans *et al*., 2002). Weeds not only limit the availability of nitrogen but also increase the growth of many weed species by higher soil nitrogen level (Blackshaw *et al*., 2003). According to Camara *et al*., (2003) nitrogen (N) is one of the important macronutrient to increase crop yield (Iftikhar *et al.,* 2010; Babar *et al.,* 2011). Shah *et al*. (2011) reported that different mulching material (organic or synthetic) has significant effect on weed suppression. Mulching is the best way used to control weeds (Kluepfel, 2010). Keeping in view the losses caused by weeds in maize crop an experiment was designed to manage weeds.

Materials and Methods

An experiment was carried out at Agriculture Research Farm, The University of Agriculture, Peshawar-Pakistan. The experiment was laid out in randomized complete block design (RCBD), replicated 3 times. The trial consisted of 7 treatments and to each replication these treatments were applied randomly. Each treatments consisted of 6 rows with row to row distance of 0.75 meter, plant to plant distance of 0.20 meter and each plot measured $4 \times 4.5 m^2$. The treatments included farmyard manure, chicken manure, black plastic, white plastic, hand weeding, eucalyptus (chopped) and weedy check.

The seed of local recommended maize variety (Azam) was sown in June 2011 with the help of dibbler and then thinned at 3 weeks after emergence to adjust the recommended number of plants per hectare. All the treatments were applied after 5 days of emergence. Hand weeding was done 3 times using hand hoe in hand weeding treatment. The crop was irrigated according to its requirements. The recommended doses of nitrogen and phosphorus that was 150 kg ha^{-1} N and 60 kg ha^{-1} P, were applied in the form of urea and DAP. Since we have used DAP as a source of phosphorus which also contains 18% nitrogen, which was adjusted by the recommended formulas. The attack of borer pest was controlled by Chlorpyrifos 40% EC @ 1.5 L ha^{-1} at 4 weeks after planting. The data were recorded from different treatments on the following parameters: nitrogen content in weed (%), weed frequency (%), fresh weed biomass (kg m^{-2}), dry weed biomass (kg m^{-2}), plant height (cm), biological yield (kg ha^{-1}), harvest index (%) and cost benefit ratio (%).

Results and Discussion

Nitrogen content in weeds (%): Nitrogen content in weeds is presented in Fig 1. Different mulching treatments showed significant effect on nitrogen contents present in weeds. Fig. 1 showed that higher nitrogen contents in weeds were observed in chicken manure treatment which are statistically at par with farmyard manure, then followed by weedy check plots. However, lower nitrogen was recorded for hand weeded plots which was statistically at par with black plastic treatment. The results for low nitrogen content in hand weeded plots may be due to limited resources available and stress by regular weeding, while high nitrogen contents in weeds in chicken manure and farmyard manure plots may be due to high level of NPK, which were already present in those manures. Weeds not only limit the availability of nitrogen but also increased the growth of many weed species by higher soil nitrogen level (Blackshaw *et al*., 2003). Many weed species are high consumer of nitrogen (Hans *et al*., 2002). Shah *et al*., (2011) reported that mulching significantly affect nitrogen uptake by weeds.

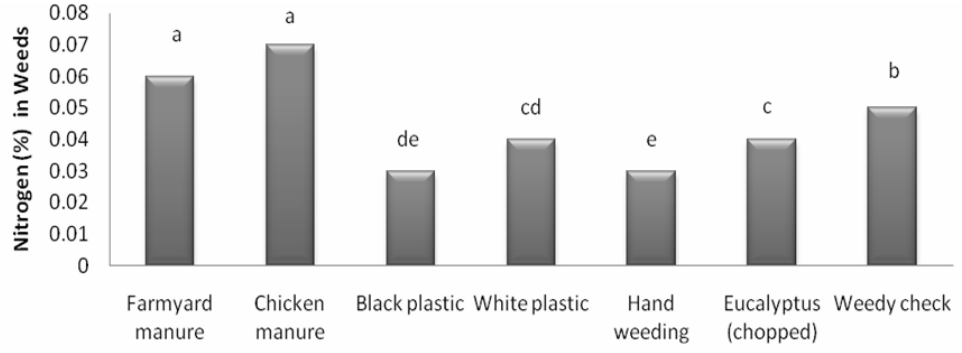

Fig. 1. Nitrogen contents of weeds (%) as affected by different mulching treatments in maize.

Weed frequency (%): The results of weed frequency showed the presence of different weed species in the study area (Table 1). Among all the recorded weed species from the study area, maximum weed frequency (71.61%) was recorded for *Cyperus rotundus* L., followed by *Echinochloa crus-gali* L. Beauv. (67.85%), while the minimum weed frequency was observed for *Convolvulus arvensis* L. (9.52). Munsif *et al.,* (2009) have also observed the presence of *Cyperus rotundus, Echinochloa crus-gali, Euphorbia* and *Digera arvensis* etc. species in maize crop.

Fresh weed biomass (kg ha^{-1}): Data regarding fresh weed biomass are shown in Table 2. The data indicated that different mulching treatments have significantly affected fresh weed biomass. The data in Table 2 show that the highest fresh weed biomass was recorded in weedy check (389.90 kg ha^{-1}) and the lowest fresh weed biomass was recorded in hand weeding (35.10 kg ha^{-1}) followed by black plastic (92.93 kg ha^{-1}), and white plastic (128.70 kg ha^{-1}). As compared to weedy checks plots hand weeded plots have minimum fresh weed biomass that may be due to physical control of weed at 30 and 60 days of emergence of crop. Zubair *et al*., (2009) reported that hand weeding effectively reduced the fresh weed biomass. Similar results were reported by Syawal (1998), Saikia & Jitendra (1999), Balaki & Rivera (1992) and Tadious & Bogale (1995) that hand weeding and black plastic effectively controlled weeds. Furthermore, they also reported that weedy check resulted in the highest weed biomass. Gul *et al*., (2009) reported the similar finding that hand weeding and black plastic mulch effectively reduced fresh weed biomass. The results are similar to the findings of Ahmad *et al*., (2007) and Ali *et al*., (2011) who stated that mulch significantly decreased total weed biomass.

Dry weed biomass (kg ha^{-1}): The results of the present study showed that different mulching treatments have significant effect on dry weed biomass (Table 2). The data revealed that the highest dry weed biomass was recorded in weedy check (57.67 kg ha^{-1}) and the lowest were recorded in hand weeding (11.07 kg ha^{-1}), followed by black plastic (17.20 kg ha^{-1}) and white plastic (22.43 kg ha^{-1}). The reduction in dry weed biomass in hand weeded plots may be due to poor regeneration after removal of weed, while in weedy check plot weeds flourished throughout the season which resulted in greater weed biomass. Zubair *et al*., (2009) reported that hand weeding effectively reduced the dry weed biomass.

Table 1. Weed frequency (%) affected by different mulching treatments in maize.

Weed species	Weed frequency (%)
Cyperus rotundus L.	71.61
Digera arvensis Forsk.	34.51
Echinochloa crus-gali L. Beauv.	67.85
Dactyloctenium aegyptium L.	28.56
Euphorbia prostrata	38.09
Convolvulus arvensis L.	9.52

Table 2. Weed and maize parameters as affected by organic and inorganic mulching techniques.

Treatments	Fresh weed biomass kg ha^{-1}	Dry weed biomass kg ha^{-1}	Plant height (cm)	Biological yield kg ha^{-1}	Harvest index
Farmyard manure	220.63 d	30.03 cd	227.83	7914.0 bc	50.02 cd
Chicken manure	257.43 c	37.03 bc	225.30	7710.5 cd	45.93 de
Black plastic	92.93 ed	17.20 e	224.37	8671.7 a	55.39 b
White plastic	128.70 e	22.43 de	225.17	8074.0 b	51.36 bc
Hand weeding	35.10 f	11.07 e	225.47	8979.0 a	60.81 a
Eucalyptus (chopped)	328.70 b	46.17 ab	223.47	7504.4 de	43.63 e
Weedy check/Control	389.90 a	57.67 a	224.23	7363.7 e	33.91 f
LSD	33.93	11.82	NS	321.80	4.10

Means of the same category followed by different letters are significantly different at p≤0.05 level using LSD test
NS= non-significant

Plant height (cm): Analysis of the data showed that different mulching treatments did not significantly affect plant height (Table 2). The data showed that the tallest height was found in farmyard manure (227.83 cm), while minimum plant height was recorded in eucalyptus (223.47 cm), which is almost similar to weedy check (224.23 cm). Khurshid *et al*., (2006) reported that maximum plant height was obtained in mulched plots, while minimum were recorded in control plots.

Biological yield (kg ha^{-1}): The statistical analysis of the data indicated that mulching have significant effect on biological yield (Table 2). The data revealed that plots treated with hand weeding gave maximum biological yield (8979 kg ha^{-1}) which were statistically at par with black plastic producing biological yield (8671.7 kg ha^{-1}]) and minimum biological yield was recorded in weedy check (7363.7 kg ha^{-1}). The minimum fresh biological yield in weedy check plots might be due heavy weed infestation. As weeds mostly reduce green area of a crop, which results in lower biological yield. While in hand weeding, black plastic and white plastic plots green area of the crop was increased due proper weed management, as a result there might be more photosynthesis process which automatically increased fresh biological yield. Similar results were reported by Nawab *et al*., (1997) that plots minimum weed infestation significantly increased biological yield. Kwabiah (2003) also reported that maximum biological yield was recorded for plastic mulch.

Harvest index (%): The statistical analysis of the data indicated that different mulching treatments have significant effect on harvest index (Table 2). The data showed that maximum harvest index (60.81%) was recorded in hand weeded plots followed by black plastic (55.39 %) and white plastic (51.36%). The lowest harvest index was recorded in weedy check (33.91). Saeed *et al*., (2010) reported maximum harvest index in less weed-infested plots.

Cost-Benefit ratio (CBR): Cost-Benefit Ratio is the ratio between gross income of a weed management practice and added cost of that practice. Various weed management methods were applied like farmyard manure, chicken manure, black plastic, white plastic, hand weeding, eucalyptus (chopped), and weedy check. All of them affected yield differently and were carried out with various costs. Maximum cost-benefit ratio was observed for farmyard manure plots (4.9) followed by chicken manure (4.6), Eucalyptus (chopped) (4.7), while the minimum cost-benefit ratio was observed for hand weeding (3.5) as shown in Table 3. However, instead of high price of plastics the CBR is yet high due to maximum net returns from yield. Khajanji *et al*., (2002) reported that hand weeding 3 times was better than weedy check in respect of cost benefit ratio as well as energy output-input ratio.

Table 3. Cost-benefit ratio and net profit as affected by various mulches.

Treatment	Gross income	Added cost	Net profit	CBR (%)
Farmyard manure	85336	17078	68258	4.9
Chicken manure	82258	17578	64680	4.6
Black plastic	93568	24478	77090	3.8
White plastic	86920	17078	69842	4.2
Hand weeding	109300	30778	92552	3.5
Eucalyptus (Chopped)	79600	16778	62882	4.7
Weedy check	…….	……..	…….	……

Conclusion and Recommendations

From the study it was concluded that different mulching techniques significantly affected all the agronomic parameters. Hand weeding resulted in better yield; however, its cost-benefit ratio was very low due to more cost of labour. Though, maximum cost benefit ratio was recorded for farmyard manure, hence it is recommended for weed control in maize crop in current scenario of Peshawar-Pakistan.

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