Weed Control Efficiency of Bioherbicides and Mulches on Yield and Yield Components of Tomato

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Abstract

An experiment was conducted to study the response of weed control efficiency of bioherbicides and mulches on yield and yield components of tomato, at the New Developmental Farm (NDF), University of Agriculture Peshawar, Pakistan during summer 2011. The effect of extracts of *Parthenium hysterophorus, Eucalyptus camaldulensis,* and *Helianthus annuus* and wheat straw and *Eucalyptus camaldulensis* mulches in relation to control was studied in tomato crop. The analysis of the data clarifies that the plants treated with wheat straw mulch showed highest plant height (48.59 m), number of branches plant^{-1} (10.19), number of days (49.62) to first fruit, number of fruits plant^{-1} (12.57) and tomato yield (28,023 kg ha^{-1}), while the lowest days (43.48) to first fruit set, number of days (39.18) to first flowering, weed density at 50 days after transplantation (23.3 m^{-2}) and weed density 120 days after transplanting (44.3) were recorded in plots treated with wheat straw mulch. The control plots showed maximum number of days (43.95) to first flowering, days (49.62) to first fruit, weed density at 50 days after transplantation (157.6 m^{-2}) with minimum number of fruit plant^{-1} (4.69), with lowest tomato yield (22,697 kg ha^{-1}). From the results obtained, it is concluded that mulches and bioherbicides enhance the yield and yield components of tomato and hence wheat straw mulch is recommended for realizing better yield of tomato.

Keywords: Weed control, bioherbicides, yield, tomato

Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular and widely grown vegetables in the world. It ranks second among vegetables next only to potato in area and production. It occupies a distinct place in the realm of vegetables because of its high nutritive value and large scale utilization. An array of processed products from tomato includes juice, ketchup, sauce, paste, puree and whole canned fruits are the main constituents of 'Pizzas'. Tomato is being grown worldwide with China, USA, Turkey, Italy, Egypt, India, Spain, Brazil, Iran and Mexico as the leading countries (Anonymous, 2003). The world annual production of tomato during 2003 was 113.30 million tons covering an area of 4.31 million ha. with the productivity of 26.28 t/ha (FAOSTAT, 2009). In Pakistan, tomato yield is unfortunately very low due to many factors. Among other pests, weeds infestation is one of the major cause of low yield. Weed infestation is a serious problem in tomato crop and uncontrolled weeds can reduce tomato yield up to a remarkable level. Weeds negatively affect the growth of the desired crops species due to the competition, allelopathy and by providing habitat for other harmful organisms (Adigun, 2002). Weeds compete with crop plants for light, nutrients, moisture and space and thus cause severe losses to yield. Generally, weeds in tomato crop are controlled by cultural practices and chemicals. Cultural practices are weather dependent while chemicals are not environmentally safe (Kassasion, 1971). Weed management practices like hand weeding and herbicide application are effective for weed control but are sometimes uneconomical in some cases due to higher costs (Cheema et al., 2003). Moreover, some weeds, which were earlier susceptible, are now herbicide resistant (Ahmad, 1996).

Due to negative effect on environment, it has increased the need for non-chemical and eco-friendly weed control methods. Mulching is a recent and important non-chemical weed control method. Mulch is a material that covers the soil surface to protect and to improve the covered area. Mulch is of two types i.e. organic mulch (living) and inorganic mulch (non-living). Organic mulch includes leaves, barks, woodchips, grass clipping etc., it retains the nutrients found in these organic matters. Inorganic material includes polyethylene sheaths, pebbles, gravels etc. Mulching is the best way used to control weeds (Kluepfel, 2010). 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 (Sturrny, 1998).

The study of allelopathy in agriculture has been extensively reviewed in the last decades by various workers by conducting experiments to demonstrate the nature of allelopathic effects of weeds on crops (Putnam and Duke, 1974). Weeds influence the crop plants by releasing phytotoxins from their seeds, decomposing residues, leachates, exudates and volatiles (Narwal, 2004). For this purpose, allelopathy may be used as a tool in weed management by applying the residues of allelopathic weeds or crop plants as mulches, growing such crops in successions and leaving their residues in the field (Altieri and Doll, 1978; Drost and Doll, 1980). In Pakistan, the population is increasing very rapidly over time therefore, there is a dire need for advanced planning and research to increase food production and improve quality in order to meet the needs of ever increasing population (GOP, 2007)

Materials and Methods

An experiment entitled "Weed control efficiency of bioherbicides and mulches on yield and yield components of tomato (*Lycopersicon esculentum* Mill.)" was carried out at New Developmental Farm (NDF), The University of Agriculture, Peshawar, Pakistan during summer 2011. The experiment was laid out in Randomized Complete Block Design (RCBD), replicated three times. There were six treatments in which three were sprayed with bioherbicides extracts including *Parthenium hysterophorus, Eucalyptus camaldulensis* and *Helianthus annuus* and two were assigned to organic mulch i.e. wheat straw and Eucalyptus mulch while one treatment was kept untreated (weed check). The seed of tomato cultivar 'Roma' was planted in the nursery during February 2011 and then transplanted to the field at Experimental areas of Horticulture research. The seedlings were planted in rows having 10-plants per row keeping row-to-row and plant-to-plant distances of 60 cm and 30 cm, respectively. The size of each plot was 4.8×3 m^2

For extract preparation the above mentioned crop and weed plants were collected at maturity, washed aDATnd then dried in oven for 72 hours at 65ºC. After drying all the plants were ground separately, weighed on electrical balance. A ground sample from each species weighing 110 g was soaked in one liter of distilled water for 24 hours filtered through muslin cloth and applied with the help of knap sack sprayer on the treatments (Cheema et al., 2003).

For mulching application, the wheat straw and fresh shoots of *E. camaldulensis* were collected and chopped then spread on the soil surface of the assigned treatments in order to suppress weeds.

During the experimentation the data were recorded on plant height (cm), No. of Days to first flowering, fruit set, No. of fruits plant^{-1} and fruit yield (kg ha^{-1}). The data were also recorded on weed density m^{-2} 15, 50 and 120 days after tomato transplanting. Quadrate having size of 33.3 × 33.3 cm^{2} size were randomly thrown three times and the weeds inside the quadrate were identified and recorded. The mean of the three quadrates were subsequently converted to weed density m^{-2}.

Results and Discussion

Weed density at 15 days after transplanting (DAT)

The data pertaining to weed density (m^{-2}) 15 days after transplanting are presented in Table 1. The treatment means indicated that the potential of different plant extracts was statistically at par with each other at 15 days after transplanting. Although the maximum (230 m^{-2}) weed density was observed in plots assigned with Eucalyptus mulch while the minimum weed density (112.0 m^{-2}) was noted in sunflower extract applied plots followed by Parthenium and Eucalyptus extracts. The better result for different plant extracts in terms of weed control in the initial stage might be due to the direct release of phytotoxic allelochemicals in the soil that cause failure in the germination of the weed seeds. The low weed densities in the treatments especially in extracts applied treatments might be due to the inhibition in the weed seed germination as reported by other researchers (Khan et al., 2011). On the other hand, the results given by the mulches is less satisfactory compared to weed extracts at the initial stage because at that stage the mulch was green, and it doesn't degrade in soil properly to exert its effect up to the mark. In similar studies Khan et al. (2004) reported that allelopathic plants extract inhibited the seed germination of wheat and associated weeds.

Weed density (m^{-2}) at 50 DAT

A significant variation was observed in the weed densities among the treatments at 50 days after transplanting. Some treatments maintained the persistence of toxicity while some lost phytotoxicity over time (Table 1). The treatment means showed that maximum (157.6) weed density m^{-2} was found in the control plot while minimum (32.3) weed density m^{-2} was computed for wheat straw mulch. The rest of the treatment gave also less weed density m^{-2} in comparison to control plots. As stated earlier the effect of mulching was not satisfactory 15 DAS due to its non degradation in the soil and after 50 DAT when it get a little bit degradation on the top soil it ceased to stop stunting the weed growth. James et al. (2003) reported that some allelochemicals mainly affect the cell division, pollen germination, photosynthesis, nutrient uptake, and specific enzyme function inside a plant.

Weed density m^{-2} at 120 DAT

Treatment means data in the Table 1 indicated that maximum weed density m^{-2} (182.6) was recorded in weedy check, because this treatment weeds grew unharmed. While minimum weed density m^{-2} (44.3) was contemplated in wheat straw mulch that was statistically at par with Eucalyptus mulch (49.3 m^{-2}) that means that after the complete mixing of the wheat straw and Eucalyptus biomass cover the soil surface that doesn't permit most of the weed seed to germinate easily. In the earlier studies, Cirujeda et al. (2012) also got good results for suppressing purple nutsedge with paper mulching in tomatoes. Moreover, organic mulching also improves soil moisture through reducing soil surface evaporation (Martens, 2001).

Table 1 Effect of organic mulches and plant extracts on weed density (m^{2}) at 15, 50 and 120 days after transplanting (DAT) as affected by different weed control techniques in tomato

Treatments	Weed density (m^{2})		
	15 DAT	50 DAT	120 DAT
Parthenium extract	115.0^{a}	65.0^{b}	77.0^{b}
Eucalyptus extract	113.0^{a}	42.6^{bc}	49.6^{b}
Sunflower extract	112.0^{a}	51.3^{bc}	60.3^{b}
Eucalyptus mulch	23.0^{b}	37.3^{c}	49.3^{c}
Wheat straw mulch	18.3^{b}	32.3^{c}	44.3^{c}
Control	113.0^{a}	157.6^{a}	182.6^{a}
LSD (0.05)	5.957	9.47	11.42

Note: Different letters in the same column indicate statistically significant differences at $P < 0.05$

Plant height (cm)

The data regarding the plant height (cm) of tomato plant are presented in Table 2. The statistical analysis of the data showed that the different allelochemicals and mulches significantly influenced the plant height of tomato plant. It is evident from the results that the highest plant height (48.59 cm) was recorded for wheat straw mulch followed by Eucalyptus mulch (45.22 cm) while the lowest plant height (34.86 cm) was noticed in control treatment. The present results indicated that organic mulching had beneficial effects on soil microbes likely through buffering the extreme fluctuations in soil moisture and temperature. Straw mulch enhanced microbial activity and mineralization of nutrients. Such effects of mulching may stem from improvements of soil C and water availability (Tiquia et al., 2002). High microbial biomass and activity often lead to high nutrient availability to crops (Wang et al., 2004).

Table 2 Effect of organic mulches and plant extracts on plant height (cm) at maturity and number of branches plant^{-1} as affected by different weed control techniques in tomato

Treatments	Tomato plant height (cm)	Number of branches plant^{-1}
Parthenium extract	40.71^{d}	9.88
Eucalyptus extract	42.02^{cd}	10.15
Sunflower extract	44.07^{bc}	9.82
Eucalyptus mulch	45.22^{b}	10.15
Wheat straw mulch	48.59^{a}	10.19
Control	34.86^{e}	8.99
LSD (0.05)	2.079	NS

Note: Different letters in the same column indicate statistically significant differences at $P < 0.05$

Number of branches plant^{-1}

The data pertaining the number of branches plant^{-1} of tomato are presented in the given Table 2. The number of branches plant^{-1} where, non significantly influenced by various treatments although during the course of study the highest numeric value for higher number (10.19 and 10.15) of branches plant^{-1} was recorded for both wheat straw mulch and Eucalyptus mulch, respectively. Similarly, lowest number of branches plant^{-1} (8.99) were observed in weedy check. Meanwhile, there was a slight decrease in number of branches plant^{-1} in the plots assigned to Parthenium and Sunflower extracts might be the negative impact of allelochemicals on the growth of tomato crop. Earlier researchers like Batish et al. (2002) also concluded that the incorporation of sunflower residues in the soil reduced the growth of sorghum and soybean. On the other hand the possible reason for increase in number of branches plant^{-1} in mulches applied plots could be the best control of weeds and consequently the maximum availability of nutrients to the crop while the reason for minimum number of branches plant^{-1} for weedy check could be due to the fact of weeds competition with the crop and lesser availability of the nutrients to the crop.

Number of days to first fruit set

Perusal of the data pertaining to number of days to fist fruit set are presented in Table 3, where the data of the present study revealed that different weed control techniques had significant effect on days to first fruiting**.** The data revealed that the maximum number of days (49.62) to first fruit set was recorded in control plots while the minimum number of days (43.48) to first fruit set were recorded for wheat straw mulch which was statistically at par with the number of days (44.28) to first fruit set in plant where sunflower extract was used. The higher number of days to fruit set in control plots may be due to higher competition, inadequate nutrients availability and heavy weed infestation causing delay to first fruiting. In similar study Rehman et al. (2010) recorded the late fruiting in the control plots due to heavy infestation of broadleaf and grassy weeds that captured the available resources from the crop plants. On the other hand, the plots assigned with different control measures such as organic mulches and extract used plots took less time in fruiting better controlled weeds and hence better availability of nutrients to the crop.

Number of days to first flowering

The data regarding number of days to first flowering are shown in Table 3. The analysis of variance revealed that that different weed control techniques had significant effect on days to first flowering of tomato. The results showed that the highest number of days (43.95) to first flowering was recorded in control treatment and the lowest number of days (39.18) to first flowering was noted in plants mulched with wheat straw which was statistically at par with number of days (39.28) to first flowering in plants where the sunflower extract was used. The minimum number of days to flowering in mulch plots was attributed to sufficient availability of nutrients and moisture near the root zone which greatly reduced the evaporation from the soil surface and resulted in the higher uptake of nutrients for plant growth. These results are in line with the previous work of Marwat et al. (2002) who stated that different weed control methods greatly affected the yield and yield component of tomato.

Table 3 Effect of organic mulches and plant extracts on days to first flowering and fruit set of tomato as affected by different weed control techniques

Treatments	Days to first flowering	Days to first fruiting
Parthenium extract	41.57^b	46.23^c
Eucalyptus extract	41.46^b	46.46^{bc}
Sunflower extract	39.28^c	44.28^d
Eucalyptus mulch	42.08^b	47.41^b
Wheat straw mulch	39.18^c	43.48^d
Control	43.95^a	49.62^a
LSD (0.05)	0.660	1.057

Number of fruit plant^{-1}

The mean data in Table 4 showed that the highest number of fruits plant^{-1} (12.57) were recorded in plot treated with wheat straw as mulch followed by number of fruits plant^{-1} (10.33) in Sunflower extract. While, the lowest number of fruits plant^{-1} (4.69) were recorded in control treatment. The highest number of fruits plant^{-1} in wheat straw mulch plots might be due to the better plant growth and availability of sufficient resources and lower weed crop competition. Moreover, mulches improve the soil physical properties, retain soil moisture and nutrients and control the weed growth. Similarly, the lowest number of fruit plant^{-1} might be due to weed crop competition for the available resources like moisture, nutrients and light. The present results are in line with the previous findings of Dennis et al. (1989) who stated that mulches positively increased the number of fruits plant^{-1} as compared to other weed control treatments. Furthermore, similar results were also obtained by Khan et al. (2012) who reported maximum number of fruits plant^{-1} in tomato treated with wheat straw mulch.

Table 4 Effect of organic mulches and plant extracts on fruit plant^{-1} and tomato yield (kg ha^{-1}) affected by different weed control techniques

Treatments	Number of fruit plant^{-1}	Yield (kg ha^{-1})
Parthenium extract	8.21^c	$25{,}320^c$
Eucalyptus extract	8.87^c	$26{,}770^b$
Sunflower extract	10.33^b	$27{,}503^{ab}$
Eucalyptus mulch	5.87^d	$24{,}093^b$
Wheat straw mulch	12.57^a	$28{,}023^a$
Control	4.69^d	$22{,}697^d$
LSD (0.05)	2.225	832.62

Yield (kg ha^{-1})

Mean data regarding yield of tomato (kg ha^{-1}) are presented in Table 3. The results revealed that the highest tomato yield (28,023 kg ha^{-1}) was recorded in wheat straw mulch which is statistically at par with sunflower extract (27,503 kg ha^{-1}) while the lowest yield (22,697 kg ha^{-1}) was recorded for control plots. The reason for maximum yield in mulch treatments was due to lesser competition for nutrients and other resources. The results are in close agreement with the previous findings of Chalfant et al. (1977) who reported that due to effective weed control, the yield increased due to lower weed crop competition for resources. Siborlabane (2000) also pointed out that the yield and quality of the fruit for tomato market varies according to the type of mulch used on the plantation.

Conclusions and Recommendations

It is concluded from the present research work that all the extracts and mulches especially wheat straw mulch enhanced the yield and its components, as a consequence of minimizing the weed density 15 DAT. All the used plant materials under study are easily available and therefore could be efficiently used for weed management. However, the proper training and popularization of the concept of mulching and bioherbicides are direly needed. The procedure for applying wheat straw mulch is very simple and needs no special techniques therefore this approach should be popularized in the farming community. The plants used in preparation of bioherbicides are very much abundant and easily available should be tested at various concentrations against different weeds for possible weed control. The results of the instant study revealed that nearly both the mulches and all the plant water extracts and specially wheat straw mulch are the stronger and potential candidates to be used for weed control in tomatoes and enhancing the vegetative growth as well as the yield of tomato crop.

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