Sains Malaysiana 45(7)(2016): 1013–1018

Jatropha curcas Leaves Mulch Effect on Seedling Emergence and Growth of Maize (*Zea mays*)

(Kesan Mulca Daun *Jatropha curcas* ke atas Percambahan Benih dan Pertumbuhan Jagung (*Zea mays*))

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ABSTRACT

Allelopathy is a process in which one plant species may usefully or adversely affect the growth of other plant species through the production of allelochemicals. During the present investigation, mulch effect of Jatropha curcas *leaves was evaluated on seed germination and seedling growth of maize varieties viz. Pioneer (V1), Azam (V2) and Jalal (V3). Mulch was applied at 1 and 2 tons/hectare. Phenolic compounds were detected in* Jatropha curcas *leaf (131.15 mg gallic acid eq./gm extract). Mulch applied at 2 tons/hectare significantly reduced seed germination (%), germination index, relative water content, root width and seedling dry weight. From the findings of the present investigation, it was inferred that* Jatropha curcas *leaves exhibited phytotoxic effects on maize at high concentrations.*

Keywords: Jatropha curcas*; maize; mulch; phenolics*

ABSTRAK

Alelopati adalah suatu proses menggunakan satu spesies pokok untuk mengawal atau menjejaskan pertumbuhan spesies tumbuhan yang lain melalui pengeluaran alelokimia. Semasa kajian ini, kesan mulca daun Jatropha curcas *dinilai pada percambahan benih dan pertumbuhan anak benih varieti jagung viz. Pioneer (V1), Azam (V2) dan Jalal (V3). Mulca telah digunakan pada 1 dan 2 tan/hektar. Sebatian fenolik dikesan pada daun* Jatropha curcas *(131.15 mg ekstrak asid galik eq./gm). Mulca yang digunakan pada 2 tan/hektar telah mengurangkan percambahan benih (%), indeks percambahan, kandungan air relatif, lebar akar dan berat kering anak benih. Daripada keputusan kajian ini, dapat disimpulkan bahawa daun* Jatropha curcas *menunjukkan kesan fitotoksik ke atas jagung pada kepekatan yang tinggi.*

Kata kunci: Fenolik; jagung; Jatropha curcas*; mulca*

INTRODUCTION

The word mulch is derived from German language 'molsh' which means soft. The definition of mulch is 'the material grown on or laid on the surface of soil'. Many materials were used as mulch i.e. plant leaves and twigs, agriculture byproducts and plastic sheets. Comparatively in term of water conservation leaf materials used as mulch was more beneficial than the same leaf materials when mixed in the soil (Singh et al. 1991). Mulch applied soil retains more water as compared to bare soil. The soil particles of bare soil are closely packed together as compared to mulch applied soil, therefore the bare soil absorbs less water of irrigation and rainfall. In summer, weed increase 25% evapotranspiration of soil moisture (Harris et al. 2004). Mulch increase soil water by decreasing evaporation and weed growth. As compared to bare soil, a 3.8 cm dense layer of straw decrease 35% evaporation. Organic mulches, plastic mulches, waxy mulches and geotextile were bad selection in this case because initially such mulches increase soil water retention by reducing evaporation but after long time it will produce unnaturally dry soil (Lakatos et al. 2000).

Study on types of mulch showed that organic mulch retains more water than inorganic and synthetic mulches (Arthur & Wang 1999; Balvinder et al. 1988; Iles & Dosmann 1999). Mulches such as stone and gravel, different plant materials and livestock manure have the ability to prevent water loss from soil (Iles & Dosmann 1999). From a practical point of view, suitable mulch will decrease the need of irrigation for all landscapes, while in some cases completely eliminate the need of irrigation (Pfammatter & Desimoz 1997). An early study showed that straw mulch of 1.5 cm (0.6 inch) decrease 34% runoff and bark mulch also decrease runoff of water (Merwin et al. 1996). The needs for irrigation will decreased by decreasing runoff and improved capacity of retention. Moreover, those mulches which protect the trees and shrubs from drought stress, also protect them from cold injury (Smith 2000). Mulch may be applied before and after planting in the fields. Mulch is particularly beneficial for high valuable vegetable crops, for crop growing during dry season and in places where heavy rains eroded the soil. Comparatively mulch materials which decompose slowly will provide long term protection to soil from erosion as compared to fastly decomposing mulch materials (Eyhorn et al. 2002). Relative water content may be defined as the amount of water a plant contains when it is fully saturated (DaCosta et al. 2004). It can be used as an important

indicator for determining the physiological status of plant (Ullah et al. 2012).

The *Jatropha curcas* (Euphorbiaceae) has gained interest as biodiesel plant throughout the world (Achten et al. 2008). Presently Pakistan is facing energy crisis. Therefore, the Jatropha cultivation and establishment of biodiesel industry in country is highly encouraged. However, before the introduction of Jatropha in the country agroforestry system, it is necessary to evaluate its interaction with various crop plants/species. The present investigation was carried out to determine effect of mulch of *Jatropha curcas* leaves on seed germination and early seedling growth of maize. Moreover, attempts were also made to investigate movement of phenolic compounds (allelochemicals) from mulch into the soil and subsequently into the maize plants.

Materials and Methods

Collection of *Jatropha curcas* leaves

The dry leaves of *Jatropha curcas* fallen on ground were collected from plants growing in Jatropha Garden of University of Science and Technology Bannu Township Campus Bannu.

Preparation of mulch of Jatropha curcas leaves

Mulch of *Jatropha curcas* was prepared by making a thin layer of leaves on the surface of soil used as culture medium in the experiment. The mulch was applied at 1 and 2 ton/hectare in a pot experiment.

Experiment was conducted in the glass house of Department of Botany, University of Science and Technology Bannu. Seeds of three maize varieties i.e. Pioneer (V1), Azam (V2) and Jalal (V3) were obtained from Agriculture Research Station Bannu KP Pakistan. Seeds were surface sterilized using 0.2% mercuric chloride solution for 3 min and subsequently washed three times with autoclaved distilled water. Seeds were sown in iron trays (60 × 36") arranged in a factorial design with three replicates for each treatment.

Determination of seed germination

Germination is defined as the emergence and development of essential structure indicative of normal seedling under favorable conditions (ISTA 1999). Normal seedling were described as those having a vigorous primary root or a set of secondary roots sufficient to anchor the seedling in the soil, hypocotyls without open carks or lesions, at least one attached cotyledon, one primary leaf and an intact terminal bud. Seedling lacking of these qualities were considered abnormal. Germination % was calculated as follow.

$$\text{Germination \%} = \text{No of seeds germinated} / \text{Tota1 number of seeds} \times 100.$$

Seedling vigor index (SVI)

SVI was determined by multiplying germination (%) with seedling lot. The seed lot showing higher SVI is considered as more vigorous. (Abdul-Baki & Anderson 1973).

Mean germination time (MGT)

Mean germination time (MGT) was calculated according to Ellis and Robert (1981).

$$\text{MGT} \quad \Sigma Dn / \Sigma n$$

where n is the number of seeds which were germinated on day D; and D is the numbers of days counted from the beginning of germination.

Relative water content of leaves

It was determined as given by Gao (2000).

$$Fw - Dw / Tw - Dw \times 100$$

where Fw is the fresh weight of leaves; Dw is the dry weight of leaves; and TW is the Turgid weight of leaves.

Determination of total phenolics content

Total phenolics were determined for Jatropha leaves used as mulch, soil covered with mulch and maize plants calorimetrically using Folin-Ciocalteau method (Singleton et al. 1999). 200 µL of extracts is mixed with 1.5 mL Folin-Ciocalteau reagent (previously diluted 10-fold with distilled water and allowed to stand at room temperature at 5 min. A 1.5 mL sodium bicarbonate solution (8%) was added to the mixture. After 90 min absorbance was measured at 725 nm using UV-Vis spectrophotometer (Shimadzu, model UV-1800).

Root and shoot length as well as seedling fresh and dry weight were recorded 12 days after sowing by using measuring tape and balance. Root Law Software (Washington State University) was used for determination of root length, root width, root area and root edges.

Statistical analysis

The data was analyzed statistically by using two ways ANOVA and comparison among treatment means was made by least significant differences test (Steel & Torrie 1984). Coefficient of correlation for various parameters was determined using Student Statistix (version 8.1 USA).

Results and Discussion

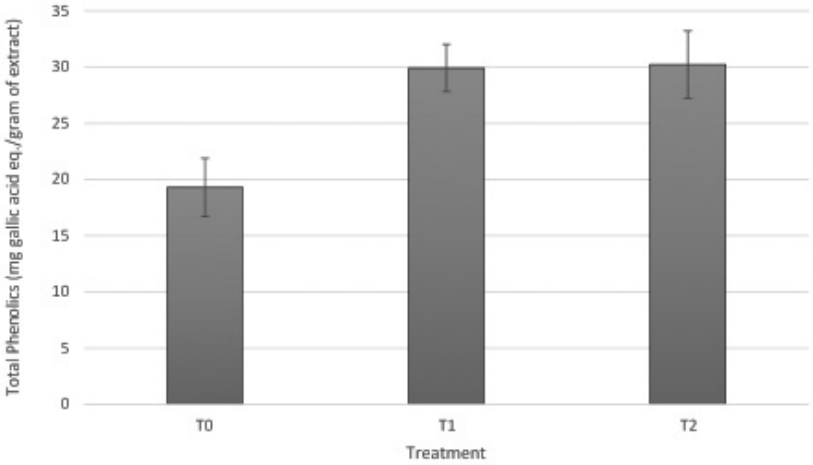
During the present investigation, phytotoxicity associated with leaves mulch of *J. curcas* was evaluated on seed germination and early seedling growth of maize. The *J. curcas* leaves used as mulch were analyzed for total phenolics content. Total phenolics content of *J. curcas* leaf was 131.15 mg gallic acid eq./gram of extract. Previous

studies have shown that major portion of plant extracts were consisted of phenolic compounds which might act as allelochemicals in natural ecosystems (Mirjalili & Karimi 2013). The results established that *J. curcas* leaf was a good source of natural phenolics. These phenolic compounds have either beneficial or drastic effects on plants (Khan et al. 2014).

Phenolic compounds present in mulch were released into the soil used as culture medium. Soil supplemented with 2 ton/hectare mulch exhibited higher (30.23 mg gallic acid eq. / gram of extract) phenolics (Figure 1).

Mulch has non-significant effect on total phenolics content of maize plants. Among the three varieties, phenolic content was significantly higher in V3 (Table 1). These results established that phenolics leached into soil from mulch diffused into maize plants.

Mulch significantly reduced relative water content of maize plants. However, the decrease in relative water content was more pronounced at 2 ton/hect mulch as compared to control. Among the three varieties, decrease in relative water content was significantly higher in V1 (Table 2). Our results confirmed that phenolic acids caused water stress in plants (Barkosky & Einhellig 2003). The probable decrease in relative water content of maize plant may be due to the fact that cells suffer from some sort of injury which resulted in wrinkling of cells with possibility



T0- No Mulch, T1-1 ton/hect, T2- 2 tons/hect

FIGURE 1. Effect of Jatropha curcas leaves mulch on total phenolics content of soil

TABLE 1. Effects of mulch prepared from leaves of *Jatropha curcas* on total phenolics content (mg gallic acid eq./gram of extract) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	65.82 AB	70.80 AB	78.34 A	71.65 A
T1	63.64 B	71.22 AB	78.62 A	71.16 A
T2	76.51 AB	73.29 AB	79.74 A	76.51 A
Means	68.66 B	71.77 AB	78.9 A	

All such m eans sharing a common English letter are statistically similar
LSD: Treatments = 8.18, Varieties = 8.18, TxV = 14.17

TABLE 2. Effects of mulch prepared from leaves of *Jatropha curcas* on relative water content (%) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	74.74 A	63.61 AB	72.69 A	70.35 A
T1	54.58 BC	69.16 AB	60.99 AB	61.58 B
T2	43.08 C	65.57 AB	70.82 A	59.82 B
Means	57.47 B	66.11 A	68.17 A	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 8.44, Varieties = 8.44, TxV = 14.62

of restricted necrosis (Anjum et al. 2011). The decrease in LRWC may be due to allelchemicals present in mulch which caused physiological drought like conditions and so that the maize plants were unable to absorb sufficient amount of water (Ullah et al. 2014)

Mulch significantly reduced seed germination (%) and germination index of maize. The decrease in germination indices was significantly more pronounced at 2 ton/hect. mulch as compared to control (Tables 3 & 4). The greater anti germination activity of leaves mulch on maize seeds at higher concentration may be attributed to the presence of large quantity of phenolics. These results were in confirmation with those of (Rizvi et al. 2000) who investigated allelopathic effects of wheat straw on growth of wild oat. The decrease in seed germination (%) can be correlated with the existence of phenolic compounds in leaves of *Jatropha curcas*, which prevented the action of gibberellins as they are main factors for seed germination; hence it is supposed that phenolic compounds limited performances of natural growth regulators (Saffari & Torabi-Sirchi 2011).

Mulch significantly reduced shoot length of maize at 2 tons/hect (Table 5). However, mulch did not significantly affect root length and root area of maize. Among the three varieties, significantly lower root area was recorded in V1 and V3 than V2 (Tables 6 & 7).

Mulch did not significantly reduce seedling fresh weight of maize. However, seedling dry weight was significantly reduced at 2 tons/hect of mulch. Among the three varieties, decrease in seedling dry weight was significantly higher in V1 and V3 than V2 (Table 8 & 9). Many findings (Cruz-Ortega et al. 2002; Sher et al. 2014) have reported that germination, radical and plumule growth exhibited deferential sensitivity to the same extract. During present investigation, shoot growth was highly affected by mulch. However, root was not susceptible to the applied mulch. Application of allelochemicals reduce fresh and dry weight of target plants (Samreen et al. 2009; Yaseen & Hssain 2014) as was also evident during present investigation.

TABLE 3. Effects of mulch prepared from leaves of *Jatropha curcas* on seed germination (%) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	66.67 B	100.00 A	100.00 A	88.89 A
T1	40 C	86.67 AB	100.00 A	75.56 AB
T2	40 C	66.67 B	93.33 AB	66.67 B
Means	48.89 B	84.44 A	97.78 A	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 16.62, Varieties = 16.62, TxV = 28.78

TABLE 4. Effects of mulch prepared from leaves of *Jatropha curcas* on germination index of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	0.93 ABC	1.36 A	1.14 A	1.14 A
T1	0.54 BC	1.03 AB	1.04 AB	0.87 A
T2	0.49 C	0.44 C	0.54 BC	0.49 B
Means	0.65 A	0.94 A	0.91 A	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 0.31, Varieties = 0.31, TxV = 0.53

TABLE 5. Effects of mulch prepared from leaves of *Jatropha curcas* on shoot length (cm) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	5.66 B	7.41 A	4.25 C	5.77 B
T1	6.92 A	8.09 A	4.48 BC	6.49 A
T2	4.50 BC	7.63 A	4.62 BC	5.58 B
Means	5.69 B	7.71 A	4.45 C	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 0.71, Varieties = 0.71, TxV = 1.22

TABLE 6. Effects of mulch prepared from leaves of *Jatropha curcas* on root length (cm) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	25.74 ABC	40.68 A	24.26 BC	30.23 A
T1	23.16 BC	37.71 AB	27.86 ABC	29.58 A
T2	14.44 C	37.55 AB	25.97ABC	25.98 A
Means	21.11 B	38.65 A	26.03 B	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 9.43, Varieties = 9.43, TxV = 16.3

TABLE 7. Effects of mulch prepared from leaves of *Jatropha curcas* on root area (cm^2) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	1.16 BCD	1.80 AB	1.11 BCD	1.35 A
T1	1.13 BCD	1.66 ABC	1.15 BCD	1.31 A
T2	0.59 D	2.05 A	0.97 CD	1.20 A
Means	0.96 B	1.84 A	1.08 B	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 0.71, Varieties = 0.71, TxV = 1.22

TABLE 8. Effects of mulch prepared from leaves of *Jatropha curcas* on seedling fresh weight (g) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	0.72 BC	1.21 A	0.46 C	0.79 A
T1	0.81 ABC	0.90 AB	0.55 BC	0.75 A
T2	0.46 C	1.13 A	0.64 BC	0.74 A
Means	0.66 B	1.08 A	0.55 B	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 0.23, Varieties = 0.23, TxV = 0.39

TABLE 9. Effects of mulch prepared from leaves of *Jatropha curcas* on seedling dry weight (g) of maize

Treatment	Varieties			Means
	V1 (Pioneer)	V2 (Azam)	V3 (Jalal)	
T0	0.12 CD	0.24 A	0.12 CD	0.16 A
T1	0.12 CD	0.22 AB	0.14 C	0.15 A
T2	0.06 D	0.16 BC	0.12 CD	0.11 B
Means	0.10 B	0.21 A	0.13 B	

All such means sharing a common English letter are statistically similar
LSD: Treatments = 0.04, Varieties = 0.04, TxV = 0.07

CONCLUSION

Jatropha curcas leaf is a good source of phenolic compounds. The *J. curcas* leaf mulch at 2 tons/hectare significantly reduced seed germination (%), germination index, relative water content, root width and seedling dry weight. It is inferred that *J. curcas* mulch is inhibitory at higher doses (2 tons/hectare) to maize and intercropping of these two plant species should be avoided. Further investigation on other plant species under field condition and particularly on weed species will lead to formulation of some novel bioherbicides.

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Received: 21 September 2015
Accepted: 21 January 2016