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RESEARCH ARTICLE

Evaluation the Effect of *Dodonaea viscosa* Jacq. Residues on Growth and Yield of Maize (*Zea mays* L.)

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Abstract

A field study was conducted in 2010 to evaluate the effect of *Dodonaea viscosa* Jacq. residues on maize (*Zea mays L.*) cultivar 5018 .A , using RCBD design with three replications .The trial comprised of four treatments such as mulching, incorporation into soil and extract, along with control which sown with maize crop without adding residues of *D. viscose***.** Data show there was little or no increase in chlorophylls , carotenes content in leaves of maize, Leaf area index (LAI) and number of ear per plant . Mulching treatment produced the highest length of maize reached to190 cm. Residues of *Dodonaea viscosa* significantly affected grain yield and yield contributing parameters , extract treatment recorded the best value 2.60 of number of ear per plant. Mulching treatment increased ear weight significantly by 41.18 % compared to control. There was significant difference in 100 grain weight between mulching and control treatments ,the increase reached to 45.51 % . Mulching treatment produced the highest plant grain yield 99.1 g , and it enhanced the plant yield by 55.82 and 39.97 % as compared to incorporation and control treatments, respectively. This increase reflected in an increase in total grain yield by 39.95 and 56.05 % , respectively . Neither protein nor oil content in maize grains were significantly affected by *Dodonaea* residues, even though there was slight increase . Carbohydrates content in maize grains were not significantly different due to *Dodonaea* residues treatments , although some decrease was observed due to slight increase in protein and oil content. There was a tendency for carbohydrates content to increase in control treatment as compared with *Dodonaea* residues treatments . The leaf tissue N%, P%, K%, Mg ppm or Fe ppm concentrations were not significantly affected by *Dodonaea* residues treatments ,However, the chemical analysis of field soil properties after harvesting demonstrated the increase in inorganic elements as compared with soil before sowing. In conclusion, Use of medicinal plants like *Dodonaea* as allelopathic agent will be a new but eco-friendly, cheaper and effective mode of weed control. Allelopathy may provide an inexpensive and more desirable method of control than more conventional methods such as the use of herbicides or mechanical removal; it may prove to be one of our best weapons for controlling weed. The infestation of pests and pathogens may be reduced simultaneously with the reduction of weeds. Additional nutrients from plant materials to soil may minimize the quantity of synthetic fertilizers needed for crops growth and development.

Introduction

During the last years, the average annual growth in agriculture sector has been frustrating due to low production of the main crops. The main factors which contribute the low yield of crops include less water for irrigation, high cost of inputs, poor quality seed, conventional sowing methods, low level of farm mechanization, unavailability of fertilizers and the poor weed management practices. In developing countries like Iraq weeds inflict 20-30 % losses in different crops on the average. Allelopathic interactions involve the production and release of chemical substances (allelochemicals) by certain plants that inhibit the growth and development of the individuals of the neighboring species and sometimes their own (autoallelopathy) **(**Rice, 1992).Allelochemicals mainly belong to secondary metabolites commonly found in plant tissues (Kobayashi, 2004).The important allelochmicals include alkaloids, terpenoids, flavonoids, steroids, tannins and phenolic compounds that usually have inhibitory effects on crops (Shaukat *et al.,* 2003). Allelochemicals are released into the environment through leaching of living plant parts, root exudates, volatilization, residue decomposition, microbial activity, and agricultural practices such as plowing of plant residues into the soil (Uniyal and Cherty, 2010). These compounds are released into the soil in sufficient quantities to affect neighboring or successional plants (Khan *et al*., 2009).

Maize is the most important cereal crop of the world grown in the irrigated and rainfed areas, while it ranks third of the most growing crop in the world (Anonymous, 2008). It is a rich source of food, fodder, feed and provides raw material for the industry (Nazir *et al*., 1994). Weeds adversely affect crop yield and quality, interfere with harvest, and increase the time and cost involved in crop production. Besides the direct effect of weeds in decreasing maize crop yield, the resultant loss of its market value is a set back to the maize growers. Weed control is, therefore, essential for obtaining high yield and better quality. (Chikoye *et al*., 2004). Incorporating allelopathy into natural and agricultural management systems may reduce the use of herbicides, insecticides, and other pesticides, reducing environment/soil pollution and diminish autotoxicity hazards (Chon *et al.,* 2002). Management systems that maintain crop residues on the soil surface have several attractive features, including weed control (Barkatullah *et al*., 2010), reduced erosion, less on-farm energy use, more available soil water (Weston, 2005), improved soil nutrient status (Akemo *et al*,.2000), and could help increase organic matter contents over time, which can provide positive benefits for these soils (Qasem and Foy, 2001). Recent research work identified a number of species that have chemicals suitable for promoting or suppressing the growth and yield of surrounding plants (Elizabeth *et al*., 2008) .

Dodonaea viscosa is considered allelopathic plant, which is capable of suppressing the germination and growth of *Pennisetum americanum* (L) Skhyuman, *Setaria italica* (L) P. Beauv and *Sorghum vulgare* Pers, which used as the test species (Barkatullah e*t al.,* 2010). The allelochemicals released from *Dodonaea viscosa* Jacq containing the following components: flavonoids, glycosides, tannins, volatile oils, terpenes, saponins and phenols and absence of alkaloids and sugars in the leaf extracts. While alkaloids, comarins, volatile oils, steroids and resins were not detected in bark extract (Esmaeel and AL-Jobori, 2011).). Duration of cover crop residue on the soil surface often determines the extent of an effective weed control period. The aim of allelopathy in agriculture was evaluated the efficacy of cultural crop management techniques to increase crop productivity while at the same time suppressing weeds(Baumann *et al*., 2001). The objective of this study was to (i) investigate the effective and sustainable treatment by using *D. viscosa* residues for the best growth , yield , and quality of maize , and (ii) estimate nutrients contributed by *D. viscosa* residues to maize.

MATERIALS AND METHODS

Plant Materials Collection

Mature leaves, bark and stems of *Dodonaea viscosa* collected from gardens of Baghdad University during May and June of 2010. The collected parts were air-dried for several days under sun light and weighted using digital balance. For mulching and incorporating treatment ,the dried plant parts were chopped into pieces (0.5-1cm length) and kept until use.. The amount of residues for spray treatment were washed with distilled water and dried , and then homogenized to fine powder by grinded separately in an eclectic grinder and then kept in plastic bags at room temperature.

Preparation of Extracts

The aqueous extracts were prepared from dried plant parts (bark,leaves and stems). A total of 7.200 kg were soaked in 72 L of distill water (100g in 1000ml) , and kept at room temperature .After 48 hours aqueous extract was filtered through the sieve (Rafiqul Hoque *et a*l., 2003). And then, the suspension was filtered through eight layer of cheese cloth (Meyer *et al*., 2006) , and kept in plastic bottle under refrigeration at 4ºC until use . According to Rafiqul Hoque *et al.* (2003) these extracts equal to 100 % concentration. Six liters from these extracts were sprayed on each $1m^2$ of the plot area after crops sowing.

Site Location and Species Selection

A experiments were conducted in a farmer's field in AL-Shaab district, Baghdad province in the period of July to November 2010. Maize grains cultivar 5018 were obtained from the Department of Field Crops, College of Agriculture, Baghdad University

Treatments and Experimental Design

The experiment was laid out in A completely Randomized Block Experimental Design (RCBD) with three replications . Each replication comprised randomly the following treatments:

i. Mulching : 600gm (3g per kg soil) of *D. viscosa* residues were maintained on the soil surface for each $1m^2$ of the plot area after sowing maize .

ii. Incorporation in soil: 600gm (3g per kg soil) of *D. viscosa* residues were incorporated in the soil for each $1m^2$ of the plot area before sowing the crop.

iii. Spray with residues extracts : 6 L. of *D. viscosa* residues extracts were sprayed on each $1m^2$ of the plot area after crop sowing.

iv. Control: plots were sown with maize without adding residues of *D. viscosa* .

The crop was managed according to the recommended conventional agronomical practices .

Measurements

Chlorophyll Extraction and Quantification

Chlorophyll content of dry leaves of maize were measured following the method of Linchtenthaler (Zhang and Kirkham,1996) . The absorbance of the pigment was measured at 646.8 nm , 663.2 nm and 470 nm for Chlorophyll - a , Chlorophyll – b and Carotenoids (Carotene + xanthophylls) , respectively using the following equations :

$Chla = 12.25A_{663.2} – 2.79A_{646.8}$ ………………………...(1)

$Chlb = 21.5A_{646.8} – 5.10A_{663.2}$ …………………………. (2)

Chltotal = Chla +Chlb ……………………….(3)

$Cx + C = (1000A_{470} – 1.82\ Chla – 85.02\ Chlb)/198$ …...(4)

Determination of Inorganic Elements

leaf samples of maize were collected during flowering and early grain formation . The leaves were dried for seven days at 60 °C, ground , and analyzed for N, P, K, Mg or Fe**.** Analysis was carried out in the Central Laboratory, Dept. of Biology, College of Science , Baghdad University.

Plant Growth Parameters

Ten plants from each plot were randomly selected during flowering period to record data on the morphological growth parameters plant height and leaf area index (LAI)

Harvesting

Maize plants were harvested at maturity stages on 22 November. Ten plants from each plot were randomly selected .The data regarding various yield components parameters, number of ears per plant , ear weight , weight of ear grain , 100 grain weight , and plant grain yield were recorded at maturity**.** Seed yield was collected from the second and third rows of each plot were sun dried properly. The weight of grains was taken and converted to yield in ton ha^{-1} **.**

Chemical Analysis

For maize grain proteins , oils or carbohydrates analyses, samples were obtained from the harvests made at maturity. Then the samples were dried at 60 °C for two weeks , grinding and analyzed in Post Studies Laboratories **,** College of Agriculture, Baghdad University.

Soil Sampling and Analysis

Soil samples were taken after harvest. Two samples were taken randomly from each plot,10-15 cm deep. The samples were mixed**,** air- dried, sieved through a sieve with 2-mm openings to remove large rock and plant debris, and pulverized**.** The small roots and stones were picked out. Soil texture and organic matter were carried out in Dept. of Laboratories, Ministry of Water Resources. The electrical conductivity (Ec) , pH , inorganic nutrients N, P, K , Mg and Fe were conducted in the Central Laboratory ,Dept. of Biology, College of Science , Baghdad University. The physical and chemical characteristics of the soil (before sowing and after harvesting) were listed in table 1.

Statistical Analysis*:*

The recorded data were statistically analyzed to obtain the level of significance using the MSTAT-computer package program. The means were separated following least significance deference (LSD) test.

RESULTS AND DISSCUSION

The measurements recorded for these parameters were presented in Table 2. These data showed that there was little or no increase in chlorophylls and carotenes content in leaves of maize. The data show that carotenes were not significantly affected by *Dodonaea* residues treatments. However carotenes tended to increase with mulching and incorporation treatments to 1.56 and 1.60 mg g^{-1}dry weight .

Using crop residues as a mulching may moderate the temperature in the top soil layer which can enhance the activity of soil microorganisms, promoting the release of nutrients, improving water infiltration, and facilitating root development and increase photosynthesis (Kladivko ,2001).

Table 1. Physical and chemical properties of field soil.

Parameters	Value before sowing	Value after harvesting
PH	6.4	6.2
Electrical conductivity (E.C)	3.95	2.68
% Sand	17	19
% Clay	19.5	18.5
% Silt	63.5	62.5
Soil texture	Silt	Silt
% Organic mater	1.1	1.4
N (ppm)	25	150
P (ppm)	1.2	2.0
K (ppm)	72	165
Fe (ppm)	0.02	0.04
Mg (ppm)	0.8	0.6

Table 2. Chlorophylls and carotenes content in leaves of maize as influenced by Dodonaea residues.

Treatments	Chl.a mg g^{-1} dry weight	Chl.bmgg^{-1} dry weight	Totalchl.Mgg^{-1} dry weight	Carotens mgg^{-1}dry weight
Mulching	13.34	5.47	18.81	1.56
Incorporation in soil	13.90	5.49	19.39	1.60
Extract	12.87	5.41	18.27	1.47
Control	12.69	5.51	18.20	1.49
LSD 0.05	N.S	N.S	N.S	N.S

Mulching treatment produced highest mean of plant height 190 cm which was significantly different (P#0.05) from control which gave the lowest plant height168 cm, and was statistically same with incorporation and extract treatments (Table 3) . These results are in line with other researchers (Khalil *et al.*, 2010; Hussain *et al.*, 2011) who indicated that the increase in plant height was due to weed suppression. Inderjit and Duke (2003) stated that plants release phytochemicals from dead tissues, and their incorporation in the soil could be accelerated by leaching thus facilitating their harmful effects in the field. However , very little weed growth occurs under the mulch as the mulches prevent penetration of light or exclude certain wave lengths of light that are needed for the weed seedlings to grow (Ossom *et al.*, 2001).

Leaf area index (LAI) of maize varied between treatments from 3.78 at mulching treatment to 3.63 at control treatment, but not significantly different. Similar results were obtained by Bavec *et al.* (2005) who found that (LAI) of maize was non-significantly different in all treatments as compared to control. There was non-significant difference in the number of ear per plant among the various treatment as shown in Table 3.Although extract treatment recorded the best value 2.60 . These results supported the work that conducted by Maqsood *et al.* (1999) who found that number of ear bearing plants per plot was not affected significantly by the duration of either weed infestation or weed eradication. Ear weight is one of the most important traits considered necessary in maize related to yield. Mulching treatment increased ear weight significantly by 41.18 % compared to control, which was not significantly different from other treatments. Similar results were reported by Heison and Collum

(1990) who found that plots treated with residue mulching produced heavy ears, also Arif *et al*.(2011) concluded that ear weight increased when crop residues used as compared to control.

Table 3. Effect of Dodonaea residues on growth parameters and yield of maize.

Treatments	Plant height (cm)	Leaf area index	Number of ears/plant	Ear weight (g)	Weight of ear grain(g)	100 grain weight (g)	Plant grain yield (g)	Total grain yield ton/ha
Mulching	190	3.78	2.20	84.00	50.20	18.10	99.10	5.29
Incorporation in soil	171	3.70	2.00	68.40	37.14	15.20	70.80	3.78
Extract	181	3.71	2.06	61.60	38.10	16.60	81.50	4.35
Control	168	3.63	2.00	59.50	34.50	14.40	63.60	3.39
LSD 0.05	19.58	N.S	N.S	17.18	12.25	3.60	25.25	1.40

There was significant difference in 100 grain weight between mulching and control treatments. The increase reached to 45.51 % . 100 grain weight was not significantly affected by incorporation and extract treatments, even though there was a tendency for increase than control. Results obtained by (Arif *et al*., 2011; Maqsood *et al*., 1999) indicate that maximum weight of grains per ear was due to crop covered with *D.* residues.

Mulching treatment produced the highest plant grain yield 99.1 g , and it enhanced the plant yield by 55.82 and 39.97 % as compared to incorporation and control treatments, respectively. This increase reflected in an increase in total grain yield by 39.95 and 56.05 %, respectively .This set of data indicates grain yield was not significantly different from extracts treatment. Similar results were also reported by (Hussain *et al*., 2008) who found that numbers of grains per cob and grain index were significantly increased by weed control treatments. Our results corroborate the findings of Shafi *et al*., (2007) who found that crop residues incorporation significantly increased grain yield of maize compared with the residues removed treatment. Similarly, Kouyate *et al*., (2000) also reported an increase in cereal grain and yields by 37 and 49%, respectively, when crop residues were incorporated in the soil compared with untreated controls (no residues incorporation).However , Jabeen and Ahmed (2009) have reported both stimulatory and inhibitory effects on various crop species with decaying materials. The reduction in grain yield due to weeds may be attributed to several factors, e.g., competition between maize and weeds for water and nutrients and allelopathic effects of weeds. Hussein in (1996) reported that controlling weeds in maize field could save 75, 11 and 54 kg/ha of N, P and K and 90, 1029 and 99 g/ha of Zn, Fe and Mn, respectively. Very little weed growth occurs under the mulch as the mulches prevent penetration of light or exclude certain wavelengths of light that are needed for the weed seedlings to grow. Mulches also promote crop development and early harvest and increase yields (Ossom *et al*., 2001). In addition, crop residues as mulch moderate the temperature in the top soil layer which can enhance the activity of soil microorganisms, promoting the release of nutrients, improving water infiltration, and facilitating root development (Kladivko, 2001).

The measurements recorded for these parameters are presented in Table 4. Neither protein nor oil content in maize grains were significantly affected by *Dodonaea* residues, even though there was slight increase. Mulching treatment gave the best results 5.98 % of oil . Whereas extract treatment gave the highest protein percentage 11.94 % . Carbohydrates content in maize grains were not significantly different due to *Dodonaea* residues treatments, although some decrease was observed due to slight increase in protein and oil content (Table.4). There was a tendency for carbohydrates content to increase in control treatment and reach to 66.43 % as compared with *Dodonaea* residues treatments .These results are in line with Ahmed (2004). Weeds compete with the main crops for nutrients and other resources and reducing the yield both qualitatively and quantitatively (Jabeen and Ahmed , 2009). So, the residue of *Dodonaea* was inhibited the growth of weeds and increase quality and quantity of the yield of maize .

Table 4. Quality parameters of maize grains as influenced by Dodonaea residues.

Treatments	% protein	% oil	% carbohydrates
Mulching	11.04	5.98	65.61
Incorporation in soil	11.50	5.61	65.31
Extract	11.94	5.14	66.21
Control	10.54	5.23	66.43
LSD 0.05	N.S	N.S	N.S

Nutrients accumulation by plant can be a quantitative measurement of the availability of nutrients in the soil and the efficiency of utilization by the plant. Data presented in Table 5 show the effect of *Dodonaea* residues treatments upon mineral elements content in leaves of maize. Responses measured were somewhat different. Nitrogen, phosphorus and magnesium uptake was higher in mulching treatment 0.99 %, 0.129 % and 168.67 ppm than for incorporation into soil and control treatments, but the increase was not significant. Potassium percentage of leaf tissue tends to increase to 0.73 % with incorporation into soil treatment, but the increase was not significantly differing from other treatments. The iron concentration in the leaf tissues was not significantly increased by *Dodonaea* residues application. However extract treatment gave the highest concentration 28.77 ppm. These results tended to support the observation of Meso *et al*. (2005) who indicate that peanut residue does not contribute significant amounts of N to succeeding crops, however, retaining residue on the soil surface provides other benefits to soils. Nitrogen uptake at control is an indication of the nitrogen released by the soil and adding fertilizer. These results suggest that the initial soil available –p and adding fertilizer were sufficiently high to adequately meet the phosphorus needs of the plants. Also these results indicated that the amount of potassium, iron and magnesium in the soil was sufficient, and additional treatment did not affect the nutrient status of the plants (Table 1). The chemical analysis of field soil properties N%, P%, K%, Mg ppm or Fe ppm after harvesting demonstrated the increase of soil mineral elements as compared with soil before sowing (Table 1). Overall, these results suggested two things: 1) the nitrogen, phosphorus and potassium in the soil and adding fertilizer, iron and magnesium in the soil were sufficiently high to supply the plants requirements; 2) nutrients uptake were severely restricted by environmental factors such as heat , weeds competition and water stress. Walker *et al.* (1989) found that the uptake of Ca, Mg and S was impaired by sweet potato plant residues were incorporated in to the soil. Nutrient uptake is of a basic importance in the growth and development of plants, and evidence is accumulating that many types of allelopathic agents affect the rate of nutrient uptake. Both increases and decreases in the nutrient uptake have been reported for plants subjected to a variety of allelopathic conditions. Cases

Table 5. Mineral elements content in the leaves of maize as influenced by *Dodonaea* residues.

Treatments	Nitrogen (ppm)	Phosphorus (ppm)	Potassium (ppm)	Iron (ppm)	Magnesium (ppm)
Mulching	0.99	0.129	0.68	28.37	168.67
Incorporation in soil	0.96	0.129	0.73	28.10	158.00
Extract	0.93	0.127	0.71	28.77	168.67
Control	0.94	0.126	0.66	27.13	165.00
LSD 0.05	N.S	N.S	N.S	N.S	N.S

of mineral imbalance, receiving plants have been created by leachates from plant residues, root exudates, and allelopathic residues (Alam *et al*., 2001). These results in line with Bhowmik and Doll (1984) who measured the uptake of phosphorus by bean plants growing alone or in association with other bean plants, pigweed or green foxtail. They found that one associated bean reduced phosphorus uptake by the test bean plant as much as by four associated bean plants. The weed species caused less reduction in phosphorus uptake than did the associated bean plants, even though these particular weed species were found to absorb large quantities of the major elements. These facts indicate that competition for limited phosphorus did not cause the reduced phosphorus uptake bean plants. Consequently the authors concluded that an allelopathic interrelationship was involved. Khalid *et al*. (2002) showed that salicylic and ferulic acids inhibition of K uptake by oat roots was greater in a medium with a low pH. There is little evidence concerning the action of specific allelochemicals on the mineral nutrition of intact plants and it is not known whether effects on the uptake or distribution of minerals are a cause of growth alterations. The inhibition or stimulation of N, P and K uptake in crop or weeds was not consistent and dependent on the residues, source, residue placement or soil texture (Alam *et al*., 2001).

Conclusion

Dodonaea residues had a clear positive effect on the growth , yield ,yield components, chlorophylls, carotenes, protein , oil and elements content characteristics of maize. Various applications of *Dodonaea* residues can be successfully used in weed control management. It had a clear inhibition effect on the growth and number of weeds grown in the field of maize; however, mulching gave better results in comparison to control. Use of medicinal plants like *Dodonaea* as allelopathic agent will be a new but eco-friendly, cheaper and effective mode of weed control. Allelopathy may provide an inexpensive and more desirable method of control than more conventional methods such as the use of herbicides or mechanical removal; it may prove to be one of our best weapons for controlling weed. The infestation of pests and pathogens may be reduced simultaneously with the reduction of weeds. Additional nutrients from plant materials to soil may minimize the quantity of synthetic fertilizers needed for crops growth and development.

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