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Synergistic effect of allelopathic plant extract on fluroxypyr efficiently to suppress weeds in corn

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Abstract:

Successful weed control is important to maximize crop yield. Use herbicides to control weeds has several undesirable effects on the environment leading to the search for other alternatives, of which allelopathy has great potential. The aim of the study is to evaluate the effect of adding the methanolic crude extracts of *Eucalyptus citriodora* and *Cucurbita pepo* leaves on Fluroxypyr herbicidal activity against corn weeds, *Corchorus olitorius* L., *Amaranthus retroflexus* L., *Portulaca oleracea* L. and *Echinochloa colonum* L. So, a field study carried out at the experimental farm, Faculty of Agric., Tanta Univ, during 2008 and 2009 summer seasons. With *E. colonum* weed species, the hoeing (H) was the most effective treatments in reducing the weed biomass density, followed by 0.75 fluroxypyr +0.25 *E. citirodora* H. mixture (F+E.c3:1) and fluroxypyr (F) treatments. In the other weed species, (F) were the most effective treatments, followed by F+E.c3:1mixture and H treatments. The control treatment had the highest weed density. There are no significant differences between the fluroxypyr and F+E.c3:1mixture treatments or between the two *Zea mays* L. (Family: Poaceae) hybrids treatments. The hybrid TWC 321 had the lowest weed plant density. It is concluded that the effective weed control through the use of a reduced rate of herbicide (75% of the recommended rate) mixed with the *E. citirodora* plant extract. But, maximum values of the benefit-cost ratio (BCR) had recorded in fluroxypyr (F) and F+E.c3:1 treatment.

Introduction

Corn is the third essential cereal crops in Egypt, while it positions third of the most growing crops in the world. It has a significant economic importance worldwide as human food, animal feed and as a crude material for an increasing range and variety of food and nonfood industry (Paliwal, 2000). Egypt has 703,921 hectares of corn, which produces 5.69 million tons/Annam, with a gap between production and consumption estimated at 7.8 million tons in 2014 (Abd ElFatah *et al*., 2015). This gap offset by imports, which places a burden on the country's budget. Because of the water resources insufficiency, cannot increase corn yield by increasing the cultivated area. The other way to increase corn productivity is by increasing unit area production (Zohry *et al*., 2016).

Weeds are undesirable plants, which compete with crops for light, soil, water and nutrients (Rajcan, and Swanton, 2001). The corn yield reduction due to weed contest reached 66-90 % (Abouziena *et al*., 2007 and Dalley *et al*., 2006). There are many difficulties that correspond to the dependence on hand-hoeing in corn, which is the lack of sufficient labor and lack of workable field conditions at critical stages of the crop-weed competition. In such a circumstance utilization of herbicides become necessary (Singh *et al*., 2009). Herbicides are effective in controlling weeds, but when used, it can lead to: disturb the ecosystem by increasing soil and water contamination (Ahmad *et al*., 2000) also; they may increase the herbicide-resistant weeds (Narwal *et al*., 2005) and they are hazardous to humans and animals (Einhellig, 2002).

Rice (1984) defined allelopathy as the effects of one plant on another plant via the release of chemicals into the environments; these effective compounds called allelochemicals (Whittaker and Feeney, 1971). Therefore, incorporating allelopathy in weed control may reduce the herbicides uses, environment pollution and diminish herbicide toxicity hazards (Chon *et al*., 2002).

Recent research identified a various species that possess chemicals capable of reducing the weeds development that associated with corn without causing significant damage to corn, including *Eucalyptus citriodora* L. (Family: Myrtaceae) and *Cucurbita pepo* L. (Family: Cucurbitaceae) (Abdallah and Amine, 2016), *Tithonia diversifolia* (Hemsl.) (Family: Asteraceae) (Oyerinde *et al*., 2009), *Sorghum halepense* L. (Poaceae) and *Cyperus rotundus* L. (Cyperaceae) (Soufan and Almouemar, 2009). Otherwise, weed control in corn can achieve with a reduced rate of the herbicides, without a yield loss (Kir and Doğan, 2009 and Pannacci and Covarelli, 2009). So, the main goal of this study is to achieve an effective weed control through the using a reduced rate of recommended herbicide Fluroxypyr tank mixed with the methanolic crude extracts of *E. citriodora* and *C. pepo* leaves.

Materials and Methods

1. **Collection of plant materials:**

In the flowering development stage, squash (*C. pepo*) and camphor (*E. citriodora*) leaves gathered from the Experimental Farm of Faculty of Agric., Tanta Univ., during 2007, at El-Gharbia Governorate.

2. **Preparation of methanolic crude extract *Cucurbita pepo* and *Eucalyptus citriodora*:**

Selected plants leaves were washed with tap water, air-dried for 15 days at room temperature (25± 2Cº). Dried leaves, milled to a fine powder, soaked in methanolic alcohol (400 g /1500 ml methanol). At room temperature, the solution stirred well at a rate of 100: 120 RPM by a shaker water bath, filtered through Whitman filter paper, evaporated to dryness. A 20% concentration prepared.

3. **Field experiments:**

To assess the allelopathic effect of plant extracts, 7 preparations of 0, 66, 75 and 100% of fluroxypyr herbicide + either of plant extract of squash or camphor examined against corn weeds (Table, 1). A field experiment conducted at the Experimental Farm, Faculty of Agric., Tanta Univ, during 2008 and 2009 corn growing seasons. The grains of corn cultivars (TWC 321 and TWC 351) seeded during the first week of June in both seasons. Corn cultivars seeds got from the Agricultural Research Center, Cairo, Egypt. Three seeds planted per hill, germinated seeds thinned to one seedling/hill after Two weeks after sowing. Corn plants received regular agricultural practices. The experiment laid out in a complete randomized block design (RCBD) with 3 replicates. Table (1) shows the different spray treatments used. The size of the experimental unit was 42 m^2. Soil texture was as clay soil (pH=7.82, organic matter = 0.91 and E. C= 2.6) without notable changes in the texture. Fluroxypyr herbicide, plant extracts, and the plant extract/fluroxypyr mixtures diluted with water and sprayed using a knapsack sprayer (Model CP3) fitted with one nozzle (2 ml / 1.5 liters). The spray has done once 15 days after sowing. Field samples and other observations logged, either with corn plants or weed population.

Table (1): Different treatments used in the field experiments.

No.	Weed control treatments	Code	Rate / Hectare
1	Control	C	----
2	Fluroxypyr (20 %)	F	480 ml/ Hectare
3	Plant extract of squash (20 %)	C.p	480 ml/ Hectare
4	Plant extract of camphor (20 %)	E.c	480 ml/ Hectare
5	Fluroxypyr + camphor leaf extract mixture (0.66: 0.33v/v)	F+E.c 2:1	320 ml + 160 ml = 480 ml/ Hectare
6	Fluroxypyr + *camphor* leaf extract mixture (0.75: 0.25 v/v)	F+E.c 3:1	360 ml + 120 ml = 480 ml/ Hectare
7	Fluroxypyr + *squash* leaf extract mixture (0.66: 0.33 v/v)	F+C.p 2:1	320 ml + 160 ml = 480 ml/ Hectare
8	Fluroxypyr + *squash* leaf extract mixture (0.75: 0.25 v/v)	F+C.p 3:1	360 ml + 120 ml = 480 ml/ Hectare
9	Hoeing (Hand weeded)	H	Twice (after 15, 45 day)

4. Weed development:

After 90 days of planting, weed samples collected within the two experimental sessions by harvesting the grown weeds from one square meter of each plot. Weeds identified and classified, dried at 105º C for 24 hours. The percent reduction in dry weight (% R) calculated according to the following formula: -

Dry weight reduction (% R)

$$= [(A - B) / A] \times 100$$

Whereas:

A = Dry matter weight of weed plants taken from the control/plot.

B = Dry matter weight of weed plants taken from treatment/plot.

5. Yield and its components:

At harvest stage (120 days from sowing), three inner rows chosen from each plot. Random samples (ten guarded plants) taken from each plot to estimate: number of rows/ears, number of grains/rows, 100 grains weight (g), ear weight (g), grain yield/plant (g) and total grain yield by kg/hectare.

6. Economic analysis:

Agriculture is an economic process. Therefore, the cost of production elements had calculated for the various weed control treatments, which represented in the (Land preparation and cultivation, seeds, mineral fertilizers, herbicides, pesticide spraying, hoeing, other pest control, the hiring charges of human labor, irrigation, harvesting and land rent). Gross revenue has calculated by multiplying the total yield in kg/ha and corn market price/kg. Net return (NR) calculated as the difference between the gross revenue and the total cost., the Benefit-cost ratio (BCR) calculated according to Li *et al.* (2005): BCR= NR/total Costs

7. Statistical analysis:

Data subjected to the proper statistical analysis as the technique of analysis of variance (ANOVA) of a complete randomized block design as described by Gomez and Gomez (1984). Means compared using the L.S.D. test as outlined by Waller and Duncan (1969). The computation was done using computer software MstateC version 3.4.

Results and Discussion

1. Weed biomass density:

Effect of fluroxypyr herbicide treatment on weed development compared with plant extracts or plant extracts/ fluroxypyr mixtures treatments studied after 90 days of corn planted (Figures, 1and 2).

Regarding season 2008, in all weed species, the weed control had the highest weed density. Also, in all weed species, except *Echinochloa colonum* L., the fluroxypyr herbicide treatments were the lowest weed density followed by 0.75 fluroxypyr +0.25 *E. citirodora* H. mixture and hoeing treatments. While with *E. colonum* weed species, the hoeing treatments were the most effective treatments for reducing weed biomass density followed by 0.75 fluroxypyr +0.25 *E. citirodora* H. mixture and the fluroxypyr herbicide treatments. There are no significant differences between the F herbicide treatments and F+E.c3:1in all treatments. The H treatments were the most effective treatments for reducing the *E. colonum* biomass density.

Regarding season 2009, the same trend had shown. Whilst, the highest weed density recorded in C treatments. The most effective treatments for reducing biomass density were the F herbicide treatments followed by F+E.c3:1mixture with *C. olitorius*, *A. retroflexus*, *P. oleracea* L. species. The H treatments were the most effective treatments in case of *E. colonum* species. There are no significant differences between the herbicide and F+E.c3:1 mixture treatment. The weed biomass increasing in all treatment with time, there is no significant difference between the two seasons.

Regarding *E. colonum* weed species, in all season, the H treatments were the most effective treatments in decline the weed biomass density, followed by F+E.c3:1 and F treatments. While in the other weed species, the lowest biomass density recorded in herbicide treatments, followed by F+E.c3:1mixture and H treatments. The C treatment had the highest weed density. There are no significant differences between the F and F+E.c3:1mixture treatments. Whilst there are significant differences between the two *Zea mays* hybrids treatments in weed biomass density. The hybrid TWC 321 had the lowest weed plant density.

Regarding *E. colonum* weed species, the most effective treatments for depressing the weed density were H following by F+E.c3:1mixture and F treatments. With respect too there weed species, the herbicide F treatments were the most effective treatments for dipping the weed biomass, followed by F+E.c3:1mixture and H treatments. The *C. pepo* plant extract and their mixtures treatments were the lowest effective one.

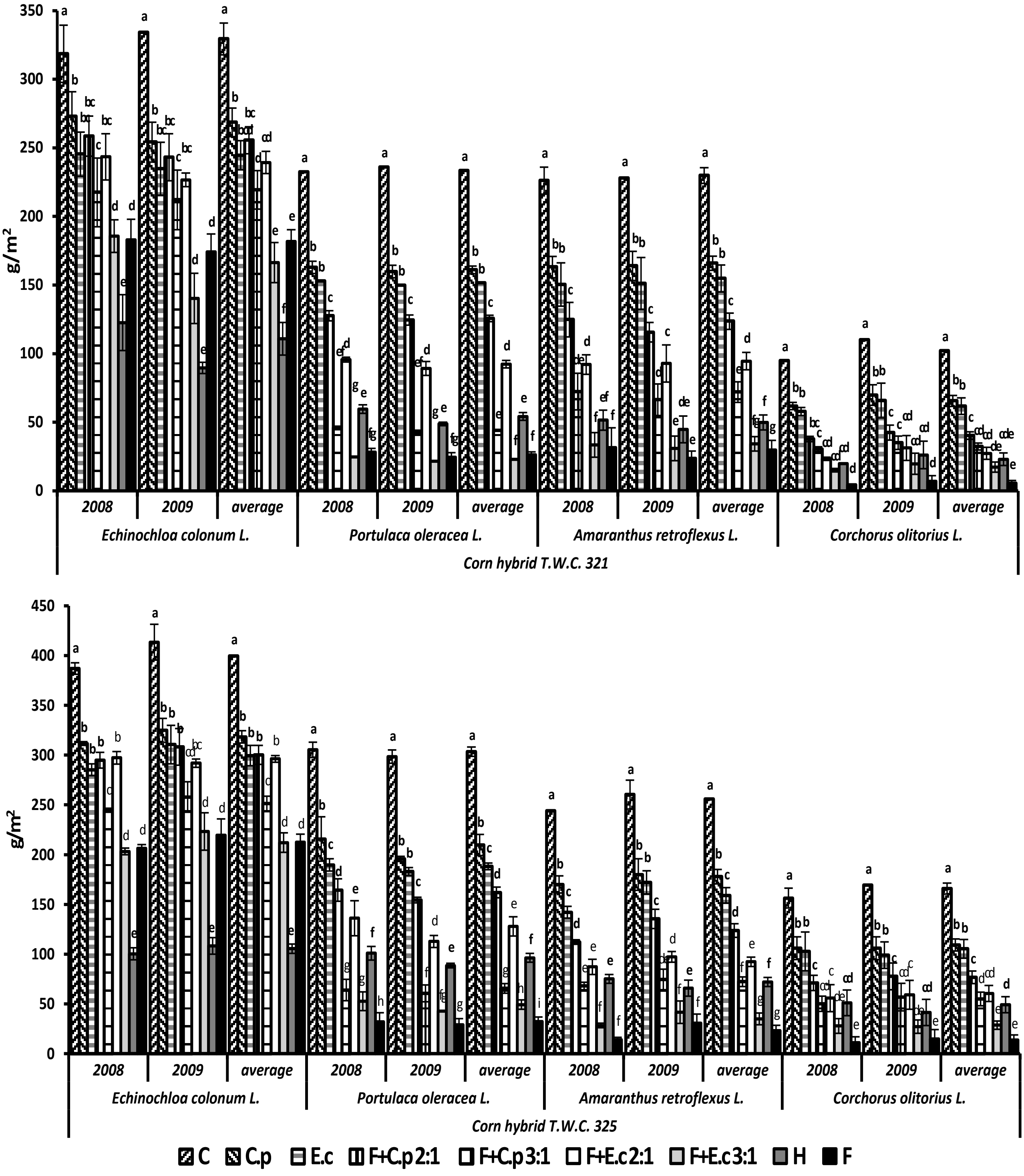

Figure (1): Effect of certain weed control treatments on weed biomass density.

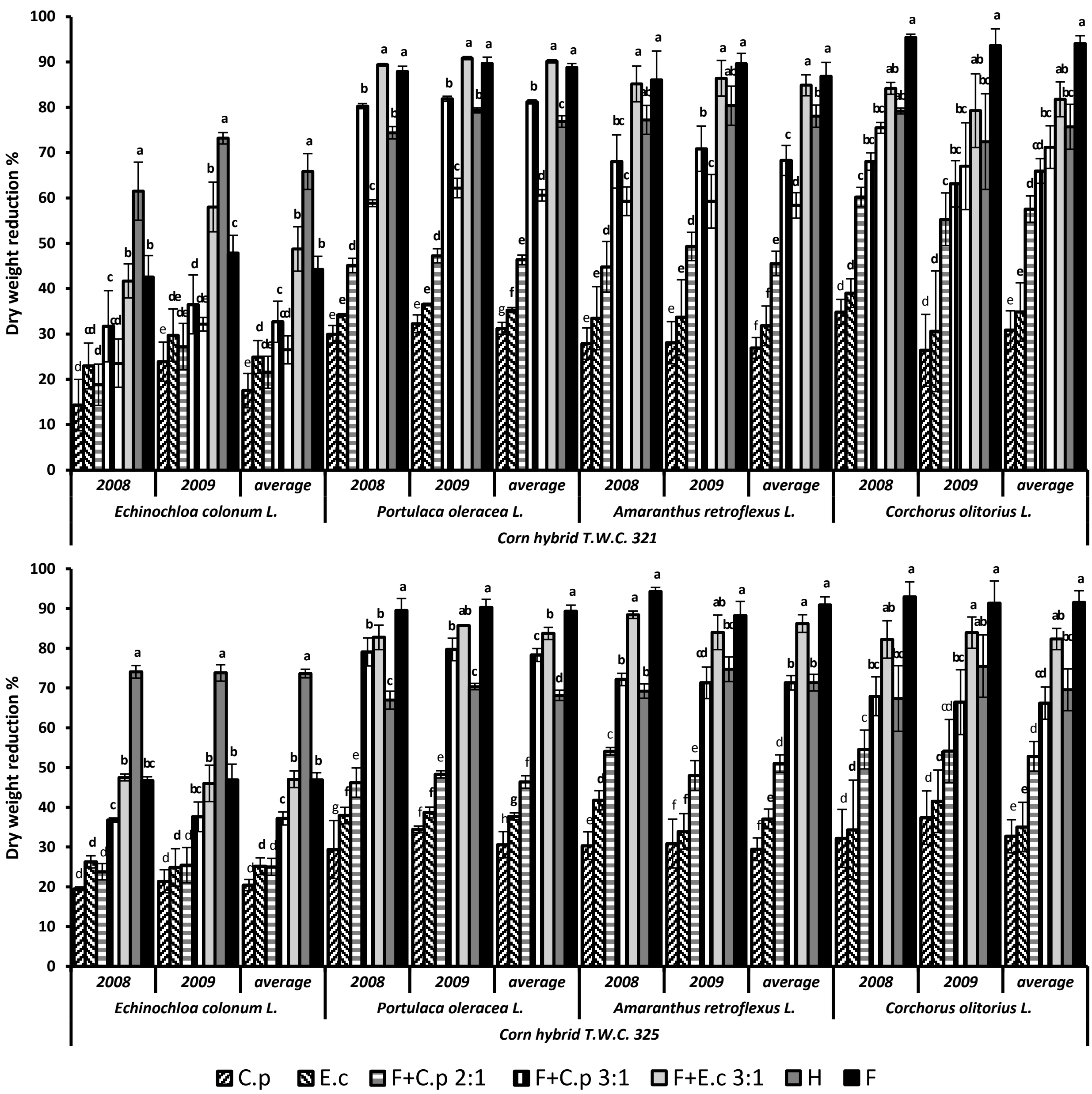

Figure (2): Dry weight reduction of certain herbs as affected by studied weed control treatments.

From the previous data, we can conclude that fluroxypyr herbicide treatments had the maximum efficacy against all weed's species except E. colonum species. The hoeing treatments were the most effective treatments for reducing the E. colonum biomass density. These outcomes concur with those of Abouziena et al. (2007), who stated that herbicide treatments had a selective activity in reducing the weed biomass while hoeing removes all weeds types. Similar funding show in other herbicides, (Guar et al., 1991) reported that apply atrazine 0.5 kg/ha had controlled the broad-leaved weeds, with no effect on the grass weeds. Pandey et al. (200l) found that Atrazine was more efficient against Ageratum conyzoides and less efficient against E. colonum and Brachiaria ramosa. Also, data revealed that; cultivars significantly influenced suppressing weed growth. Where the hybrid TWC 321 had the lowest weed plant density. This may be because of that TWC 321 hybrid was taller than TWC351(Amine 2013), also, maybe because of the differential rooting patterns, higher leaf area index, more light interception, vegetative growth habit and allelochemicals (Abouziena et al., 2008; Dhima et al., 2008 and Seavers and Wright, 1999). Similar findings on the effect of corn cultivars on weeds recorded by Begna et al. (2001) and Gurney et al. (2002). Abouziena et al. (2013) found that SC 164 had lower weed dry weight than that of SC 166 cv. In contrast, Oliveira et al. (2011) reported that no differences found between dry matters of weeds shoot that occurred in plots of the three cultivars tested.

2. Effect of certain weed control treatments on corn yield and yield component:

The effect of fluroxypyr herbicides, plant extract, and plant extracts/fluroxypyr mixtures on the corn yield and yield component studied (Figures, 3 and 4).

Data revealed that in season 2008: corn hybrid 321 treated with 0.66 fluroxypyr +0.33 *E. citirodora* (F+E.C2:1) mixture had the highest values of the raw No./ear. Whilst the control treatment had the lowest one. There are no significant differences among other treatments. While, with corn hybrid-351, there are no significant differences between treatments. There are significant differences between the two-corn hybrid. However, the 351-hybrid had the highest values in this respect.

Corn hybrid-321 control weeded and *C. pepo* plant extract treatments had the lowest values of grain No./raw. Whilst the F treatments were the highest one. Regarding corn hybrid-351, the highest grain No./raw values recorded in hoeing, F+E.c3:1, F+E.c2:1treatments. *C. pepo* plant extract and control treatments had the lowest values in this respect.

Regarding corn hybrid 321, the highest values of 100-grain weight recorded in F+E.c3:1treatments followed by hoeing and F+E.c2:1treatments. The weeded control treatment had the lowest values in this respect. Regarding corn hybrid-351, the control treatments had the lowest values in 100-grain weight. Whilst there are no significant differences among the other treatments.

In corn hybrid-321, ear weight/plant recorded the highest values with F herbicide, F+E.c3:1, F+E.c2:1and H treatments. The control-weeded treatments had the lowest values in this respect. Whilst, in the case of hybrid-351, F+E.c3:1, F+E.c2:1, H (twice) and *E. citirodora* plant extract treatments had the highest values of the ear weight/plant. Whilst control treatments had the lowest one.

Regarding corn hybrid-321, F treatments had the highest values of grain yield/plant (204.8g/plant) followed by hoeing and F+E.c3:1treatments (180.2, 189.0 g/plant respectively). Whilst, control treatments had the lowest values in this respect (61.7g/plant). With respect to corn hybrid-351, F+E.c3:1treatments overcome the other treatments in grain yield/plant (170.0 g/plant). Followed by the F, hoeing, and F+E.c2:1treatments (168.6, 167.7 and 166.9 g/plant respectively).

In season 2009, In the case of corn hybrid-321**,** H treatments had the highest values of rows No./ear. Whilst, the control treatments had the lowest values in this respect. There are no significant differences among the other treatments.

On the other hand, with respect to corn hybrid-351, control treatment had the lowest values of ear rows No./ear. There are no significant differences among the other treatments.

Corn 321-hybrid treated with F, H, and F+E.c3:1 had the highest values of the grain No./plant. No significant differences found among the other treatments.

With respect to hybrid-351, the highest values of grain No./ear recorded in F+E.c3:1treatments while *C. pepo* plant extract treatments had the lowest values in this respect.

Corn hybrid-321 control treatments had the lowest values of 100-grain weight. There are no significant differences among the other treatments. The same trend had shown in corn hybrid-351. With respect to corn hybrid-321, F treatments followed by hoeing and F+E.c3:1treatments had the highest values of ear weight/plant. The control treatments had the lowest values in this manner. With respect to corn hybrid-351, the F followed by F+E.c3:1 treatment had the highest values of the ear weight/plant. The control-weeded treatment had the lowest value in this respect.

Corn hybrid-321 treated with F+E.c3:1had defeat other treatments in grain yield/plant, followed by F, H and F+E.c2:1treatments (184.2, 184, 171.6 and 141.5 g/plant respectively.). In the case of *corn* hybrid-351, F treatment had the highest value of grain yield/plant (171.1 g/plant) followed by F+E.c3:1and F+E.c2:1treatments (165.1, 162.6 g/plant respectively). The weeded control had the lowest value in this respect (76.7 g/plant). With respect to the two corn hybrids, the control treatments had the lowest values of raw No./ear. There are no significant differences among the other treatments.

Grain No./raw had recorded the highest *values* in *corn* hybrid-321 treated with F and hoeing treatments followed by F+E.c3:1treatment. While in the case of *corn* hybrid-351 the highest values of grain No./raw had recorded in, F+E.c3:1treatment followed by H and F treatments. The control-weeded treatments had the lowest values of grain No./raw in the two hybrids.

Corn hybrid-321 treated with F+E.c3:1had the highest value of 100-grain weight followed by H and F treatments. Control-weeded treatment had the lowest value in this respect. With respect to corn hybrid-351, control-weeded treatment had the lowest value of 100-grain weight. There are no significant differences among other treatments.

Ear weight/plant had recorded the highest values in F, F+E.c3:1and H corn hybrid-321 treated treatments. However, control treatment had the lowest value in this respect. The same trend had shown in the case of corn hybrid-351. F, F+E.c3:1, and hoeing treatments had the highest values of ear weight/plant. Whilst the control-weeded treatment had the lowest one.

With respect to corn hybrid-321, F, and F+E.c3:1overcome the other treatments in grain yield/plant (194.4 and 186.6 g/plant respectively). Control treatment had the lowest value in this respect (61.02 g/plant). With respect to corn hybrid-351, F, F+E.c3:1, F+E.c2:1and H treatments had the highest values of grain yield/plant (169.8, 167.6, 164.8 and 157.8 g/plant respectively). The control treatment had the lowest value (57.5 g/plant).

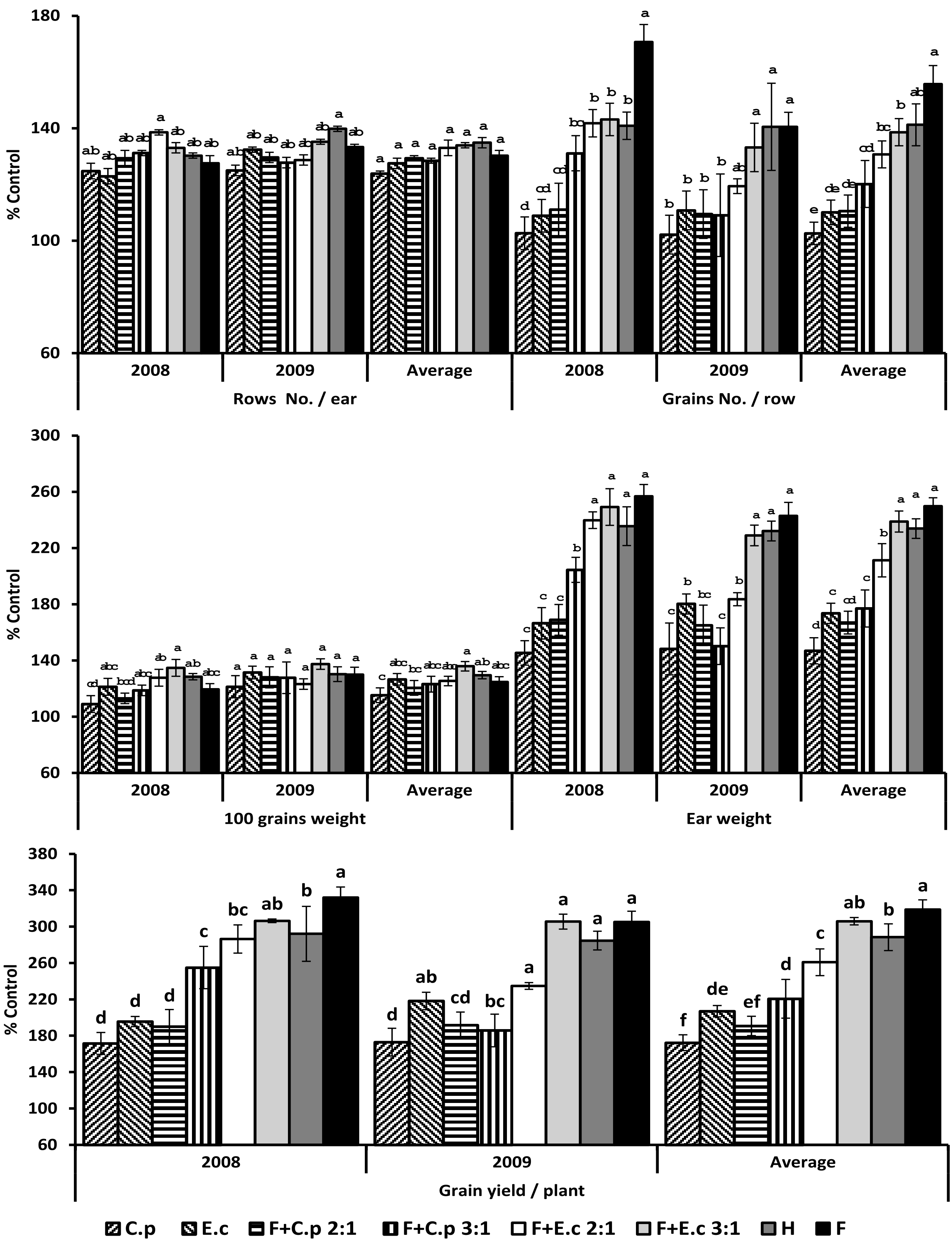

Figure (3): Effect of certain weed control treatments on corn yield and yield component of corn hybrid T.W.C 321.

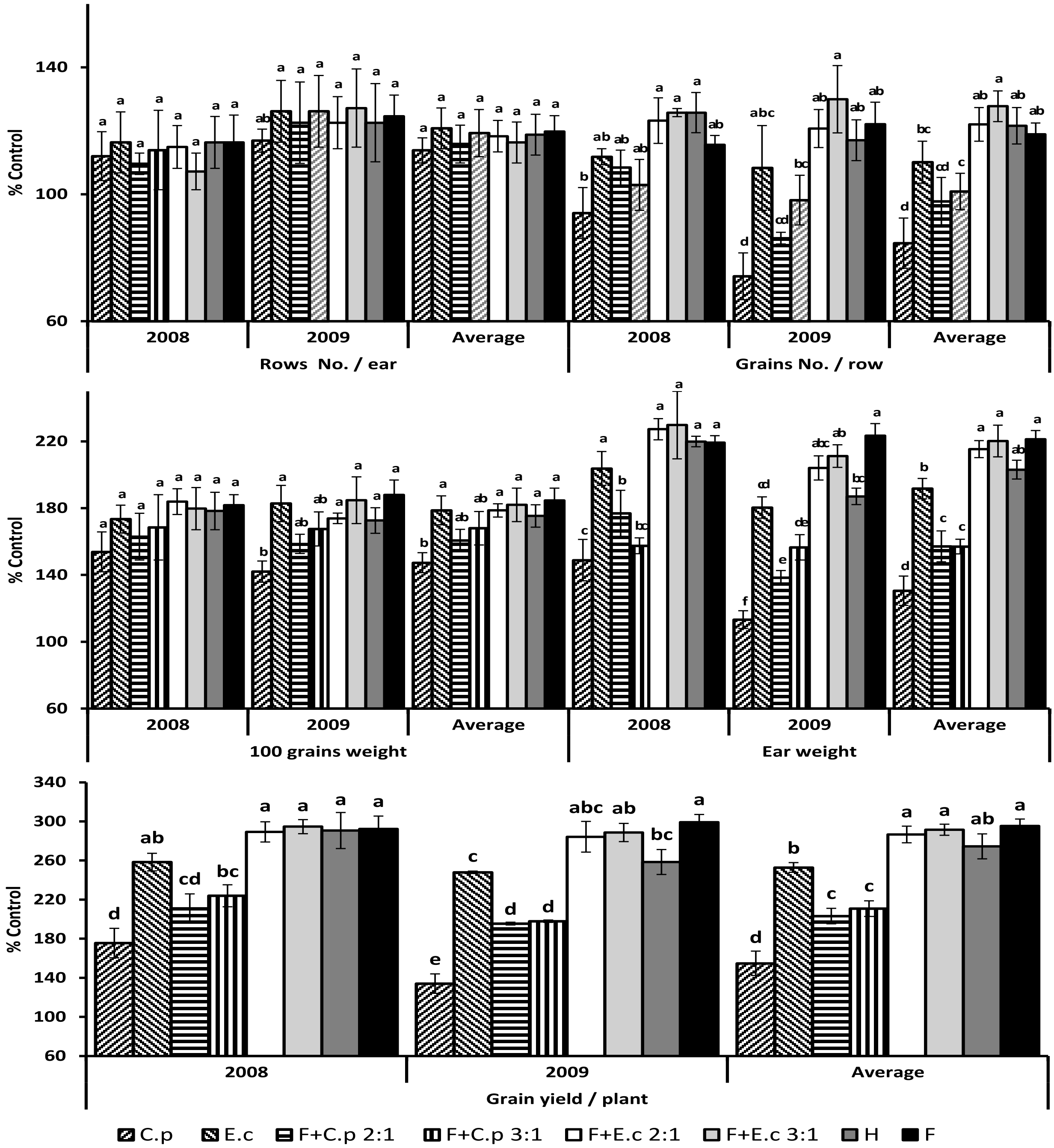

Figure (4): Effect of certain weed control treatments on corn yield and yield component of corn hybrid T.W.C. 325.

There is a significant difference between the two-corn cultivar in all yield and yield component characteristics. Significant differences in grain yield and yield components between corn cultivars reported by Ahmed and El-Housini, 2012; Abdel-Wahed et al., 2006; Maswada and El Gamal, 2013; El-Gizawy and Salem, 2010; Ibeawuchi et al., 2008; Mehasen and Al-Fageh, 2004; Salah et al., 2011 and Sedhom et al., 2012. These differences may be because of the genetical differences among cultivars and different genotypes regarding dry matter partitioning (carbon equivalent, yield energy/plant and per feddan for kernels and straw yields, shoot biomass and harvest index coefficient energy) (Salah et al., 2011.(

The control treatments had the lowest value in all parameters of yield and yield component., fluroxypyr herbicide treatments had the highest values in this respect. A similar finding observed by Mohammadi et al. (2012) who reported that full season weedy condition diminished 100-seed weight, seedling vigor index and seed protein content of the produced seeds. Also, Abouziena et al. (2013) reported that the control treatment had the minimum harvest index, with a significant reduction in seed protein and total soluble carbohydrates content. The significant diminish got in yield and yield parameters for un-weeded corn crop reflect the reduced effect of weed competition (Akobundu, 1992). While several researchers showed that fluroxypyr had a height efficacy in controlling weeds in corn (Abouziena et al., 2007 and Yehia et al. 1992). Ahmed et al. (2008) showed that Fluroxypyr provided the best treatment for controlling broad-leaved weeds.

Regarding corn hybrid-351, the fluroxypyr herbicide treatments had followed by the 0.75 fluroxypyr +0.25E. citirodora (F+E.C3:1) treatments and 0.66 fluroxypyr+0.33E. citirodora (F+E.C2:1) treatments with no significant difference among them, that in all yield and yield component criteria. While hoeing treatments influenced it. Regarding corn hybrid-321, the fluroxypyr herbicide treatments followed by hoeing treatments on grain no./raw, raw no./ear parameters. While fluroxypyr herbicide treatments followed by 0.75fluroxypyr +0.25E. citirodora (F+E.C3:1) treatments and hoeing in 100-grain weight and ear weight/plant, with no significant difference among them.

Regarding the two corn hybrids, regardless of control treatment, there are no significant differences among the other treatments in the values of raw No./ear. This agrees with, Abouziena et al. (2013) who report that no critical varied between the two cultivars tested in raw No./ear, kernels No. /row, ear grain weight, and biological yield criteria.

Using a reduced rate of herbicide (75% of recommended rate) mixed with the E. citirodora plant extract had secure the same effect in reducing biomass of weed. In addition, this mixture was more effective in controlling the narrow-leaved weeds E. colonum. This may due to that E. citirodora plant extract influenced seed germination of E. colonum (AbdAllah and Amin, 2016). Anyway, many researchers found that using a low rate of herbicide gave a sufficing weed control in corn crop (Abouziena et al., 2013; El-Metwally et al., 2002 and Parwada and Mudimu, 2011.(

Use of allelopathic plant extracts with reduced rates of herbicides to control weeds in arable crops has become turned into an entrenched fact (Jabran et al., 2008). The effect of combined Allelopathic plant extracts and herbicides application helps to reduce the amount of herbicide used (Cheema et al., 2005 and Razzaq et al., 2012.(

For instance, reduced rates of herbicides like glyphosate, bromoxynil, butachlor, ethoxysulfuron ethyl, iodosulfuron, isoproturon, MCPA, mesopleuron, metribuzin, peninsula, fenoxaprop, fenoxaprop-p-ethyl, pretilachlor when tank mixed with allopathic water extracts of crops (sorghum, sunflower, brassica, rice) proffer booming weed control in cotton, brassica, wheat and rice (Cheema et al., 2010; Elahi et al., 2011; Iqbal et al., 2009; Mahmood et al., 2009; Razzaq et al., 2010 and 2012; Rehman et al., 2010 and Wazir et al., 2011). Likewise, Khaliq et al. (2012) assess the economic effect of reduced rates (a quarter and a half of the label dose) of a post-emergence bispyribac sodium herbicide applied alone or in a blend with Eucalyptus camaldulensis Dehnh., Mangifera indica L., and Morus alba L. water extracts in direct seeded rice (Oryza sativa L.) fields. They found that tank mixing of E. camaldulensis water extracts with reduced herbicide dose were more effective in suppression the weed density and dry weight than those recorded for the same herbicide dose used alone. Shahid et al.

(2007) tested the herbicidal potential of aqueous extracts of sorghum (Sorghum bicolor), sunflower (Helianthus annuus), johnsongrass (Sorghum helepense), neem (Azadirachta indica), eucalyptus (Eucalyptus camaldulensis) and acacia (Acacia nilotica) alone and in incorporation with herbicides against weeds of wheat. They found that blend of Sunflower extracts with Carfentrazone–ethyl ester (half of the label dose) exhibited almost similar weeds control and gain more wheat grain yield.

3. Benefit-cost ratio (BCR) and net return (NR):

The benefit-cost ratio (BCR) and net return (NR) affected by weed control treatments (Table, 2). Regarding corn hybrid-321, Benefit cost ratio (BCR) had recorded the maximum values in fluroxypyr (F), 0.75 fluroxypyr +0.25 *E. citirodora* (F+E.c3:1) and hoeing(H) corn hybrid-321 treated treatments. While control(c) treatment had the lowest value in this respect (2.49, 2.37, 2.07 and 0.15 respectively). The similar trend had shown with corn hybrid-351 F, F+E.c3:1and F+E.c2:1treatments had the highest values of BCR (1.90, 1.88, and 184 respectively), followed by the H treatment (1.62). Whilst the C treatment had the lowest one (0.03).

When taking a net return (NR) into consideration, the herbicide treatments had the highest values of NR (2773.08 and 2120.14 $/ha for corn for hybrid-321 and 351 respectively). Followed by the 0.75 fluroxypyr +0.25 *E. citirodora* (F+E.c3:1) treatments (2624.12 and 2083.94 $/ha for corn hybrid-321 and 351 respectively).; hoeing treatments had a moderate NR (2371.01 and 1857.58 $/ha for corn hybrid-321 and 351 respectively), because of the high costs of the hoeing process compared to other treatments.

Table (2): Inputs and outputs items of maize crop as affected by weed control treatments (means over 2008 and 2009).

Economical items	Characters	Unit	Weed control treatments								
			C	F	C.P	F+C.P 2:1	F+C.P 3:1	E.C	F+E.C 2:1	F+E.C 3:1	H
List of inputs	Land preparation and cultivation	$ ha^{-1}	52	52	52	52	52	52	52	52	52
	Seed price		86.6	86.6	86.6	86.6	86.6	86.6	86.6	86.6	86.6
	Mineral fertilizers		129.9	129.9	129.9	129.9	129.9	129.9	129.9	129.9	129.9
	Herbicide price		-	32.5	4.3	23.1	25.4	4.3	23.1	25.4	-
	Spray cost		-	21.7	21.7	21.7	21.7	21.7	21.7	21.7	-
	Hoeing cost		-	-	-	-	-	-	-	-	86.6
	Another pest control		43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3
	Labor costs		43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3	43.3
	irrigation		121.2	121.2	121.2	121.2	121.2	121.2	121.2	121.2	121.2
	Harvesting		64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9	64.9
	Land rent		519.5	519.5	519.5	519.5	519.5	519.5	519.5	519.5	519.5
Total cost ha^{-1} season^{-1}			1060.6	1060.6	1114.7	1086.6	1105.3	1107.7	1086.6	1105.3	1107.7
TWC 321 hybrid											
List of outputs	Grain yield	Kg ha^{-1}	3196.3	10182.3	5503.1	6097.1	7050.5	6607.9	8333.8	9773.8	9214.3
	Farm gate price (locally price)	$ Kg^{-1}	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Gross revenue		$ ha^{-1}	1220.40	1220.4	3887.8	2101.2	2328	2692	2523	3182	3731.8
Net return (NR)		$ ha^{-1}	159.8	159.8	2773.1	1014.6	1222.7	1584.3	1436.4	2076.7	2624.1
Benefit-cost ratio (BCR)			0.15	2.49	0.93	1.11	1.43	1.32	1.88	2.37	2.07
TWC 351 hybrid											
List of outputs	Grain yield	Kg ha^{-1}	3009.8	8895.9	4662.4	6118.6	6347.0	7617.8	8629.8	8777	8263.1
	Farm gate price (locally price)	$ Kg^{-1}	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
Gross revenue		$ ha^{-1}	1094.5	3234.9	1695.4	2225	2308.0	2770.1	3138.1	3191.6	3004.8
Net return (NR)		$ ha^{-1}	33.9	2120.1	608.9	1119.6	1200.3	1683.5	2032.8	2083.9	1857.6
Benefit-cost ratio (BCR)			0.03	1.90	0.56	1.01	1.08	1.55	1.84	1.88	1.62

Notes: (C), Control; (F), Fluroxypyr ; (C.p), C. pepo plant extract; (F+C.p2:1), Fluroxypyr+C. pepo(0.66 :0.33); (F+C.p3:1), Fluroxypyr+C.pepo(0.75 :0.25); (E.C), E.citirodora plant extract; (F+E.c2:1), Fluroxypyr +E.citirodora(0.66 :0.33); (F+E.c3:1), Fluroxypyr+E.citirodora (0.75 :0.25); (H); Hoeing; (Exchange rate: EGP (LE) ≈ 0.18 US$; rate in 2009.)

It is conclded that the effective weed control through the use of a reduced rate of herbicide (75% of the recommended rate) mixed with the *E. citirodora* plant extract. But, maximum values of benefit-cost ratio (BCR) had recorded in fluroxypyr (F) and 0.75 fluroxypyr +0.25E. This means that the use of herbicide fluroxypyr was more effective compared with the reduced dose of herbicides/plant extract mixture. This may be because of the low price of the herbicide and low cost of herbicide spraying process, in that time. But it compensates desired to benefit lowering environmental pollution and reduce toxicity to non-target organisms. Also, the tank mixed technique has difficulties, which represented in the difficult to implement by the simple farmer. Therefore, we hope to study how to convert plant extracts into formulation ready-to-use.

Conflict of Interest

The present study was performed in absence of any conflict of interest.

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