J. of Plant Production, Mansoura Univ., Vol. 11 (2): 127 - 137, 2020

Journal of Plant Production

Journal homepage: www.jpp.mans.edu.eg
Available online at: www. jpp.journals.ekb.eg

Determination Critical Periods of Weed Competition and Weed Control Influence on Yield Productivity of Sweet Pepper (*Capsicum annuum* L.)

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ABSTRACT

Field experiments were carried out at Sids Research Station, Agricultural Research Center during 2016 and 2017seasons to determine the critical period of weed competition in pepper yield and study the effect of some pre-emergence herbicides on controlling weeds and its reflection on yield and its component of pepper. It could be concluded that some safe alternatives to mechanical weed control hand hoeing (twice), are the use of mulching by black polyethylene or reduced rate of pendimethalin (0.850 L.\fed) and butralin (1.25 L.\fed.) for weed control during the pepper crop to produce good fruit yield free from herbicidal residues. Mathematical models between weed-free duration periods were quadric 8.3 and 7.0 weeks from transplanting. The application of pendimethalin at 0.850 l.\feddan supplemented with one hand hoeing and black polyethylene mulch were the best treatments to reduce weed biomass, followed by hand hoeing twice and butralin at 1.25l.\feddan supplemented with one hand hoeing to face weed problem in critical period of weed competition and herbicidal residues in edible pepper fruits were below the maximum residue limit. The relationship between all characters were negatively and significant correlated with weed biomass and positive with pepper fruit yield in both seasons. Practical implications of this research are that planting pepper need weed management in 8 weeks from transplanting from weed competition which can be achieved by either the use of pendimethalin or butralin at a full recommended rates or followed by one hand hoeing or black polyethylene mulching to prevent early weed competition to pepper crop.

Keywords: Pepper(*capsicum annuum* L.), critical period, competition, weed control, residues herbicides.

INTRODUCTION

Pepper (*Capsicum annuum* L.) is an important vegetable crop widely grown in world had long growing season and favorable to the growth of weeds (Granberry and Colditz, 1990). One of the first steps in designing optimal weed control system is to identify the critical period of weed control in any crop (Swanton and Wise 1991). The critical period in the crop growth cycle during which weeds must be controlled to prevent yield loss (Neito *et al.* 1968). In general, critical period has a beginning and end. Weeds emerged before or after the critical period may not represent a threat to crop yield. This information can aid farmers in making decisions on the need for and timing for weed control (Knezevic et al 2003). Khan *et al.* (2012) mentioned pepper is less competitors to weeds, which can cause pepper yield loss by 60–80% where decreased number of pepper fruits per plant which are proportional to the duration of weeds competition. So, weed management is the key for increasing both yield and quality of pepper. Some researchers tried to determine the critical period of weed interference in pepper as Pyon *et al* (1999) and Blanco *et al* (2018) found that chili pepper required an average of 12.2 weeks of weed-free maintenance to avoid losses above 5%. Using a 5% yield loss level and about 2-9 weeks after transplanting when weed infestation significantly depressed in plant height and vigor, number of the branches and fruits per plant and fruit yield. Zimdahl (2004) cited that weed-free period (weeks) required after transplanting with 5% yield loss 6.7-15.3 weeks. Hoeing is still the most common weed control method in vegetable crops because it has a high weed control efficacy. On the other side, hoeing is high cost, the labor is unavailable in some regions and it is unsuitable for large farms and there is a need for some alternatives to weed control in pepper as the use of plastic mulch, selective grass herbicides, but no herbicides registered for control broadleaved weed in pepper in Egypt.

Ashrafuzzaman *et al.* (2011), Khan *et al.* (2012) and Shehata *et al.* (2017) found that black plastic mulch was suppressed the weed growth and thereby, increased plant height, number of primary branches and fruit yield of pepper, the fruits had the highest vitamin-C content, but, did no effect on fruits length and diameter. The lowest weed density at 90 DAP was recorded in black plastic mulches, mulch treatments produced yield similar to hoeing, plastic mulch is recommended for weed control in green pepper, for better conservation of soil moisture and nutrients for good crop growth and higher yield. Suwon and Judah (1985) and Singh *et al.*, (1988), reported that soil temperature increased with the use of plastic mulch. Mulching stimulates the microbial activity in soil through improvement of soil agro-physical properties (Strizaker *et al.*, 1989). Mulching also, improves the soil physical condition (Kwon *et al.* 1988) and could account for increased yield (Siti et al. 1994 and Nagalakshmi et al. 2002) and Ocharo *et al.* (2018) found that black plastic mulch was the superior treatment in controlling

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DOI: 10.21608/jpp.2020.79106

broadleaved, grassy, and total weeds, then metribuzin herbicide came in the second rank in controlling broadleaved weeds. pendimethalin is very good efficacy on weeds (Subhra and Pabirta, 2014 and Glatkova and Pacanoski, 2019). Up till now, there is no sustainable strategies for integrated weed management in pepper in Egypt. This need to throw lights about weed pepper interference or registered herbicides or other alternative methods for weed control in this crop. The main goals of this work were to determine the critical period of weed competition and study the effect of different weed control methods in pepper field with monitoring herbicidal residues in pepper fruits.

MATERIALS AND METHODS

Four field experiments were carried out at Sids Horticultural Research Station, Beni-Suef Governorate, Horticultural Research Institute, Agricultural Research Center, Egypt, in clay soil during the two successive summer seasons 2016 and 2017. Two of them were to determine the critical period for weed control in pepper and the other two experiments to study effect of twelve weed control treatments on weeds, yield and its component as well as monitor residue of herbicides in the fruit of Golf cv. pepper (*Capsicum annuum* L.).

Critical period of weed /pepper competition (1st two experiments):

According to the scheme designed by Dawsan (1970) to study time and duration of weed infestation in relation to weed-crop competition. Twelve treatments applied in two groups up to 0, 2, 4, 6, 8 and 10 weeks after transplanting for each. 1st group of treatments was as six initial weed-free periods in which plots were kept free of weeds for 0, 2, 4, 6, 8 and 10 weeks after transplanting (WAT), and then weeds were allowed to grow until harvest. 2nd group of treatments (opposite the 1st group) was as another six initial weed-infested periods in which, weeds were allowed to grow for 0, 2, 4, 6, 8 and 10 WAT, after which the plots were kept free of weeds until harvest. A randomized complete block design with four replications was used where weed were removed manually. For determination the critical period of weed/pepper yield competition biological yield curve with time of weed removal or weed competition were drawn as well as mathematical models which fit this relationship. The quadratic equation was fit to determine the beginning of the critical period for weed control (CPWC), and the compere equation was used to determine the end of the CPWC for acceptable yield loss levels of 10%. Goodness of fit was studied in terms of minimum mean square error (MSE) and maximum R^2, as $y = a + bx + cx^2$ (Neter *et al*., 1990), where y = the pepper yield kg/m^2 in ton, a= the y intercept, b = the linear coefficient of regression, c= the quadratic coefficient of regression, x = the duration of applied weed-free or weed-competition period.

Weed control experiments (2nd two experiments):

The effect of twelve treatments for weed control on weeds, yield and its component of pepper (*Capsicum annuum* L.) cv. Golf, in a randomized complete block design with three replicates. The treatments is pre-emergence herbicides *i.e.,*

1- Amex 48% EC (butralin) was applied at rate 2.5 L/feddan on soil surface as pre transplanting irrigation.
2- Amex 48% EC(butralin) at rate 1.25 L/fed. as pre-transplanting irrigation then followed by hand hoeing after 45days from transplanting.
3- Stomp extra 45.5% CS (pendimethalin) was applied at rate 1.7 L /fed. as on soil surface as pre transplanting irrigation.
4- Stomp extra 45.5 % CS (pendimethalin) at rate 0.850 L/fed. as pre- transplanting irrigation then followed by hand hoeing after 45 days from transplanting.
5- Harness 84 % EC (acetochlor) was applied at rate 0.75 L/fed. as on soil surface as pre transplanting irrigation.
6- Harness 84 % EC (acetochlor) was applied at rate 0.5 L/fed. as pre transplanting irrigation then followed by hand hoeing after 45 days from transplanting.
7- Sencor 70 % WP (metribuzin) was applied at rate 150g/fed. as post-emergence at 14 days from transplanting.
8- Sencor 70% WP (metribuzin) applied at rate 100 g/fed. as pre transplanting irrigation then followed by hand hoeing after 45 days from transplanting.
9- Black polyethylene mulch 0.150 mm thick pre transplanting.
10- Rice straw mulch.
11- hand hoeing (twice) at 20 and 45 days after transplanting.
12- Unweeded check.

Herbicides were applied by CP3 knapsack sprayer with 200 l. water/feddan, while plastic sheets covered soil surface. The holes were made using mineral tubes with sharped edge with 30 cm distance between the holes. The used herbicides characteristic were mentioned in Table (1).

Experimental layout

In all experiments, on 17th and 24th April of 2016 and 2017 successive summer seasons, respectively, Golf cv. Pepper plants 40 days old were transplanted, in hills, to open experimental field in four rows, 4 m long and 0.8 m wide. The experimental unit area was 12.8 m^2. The other agricultural practices were done as recommended, considering the special treatments for each experiment.

Data recorded

In the experiment critical period of weed/pepper competition weed, treatment of weed free periods the weeds removal in the certain time for treatment and leave to the end of the season and then weed survey were taken.

While, the treatment of weed competition periods the weed were left for the certain time and weed survey were taken and then removed weeds to the end of the growing season. In the experiment weed control treatments, weed assessment was carried at 70 days from pepper transplanting. Weeds were hand pulled from one square meter randomly chosen from each plot were identified according to Tackholm (1974) and classified into their species and divided into the following groups, *i.e.*, grassy, broad- leaved and total of Annual weeds and recorded fresh weight of each group (g/m^2). On 70 days from pepper transplanting, three pepper plants were randomly chosen from each plot to evaluate of vegetative growth traits as, plant height (cm), number of branches/plant, both fresh and dry weight plant (g/plant). The collecting pepper fruits at marketable green-maturity stage were randomly chosen from each plot to estimate, fruit length (cm), fruit diameter (cm), fruit weight(g) and fruits weight/plant(g). The fruits were collected five times when having attained full size and estimated the fruit yield (ton/feddan). Fruit samples were randomly taken from each experimental plot to determine vitamin C (ascorbic acid) content as mg per 100g fresh fruit weight according to methods of A.O.A.C. (1990) and total soluble solid (TSS) by hand refractometer.

Table 1. Trade names, common names, formulations % a.i., chemical names and mode of action of the four herbicides used in the current study.

Trade name	Common name	Formulation and a.i. %	Chemical name	Mode of action
Amex	butralin	48% EC	4-(1,1-dimethylethyl)-N-(1-methylpropyl)-2,6 dinitrobenzenamine	Inhibits microtubule formation and disrupting cell division.
Stomp extra	pendimethalin	45.5% CS	(N-(1-ethylpropyl)–3,4dimethyl2,6dinitrobenzenamin	Inhibits cell division and cell elongation. It is listed in the K1-group according to the HRAC classification.
Harness	acetochlor	84% EC	2-chloro-N-ethoxymethyl-6'-ethylaceto-o-toluidide	Inhibits cell division by blocking protein synthesis; more recent research suggests chloroacetamide may inhibit synthesis of very long chain fatty acids
Sencor	metribuzin	70% WP	4-amino-6-(1,dimethylethyl)-3-(methylation)1,2,4-triazip-5 (4H) one	Photosynthetic electron transport inhibitor at the photosystem II receptor site. Selectivity is due to metabolism (mostly conjugation) within the plant.

Herbicides residues determination

Herbicides residues of Amex (butralin), Stomp extra (pendimethalin), Harness (acetochlor) and Sencor (metribuzin) in pepper fruits (at 80 days after transplanting) were determined according to the method of EL-Beit *et al.* (1978) with some modifications in Central Laboratory for Pesticides, Agriculture Research Center, Dokki, Giza, Egypt.

Statistical analysis

All data were statistically analyzed according to the method described by Snedecor and Cochran (1981). Means were compared using Duncan's multiple range test as published by Duncan (1955). All statistical analyses were performed using analysis of variance technique by means of MSTATC computer software package (Freed *et al*., 1991). The relative and actual yield was subjected to analysis of variance using regression curve, estimation functions to analysis of statistical procedures for social sciences (SPSS 16 for windows). Equations describing crop yield response to weed interference treatments were fitted to the pepper fruit yield data using a nonlinear regression analysis according to the procedure outlined by Knezevic *et al*., (2003). The simple correlation coefficients were calculated following Singh and Chaudhary (1985).

RESULTS AND DISCUSSION

Critical period of weed / pepper competition (1st two experiments)

Predominated weed species in weed community in the experimental fields in both seasons were *Portulaca oleraceus* L., *Hibiscus trionum* L., *Amaranthus virdis* L., *Corchorus olitorius* L., *Sonchus oleraceus* L., *Malva parviflora* L., *Euphorbia geniculata* L., *Chenopodium album* L., and *Solanum nigrm* L. as annual broad-leaved weeds and *Echinochloa colonum* L. and *Brachiaria eruciformis* L. as annual grassy weeds. Data in Table (2) showed that the rate of weed infestation in unweeded check treatment was heavy and reached to 5442 and 5788 g/m^2 (22.86 and 24.31 ton/feddan) fresh weight for weed species mixture which caused the loss of pepper yield estimated by 89.74 and 91.89 % as compared to the pepper yield of weed-free treatments in 2016 and 2017 seasons, respectively. These results are in agreement with those obtained by Granberry and Colditz 1990 and Khan *et al.* 2012, they found that weeds can cause pepper yield loss by 60-80%. Thus, this level of weed infestation, enough sufficient to estimate yield losses precisely under various weed removal or competition periods for estimating the critical period of weed/pepper competition periods. Results showed that increasing intervals of weed removal gave gradual decrease in the weight of total weeds until the twelve treatments periods (ten weeks) in both seasons. Table (2) show the significantly effects of weed free or weed competition durations period on the pepper studied traits, *i.e.,* plant height, number of branches/plant, fruit length, fruit diameter, fruit weight, fruits weight/plant and fruit yield/feddan in both seasons. These characters tended to increase gradually with increasing weed–free durations. The plant height, number of branches/plant, fruit length, fruit diameter, fruit weight, fruits weight/plant and fruit pepper yield/feddan increased by 28.11, 45.38, 58.73, 42.86, 73.20, 92.58 and 89.74 % more than weed competition for whole season in 2016 season and 34.34, 43.59, 47.62, 42.55, 70.66, 93.24 and 91.89 % than weed competition for the whole season in 2017 season, respectively. These results indicate clearly that pepper quality and yield traits improved with elimination of weeds in pepper field and need to be cleaned from weeds all over the season. These results are in agreement with those obtained by Granberry and Colditz 1990 and Khan *et al.* 2012. Estimation the critical period (CPWC) for weed competition in pepper fields by biological curve and regression (mathematical models) approach were performed. Fig (1) show that determine the critical periods from biological curve which draw the relationship between pepper yield as ton per feddan and weed competition or removal periods that the critical weed competition duration extend from two weeks after pepper transplanting until eight weeks and the critical point where pepper yield losses from early or late weed competition is equal like five weeks from transplanting.

Table 2. Effect of weed competition durations on growth and pepper yield ton/fed. during 2016 and 2017 seasons.

Characteristics Weed competition period	Total weeds (g/m²)	Plant height (cm)	Branches /plant	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)	Fruits weight/ plant (g)	Fruit yield (ton/fed.)
				2016				
WFP for 2W	3760.0 b	55.0 e	3.1 c	3.7 f	3.8 c	21.0 g	280.0 g	3.2 e
WFP for 4W	1876.0 e	61.2 d	3.5 b	4.8 d	4.3 b	32.0 d	481.0 e	4.5 d
WFP for 6W	1109.7 g	65.0 c	3.8 a	5.5 c	4.7 a	34.0 c	530.0 d	5.9 c
WFP for 8W	313.7 i	66.0 bc	3.9 a	6.0 b	4.8 a	35.0 b	580.0 c	6.9 b
WFP for 10W	188.0 j	67.0 ab	3.9 a	6.2 ab	4.8 a	35.5ab	599.0 b	7.6 a
WFP for WHS	19.3 i	68.3 a	3.9 a	6.3 a	4.9 a	36.2 a	633.1 a	7.8 a
WCP for 2W	109.0 k	60.0 d	2.9 cd	4.8 d	4.2 b	30.0 e	390.0 f	7.0 b
WCP for 4W	834.0 h	56.0 e	2.7 d	4.0 e	3.9 c	24.5 f	200.0 h	6.1 c
WCP for 6W	1491.7 f	51.0 f	2.4 de	4.0 e	3.3 d	15.0 h	130.0 i	4.3 d
WCP for 8W	2036.0 d	48.0 gh	2.2 ef	3.2 g	2.8 e	12.0 i	90.0 j	2.5 f
WCP for 10W	3176.3 c	47.0 h	2.1 ef	2.8 h	2.7 e	10.5 j	66.1 k	1.4 g
WCP for WHS	5442.0 a	49.1 g	2.13 b	2.6 h	2.8 e	9.7 j	47.0 l	0.8 h
				2017				
WFP for 2W	3870.0 b	62.3 c	3.3 d	4.7 e	3.9 e	17.3 e	200.5 g	3.1 f
WFP for 4W	2092.0 e	64.5 b	3.4 c	5.3 d	4.2 cd	21.0 d	350.5 e	4.8 d
WFP for 6W	1172.0 g	65.9 ab	3.7 b	5.8 c	4.4 bc	22.7 c	435.9 d	5.9 c
WFP for 8W	324.0 i	66.0 ab	3.7 b	6.0 bc	4.5 ab	25.0 b	495.0 c	7.0 b
WFP for 10W	213.0 j	66.2 ab	3.8 a	6.0 b	4.6 ab	25.0 b	527.1 b	7.0 b
WFP for WHS	23.0 i	66.4 a	3.9 a	6.3 a	4.7 a	31. 7 a	590.5 a	7.4 a
WCP for 2W	132.3 k	56.2 d	3.0 e	4.3 f	4.0 de	20.3 d	356.0 e	7.0 b
WCP for 4W	880.7 h	52.0 e	2.7 f	3.9 g	3.2 f	15.3 f	221.6 f	6.1 c
WCP for 6W	1765.0 f	49.8 f	2.6 f	3.6 h	2.8 g	13.3 g	130.6 h	4.3 e
WCP for 8W	2367.0 d	46.3 g	2.4 g	3.5 hi	2.7 g	10.2 h	88.0 i	2.7 g
WCP for 10W	3246.0 c	44.6 h	2.4 g	3.1 j	2.6 g	9.0 h	55.5 j	1.7 h
WCP for WHS	5788.0 a	43.6 h	2.2 g	3.3 ij	2.7 g	9.3 h	39.9 k	0.8 i

WHS: treatments for Whole season WFP: weed free period WCP: weed competition period
Means followed by the same alphabetical letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

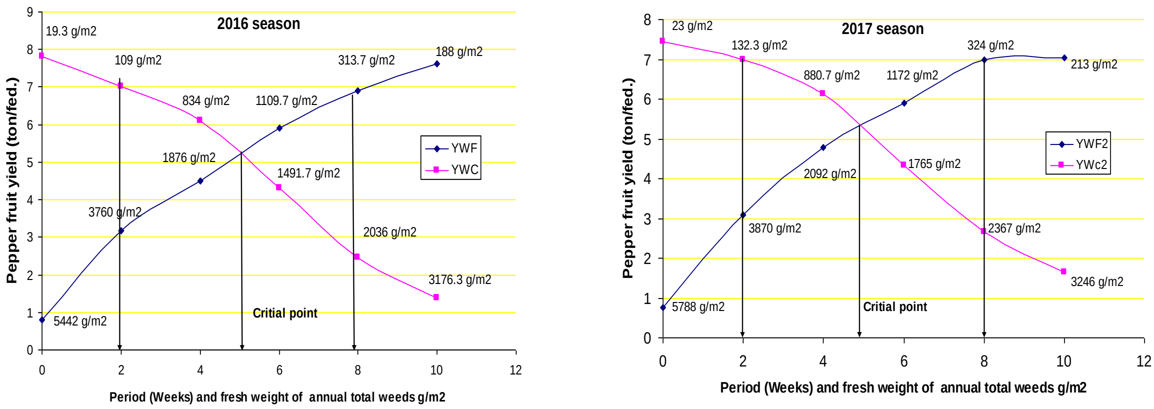

Fig 1. Biological curve of weed competition or weed removal periods for pepper yield (ton\feddan).

In these approaches, three mathematical models being, *i.e.*, linear, quadratic, and logistic models were used to know the fitness which fit to describe the relationship between pepper yield (ton/fed.) and the period of weed removal or weed competition. It was clearly that (Table 3 & 4) the suitable model which fitted for prediction yield losses in pepper is quadratic equation because the correlation coefficient (r^2) was greater than linear or logistic models and standard error (SE) were smaller than they those of the mentioned models in the two seasons. The respective values of r^2 (SE) for quadratic model were 0.984 (0.321) and 0.994 (0.185) for weed-free and being 0.983 (0.198) and 0.980 (0.182) for weed-competition in 2016 and 2017, respectively. On the other hand, the critical period for weed control over all studied agricultural practices according to the recommended allowed loss yield value (10%) being 8.3 and 7 weeks for weed-free and being 1.5 and 1.8 weeks for weed-competition in 2016 and 2017, respectively (Table 3). Pepper yield components were declined linearly with decreasing weed competition duration which were sensitive to weed interference and closely resembled the pattern and extent, response to pepper yield. These results are in agreement with obtained by Labrada and Paredes (1983), Pyon *et al.* (1999) and Blanco *et al.* (2018). This call to weed control strategies to cause eight weeks to obtain yield from weed-free periods for the seasons. The increases or decreases in pepper yield per feddan were strongly and significantly correlated with different yield components. That may be due to the slow growth of pepper in the first stages and gave poor vegetative growth in one side and weeds growth faster than pepper in other side. Evidently, weed free maintenance for one to eight weeks after transplanting is required for the high pepper fruit yield (Pyon *et al.*, 1999 and Zimdahl, 2004).

Table 3. Parameters of the three studied models of the effect of weed free or weed competition periods on yield of pepper (ton/fed.) in 2016 and 2017 seasons.

Season	Weed competition and Weed-free	Models	R^2	SE	Prediction equation	CPWC/ week allowed losing yield (10%)
2016	Weed-free	Linear	0.952	0.545	Y=1.483+ 0.667x	
		Logistic	0.780	0.379	Y= ln (0.686) + ln (0.821)x	
		Quadratic	0.984	0.321	Y= 0.920+ 1.090x - 0.042x^2	8.3
	Weed competition	Linear	0.973	0.411	Y= 8.252 - 0.682x	
		Logistic	0.910	0.340	Y=ln(0.102) + ln (1.191)x	
		Quadratic	0.983	0.198	Y=7.942 – 0.449x- 0.023x^2	1.5
2017	Weed-free	Linear	0.918	0.682	Y=1.603+ 0.631x	
		Logistic	0.743	0.422	Y= ln (0.701) + ln (0.820)x	
		Quadratic	0.994	0.185	Y= 0.774+1.253 - 0.062x^2	7
	Weed competition	Linear	0.965	0.435	Y= 7.995 - 0.626x	
		Logistic	0.900	0.339	Y=ln(0.108) + ln (1.167)x	
		Quadratic	0.980	0.182	Y=7.636 -0.356x- 0.0271x^2	1.8

Table 4. Estimation the expected pepper fruit yield under difference duration in 2016 and 2017 seasons.

Treatments (Weeks)	2016		2017	
	Predicted fruit yield (ton /fed.)	% of yield for weed free and weed competition	Predicted fruit yield (ton /fed.)	% of yield for weed free and weed competition
		Weed free period (WFP)		
0 WFP *	0.92	11.51	0.77	10.90
WFP for 2W	2.93	36.69	3.03	42.70
WFP for 4W	4.61	57.66	4.79	67.52
WFP for 6W	5.95	74.42	6.06	85.35
WFP for 8W	6.95	86.99	6.83	96.20
WFP for 10W	7.62	95.35	7.10	100.00
		Weed competition period (WCP)		
0 WCP **	7.94	100	7.64	100
WCP for 2W	6.95	87.53	6.8	89.26
WCP for 4W	5.78	72.75	5.78	75.69
WCP for 6W	4.42	55.65	4.53	59.30
WCP for 8W	2.88	36.24	3.06	40.07
WCP for 10W	1.15	14.51	1.38	18.02

*** 0 WFP: Weed competition for whole season. ** 0 WCP: Weed free for whole season.**

Effect of weed control treatments (2nd two experiments)

Weed survey in experimental fields show that annual predominated weed species in both seasons were Purslane (*Portulaca oleraceus* L.), bladder hibiscuss (*Hibiscus trionum* L.), pig weed *(Amaranthus virdis* L.), wild jute or nalta (*Corchorus olitorius* L.), sow- thistle *(Sonchus oleraceus* L.), cheese weed Little or mallow *(Malva parviflora* L.), spurge *(Euphorbia geniculata* L.), white goosefoot *(Chenopodium album* L.), cocklebur *(Xanthium strumarium* L.) and black nightsade *(Solanum nigrm* L.) as annual broad-leaved weeds and jungle rice *(Echinochloa colonum* L.) and broadleaf signal Grass *(Brachiaria eruciformis* L.) as annual grassy weeds which were the most important weeds of pepper fields. Data in Table (5) show that the effects of all weed control treatments significantly decreased fresh weight of broad-leaved, grasses and total weeds an unweeded check in both seasons. Stomp extra (0.850 L.\fed) supplement with one hand hoeing (97.4 & 98.3%), black polyethylene (97.5 & 97.4%) and Amex at 1.25l\fed. supplemented with one hand hoeing (94.6 & 97.0%) gave highest weed control percentage of broad-leaved, grasses and total weeds followed by hand hoeing twice(90.6 & 93.4%), rice straw (90.5 & 91.4%), Harness at 0.5 l\fed. supplement with one hand hoeing (89.5 & 90.1%) and Sencor 100g\fed. supplement by one hand hoeing (88.1 & 89.5%) in both seasons than other treatments. Thus, for bio- Organic farming can be used black polyethylene mulch and hand hoeing twice in pepper while the rest can be used for treatments in the open cultivation. These results are in agreement with those found by Galal *et al.* (2019), Schonbeck(1998) and Ashrafuzzaman *et al.* (2011). They found that black plastic mulch was more effective in suppressing weed growth. Khan *et al.* (2012) found that the lowest fresh weight of weed in chilli was recorded by hand weeded, pendimethalin and pendimethalin supplemented with one hand weeding. Subhra and Pabitra (2014) and GLatkova and Pacanoski (2019) reported that pendimethalin herbicide treatment provided control efficacy more than 90%.

Pepper vegetative growth traits:

Table (6) show that all weed control treatments exhibited significant effects on plant height, number of branches per plant, fresh weight/plant and dry weight/plant in both seasons. The tallest plant, the highest values of fresh and dry weight /plant and number of branches per plant were resulted from black polyethylene mulch, Stomp extra at 0.850 l/fed supplemented with one hand hoeing and Amex at 1.25 l/fed. Supplement with one hand hoeing followed by hand hoeing twice and Stomp extra at 1.7 l/fed. in both seasons. These results are attributed to the decrease in weed biomass by weed control treatments. Ashrafuzzaman *et al.* (2011) found that the increased plant height and the highest number of branches per plant was obtained from weed control by black plastic mulch due to in mulched plants was possibly better availability of soil moisture and optimum soil temperature.

Yield, yield components and fruit quality

Pepper fruit length, fruit diameter and fruit weight were significantly affected by all weed control treatments (Table 6). Stomp extra at 0.850 l/fed supplement with one hand hoeing, hand hoeing twice, black polyethylene mulch, Amex at 1.25 l/fed. supplemented with one hand hoeing and Stomp extra at 1.7 l/fed. resulted tallest fruit and highest values of fruit diameter and fruit weight in both seasons. Both fruit yield /plant and fruit yield /feddan showed significant differences for all treatments (Table 7). The greatest fruit yield g/plant and ton/feddan was obtained from Stomp extra at 0.850 l/fed followed by one hand hoeing, black polyethylene mulch and hand hoeing twice followed by Amex at 1.25 l./fed. followed by one hand hoeing in both seasons. Total soluble solid (TSS) and vitamin C content was significantly affected by all studied weed control treatments (Table 7).

Table 5. Effect of some herbicide and mulching treatments on fresh weight of weeds (g/m^2) of pepper yield in 2016 and 2017 seasons.

Weed control treatments (rate/feddan)	Broad leaved weeds (g/m^2)	Controlling %	Grassy Weeds (g/m^2)	Controlling %	Total Weeds (g/m^2)	Controlling %
			2016			
Amex (2.5 L.)	542.3 b	75.7	224.0 cd	79.5	766.3 b	77.0
Amex (1.25 L.) followed by one hand hoeing	121.3 de	94.6	64.7 f	94.1	186.0 ef	94.4
Stomp extra (1.7 L.)	352.7 c	84.2	216.7 cd	80.2	569.3 c	82.9
Stomp extra (0.850 L.) followed by one hand hoeing	59.0 e	97.4	46.3 f	95.8	105.3 f	96.8
Harness (0.750 L.)	612.7 b	72.6	281.7 c	74.2	894.3 b	73.1
Harness (0.5 L.) followed by one hand hoeing	235.3 cd	89.5	93.7 ef	91.4	329.0 de	90.1
Sencor (150g)	579.0 b	74.1	356.7 b	67.4	935.7 b	71.9
Sencor (100g) followed by one hand hoeing	265.3 cd	88.1	154.7 de	85.9	420.0 cd	87.4
Black polyethylene mulch	55.7 e	97.5	44.0 f	96.0	99.7 f	97.0
Rice straw mulch	211.3 cde	90.5	148.3 de	86.4	359.7 de	89.2
Hand hoeing (twice)	209.0 cde	90.6	90.0 ef	91.8	299.0 de	91.0
Unweeded check	2232.0 a	0.0	1094.0 a	0.0	3325.0 a	0.0
			2017			
Amex (2.5 L.)	593.3 b	76.5	212.3 c	80.7	805.7 b	77.8
Amex (1.25 L.) followed by one hand hoeing	76.7 d	97.0	53.0 e	95.2	129.7 d	96.4
Stomp extra (1.7 L.)	503.3 bc	80.1	174.3 c	84.2	677.7 bc	81.3
Stomp extra (0.850 L.) followed by one hand hoeing	42.0 d	98.3	40.3 e	96.3	82.3 d	97.7
Harness (0.750 L.)	650.7 b	74.3	305.0 b	72.3	955.7 b	73.7
Harness (0.5 L.) followed by one hand hoeing	249.3 cd	90.1	85.0 de	92.3	334.3 d	90.8
Sencor (150g)	629.7 b	75.1	309.0 b	71.9	938.7 b	74.1
Sencor (100g) followed by one hand hoeing	265.7 cd	89.5	153.0 cd	86.1	418.7 cd	88.5
Black polyethylene mulch	65.7 d	97.4	55.0 e	95.0	120.7 d	96.7
Rice straw mulch	217.0 cd	91.4	131.0 cde	88.1	348.0 d	90.4
Hand hoeing (twice)	166.0 d	93.4	77.3 de	93.0	243.3 d	93.3
Unweeded check	2528. a	0.0	1100.0 a	0.0	3628.0 a	0.0

Means followed by the same alphabetical letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

Table 6. Effect of some herbicide and mulching treatments on four traits of pepper in 2016 and2017 seasons.

Weed control treatments (rate\feddan)	Plant height (cm)	Number of branches/ plant	Fresh weight\ plant(g)	Dry weight\ plant(g)	Fruit length (cm)	Fruit diameter (cm)	Fruit weight (g)
	2016						
Amex (2.5 L.)	60.7 c	3.2 de	370.3 d	57.8 fg	5.2 cd	3.5 b	26.8 cd
Amex (1.25 L.) followed by one hand hoeing	63.3 b	3.5 bc	501.3 ab	76.7 cd	5.4 bc	3.8 a	30.8 b
Stomp extra (1.7 L.)	62.3 bc	3.7 b	410.3 cd	70.7 de	5.4 bc	3.8 a	29.9 b
Stomp extra (0.850 L.) followed by one hand hoeing	67.5 a	4.0 a	540.4 a	93.9 a	5.8 a	4.0 a	34.6 a
Harness (0.750 L.)	52.2 e	2.7 f	365.2 d	58.0 fg	4.9 ef	3.3 c	20.7 f
Harness (0.5 L.) followed by one hand hoeing	48.0 f	3.0 e	395.4 d	57.8 fg	5.0 def	3.0 d	19.3 f
Sencor (150g)	53.7 e	3.1 e	405.3 d	60.2 f	4.7 f	3.0 d	23.4 e
Sencor (100g) followed by one hand hoeing	56.2 d	3.2 de	430.5 cd	66.8 e	5.0 def	3.2 cd	24.8 de
Black polyethylene mulch	68.3 a	3.4 cd	550.5 a	95.6 a	5.5 b	3.8 a	33.5 a
Rice straw mulch	60.7 c	3.2 de	468.7 bc	77.6 c	5.1 de	3.4 bc	29.3 bc
Hand hoeing (twice)	63.0 b	3.7 b	503.3 ab	84.6 b	5.6 ab	3.9 a	34.0 a
Unweeded check	45.3 g	2.1 g	395.0 d	52.7 g	4.4 g	3.0 d	20.3 f
	2017						
Amex (2.5 L.)	61.1 cd	3.2 cd	390.0 bcd	60.0 e	5.1 bcd	3.7 ab	28.2 b
Amex (1.25 L.) followed by one hand hoeing	63.1 bc	3.4 bc	508.3 ab	79.3 c	5.5 ab	3.8 a	33.2 a
Stomp extra (1.7 L.)	62.1 c	3.5 b	433.3 bcd	77.0 c	5.4 abc	3.8 ab	33.1 a
Stomp extra (0.850 L.) followed by one hand hoeing	68.0 a	3.9 a	586.7 a	95.3 a	5.7 a	4.0 a	34.7 a
Harness (0.750 L.)	53.7 ef	2.5 e	356.7 cd	59.3 e	5.1 bcd	3.4 bc	20.1 d
Harness (0.5 L.) followed by one hand hoeing	52.1 fg	3.1 d	395.0 bcd	59.3 e	4.7 de	3.2 cd	21.3 cd
Sencor (150g)	55.1 ef	3.1 d	416.7 bcd	60.7 e	4.6 e	3.1 d	22.3 cd
Sencor (100g) followed by one hand hoeing	57.2 de	3.3 bcd	440.0 bcd	67.7 d	5.0 cde	3.2 cd	24.3 c
Black polyethylene mulch	68.8 a	3.1 d	603.3 a	97.3 a	5.4 abc	3.9 a	33.0 a
Rice straw mulch	62.2 c	3.1 d	476.7 abc	80.0 c	5.1 bcd	3.7 ab	29.4 b
Hand hoeing (twice)	67.1 ab	3.6 b	361.7 bcd	86.7 b	5.5 ab	3.9 a	34.5 a
Unweeded check	48.0 g	2.3 f	310.0 d	52.0 f	4.8 de	3.5 bc	22.1 cd

Means followed by the same alphabetical letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

Table 7. Effect of some herbicide and mulching treatments on four traits of pepper in summer 2016 and 2017 seasons.

Weed control treatments (rate\feddan)	TSS (%)	Vitamin C (mg/100g)	Fruit yield/plant (g)	Fruit yield / feddan (ton)
2016				
Amex (2.5 L.)	6.3 d	80.3 abc	390.6 d	4.7 de
Amex (1.25 L.) followed by one hand hoeing	6.2 de	79.0 bcd	427.6 bcd	5.5 b
Stomp extra (1.7 L.)	6.6 c	80.0 abc	397.8 cd	5.4 b
Stomp extra (0.850 L.) followed by one hand hoeing	7.2 a	83.3 ab	512.5 a	6.7 a
Harness (0.750 L.)	6.4 cd	73.3 de	239.4 ef	2.5 g
Harness (0.5 L.) followed by one hand hoeing	6.2 de	75.0 cde	183.8 f	2.9 g
Sencor (150g)	6.0 ef	71.3 ef	234.5 ef	4.1 f
Sencor (100g) followed by one hand hoeing	6.1 de	66.3 fg	276.8 e	4.3 ef
Black polyethylene mulch	7.4 a	86.7 a	484.0 ab	5.6 b
Rice straw mulch	6.9 b	80.7 abc	410.6 bcd	4.8 cd
Hand hoeing (twice)	7.3 a	84.7 ab	478.9 abc	5.2 bc
Unweeded check	5.7 f	62.7 g	71.53 g	0.7 h
2017				
Amex (2.5 L.)	6.3 cd	77.3 cde	347.7 c	4.9 d
Amex (1.25 L.) followed by one hand hoeing	6.3 cd	77.3 cde	452.0 ab	5.9 bc
Stomp extra (1.7 L.)	6.5 c	80.0 abc	401.6 bc	6.0 b
Stomp extra (0.850 L.) followed by one hand hoeing	7.2 ab	83.3 abc	523.5 a	7.0 a
Harness (750 L.)	6.5 c	73.0 def	184.1 d	2.7 g
Harness (0.5 L.) followed by one hand hoeing	6.3 cd	71.3 ef	182.8 d	3.1 f
Sencor (150g)	6.0 de	69.7 fg	333.5 c	3.9 e
Sencor (100g) followed by one hand hoeing	6.1 de	67.3 fg	366.7 c	4.2 e
Black polyethylene mulch	7.5 a	84.7 a	460.5 ab	5.8 bc
Rice straw mulch	6.9 b	78.0 bcd	400.4 bc	4.8 d
Hand hoeing (twice)	7.5 a	84.0 ab	480.8 a	5.8 bc
Unweeded check	5.7 e	64.0 g	70.63 e	0.7 h

Means followed by the same alphabetical letters within each column do not differ significantly according to Duncan's Multiple Range test at the 5% level.

Stomp extra at 0.850 l\fed supplement with one hand hoeing, black polyethylene mulch and hand hoeing twice were the highest for TSS and vitamin C content values in both seasons. Generally, the treatment of Stomp extra at 0.850 l/fed supplemented with one hand hoeing and black polyethylene mulch were the best treatments for all traits followed by hand hoeing twice and Amex at 1.25l/fed. supplemented with one hand hoeing. For the used individual herbicides, the treatment Stomp extra at 1.7 l/fed. exceed over all individually herbicides followed by Amex at 2.5 l/fed. Moreover, black polyethylene mulch suppressed weed growth and gives good pepper vegetative growth, fruit characters and fruit yield (quantitative and quality traits).

Therefore, black polyethylene can be recommended as an effective mulching material for the better yield of pepper. Similar results were obtained by Glatkova and Pacanoski (2019) who found that all weed control treatments including pendimethalin produced significantly higher dry chilli yield compared with unweeded check. Ashrafuzzaman *et al.* (2011) found that mulching produced highest fruit yield per plant and fruit yield per hectare than for the control and had positive effect in generating increases of fruit yield. Black plastic mulch produced the highest fruit weight per plant (533.4 g) and per hectare (21.3 ton). Khan *et al.* (2012) reported that hand weeding gave highest fruit length and yield. Galal *et al.*(2019) reported that some alternative mechanical weed control hand hoeing (twice), mulching by black polyethylene or reduced rate of Stomp extra (1.275 l./fed.) integrated with one hoeing or using full rate (1.7 l./fed.) only for weed control.

Correlation coefficients between weed classified groups and pepper traits:

Table (8) show the correlation coefficients between broad leaved weeds, grassy weeds and total weeds with pepper yield, yield components during summer 2016 and 2017 seasons.

Table 8. Correlation between weight of broad leaved, grassy weeds and total weeds with yield and yield components in pepper during summer 2016 and 2017 seasons.

Seasons	2016			2017		
Traits	Broad leaved weeds (g/m^2)	Grassy weeds (g/m^2)	Total weeds (g/m^2)	Broad leaved weeds (g/m^2)	Grassy weeds (g/m^2)	Total weeds (g/m^2)
Plant height	-0.685^{**}	-0.665^{**}	-0.683^{**}	-0.663^{**}	-0.664^{**}	-0.664^{**}
Number of branches/plant	-0.763^{**}	-0.698^{**}	-0.765^{**}	-0.744^{**}	-0.725^{**}	-0.713^{**}
Fruit length	-0.672^{**}	-0.387^{*}	-0.684^{**}	-0.654^{**}	-0.396^{*}	-0.463^{**}
Fruit diameter	-0.492^{**}	-0.304^{ns}	-0.502^{**}	-0.480^{**}	-0.298^{ns}	-0.463^{**}
Fruit weight	-0.557^{**}	-0.495^{**}	-0.555^{**}	-0.541^{**}	-0.510^{**}	-0.478^{**}
TSS	-0.579^{**}	-0.579^{**}	-0.586^{**}	-0.565^{**}	-0.572^{**}	-0.567^{**}
Vitamin C	-0.669^{**}	-0.614^{**}	-0.670^{**}	-0.612^{**}	-0.618^{**}	-0.594^{**}
Fruit yield/plant	-0.712^{**}	-0.709^{**}	-0.712^{**}	-0.693^{**}	-0.725^{**}	-0.723^{**}
Fruit yield/feddan	-0.798^{**}	-0.781^{**}	-0.796^{**}	-0.783^{**}	-0.789^{**}	-0.785^{**}

ns, *, ** nonsignificant, significant and highly significant correlation coefficients, respectively.

Correlation coefficients between broad leaved, grassy weeds and total weeds with plant height, number of branches/plant, fruit length, fruit diameter, fruit weight, TSS, Vitamin C, fruit yield/plant and fruit yield/feddan were negative and highly significant in both seasons except grassy weeds with fruit length were negative and significant in both seasons. On the other hand, correlation coefficients between grassy weeds with fruit diameter are non-significant in both seasons, showing that pepper crop productivity severely affected by weed compotation. These results are agreement with those Galal *et al.* (2019).

Phenotypic correlation coefficients among the Pepper studied traits

Phenotypic correlation coefficients for all comparisons among the studied traits are presented in Table 9 which show that fruit yield per feddan was positively and highly significant correlated with each of plant height, number of branches, fresh weight/plant, dry weight/plant, fruit length, fruit diameter, fruit weight, and fruit yield per plant in both seasons. Sharma *et al.* (2010) found that fruit length, fruit diameter and number of fruits per plant revealed significant positive correlation with fruit yield per plant. Thakur *et al.* (2019) found that highly significant and positive correlation of yield per plant with number of fruits per plant, fruit weight and number of primary branches.

Table 9. Correlation coefficients among different pairs of characters in pepper duration summer 2016 and 2017 seasons.

Traits	Number of branches /plant	Fresh weight /plant	Dry weight /plant	Fruit length	Fruit diameter	Fruit weight	Fruit yield /plant	Fruit yield /feddan
			2016					
Plant height	0.815**	0.817**	0.853**	0.849**	0.849**	0.918**	0.937**	0.919**
Number of branches/plant	-	0.740**	0.728**	0.858**	0.759**	0.798**	0.829**	0.920**
Fresh weight/plant		-	0.960**	0.795**	0.708**	0.835**	0.805**	0.803**
Dry weight/plant			-	0.815**	0.754**	0.876**	0.827**	0.780**
Fruit length				-	0.861**	0.846**	0.886**	0.838**
Fruit diameter					-	0.876**	0.844**	0.781**
Fruit weight						-	0.910**	0.867**
Fruit yield/plant							-	0.896**
			2017					
Plant height	0.739**	0.858**	0.882**	0.742**	0.641**	0.872**	0.868**	0.878**
Number of branches/plant	-	0.679**	0.637**	0.490**	0.415**	0.705**	0.810**	0.865**
Fresh weight/plant		-	0.949**	0.669**	0.627**	0.785**	0.847**	0.834**
Dry weight /plant			-	0.755**	0.672**	0.840**	0.839**	0.829**
Fruit length				-	0.688**	0.786**	0.674**	0.652**
Fruit diameter					-	0.818**	0.609**	0.623**
Fruit weight						-	0.837**	0.851**
Fruit yield/plant							-	0.926**

**** highly significant correlation coefficients.**

Herbicides residues detection

Table 10 and Figures 2-5, show that the estimated applied herbicides residues in fresh fruit pepper at 80 days from transplanting were lower than their permissible maximum residual level (MRL) in edible parts as set by EU 0.05 µg /g for Stomp extra 45.5% as pendimethalin at the rate 1.7 and 0.850 l. /fed. was 0.002016 and 0.0015774µg /g, MRL 0.01µg /g for Amex 48% as butralin at 2.5 and 1.25 l./ fed. was 0.002008 and 0.001845µg/g and MRL 0.01µg /g for Harness 84% as acetochlor at 0.75 and 0.5 l.\fed. was 0.0072877 and 0.0055743 µg/g but Sencor 70% as metribuzin at 150 and 100 g.\fed. was not detected. Harness residues in fresh fruit pepper was higher than those of Stomp extra or Amex in one side and adding one hand hoeing after 45 days from transplanting with reduced rates of these herbicides had lower residues than the recommended rates which may be due the role of hoeing in breaking herbicides which can be decreased the rate of herbicides and the role of hoeing in breaking herbicides which make the herbicide is quicker dissipated in soil in another side. These herbicides can be degraded depends on the soil microbe's population and their activity, soil constituent e.g. organic matter and clay. These results are in agreement with previous residual obtained by Hassanein et al. (2014) who found that there was no any residues from pendimethalin, butralin and metribuzin herbicides which existed in tomato fruits and Galal et al. (2019) which reported that herbicide residues for Stomp extra, Amex, Gesagard and Ultra afalon herbicides were below the maximum residue limit in pea seeds.

Table 10. Residues for Amex (butralin), Stomp extra (pendimethalin), Harness (acetochlor) and Sencor (metribuzin) in green fruit pepper during 2016.

Herbicides & rate/fed.	Retention time (min.)	Herbicide residues µg/g (ppm)	Maximum residue level (MRL) µg /g -ppm
Standard of Amex	2.380	-	-
Amex 48% (2.5 L.\fed.)	2.402	0.002008	0.01
Amex 48%(1.25 L.\fed.) followed by one hand hoeing	2.391	0.001845	0.01
Standard of Stomp extra	3.477	-	-
Stomp extra45.5% (1.7 L. \fed.)	3.455	0.002016	0.05
Stomp extra 45.5% (0.850 L.\fed.)followed by one hand hoeing	3.468	0.0015774	0.05
Standard of Harness	4.113	-	-
Harness 84% (0.750 L. \fed.)	4.096	0.0072877	0.01
Harness 84% (0.5 L. \fed.) followed by one hand hoeing	4.100	0.0055743	0.01
Standard of Sencor	4.037	-	-
Sencor70% (150g/fed.)	-	Not detected (ND) *	0.1
Sencor70% (100g\fed.) followed by one hand hoing	-	Not detected (ND)*	0.1

*** Not detection: Below detection limit 0.01 ppm for Sencor**

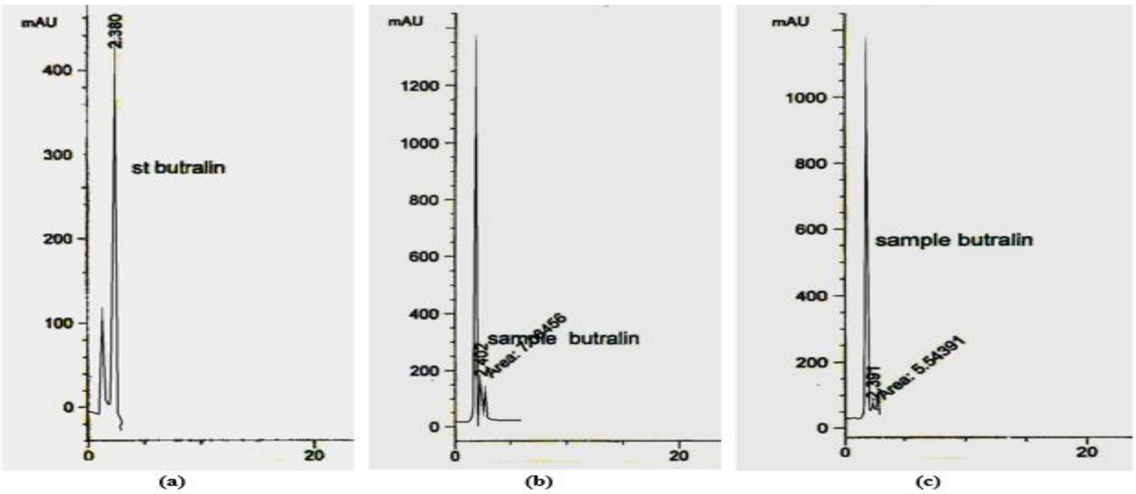

Fig. 2. (a) Chromatogram of standard of Amex (butralin)
(b) Chromatogram of sample Amex (butralin) at 2.5 L./fed. in fruit pepper
(c) Chromatogram of sample butralin at 1.25 l./fed. followed by one hoeing in fruit pepper.

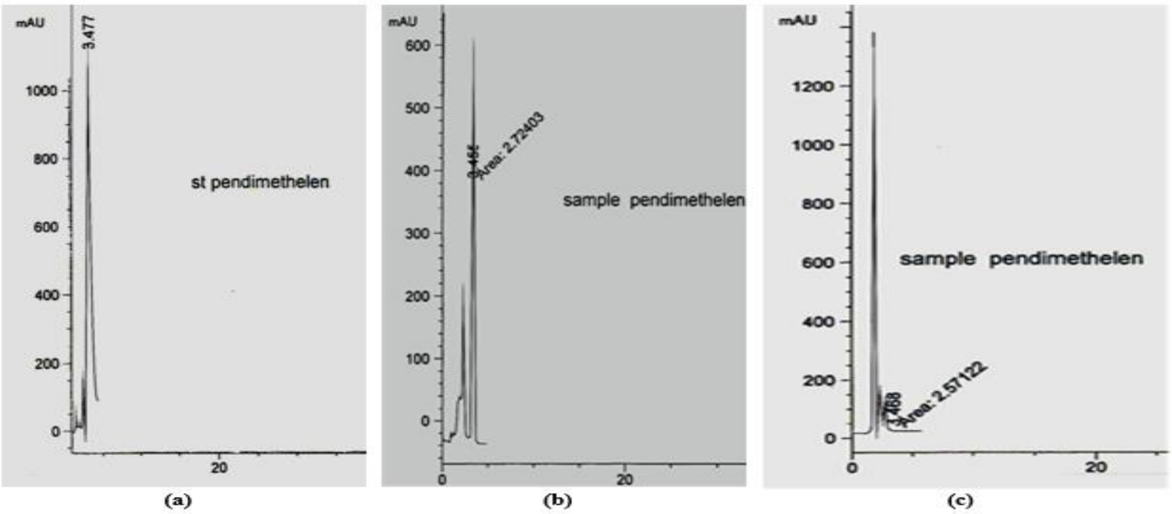

Fig. 3. (a) Chromatogram of standard of stomp extra (pendimethalin)
(b) Chromatogram of sample Stomp extra (pendimethalin) at 1.7.L./fed. in fruit pepper
(c) Chromatogram of sample Stomp extra (pendimethalin) at 0.850 L./fed. followed by one hoeing in fruit pepper.

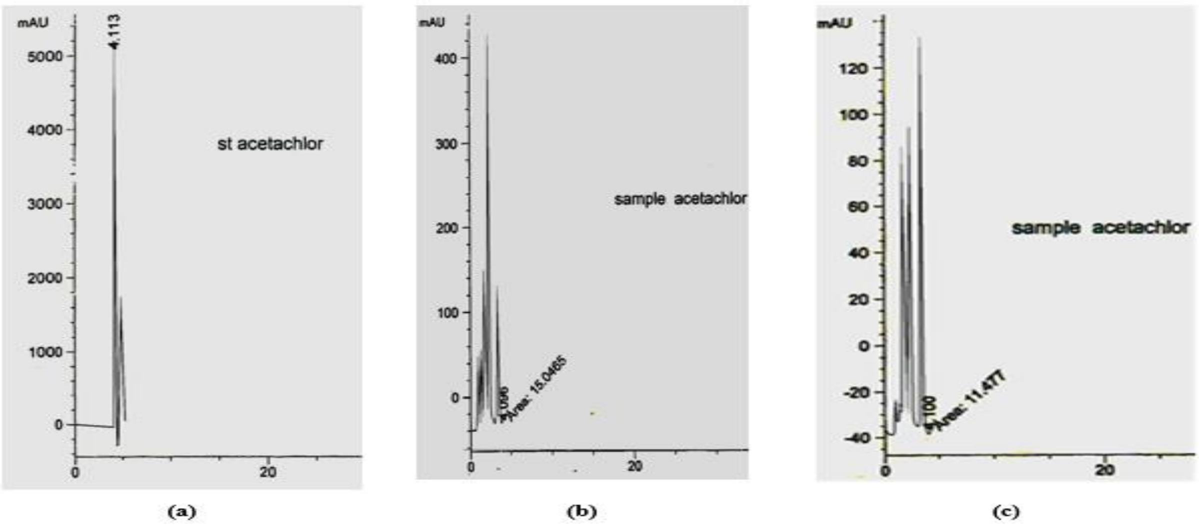

Fig. 4. (a) Chromatogram of standard of Harness (acetochlor)
(b) Chromatogram of sample Harness (acetochlor) at 0.75 L./fed.in fruit pepper
(c) Chromatogram of sample Harness (acetochlor) at 0.5 L./ fed. followed by one hoeing in fruit pepper.

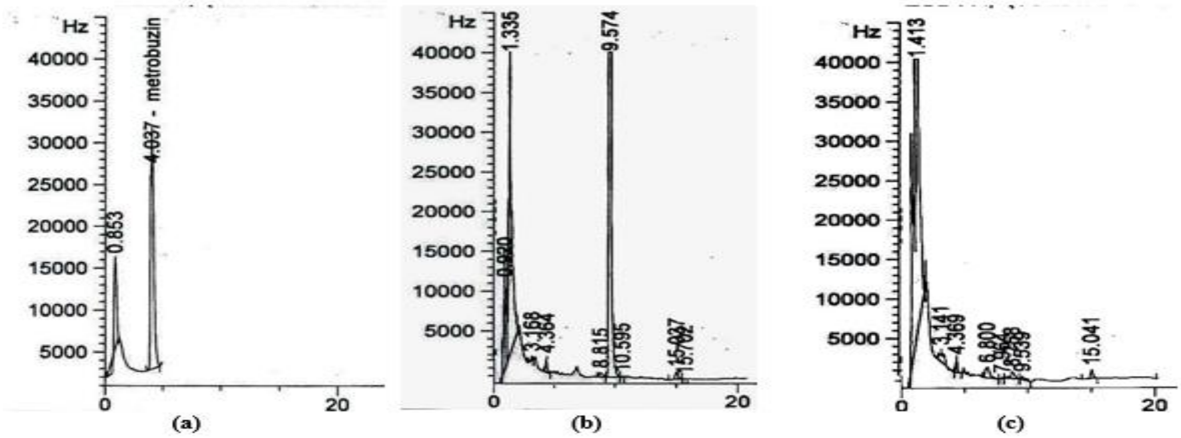

Fig. 5. (a) Chromatogram of standard of Sencor (metribuzin).
(b) Chromatogram of sample Sencor (metribuzin) at 150 g./fed. in fruit pepper
(c) Chromatogram of sample Sencor (metribuzin) at 100 g./fed. followed by one hoeing in fruit pepper .

CONCLUSION

From the present results, the pepper crop is very sensitive to weed competition for whale growing season so to need control weeds through the critical period (up to 8 weeks after transplanting) under the high infestation by weeds which presented early with beginning growing season. The results also, concluded that some safe alternatives to mechanical weed control hand hoeing (twice), are the use of mulching by black polyethylene or reduced rate of Stomp extra (0.850 L.\fed) and Amex (1.25 L.\fed.) for weed control during the pepper crop to produce good fruit yield free from herbicidal residues which can be used fairly in organic farming conditions in Egypt.

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تقدير الفترة الحرجة لمنافسة الحشائش ومعاملات مكافحة الحشائش على الانتاجية فى الفلفل الحلو

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أجريت اربع تجارب حقلية بمحطة بحوث البساتين بسدس التابعة لمركز البحوث الزراعية بمحافظة بنى سويف بمصر خلال الموسمين الصيفين لعامى ٢٠١٦و٢٠١٧ بهدف دراسة تأثير اثنى عشر معاملة (ستة فترات لمنافسة الحشائش تحت ظروف الكثافة الطبيعية للحشائش بأرض التجربة وستة فترات من إزالة الحشائش) وايضا دراسة تأثير اثنى عشر معاملة لمكافحة الحشائش بمبيدات الحشائش أو باستخدام التغطية بالبلاستيك الاسود علي الحشائش ومحصول الفلفل ومكوناته فى تصميم قطاعات كاملة العشوائية واقتفاء متبقيات مبيدات الحشائش فى ثمار الفلفل باستخدام جهاز التحليل الكروماتوجرافى عالى الكفاءة HPLC. أوضحت النتائج أن كثافة الحشائش في معاملة المقارنة (ترك الحشائش طوال الموسم) قدرت بحوالي ٢٢,٨٦ ، ٢٤,٣١ طن /الفدان وزن غض والتي قد أحدثت نقص في محصول الفلفل تراوح بين ٨٩,٧ ، ٩١,٩% عند ترك الحشائش لمنافسة نباتات الفلفل طوال الموسم مقارنة بمعاملات أزالة الحشائش طوال الموسم. أوضحت دراسة العلاقة بين فترات الإزالة والمنافسة ومحصول الفلفل وبإستخدام رسم منحنيات المحصول وعلاقة ذلك بفترات ترك الحشائش وفترات ازالتها biological curse وايضا بإستخدام النماذج الرياضيه (mathematical models) أن النقص أو الزيادة في محصول الفلفل يتبع معادلات من الدرجة الثانية حيث أن الفترة الحرجة لمنافسة الحشائش الفلفل كانت محصورة ما بين ٢-٨ أسابيع من الشتل وان افضل المعاملات فى مكافحة هذه الحشائش مع زيادة المحصول هى باستخدام ستومب اكسترا بمعدل ٠,٨٥٠ لتر للفدان متبوعة بعزقة واحدة بعد ٤٥ يوم من الزراعة ومعاملة التغطية بالبلاستيك الاسود ومعاملة العزيق مرتين والمعاملة بمبيد اميكس بمعدل ١,٢٥ لتر للفدان متبوعة بعزقة واحدة بعد ٤٥ يوم من الزراعة حيث ارتبطت هذه المعاملات سلبيا مع كمية الحشائش وايجابيا مع المحصول ومكوناته فى الفلفل. كانت افضل المعاملات للمبيدات منفردة هى باستخدام ستومب اكسترا ١,٥ لتر للفدان تليها اميكس ٢,٥ لتر للفدان وكانت متبقيات المبيدات اقل من الحد المسموح به دوليا. توضح هذه الدراسة ضرورة ادارة الحشائش فى محصول الفلفل باستخدام ستومب اكسترا بمعدل ٠,٨٥٠ لتر للفدان متبوعة بعزقة واحدة بعد ٤٥ يوم من الزراعة ومعاملة التغطية بالبلاستيك الاسود ومعاملة العزيق مرتين والمعاملة بمبيد اميكس بمعدل ١,٢٥ لتر للفدان متبوعة بعزقة واحدة بعد ٤٥ يوم من الزراعة او ستومب اكسترا بمعدل ١,٧ لتر للفدان او اميكس بمعدل ٢,٥ لتر للفدان لازالة الحشائش فى محصول الفلفل خلال الفترة الحرجة بدون وجود متبقيات للمبيدات المستخدمة فى ثمار الفلفل مما يتيح استراتيجيات مكافحة الحشائش فى محصول الفلفل بالمبيدات الآمنة ونظم تغطية الحشائش.