SELECTIVITY OF FOUR PRE-EMERGENCE HERBICIDES ON WEED GROUPS ASSOCIATED WITH COTTON (GOSSYPIUM BARBADENSE; GIZA, 80) AND THEIR JOINT IMPACT WITH HAND WEEDING

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Abstract

Four pre-emergence herbicides; Amex EC-48% (butralin) at 2.5 L (1.2 kg a. i.) per feddan (0.42hectar); Stomp extra SC-45.5% (pendimethalin) at 1.7 L (0.7735 kg. a. i.); Lumax SC-15% (mesotrione) at 1L. (0.15 kg. a. i.) /feddan and Gardo EC-96% (s-metolachlor) at 0.6L (0.576 kg. a. i.) /feddan were evaluated as single treatments and also in combination with one hand hoeing at 60 days after sowing. Data for the number of individual weeds and green biomass of each weed species were calculated. For each weed group, population density and green biomass were pooled for the species from the same group. Efficiency of tested herbicides as single treatments and in combination with one hand hoeing against the four targeted weed groups was compared. Percentages of the reduction in the population density and the green biomass of the two year pooled data were used in the comparison among treatments. **Amex, stomp extra and Gardo,** as single treatments at the recommended field rate were ineffective against annual broad leaved weeds; however, their integration with one hand hoeing increased their performance and this enrichment may be a sole effect of hand hoeing once. Dissimilarly, **Lumax** moderately controlled annual herbs and its effect increased when one hoeing was integrated to reach the same magnitude of weeded control treatment (hand hoeing twice at 30 and 60 days after sowing.). **Amex, Stomp extra and Gardo** performed well against annual grasses; the excellent performance was with Stomp extra, offering more than 90% reduction in this weed group. Amex and Gardo offered moderate effect with 77.71 and 66.83% compared to 64.29% in weeded control treatment. Hand hoeing once enhanced the performance of Amex and Gardo to 91.07 and 97.27%, respectively. Contrary, **Lumax** was ineffective on annual grasses as a single treatment and its performance enhanced by 37.65% when integrated with hoeing once. It seems that Amex, Stomp extra and Gardo are selective on annual narrow leaved weeds and Lumax was selective on annual broad leaved weeds. Tested herbicides were not effective against perennial broad leaved weeds neither when used alone or in combination with one hand hoeing. With the exception of Lumax, tested herbicides performed well as single treatments against perennial narrow leaved weeds. However, their integration with one hand hoeing antagonized the performance of Amex, stomp extra and Gardo; this negative impact was achieved when the comparison was based on the population density and the green biomass. Moreover hand weeding twice was not effective against this weed group.

Introduction

Cotton is an economic crop in Egypt and worldwide; however in Egypt the area cultivated with cotton is very much reduced because of the high cost of its production. A big part of its cost is related to the control of pests including weeds. Weed genera affect the quantitative and qualitative production of cotton bales and therefore resulting in the reduction of income (**Smith *et al*., 2000**). In addition to the competition of weeds with crop plants on different resources of life, weeds are an important plant hosts for insects. Although feeding by insects can have positive effects on crop productivity; however, weeds also indirectly affect crops via their influence on beneficial insects, and by harboring plant and insect diseases (**Capinera, 2006).**

Weed control via either using herbicides or hand weeding may cost the cotton grower $A187/ha annually **(Charles, 1991). Riar *et al.*, 2013** in the USA calculated the cost of chemical control of weeds in cotton to be ranged from $114 to $137/hectar. There is an urgent need for controlling cotton pests including weeds using long residue herbicides (**Riar *et al.*, 2013)**.

The traditional weed control treatments are more difficult, less effective and more expensive, in addition to the rare of agricultural laborers. Recent approach in weed control is to integrate cultural and chemical treatments to increase the wide spectrum of selective herbicides and reduce the environmental contamination. So the objective of this study is to evaluate the selectivity of four preemergence herbicides on different weed groups. Also, to identify the role of integrating hand hoeing once on the performance of tested herbicides on targeted weed groups.

Materials and Methods

1. Experimental design and tested herbicides:

In 2014, an area of about 1050m^2 was divided to 40 plots of ~26m^2 each. However, in 2015, similar area was divided into 30 plots of~35m^2 each. Cotton (*Gossypium barbadense*; cv. Giza 80) was sown in April 13, and April 6 in 2014_and 2015, respectively. In 2014, eight replicates were randomly chosen for each herbicide treatment; however they were reduced to six in 2015. Four preemergence herbicides; Amex EC-48% (butralin) at 2.5 L (1.2 kg a. i.) per feddan (0.42hectar); Stomp extra SC-45.5% (pendimethalin) at 1.7 L (0.7735 kg. a. i.); Lumax SC-15% (mesotrione) at 1L. (0.15 kg. a. i.) /feddan; and Gardo EC-96% (s-metolachlor) at 0.6L (0.576 kg. a. i.) /feddan.

The selected plots for each herbicide received the recommended field rate just after sowing and before the first irrigation that was conducted within 24 hours after sowing. At sixty days after sowing, half of those plots were randomly chosen to conduct hand hoeing as an additional treatment. Similarly, half of the control replicates were received hand hoeing twice at 30 and 60 days after sowing and served as weeded control treatment. The replicates that did not receive any weed control treatment served as unweeded control treatment.

2. Technique used for the management of weed groups:

At 90 days after sowing, weed individuals were carefully pulled from a square meter randomly chosen from each plot. Weed collections were taken to the laboratory and each collection was segregated into four groups (annual broad, annual narrow, perennial broad and perennial narrow). Number and green biomass of each group were recorded and means were compared between treatments using one way analysis of variance followed by Duncan Multiple Comparison test at 5% level of probability **(Gomize and Gomize, 1984)**. The two year data were combined and were used to calculate percentages of reduction in either the population density or the green biomass.

Reduction percentage = ((Control – treatment)/ control))*10**0**

Results

1. Weed group survey and their frequency profiles

Four weed groups were surveyed in the untreated plots during 2014 and 2015 cotton growing seasons. Based on the population density of each group, annual narrow was the most abundant group in 2014; it represented 50.64 followed by annual broad (35.83%) > perennial broad (7.48%) and the least abundant group was perennial narrow **(6.05%; Figure 2, set A)**. Data in 2015 confirmed that annual narrow exhibited the greatest population, representing 98.94% of the population density of all groups (**Figure 2, Set B**). Weeds related to annual and perennial broad leaved weeds were negligible; their representative altogether did not exceed 1.1%. Perennial grasses were not detected in the untreated plots during 2015 cotton growing season.

When the relative abundance of the four weed groups was based on the green biomass **(Figure 3);** annual narrow represented 43.33% in 2014 **(Set C)** compared to 85.17% in 2015 **(Set D)**. Annual broad was in the second order, representing in 2014 and 2015 35.94 and 11.82% (**Set C and Set D in Figure 3**, respectively). Perennial broad represented 15.23 and 3.01% in 2014 and 2015, respectively. Perennial narrow was the least abundant group with 5.51% in 2014; however it was not detected in the untreated plots in 2015 cotton growing season.

2. Selectivity of tested herbicides on annual broad

In general, less population density from annual broad was recorded in 2015 than that in 2014. In 2014, population density was significantly less in Lumax-hand hoeing combined treatment; weeded control treatment; Gardo-1HO and Stomp-1HO. In contrast, the greatest number was in Stomp extra single treatment that was significantly greater than that in the unweeded control treatment. The pattern of herbicidal efficiency was somewhat different based on 2015 data, but still Lumax is superior. In 2015, the greatest efficient treatments were Lumax single and combined treatments, Amex single treatment and weeded control treatment. Statistically, the greatest number of annual broad was in Gardo both treatments; moreover, were significantly different from the unweeded control treatment. Per cent reduction in the population density was the greatest in Lumax with hoeing and weeded control treatment (88.85 and 81.36%, respectively) and the least effective group was Amex-, Stomp extra- and Gardo-single treatment **(Table, 2)**. This confirmed the importance of integrating hand hoeing at 60 days after sowing with preemergence herbicides in order to obtain satisfactory control of annual broad leaved weeds.

It is more accurate to depend on the fresh biomass of weeds because this parameter reflects the effect on weed seed germination and the growth habit of individuals. In 2014, weeded control and stomp extra followed by one hand hoeing seemed to be the greatest efficient treatments followed by Gardo and Amex treatments, each combined with hand hoeing. Dissimilarly the least effective treatment was Lumax as a single treatment that came in the same order of unweeded control treatment. In 2015, Lumax single treatment and weeded control treatment were superior. In contrast, Amex combined treatment; stomp extra both treatments and Gardo both treatment were ineffective came in the same magnitude of unweeded control treatment. Percent reduction in the green biomass was the best in weeded control treatment (83.98) followed by Lumax with hoeing (71.12) followed by Lumax single treatment (59.11). The treatment of Amex, Stomp extra and Gardo were ineffective and hoeing once did not significantly improve their activity. Based on this data, it could be concluded that Lumax is the only herbicide treatment exhibited moderate performance; however, did not reach the order of weeded control treatment and the other three herbicides were ineffective in controlling annual broad leaved weeds.

3. Selectivity on annual grasses

In 2014, as in **Table (3),** the highest number of annual grasses was in Lumax single treatment that was insignificantly differed from the unweeded control treatment (84.50 versus 79.50individuals /m^2). Statistically, the least number was in Amex both treatments, Stomp extra both treatment and Gardo followed by hand hoeing once; they were significantly better than weeded control treatment. In 2015, Lumax single treatment was the worst came in the same statistical magnitude of unweeded control treatment. In contrast the best was offered by Amex combined treatment; Stomp extra both treatments, and Gardo combined treatment; they were significantly better than weeded control treatment. Per cent reduction in the two year combined data revealed that Amex combined with hoeing, stomp extra both treatments and Gardo combined treatment, offered more than 90% reduction in the population density of annual grasses followed by Amex single treatment (77.71%) compared to 64.29% in weeded control treatment. Lumax was ineffective as a single treatment; however, its performance enhanced by 37.65% when integrated with hand hoeing. Based the comparison on the green biomass, in 2014, Lumax both treatment were ineffective with the green biomass did not significantly differ with that in the unweeded control treatment. The greatest efficient treatments were Amex and Stomp extra, all treatments as well as Gardo combined treatment, the five treatments were significantly better than weeded control treatment. Data in 2015 reconfirmed that Lumax was ineffective and also reconfirmed the best offer with Amex and stomp extra all treatments as well as Gardo combined treatment. Weeded control treatment was statistically similar to Gardo and Amex single treatments. Again Amex and stomp extra all treatments and Gardo combined treatment exhibited from 83.49 to 97.69% reduction in the green biomass followed by weeded control treatment (61.16) and Gardo single treatment (53.03%). Lumax was ineffective as a single treatment and hoeing once enhanced its performance in reducing the green biomass by only 37.26

4. Selectivity on all annual weeds

In 2014, Lumax single treatment and Gardo single treatment were statistically in the same order of unweeded control treatment **(Table, 4)**. It's understandable that the four herbicides when integrated with hand hoeing once were superior to that when used as single treatments. In 2015, mean number of annual weeds was about three times greater than that in 2014; however, the population density data in 2015 reconfirmed that Lumax was ineffective and the treatments of Amex and Stomp extra either when they used as single treatments or when they integrated with hoeing once as well as Gardo combined treatment were the greatest effective treatments. Percent reduction ranged from 70.15% in Amex single treatment to 92.53% in Gardo combined treatment compared to 65.78% in weeded control treatment. The reduction in the population density of all annual weeds did not exceed 42.13% when Lumax integrated with hand hoeing once.

In 2015, again Lumax was ineffective with mean population density was insignificantly less compared to the unweeded control treatment. Typically as established based on the population density in 2014, Amex and Stomp extra all treatments and Gardo combined treatment exhibited the greatest herbicidal efficacy. Population density of the previously mentioned treatments was insignificantly less than that in weeded control treatment.

Although of the green biomass was about three times greater in 2015 than that in 2014, but treatments kept the same order as in 2014. For explanation, Lumax single treatment was insignificantly different from un-weeded control treatment. Also, Amex and Stomp extra all treatments and Gardo combined treatment were superior and came in the same order of weeded control treatment.

Per cent reduction in the green biomass ranged from 64.64% in Amex combined treatment to 79.59% in Gardo combined treatment compared to 65.74% in weeded control treatment. Reduction percentage was negligible in Lumax single treatment (15.28%) and reached to 44.05% when it integrated with hoeing. We recommend, not using Lumax particularly when annual grasses are dominant in cotton field. Any of the other three chemicals when integrated with hoeing offered the best in controlling all annual weeds, particularly annual grasses.

5. Selectivity on perennial grasses

Perennial grasses were not observed in the untreated plots during 2015 cotton growing seasons. It is amazing that population density was significantly greater in three treatments (Lumax single treatment, Gardo combined treatment as well as weeded control treatment) compared to the unweeded control treatment **(Table 5).**

In contrast, the greatest efficient treatments were Amex single treatment, Stomp extra and Lumax all treatments. More surprising, Amex when integrated with hoeing was less effective than when used as a single treatment. It was clearly evident that per cent reduction in Gardo, Amex and Stomp extra single treatments was 76.32; 97.37 and 100%, respectively. However, percent reduction dropped (-139.47, -7.90 and 15.79%, respectively) when the three chemicals was followed by one hand hoeing. It's hard to find explanation for this unexpected result that hoeing antagonized the effect of Gardo, Amex and stomp extra. More surprising that weeded control treatment with hand hoeing twice resulted in increasing the perennial grasses more than the unweeded control treatment. The only acceptable explanation for this strange finding is that with losing competition with annual weeds that effectively controlled in the previously mentioned treatments, the growth of perennial grasses is stimulated.

Dissimilarly, the population density in Lumax single treatment increased by 171.05% more than the unweeded control treatment; however, integrating hand hoeing caused reduction in population density by 55.26%. Mean fresh weight of perennial grasses were less in Stomp extra both treatments, however, the difference with the unweeded control was only significant in Stomp extra single treatment. Fresh weight was reduced by 100 and 76.06%, respectively in Stomp extra single and combined treatments. The fresh weight in the treatments of Amex and Gardo were insignificantly less than that in the unweeded control treatment. Per cent reduction in the fresh weight was 90.15 (Amex single treatment), 0.0 (Amex combined treatment), 90.48% (Gardo single treatment) and 32.27% (Gardo combined treatment). Mean fresh weight of perennial grasses in Lumax both treatments was insignificantly greater than the unweeded control treatment; moreover, the fresh weight of perennial grasses in both Lumax treatments increased by 32.10% more than the unweeded control treatment.

6. Selectivity on perennial herbs

Convolvulus arvensis var. *arvensis* was the only perennial herb monitored in the two seasons. Population density in 2014 was the greatest in Amex single treatment, Lumax single treatment and Gardo both treatments **(Table, 6)**. However, mean number in Gardo was significantly greater than that in the unweeded control treatment. With the exception of Gardo combined treatment, the rest of weed control treatments were insignificantly different from the unweeded control treatment. 2015 data confirmed that Amex combined treatment, stomp extra single treatment and Gardo both treatments exhibiting perennial individuals that were significantly greater than that in the unweeded control treatment. For Amex single treatment, stomp extra combined treatment, Lumax both treatments, mean number was insignificantly less than the unweeded control treatment. Weeded control treatment was the only treatment exhibited significantly less population density than the unweeded control treatment. Lumax combined treatment and weeded control treatment reduced the population density by 30.75 and 17.02%, respectively. The rest resulted in increasing the population more than the unweeded control treatment.

Compared to the green biomass monitored in 2014 in the unweeded control treatment, it was significantly greater in stomp extra, Lumax and Gardo single treatments. For the rest, it was insignificantly greater in Amex single treatment; however, was insignificantly less for the rest of treatments included weeded control treatment. In 2015, the green biomass in Stomp extra single treatment, and Gardo single treatment was significantly greater than that in the unweeded control treatment. The rest of weed control treatments were insignificantly less than the unweeded control treatment. Only three treatments showed remarkable reduction in the green biomass (20.65 for Amex combined treatment; 60.16% for Lumax combined treatment and 79.33% for the weeded control treatment. Except those treatments, green biomass increased more than the unweeded control treatment.

7. Selectivity on all perennial weeds

In 2014, population density of all perennial weeds was significantly greater in Lumax single treatment and Gardo combined treatment compared to the unweeded control treatment **(Table, 7)**. In contrast, mean population density was insignificantly different in the other treatments compared to the unweeded treatment. In

2015, the trend was somewhat different; the population of perennial weeds significantly increased in Amex combined treatment, Stomp extra single treatment, and Gardo both treatments. With the exception of weeded control treatment, the rest had population density of perennial weeds that was insignificantly greater than those in the unweeded control treatment. Weeded control treatment was the only treatment exhibited significantly less weed number than the unweeded treatment.

Stomp extra both treatment Lumax single treatment, Gardo both treatments and weeded control treatment were ineffective in reducing the populations of perennial weeds. Slight control was achieved in Amex both treatments (< 10.0%). Lumax combined treatment was the only treatment reduced perennial weed population by 41.21%. Based the comparison on the green biomass in 2014, the only effective treatments were stomp extra combined treatment and weeded control treatment with green biomass averaged 50.97 and 37.72, respectively compared to 160.12 gm/m^2 in the unweeded control treatment. In 2015, average weight of perennial weeds was insignificantly less in the treatments of Lumax and weeded control treatment. For the other treatments, green biomass was significantly different with the unweeded control. Weeded control treatment was the only treatment exhibited the greatest reduction in the green biomass (81.41%) followed by Lumax combined treatment (42.42%); Amex combined treatment (16.67) and Gardo combined treatment (1.88%). It could be concluded based on the reduction in the population density that none of the four herbicidal treatment and weeded control treatment is recommended to use against perennial weeds. However based on the reduction percentages in the green biomass, weeded control treatment is the only treatment to be recommended against when the perennial weeds are dominant. It is more accurate to depend on the reduction in the green biomass because some herbicides do not affect weed seed germination, however may be acted as a strong inhibitor of seedling root or/and shoot growth. In addition the biomass of weeds is negatively more affected on the growth of crop plants.

8. Selectivity on all weed flora

In 2014, the population density of all weed flora in Lumax single treatment was insignificantly greater than that in the unweeded control treatment **(Table, 8)**. Contrary, the greatest efficient treatment with the least population was Amex both treatments, Stomp extra combined treatment, Gardo combined treatment as well as weeded control treatment. Data in 2015 reconfirmed that Lumax single treatment exhibited the greatest number; however, it was insignificantly different from the unweeded control treatment. Also, the lowest number of weeds was in Amex both treatments, Stomp extra both treatments and Gardo combined treatment; they were significantly less (except Amex single treatment) than the weeded control treatment. Amex combined treatment, stomp extra both treatments, and Gardo combined treatment offered > 80% reduction in the population density followed by weeded control treatment (62.57); Gardo single treatment (53.769) and Lumax combined treatment (42.09). Lumax single treatment completely failed to control all weed flora (-6.96%). Data of green biomass determined in 2014 revealed that Lumax single treatment, Gardo single treatment were insignificantly less than the unweeded control treatment. In contrast, Amex and Stomp extra both treatments, Gardo combined treatment and weeded control treatment exhibited the least fresh weight. Mean fresh weight of all weed flora measured in 2015 in Lumax single treatment and Gardo single treatment were insignificantly less than that in unweeded control treatment. The best offered by Amex and Stomp extra both treatments, Lumax combined treatment, and Gardo combined treatment as well as weeded control treatment. Per cent reduction in the green biomass in those treatments ranged from 41.65 in Stomp extra single treatment to 73.35 in Gardo combined treatment compared to 65.98 in weeded control treatment. The least effective treatments were Lumax single treatment and Gardo single treatment with 11.29 and 12.86% reduction in the green biomass of all weed flora, respectively.

Discussion

It seems from the current study that annual narrow followed by annual broad were the greatest abundant groups. In contrast, Perennial narrow was the least abundant group with 5.51% in 2014; however it was not detected in 2015. In the present study, two annual narrow species were surveyed and two perennial grasses were surveyed in 2014 only, one perennial her was surveyed in the seasons. Almost, 11 weed species from annual broad were surveyed, however the predominant species only five. **Clewis *et al.* (2008)** in US five states, surveyed annual grasses to be barnyardgrass, broadleaf signalgrass, goosegrass, and large crabgrass. Also broadleaf weeds evaluated included entireleaf morningglory, pitted morningglory, sicklepod, and smooth pigweed.

The two tested dinitroaniline herbicides; pendimethalin (with the trade name, Stomp extra), and butralin (commercially named Amex) are evaluated in the current study. Pendimethalin inhibits cell division and cell elongation. It is listed in the K1-group according to the HRAC classification and butralin from the same group inhibits microtubule formation and disrupting cell division.

From the finding in this study, Amex, and stomp extra were ineffective against annual broad leaved weeds; however their integration with one hand hoeing at 60 days after sowing increased their performance to some extend, probably this enhancement was a sole effect of hand hoeing once. They performed well against annual grasses; the excellent performance was with Stomp extra, offering more than 90% reduction in this weed group followed by Amex (77.71%) compared to 64.29% efficiency in weeded control treatment. Hand hoeing once enhanced the performance of Amex to 91.07. It seems that Amex, Stomp extra are selective on annual grasses, they performed well as single treatments against perennial grasses. However, their integration with one hand hoeing antagonized their effect against this weed group. Concerning the use of herbicides for weed control in cottons several researchers have shown that dinitroaniline herbicides such as pendimethalin and butralin were more effective in controlling summer weeds and need light hoeing as complements **(Fayed *et al*. 1983, and Khan *et al*. 2001).** They obtained highest seed cotton yield with application of pendimethalin. **Ghourab (1990)** stated that combination of Goal and Amex showed higher seed cotton yield than single application of both herbicides. Reduced rate of herbicides could be used when it combined with other herbicides or any other means of weed control. **Cheema *et al.* (2003)** confirmed that 1/3 the recommended field rate of pendimethalin (333 g a.i. ha^{-1}) combined with concentrated sorgaab at 10 L ha^{-1} reduced total weed dry weight by 50-74%. However, the recommended rate of pendimethalin 33% applied on dry bed furrow before applying irrigation produced 82.5 % broad leaf and 84.1 % narrow leaf control which ultimately led towards obtaining seed cotton yield was 115.1% higher than the weedy check **(Dilbaugh *et al.*, 2009)**. **Nobrega *et al.* (1998)** confirmed that diuron (1.5 kg/ha) + pendimethalin (1.5 kg/ha) was from the most efficient pre-emergence mixtures for controlling weeds for a period of 60 days after planting. Pendimethalin is effective in controlling summer weeds and need light hoeing as complements **(Fayed *et al*. 1983, and Khan *et al*. 2001). Khan and Ul-Haq (2004)**) reported weed density to be 189 in the untreated in comparison with 27 and 39 the weed number in the Stomp 330-E and hand weeded plots respectively; they found that *Cyperus rotundus* was the most tolerant to all herbicides. **Richardson *et al*. (2007a)** reported that pendimethalin is usually controlled annual grasses. **Dilbaugh *et al.* (2009)** indicated that application of pendimethalin 33% on dry bed furrow before applying irrigation produced 82.5 % broad leaf and 84.1 % narrow leaf control which ultimately led towards obtaining seed cotton yield of 2689 kg ha-1 which was 115.1% higher than the weedy check. **Concerning the great efficiency of Amex on annual and perennial grasses, Mahmoud and Sabra (2009) obtained** maximum weed reduction and maximum yield increment when butralin was mixed with acetochlor. In addition**, Eldabaa et al. (2012)** obtained 88% control of soybean weeds in butralin at 2.25 L fed^{-1}treatment with insignificant difference with hoeing treatment in this respect. In more recent study by **Soliman *et al*. (2014)** in Egypt, obtained the highest values of weed control and yield with one from dinitroaniline herbicides (pendimethalin or butralin) followed by one hand hoeing.

Metolachlor is a popular herbicide in the United States **(**Metolachlor is becoming less and less common. As originally formulated metolachlor was applied as a racemate; a 1:1 mixture of the (*S*) - and (*R*)-stereoisomers. The (*R*)-enantiomer is inactive, and modern production methods afford only (*S*)-metolachlor, thus current application rates are far lower than original formulations. It iinhibits plant growth due to a reduction in both cell division and enlargement. It is a shoot inhibitor.Gardo acts like Amex and Stomp extra on annual grasses; however having different mechanism of action. Similarly to tested dinitroanile herbicides, it was ineffective against annual and perennial herbs; effective against annual and perennial grasses. However, hoeing antagonized its effect on annual grasses. With hand hoeing effective control of annual broad in addition to the performance of herbicide against annual grasses. These circumstances may stimulate the growth of perennial grasses in annual weeds free plots. **Recent advantages in weed control not to depend in single herbicide treatment; Cheema *et al.* (2003)** confirmed that 1/3rd of the recommended rate of S-metolachlor (667 g a.i. ha^{-1}) combined with concentrated sorgaab at 10 L ha^{-1} at sowing reduced total weed dry weight by 58-71%. **In the current study none of the four tested herbicides was effective against perennial broad leaved weeds even when they integrated with hand hoeing. In agreement, Khan and Hassan, (2003)** stated that S. Metolachlor proved very effective against most weeds except *Convolvulus* species. In the present study good control with Gardo against perennial grasses. **Khan and Hassan, (2003)** obtained acceptable control of *Cyperus* species, which is hard to control with other herbicides. . **Clewis *et al.* (2006)** mentioned that S-metolachlor was not beneficial for late-season control of entireleaf morningglory, jimsonweed, pitted morningglory, or yellow nutsedge. Cotton lint yield was increased 220 kg/ha with the addition of S-metolachlor to either glyphosate formulation compared with yield from glyphosate alone. **Webster *et al.* (2006)** found that s-metholachlor at 1.07 and 1.60 kg ai/ha was one from the most effective (>=80% control) herbicides. **Everman *et al*. (2007)** found when S-metolachlor added to glufosinate EPOST good control of all weeds except sicklepod, ivyleaf morningglory, and entireleaf morningglory. **Scroggs *et al.* (2007b)** evaluated glyphosate in combination with S-metolachlor and other residual herbicides and obtained optimum control of barnyardgrass and brown top millet. **Sparrow *et al.* (2007)** confirmed that the addition of S-metolachlor to glufosinate EPOST improved control of all weeds (common lambsquarters, common ragweed, entireleaf morningglory, ivyleaf morningglory, jimsonweed, pitted morningglory, purple nutsedge, and sicklepod) except sicklepod, ivyleaf morningglory, and entireleaf morningglory. **Clewis *et al.* (2008)** in USA found that the addition of s-metolachlor to glyphosate-TM EPOST systems (85 to 98% control) compared with glyphosate-TM EPOST alone (65 to 91% control). In the present study, the authors confirmed the efficiency of S-metolachlor on grasses not broad leaved weeds, which come in agreement with **Zemolin *et al.* (2014)** who stated that S-metolachlor is a preemergence herbicide used for the control of annual grasses and small-seeded broadleaf weeds in more than 70 agricultural crops worldwide.

Mesotrione, trade name Callisto or Lumax, is a broadleaf herbicide. Mesotrione is a systemic herbicide with both preemergence and postemergence activity. It was developed by Ciba-Geigy (**Kiely *et al*., 2004**). It inhibits plant pigment biosynthesis, specifically an enzyme called *4*-hydroxyphenylpyruvate dioxygenase (HPPD). Because mesotrione inhibits amino acid conversion and carotenoid biosynthesis, this results in the plant being unable to protect chlorophyll from decomposition by sunlight. Bleaching occurs within a week, but plant death may take up to two weeks. When applied preemergence, weeds take up the product through soil during emergence and growth. In the current study Lumax was selective in annual broad leaved weeds and was ineffective against grasses. In coincidence with this finding, **Sutton *et al*., 2002** confirmed that mesotrione provides control of the major broad-leaved weeds**.** Lumax (mesotrione) was ineffective as a single treatment on annual grasses and its performance enhanced by 37.65% when integrated with hoeing once. It was not effective against perennial herbs or perennial grasses neither when used alone or in combination with hoeing once. **Charles (1998)** annual grasses such as *Echinochloa crus-galli* were difficult to control without using residual herbicides. **Idziak *et al.* (2013)** found that mesotrione at 120 g ha^{-1} effectively controlled all weed species in sorghum, except *Geranium pusillum.*

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Table (1): Arabic, common, Latin and family names of eighteen weed species surveyed in the unweeded control plots at ninety days post sowing cotton in 2014 and 2015 seasons. Weed species arranged in genera alphabetic order.

Arabic name	Common name	Scientific name	Family	Description
حشيشة الأرانب 2015/2014	Sweet signal grass, Signal grass	*Brachiaria repans,* L. Gardner et Hubb	Gramineae	Annual grass
العليق الافرنجي 2015/2014	Field bindweed	*Convolvulus arevensis* var. *arvensis,* L.	Convolvulaceae	Perennial herb
ملوخية شيطاني 2014/2015	Nalta jute, Jews mallow	*Corchorus olitorius,* L.	Tiliaceae	Annual summer herb
النجيل 2015/2014	Bermuda grass	*Cynodon dactylon,* L. pers	Gramineae	Perennial herb
سعد 2015/2014	Purple nut sedge	Cyperus rotundus	Cyperaceae	Perennial herb
الداتورا 2015	Jimson weed	*Datura quercifolia*	Solanaceae	Annual summer herb
أبو ركبة 2015/2014	Deccan grass, Jungle rice, awnless, Barnyard grass	*Echinochloa colonum*	Gramineae	Annual summer grass
لبينة أو أم اللبن أو الشربة 2014	Mexican fir plant, Cat's milk, mad woman's milk, sun euphorbia, Sun spurge, Umbrella milk weed, Wart spurge, Wart weed	*Euphorbia helioscopia*	Euphorbiaceae	Annual summer herb
التيل الشيطانى 2015/2014	Bladder hibiscus	*Hibiscus trionum,* L.	Malvaceae	Annual summer herb
النفل الحلو 2015/2014	California burclover, toothed bur clover, toothed medick, burrmedic	*Medicago polymorpha*	Fabaceae	Annual winter herb
الرجلة 2014/2015	Pig weed, Common Purslane	*Portulaca oleracea*	Portulacaceae	Annual summer herb
الحميض 2015	Dentated dock	*Rumex dentatus,*L	Polygonaceae	Annual winter herb
عنب الديب 2015	Black nightshade	*Solanum nigrum*,L.	Solanaceae	Annual summer herb
الجعضيض 2015/2014	Sow thistle, Smooth sow thistle, annual sow thistle, Swinies	*Sonchus oleraceus*	Asteraceae	Annual winter or biannual herb
ذقن الشيخ 2015	Malta cross,Puncturevine	*Tribulus terrestris*, L	zygophyllaceae	Annual summer herb
حريق 2015	Small nettle	*Urtica urens*,L.	Urticaceae	Annual winter herb
بسلة شيطانى، جلبان 2015	Common vetch	*Vicia sativa,*L	Leguminosae	Annual winter herb
الشبيط 2014	Cocklebur, Rough Cocklebur, Broad cocklebur	*Xanthium pungens*	Asteraceae	Annual herb

Figure (1). Photos of weed species surveyed in cotton control plots at 90 days after sowing. Those photos arranged in genera alphabetic order.

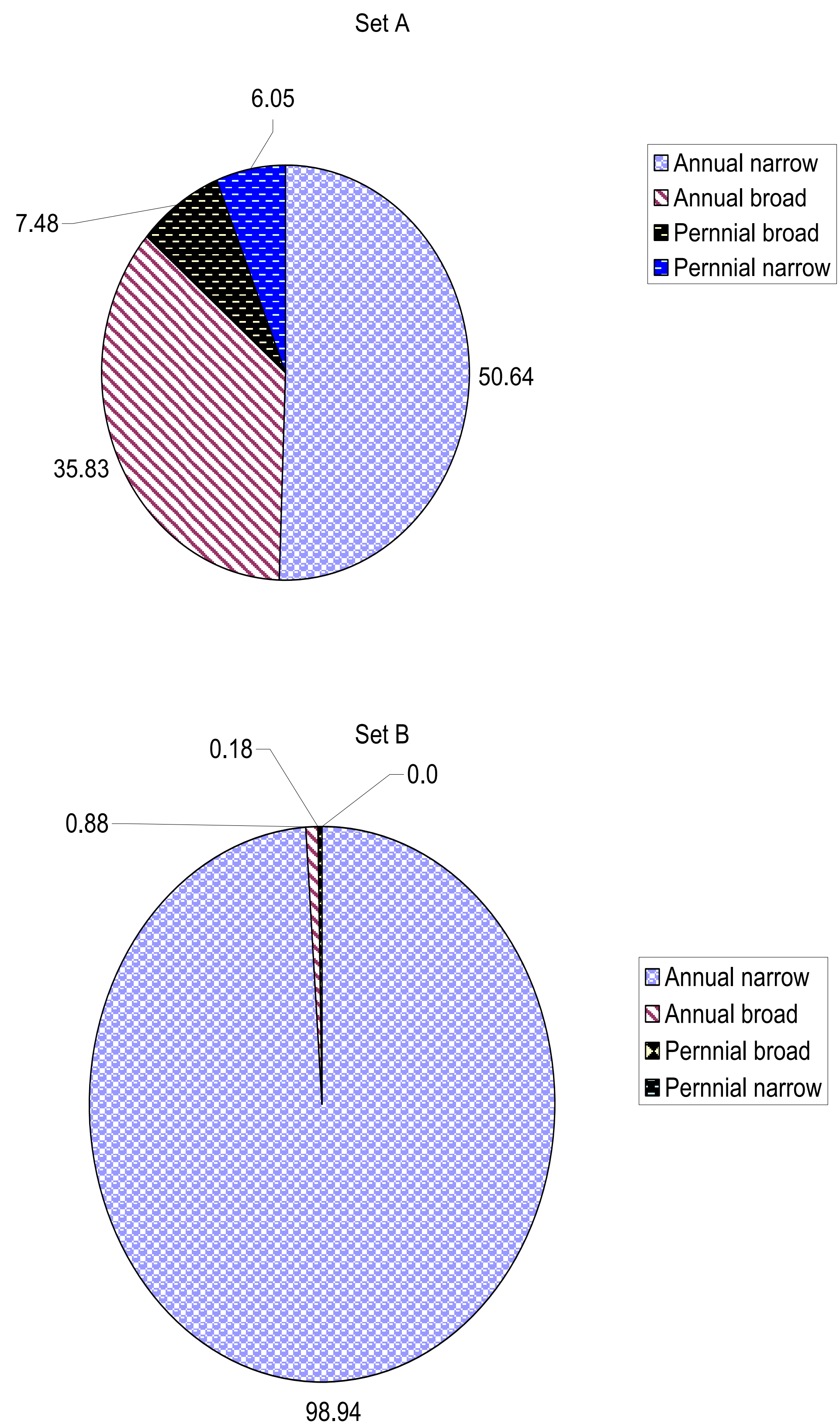
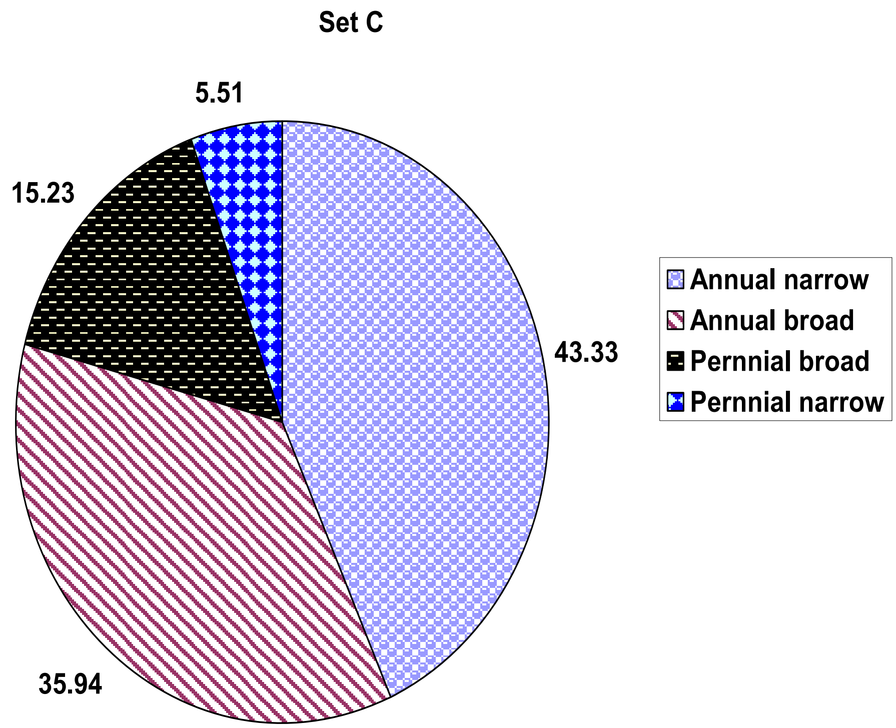


Figure (1A). frequency profiles based on the population density of the four weed groups monitored at 90 days after sowing in 2014 (Set A) and 2015 (Set B).



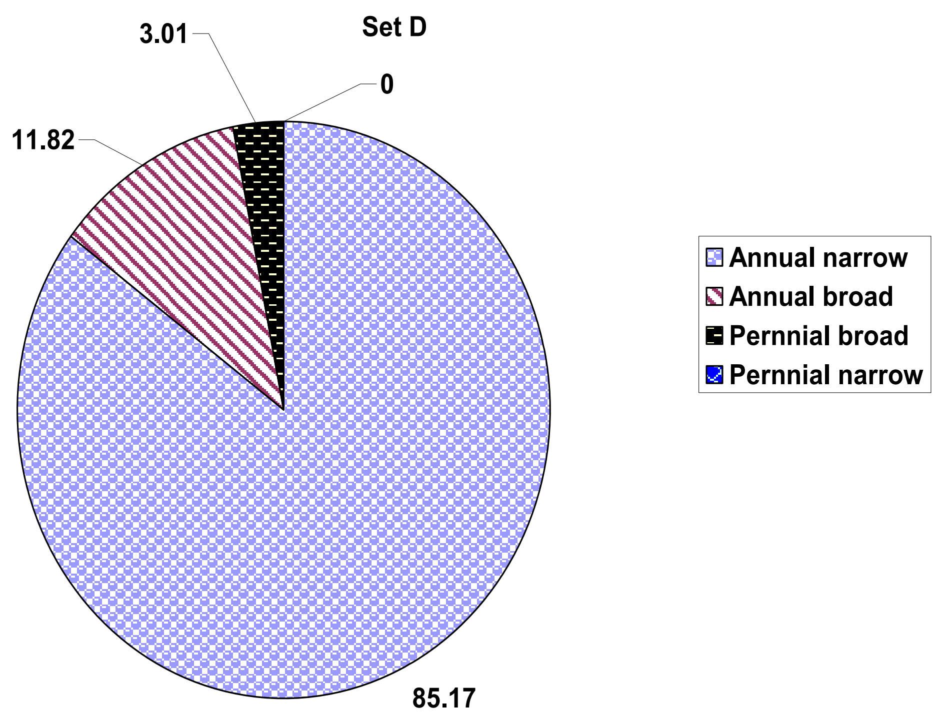


Figure (1B). frequency profiles based on the green biomass of the four weed groups monitored at 90 days after sowing in 2014 (Set A) and 2015 (Set B).

Table (2): Mean population density and fresh weight of annual broad group monitored at 90 days post planting in 2014 and 2015 cotton growing seasons.

Treatments	Rate (F.M. /fed.)	Mean number of weeds (individual weed/m^2)				Mean fresh weight (gm./m^2)			
		2014	2015	Mean	%Red.	2014	2015	Mean	%Red.
Amex, EC-48%	2.5L	64.0 ± 12.48b	2.67 ± 0.34bcd	33.34	-8.85	107.09 ± 29.55bcd	342.25 ± 114.85abcde	224.67	13.09
	2.5L + 1HO	25.50 ± 8.29c	6.17 ± 2.48bc	15.84	48.29	50.0 ± 17.24cd	626.28 ± 294.95a	338.14	-30.80
Stomp extra, SC- 45.5%	1.7L	87.25 ± 28.54a	8.33 ± 2.06b	47.79	-56.05	67.22 ± 22.11cd	452.99 ± 155.33ab	260.11	-0.61
	1.7L + 1HO	23.0 ± 11.62cd	8.34 ± 2.39b	15.67	48.83	16.63 ± 6.30d	414.36 ± 194.95ab	215.50	16.64
Lumax, SC-15%	1L	47.25 ± 14.27b	0.0d	23.63	22.86	211.43 ± 75.27ab	0.0e	105.72	59.11
	1L + 1HO	5.50 ± 1.19d	1.33 ± 0.67cd	3.42	88.85	62.37 ± 26.64cd	87.03 ± 50.35cde	74.70	71.115
Gardo, EC-96%	600ml	61.25 ± 14.29b	23.33 ± 7.34a	42.29	-38.09	137.43 ± 33.82bc	468.58 ± 137.61ab	303.01	-17.21
	600ml + 1HO	12.25 ± 6.26cd	22.66 ± 10.34a	17.46	43.01	45.79 ± 21.12cd	409.93 ± 137.75abcd	227.86	11.86
Weeded control	2HO	10.75 ± 2.59cd	0.67 ± 0.34cd	5.71	81.36	24.04 ± 8.89d	58.77 ± 33.99de	41.41	83.98
Un-weeded control	---	56.25 ± 10.83b	5.0 ± 1.62bcd	30.63	0.0	277.54 ± 70.47a	239.50 ± 69.77bcde	258.52	0
$LSR_{0.05}$		18.6993	6.1595709	---	---	109.5042072	355.3734571	---	---

For each column, means share at least one letter are not significantly different based on one way analysis of variance followed by Duncan Multiple Comparison test.

Table (3): Mean population density and fresh weight of annual narrow group monitored at 90 days post planting in 2014 and 2015 cotton growing seasons.

Treatments	Rate (F.M. /fed.)	Mean number of weeds (individual weed/m^2) 2014	2015	Mean	%Red.	Mean fresh weight (gm./m^2) 2014	2015	Mean	%Red.
Amex, EC-48%	2.5L	6.0 ± 1.87d	136.6 ± 65.65c	71.30	77.71	3.53 ± 1.59e	336.70 ± 191.59ef	170.125	83.489
	2.5L + 1HO	0.50 ± 0.29d	56.67 ± 14.35d	28.59	91.07	29.49 ± 5.24de	205.80 ± 42.27fg	117.65	88.58
Stomp extra, SC- 45.5%	1.7L	6.75 ± 5.22cd	0.0d	3.38	98.95	47.53 ± 19.73de	0.0g	23.77	97.69
	1.7L + 1HO	2.25 ± 1.03d	49.67 ± 24.61d	25.96	91.89	14.02 ± 10.48e	222.30 ± 121.61fg	118.16	88.53
Lumax, SC- 15%	1L	84.50 ± 42.93a	599.67 ± 26.97a	342.09	-6.93	266.23 ± 65.98ab	1706.0 ± 170.74a	986.12	4.29
	1L + 1HO	41.25 ± 21.01b	357.67 ± 72.57b	199.46	37.65	329.10 ±49.25a	963.80 ± 182.37bc	646.45	37.26
Gardo, EC- 96%	600ml	38.25 ± 27.13b	174.0 ± 78.77c	106.13	66.83	129.24 ± 37.66cd	838.70 ± 88.45cd	483.97	53.03
	600ml + 1HO	14.50 ± 6.06bcd	3.0 ± 1.50d	8.75	97.27	53.60 ± 6.12de	16.89 ± 9.76fg	35.25	96.58
Weeded control	2HO	35.50 ± 6.44bc	193.0 ± 37.24c	114.25	64.29	226.95 ± 48.30bc	573.40 ± 72.39de	400.18	61.16
Un-weeded control	---	79.50 ± 31.52a	560.337 ± 86.92a	319.92	0	334.58 ± 50.44ab	1726.0 ± 214.12a	1030.29	0.0
$LSR_{0.05}$		29.49674	73.467454			106.0593	324.59604	---	---

For each column, means share at least one letter are not significantly different based on one way analysis of variance followed by Duncan Multiple Comparison test.

Table (4): Mean population density and fresh weight of all annual weeds monitored at 90 days post planting in 2014 and 2015 cotton growing seasons

Treatments	Rate (F.M. /fed.)	Mean number of weeds (individual weed/m^2)				Mean fresh weight (gm./m^2)			
		2014	2015	Mean	%Red.	2014	2015	Mean	%Red.
Amex, EC-48%	2.5L	70.0 ± 12.69bc	139.27 ± 95.87de	104.64	70.15	110.62 ± 31.05de	678.95 ± 306.73def	394.79	69.37
	2.5L + 1HO	26.0 ± 7.31d	62.84 ± 26.23ef	44.42	87.33	79.49 ± 22.74de	832.08 ± 337.15cde	455.79	64.64
Stomp extra, SC- 45.5%	1.7L	94.0 ± 31.80b	8.33 ± 4.46f	51.17	85.40	114.75 ± 42.11de	452.99 ± 155.33ef	283.87	77.97
	1.7L + 1HO	25.25 ± 11.74d	58.0 ± 25.62ef	41.63	88.13	30.65 ± 11.80e	636.66 ± 316.29def	333.66	74.11
Lumax, SC-15%	1L	131.75± 42.52a	599.67± 28.42a	365.71	-4.33	477.66 ± 141.27ab	1706.0 ± 171.01ab	1091.83	15.28
	1L + 1HO	46.75 ± 25.94cd	359.0 ± 121.64b	202.88	42.13	391.47 ± 76.64bc	1050.83 ± 232.46bcd	721.15	44.05
Gardo, EC-96%	600ml	99.50 ± 20.07ab	197.33 ± 131.86cd	148.42	57.66	266.67 ± 71.32cd	1307.28 ± 225.01bc	786.98	38.94
	600ml + 1HO	26.75 ± 33.24d	25.66 ± 15.53f	26.21	92.53	99.39 ± 27.12de	426.82 ± 147.55f	263.11	79.59
Weeded control	2HO	46.25 ± 4.03cd	193.67± 41.07d	119.96	65.78	250.99 ± 57.39cd	632.17 ± 106.41def	441.58	65.74
Un-weeded control	---	135.75 ± 38.15a	565.34 ± 124.74a	350.55	0.0	612.12 ± 120.96a	1965.50 ± 284.16a	1288.81	0.0
$LSR_{0.05}$		36.28319	112.26956	---	---	206.5855	534.89399	---	---

For each column, means share at least one letter are not significantly different based on one way analysis of variance followed by Duncan Multiple Comparison test.

Table (5): Mean population density and fresh weight of perennial narrow leaved weeds monitored at 90 days post planting in 2014 cotton growing seasons. Different trend was achieved when the comparisons based on the green biomass.

Treatments	Rate (F.M. /fed.)	Mean number of weeds (individual weed/m^2)		Mean fresh weight (gm./m^2)	
		Population density	%Reduction	Green biomass	%Reduction
Amex, EC-48%	2.5L	0.25 ± 0.13c	97.37	4.19 ± 2.09ab	90.15
	2.5L + 1HO	10.25 ± 2.49bc	-7.90	42.52 ± 14.69ab	0.0
Stomp extra, SC- 45.5%	1.7L	0.0c	100	0.0b	100.0
	1.7L + 1HO	8.0 ± 2.44c	15.79	10.18 ± 3.58ab	76.06
Lumax, SC-15%	1L	25.75 ± 6.21a	-171.05	56.17 ± 45.48a	-32.10
	1L + 1HO	4.25 ± 1.05c	55.26	56.17 ± 24.53a	-32.10
Gardo, EC-96%	600ml	2.25 ± 0.83c	76.32	4.05 ± 1.56ab	90.48
	600ml + 1HO	22.75 ± 6.96a	-139.47	28.8 ± 13.30ab	32.27
Control treatment	Weeded	20.25 ± 6.78ab	-113.16	4.19 ± 2.09ab	90.15
	Unweeded	9.50 ± 3.15bc	0.0	42.52 ± 14.69ab	0.0
$LSR_{0.05}$		13.47884	---	52.79399	52.79399

For each column, means share at least one letter are not significantly different based on one way analysis of variance followed by Duncan Multiple Comparison test.

Table (6): Mean population density and fresh weight of perennial broad leaved weeds monitored at 90 days post planting.

Treatments	Rate (F.M. /fed.)	Mean number of weeds (individual weed/m²) 2014 right	2015	Mean	%Red.	Mean fresh weight (gm./m²) 2014	2015	Mean	%Red.
Amex, EC-48%	2.5L	12.25 ± 5.81bcd	3.33 ± 1.67cde	7.79	-22.20	168.20 ± 26.96bcd	192.30 ± 48.53c	180.25	-101.80
	2.5L + 1HO	7.25 ± 1.70d	7.67 ± 2.41bc	7.46	-17.02	41.73 ± 10.09ef	100.02 ± 28.94c	70.88	20.65
Stomp extra, SC- 45.5%	1.7L	9.50 ± 4.56cd	12.67 ± 4.09a	11.09	-73.88	216.10 ± 36.89b	830.25 ± 219.59a	523.18	-485.80
	1.7L + 1HO	11.25 ± 3.95bcd	4.0 ± 3.0cd	7.63	-19.61	40.79 ± 7.61ef	182.10 ± 51.13c	111.45	-24.78
Lumax, SC-15%	1L	15.50 ± 8.87bc	1.0 ± 0.58d	8.25	-29.41	184.50 ± 70.50bc	60.32 ± 22.382c	122.41	-37.05
	1L + 1HO	5.50 ± 3.93d	3.33 ± 3.34cde	4.42	30.75	14.36 ± 3.93f	56.80 ± 32.86c	35.58	60.16
Gardo, EC-96%	600ml	25.0 ± 3.39a	10.33 ± 4.09ab	17.67	-177.10	314.40 ± 49.08a	519.78 ± 149.37b	417.09	-367.0
	600ml + 1HO	17.50 ± 8.66b	5.0 ± 1.0c	11.25	-76.47	80.80 ± 20.23def	107.40 ± 14.450c	94.10	-5.357
Weeded control	2HO	10.25 ± 3.49cd	0.33 ± 0.33e	5.29	17.02	33.53 ± 5.84ef	3.40 ± 1.97c	18.47	79.326
Un-weeded control	---	11.75 ± 0.95bcd	1.0 ± 1.0d	6.38	0.0	117.60 ± 24.96cde	61.03 ± 35.31c	89.32	0.0
$LSR_{0.05}$		7.1436	3.5803			93.88231	223.9311	---	---

For each column, means share at least one letter are not significantly different based on one way analysis of variance followed by Duncan Multiple Comparison test.

Table (7): Mean population density and fresh weight of all perennial weeds monitored at 90 days post planting in 2014 and 2015 cotton growing.

Treatments	Rate (F.M. /fed.)	Mean number of weeds (individual weed/m^2)				Mean fresh weight (gm./m^2)			
		2014	2015	Mean	%Red.	2014	2015	Mean	%Red.
Amex, EC-48%	2.5L	17.50 ± 10.33cd	3.33 ± 1.67cde	10.415	6.382	172.39 ± 26.42bc	192.30 ± 48.53c	182.35	-64.91
	2.5L + 1HO	12.50 ± 1.66d	7.67 ± 2.41bc	10.085	9.3483	84.26 ± 13.33cde	100.02 ± 28.94c	92.14	16.67
Stomp extra, SC- 45.5%	1.7L	9.50 ± 4.56d	12.67 ± 4.09a	11.085	0.3596	216.13 ± 36.89b	830.25 ± 219.59a	523.19	-373.15
	1.7L + 1HO	19.25 ± 5.81bcd	4.0 ± 3.0cd	11.625	-4.494	50.97 ± 7.84e	182.10 ± 51.13c	116.54	-5.39
Lumax, SC-15%	1L	41.25 ± 10.01a	1.0 ± 0.58d	21.125	-89.89	240.67 ± 61.736ab	60.32 ±22.38c	150.50	-36.10
	1L + 1HO	9.75 ± 4.39d	3.33 ± 3.34cde	6.54	41.213	70.54 ± 22.57de	56.80 ± 32.86c	63.67	42.42
Gardo, EC-96%	600ml	27.25 ± 4.27bc	10.33 ± 4.09ab	18.79	-68.9	318.40 ± 48.79a	519.78 ± 149.37b	419.09	-279.01
	600ml + 1HO	40.25 ± 15.34a	5.0 ± 1.0c	22.625	-103.4	109.60 ± 22.17cde	107.40 ± 14.45c	108.50	1.88
Weeded control	2HO	30.50 ± 13.75ab	0.33 ± 0.33e	15.415	-38.56	37.72 ± 10.63e	3.40 ± 1.97c	20.56	81.41
Un-weeded control	---	21.25 ± 6.89bcd	1.0 ± 1.0d	11.125	0.0	160.12 ± 28.28bcd	61.03 ± 35.31c	110.58	0.0
$LSR_{0.05}$		12.17954	3.5803	---	---	89.96751	223.9311	---	---

For each column, means share at least one letter are not significantly different based on one way analysis of variance followed by Duncan Multiple Comparison test.

Table (8): Mean population density and fresh weight of all weed flora monitored at 90 days post planting in 2014 and 2015 cotton growing seasons

Treatments	Rate (F.M. /fed.)	Mean number of weeds (individual weed/m^2)				Mean fresh weight (gm./m^2)			
		2014	2015	Mean	%Red.	2014	2015	Mean	%Red.
Amex, EC-48%	2.5L	87.5 ± 13.19de	142.60 ± 92.66cd	115.05	68.189	279.07 ± 56.29cd	871.25 ± 354.39de	575.16	58.41
	2.5L + 1HO	38.50 ± 6.89e	70.51 ± 27.77d	54.505	84.93	131.47 ± 22.19d	932.10 ± 366.16de	531.79	61.55
Stomp extra, SC- 45.5%	1.7L	103.50 ± 29.45cd	21.0 ± 7.49d	62.25	82.788	330.85 ± 78.44bcd	1283.20 ± 374.98bcd	807.03	41.65
	1.7L + 1HO	44.50 ± 12.55e	62.0 ± 18.61d	53.25	85.277	79.44 ± 19.462d	818.76 ± 367.90de	449.10	67.53
Lumax, SC-15%	1L	173.0 ± 33.73a	600.67 + 120.83a	386.835	-6.958	687.40 ± 187.34a	1766.30 ± 193.12abc	1226.85	11.29
	1L + 1HO	56.50 ± 39.097e	362.33 ± 118.31b	209.415	42.098	410.09 ± 65.97bc	1107.60 ± 265.60cde	758.85	45.13
Gardo, EC-96%	600ml	126.75 ± 16.73bc	207.66 ± 130.86c	167.205	53.769	583.32 ± 121.18ab	1827.10 ± 375.24ab	1205.21	12.86
	600ml + 1HO	67.0 ± 23.33e	30.66 ± 15.19d	48.83	86.499	202.94 ± 50.55cd	534.22 ± 161.95e	368.58	73.35
Weeded control	2HO	76.75 ± 10.36de	194.0 ± 40.96c	135.375	62.569	305.40 ± 75.43cd	635.57 ± 108.354de	470.49	65.98
Un-weeded control	---	157.0 ± 40.64ab	566.34 ± 124.58a	361.67	0	990.14 ± 144.26a	2026.81 ± 319.29a	1383.0	0.0
$LSR_{0.05}$		35.02227	121.67945	---	---	271.63188	673.13814	---	---

For each column, means share at least one letter are not significantly different based on one way analysis of variance followed by Duncan Multiple Comparison test.