513
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RESPONSE OF WHEAT PLANTS AND ACCOMPANIED WEEDS TO SOME NEW HERBICIDES ALONE OR COMBINED IN SEQUENCE

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ABSTRACT

Weeds represent the most serious problem in wheat in Egypt. For their control, two field experiments were carried out during two winter seasons (2004/2005) and (2005/2006) at National Research Centre experimental station at Shalakan, Kalubia Governorate. Some groups of herbicides (Dirby, Harmony extra, Granstar, Ecopart, Illoxan, Topic and Arelon) as well as hand weeding and unweeded treatments were evaluated in wheat. In addition, herbicide combinations were also assessed. Harmony extra at 24 g / fed. provided acceptable control for broad leaved weeds but failed to control completely narrow-leaved weeds. Topic at 140 g / fed. provided great control of narrow weeds (97.68% reduction in dry weight after 90 days from sowing). Mixtures of both Harmony extra +Topic at rates (18 g / fed. +105 g / fed.) were better than Harmony extra alone for weed control (99.19 % control, 90 days after sowing) and grain yield. Concerning the other herbicides, Granstar + Topic were effective in controlling both broad and narrow weeds. The efficacy of Harmony extra + Illoxan was lower (91.2% control). Overall, Arelon or mixture of Harmony extra +Topic were the most effective treatments with regard to weed control and wheat growth, yield and its attributes. However, no carryover damage with all used herbicides was observed on wheat. Estimating individual amino acids in the yielded grain revealed increase in essential and nonessential amino acids due to single or combined application of herbicides. Pronounced increase was recorded with Harmony extra and Topic.

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INTRODUCTION

Wheat is one of the most important crops in the world. It is considered the main source of foods in Egypt. So, increasing wheat production must be a national interest to minimize the gab between production and consumption.

Weeds are the most important problem in wheat causing loss of yield. The reduction of wheat yield due to weed infestation amounted 30.7% **(Nisha *et al* 1999)**, 31.9% (**Tiwari and Parihar, 1997)** to 61% **(Hucl, 1998)** as compared to weed free control. Weeds may affect wheat production in many ways; wheat yield may be reduced significantly when weeds compete with wheat plants for light, water and minerals (**Hussein, 2002**).

Weeds may also inhibit wheat growth through release of allelopathic chemicals that are toxic to wheat plants (**Ortega *et al* 2002**). In addition, weeds or weed seeds contaminating harvesting grains may reduce quality. Moreover, weeds may interfere with harvesting and raise the moisture contents of the harvested grains, leading to damage from heat and pests in storage (**Al-Khatib, 1995**). Moreover, weeds are part of the ecology of a field and can have other less obvious effects, such as serving as a reservoir for insects (**Marshall *et al* 2003**) and diseases (**Ramappa *et al* 1998**).

Weeds can be controlled by mechanical methods, but dependence on these methods alone decreased weed control consistency, crop yield and economic return (**Mount Pleasant *et al* 1994**). So, using herbicides is one option to control weeds effectively in wheat.

Several weed control strategies are available to control weeds in wheat. Ecopart (pyraflufen ethyl) was introduced as a new selective herbicide for control of broadleaved weeds in cereals (**Miura *et al* 1993**). It discovered by Nihon Nohyaku Co. Ltd. and belongs to the chemical group of phenylpyrazoles. It is well known as a substance of the wild family of PPO-inhibitors (inhibits the plant enzyme protoporphyrinogen oxidase). It causes rapid necrosis and desiccation of stems and leaves in sensitive species in the presence of light (**WSSA Herbicide Handbook Committee, 2002, p. 374 and Ivany, 2005**). The herbicide used in co-formulations with different herbicides for control of broadleaved weeds in cereals (**Scheer *et al* 2004**).

Illoxan (diclofop methyl) and Topic (clidinafop-propargyl) are two selective grass herbicides related to aryloxyphenoxy propionate which are active against acetyl Co enzyme A carboxylase in sensitive species (**Burton *et al* 1989 and Bradely *et al* 2001**). They are used alone to control narrow weeds (grasses) or mixed with substituted urea e.g., Harmony extra (thifensulfuron), Granstar (tribenuron), Arelone (isoproturon) or others (**Heredia, 2001**). These groups of herbicides are used to control broadleaved weeds through inhibiting branched chain amino acids (leucine, isoleucine and valine) by inhibiting one key plant enzyme acetolactate synthase (**Buker *et al* 2004**).

Illoxan or topic was found to reduce weed dry matter e.g., *Phalaris minor, Lolium rigidum* and in turn increased wheat grain yield (**Kumer *et al* 2005** and **Saini and Angiras, 2005**). While, **Saad El-Din and Ahmed (2004)** reported that application of Granstar significantly decreased weed population and weight of weeds grown in wheat fields as compared to unweeded treatment. However, It was proved that weed control was more consistent when two herbicide applications were used compared with single application, **Fenni *et al* (2002)** stated that combination of Illoxan with Bromonxyl controlled effectively both broad and narrow leaved weeds and increased wheat grain yield by more than 1200 kg/ha compared with unweeded control. Similarly, Illoxan + Sinal at 0.027 + 0.66 L / fed controlled broad and narrow leaved weeds in wheat and increased wheat grain yield compared to single application (**Sharara *et al* 2006**). Similar results were obtained by (**Khan *et al* 2004**; **Barros *et al* 2005** and **Tiwari *et al* 2005**). However, improving wheat growth, yield and its components due to application of isoproturon was achieved by **El-Metwally (2002).**

Therefore, this study aimed to evaluate the efficacy of some herbicides used alone (at recommended rates) and combined in sequence (at lower rates) on growth, yield, yield attributes and total amino acids as well as associated weeds.

MATERIALS AND METHODS

Two field experiments were conducted at the Agricultural Experimental station at National Research Centre, in Shalakan, Kalubia Governorate, Egypt to study the effect of some herbicides related to different groups alone or combined in sequence on controlling weeds in wheat during two winter seasons (2004/2005) and (2005/2006). The soil texture was clay loam with 1.72 % organic matter and pH 8.12. The experimental unite (plot) area was 10.50 m^2 (1/400feddan). Wheat grains (*Triticum aestivum* L.) cv. Giza 168 was broadcasted on the soil at the rate of 60kg/ feddan on both seasons. The grains were sown at 20 November in 2004/2005 and 27 November in 2005/2006. The other cultural practices were applied as usual. Harvesting was performed in 20 and 27 of May in the first and second seasons, respectively. The experiments consisted of 17 treatments including control and hand weeding. Weed control treatments with three replicates were arranged randomly as follow:

1-Dirby (30cm/fed.) 2-Harmony (24g / fed.).
3-Ecopart (250cm/fed.). 4-Granstar (8g/fed.)
5-Illoxan (1 L / fed). 6-Topic (140g / fed).
7-Dirby + Illoxan (22.5 cm + 0.75 L).
8-Dirby + Topic (22.5 cm + 105 g).
9-Harmony + Illoxan (18g + 0.75L).
10-Harmony + Topic (18 g + 105 g).
11-Ecopart + Illoxan (187.5cm + 0.75 L).
12-Ecopart + Topic (187.5 cm + 105 g).
13-Granstar + Illoxan (6 g + 0.75 L).
14-Granstar + Topic (6 g + 105g).
15-Arelon (1.25 L / fed).
16-Hand weeding after 35 days from sowing.
17-Unweeded (Without control).

The herbicides were sprayed with knapsack sprayer. The common, trade and chemical names as well as the rate of application of the herbicides used are shown in **Table (1)**.

Weed samples from one square meter were taken randomly from each plot 60 and 90 days after sowing. After heading stage samples of ten wheat plants were taken randomly from each plot to determine flag leaf area (cm^2). Samples of ten wheat tillers were taken randomly from each plot at the end of the season to measure plant height (cm), Spike length (cm), number of spikelets / spike, number of grains / spike, weight

of grains / spike and weight of 1000-grains (g). At harvest, samples from one square meter were taken and the following measurements were recorded:

Number of spikes /m^2 , grain yield (ardab / fed.) and straw yield (ton / fed.).

Combined data of the two seasons were statistically analyzed according to **Little and Hills (1978).**

Chlorophyll concentration of leaves

Total chlorophyll was measured by using MINOLTA CHLOROPHYLL METER 502 (SPAD) Soil and plant analysis Department from Minolta Company. Leaf chlorophyll a concentration evaluated with SPAD units was transformed to mg /m^2 by the following equation, (**Monje and Bugbee, 1992**): Chl. = 80.05 + 10.40 x (SPAD).

Total aminoacids

Hydrolysis was carried out according to the method of **Spitz, (1973)** as follow: A known weight of grinded grains was placed in a test tube with screw cap; 10ml of 6N HCl was added. The test tubes were transformed to an electric oven at 110°C for 24 hours. The extract was filtrated, then transferred quantitatively to evaporating flask and allowed to remove HCl under vacuum.

Total amino acid analyses were performed on an Eppendorf-Germany LC 3000 amino acid analyzer. The operating conditions were: flow rate, 0.2ml/min.; Pressure of buffer from 0 to 50 bars; pressure of reagent from 0 to 150 and reaction temperature 123°C.

RESULTS

Weed growth

The major weed species which were found in the wheat fields were annual broad leaved weeds, i.e. *Chenopodium album* L.; *Beta vulgaris* L.; *Melilotus indicus* L. and *Ammi majus* L. while the dominant annual grass weeds were *Avena fatua* L. and *Lolium temulentum* L.

Broad leaved weeds

Data in **Table (2)** reveal that all weed control treatments decreased significantly the fresh and dry weight of broadleaved weeds after 60 and 90 days from sowing as compared to the unweeded check. In general, application of Harmony or Granstar alone or combined with topic or Illoxan recorded the highest significant reduction in both fresh and dry weights of broadleaved weeds. It is worthy to mention that while the reduction in dry weight at 90 days after sowing reached to 87.38-99.24% due to combined treatments of topic and other herbicides, this reduction recorded 16 % by Topic alone as compared to unweeded control.

Narrow leaved weeds

As indicated in **Table (2)**, the application of all herbicides alone or in combined application were found to inhibit significantly both fresh and dry weight of grasses at both stages (after 60 and 90 days). Maximum significant reduction was realized by Arelon alone where it recorded 99.92 and 99.23% reduction in dry weight after 60 and 90 days from sowing in comparison to unweeded control. In addition, Topic alone or in combined spraying induced great significant inhibition where it reached 97.68 % reduction in dry weight 90 days after sowing. This reduction recorded 89.66, 97.68, 85.79 and 95.35 % when sprayed with Dirby, Harmony, Ecopart or Granstar, respectively.

Total weeds

The data in **Table (2)** show that all weed control treatments decreased significantly the total fresh and dry weight of weeds after 60 and 90 days from sowing in comparison to the unweeded control. The highest significant reductions in total dry weight were obtained by Arelon (99.30 and 98.96 %), Harmony + Topic (99.03 and 98.26), Granstar + Topic (98.47 and 97.22 %) and Granstar + Illoxan (96.80 and 95.02 %), respectively in comparison with unweeded control in the combined of the two seasons. The lowest reduction in total dry weight after 60 and 90 days from sowing recorded by using single treatment of Ecopart (43.21 and 50.39 %) or Granstar (50.96 and 52.82).

Wheat studies

Growth characters

Flag leaf area (cm^2) and plant height (cm): Data recorded in **Table (3)** indicate that flag leaf area and plant height were markedly increased due to controlling weeds by different herbicide treatments alone or in sequence as compared to the

Table 3. Comparative studies between the effect of some herbicides alone or their combinations on plant height, flag leaf area and total chlorophyll contents in the leaves of wheat cv. Giza 168 at heading (Combined analysis of the two seasons).

Treatments	Rate / fed	Plant height (cm)	Flag leaf area (cm^2)	chlorophyll contents mg / m^2
Dirby	30 cm	93.75	34.65	477.33
Harmony	24 g	94.17	35.20	480.45
Ecopart	250 cm	91.77	33.50	474.73
Granstar	8 g	91.88	34.11	474.73
Illoxan	1 L	89.10	33.10	466.41
Topic	140 g	94.10	34.75	480.45
Dirby +Illoxan	22.5 cm+ 0.75 L	98.10	37.62	496.05
Dirby+Topic	22.5 cm+ +105 g	98.99	38.90	506.45
Harmony+Illoxan	18g+ 0.75 L	98.53	38.72	508.01
Harmony+Topic	18g +105 g	103.00	42.17	557.41
Ecopart+Illoxan	187.5cm +0 .75L	96.42	36.50	496.05
Ecopart+Topic	187.5cm + 105 g	96.99	38.11	481.49
Granstar+Illoxan	6g + 0.75L	99.96	39.30	537.13
Granstar+Topic	6 g + 105 g	101.42	40.15	537.65
Arelon	1.25 L	101.88	41.92	528.81
Hand weeding	-	94.33	37.45	481.49
Unweeded	-	87.75	32.00	441.97
LSD at 5 %		3.40	1.24	15.38

unweeded and hand weeding treatments. Maximum values were detected with Harmony + Topic followed by Arelon, Granstar +topic, Gransrar + Illoxan and Dirby + Topic, respectively. The lowest values were recorded with the unweeded check.

Grain yield and its components

Number of spikes / m²

The results in **Table (4)** indicate that the majority of herbicide mixtures induced great significant increase in number of spikes /m^2. The increase was higher with mixture than individual herbicides. Mixed treatments of herbicides caused marked significant increase especially with Harmony + Topic (66.67 % over unweeded control). Similarly great significant increase was obtained due to Arelon alone (62.96% over unweeded control). However, the lowest number was recorded with unweeded check.

Spike length (cm)

The data presented in **Table (4)** indicate that spike length increased significantly over the unweeded control due to most herbicide treatments alone or in combined treatments. Maximum increase was obtained by adding the herbicide Topic to Harmony extra followed by single herbicide treatment of Arelon. In contrast, unweeded plots recorded the lowest values in spike length.

Number of spikelets/spike and number of grains / spike

The obtained results **(Table 4)** indicate that the number of spikelets and number of grains /spike increased significantly mostly by herbicide mixture. However, significant increase was observed to lesser extent by individual herbicides. Arelon exhibited large significant increase that corresponded to the effect of combined treatments of Harmony + Topic and exceeded to a great extent the effect of other herbicide mixtures as compared to the unweeded control.

Weight of grains /spike (g)

The results in **Table (4)** indicate that treating wheat plants with herbicides alone or in combination appeared to enhance significantly weight of grains / spike as compared with unweeded control. The increase was noticeable with application of Harmony and Topic (74.59 % over unweeded control). In addition, Arelon caused great significant increase (56.35 %).

Weight of 1000-grain / spike (g)

The data illustrated in **Table (4)** reveal that foliar application of herbicides increased significantly weight of 1000grains. No evidence refers to antagonistic action between mixed herbicides; consequently, the response was higher with combined treatments. Moreover, Arelon recorded marked significant increase. The most effective treatment obtained with combined treatments of Harmony with Topic, the increase reached to 35.25% over unweeded control. It is worthy to mention that Arelon recorded 19.27%.

Grain yield (ardab /feddan)

Data in **Table (4)** show great significant differences in wheat grain yield (combined of the two seasons) due to all herbicides and hand weeding treatments. Multiple herbicide application resulted in higher grain yield than single herbicide application. Thus, the highest grain yield was remarkable with Harmony + Topic followed by Arelon, Granstar + topic or Granstar + Illoxan. These superior treatments increased the average of grain yield than unweeded treatment by 82.84, 76.04, 73.28 and 67.65 %, respectively.

Straw yield (ton /feddan)

Table (4) shows that all herbicidal treatments increased significantly straw yield (ton / feddan). The increase was higher with the herbicide mixtures. The herbicide Arelon also recorded high significant increase. However, no evidence refers to great variation between individual treatments.

Biological yield (kg /feddan)

The results in the same table indicate that the biological yield (kg / feddan) follow similar trend of grain yield.

Chemical analysis

Chlorophyll contents (Spad, mg/m2)

The data of chlorophyll content (mg/m2) in **Table (3)** reveal that total chlorophyll content increased significantly under each herbicide treatment especially with those of mixed application. The extent of increase depended upon type of herbicide application as well as type of supplemented herbicides. The most remarkable increase in chlorophyll content was noticed with Topic when supplemented with Harmony, Granstar +topic, Gransrar + Illoxan, respectively. Arelon as well recorded large significant increase.

Total amino acids

Amino acids are the building blocks of protein. Protein has an important job in building and rebuilding body tissue and providing the body with nitrogen, an essential element for all living beings. So, estimating the contents of amino acids is important. The results reveal both essential and non-essential amino acids in the yielded grains.

As indicated in **Table (5)** that total amino acids increased greatly over unweeded control due to treatments with different herbicides alone or in combinations. In general, detectable increases were recorded with herbicide mixtures. The greatest increase was estimated with foliar application of both herbicides Harmony and Topic which increased both essential and nonessential amino acids. Individually, this treatment increased essential amino acids, therionine, cystine, methionine, isoleucine, leucine, tyrosine, phenylalanine, histidine and lysine. Observable increase was obtained also in non essential amino acids especially, glutamic, aspartic, alanine and glycine. It is worthy to mention that remarkable increase was recorded in individual amino acids due to mixed application of Ecopart and Illoxan, but this increase was accompanied by striking increase in ammonia as compared to the untreated control. It is also interesting to mention that there is observable increase in total amino acids with the single treatment of the herbicide Harmony as compared to the control.

DISCUSSION

Mechanized agriculture usually necessitates the use of herbicides. Herbicides account for about half the money spent worldwide on substances for plant protection **(Cobb and Kirkwood, 2000)**.

The high cost of labor is one of the main reasons for using herbicides in agriculture. It is cheaper and faster to keep a field free of weeds by using herbicides than by manual labor.

Thus, the recommended rates of herbicides, types with new active ingredients (ai) have been developed, which inhibit certain basic biochemical processes in sensitive species. These herbicides have definite target sites resulting in the inhibition of, for example, the synthesis of fatty acids ((e.g, diclofop methyl or clidinafop-propargyl)**,** certain amino acids (e.g. Isoproturon, Tribenuron-methyl or Thifensulfuron), carotenoides or chlorophylls (e.g., pyraflufen-ethyl) and others.

The herbicides used in the present work have different targets in plants. These target sites are acetyl coenzyme-A carboxylase (diclofop methyl or clidinafop-propargyl); the key enzyme of fatty acid biosynthesis. (Cobb and Kirkwood, 2000); acetolactate synthase the key plant enzyme inhibiting branched chain amino acids leucine, isoleucine and valine (**Buker *et al* 2004**) and the plant enzyme protoporphyrinogen oxidase (**Ivany, 2005**).

All are selective post-emergence herbicides with intensive control of broad-leaved weeds or grass weeds in cereals and dicot crops. Arelon, Dirby, Harmony extra, Ecopart and Granstar are well-known selective post emergence herbicides for controlling broadleaved weeds **(Khan *et al* 2004; Ivany, 2005; Kumar *et al* 2005 and Tiwari *et al* 2005)**. In addition, Illoxan and Topic also provides complete control of grass weeds in wheat **(Shaban *et al* 2004 and Saini and Angiras, 2005)**. Thus, in the present work, the above-mentioned herbicides were applied with wheat. Each herbicide is applied as a foliar spray (postemergent), when the crop plant is approximately 20-25 days-old according to the recommendation of each **(Table, 1)**. At such an early age, the crop is subjected to the applied herbicide alone or in combined application as in **Table (2)**. The effects of these herbicides were traced, either alone or in sequence on the growth of broad and grassy weeds and productivity of wheat. Then, the herbicide effects were compared with corresponding criteria of the control plants.

The results obtained with the different growth criteria of both broad and narrow weeds [fresh and dry weight (**Table, 2**)] revealed that foliar spray with Arelon, Dirby, Harmony extra, Ecopart and Granstar caused a greatly significant decrease in the fresh and dry weight of weeds specially at all stages of growth and development. Inhibition of weed growth was also recorded in response to application of these herbicides or similar herbicides **(Khan *et al* 2004; Chen *et al* 2005; Kumar *et al* 2005; Saini and Agiras, 2005 and Tiwari *et al* 2005)**. In addition, the results of the present work further indicated that Illoxan and Topic had a greater influence on the reduction of growth of narrow weeds. In this connection, (**Singh, 2004 and Tagour, 2006**) also approached similar conclusions. Furthermore, it is worthy to mention that, application of the above mentioned herbicides in mixture caused further reduction in both fresh and dry weight of broad and narrow weeds as compared to the unweeded control. Similar results were obtained by several workers (**Fenni *et al* 2002; Shaban *et al* 2004; Barros *et al* 2005; Kumar *et al* 2005 and Tiwari *et al* 2005).**

The above mentioned reduction in fresh and dry weight of the weeds treated with different herbicides was accompanied by a greatly significant increase in the chlorophyll contents in wheat leaves as well as increase in wheat yield. The increase in yield resulted from an increase in the number of spikes / plant, number of spikelets /spike, which was reflected on the weight of grains per spike, the weight of 1000-grain as well as grain yield / feddan (**Table 4**). In this connection many investigators proved that controlling weeds decreased yield loss and increased net return (**Fenni *et al* 2002; Tharp *et al* 2004; Kumar *et al* 2005 and Tagour, 2006).**

The results in **Table (5)** show increased levels of individual amino acids in the yielded wheat grains by herbicidal treatments alone or in combination. This increase in response to increase in growth as well as increase in yield. Consequently, this increase may be attributed to increase in amino acid biosynthesis (**Cooley and Foy, 1992**).

The results from this study indicate availability of using most herbicide mixtures to control both broad and narrow weeds without damage to wheat plants. The results also show that the herbicide Arelon or Harmony as well as its contribution with the herbicide Topic provided effective control of weeds prevailed in wheat. The results also indicate that these effects were accompanied with maximum increase in yield and amino acids in the grain yielded indicating the most appropriate treatments. Meanwhile, the combined treatment of Ecopart and Illoxan gave also acceptable weed control as well as increase in yield and amino acids, however, this increase contained striking increase in ammonia.

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