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Araştırma Makalesi/*Research Article (Original Paper)*

Effect of Glyphosate on Some Protective Systems in *Zea mays* L.

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Abstract: Glyphosate is an herbicide that is applied after non-selective germination and affects plant growth. In this study, glyphosate was applied to *Zea mays* L. after germination, at a concentration range from 0.017 to 0.145 M in a growth chamber. The effects of this herbicide on some antioxidant enzymes, lipid peroxidation, total chlorophyll and total carbohydrate content were investigated on days 1, 5 and 10 following the application. Results showed that peroxidase (POD), ascorbate peroxidase (APX), superoxide dismutase (SOD), catalase (CAT) and glutathione-S-transferase (GST) were increased in the groups treated with glyphosate on days 5 and 10, but the activities of reduced glutathione (GSH) and glutathione reductase (GR) were decreased on day 10. Malondialdehyde (MDA) content indicating lipid peroxidation was increased on days 1, 5 and 10. Changes in total chlorophyll and total carbohydrate contents were found to be time-dependent. These increases and decreases in the antioxidant activities, MDA content, total chlorophyll and total carbohydrate content in *Zea mays* L. were determined as a symptom of cytotoxicity caused due to glyphosate.

Keywords: Antioxidant, Glyphosate, Lipid peroxidation, Total chlorophyll, Total carbohydrate

Glifosatın Mısır (*Zea mays* L.)'da Bazı Koruyucu Sistemlere Etkisi

Özet: Glifosat bitki gelişimine etki eden seçici olmayan çimlenme sonrası ugulanan bir herbisittir. Bu çalışmada, glifosat *Zea mays* L.'a çimlenme sonrası 0.017-0.145 M konsantrasyon aralığında iklim odasında uygulanmıştır. Bu herbisitin bazı antioksidan enzimler, lipid peroksidasyonu, total klorofil ve toplam karbohidrat içeriği üzerindeki etkileri uygulamayı takiben 1., 5. ve 10. günlerde araştırılmıştır. Peroksidaz (POD), askorbat peroksidaz (APX), süperoksit dismutaz (SOD), katalaz (CAT) ve glutatyon-S-transferaz aktiviteleri glifosat uygulanan gruplarda 1. 5. ve 10. günlerde artış gösterirken, redükte glutatyon (GSH) ve glutatyon redüktaz (GR) aktivitesi 10. günde azalış göstermiştir. Lipid peroksidasyonunu gösteren malondialdehid (MDA) içeriği 1., 5. ve 10. günlerde artış göstermiştir. Total klorofil içeriği ve total karbohidrat içeriği zamana bağlı olarak değişim göstermiştir. Mısır'da antioksidan aktivite, MDA, toplam klorofil ve karbohidrat içeriğinde artış ve azalışın olması glifosattan dolayı bir sitotoksisite semptomu olarak saptanmıştır.

Anahtar kelimeler: Antioksidan, Glifosat, Lipid peroksidasyonu, Toplam klorofil, Toplam karbohidrat

Introduction

Pesticides are an integral component of modern agriculture and production processes in all agro ecosystems around the world necessitate the application of one or more pesticides (Eash and Bushway 2000; Sikkema et al. 2008). Herbicides, which constitute an important class of pesticides, are used to control weeds in agricultural areas. Although proper use of herbicides provides economic benefits for plant production, herbicide application on a continuous basis creates numerous environmental problems by causing adverse effects on crop growth (Cao et al. 2008; Seiber and Kleinschmidt 2011; Chen et al. 2015). Glyphosate is a post-emergent, systemic, non-selective, broad-spectrum herbicide that has been used to control the growth of annual and perennial weeds and volunteer crops in a wide range of situations (Perez Jones and Mallory Smith 2010). The herbicidal effects of glyphosate are caused due to the inhibition of the 5-enolpyruvylshikimate-3-phosphate synthase, an enzyme from the shikimate pathway (Siehl 1997). Thus, it weakens general metabolic processes such as protein synthesis (Geiger et al. 1986; Maria et al. 2005) and photosynthesis (Bott et al. 2008).

Reactive oxygen species (ROS) are formed when plants are exposed to abiotic stress (Wu and Tiedemann 2002). The POD electron donor is an enzyme used to cleanse H_2O_2 (De Gara 2004). When APX moves with SOD, it plays an important role in cleansing processes (Wang et al. 2004). SOD belongs to a class of metalloproteins that

catalyse the dismutation of superoxide (O_2^-) into molecular oxygen (O_2) and H_2O_2. GSH is a tripeptide derived from the amino acids glutamic acid, cysteine and glycine (Ogawa 2005). It is a multifunctional intracellular antioxidant and has been demonstrated to be the major thiol-disulphide redox buffer of the cell (Kurutas 2016). GR is an enzyme whose prosthetic group is flavin adenine dinucleotide, and it is found in the cytosol and mitochondria in a dimeric structure. It catalyzes the reduction reaction of oxidized glutathione in the presence of NADPH (Halliwell 1994). In plants, GST genes are promoted by several growth regulators, heavy metals, chlorocarbons and oxidative stress factors. Detoxification of lipid hydroperoxides and fungal toxins, increased tolerance to drought and some mechanisms of antioxidative defense against pathogens are among the natural functions of GST in plants (Schröder 2001).

Oxidative stress induced by various herbicides causes lipid peroxidation by distorting membrane integrity (Lambert and Bondy 1989; Nordquist et al. 1994). Inhibition created in the photosynthetic electron transport causes pigment content and decrease in plant growth (Huang et al. 2006; Huang and Xiong 2009). Carbohydrate content is also affected by this situation (Saladin et al. 2003; Magne et al. 2006).

This study was conducted to investigate the effects of herbicide glyphosate, which is used for controlling the growth of weeds, on some biochemical parameters in *Zea mays* (corn) "Martha F1" culture form. The effects of glyphosate on culture plants were determined by evaluating total antioxidant activities, total chlorophyll and total carbohydrate content, which are known to be important in plant development.

Materials and Methods

Plant materials and treatment conditions

In this study, *Zea mays* cv. "Martha F1" seeds were obtained from May Company. Glyphosate was provided from Safa Company. The samples were grown in perlite, and Hoagland culture solution (Hoagland and Arnon 1938) was used for irrigation. These procedures were carried out in a climate chamber. The temperature of the chamber was set at 23°C ± 2°C, with ambient air humidity of approximately 60%. The samples were analysed in triplicate. *Zea mays* (21 days old) seedlings of appropriate size were treated with glyphosate after germination (postemergence) at doses 0.017, 0.023, 0.030, 0.039, 0.051, 0.066, 0.085, 0.111 and 0.145 M by spraying. Samples were collected on days 1, 5 and 10 from the treatment groups and analysed.

POD Analysis
POD analysis was described by Peters et al. (1988) and Mac Adam et al. (1992). Enzyme activity was measured at 436 nm for 1 minute by spectrophotometer (Shimadzu UV-1201V).

APX Analysis
APX analysis was assayed according to method of Nakano and Asada (1981) and Çakmak (1994). The oxidation of ascorbate was determined by the change in absorbance at 290 nm (ε= 2, 8mM^{-1} cm^{-1}).

SOD Analysis
The SOD test was carried out according to McCord and Fridovich (1969). Enzyme activity was determined as absorbance change at 550 nm wavelength in 1 minute.

CAT Analysis
The CAT activity was assayed according to Luck (1963). CAT activity was determined by monitoring the decrease in the absorbance at 240 nm as a consequence of H_2O_2 disappearance.

GSH Analysis
GSH content was determined according to Akerboom and Sies (1981). The absorbance change for 1 minute at a wavelength of 420 nm was calculated for the total GSH content.

GR Analysis
GR activity was performed according to the method of Cribb et al. (1989). Enzyme activity was determined as absorbance change obtained in 3 minutes at 405 nm.

Glutathione S-Transferase Analysis
The GST was determined as to Habig et al. (1974). The enzyme activity was assayed as absorbance change obtained in 1 minute at 344 nm.

MDA Analysis
MDA was calculated according to Heath and Packer (1968). The absorbance of the supernatant was measured at 532 nm and 600 nm. The extinction coefficient for MDA is 155 mM^{-1} cm^{-1}. The results were expressed as μmol MDA g^{-1} FW.

Total Chlorophyll Analysis
Extraction and purification of total chlorophyll were made according to De Kok and Graham (1980). The absorbance values were read at 662, 645, 470 nm according to Lichtenthaler and Welburn (1983).

Total Sugar Analysis
The total amount of sugar was determined according to Rosenberg (1980). Glucose values were calculated corresponding to the standard values entered in the Slide program on the computer.

Total Soluble Protein Assay
Soluble protein concentration was measured using bovine serum albumin as standard at 595 nm according to the method of Bradford (1976).

Statistical Analysis
Statistical analysis was made using the the SPSS 15.0 software. Duncan's (1955) and *t* tests were used to determine the differences between averages. In the analyses, $p < 0.05$ was considered statistically significant.

Results and Discussion

Changes in Antioxidant Enzyme Activity

Plants exposed to stress may overcome the oxidative stress by the activation of some or all the antioxidant defence systems. POD constitutes one such group of enzymes that scavenges ROS besides having other defensive roles (War et al. 2012). Changes occurring in the amount of POD depending on the days when glyphosate was applied to *Zea mays* leaves after germination were examined, which showed the lowest POD activity in the control group on day 1. POD activity was thereafter increased on days 5 and 10. The highest POD activities of 6.79 and 10.41 U mg^{-1} protein were found respectively in the groups that received 0.051 and 0.066 M glyphosate on day 10 (Table 1). Basantani et al. (2011) also reported similar findings in their study, where an increase in POD activity was observed after glyphosate administration in the two variants of *Vigna radiata* L. Ascorbate is one of the most important antioxidants and reacts directly with hydroxyl radicals, superoxide and singlet oxygen. In addition to its significant role in the regulation of photosynthesis and in light protection, it also plays an important role in the preservation of the activities of enzymes containing metal ions as a prosthetic group against stress (He et al. 2011; Srivastava et al. 2011). Regarding the APX activity after the application of glyphosate to *Zea mays* leaves depending on the application days, the highest APX activity was observed in the group that received 0.039 M glyphosate on day 1, in the group that received 0.085 M glyphosate on day 5 and in the group that received 0.111 M glyphosate on day 10 (Table 1). Similar results were reported by Jiang and Yang (2009), who observed that low concentrations of the herbicide prometryne applied to wheat plants increased the APX activity and it reduced it at low concentrations ($p<0.05$).

Table 1. Alteration in POD and APX activity in *Zea mays* exposed to glyphosate

Glyphosate (M)	POD (U mg^{-1} protein)			APX (U mg^{-1} protein)		
	1st day	5th day	10th day	1st day	5th day	10th day
Control	A 3.89 e	A 3.92 e	A 3.94 g	A 0.57 ef	A 0.58 g	A 0.54 h
0.017	C 4.11 cde	B 4.49 d	A 5.08 f	B 0.66 cd	B 0.62 fg	A 1.05 g
0.023	C 3.97 de	B 5.10 c	A 6.41 e	B 0.71 bc	B 0.67 f	A 1.07 g
0.030	C 4.19 cde	B 4.72 d	A 6.56 e	C 0.77 ab	B 0.84 cd	A 1.14 fg
0.039	C 4.33 bc	B 5.19 c	A 6.64 e	B 0.83 a	C 0.79 de	A 1.25 ef
0.051	C 4.95 a	B 6.79 a	A 8.73 d	C 0.62 de	B 0.77 e	A 1.49 d
0.066	C 4.58 b	B 6.68 a	A 10.41 a	C 0.67 cd	B 0.87 c	A 1.28 e
0.085	C 3.96 de	B 5.94 b	A 9.36 c	C 0.52 f	B 0.98 a	A 1.66 c
0.111	C 4.22 c	B 6.29 b	A 9.32 c	C 0.56 ef	B 0.95 ab	A 2.38 a
0.145	C 4.18 cde	B 6.01 b	A 9.94 b	C 0.67 cd	B 0.90 bc	A 1.98 b

The different lower case letters indicate significant differences ($p<0.05$) among the different concentrations of glyphosate according to Duncan's tests. The different upper case letters indicate significant differences ($p<0.05$) for each concentration of glyphosate according to independent samples *t* tests.

The superoxide radicals formed in plant cells due to stress are transformed to H_2O_2 by the reaction of the SOD enzyme (Dixit et al. 2001; Mittiova et al. 2002). The highest SOD activity of 4.11 U mg^{-1} protein was found in the group that received 0.145 M glyphosate on day 1. SOD activity was increased on days 5 and 10 (Table 2). The lowest CAT activity was detected in the control groups. CAT activity was also increased in parallel with the increase in the number of days. The highest CAT activity of 6.84 U mg^{-1} protein was observed in the group treated with 0.145 M glyphosate on day 10 (Table 2).

Table 2. Alteration in SOD and CAT activity in *Zea mays* exposed to glyphosate

Glyphosate (M)	SOD (U mg^{-1} protein)			CAT (U mg^{-1} protein)		
	1st day	5th day	10th day	1st day	5th day	10th day
Control	A 3.16 f	A 3.15 i	A 3.16 j	A 3.09e	A 3.04 h	A 3.07 i
0.017	C 3.42 de	B 3.70 h	A 4.10 i	C 3.22 d	B 3.32 g	A 3.42 h
0.023	C 3.36 e	B 3.68 h	A 4.36 h	C 3.26 d	B 3.48 f	A 3.82 g
0.030	C 3.45 d	B 3.91 g	A 4.55 g	C 3.26 d	B 3.48 f	A 4.30 f
0.039	C 3.68 c	B 4.20 f	A 4.83 f	C 3.44 b	B 3.90 c	A 4.54 e
0.051	C 3.67 c	B 4.28 e	A 5.16 e	C 3.48 b	B 3.64 e	A 4.87 d
0.066	C 3.75 b	B 4.52 d	A 5.80 d	C 3.37 c	B 3.77 d	A 4.90 d
0.085	C 3.70 bc	B 4.79 c	A 5.94 c	C 3.48 b	B 3.86 c	A 5.40 c
0.111	C 3.68 c	B 4.93 b	A 6.22 b	C 3.54 a	B 4.07 b	A 5.94 b
0.145	C 4.11 a	B 5.24 a	A 6.84 a	C 3.57 a	B 4.70 a	A 6.85 a

The different lower case letters indicate significant differences ($p<0.05$) among the different concentrations of glyphosate according to Duncan's tests. The different upper case letters indicate significant differences ($p<0.05$) for each concentration of glyphosate according to independent samples *t* tests.

The lowest GSH activity was detected in control groups on days 1, 5 and 10. GSH activity was increased in the groups that received 0.017–0.051 M glyphosate on days 5 and 10. However, the GSH activity was decreased in the groups treated with 0.066–0.145 M glyphosate on day 10 when compared to that day 5. The highest GR activity of 0.125 U mg^{-1} protein was observed in the group that received 0.085 M glyphosate on day 1. The GR activity was increased on day 5, but it decreased on day 10. The lowest GR activity (0.080–0.082 U mg^{-1} protein) was detected in the control groups on days 1, 5 and 10. GST activity was also also found to be the lowest in the control groups (Table 3).

Jiang and Yang (2009) investigated the oxidative stress induced by prometryne in wheat and found that it caused significant changes in the activity of antioxidant enzymes including SOD, POD, CAT, APX and GST. Peixoto et al. (2008) examined the effect of three different herbicides, 2,4-D, paraquat and dicamba, on the antioxidant system in potato tubers. They showed that paraquat induced CAT activity at low concentrations but inhibited the same at high concentrations. Paraquat also stimulated SOD activity whereas 2,4-D and dicamba induced the same at high concentrations. Furthermore, GST activity was poorly inhibited by paraquat. These results are in agreement of with our findings.

Changes in MDA

In some situtations, the reduction in oxidative stress protection causes changes in lipid peroxidation and free radical formation. MDA is oxidised product of membrane lipids and accumulates when plants are exposed to oxidative stress. Regarding the changes in MDA levels in this study the highest level of MDA on day 1 was found in the group that received 0.066 M glyphosate and the lowest MDA level was detected in the group that received 0.017 M glyphosate. The level of MDA was found to be increased on days 5 and 10. The highest level of MDA of 14.00 µmol MDA g^{-1} wet weight was detected in the group treated with 0.145 M glyphosate on day 10 (Table 4). Liu et al. (2009) determined the levels of MDA, O_2^- and H_2O_2 content and antioxidant enzyme activities in cucumber cultivar on which they applied drought stress and paraquat. They detected a change in the levels of MDA, O_2^- and H_2O_2 due to effect of drought. However, they reported that the plants that received paraquat pre-treatment showed lower levels of MDA, $O_2^{\cdot-}$ and H_2O_2 than those of plants that were not pretreated.

Table 3. Alteration in GSH, GR and GST activity in *Zea mays* exposed to glyphosate

Glyphosate (M)	GSH (U mg^{-1} protein)		
	1st day	**5th day**	**10th day**
Control	A 1.81 e	A 1.84 i	A 1.83 f
0.017	C 1.92 d	B 2.16 h	A 2.89 e
0.023	C 2.14 c	B 2.92 g	A 3.27 d
0.030	C 2.30 b	B 3.10 g	A 3.82 c
0.039	C 2.34 ab	B 3.37 f	A 4.27 b
0.051	C 2.16 c	B 3.61 e	A 4.19 b
0.066	C 2.36 ab	A 5.01 d	B 4.17 b
0.085	C 2.34 ab	A 5.81 c	B 4.67 a
0.111	C 2.40 a	A 6.30 b	B 4.12 b
0.145	C 2.42 a	A 6.71 a	B 4.28 b
	GR (U mg^{-1} protein)		
	1st day	**5th day**	**10th day**
Control	A 0.082 g	A 0.080 f	A 0.080 g
0.017	C 0.112 de	A 0.334 c	B 0.277 a
0.023	C 0.117 bcd	A 0.376 b	B 0.258 b
0.030	C 0.119 bc	A 0.372 b	B 0.237 c
0.039	C 0.110 e	A 0.398 a	B 0.205 d
0.051	C 0.110 e	A 0.377 b	B 0.206 d
0.066	C 0.121 ab	A 0.405 a	B 0.270 ab
0.085	C 0.125 a	A 0.355 b	B 0.203 d
0.111	C 0.115 cd	A 0.289 d	B 0.183 e
0.145	C 0.104 f	A 0.267 e	B 0.133 f
	GST (U mg^{-1} protein)		
	1st day	**5th day**	**10th day**
Control	A 0.079 f	A 0.078 g	A 0.78 h
0.017	C 0.091 abcd	B 0.101 f	A 0.134 g
0.023	C 0.092 abc	B 0.136 de	A 0.194 f
0.030	C 0.094 a	B 0.133 e	A 0.199 f
0.039	C 0.090 bcd	B 0.142 c	A 0.285 e
0.051	C 0.093 ab	B 0.154 a	A 0.328 c
0.066	C 0.088 de	B 0.148 b	A 0.358 b
0.085	C 0.090 cd	B 0.136 d	A 0.376 a
0.111	C 0.090 cd	B 0.135 de	A 0.300 d
0.145	C 0.086 e	B 0.135 de	A 0.373 a

The different lower case letters indicate significant differences ($p<0.05$) among the different concentrations of glyphosate according to Duncan's tests. The different upper case letters indicate significant differences ($p<0.05$) for each concentration of glyphosate according to independent samples *t* tests

Table 4. Alteration in MDA content in *Zea mays* exposed to glyphosate

Glyphosate (M)	MDA (µmol MDA g^{-1} fresh weight)		
	1st day	**5th day**	**10th day**
Control	A 5.87 e	A 5.89 h	A 5.77 f
0.017	C 5.78 e	A 5.95 h	B 5.83 f
0.023	C 6.17 d	B 6.56 g	A 7.27 e
0.030	C 6.16 d	B 7.73 d	A 10.58 d
0.039	C 6.71 bc	B 7.14 f	A 11.43 c
0.051	C 6.91 ab	B 8.85 b	A 12.64 b
0.066	C 6.92 a	B 9.20 a	A 12.11 b
0.085	C 6.57 c	B 8.56 c	A 12.31 b
0.111	C 6.52 c	B 7.48 de	A 12.18 b
0.145	C 6.26 d	B 7.29 ef	A 14.00 a

The different lower case letters indicate significant differences ($p<0.05$) among the different concentrations of glyphosate according to Duncan's tests. The different upper case letters indicate significant differences ($p<0.05$) for each concentration of glyphosate according to independent samples *t* tests.

Changes in total chlorophyll

In the present study the highest total chlorophyll amount was found in the control group on days 1, 5 and 10. The total chlorophyll levels were as lower as 12.36 µg g^{-1} in the group that received 0.085 M glyphosate on day 1, 9.63 µg g^{-1} in the group that received 0.145 M glyphosate on day 5 and 9.53 µg g^{-1} in the group that received 0.10 M glyphosate on day 10. The decrease in total chlorophyll amount was determined according to the increase in the number of days (Table 5). Ekmekçi and Terzioğlu (2005) investigated the effects of paraquat on oxidative stress in wild and cultivated wheat. They reported that paraquat caused a decrease in chlorophyll (a+b) and carotenoid content at high concentrations. Kana et al. (2004) analysed the effects of the herbicide clomazone on photosynthesis, which was applied before germination to barley (*Hordeum vulgare* L.) leaf. They observed that increased concentrations of clomazone caused a decrease in chlorophyll (a+b) and carotenoid levels. When compared to control, in a study conducted on *Zea mays* plant to which the herbicide mesotrione was applied, it was observed that while KI a, Kl b and total chlorophyll levels were decreased on days 5, 10 and 15, the carotenoid levels were increased (Giray Kurt 2007). Similar findings were observed in our study examining the relationship between photosynthetic pigment and antioxidant system wherein a lipid peroxidation resulted in an increase in POD and APX activities from antioxidant enzymes that protect the membrane from peroxidation.

Table 5. Alteration in total chlorophyll in *Zea mays* leaves exposed to glyphosate

Glyphosate (M)	**Total chlorophyll (µg g^{-1})**		
	1st day	**5th day**	**10th day**
Control	A 13.10 a	A 13.10 a	A 13.10 a
0.017	A 13.03 a	B 11.76 b	B 11.79 b
0.023	A 13.06 a	B 11.76 b	B 11.78 b
0.030	A 12.91 ab	B 11.62 b	B 11.63 c
0.039	A 12.78 bc	B 11.33 c	B 11.34 d
0.051	A 12.88 ab	B 11.36 c	B 11.33 d
0.066	A 12.59 c	C 9.51 d	B 9.89 e
0.085	A 12.36 d	B 9.72 d	C 9.57 f
0.111	A 12.60 c	B 9.70 d	C 9.53 f
0.145	A 12.79 bc	B 9.63 d	B 9.57 f

The different lower case letters indicate significant differences ($p<0.05$) among the different concentrations of glyphosate according to Duncan's tests. The different upper case letters indicate significant differences ($p<0.05$) for each concentration of glyphosate according to independent samples *t* tests

Changes in total carbohydrate

In the present study, total carbohydrate content was decreased on days 5 and 10 (Table 6). Different findings have been observed regarding the changes in carbohydrate content in plants under different stress conditions. For example, it has been reported that the fructose content in the vine plant, which was treated with the herbicide flumioxazin, decreased depending on the applications days whereas the starch content showed a decrease and an increase (Saladin et al. 2003). Magne et al. (2006) reported that administration of the herbicide flazasulphuron to *Vitis vinifera* L. decreased both the starch content (74%) and soluble carbohydrate levels (90%).

Table 6. Alteration in total carbohydrate in *Zea mays* leaves exposed to glyphosate

Glyphosate (M)	**Total carbohydrate (µg g^{-1})**		
	1st day	**5th day**	**10th day**
Control	A 0.57 a	A 0.56 a	A 0.55 a
0.017	A 0.52 a	A 0.50 a	B 0.46 b
0.023	A 0.49 b	A 0.45 b	B 0.37 c
0.030	A 0.47 b	A 0.40 b	B 0.33 c
0.039	A 0.45 b	B 0.37 c	C 0.30 c
0.051	A 0.46 b	B 0.38 c	C 0.28 d
0.066	A 0.50 a	B 0.35 c	C 0.24 d
0.085	A 0.49 b	B 0.37 c	C 0.28 d
0.111	A 0.48 b	B 0.26 d	C 0.16 e
0.145	A 0.45 b	B 0.28 d	C 0.22 b

The different lower case letters indicate significant differences ($p<0.05$) among the different concentrations of glyphosate according to Duncan's tests. The different upper case letters indicate significant differences ($p<0.05$) for each concentration of glyphosate according to independent samples *t* tests

Despite the fact that the plant *Zea mays* has a high economic value and is widely cultivated in our country, it cannot meet the domestic demands due to which production deficit is covered by imports. In this study, conducted in the viewpoint of the type benefits or harms exerted by the herbicides that are commonly used in the biological struggle in our country as in other countries, in fields where culture plant cultivation is common, it was observed that glyphosate causes significant phytotoxicity in *Zea mays*, and has negative effects on the antioxidant system, the pigment system and the total carbohydrate content. The obtained data suggest that improper use of herbicides to control the growth of weeds in plant cultivation lead to serious economic losses and significant adverse effects on the plant's biochemical structure.

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