Selcuk Journal of Agriculture and Food Sciences

http://sjafs.selcuk.edu.tr/sjafs/index

Review Article

SJAFS
(2020) 34 (1), 111-117
e-ISSN: 2458-8377
DOI:10.15316/SJAFS.2020.203

Possible Effects of Climate Change on Weeds in Agriculture

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ARTICLE INFO

Article history:
Received date: 25.10.2019
Accepted date: 01.04.2020

Edited by:
Duran YAVUZ; *Selçuk University, Turkey*

Reviewed by:
İlhan ÜREMİŞ; *Hatay Mustafa Kemal University, Turkey*
Süleyman Gürdal TÜRKSEVEN; *Ege University, Turkey*

Keywords:
Climate Change
Agriculture
Weeds

ABSTRACT

In recent years, activities such as rapid population growth, industrialization, urbanization and unconscious consumption of natural sources, have many negative effects on natural balance. As a result of these negativities, environmental problems arise. Global warming is one of the environmental problems faced today. Global warming can be defined as, the process of overheating of the Earth more than it should be due to greenhouse gases, such as H_2O (water vapor), CO_2 (carbon dioxide) and CH_4 (methane), slight prevention of sunlight reflecting from the Earth to the space. It is inevitable that, the rise of CO_2 concentration due to the global warming and the changes in the precipitation regime and amount because of the heat will affect plants as a whole. As a matter of fact, different researchers presented that the climate change and increase in CO_2 concentration cause alteration in plant growth, the rise in carbon dioxide affect the progress of cultivated plants in a positive way whereas, the rise in the heat and ozone affect the progress in a negative way. As a result of global warming, it can be thought that increasing CO_2 amount will increase crop production in general. However, the existence of weeds, which cause serious losses in productivity and quality, refute this opinion. The genetic variability of the weeds, which are constantly competing against cultivated plants in terms of light and place, is quite rich when compared with cultivated plants. Therefore, they can adapt to any changes that occur in the environment. Ultimately, cultivated plants would be affected more by the differences caused by global warming. Moreover, as a result of climate change, the decrease in the event of herbicide activity, an effective weapon against the weeds, will make weeds much bigger matter.

1. Introduction

In recent years, rapid population growth, industrialization, urbanization and unconscious use of natural resources cause environmental problems (Yıldız et al 2000). Global warming is one of the environmental problems faced today.

It can be defined greenhouse gases known as H_2O (water vapor), CO_2 (carbon dioxide) and CH_2 (methane), a variety of gases, the sun's rays reflected from the Earth after partially blocking the exit out of the atmosphere as a result of further warming of the Earth (Lynas 2008).

"Greenhouse gases" are gases of both natural and human origin that absorb and emit infrared radiation in the atmosphere (Fig. 1).

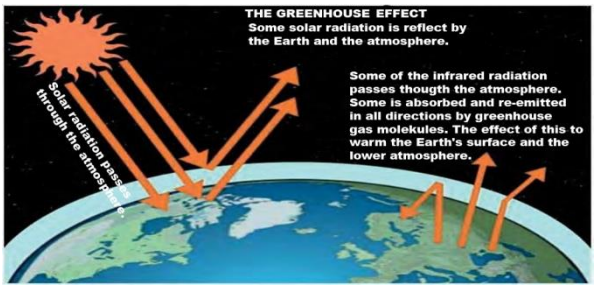

Figure 1
Greenhouse effect (Atabay et al., 2014)

Agricultural activities are responsible for about 20% of the world's growing greenhouse gases. So energy consumption, Plant Production, Animal Husbandry, fertilization, spraying, etc. in particular, CO_2, CH_4 and N_2O are responsible for increasing greenhouse gases (Fig. 3) (Houghton 2003; Pathak & Wassmann 2007).

Greenhouse gas emissions from carbon-source soils are increasing as a result of improper land use and unconscious and excessive fertilizing and pesticides (Fig. 4) (Lal 2006). The share of major greenhouse gases in global climate change is given in Figure 2.

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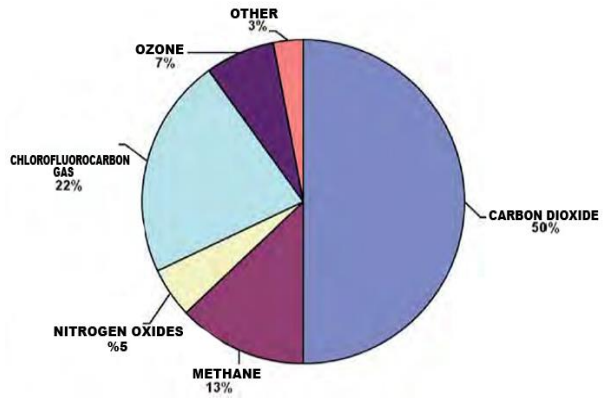

Figure 2
Share of greenhouse gases in global climate changes (Atabay et al 2014)

According to the Intergovernmental Panel on Climate Change (IPCC), atmospheric CO_2 concentration increased by 31% over the last 250 years. The average global temperature has also increased by 0.6°C in the last hundred years (IPCC 2002).

2. Turkey's Status

Turkey has started to experience its driest seasons in recent years. It is observed that deviations in the amount and distribution of rainfall seen throughout our country have negative consequences in underground and above ground water reserves and that these deviations have continuity (Fig. 5; Fig. 6) (Türkeş 2001).

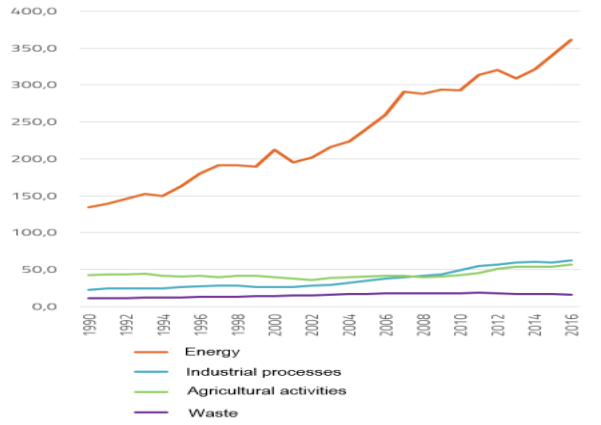

Figure 3
Development of greenhouse gas emissions by sector in Turkey 1990-2016 (Gündoğan 2018)

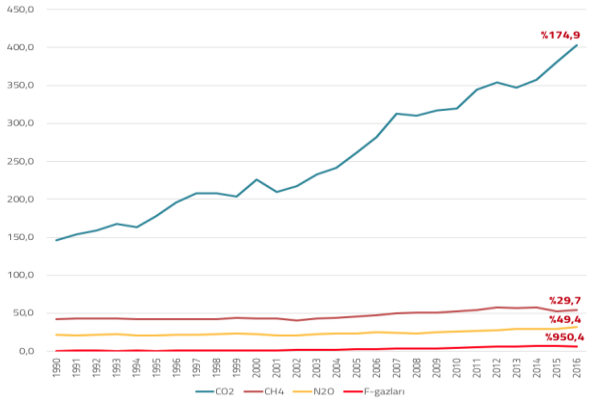

Figure 4
Development of greenhouse gas emissions by in Turkey (million tonnes) and change (%) 1990-2016 (Gündoğan 2018)

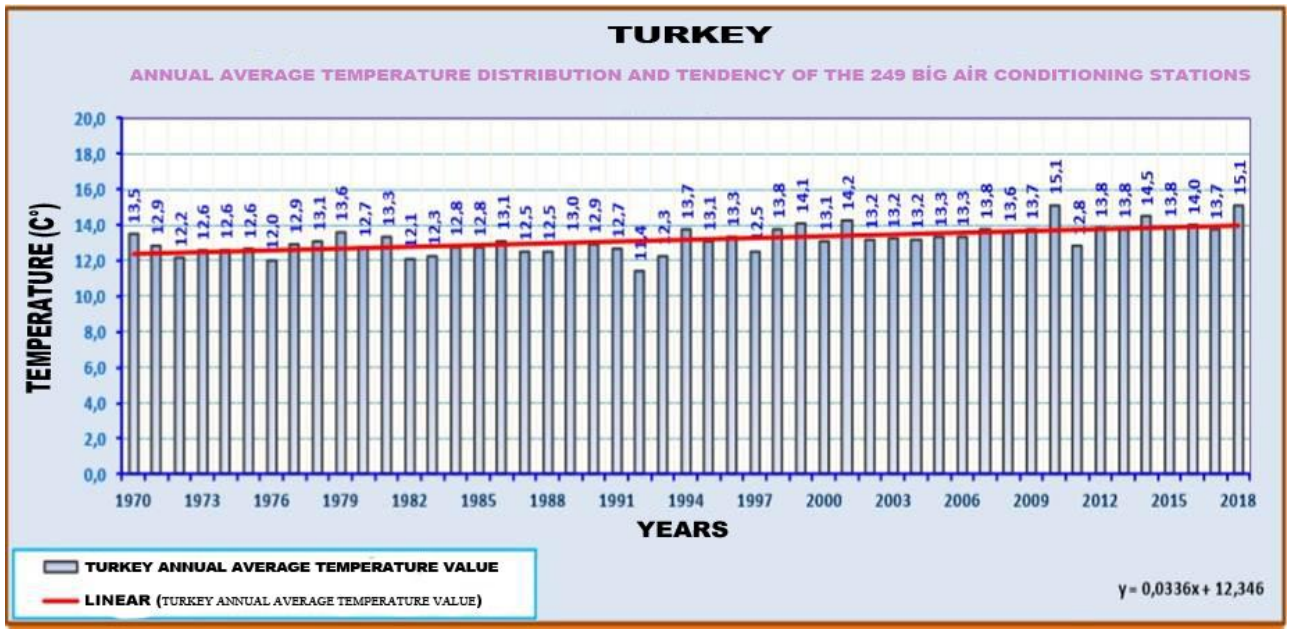

Figure 5
Turkey long-therm average temperature data (Anonymous 2019a)

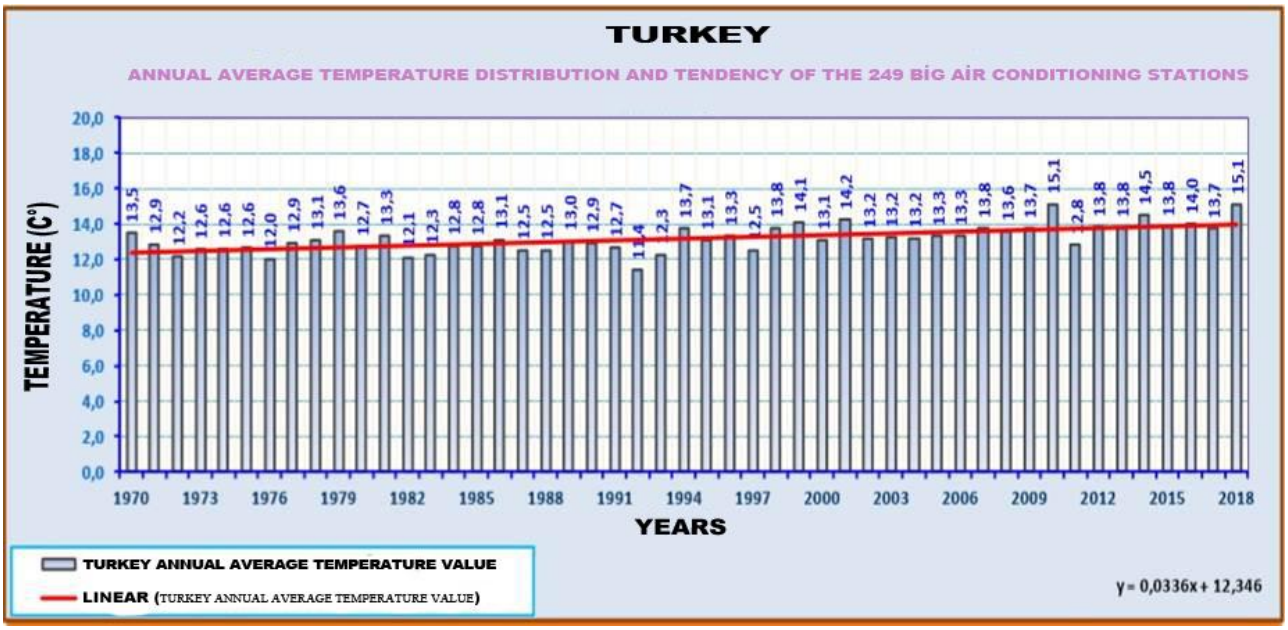

Figure 6
Long-term distribution of total annual precipitation data in Turkey (Anonymous 2019b)

3. Impact of Climate Change on Weeds

It has been shown that climate change and the increasing amount of CO_2 have a positive effect on the growth of crop plants in general, while increasing temperature and ozone have a negative effect (Ainsworth & Long 2005; Morgan et al 2006; Ainsworth 2008).

C_3 plants are temperate climate plants that need high CO_2 concentration, low temperature, and low ability to use light. C_4 plants need low CO_2 concentration, high temperature and lower water. They are resistant to seasonal drought and have a high ability to use light and are predicted to be adversely affected by the increased CO_2 rate (Doğan & Tüzer 2011).

Studies have shown that C_3 plants respond better to the increased amount of CO_2 than C_4 plants (Heyman & Sadras 2010). In general, doubling the concentration of CO_2 increases the biomass in C_3 plants by about 40%, while in C_4 plants this rate remains at 11% (Kimball 1983). However, the level of increase varies greatly depending on the type of plant. As a result of the increased in CO_2 concentration, growth in 27 herbaceous C_3 plants increased by 79-272% and in 11 different C_4 plants increased by 56-250% (Patterson & Flint 1990).

Since plants other than sorghum, maize and sugarcane etc. are C_3 plants, which are of global economic importance, it can be thought that climate change will give advantages to cultured plants and weeds will not pose a major problem. Furthermore, the fact that the important weeds that cause problems on earth are C_4 plants in general supports this judgment.

For example, only 4 of the 18 most important weeds in the world are reported to be C_3 plants (Holm et al 1977). However, one thing that is overlooked is that the number of species found in agricultural areas is far above that. It is the fact that these weeds, which under favorable conditions cause second degree damage, can replace others. Weed survey studies conducted in different cultivated plants in the world clearly reveal this situation (Uluğ et al 1993; Özer et al 2001).

Each cultured plant has its own unique weed and they are generally adapted to the production process of that cultured plant (Özer et al 2001). Wild oats, common Lamb's quarters, and barnyard grass are examples of wheat problems. In addition, the positive effect of the increase in the amount of CO_2 when compared with the same photosynthesis method of cultured plants and weeds is in favor of weeds.

a b c

Figure 7
a) *Avena fatua* **b)** *Chenopodium album*
c) *Echinochloa crus-galli* (Anonymous 2019c)

According to Patterson (1995), 2 times the amount of CO_2 increases the total weight of weeds by an average of 130% in C_3 weeds and 115% in C_4 weeds. Both C_4 and C_3 weeds will continue to pose problems in plantation as they adapt rapidly to new environmental conditions created by global warming. Even if the effectiveness of C_4 weeds decreases in agricultural areas due to increased temperature and CO_2, it is likely that C_3 weeds will be replaced immediately.

3.1. Effect on Weed-Crop Competition

Depending on the type of crop plant and weeds, competition is sometimes expected to change in favor

of cultured plant and sometimes weeds (Patterson, 1995). However, high CO_2 conditions are generally expected to make C_3 weeds more competitive (Ziska 2000).

Indeed, one study found that the ability of soybeans to respond positively to increased carbon dioxide is reduced by weeds. In competition with *Chenopodium album*, a C_3 weed, the decline in soybean yield was highest. However, when it competes with a C_4 plant, the redroot pigweed (*Amaranthus retroflexus*), the intensity of the competition was lower.

Figure 8
Amaranthus retroflexus (Anonymous 2019d)

3.2. Effect on Perennial Weeds and Herbicides

The control of perennial weeds is extremely difficult as it depends on the elimination of vegetative reproductive organs. For success it often has to be applied together with the use of the herbicide with mechanical control.

However, due to the increase in photosynthesis products, the increase is expected in vegetative reproductive organs such as rhizome, stolon, and root. While this increase will lead to an increase in the vegetative reproductive capacity of perennial weeds, it will also make it more difficult to control.

a b c

d e f

Figure 9
Some perannual weeds
a) *Sorghum halepense*, **b)** *Cirsium arvense*, **c)** *Acroptilon repens*, **d)** *Elymus repens*, **e**) *Alhagi pseudalhagi*, **f)** *Convolvulus arvensis* (Anonymous 2019e)

In addition, differences in the structure of weeds leaves and reasons such as the accumulation of starch in the leaves of C_3 plants lead to a decrease in the effect of herbicides used (Figure 10). Therefore, climate changes probably suggest that perennial weeds, especially invasive species, will increase in agricultural areas and become a bigger problem (Ziska & Teasdale 2000; Ziska et al 2004; Ziska 2008).

Figure 10
Effect of glyphosate on *Cirsium arvense* depending on the amount of carbon dioxide (Ziska 2010)

3.3. Impact of Climate Change on Invasive Plants

Studies under controlled conditions suggest that the response of invasive plants to climate change, especially CO_2 increases, is generally higher than that of local species (Willis et al 2010).

The increase in temperature is also thought to trigger the growth of invasive plants and thus cause them to complete their life span in a shorter time than normal. Thus, it is estimated that plants may show higher fertility and increase their spread (Burke & Grime 1996; Blicker et al 2002; Kolb et al 2002; Morris et al 2002; Gerlach & Rice 2003; Leger & Rice 2003).

Figure 11
Invasive parasite weed *Cuscuta campestris* Yunck. (Tamer 2012)

4. Weed Control Due to Climate Change

Herbicides are one of the most effective weapons in weed control. Reduced herbicide activity due to climate change will make weeds a much bigger problem (Ziska 1998; 2008; Ziska & Goins 2006). In addition, environmental stress conditions affecting cultured plants will also make cultured plants more susceptible to disease, pest and weed competition (Patterson 1995). This puts the management of weeds, which are a problem in agricultural fields due to climate change, in a much more important position. Indeed, yield losses from weeds are expected to increase.

5. Example Studies of Importance

Elymus repens (quack grass) growth, photosynthetic activity and tolerance observed under conditions of increased CO_2 glyphosate the chemical management in seeking to it was concluded that it would be difficult perennial weeds (Ziska & Teasdale 2000).

Ziska and Faulkner (2004), investigated the effectiveness of normal and augmented CO_2 conditions on the growth, biomaterial and glyphosate susceptibility of village references: canada thistle (*Cirsium arvense*). According to the results, it is stated that in the future, the chemical control of canada thistle and other perennial weeds will be difficult under high CO_2 conditions.

a b

Figure 12
a) *Cirsium arvense*, **b)** *Elymus repens* (Anonymous, 2019f)

Hobbs and Mooney (2005) reported that while climate change affects biodiversity on the one hand, it also promotes biological invasions from weed species that can easily adapt to extreme conditions. Loss of biodiversity due to biological invasions becomes even more serious due to climate change.

Stinson and Bazzaz (2006) found that high CO_2 administration increased the reproductive capacity and biomaterial of the invasive weed, *Ambrosia artemisiifolia*. Rogers et al (2008) investigated the effects of increased CO_2 on the growth of *Cyperus rotundus* and *C. esculentus*. The study concluded that these two invasive species would be more likely to spread in the future.

Figure 13
Cyperus rotundus (Anonymous 2019g)

Göncü (2013), in his study corn of different CO_2 ratios (*Zea mays* L.), the problem in *Sorghum halepense*, *Echinochloa cruss-galli*, *Amaranthus blitoides* and *Solanum nigrum*'s growth, competition and herbicide sensitivity was aimed to determine. The high CO_2 ratio positively affected the output of some weeds. In normal CO_2 conditions weeds reduced maize growth, while in high CO_2 conditions there was no decrease in growth. It has been determined that the growth parameters of weeds reach higher values in high CO_2 and competitive conditions. It has also been determined that generally high CO2 conditions can cause a decrease in herbicide activity.

Meşe (2014)' s research aimed to determine the growth, competition and herbicide susceptibility of weeds of Avena sterilis, *Phalaris minor*, *Galium tricornutum*, *Sinapis arvensis*, which are problems in wheat of different CO_2 ratios. Weed competition has caused a decrease in wheat growth in different CO_2 conditions. Weed growth was not affected by CO_2 in the non-competitive environment, while reductions were seen in the competitive environment. It has also been observed that herbicide sensitivity is lower in narrow-leaved weeds and increased in broad-leaved weeds.

Over the past few decades, significant transformations have been induced by changing climate in the weed flora of agroecosystems, worldwide, allowing

thermophile, late-emerging weeds, and some opportunistic weeds to become more abundant in some cropping systems. Increasing CO_2, as the most important greenhouse gas, affects plants by changing the species distribution, alteration in reproduction timing and length of growing seasons. Climate change directly influences arable weeds through raising the temperature and changing the precipitation pattern (Peters et al 2014).

Jabran and Doğan (2015) examined the effect of normal and 2 times dose CO_2 ratio on the growth of *Lolium perenne* and *Medicago sativa*. As a result of the trial, L. with increased CO_2 application positive relationship between age-dry weight and chlorophyll content of perenne plants was determined. *M. sativa*, however, the overall CO_2 increase was not affected by age and dry weight.

a b

Figure 14

a) *Medicago sativa*, **b)** *Lolium perenne* **(**Anonymous, 2019h)

Jabran et al (2015) evaluated the effect of ambient (current level of CO_2 in the atmosphere) and simulated (double of normal CO_2) CO2 levels on the invasive weed species *Potentilla recta* L. The invasive weed species was grown under normal (~400 ppm) and elevated (~800-850 ppm) CO_2 in a controlled glasshouse. The data about fresh weight, dry weight, number of leaves, plant height and chlorophyll index were recorded. The studies indicated that the elevated CO_2 levels increased the growth of *P. recta*. The high levels of CO_2 increased the fresh weight, dry weight, plant height and number of leaves of *P. recta* compared with ambient CO_2 while chlorophyll index was not affected.

Tursun et al (2018) conducted a study to determine the reactions of some weeds (*Amaranthus retroflexus, Portulaca oleracea, Physalis angulata, Sorghum halepense*) to different CO_2 concentrations and different temperatures under greenhouse conditions. As a result of the study, parallel to the increase in CO_2, even if there is some positive growth in plants, they stated that the increase in environmental temperature would negatively affect crops and agriculture.

6. Conclusion and Recommendations

Studies have shown that the increased CO_2 concentration associated with climate change can have positive reactions to the growth of cultivated plants such as corn, cotton, soybean, wheat, and rice (Alberto et al 1996; Ziska & Bunce 1997; Reddy et al 1999; Ziska 2000; Ziska & Goins 2006; Patel et al 2008; Zhu et al 2008; Erbs et al 2009). However, there are also findings that reactions to changes in weeds may be higher than in cultured plants (Ziska & Bunce, 1993; Ziska & Bunce 1997; Ziska 2002; Pandey et al 2003). Therefore, it is a fact that changing conditions will affect weed-crop competition. Changes in the methods of management weeds will be inevitable.

Determination of the adaptation potentials of weeds to climate changes should be one of the priority objectives of weeds science (Neve et al 2009). However, it has not yet been fully revealed how factors such as temperature, amount of CO_2, light and water in field conditions affect weed growth and the effectiveness of herbicides. Therefore, detailed studies on this subject are needed to reach a final judgment.

It is known that climate change can significantly affect the growth, reproduction, distribution, competitiveness, etc. of invasive plants. It also suggests that the species in question will increase, especially in agricultural areas, and become a bigger problem (Ziska & Teasdale 2000; Ziska et al 2004; Ziska 2008). Therefore, invasive plants need to be dealt with again and more carefully in the context of the possible impacts of climate change.

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