Functional analysis of competition for resources between durum Wheat (*Triticum turgidum* L. var. *durum*) and two species of weeds *Galiuma parine*, *Fumaria officinalis* in Tiaret, Algeria

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Abstract

Given the important role of weeds in the biodiversity and biofertilisation of agricultural soils, the main objective of our study is to estimate their impact on the availability of mineral elements in the soil and on the physiological parameters and crop yield of cereals in a semi-arid environment. Thus, two most common weeds are *Galiuma parine* and *Fumaria officinalis* in the study area with 30 and 20 plants/m² respectively were selected and combined with durum wheat (*Triticum turgidum* L. var. *durum*), with the same densities to form three combinations on twelve plots of 1 m². These are Wheat-*G. parine* (TtGa), Wheat-*F. officinalis* (TtFo) and Wheat-*G. parine*-*F. officinalis* (TtGaFo) compared simultaneously with a pure durum wheat (Tt) treatment. Physical-chemical analyses were carried out before sowing and during heading stage for the soil and after harvest for the soil and the plant (Tt). The results showed that the presence of both weeds was only beneficial effects on both physiological and wheat yield parameters and on soil fertility with a significant increase of N, P₂O₅, K, Na and CaCO₃. Hence, we will have to think of other associations to possibly reduce the input of phytochemicals and move to develop agroecology.

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Introduction
Strategic cereal crop for the majority of world’s populations, durum wheat (*Triticum turgidum* L. var. *durum*) belongs to the Gramineae family, which is grown in arid and semi-arid regions of Algeria (Bouthiba et al., 2008). High productivity of this crop requires good weed control in field (Siyahpoosh et al., 2012). But, weed control in recent decades has led to the intensive use of herbicides which has caused serious pollution problems and damage to biodiversity (Zhang et al., 2015). Chemical fertilisers are the main factors to maintain soil fertility, but more application with unsuitable management reduces organic matter availability in soil (Galal and Shehata, 2015) and decline number of weeds (Franke et al., 2009).

Therefore, in many developing countries this has led to restrictions in the use of herbicides and to the promotion of agro ecosystems (Olesen et al., 2004). The presence of weeds in cultivated crops can affect production and quality of the crop by competing for light, moisture, nutrients and space (Ashenafi and Dalga, 2014).

Wheat grain yield loss has been found to be 30% due to weed infestation (Khan et al., 2016). In other hand, many studies indicate that weed diversity may have a positive impact on the functioning of agro-ecosystems (Franke et al., 2009). It is in this sense that our study will be oriented where it will be shown that weeds can become service plants if they are used in a more efficient way.

Materials and methods
Presentation of the study area
The study was carried out at Experimental Farm of Tiaret University (North-West, Algeria). With fallow as a previous cultural, a silty-sandy to sandy-loamy texture, irregular rainfall (275 to 550 mm) and average temperatures ranging from 5 to 36 °C.

The site is located in a rain-fed and cereal area at an altitude of 956 m, latitude of 35°15’11”N and longitude of 01°14’04”E.

Plant material
Thus, among several species of weeds inventoried in the wheat fields in the study area, our choice for the experiment focused on two species for their abundance: *Galium aparine* L. and *Fumaria officinalis*. The first is part of the family of Rubiaceae, also called Cleaver (Ramdani et al., 2013). It has a climbing, prostrate or sometimes low and erect habit, and is found in grassy, partially shaded habitats at lower elevations (Marwat et al., 2013). It is relatively resistant to depth of sowing and soil aggregate size (Fahad et al., 2015), can germinate in a wide range of temperatures <5 °C and > 20 °C (Mennan and Zandstra, 2005).

The second, common Fumitory belongs to the family of Fumariaceae, annual and perennial plants. It is a small common weed that contains many chemical components such as alkaloids, flavones and phenols (Goetz et al., 2009). And is found in grassy, partially shaded habitats at lower elevations (Marwat et al., 2013).

Experimental protocol
The interest of our work is to design the competitive effect of these two weeds *G. aparine* (Ga) and *F. officinalis* (Fo) on the availability of mineral elements in the soil and the yield of durum wheat (Tt).

The evaluation of the competitive impact of the insertion of Galium and Fumaria with durum wheat without the use of phytochemicals for the control of weeds has been compared between several associations TtGa, TtFo, TtGaFo and a corresponding control, wheat only (Tt). Everything was done on twelve micro-plots of 1x1m with 03 repetitions for each combination.

The previous crop of the experimental plot being an unworked fallow, which allowed a maximum emergence of weed species. After exploration of the study area, the highest level of weed contamination was characterized by *G. aparine* and *F. officinalis* with average densities of 30 and 20 plants/m², respectively. More frequent and more abundant in the
study area, these species were retained with the same densities during the different combinations in the experiment. Thus, the sowing were always carried out in December on the micro-plots randomly installed for each combination (TtGa, TtFo and TtGaFo) with as control wheat alone (Tt). To ensure the reproducibility of the experiment, all plots were received the same manual weeding every week during the growth period. No serious incidence of insects or diseases was observed and no chemicals were applied to either plants.

In each treatment, soil samples were taken from top soil (0-30 cm) using a manual agricultural auger, before sowing, at heading period and at the end of the season. All the collected samples were achieve the physical-chemical analyses. Other samples of wheat (Tt) at the heading stage and after growing season have undergone almost the same analysis, and have been measured for physiological and yield parameters.

The total concentration of nitrogen N (%) was measured by the Kjeldahl method (ISO 11261), the available phosphorus P$_2$O$_5$ (ppm) was determined by the method of Joret Hebert AFNOR: X31-161 and the determination of the inorganic ions K and Na was performed according to the method described by Lafon et al., 1996.

Organic matter MO (%) was determined by the method of Anne (1945) and soil carbonate analysis were determined using the Bernard calciminer. At the time of harvest, the wheat plants were collected manually to measure physiological and yield parameters (number and height of tillers, number of ears per m$^2$, number of grains per ear, weight of grains per ear and weight of grains per m$^2$).

We used excel windows for statistical analysis, the results obtained during the experimentation were presented graphically where they are in the form of histograms with their standard deviations to illustrate the different comparisons between treatments.

### Results

**Effect of weeds on total soil nitrogen (N%)**

Better progress soil nitrogen was noted in all treatments at the end of the season comparing to the beginning of the season.

The best increase was showed in the combination of both weeds with wheat in treatment TtGaFo with 0.45% while it was minimal in the treatment control (Tt) with only 0.23% (Fig. 1).

![Fig. 1. Effect of weeds on soil nitrogen (N%).](image1)

**Effect of weeds on soil available phosphorus (P$_2$O$_5$)**

After harvest, the quantity of available phosphorus in the soil increased significantly in presence of galium (TtGa). We were recorded 224.68 ppm compared to the beginning of the season with 187.37 ppm, while there were a strong depression (85.72 ppm) of this element in the treatment control (Tt) (Fig. 2).

![Fig. 2. Effect of weeds on soil available phosphorus (P$_2$O$_5$).](image2)

**Effect of weeds on soil potassium (K)**

The soil potassium content decreased in all treatments tested after harvest compared to the beginning of the experiment except treatment (TtFo) where the concentration of K was higher, it reached a quantity of 33U (Fig. 3).
Effect of weeds on available potassium (K)
Fig. 3. Effect of weeds on available potassium (K).

Effect of weeds on concentration of sodium (Na)
In the absence of weeds (Tt), soil sodium content was lower at heading period than the other combinations but after harvest, soil sodium was accumulated considerably in presence of both weeds compared to the presence of only one weed with wheat where it was slightly increased in TtGa (Fig. 4).

Effect of weeds on soil organic matter (OM%)
The concentration of organic matter in soil was decreased continuously from the beginning of the season regarding to the treatment control (Tt). While the combination of each of the weeds tested with durum wheat favors a low increase in the soil organic matter and this content was decreased during the joint association of the two weeds with wheat (TtGaFo) during and at the end of the agricultural cycle (Fig. 5).

Effect of weeds on yield components of wheat

Number of tillers
There were no detectable differences among the different associations. The number of tillers per plant at the treatments TtGaFowith 3.96 and TtFo with 3.30 was higher compared to the treatment Tt, while the plot TtGa where recorded the lowest number with 2.37 (Fig. 7).

Number of grains per spike
The number of grains per ear is considered as the main yield element in wheat crop. Results showed less variation in all the associations. The maximum and minimum values were obtained in treatment Tt and treatment TtGaFo, respectively with 56 and 50 grains/spike. These values did not decline significatively in the presence of F. officinalis and G. aparine (Fig. 7).

Effect of weeds on soil calcium carbonate content (CaCO3%)
Calcium carbonate analysis on soil recorded the lowest values at the beginning of the wheat crop. During this period, the accumulation of calcium carbonate in the TtGaFo treatment were much higher than the other area where the treatment TtFo were the lower. After harvest, there were no significant differences compared to the first time (Fig. 6).

Effect of weeds on soil available sodium (Na)
Fig. 4. Effect of weeds on soil available sodium (Na).

Effect of weeds on soil calcium carbonate content (CaCO3).
Fig. 6. Effect of weeds on soil calcium carbonate (Ca CO₃).

Effect of weeds on number of tillers/plant, number and weight of grains/ear.
Fig. 7. Effect of weeds on number of tillers/plant, number and weight of grains/ear.
Grains weight per spike
Grains weight per spike plays an important role in yield formation, because it affects harvest index. Despite some slight variations, data related to grains weight per spike indicated that presence of two weeds has not significantly affected it. The combination of TtFo gave the highest grain weight per spike with 3.19 g. Whereas, the lowest weight was observed in combination of both weeds with durum wheat (TtGaFo) with 2.74 g (Fig. 7).

Maximum height of wheat plants
The maximum height is considered the best indicator of the effects of competition. Data showed that the presence of the weeds G. aparine and F. officinalis has not a significant effect on the maximum height of wheat plants. The tallest plant (102.67 cm) of wheat were observed in the plot TtGa, while the shortest (96.83 cm) were recorded in plot TtFo (Fig. 8).

Number of ears per m²
Data analysis indicated a small decrease in the number of ears per m². It is clear that the best results were observed in TtGa treatment followed by plots in which G. aparine and F. officinalis were associated with wheat (TtGaFo) with 564 / m². Although minimum spikes 410/m² were recorded on the treatment Tt (Fig. 8).

Weight of grains/m²
An examination of data on weight of grains/m² presented in Figure 8. indicated that good results were registered in treatment TtFo with 565g/m² followed by treatment TtGaFo with 535g/m² comparing to the treatment control. Whereas, the treatment TtGa were showed the lowest result with 351g/m².

Discussion
A new approach to biodiversity-friendly weed management is therefore intentional to improve the beneficial functions derived from weeds by maintaining desirable species with high value for the agro-ecosystem (Tilman et al., 2002).

After examining the information available in literature on the impact of yield crop and soil nutrient content, we have focused on combination of two weeds Galium aparine and Fumaria officinalis with durum wheat in semi-arid zone. According to (Dangwal et al., 2010), weeds compete with cultivated species for space, water, sunlight, moisture and nutrients.

Effect of weeds on nutrient elements
Through the results of this preliminary investigation, the joint association of two weeds G. aparine and F. officinalis with durum wheat improves significantly the concentrations of total nitrogen and available phosphorus in the soil. In addition, the combination of these two species with the variety of durum wheat has given good results compared to the control treatment. But, we showed a remarkable fall in amount of potassium (K) in the soil in presence of weeds. Contrary to (Lehoczky et al., 2013), they found that the competition for total nitrogen (N) was very hard between maize and weeds. Thus, (Shafiq et al., 1994) stated that weeds compete more effectively with rainfed wheat for nitrogen.

While another authors (Galal and Shehata, 2015) declared that some weeds may be beneficial for rice in soils contaminated with heavy metals such as C. deformis, which accumulated lower amounts of macronutrients and higher concentrations of heavy metals.

Effect of weeds on crop yield
In cultivated fields, the interest of maintaining weed does not significantly reducing the yield of the crop-cultivated species as some researchers have shown (Cook et al., 1997).
The obtained results prove that 30 plants/m² of Galiuma parine and 20 plants/m² of Fumaria officinalis has not remarkable significant influence in wheat yield. Same results have been found by (Tlig et al., 2012) in their test of interspecific competition between weed and barley (Hordeum vulgare), when they stated that Diplotaxis hara has not got a significant competitive effect on the growth parameters of barley and presence of this weed has not affect the parameters of barley yield.

The presence of 30 plants of Galiuma parine in treatments causes a slight decrease in the number of tillers per plant and number of grains per spike compared to treatment wheat only, while the number of spike per m² and maximum height of plants have increased. These results agree to ascertainment of (Armin and Asghripour, 2011), they said that wild oat had harmful effects on wheat yield, so increase in wild oat density results in the reduction of wheat yield through decrease in fertile tiller per plant and spike/m².

Generally, our results differ from those of (Mennan, 1998), when they reported that ten plants of G. aparine/m² reduced wheat grain yield by 18% in Turkey. In addition, (Aziz et al., 2009) said that Galium species might cause yield losses up to 32% at densities of 72 plants/m² in wheat. In other research, winter wheat yields were reduced from 12 to 57% by G. aparine competition in field trials in England (Wilson and Wright, 1987). (Baye and Bouhache, 2007), in their study, showed that growth parameters of maize were affected by the presence of silverleaf nightshade, also, Parthenium weed (Parthenium hysterophorus L.) has caused yield losses on maize (Zea mays L.); These results were reported by (Safdar et al., 2015). About the other weed, 20 plants of Fumaria officinalis increase number of tillers per plant, weight of grains per spike and weight of grains per m², whereas its presence affect slightly on number of grains per spike and height of plants. In collected works, we do not found results comparable or dissimilar.

The competition between crop and weeds is often maximum when they share the same resources at the same time. This is often the case of plants of the same species where the architecture is very similar (wheat and black-grass/oilseed rape and wild mustard/beetroot and goosefoot) (Valantin-Morison et al., 2008).

Conclusion
The available results are highly variable, but we note generally any significant reduction in crop yields in the presence of weeds. In our case, the two weeds tested (G. aparine and F. officinalis) has not caused a significant loss in crop yield and it has a beneficial impact on soil nutrients.

References


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