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ALLELOPATHIC EFFECT OF AQUEOUS EXTRACTS OF THE COMMON ASSOCIATED SPECIES ON THE GERMINATION OF RAINFED BARELY GRAINS

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ABSTRACT:

The present study was conducted in the laboratory to study the allelopathic potentials of most common associated native species (*Glebionis coronaria, Achillea santolina, Erucaria microcarpa, Carrichtera annua, Vicia lutea*) with rainfed barely on its germination. Various concentrations of shoot (leaf and stem) aqueous extracts from the associated species (0%, 10%, 30%, 50%, 80% and 100%) were valued. The results showed that the aqueous extract of 50% concentration had the highest be inhibitory effect on the germination of barely grains compared to control. Under this concentration, the percentage of germination was ranging from 2.2 for *C. annua* extract to 13.3 for *G. coronaria* extract. For *A. santolina*, the lowest germination percentage of barely grains (2.2%) was obtained with concentration 80%. On the other hand, under aqueous extract of *V. lutea* with 30% concentration, the lowest value for germination percentage for barely grains was obtained (20%). The highest values for plumule and radicle length of barely were obtained under control conditions and 10% concentration of *G. coronaria* and *E. microcarpa* extracts. The lowest values for plumule and radical were obtained at aqueous concentrations of 30%, 50% and 80% depending on species. The germination velocities for all the studied species were highest at control and 10% concentrations but decreased under 50%, 80% and 100% concentrations of the studied species. These results help in improving our understanding to the inhibitory effects of the common associated wild species with rainfed barely on its germination and growth.

Keywords: ***Allelopathy; aqueous extract; germination; rainfed barely; associated species***

INTRODUCTION:

Allelopathy was defined as the direct and indirect detrimental or profitable effects of one plant to another through the production of biochemical compounds into the environment (Rice, 1984). Allelopathy is also regarded as biochemical warfare. Plants could inhibit the seed germination and growth of other plants by means of producing toxic chemicals, i.e. allelopathins or allelochemicals. These allelochemical are exuded by plants and inhibit the emergence or the growth of other plants. The allelopathic effects of these chemicals are often noted to occur in the first stages in the life cycle (Alagesaboopathi, 2014). This leads to suppression of seed germination and seedling growth, allelochemicals could be produced in any organ of the plant; below- or above-ground parts.

According to Nevo (1992) cultivated barley (*Hordeum vulgare* L.) is growing in a zone of diverse environments, with greater concentration in temperate areas and high altitudes of the tropics and subtropics. Other than the cool highlands, barley is rarely growing in the

tropics, as it is not suitable to be cultivated at warm humid climates. Barley requires a temperate climate; but it is also a valuable and resilient in arid and semi-arid areas of Asia, the Middle East and North Africa (FAO, 2004). Barley is considered as a food crop in many parts of the world. The archeological evidences indicate that barley was important than wheat in agriculture-based culture and was mainly grown for human consumption (Poehlman, 1985). Barley has good resistance to dry heat in comparison with other small grains. This feature allows it to grow near desert areas such as North Africa (Zhou, 2010).

In Egypt, barley is a main crop, which is grown in Nile valley, the north Mediterranean coastal regions and in the newly reclaimed saline soil lands. Drought stress causes reduction of barley grain yield production, which is harshly affected by rain-fed area conditions (Forster et al., 2004). Rainfed agriculture in the Egyptian northwest coast constitutes an important part of the existent economic activities. According to the Food and Agricultural organization (FAO, 2017) barley production in Egypt was 115478 tons in 2017.

The presence of associated species, either weedy or native species, may have negative impacts on the harvested yield of rainfed barely. This could be through competition for nutrients or exuding allelochemicals that inhibit seed germination and/or plant growth. According to our census for the floristic composition in rainfed barely at Marsa-Matrouh, the most common associated wild species were: *G. coronaria, A.santolina, E.microcarpa, C. annua and V.lutea.* Therefore, the main objective of the present study is to investigate the allelopathic potentials of aqueous extracts of these species with the germination of rainfed barely.

MATERIALS AND METHODS

STUDY AREA AND CLIMATE

The Mediterranean coastal belt consists of a coastal plain and tableland. The coastal plain is wide with calcareous sand dunes along the coast and series of long calcareous ridges that running parallel to the sea with depressions containing salt marshes. The inland tableland is a relatively flat plateau containing rich steppe habitat (Abdel Meguid *et al*., 2006 a & b). Marsa-Matrouh city (Matrouh Governorate) belongs to the northwestern Mediterranean coast ($27^0 38^\backslash$ E and $26^0 59^\backslash$ E, Fig. 1). The main source of irrigation water in the area is the rainfall. The distribution of rainfall along the coastal zone is not even. The amount of rainfall shows steady decrease in the inland direction (FAO, 1970). The Mediterranean coastal zone of Egypt receives noticeable amounts of rainfall, especially in winter. The rainy period is from October to April. In summer, no or few rains are recorded, while in autumn, occasional heavy rain may occur (Zahran & Willis, 2009).

The Mediterranean coastal region of Egypt lies in Meig's "warm coastal deserts" (Meigs, 1973, Fig. 2): the warmest months in summer with mean temperature less than 30ºC, and the coldest month with mean temperature above 10ºC, though occasional short rain storms occur in winter, most of the days are sunny and mild from the map of the world distribution of arid regions (UNESCO, 1977). In general, monthly temperature varied between 14.4 and 26.8°C, wind speed averaged at 18.9 km/hr, and

the average annual rainfall ranged from 100 to 190 mm (DRC staff, 2007-2015).

PLANT SAMPLING AND PREPARATION

We could not collect enough material from root system of the target plants (*G. coronaria, A. santolina, E.microcarpa, C.annua* and *V. lutea*) to test their allelochemical effect on barley variety Giza$_{126}$, so we only collected the shoot system of the target plants. This variety was found in a separate work as the best germinating variety among three other ones used for cultivation in Marsa-Matrouh under laboratory conditions (unpublished data). The most common associated wild species with barely were collected from the fields of rainfed barely at Marsa-Marouh city. The aboveground parts of the plants were collected in considerable amounts. Then, the shoots of each species (i.e. donor species) were separately chopped with a knife into very tiny bits. The plant materials were dried in shade, then ground in a mill to coarse uniform texture and stored in glass jars until use. Dried powders of shoots of the common associated species (10 g for each) were extracted with 100 ml distilled water. The extraction was carried out in dark conditions for 24 h at 25^{o}C. Then, the supernatant was centrifuged at 3000 rpm for 10 minutes. The extracts were kept in a refrigerator at 5^{o}C for 24 hr (Al Charchafchi *et al*., 2007). Series of dilutions were prepared from the stock solution (10, 30, 50, 80 and 100%, besides the control) and were tested for their effects on germination parameters, and seedling growth of barley variety Giza$_{126}$ incubated in dark at 20°C (optimum temperature).

GERMINATION BIOASSAY

Petri-dish experiment was carried out to investigate the potential allelopathic effects of the target species aqueous extracts on germination percentage (GP), Mean time to germination (MTG) and average length of both plumule (PL) and radical (RL) lengths in barley. 15 grains of barley were arranged in 9-cm diameter petri-dishes lined with two discs of Whatman No.1 filter paper in dark at 20^{o}C dark condition. 15 ml of the respective donor species aqueous extracts (0, 10, 30, 50, 80 and 100%) were added daily to three replicates of barley grains petri-dishes, and this was repeated for each donor species. Before sowing, the grains were immersed in commercial sodium hypochlorite 7% for 2 minutes for surface sterilization then rinsed four times with distilled water. Germination percentages were recorded daily for seven successive days, while PL and RL lengths were recorded at the last day of germination.

DATA ANALYSIS

The mean time for germination index (MTG) was calculated to determine the allelopathic effects of the aqueous extracts of the tested species on the grains of barely variety Giza$_{126}$.

$$MTG = \Sigma (n_i \times d_i) / N$$

Where n is the number of seeds germinated at day i, d is the incubation period in days and N is the total number of seeds germinating in the treatment (Redondo-Gómez *et al*., 2007). It's worthy to note that MTG was calculated daily for seven successive days after the emergence of radicle (DAE). The difference between the germination indices for different aqueous extracts of each species for each day was tested using one-way ANOVA, followed by Post Hoc test (SPSS, 2006).

RESULTS

Allelopathic effect of the target species on the germination of barley

Figure 3 summarizes the percentages of seed germination of barley variety Giza$_{126}$ at different concentrations of target species (*G. coronaria, A.santolina, E.microcarpa, C.annua* and *V. lutea*). For *G.coronaria*; it was observed There were significant differences between the germination (%) of barley tested by *G. coronaria* extract of different concentrations (10, 30, 50, 80 and 100%, besides the control). At control conditions, barley grains had the highest germination percentage (93.3%), followed by (71.1% and 28.9%) for concentrations 10% and 30%, respectively. On the other hand, concentration 50% had the lowest germination percentage (13.3%). Moreover, no germination was occurred at concentrations 80% and 100%. The differences between all concentrations were significant at $p < 0.05$ at the end of the experiment.

For *A. santolina*, it was observed that after 7 days of incubation under dark condition and at 20 ˚C:, there were significant differences between the germination (%) of barley tested by *A. santolina* extract of different concentrations (10, 30, 50, 80 and 100%, besides the control).Barley grains at control had the highest germination percentage (93.3%), followed by (51.1%, 13.3% and 8.9%) for concentration 10%, 50% and 30%, respectively. The germination percentages at these concentrations were significantly different at $p<0.05$ at the end of the experiment. On the other hand, concentration 80% had the lowest germination percentage (2.2%). Moreover, no germination was completely inhibited at concentration 100%.

For *E. microcarpa*, it was observed that after 7 days of incubation under dark conditions and at 20 ˚C. There were significant differences between the germination (%) of barley tested by *E. microcarpa* extract of different concentrations (10, 30, 50, 80 and 100%, besides the control). At control, barley grains had the highest germination percentage (93.3%), followed by 80.0%, 64.4% and 11.1% for concentration 10%, 30% and 80%, respectively. Among different concentrations, the germination percentage at control conditions was significantly different from that were obtained at 30%, 50%, 80% and 100% concentrations ($p < 0.05$) at the end of the incubation period. On the other hand, concentration 50% indicated the lowest germination percentage (8.9%). No germination was reported at concentration 100%.

For *C. annua*, it was observed that, there were significant differences between the germination (%) of barley tested by *C. annua* extract of different concentrations. Barley grains at control had the highest germination percentage (93.3%), followed by 68.9%, 6.7% and 4.4% for concentrations 10, 30% and 80%, respectively. On the other hand, concentration 50% had the lowest germination percentage (2.2%). The germination percentages at control and 10% concentrations were significantly different from all other concentrations at $p<0.05$ at the end of the experiment. Moreover, no germination was obtained at concentration 100%.

For *V. lutea*, it was observed that after 7 days of incubation under dark conditions and at 20˚C. There were significant differences between the germination (%) of barley tested by *V. lutea* extract of different concentrations (10, 30, 50, 80 and 100%, besides the control).Barley grains at

control had the highest germination percentage (93.3%), followed by 68.9% and 24.4% for concentration 10 and 50%, respectively. On the other hand, concentration 30% had the lowest germination percentage (20%). The germination percentages at control and 10% concentrations were significantly different from all other concentrations at p<0.05 at the end of the experiment. There was no germination at concentration 80% and 100%.

Allelopathic effect of the target species on plumule and radicle lengths of barley

Figure 4 summarizes the allelopathic effect of the target species on plumule and radicle lengths of barley seedling, for *G. coronaria,* it was observed that the plumule length of barley seedlings, after 7 days of incubation was 7.2cm for concentration 10% followed by (6.9 and 5.0 cm) for control and 50%, respectively. In contrast, concentration 30% had the lowest shoot length (2.2 cm). On the other hand, the radicle length of barley seedlings was 11.2cm for concentration 10% followed by (8.2 and 2.6 cm) for control and 30%, respectively. Concentration 50% had the lowest root length: (2.4 cm).

For *A. santolina,* the plumule length of barley incubated seedlings was 6.9 cm for control followed by (4.4, 3.5 and 2.0 cm) for 10%, 50% and 80%, respectively. On the other hand, the radicle length of barley seedlings was 8.2 cm for control treatment followed by (6.9, 2.2 and 1.8 cm) for concentrations 10%, 50% and 80%, respectively. In contrast, concentration 30% had the lowest shoot and root lengths (0.2 and 0.9 cm, respectively).

For *E. microcarpa,* the plumule length of barley seedlings was 7.7cm for 10% followed by 6.9, 5.4 and 3.8 cm for control, 30%and 50%, respectively, while, concentration 80% had the lowest plumule length (1.1cm). On the other hand, the radicle length of barley seedlings was 8.2cm for control, followed by 7.5, 5.2 and 1.2 cm for 10%, 30% and 50%, respectively. Concentration 80% had the lowest radicle length (0.5 cm).

For *C.annua,* it was observed that the plumule length of barley seedlings, after 7 days of incubation was 6.9 cm for control followed by 4.2, 0.7 and 0.8 cm for 10%, 80% and 30%, respectively. Concentration 50% had the lowest shoot length (0.2 cm). On the other hand, the radicle length of barley seedlings was 8.2 cm for control, followed by 6 cm for 10%, while concentration 30% had the lowest radicle length (0.7 cm).

For *V. lutea*, it was observed that the shoot length of barley seedlings, after 7 days of incubation was 6.9 cm for control followed by 6.7 and 2.4 cm for 50% and 30%, respectively. In contrast, the concentration of 10% had the lowest plumule length (2.3 cm). The radical length of barley seedlings was 8.2cm for control followed by 5.6 and 1.1 cm for 10% and 30%, respectively. Concentration 50% had the lowest radical length (0.5 cm).

GERMINATION VELOCITY

The germination velocities (mean time to germination) for all the studied species were highest at control and 10% concentrations (Fig. 6.). For all species, MTG was 23.3% for all the studied species. On the contrary, remarkable decrease in the germination velocity was noticed at concentrations 50%, 80% and 100%.

DISCUSSION

Weeds are plants that grow where they are not wanted. They differ from other plants in being more aggressive, having specific characteristics that make them more competitive (Gomaa, 2012). They are reported to be one of the main factors that limiting agricultural production system (Radicetti *et al*., 2013). Losses that occurred in yields due to weeds are a major reason for low yields in direct-seeded cereals systems (Haefele *et al*., 2000) and there is a significant way to improve weed control (Johnson *et al.*, 2004). Raising seedlings in a seedbed gives the cereal crop a competitive ability advantage over weeds and this has long been one of the main components of weed management in cropping systems (Bastiaans *et al.*, 2000).

Although barely has allelopathic potentiality against some crops and weeds, it seems that it is not protected against the allelopathic effects of the associated weeds. The studies associated species in the present study had inhibitory effects on the germination and growth of barely. This emphasize on the fact that weeds can adapt to a wide range of environments and compete with barley growth, resulting in its reduced growth and productivity (Burleigh *et al*., 1988). In agreement with our findings, Tammam *et al*. (2011) reported that *A. santolina* had phytotoxic potential on broad bean (*Vicia faba* L.) and barely. They observed that *A. santolina* extract had inhibitory effect on the lengths of plumule and radicle of the two economically important crops, and broad bean and barely had the maximum inhibition effect at 16% concentration of *A. santolina* extract. On the other hand, the aqueous extracts of *G.coronaria* were tested for their allelopathic properties on seed germination and seedling growth of two annual weeds (*Sinapis arvensis* and *Phalaris canariensis*) and two crops (*Triticum durum* and *Zea mays*). The phytotoxic effect of aqueous extracts of *G.coronaria* inhibited the germination and reduced the seedling growth of the tested species (Hosni *et al.*, 2013). Up to our knowledge, the allelopathic effects of *V.lutea* on other plants have not studied yet. There are few reports on the allelopathic effects of *V. villosa*, *V. sativa* and *V. cracca* on other weeds (White *et al.*, 1989; Chung & Miller, 1995; Koloren, 2007). The variations between the studied species in the effects of its water extracts on barely may be attributed to the nature of the allelochemicals secreted by the donor plant. Similar results have been reported by El-Khatib & Abd-Elaah (1998) and Abdel-Farid *et al*. (2013).

In conclusion, the present laboratory bioassays confirmed the presence of some water-soluble allelochemicals that leached from the studied associated species with barely into water. These allelochemicals led to reduction in seed germination of barely and inhibited the growth of plumule and radicle of its seedlings. This study improved our understanding on the crop-weed interaction in barely fields and it could help in the management of barely fields. Consequently, continuous weed control in the fields of rainfed barely is necessary to avoid loss in yield production.

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TABLES

Table 1. Mean time to germination (MTG) of common associated species associated with barley variety (Giza 126) at 20˚C under dark conditions.

Species	MTG					
	Concentrations (%)					
	Control	10	30	50	80	100
Glebionis coronaria	23.3	17.4	6.6	4.2	0	0
Erucaria microcarpa	23.3	19.2	15.0	2.5	2.5	0
Carrichetra annua	23.3	16.5	1.6	0.4	0.8	0
Achillea santolina	23.3	11.2	1.6	3.6	0.6	0
Vicia lutea	23.3	16.9	4.8	5.9	0.0	0

FIGURES

Fig. 1.Map of the Mediterranean region of Egypt indicating the study area Source: google maps at https://www.google maps.com.

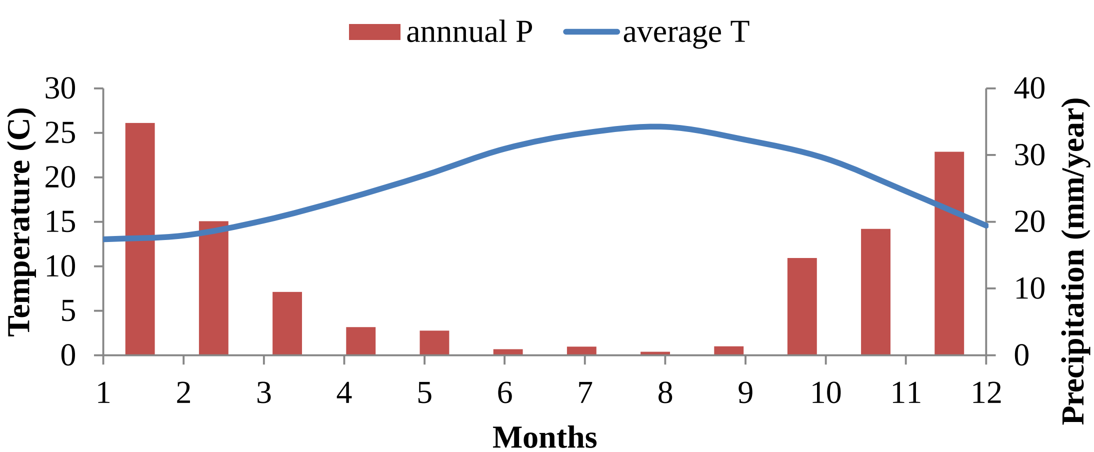

Fig. 2.Mean of monthly precipitation and temperature of Marsa-Matrouh from 1901-2016.

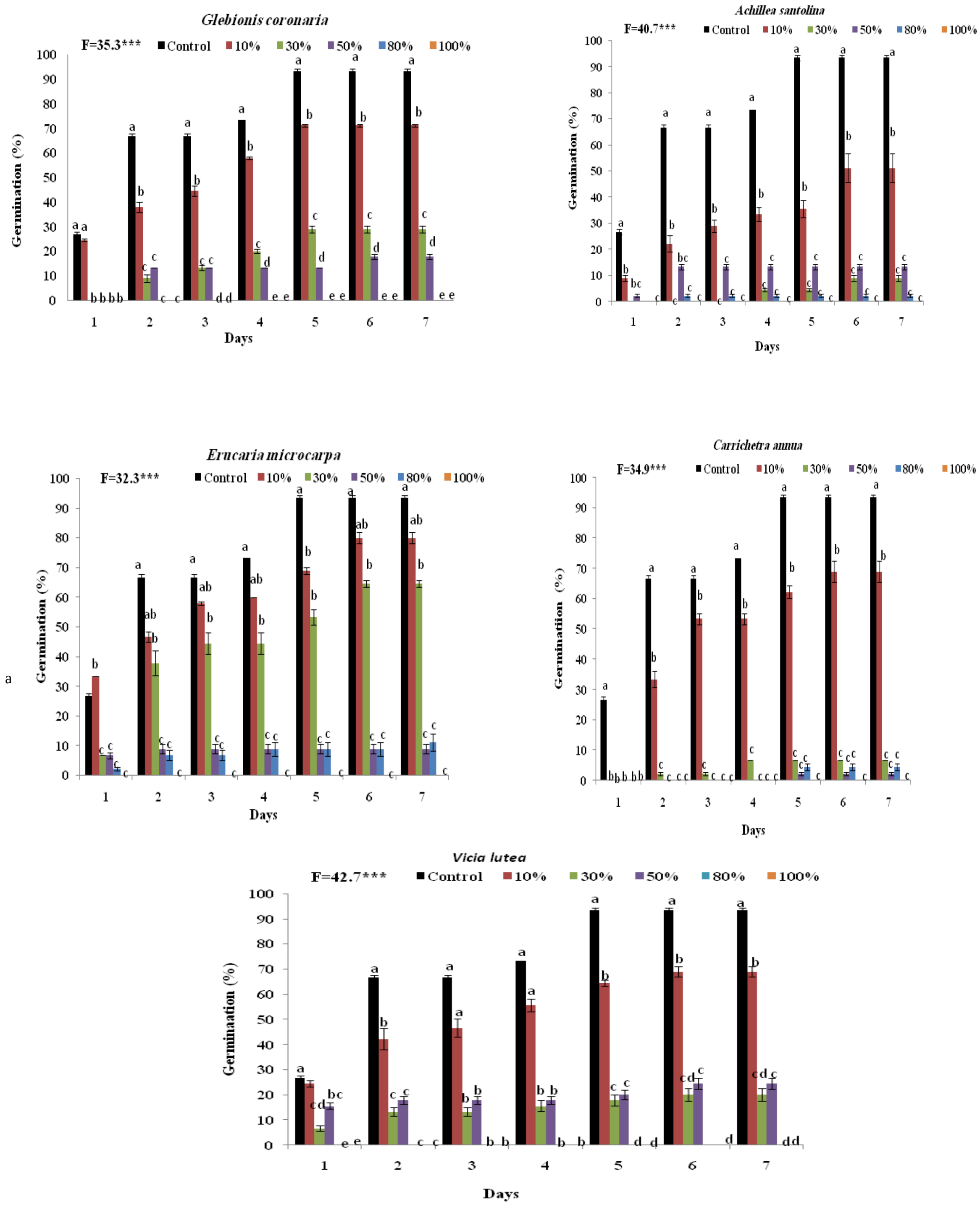

Fig. 3.Allelopathic effect of the target species (*Glebionis coronaria, Achillea santolina, Erucaria microcarpa, Carrichetra annuaand Vicia lutea)* on the germination of barley variety Giza 126 under dark conditions at 20˚C. All treatments are significantly different at $p<0.001$.
Different letters above columns means significantly different germination percentages.
Standard error bars are shown above columns.

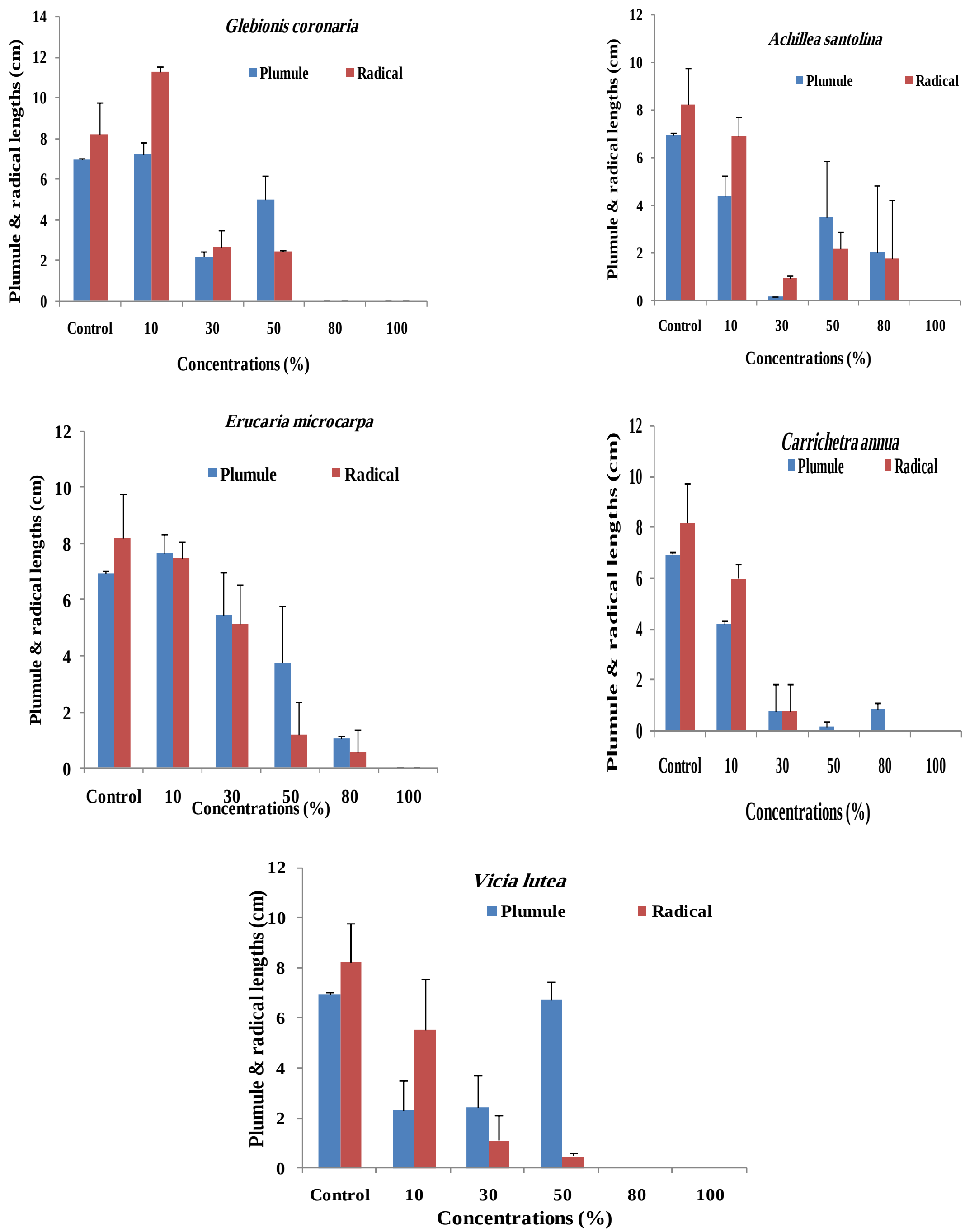

Fig. 4.Allelopathic effect of the target species (*Glebionis coronaria, Achillea santolina, Erucaria microcarpa, Carrichetra annua and Vicia lutea)* on plumule and radical lengths of barley variety Giza126 under dark conditions at 20˚C. Standard error bars are shown above columns.

تأثير التضاد الكيميائي للمستخلصات المائية للأنواع المصاحبة على إنبات بذور الشعير

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الملخص العربى

أجريت الدراسة الحالية في المعمل لدراسة إمكانية تأثير التضاد الكيميائي لأكثر الأنواع الشائعة والمصاحبة للشعير المروي بالمطر علي إنبات بذوره وهذه الانواع هي (كريزانسيم ، غوبيشه، الروق، كنبره، بخران). تم تقييم تأثير المستخلصات المائية للنباتات بتركيزات مختلفة (٠%، ١٠%، ٣٠%، ٥٠%، ٨٠% و ١٠٠%). أظهرت النتائج أن قدرة البذرة علي الانبات من أهم مراحل النمو في المحاصيل التي من الممكن ان تتأثر بالمواد الكيميائية التي تفرزها النباتات المصاحبة للمحصول في التربة. اوضحت النتائج ان تركيز ٥٠% له أعلي تأثير علي تثبيط النمو للشعير مقارنة بالكنترول حيث أن أوضحت النتائج أن نسبة الإنبات تتراوح من ٢.٢% لنبات الكنبره إلي ١٣.٣% للكريزانسيم . بالنسبة لغوبيشة اقل نسبة انبات لحبوب الشعير هي ٢.٢% عند تركيز ٨٠%. من ناحيه أخري، أقل نسبة إنبات لحبوب الشعير كانت ٢.٢% تحت تركيز ٢٠% لنبات بخران. أعلي قيمه لطول الجذير والريشة كانت لتركيز الكنترول ولتركيز ١٠% لكريزانسيم وكنبرة. بينما أقل قيمة لطول الجذير والريشة كانت لتركيز ٥٠% و ٣٠% و٨٠% اعتمادا علي نوع النبات. سرعة النمو لكل الأنواع التي تم دراستها مثلت بأعلي قيمة للكنترول وتركيز ١٠%. بينما كانت أقل قيمة لتركيز ٥٠%, ٨٠% و١٠٠%. تساعد النتائج التي توصلنا اليها إلي تحسين فهمنا لقدرة الأنواع المصاحبة لنبات الشعير المروي بالمطر علي تثبيط قدرة حبوب الشعير علي الأنبات.