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V. SUMMARY

Plants are exposed to a wide variety of enemy organisms, which can damage their tissues and cause a severe reduction in the quantity as well as the quality of the crops. In the last two decades, scientists all over the world tried to minimize the use of synthetic chemicals for the management of plant pathogens, insects and weeds to avoid the environmental pollution hazards. In addition to the target pathogen, pesticides may also kill various beneficial organisms. The increasing incidence of resistance among pathogen towards synthetic chemicals is also a cause of serious concern.

Alternative disease management using natural compounds and other resistance types needs to be considered to inhibit the growth of plant pathogens or to act on plant tissues as elicitor of the plant defense mechanism in order to exploit renewable resource(s) for crop protection in agriculture.

The development of bio-pesticides has been challenged for the pest control strategy in recent years. One source of potential new pesticides is natural products produced by algae.

Marine algae represent a great source of a vast variety of complex natural products and could be a promising source of novel bioactive compounds that can help plant survival by offering protection against stress imposed by pathogens.

The aim of this study:

1. Evaluation of different solvents extracts of green alga (*Ulva lactuca*) beside water extracts with different concentrations for their antifungal activity against the plant pathogenic fungi.
2. Evaluation of the effect of seasonal variation on the antifungal activity of methanol *Ulva lactuca*.
3. Identification of the content of alga extract by using GC-MS.
4. Evaluation of the water green alga extract (*Ulva lactuca*) and some commercial algae products against *Phytophthora infestans* (the causal agent of late blight disease which is one of the most dreaded diseases of potato worldwide and cause significant loss in production).
5. Determination of the efficacy of green alga (*Ulva lactuca*) extract and some commercial algae products for management of late blight disease of two varieties of potatoes (Burren and Lady pulford) under field conditions, besides the investigation of

the ability of these algae to elicit induced resistance in potato against late blight disease caused by *Phytophthora infestans*.

6. Studying the effect of green alga (*Ulva lactuca*) extract and these commercial algae products on yield and yield components of the two varieties of potato.

The most important results of this work were as follow:

- 1. Fungicidal activity of *Ulva lactuca* extracts against phytopathogenic fungi.**

- 1.1 Solvent extract:**

The present study was undertaken to explore the inhibitory effect of seaweed extracts of *Ulva lactuca* (green alga) with five solvents (methanol, Ethanol, Methylene chloride, chloroform and hexane) at different concentrations (100, 200, 250, 500, 1000, 1500, 2000, 4000 8000 ppm) against the mycelial growth of *Fusarium solani*, *Rhizoctonia solani*, *Sclerotinia sclerotiorum*, *Alternaria solani*, *Phytophthora infestans* and *Botrytis cinerea* in terms of radial growth inhibition.

Methanol extract of *Ulva lactuca* showed the highest antifungal activity against all the tested fungi especially *Phytophthora infestans*, *Sclerotinia sclerotiorum* and *Alternaria solani* with EC₅₀ values of 1149, 1225 and 1330 µg ml⁻¹, respectively. Methylene chloride extract exhibited the strongest antifungal effect against *Phytophthora infestans* with EC₅₀ value of 891 µg ml⁻¹.

Phytophthora infestans was most sensitive fungi than the other tested fungi to all solvent extracts of *Ulva lactuca*. Chloroform extract of *Ulva lactuca* showed weaker antifungal activity against all the tested fungi. Concerning to the effect of ethanol extract, it gave a moderate effect against most of the tested fungi while it was the most effective one against *Botrytis cinerea* with EC₅₀ value of 1017.8 µg ml⁻¹.

- 1.2 Water extract:**

Water extract showed a moderate antifungal activity against all the tested plant pathogenic fungi. *Phytophthora infestans* was most sensitive than the other tested fungi.

- 2. Seasonal variation and antifungal activity of methanol alga extract**

All Samples of *Ulva lactuca* (green alga) were collected through four Seasons, Autumn (season 1, Septmeber-December), Winter (season 2, December-March), Spring (season 3, March-June), and Summer (season 4, June-September). Every season was evaluated for its antifungal activity, the highest antifungal activity was recorded in winter season while the lowest one was in summer.

- 3. GC-MS analysis of methanolic extracts of *Ulva lactuca*.**

GC-MS analysis of methanolic extract of *Ulva lactuca* showed that the major compounds have twelve peaks indicating the presence of twelve compounds. Antifungal compounds from alga extracts are form a wide range of chemical classes, including indoles, terpenes, acetogenins, phenols, fatty acids and volatile halogenated hydrocarbons.

4. Antifungal activity of water green alga extract and commercial products of macroalgae on *phytophthora infestnas*.

The antifungal activities of water extract of green alga *Ulva lactuca* with 1000, 2000 and 4000ppm, Algaefol, Strat S, and Cytokan in terms of radial growth inhibition were studied. Water extract of *Ulva lactuca* exhibited the strongest antifungal effect against *Phytophthora infestan* with EC₅₀ value 1382.1 µg ml⁻¹. While Strat- s and Algifol had a moderate antifungal activity with EC₅₀ values of 1565 and 2113.8µg ml⁻¹, respectively. Cytokan ranked last in the antifungal activity.

5. Efficacy of green algae extract and commercial algae products on Disease severity Index (DSI) and Foliage Protection Percentage (FPP) of potato late blight.

Field experiments were conducted to study the efficacy of algae extracts (1000, 2000 and 4000 ppm) and commercial algae products (Cytokan-s, Start-s and Algifol) besides the standard fungicide diathane M-45 on late blight disease caused by *Phytophthora infestans* in potato (*Solanum tuberosum*, L.).

Within the variety trial, two varieties were chosen: Lady Pulford (LP) and Burren(B). These varieties have been recently introduced to Egypt as promising varieties for potato production.

It was clear that the most effective treatment was Algifol with a mean value of disease severity index (DSI) 0.82 with no significant values with other treatments. It is notable that the fungicide treatment was less influential in terms of reduction in DSI with a value of 1.42. Given the varieties, it was obviously clear that there was not a significant difference in the response of them towards the disease with a general mean of DSI value 1.38 for Burren variety and 1.47 for the Lady Pulford. Concerning the sprays, continued reduction moral clear and obvious until the third spray fell this effect in the fourth one.

The same results can be reached for the foliage protection percentage which ranged from 62.2 to 76% in the Burren variety while it ranged from 48.2 to 76.4% for Lady Pulford variety.

6. Effect of green alga (*Ulva lactuca*) extracts and commercial algae Products on some physiological parameters of leaves related to induced resistance.

6.1. moisture content percentage of potato leaves.

The values of moisture percentage content as mean of the two potato varieties and the mean of the four sprays appeared as the first spray had highest moisture content than the other three sprays and ulva extract had a significant increasing effect.

6.2. Total soluble phenols of potato leaves.

Total soluble phenols markedly increased in leaves of all treated potato plants in the last spray in the two varieties. Results also showed that the average content of phenols in all treatments and all sprays have increased in the two varieties, but this level of increase was larger and more pronounced in the potato variety Lady Pulford than the other one, Burren. It was not surprise that the variety Lady Pulford had high content of polyphenols than Burren variety, since it was consistent with being the most tolerant to disease.

6.3. Protein content of potato leaves.

It was clear that levels of total soluble protein significantly, increased in potato plants treated with green alga extract and commercial algae products, especially the treatment of green alga extract at the concentration 4000, 1000 ppm and the commercial alga Cytokan-S since values of protein contents were 1995.98, 1819.54 and 1695.98 mg / gm potato leaves, respectively. It is notable that these treatments increased the protein content of potato leaves even more than the standard fungicide diathane M-45 which gave 1256.90 mg protein/gm fresh weight of potato leaves.

6.4. Polyphenol oxidase activity (PPO) of potato leaves.

The data showed that all the treatments of green alga extracts and commercial algae products significantly increased the activity of polyphenol oxidase (PPO) in the two varieties of potato leaves compared with the control treatment during the four sprays. Within the varieties, there was a significant difference in the response of PPO activity in Lady Pulford and Burren. The burren variety was higher in the level of PPO activation than

the variety Lady Pulford. In general the most activation within two varieties and four sprays found in Ulva extract since, the activation of PPO reached to 32.53%. Concerning the sprays there was no significant difference between the four sprays.

6.5. Ribonuclease activity (RNase) of potato leaves.

In general, the activity of RNase of potato leaves was increased in all treatments, and the order of this activation as mean of two varieties and the four sprays was the ulva extract at 2000ppm, ulva extract at 1000ppm, algifol, cytokan-s and strat-s with rate 28.19, 23.22, 21.73, 19.29 and 12%.

It could be seen from the correlation relationship between the disease severity index and the four physiological parameters of the two potatoes varieties for this study as result of the used seven treatments. The values of correlation factor (r) confirmed the results obtained previously since we noticed a negative correlation between the disease severity index and the four tested parameters which are related to induced resistance against the phytopathogenic disease. Finally, we could say the use of algae extract might help to overcome the pathogen infection by increasing levels of defense-related enzymes, phenolic and protein substances.

7. Effect of green alga (*Ulva lactuca*) extract and commercial algae on Yield and Yield Components of potato plants.

7.1. Tubers yield as ton/ feddan.

The largest yield was awarded to the treatment of diathane M45, Start-s, Cytokan-s, Algifol with yield 4.83, 5.04, 4.83 and 4.62 ton per feddan, respectively and percentage of control increased to the treatment of diathane M-45, Start-s and cytokan-s and reached to 185,110,105%, respectively for the Burren variety. Concerning to the variety Lady Pulford, the same trend was also observed since it ranged between 7.14 and 3.99 tons compared to 4.62 tons for the control treatment. The largest yield was awarded to the treatment of diathane M-45, ulva extract 2000ppm, cytokan-s and algifol with yield values 7.14, 5.46, 5.25 and 5.04 ton per feddan

7.2. Dry matter percentage of potato tubers.

Data illustrated that there were variables effects of the seven treatments and untreated control on dry matter percentage of the potato tubers. The dry matter content of

potato tubers was increased by Algifol with a value of 31.34% for Burren variety and 26.01% for lady Pulford variety.

7.3. Total Soluble Solids (%TSS) content of potato tubers.

No significant differences between the treatments remember the impact on the total soluble solids content in both two potato varieties. The largest T.S.S was awarded to the treatment of ulva extract, Start-s, Algifol and Cytokan-s with mean values of 5.5, 5.40, 5.33 and 5.10%, respectively.

7.4. Total acids as Citric acid content of potato tubers.

The highest increase of citric acid percentages in potato tubers with a significant effect were observed in Cytokan-s, ulva extract, since citric acid percentage were 0.12 and 0.1%, respectively. concern varieties, it was found that the level of increase in citric acid was higher in the potato variety Burren compared to its level in the other variety Lady Pulford.

7.5. Ascorbic acid content of potato tubers as ($\mu\text{g}/\text{gm f.wt.}$).

The highest amount of ascorbic acid found as mean of the two varieties was the share of in Cytokan-s, ulva extract and algifol as follows 468.66, 448.35 and 422.81 $\mu\text{g}/\text{gm}$ fresh wt. of potato tubers, respectively.

7.6. Poly Phenol content of potat tubers as $\mu\text{g tannic}/\text{gm f.wt.}$

All the treatments significantly increased the total phenol content of the potato tubers in variety Burren. Highest total soluble phenols were recorded in algifol and Cytokan-S with values of 963.95 and 854 $\mu\text{g tannic acid}/\text{g}$ fresh wt. of potato tuber followed by Strat-S and ulva extract at 1000ppm with Values of 799.24, 771.29 and 548.39 $\mu\text{g tannic acid}/\text{g}$ fresh wt. of potato tuber. The same trend was noticed in Lady Pulford variety.

From interestingly, the standared fungicide diathane M-45 has occupied the last place in the increase of the level of phenols in potato tubers as average for potato cultivars for all treatments, but more than that it reduced phenols content in potato variety Burren.