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Financial Benefit of Using Fungicides Alternatives over Systematic Fungicide Spraying Strategies against Foliar Diseases of Some Vegetables grown under Protected Cultivation System in Egypt

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Abstract* - A study for the economic importance of some fungicides alternatives against foliar diseases affecting growing vegetables, cucumber, tomato and pepper under protecting cultivation system was carried out. Two foliar spray treatments, [Calcium chloride + Saccromyces cerevisiae + Chitosan] and [Potassium bicarbonate + Thyme oil] comparing with the recommended followed program of chemical fungicides were carried out under commercial plastic house conditions. The applied alternatives resulted in a high reduction in foliar diseases Downy and Powdery mildews of Cucumber and Pepper and Early and Late blights diseases incidence of Tomato plants. As for calculated data for foliar approaches, the average yield of cucumber was increased by 148.4 and 137.7% at the applied treatments, [Calcium chloride+ S. cerevisiae + Chitosan] and [Potassium bicarbonate + Thyme oil]. Furthermore, these two treatments had a positive effect on Tomato yield reflected in an increase estimated as 146.6 and 140.4%, respectively. Similarly, an increase by 131.2 and 123.3% was recorded for Pepper sprayed with the two fungicide alternatives, in respective order. The calculated costs for the applied fungicide alternative treatments, [Calcium chloride + S. cerevisiae + Chitosan] and [Potassium bicarbonate + Thyme oil] were 192.4 and 63.2 L.E., respectively. Meanwhile, the fungicide treatment was calculated as 383.0, 360.0 and 273.0 L.E. for cucumber, tomato and pepper, respectively. These results lead to calculate the reduction in fungicide alternatives application to be 190.6, 167.6 and 80.6 and 319.8, 296.8, 209.8 L.E. for cucumber, tomato and pepper, respectively. As for reduction (%) in applied treatments in relative to fungicides approaches was calculated as 49.7, 46.5, 29.5% and 83.4, 82.4, 76.8% for applied treatments, [Calcium chloride + S. cerevisiae + Chitosan] and [Potassium bicarbonate + Thyme oil], respectively. The profitability gained over fungicide treatment (Increased yield price in L.E. - treatment cost in L.E.) calculated as 1005.1, 601.1, 160.1 and 869.3, 625.3, 200.8 L.E. for cucumber, tomato and pepper at the two foliar applied treatments, respectively. Taken in consideration that 1 USD ($) equal 6.89 EGP (L.E.).

Index Terms—**economic importance, financial profit, foliar application, fungicides alternatives.**

I. INTRODUCTION

Vegetable crops grown under protected cultivation, which considered as Egypt's largest export national income, facing a serious problem due to diseases infection that cause about 20-30 % loss of produced yield because of favorable environment for disease incidence and development [1]. Plant diseases represent an important role of growing vegetables under protected cultivation system and considered a serious problem and limiting factor for their production**.** Overall, most vegetable crops under protected cultivation system suffered losses due to the favorable conditions for most diseases as high humidity and temperature. The most prevalent fungal and bacterial diseases on vegetables continue to plague growers because they are difficult to prevent, and remedial disease management tools are generally suppressive at best. Economic losses caused by plant diseases are one of the main problems in crop management and postharvest storage. Some chemical fungicides are able to present curative and preventive action at the same time. Generally, they have a high persistent action; therefore they can develop a preventive action for long time. In spite of their effective action depend on dose and mode of plant application; it is known that they present a high effectively. This fact together to the simple application, handle and low cost, these chemical products have been used from approximately 1950. However, the massive and continue use of these products, together to the lack of controlled and adequate conditions for using them it have generated numerous problems such as new fungal pathogen strains resistant to fungicides and the increase of waste residues and the toxic effects for humans and animals. The impact of plant pests on the aspiring producer of greenhouse vegetables is direct and significant. Also, pests and diseases represent a major constraint hindering the production of vegetable crops growing in plastic houses under protected cultivation system. Therefore, many control practices need to be integrated in order for minimizing this figure to occur. The widespread use of synthetic fungicides (chemical fungicides) in agriculture is a relatively recent phenomenon, and most of the major developments have taken place during the last 60 years. It has been the major way of fungal disease control in the world during the past decades and nowadays it plays an important role in crop protection. However, the chemical residues are liable to remain on the plant or within its tissues following fungicidal treatment. Fungicide residues in plants and their fruits pose a great health risk to the consumer, led to the search for safe alternatives to synthetic fungicides. In days gone by, farmers often ignored or did not recognize the effect that fungal pathogens had on the yield and quality of their crops. Nowadays, however, the losses are unacceptable, and farmers rely on the use of chemicals to control fungal diseases. As a consequence, commercial fungicides have become an important component of the total agrochemical business with worldwide sales. Environmental protection is a basic element of sustainable agricultural development. Agricultural protection practices however can cause negative externalities. One of main concerns of the externality is the negative effects of pesticide. Concerns on the negative effects of pesticide use have motivated the development of Alternative Pest Management (APM) programs against pests and diseases affecting vegetables growing in plastic houses under protected cultivation system. The importance of the present work, therefore, based on the use of induce resistance compounds and bio-control agents that able to suppress diseases incidence and development as well as to compete undesirable conditions in order to, adapt easily to environments when applied, and eliminate the necessity of using the pesticides for controlling plant pathogens. Therefore, the aim of the present study was to carry out economic assessment on the benefits of using fungicide alternatives against foliar diseases affecting some vegetables comparing with the adoption of fungicide practices used in plastic houses under protected cultivation system.

II. MATERIALS AND METHODS

A simple study for the economic importance of fungicides alternatives against foliar diseases affecting vegetables growing under protecting cultivation system was carried out during two successive growing seasons 2012-2013. This study was conducted with different vegetables, *i.e.* Cucumber, tomato and pepper grown in commercial plastic houses at different locations. Cucumber grown for two seasons in plastic houses - Ministry of Agriculture and Soil reclamation at Tookh location. Tomato and pepper grown for the first season in plastic houses - Ministry of Agriculture and Soil reclamation at Haram location, while the second season was carried out in plastic houses - Researches and Experimental Station – National Research Centre at Nubaria location. The economic calculations for the applied cost-effective fungicide alternatives comparing with fungicidal treatments were conducted as a model of plant spray treatment against foliar diseases and their effect on the yield loses. The other crop production costs, *i.e.* soil preparation the cost price of transplants, transplantation process, numbers of using sprayer machine and labors costs were the same in either fungicide or alternatives approaches, and hence not included in the analysis. The profitability of using the fungicide alternatives against foliar diseases comparing with chemical fungicides application was estimated according the guidance and suggestions provided in previous reports [2, 3, 4].

III. MODEL STUDY

The experimental plastic house consists of 5 rows, each (0.9 x 60m, width x long) divided into 3 parts 20m long, and every part considered as one replicate. Five replicates were used for each particular treatment in complete randomized design. The growing vegetables were sprayed with proposed treatments 4 times with 15 days intervals after transplanting date at the rate of 50L/plastic house. At all locations, the growing vegetables in the experimental plastic houses received only the recommended pesticides against harmful insects, *i.e.* aphids, trips, white fly, etc. as needed. Meanwhile, only the check control received traditional programs for controlling foliar diseases which recommended by the follow up committee of Protected Cultivation Administration Office, Ministry of Agriculture and Soil Reclamation.

The following treatments were applied as foliar spray:

1. Calcium chloride (20mM) + *S. cerevisiae* $10x10^{10}$cfu/mL (10ml/L) + Chitosan (0.05mM)
2. Potassium bicarbonate (20mM) + Thyme oil (5ml/L)
3. Control (received only the fungicides approaches following the protective program recommended by Agriculture Research Centre, Protected Cultivation, Ministry of Agriculture and Reclaimed soil) stated in Tables (3,4 and 5).

For the experimental conditions model in this study the estimated net return (Rn) for alternatives approaches was used to determine the foliar spray treatments cost per plastic house. The actual cost of each treatment achieved through calculated parameters, *i.e.* the alternatives and fungicide application costs, the difference cost between alternatives and fungicide approaches, the average obtained yield and its increase in response to applied alternative treatments per each vegetable tested throughout the two growing seasons. Then the cost price for both treatment and the increased yield at all applied treatments were calculated. Thereafter, profitability over fungicidal treatment and reduction in costs were calculated as net returns of applied approaches. The net returns from fungicide alternatives application was calculated as the following equations:

$Rn_1 = (YK \times YP) - (AC)$

$Rn_2 = FC - AC$

Where:

Rn_1 : the net return from fungicide alternatives application.

Rn_2 : reduction in cost (L.E.) of applied fungicide alternative approaches.

YK : yield increase in Kg.

YP : the commercial price of each Kg in L.E. per each vegetable.

FC : the fungicide application cost.

AC : fungicide alternatives application cost.

Statistical Analysis

The obtained data of plastic house experiments were set up in Completely Randomized Design (CRD). The data collected were analyzed by analysis of variance (ANOVA) test was used to analyze some other obtained data. General Linear Model option of the Analysis System SAS [5] was used to perform the analysis of variance. Duncan's Multiple Range Test was used for means separation [6]. The statistical analysis procedures were kindly carried out by Statistical Consulting Office, National Research centre, Egypt.

IV. RESULTS

The obtained results in Fig. (1) Show the average Downy and Powdery mildews incidence of Cucumber grown in

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plastic house at Tookh location throughout two successive growing seasons 2012-2013. Presented data reveal that all applied treatments have drastic effect on Downy and Powdery mildews incidence comparing with fungicide treatment. Announced high significant effect of treatments, [Calcium chloride + *S. cerevisiae* + Chitosan] and [Potassium bicarbonate + Thyme oil] that they could affect both diseases incidence which recorded in average as 12.5, 10.8% and 12.0, 13.4% comparing with 47.6, 46.6% at fungicide treatment, respectively. Moreover, regardless the cultivated area, the efficacy of applied treatments revealed a significant reduction in various recorded foliar diseases incidence of tomato and pepper grown at Haram and Nubaria locations.

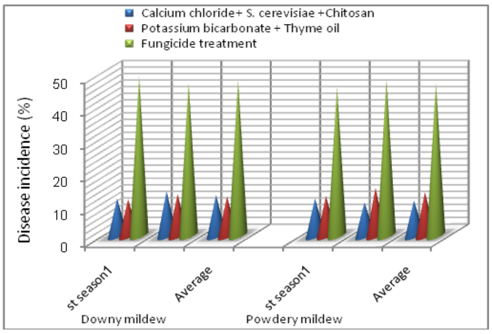

Fig. (1) Downy and powdery mildew diseases incidence (%) in response to application of plant inducers formula against foliar diseases of Cucumber grown in plastic houses under protected cultivation system at Tookh location.

In this regard, early and late blights diseases incidence and reduction of tomato plants (Fig. 2) show that the average recorded diseases incidence for early and late blights were 3.7, 7.8%; 5.1, 7.7% and 23.7, 27.2% at applied treatments of [Calcium chloride + *S. cerevisiae* + Chitosan], [Potassium bicarbonate + Thyme oil] and fungicide, respectively. Similar trend was also observed concerning pepper plants that the average recorded Downy and Powdery mildews incidence was 17.4, 12.0% and 14.2, 10.9% at [Calcium chloride+ *S. cerevisiae* +Chitosan] and [Potassium bicarbonate + Thyme oil] comparing with 31.1, 31.6% in fungicide treatment throughout the two growing seasons, respectively (Fig. 3).

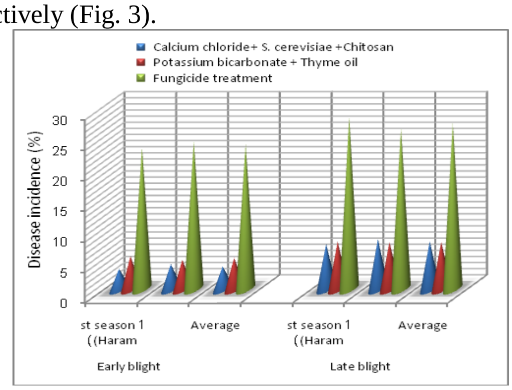

Fig. (2) Early and late blights diseases incidence (%) in response to application of plant inducers formula against foliar diseases of tomato grown in plastic houses under protected cultivation system at Haram and Nubaria locations.

Data analysis

Illustrated data in Fig.(4) show the average obtained yield of cucumber (grown in Tookh location), tomato and pepper (grown in Haram and Nubaria locations) in response to foliar application of different fungicide alternatives formula in plastic houses under protected cultivation system throughout two successive growing seasons 2011-2012. The recorded yield at applied treatment, [Calcium chloride + *S. cerevisiae* + Chitosan], of cucumber, tomato and pepper were 1468, 1663 and 988 Kg/plastic house with an increase over fungicide treatment estimated by 148.4, 146.6 and 131.2%, respectively. As for applied treatment, [Potassium bicarbonate + Thyme oil] the average yield recorded were 1362, 1593 and 929 Kg/plastic house with an increase in yield over fungicide treatment calculated as 137.7, 140.4 and 123.3%, in respective order. Meanwhile the average obtained yield in fungicide treatment were 989, 1134 and 753 Kg/plastic house for cucumber, tomato and pepper, in respective order.

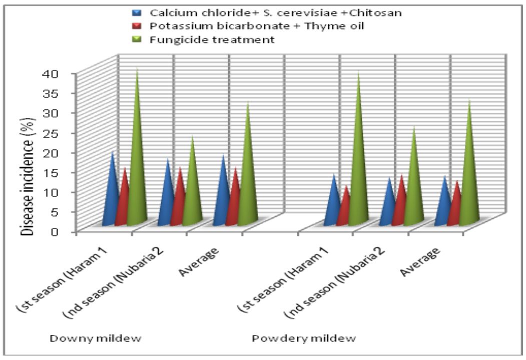

Fig. (3) Downy and powdery mildew diseases incidence (%) in response to application of plant inducers formula against foliar diseases of Pepper grown in plastic houses under protected cultivation system at Haram and Nubaria locations

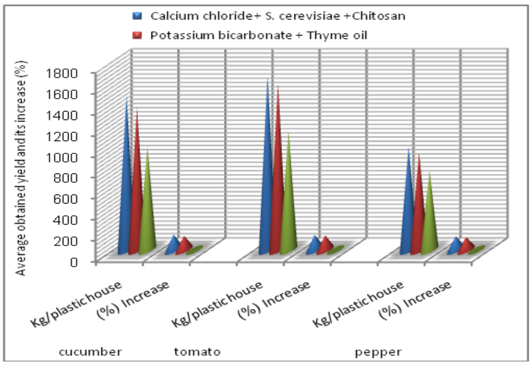

Fig. (4) Average obtained yield of cucumber, tomato and pepper in response to foliar application of different formula in plastic houses under protected cultivation system at different locations

Data presented in Fig. (4) for the yield increase as well as data presented in Table (1) for the cost price of fungicides application in addition to the cost price of fungicide alternatives approaches (stated below) were used as guidance for calculation the profitability of foliar application for different formula comparing with fungicide treatment applied in plastic houses under protected cultivation system. Presented calculated data (Table, 1) referred to the following parameters taken in consideration that each plastic house sprayed with 50L and each Liter contains:

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- For T1 (Calcium chloride (20mM-2.2 g/L) + *S. cerevisiae* 10x10^{10}cfu/mL (10ml/L) + Chitosan (0.05mM- 0.5g/L)
- For T2 (Potassium bicarbonate (20mM- g/L) + Thyme oil (5ml/L)
- For T3 (Fungicide treatment)

Materials price:

- Price of Calcium chloride = 60 L.E. /Kg; each gram= 0.06 L.E.
- *S. cerevisiae* = 8 L.E. /Kg; each gram= 0.008 L.E.
- Price of chitosan = 1500 L.E. /Kg; each gram= 1.5 L.E.
- Price of Potassium bicarbonate = 8.0 L.E. /Kg; each gram= 0.008 L.E.
- Price of Thyme oil = 60 L.E. /liter each mL= 0.06 L.E.

The cost price of applied treatments:

- For T1 (Calcium chloride + *S. cerevisiae* + Chitosan) = 2.2 g X50 L X 0.06 L.E. + 10 g X 50 L X 0.008 L.E. + 0.5 g X50 L X1.5 L.E. = 6.6 + 4.0 + 37.5 = 48.1 L.E. X 4 (numbers of application) = 192.4 L.E.
- For T2 (Potassium bicarbonate + Thyme oil) = 2 g X 50 L X 0.008 L.E. + 5 mL X 50 L X 0.06 L.E = 0.8 + 15.0 L.E. = 15.8 L.E. X 4 (numbers of application) = 63.2 L.E.
- For T3 (Fungicide treatment) = 383.0, 360.0 and 273.0 for cucumber, tomato and pepper referring to data presented in Tables (3, 4, 5).

Data in Table (2) show that the calculated costs for the applied fungicide alternative treatments, [Calcium chloride + *S. cerevisiae* + Chitosan] and [Potassium bicarbonate + Thyme oil] were 192.4 and 63.2 L.E., respectively. Meanwhile, the fungicide treatment was calculated as 383.0, 360.0 and 273.0 L.E. for cucumber, tomato and pepper, respectively. These results lead to calculate the reduction in fungicide alternatives application to be 190.6, 167.6, 80.0 and 319.8, 296.8, 209.8 L.E. for cucumber, tomato and pepper at treatments [Calcium chloride + *S. cerevisiae* + Chitosan] and [Potassium bicarbonate + Thyme oil], respectively. As for reduction (%) in applied treatments in relative to fungicides approaches was estimated by 49.7, 46.5, 29.5% and 83.4, 82.4, 76.8% for applied treatments, [Calcium chloride + *S. cerevisiae* + Chitosan] and [Potassium bicarbonate + Thyme oil], respectively. In addition, it should be taken in consideration the cost of number of sprayer machine (tractor) used in fungicide treatments which were 10, 8 and 11 times comparing with 4 times in fungicide alternatives treatments (Tables 3, 4, 5). This cost was neglected from calculations.

Thereafter, in order to calculate the profitability of fungicide alternatives application, the cost price of increased yield due to these treatments was estimated for each grown vegetable. The calculated data presented in Table (2) revealed that the average increased yield (Kg) of cucumber, tomato and pepper was 479.0, 529.0, 235.0 Kg and 373.0 459.0, 176.0 Kg at applied treatments [Calcium chloride + *S. cerevisiae* + Chitosan] and [Potassium bicarbonate + Thyme oil], respectively. Data also, show the commercial price of the increased yield which was estimated by 1197.5, 793.5, 352.5 and 932.5, 688.5, 264.0 L.E. at the applied treatments, in respective order. Also, data presented in Table (2) show the extracted gained benefit over fungicide treatment (Increased yield price - treatment cost) which calculated as 1005.1, 601.1, 160.1 L.E. and 869.3, 625.3, 200.8 for cucumber, tomato and pepper at the foliar applied treatments of [Calcium chloride+ *S. cerevisiae* + Chitosan] and [Potassium bicarbonate + Thyme oil], respectively. These figures calculated as reduction (%) in costs over fungicide approaches by 49.7, 46.5, 29.5% and 83.4, 82.4, 76.7% in respective order to applied fungicide alternatives treatments. In general, the two applied fungicide alternatives proved their efficacy to reduce the incidence of vegetable root rot and foliar diseases, increase the obtained yield and as well as reduce the foliar application costs and increase the income profit comparing with the fungicide approaches and avoiding the environmental pollution at the same time.

V. DISCUSSION

Fungicides are routinely applied to control fungal diseases of agricultural crops, with the main goal of preventing yield loss (or increasing yield) and hence maximizing economic returns. When making a decision on whether or not to apply a pesticide, a farmer has to choose between three possible control strategies. These are to spray prophylactically, never spray, or spray according to the recommendations of tactical models [7,8]. Tactical models are designed to advise farmers of the need and, sometimes, timing of applying crop protection measures [9]. A risk indicator is a measurement or a calculation performed to assess the risk that a pest or a disease will produce severe yield losses in a crop. Indicators range from simple sampling models [10] that estimate disease intensity in a field to complex forecast models that take into account the influence of the environment on the pathogen and predict the likelihood of future disease development [11,12]. However, a single rule usually will best fit the management goals of the decision maker [13]. Tactical models are considered to be one of the main cornerstones of the implementation of integrated pest management (IPM) programs. Accordingly, many research projects are aimed at development of such systems. However, until now, there has been a low level of adoption of tactical models by farmers [9, 13, 14]. Incentives for IPM adoption are very diverse. Although environmental issues were a driving force behind the development of IPM, they apparently act as a minor incentive with regard to pest control decisions by farmers [15]. On the other hand, the need for IPM programs to offer cost advantages over conventional strategies is often cited as a major incentive for IPM adoption [16]. Accordingly, one can suppose that the likelihood of adoption of tactical models by farmers is highly correlated with the financial advantage that this strategy can offer over conventional crop protection strategies. Although the financial dimension of disease management probably is quite important to those who decide whether to use IPM, it often is not considered by those that develop the models [17]. The use of synthetic fungicides has been the major commercial means of post harvest decay control for several decades. The fact that the

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effectiveness of synthetic fungicides has been reduced by the frequent development of resistance by the pathogens further highlighted the need for new substances and methods for the control of storage diseases. Naturally occurring plant products are important sources of antifungal compounds with low toxicity to mammals and safe to the environment which may serve as substitutes for synthetically produced fungicides. It was later suggested that these compounds might be developed either as products by themselves or used as starting point for synthesis [18]. The continuing development of fungicide resistance in plant and human pathogens necessitates the discovery and development of new fungicides. In this regard, evaluating natural products *e.g.* plant extracts and some compounds obtained from plants as a source of new pesticides is one strategy for the discovery of new chemical moieties that have not previously been created by synthetic chemists [19]. Also, among these natural compounds, the biocides are extracted from plants and some of them are used as additives in food industry. They present different formulates according to their application mode [20]. These natural biocides present a wide mode of action and, in general, they are composed by plant extracts, like citrus extracts which are neither toxic nor corrosive. Moreover, they are not irritate and are biodegradable with a good antimicrobial activity and fungicide properties. Moreover, the optimization of plant natural compounds fungicides against fungal diseases for agriculture is an important research because it would permit to search some important alternatives to the use of synthetic fungicides. It is becoming increasingly desirable to replace certain existing products with compounds of lower toxicity to non-target species and acceptable levels of persistence in the environment. The applied fungicide alternative foliar spray treatments in the present study proved to be more economic, strong and challenger comparing with synthetic fungicides for controlling foliar diseases of tested vegetables grown under plastic house conditions. Furthermore, present research focused on finding compounds that are safe to human and environment by using plant resistances inducers and bio-agent. An alternative to pesticide application is that, it may be possible to utilize a scheme of inducible plant defense which may provide protection against a broad spectrum of disease-causing pathogenic microorganisms. In this regard, biological control using microbial antagonists has shown potential as an alternative for natural control of plant pathogens instead of synthetic chemical fungicides [21,22]. The mode of action of antagonistic yeasts may be competition for space and nutrients [22,23], production and induction of host resistance [24,25,26]. In large-scale tests, the use of biological control often needed to be combined with low doses of synthetic fungicides to obtain a level of disease control equivalent to synthetic fungicides [27]. It was also reported that in order to completely eliminate the use of synthetic fungicides, more environmentally friendly and harmless compound (s) should be explored to improve the activity of the antagonist. Selected chemicals such as calcium chloride [28,29] in combination with biological control agents have been demonstrated to give beneficial effects on control of fruit decay. The control is not total, but in combination with bioactive additives it is possible to obtain the efficacy of the chemical standard [30,31]. Another alternative control method is given by enhancing natural resistance of plants towards the pathogen. Compounds which are triggering plant's own defense mechanisms are termed elicitors. In the present study, application of different formula of chemical plant resistance inducers as foliar spray resulted in reduction of downy and powdery mildews of cucumber and pepper , tomato early and late blights diseases incidence which reflected positively in plant stand and its healthy growth as well as its produced yield. The obtained results showed high efficacy of application plant resistance inducers Calcium chloride, Potassium bicarbonate, Thyme oil, Chitosan, *S. cerevisiae* as foliar spray treatments during the growing growth season against foliar diseases of cucumber, tomato and pepper plants. In this regards, many investigators studied the influence of various salts on microorganisms. There was a considerable interest in the use of potassium bicarbonate ($KHCO_3$) for controlling various fungal diseases in plants [32,33]. Bicarbonates are widely used in the food industry [34] and were found to suppress several fungal diseases of cucumber plants [35]. Also, spraying with $KHCO_3$ solution provided the most effective protection against plant diseases [33,37]. Furthermore, many researchers have shown that addition of $CaCl_2$ (2% w/v) to the formulation of the yeast bio-control agent, *Candida oleophila*, enhanced the ability of this yeast to protect apples against postharvest decay [28,29]. Thyme essential oil as natural alternatives that demonstrate low toxicity to humans is desirable to be used in the present work. Thyme oil applied in combination with potassium bicarbonate or chitosan showed effective reduction in foliar diseases incidence more than 50% reduction in Tomato Early and Late blights [37]. Also, Thymol has been reported to have fungicidal activities and fumigation with thymol has been used for control of postharvest fungal diseases [38,39]. Moreover, Chitosan had shown effective influence, in the present work, for reducing foliar diseases when sprayed in combined treatment. These records were confirmed with previous reports [40,41,42,43]. Chiosan, in recent years, [44] recorded that chitosan/copper complex retained a presence on the potato leaf surface late and early blights where infection by either *A. solani* or *P. infestans* occurs.

VI. CONCLUSION

The uniqueness of the present research stems from the new approach to get superior integration management include both fungal and yeast strains as well as elicitors for inducing diseases resistance that capable to control vegetable diseases without using any pesticides. The profitability of foliar spray treatments for any crop protection strategy against foliar diseases depends on the potential of plant stand and the cost and efficiency of the protection measure. Broadcast utilization of the present outcome results for production of high quality bio-control and chemical compounds agents able to suppress or limit diseases infection, avoid the necessity of using the pesticides, reduce the production cost as well as increase the productivity and quality at the same time demonstrate the importance of this work.

VII. ACHNOLEDGEMENTS

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APPENDIX

Table (1) Average costs of plant spraying approaches with fungicide and fungicide alternatives for controlling foliar diseases of Cucumber, Tomato and Pepper grown in plastic houses under protected cultivation system at different locations during two successive growing seasons

Treatment	Treatment cost (L.E.)*			Reduction in treatment cost (L.E.)*			Cost reduction (%)		
	cucumber	tomato	pepper	cucumber	tomato	pepper	cucumber	tomato	pepper
Calcium chloride + *S. cerevisiae* + Chitosan	192.4			190.6	167.6	80.6	49.7	46.5	29.5
Potassium bicarbonate + Thyme oil	63.2			319.8	296.8	209.8	83.4	82.4	76.8
Fungicide treatment	383.0	360.0	273.0	-	-		-	-	-

Table (2) Profitability to foliar application of different formula in plastic houses under protected cultivation system at different locations

Measured parameter	Treatment								
	Calcium chloride + *S. cerevisiae* + Chitosan			Potassium bicarbonate + Thyme oil			Fungicide treatment		
	Cucumber [1]	tomato [2]	Pepper [3]	Cucumber [1]	tomato [2]	Pepper [3]	Cucumber [1]	tomato [2]	Pepper [3]
Av. yield Kg/plastic house	1468.0	1663.0	988.0	1362.0	1593.0	929.0	989.0	1134.0	753.0
Yield increase Kg over control	479.0	529.0	235.0	373.0	459.0	176.0	-	-	-
yield increase %	148.4	146.6	131.2	137.7	140.4	123.3	-	-	-
Increased yield price	1197.5	793.5	352.5	932.5	688.5	264.0	-	-	-
Treatment cost	192.4			63.2			363.0	500.0	273.0
Reduction costs in L.E.[4]	**190.6**	**167.6**	**80.6**	**319.8**	**296.8**	**209.8**			
Reduction in costs over fungicide %	49.7	46.5	29.5	83.4	82.4	76.8	-	-	-
Profitability L.E. [5]	**1005.1**	**601.1**	**160.1**	**869.3**	**625.3**	**200.8**	-	-	-

[1] Cucumber commercial price for one Kg = 2.5 L.E.
[2] Tomato commercial price for one Kg = 1.50 L.E.
[3] Pepper commercial price for one Kg = 1.50.5 L.E.
[4] Reduction costs in L.E. = fungicide treatment cost – applied treatment
[5] Profitability L.E. = Increased yield price - treatment cost

Table (3) Protective program against fungal diseases for growing cucumber in plastic houses and its financial cost *

No.	Time of Treatment	Disease	Fungicide	Concentration (ml & gm/100 liter)	Dose / plastic house (gm & ml)	Cost (L.E.)
1	After 7 days from transplanting date	Downy mildew	Ridomil Gold	200 gm	200 gm	35.0
2	After 7 days from previous spray	powdery mildew	Tobaz -100	40 ml	40 ml	15.0
3	After 7 days from previous spray	Downy & powdery mildews	Amistar- Top	50 ml	50 ml	50.0
4	After 10 days from previous spray	Downy mildew	Previcure –N	250 ml	250 ml	65.0
5	After 10 days from previous spray	Downy mildew	Aquagen-pro	40 gm	40 gm	45.0
6	After 7 days from previous spray	powdery mildew	Tobaz-100	40 ml	40 gm	15.0
7	After 7 days from previous spray	powdery mildew	Sulpher	300 gm	300 gm	18.0
8	After 7 days from previous spray	powdery mildew	Copper Oxychloride	300 gm	300 gm	25.0
9	After 10 days from previous spray	Downy mildew	Previcure –N	250 ml	250 ml	65.0
10	After 7 days from previous spray	Downy & powdery mildews	Amistar- Top	50 ml	50 ml	50.0
Treatment cost						**383.0**

* The followed protective program is recommended by Agriculture Research Centre, Protected Cultivation, Ministry of Agriculture and Reclaimed soil

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Table (4) Protective program against fungal diseases for growing tomato in plastic houses and its financial cost *

No.	Time of Treatment	Disease	Fungicide	Concentration (ml & gm/100 liter)	Dose /plastic house (gm & ml)	Cost L.E.
1	After 10 days from transplanting date	Powdery mildew & blights	Sulpher macrony	250 gm/100 L	250 gm	5
2	After 10 days from previous spray	Powdery mildew & blights	Sulpher macron	250 gm/100 L	250 gm	5
3	After 15 days from previous spray	Powdery mildew & blights	Ridomil plus	150 ml/100 L	225 ml	55
4	After 10 days from previous spray	Fruit rots	Acrobate copper	250 ml/100 L	375 ml	80
5	After 10 days from previous spray	Powdery mildew & blights	Ridomil plus	150 ml/100 L	300 ml	75
6	After 10 days from previous spray	Fruit rots	Acrobate copper	250 ml/100 L	500 ml	110
7	After 15 days from previous spray	Protection to the previous approaches	Agricultural sulpher	5 Kg	5 Kg	15
8	After 15 days from previous spray	Protection to the previous approaches	Agricultural sulpher	5 Kg	5 Kg	15
Treatments cost						**360**

* The followed protective program is recommended by Agriculture Research Centre, Protected Cultivation, Ministry of Agriculture and Reclaimed soil

Table (5) Protective program against fungal diseases for growing pepper in plastic houses and its financial cost *

No.	Time of Treatment	Disease	Fungicide	Concentration (ml & gm/100 liter)	Dose /plastic house (gm & ml)	Cost L.E.
1	After 10 days from transplanting date	Powdery mildew	Bunch	3 ml	3 ml	15.0
2	After 10 days from previous spray	powdery mildew	Tobaz -100	40 ml	80 ml	30.0
3	After 15 days from previous spray	powdery mildew	Ridomil Gold	200 gm	200 gm	35.0
4	After 15 days from previous spray	powdery mildew	Bunch	3 ml	3 ml	15.0
5	After 15 days from previous spray	powdery mildew	Tobaz-100	40 ml	80 ml	30.0
6	After 15 days from previous spray	powdery mildew	Sulpher	300 gm	300 gm	18.0
7	After 15 days from previous spray	powdery mildew	Copper Oxychloride	300 gm	300 gm	25.0
8	After 15 days from previous spray	powdery mildew	Diathane –M45	250 gm	250 gm	32.0
9	After 15 days from previous spray	powdery mildew	Tobaz -100	40 ml	80 ml	30.0
10	After 15 days from previous spray	powdery mildew	Sulpher	300 gm	300 gm	18.0
11	After 15 days from previous spray	powdery mildew	Copper Oxychloride	300 gm	300 gm	25.0
Treatments cost						**273.0**

* The followed protective program is recommended by Agriculture Research Centre, Protected Cultivation, Ministry of Agriculture and Reclaimed soil