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Expert system to determine a proper control method for certain hemipterous (Hemiptera) insects according to site conditions

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Abstract:

Insects that follow the hemipterous (Hemiptera) insects infest various horticultural and field crops, causing great damage and severe losses to farmers. Therefore, it was necessary to build a system to facilitate determine the appropriate control method for field conditions as soon as possible to reach satisfactory results for farmers. An expert system was built based on the opinions of specialized and experienced experts. Experience in the field and review of research and references, specialized in pest control of hemipterous insects to enhance the accuracy and efficiency of the expertise system provided. The research aims to build an expert system to choose the optimal control method according to the site conditions. The expert system (ES) outcome was tested and evaluated by 9 cases studies (4 actual and 5 virtual cases). The results of testing and evaluating the case study showed the efficiency of the proposed ES in determining the optimal method for controlling insects that follow hemipterous insects according to field conditions, including abnormal and extreme conditions.

Introduction

The infestation of insects, especially the hemipterous insects belonging to Order Hemiptera and super family Coccoidea to any crops causes a various damages and loss in yield which consider a major problem for agriculture sector. It was important to detect the most appropriate control method to achieve the benefit of the successful and healthy harvest in quality and quantity.

For proper pest management, proper human experts are required. But there are too few to cover the cultivated area. To mitigate the lack of human experts and to help farmers to receive an accurate decision , an expert system for insect pest management would be useful (Ghosh and Samanta, 2003).

Expert systems are intelligent systems that depend on inference and specific expertise of a human expert. They are employed widely to solve the complex problem in multiple domains, such as agriculture, medicine, oil exploration, etc. They are mostly suited in situations where the human expert is not readily available, The applications of expert system are rapidly increasing. Such applications are very effective in situations when the domain expert is not readily available (Negied, 2014).

Expert systems can be used as a powerful tool in this area since they can provide growers with recommendations

to efficiently manage their plantation. Expert system technology has been applied to a variety of agricultural problems since the early 1980s (El-Azhary *et al*., 2000).

In Italy, an expert system for integrated pest management of apple orchards (POMI) (Gerevini *et al.*, 1992) has been developed. POMI addresses the first preliminary phase of the complex process of apple orchard integrated control, namely the detection of the insect population in the field and the approximate population dimension.

CUPTEX is an expert system, which has been developed for handling management of cucumber disorders (Rafea *et al.*, 1995). The main objective of this expert system was to identify the cause of an abnormal observation, and to propose the appropriate remediation. However, the user optionally can consult directly the remediation part if he/she knows the causes of the problem. In this case, the system starts by confirming these causes before giving the recommended remediation.

This paper aimed to build an expert system to facilitate the selection of the appropriate and accurate hemipterous insect control method to farmers and technical agricultural engineers.

Materials and methods

The aim of this study is to assist a proper control method selection for hemipterous insects according to field conditions. The control methods were selected according to (Awadallah *et al.* (1984), Balasubramani and Swamiappan (1994), Chen and Liu (2002), Mangoud and Abou-Setta (2012), El-Hefny *et al*. (2011), Hassan *et al.* (2012), Helmy *et al*. (2012), Buss and Dale (2016) , Abd-Rabou *et al*. (2012) and El-Sahn *et al*. (2019).

1. Procedure for the selection of the proper control methods:

The decision Table (1) was developed to present prevailing hemipterous insects control methods and qualifier conditions that prepared for the qualifiers leading to a proper control method selection for hemipterous insect according to field conditions, using methodology of Awady *et al.* (1997) and Awady *et al.* (2006 and 2016), aided with expertise, agricultural engineers members in different agricultural stations and technical workers, labors and knowledge data collected from literatures of published research, related books and review articles, to illustrate qualifier conditions.

Each case study had scores of confidences for each control method, which reflect the suitability to the circumstances. Virtual scores were allotted to different choices according to different qualifiers.

Consultations were held with domain experts to determine the qualifiers and test the outcomes of case studies, irregular outcomes were adjusted via values embedded in different rules, their effects were remarking on target and correlated choices, this procedure was iterated until obtaining satisfactory results.

Nine representation farms, including extreme cases with a wide variety of field conditions (4 actual and 5 virtual) showed in Table (2) and used to test the proposed expert system (ES) results.

The derived decision table is validated in actual and virtual case studies to test and compare and agreement with the outcomes from derived decision table for all site conditions including extreme site conditions.

2. Control methods:

The control methods were used according to expertise and literature published:

2.1. Mechanical control: Pruning and remove weeds.

2.2. Biological control: Parasitoids, predators and micro-organisms.
2.3. Chemical control: Chemical compounds, mineral oils, plant extracts, IGRs and mixtures.
3. Qualifiers:

The following qualifiers and factors were selected according to experts opinion:

1. Plant conditions:
1.1. Species : Fruit, Vegetable, ornamental plants, medicinal and aromatic plant and crops.
1.2. Age in years: more or less than 5 years.
1.3. Planting type: Organic and non-organic.
2. Field conditions :
2.1. Area in feddans: more or less than 5 feddans.
2.2. Labor: Un specialist and specialist.
2.3. Application availability: Backpack sprayer, trolley sprayer and manual sprayer.
2.4. Location: Open field and green house.
3. Pest conditions :
3.1. Species: Scale insects, mealybugs, white flies and aphids.
3.2. % infestation/plant: more or less than 5%.
3.3. Infestation intensity/field: more or less than 5%.
3.4. Infestation Season: Summer, autumn, winter and spring.
3.5. Infested plant stage: Vegetation, flowering, fruiting and dormancy.
4. Feasibility:

Cost, efficiency, initial reduction time, yield quantity and quality. Allotted weight of each qualifier was suggested according to the experts' judgment by sorting qualifiers based on their importance and effectiveness on control methods.

Each qualifier was given a weight based on its effect on control method selection among affected qualifier. This weight was multiplied times score to get final score used to judge control methods appropriateness according to site conditions.

Case study Validation and evaluation:

Four actual cases and 5 virtual cases, including extreme cases were used to test the proposed expert system (ES) outcome. Cases were exposed to consultation with domain experts for validation of decision table results. Each of control methods was weighed under each suggested case.

The manipulation of decision table done using excel software, the highest score represented the most control method appropriateness of the case study.

The actual case outcomes were evaluated by calculate and compare insect population reduction percent rate with the recommendation according to The Accredited Agricultural Recommendations annual book (2020), after field application of control method with the /highest score gained from the proposed ES.

Figure (1) representational qualifier allotted weight percent, according to expert judgements.

Table (1): Decision table.

Qualifiers		Alloted weight	Qualifiers factors	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoid	Predator	Micro-organisms	Chemical compounds	Mineral oils	Plant extract	IGRs	Mixture
Plant conditions	Species	1.5	Fruit	6	5	5	6	4	2	8	5	4	7
			Vegetable	2	7	4	6	3	2	7	4	3	5
			Ornamental plant	5	3	4	7	6	5	8	5	5	8
			Medicinal and aromatic plant	8	8	6	8	7	2	6	6	4	4
			Crops	6	8	5	5	4	7	8	4	3	7
	Age in years	1	<5	5	6	6	7	7	5	8	5	5	6
			>5	7	6	6	7	7	5	8	5	5	6
	Planting type	1.75	Organic	8	8	8	8	7	1	5	9	6	1
			Non organic	8	7	6	7	5	6	7	6	6	7
Field conditions	Area	1	<5	7	7	8	8	7	6	8	8	7	8
			>5	6	7	6	3	2	6	7	2	2	7
	Labor	0.5	Unspecialist	7	7	2	2	2	7	8	5	5	7
			Specialist	6	6	6	7	7	7	8	6	5	8
	Application availability	1.25	Backpack sprayer	1	1	1	1	5	6	6	3	5	6
			Trolley Sprayer motor	1	1	1	1	6	7	9	5	6	7
			manual sprayer	1	1	7	8	1	1	1	1	1	1
	Location	1.25	Open field	7	9	6	7	6	7	8	6	6	7
			Green house	7	8	9	9	8	6	8	6	6	7
Pest conditions	Species	1.25	Scale insects	7	6	6	8	2	5	9	5	5	6
			mealybugs	7	6	6	8	1	5	9	5	5	6
			White flies	7	9	7	8	2	5	7	1	1	5
			Aphids	6	9	5	7	6	7	7	5	3	7

Table (1) : Continued.

	Qualifiers	Alloted weight	Qualifiers factors	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoid	Predator	Micro-organisms	Chemical compounds	Mineral oils	Plant extract	IGRs	Mixture
Pest conditions	% infestation /plant	1.75	<5	3	5	7	9	7	1	1	3	1	1
			>5	8	8	5	4	3	8	9	2	2	9
	Infestation intensity/field	1.75	<5	8	9	7	7	8	7	9	5	5	7
			>5	4	6	4	6	4	8	9	7	6	9
	Infestation Season	1	Summer	3	7	5	7	6	5	5	3	3	6
			Autumn	7	9	3	3	2	6	7	5	5	7
			Winter	9	9	3	6	2	7	9	3	2	8
			Spring	3	6	4	5	2	1	1	1	1	1
	Infested Plant stage	1.25	Vegetation	5	8	6	7	6	7	9	7	6	8
			Flowering	1	7	8	9	3	1	1	1	1	1
			fruiting	1	8	8	9	2	1	1	1	1	1
			Dormancy	9	9	5	6	6	7	8	4	4	8
Feasibility		1.75	Cost	9	9	4	5	3	5	6	5	5	8
			Efficiency	8	8	5	8	4	8	8	5	5	9
			Initial reduction time	9	8	5	7	3	9	6	5	5	9
			Yield quantity	6	5	4	5	5	5	7	7	6	7
			Yield quality	5	5	4	5	5	3	7	7	4	7

Table (2): Site conditions data under investigation.

Site conditions		Case study								
		A	B	C	D	E	F	G	H	I
Case situation		Actual	Actual	Actual	Virtual	Virtual	Actual	Virtual	Virtual	Virtual
Plant	Species	Mandarin	Mango	Orange	Grape vine	*Cycas*	Sugar cane	Roselle	Sweet pepper	Cucumber
	Age	6	8	7	3	2	2	6 months	2 months	1 month
	Planting type	Non organic	Non organic	Non organic	Non organic	Non organic	Non organic	Organic	Organic	Organic
Field	Area	3 feddans	2 feddans	6 feddans	1 feddans	50 m2	6 feddans	1 feddan	360 m2	360 m2
	Labor	Unspeciali-st	Unspecia-list	Specialist	Unspec-ialist	specialist	Unspec-ialist	Specialist	Specialist	Specialist
	Application availability	Trolley sprayer motor	Trolley sprayer motor	Trolley sprayer motor	Backpa-ck sprayer	manual sprayer	Trolley Sprayer motor	Backpack sprayer	Backpack sprayer	Manual sprayer
	Location	Open field	Open field	Open field	Open field	Green house	Open field	Open field	Green house	Green house
Pest	Species	Scale insects	Scale insects	Scale insects	Mealyb-ugs	Scale insects	Scale insects	White flies	White flies	Aphids
	% infestation/plant	40	40	30	5	60	40	5	5	3
	Infestation intensity/ field	60	60	50	20	70	50	4	40	5
	Infestation Season	Autumn	winter	Summer	Summer	Summer	Spring	Summer	Summer	Spring
	Plant phenology	Vegetation	Vegetation	Vegetation	Vegetation	Vegetation	Vegetation	Flowering	fruiting	Flowering

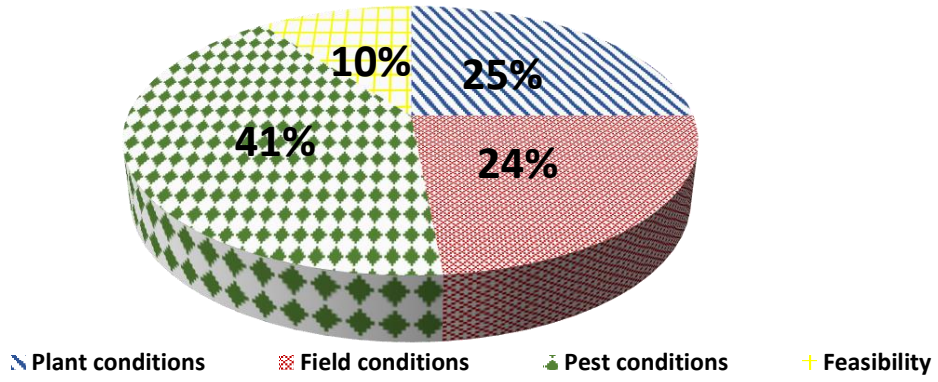

Figure (1): Qualifiers weight percent used for control method selection

Results and discussion

In the following results presentation and discussion of the case study used. Figure (2) showed the total score for all hemipterous insect control methods under study, according to field conditions that presented in Table (1).

Nine case studies (4 actual and 5 virtual cases) were implemented to evaluate the efficiency of the expert system design to detect the appropriate control method according to site conditions including the extreme conditions.

The results of the proposed expert system were evaluated by calculating insect reduction percent and minimum time for the highest insect reduction percent was determined for the control method with highest score gained proposed from expert system.

1. Case (A):

Table (3) presented field conditions for the actual case (A) in Fayoum Governorate as follows: Plant conditions: The plant species were mandarin, trees were 6 years old, planting type non organic.

Field conditions, planted area 3 feddans, unspecialist labor, application availability trolley sprayer motor, located in an the open field, insect species scale insects (*Parlatoria ziziphi*), infestation percent /plant40%, infestation intensity/field 60% infestation season was autumn, plant phenology vegetation.

The highest score gained for chemical control with mineral oil with 186 and the insect % reduction ratio was 94.8% after 15 days from the application which is considered good reduction % according to expert judgment.

2. Case (B):

Table (4) showed case B in Qaluobiya Governorate the following site conditions. Planting conditions were mango with 8 years, non organic, field conditions were mango was planted in 2 feddans with non specialist labor and trolley sprayer motor, in the open field.

Pest conditions were, the insect species were a scale insect with 40% infestation and 60% infestation intensity/field, planting season was winter plant phenology was vegetation. The highest score gained for chemical control with mixture was 178.5. The reduction percent to 89.1% after two weeks from application with summer

oil (Super misrona) mixed with organophosphorus compound (Malathion).

3. Case (C):

Table (5) represents case C in Giza Governorate, with site conditions: Plant conditions; plant species orange (7 years old), non organic. The field conditions were 6 feddans with specialist labors and the trolley sprayer motor was available in the open field.

Pest conditions, it was hard scale insects (*Lepidosaphes beckii*) with 30% Infestation/plant, Infestation intensity/field was 50%, the application season was summer and plant phenology was vegetation.

The highest score gained for chemical control with mixture was 176 The reduction percent recorded was 99.7%when summer oil (Star oil) mixed with IGR (admiral) compound were applied. The recorded reduction was 99.7%.

4. Case (D):

Table (6) represented case D (virtual case study) with site conditions; for the plant conditions the plant species were grape vine with 3 years, non organic. Field conditions where grape planted in one feddan with unspecialist labor and backpack sprayer was available.

The location was open field. Pest conditions were grape was infested with mealybugs (*Icerya seychellarum*) with 5% infestation/ plant and 20 % Infestation intensity/field in summer season and plant phenology was vegetation. The highest score gained for chemical control with mixture with 167.5.

5. Case (E):

Table (7) represented case E with of (virtual case study) site conditions; Plant conditions were; the plant was cycas palmlike with age 2 years (planted in pots), and planting type was non organic.

Field conditions: area was 50 m^2 with specialist labor and application availability was manual sprayer in the green house. Pest conditions where the infestation was with scale insects (*Saissetia coffeae*) % infestation/plant was 60% and infestation intensity/field 70% infestation in summer season in vegetative stage. The highest score gained for chemical control with mixture with 177.25 .

6. Case (F):

Table (8) represented case F in Qena Governorate, with site conditions: Plant conditions plant was sugar cane with 2 years , non organic plantation.

Field conditions were 6 feddans, unspecialist labor, trolley sprayer motor and location were open field. Pest conditions where the infestation was with soft scale insects (*Pulvinaria tenuivalvata*) and % infestation/ plant was 40% and infestation intensity/field 50%. The infested plant stage was vegetation in spring season.

The highest score gained for chemical control with mineral oil with 179. The actual reduction percent of mineral oil when applied was 83.4 % after a month (KZ oil) from the application.

7. Case (G):

Table (9) represented case G by (Virtual case study) with site conditions, planted with roselle with 6 months, organic,1 feddan and specialist labor with backpack sprayer in open field infested with white flies % infestation/plant 5% and infestation intensity/field 4% in summer and infested plant stage was flowering.

The highest score gained from mechanical control with weed, remove with 166.25.

8. Case (H):

Table (10) represented case H (Virtual case study) with site conditions: Plant conditions were planted with sweet pepper with 2 months age, organic plantation, field

conditions were the area was 360 m^2 , specialist labor, application availability with backpack sprayer in the green house.

Pest conditions: Sweet pepper was infested with white flies with % infestation/plant 5% and infestation intensity/field 40% planted in summer on fruiting stage. The highest score gained from biological control with predators with 161.

9. Case (I):

Table (11) represents case I (Virtual case study) with site conditions: Plant conditions were the plant species were cucumber with 1-month age, organic, plantation. Field conditions were the area was 360 m^2 with specialist labor a manual sprayer as application availability in the green house.

Pest conditions were infested with aphids with % infestation/plant 3% and infestation intensity/field 5% . Infestation season in spring and the infested plant stage was flowering. The highest score gained from Biological control with predators with 168.25.

From the previously mentioned data it was clear that **:**

- Application with mineral oil as a chemical control gained the highest score of 186 and 179 for actual cases A and F for mandarin and sugar cane crop, respectively.
- Whereas, actual cases B, C, D and E showed the highest score were 178.5, 176, 167.5 and 177.75 for mixtures representing chemical control hemipterous control methods of mango, orange, grape vines and cycas palmlike , respectively and using predator as a biological control method for virtual cases I and H with sweet pepper and cucumber gained the highest score of 186.25 and 161, respectively.
- Finally, weed removing for mechanical control method gained of 166.25 the highest score in case G with roselle plants .

This paper is a pioneer, expert system (ES) for selecting the proper and accurate pest management of hemipterous insects infesting various crops according to field conditions.

The evaluation of ES revealed a successful attempt to help agricultural sector workers. However, it needs more efforts to facilitate the proposed (ES) usage to meet farmers' needs.

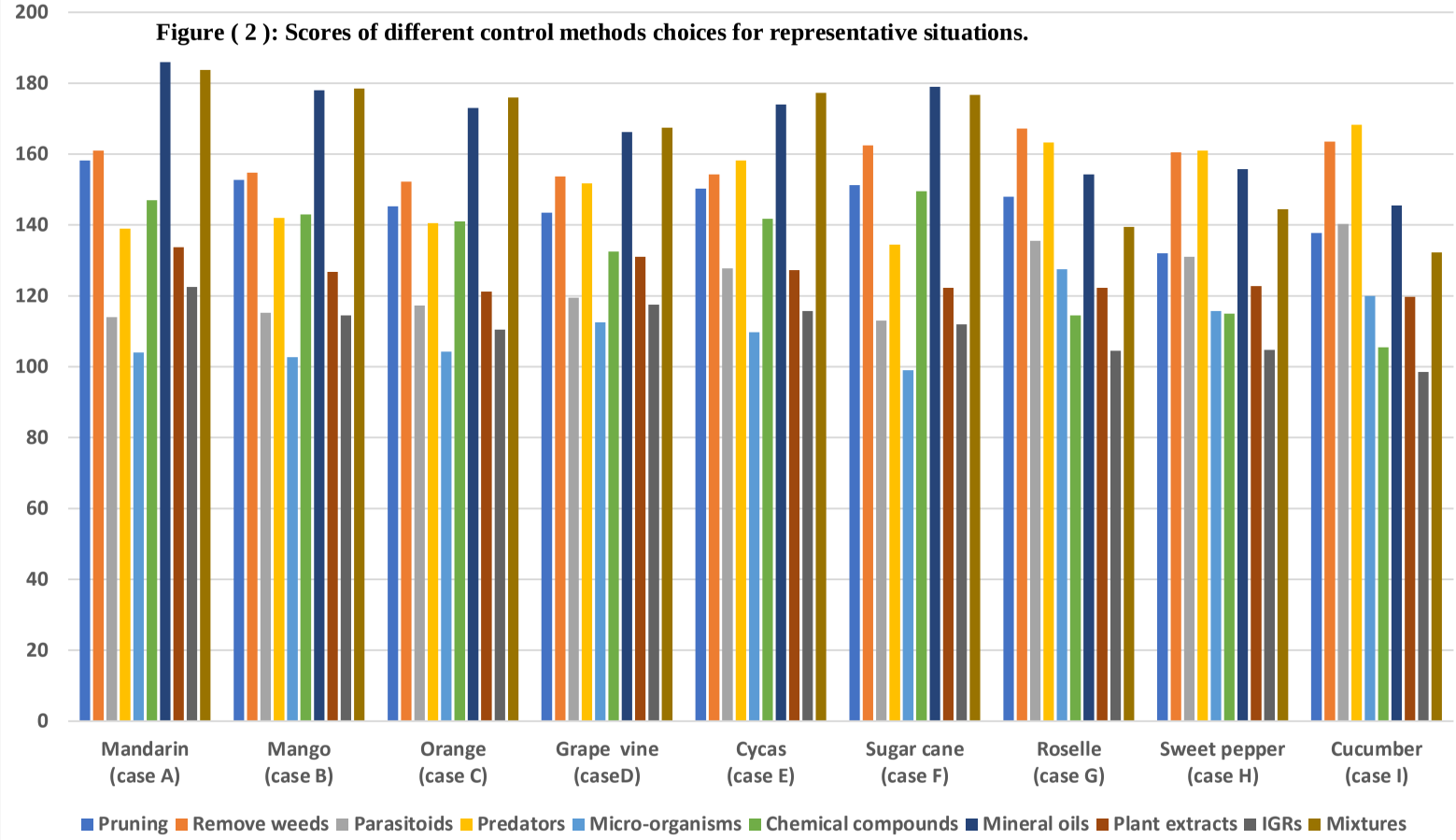

Figure (2): Scores of different control methods choices for representative situations.

Table (3): Result score of case A.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case A	Plant	Species	Mandarin	9	7.5	7.5	9	6	3	12	7.5	6	10.5
		Age in years	6	7	6	6	7	7	5	8	5	5	6
		Planting type	Non organic	14	12.25	10.5	12.25	8.75	10.5	12.25	10.5	10.5	12.25
	Field	Area	3 feddans	7	7	8	8	7	6	8	8	7	8
		Labor	Unspecialist	3.5	3.5	1	1	1	3.5	4	2.5	2.5	3.5
		Application availability	Trolley Sprayer motor	1.25	1.25	1.25	1.25	7.5	8.75	11.25	6.25	7.5	8.75
		Location	Open field	8.75	11.25	7.5	8.75	7.5	8.75	10	7.5	7.5	8.75
	Pest	Species	Scale insects	8.75	7.5	7.5	10	2.5	6.25	11.25	6.25	6.25	7.5
		% infestation/plant	40	14	14	8.75	7	5.25	14	15.75	3.5	3.5	15.75
		Infestation intensity/field	60	7	10.5	7	10.5	7	14	15.75	12.25	10.5	15.75
		Infestation Season	Autumn	7	9	3	3	2	6	7	5	5	7
		Plant phenology	Vegetation	6.25	10	7.5	8.75	7.5	8.75	11.25	8.75	7.5	10
	Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			158.25	161	114	139	104	147	186	133.75	122.5	183.75

Table (4): Result score of case B.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case B	Plant	Species	Mango	9	7.5	7.5	9	6	3	12	7.5	6	10.5
		Age in years	8	7	6	6	7	7	5	8	5	5	6
		Planting type	Non organic	14	12.25	10.5	12.25	8.75	10.5	12.25	10.5	10.5	12.25
	Field	Area	2 feddans	7	7	8	8	7	6	8	8	7	8
		Labor	Non specialist	3.5	3.5	1	1	1	3.5	4	2.5	2.5	3.5
		Application availability	Trolley Sprayer motor	1.25	1.25	1.25	1.25	7.5	8.75	11.25	6.25	7.5	8.75
		Location	Open field	8.75	11.25	7.5	8.75	7.5	8.75	10	7.5	7.5	8.75
	Pest	Species	Scale insects	1.25	1.25	8.75	10	1.25	1.25	1.25	1.25	1.25	1.25
		% infestation/plant	40	14	14	8.75	7	5.25	14	15.75	3.5	3.5	15.75
		Infestation intensity/field	60	7	10.5	7	10.5	7	14	15.75	12.25	10.5	15.75
		Infestation Season	winter	9	9	3	6	2	7	9	3	2	8
		Plant phenology	Vegetation	6.25	10	7.5	8.75	7.5	8.75	11.25	8.75	7.5	10
	Total Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			152.75	154.75	115.25	142	102.75	143	178	126.75	114.5	178.5

Table (5): Result score of case C.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case C	Plant	Species	Orange	9	7.5	7.5	9	6	3	12	7.5	6	10.5
		Age in years	7	7	6	6	7	7	5	8	5	5	6
		Planting type	Non organic	14	12.25	10.5	12.25	8.75	10.5	12.25	10.5	10.5	12.25
	Field	Area	6 feddans	6	7	6	3	2	6	7	2	2	7
		Labor	Specialist	3	3	3	3.5	3.5	3.5	4	3	2.5	4
		Application availability	Trolley Sprayer motor	1.25	1.25	1.25	1.25	7.5	8.75	11.25	6.25	7.5	8.75
		Location	Open field	8.75	11.25	7.5	8.75	7.5	8.75	10	7.5	7.5	8.75
	Pest	Species	Scale insects	1.25	1.25	8.75	10	1.25	1.25	1.25	1.25	1.25	1.25
		% infestation/plant	30	14	14	8.75	7	5.25	14	15.75	3.5	3.5	15.75
		Infestation intensity/field	50	7	10.5	7	10.5	7	14	15.75	12.25	10.5	15.75
		Infestation Season	Summer	3	7	5	7	6	5	5	3	3	6
		Plant phenology	Vegetation	6.25	10	7.5	8.75	7.5	8.75	11.25	8.75	7.5	10
	Total Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			145.25	152.25	117.25	140.5	104.25	141	173	121.25	110.5	176

Table (6): Result score of case D.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case D	Plant	Species	Grape vine	9	7.5	7.5	9	6	3	12	7.5	6	10.5
		Age in years	3	5	6	6	7	7	5	8	5	5	6
		Planting type	Non organic	14	12.25	10.5	12.25	8.75	10.5	12.25	10.5	10.5	12.25
	Field	Area	1 feddans	7	7	8	8	7	6	8	8	7	8
		Labor	Unspecialist	3.5	3.5	1	1	1	3.5	4	2.5	2.5	3.5
		Application availability	Backpack sprayer	1.25	1.25	1.25	1.25	6.25	7.5	7.5	3.75	6.25	7.5
		Location	Open field	8.75	11.25	7.5	8.75	7.5	8.75	10	7.5	7.5	8.75
	Pest	Species	mealybugs	8.75	7.5	7.5	10	1.25	6.25	11.25	6.25	6.25	7.5
		% infestation/plant	5	5.25	8.75	12.25	15.75	12.25	1.75	1.75	5.25	1.75	1.75
		Infestation intensity/field	20	7	10.5	7	10.5	7	14	15.75	12.25	10.5	15.75
		Infestation Season	Summer	3	7	5	7	6	5	5	3	3	6
		Plant phenology	Vegetation	6.25	10	7.5	8.75	7.5	8.75	11.25	8.75	7.5	10
	Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			143.5	153.75	119.5	151.75	112.5	132.5	166.25	131	117.5	167.5

Table (7): Result score of case E.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case E	Plant	Species	Cycas	7.5	4.5	6	10.5	9	7.5	12	7.5	7.5	12
		Age in years	2	5	6	6	7	7	5	8	5	5	6
		Planting type	Non Organic	14	12.25	10.5	12.25	8.75	10.5	12.25	10.5	10.5	12.25
	Field	Area	50 m2	7	7	8	8	7	6	8	8	7	8
		Labor	Specialist	3	3	3	3.5	3.5	3.5	4	3	2.5	4
		Application availability	manual sprayer	1.25	1.25	8.75	10	1.25	1.25	1.25	1.25	1.25	1.25
		Location	Green house	8.75	10	11.25	11.25	10	7.5	10	7.5	7.5	8.75
	Pest	Species	Scale insects	8.75	7.5	7.5	10	2.5	6.25	11.25	6.25	6.25	7.5
		% infestation/plant	60	14	14	8.75	7	5.25	14	15.75	3.5	3.5	15.75
		Infestation intensity/field	70	7	10.5	7	10.5	7	14	15.75	12.25	10.5	15.75
		Infestation Season	Summer	3	7	5	7	6	5	5	3	3	6
		Plant phenology	Vegetation	6.25	10	7.5	8.75	7.5	8.75	11.25	8.75	7.5	10
	Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			150.25	154.25	127.75	158.25	109.75	141.75	174	127.25	115.75	177.25

Table (8): Result score of case F.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case F	Plant conditions	Species	Sugar cane	9	12	7.5	7.5	6	10.5	12	6	4.5	10.5
		Age in years	2	5	6	6	7	7	5	8	5	5	6
		Planting type	Non organic	14	12.25	10.5	12.25	8.75	10.5	12.25	10.5	10.5	12.25
	Field conditions	Area	6 feddans	6	7	6	3	2	6	7	2	2	7
		Labor	Unspecialist	3.5	3.5	1	1	1	3.5	4	2.5	2.5	3.5
		Application availability	Trolley Sprayer motor	1.25	1.25	1.25	1.25	7.5	8.75	11.25	6.25	7.5	8.75
		Location	Open field	8.75	11.25	7.5	8.75	7.5	8.75	10	7.5	7.5	8.75
	Pest conditions	Species	Scale insects	8.75	7.5	7.5	10	2.5	6.25	11.25	6.25	6.25	7.5
		% infestation/plant	40	14	14	8.75	7	5.25	14	15.75	3.5	3.5	15.75
		Infestation intensity/field	50	7	10.5	7	10.5	7	14	15.75	12.25	10.5	15.75
		Infestation Season	Spring	3	6	4	5	2	1	1	1	1	1
		Infested Plant stage	Vegetation	6.25	10	7.5	8.75	7.5	8.75	11.25	8.75	7.5	10
	Total Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			151.25	162.5	113	134.5	99	149.5	179	122.25	112	176.75

Table (9): Result score of case G.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case G	Plant conditions	Species	Roselle	12	12	9	12	10.5	3	9	9	6	6
		Age	6 months	5	6	6	7	7	5	8	5	5	6
		Planting type	Organic	14	14	14	14	12.25	1.75	15.75	15.75	10.5	1.75
	Field conditions	Area	1 feddan	7	7	8	8	7	6	8	8	7	8
		Labor	Specialist	3	3	3	3.5	3.5	3.5	4	3	2.5	4
		Application availability	Backpack sprayer	1.25	1.25	1.25	1.25	6.25	7.5	7.5	3.75	6.25	7.5
		Location	Open field	8.75	11.25	7.5	8.75	7.5	8.75	10	7.5	7.5	8.75
	Pest conditions	Species	White flies	8.75	11.25	8.75	10	2.5	6.25	8.75	1.25	1.25	6.25
		% infestation/plant	5	5.25	8.75	12.25	15.75	12.25	1.75	1.75	5.25	1.75	1.75
		Infestation intensity/field	4	14	15.75	12.25	12.25	14	12.25	15.75	8.75	8.75	12.25
		Infestation Season	Summer	3	7	5	7	6	5	5	3	3	6
		Infested Plant stage	Flowering	1.25	8.75	10	11.25	3.75	1.25	1.25	1.25	1.25	1.25
	Total Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			148	167.25	135.5	163.25	127.5	114.5	154.25	122.25	104.5	139.5

Table (10): Result score of case H.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case H	Plant conditions	Species	Sweet pepper	3	10.5	6	9	4.5	3	10.5	6	4.5	7.5
		Age	2 months	5	6	6	7	7	5	8	5	5	6
		Planting type	Organic	14	14	14	14	12.25	1.75	15.75	15.75	10.5	1.75
	Field conditions	Area	360 m2	7	7	8	8	7	6	8	8	7	8
		Labor	Specialist	3	3	3	3.5	3.5	3.5	4	3	2.5	4
		Application availability	Backpack sprayer	1.25	1.25	1.25	1.25	6.25	7.5	7.5	3.75	6.25	7.5
		Location	Green house	8.75	10	11.25	11.25	10	7.5	10	7.5	7.5	8.75
	Pest Conditions	Species	White flies	8.75	11.25	8.75	10	2.5	6.25	8.75	1.25	1.25	6.25
		% infestation/plant	5	5.25	8.75	12.25	15.75	12.25	1.75	1.75	5.25	1.75	1.75
		Infestation intensity/field	40	7	10.5	7	10.5	7	14	15.75	12.25	10.5	15.75
		Infestation Season	Summer	3	7	5	7	6	5	5	3	3	6
		Infested Plant stage	fruiting	1.25	10	10	11.25	2.5	1.25	1.25	1.25	1.25	1.25
	Total Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			132	160.5	131	161	115.75	115	155.75	122.75	104.75	144.5

Table (11): Result score of case I.

	Site conditions		Case conditions	Mechanical control		Biological control			Chemical control				
				Pruning	Remove weeds	Parasitoids	Predators	Micro-organisms	Chemical compounds	Mineral oils	Plant extracts	IGRs	Mixtures
Case I	Plant conditions	Species	cucumber	3	10.5	6	9	4.5	3	10.5	6	4.5	7.5
		Age	1 month	5	6	6	7	7	5	8	5	5	6
		Planting type	Organic	14	14	14	14	12.25	1.75	15.75	15.75	10.5	1.75
	Field conditions	Area	360 m2	7	7	8	8	7	6	8	8	7	8
		Labor	Specialist	3	3	3	3.5	3.5	3.5	4	3	2.5	4
		Application availability	manual sprayer	1.25	1.25	8.75	10	1.25	1.25	1.25	1.25	1.25	1.25
		Location	Green house	8.75	10	11.25	11.25	10	7.5	10	7.5	7.5	8.75
	Pest conditions	Species	Aphids	7.5	11.25	6.25	8.75	7.5	8.75	8.75	6.25	3.75	8.75
		% infestation/plant	3%	5.25	8.75	12.25	15.75	12.25	1.75	1.75	5.25	1.75	1.75
		Infestation intensity/field	5%	14	15.75	12.25	12.25	14	12.25	15.75	8.75	8.75	12.25
		Infestation Season	Spring	3	6	4	5	2	1	1	1	1	1
		Infested Plant stage	Flowering	1.25	8.75	10	11.25	3.75	1.25	1.25	1.25	1.25	1.25
	Total Feasibility			64.75	61.25	38.5	52.5	35	52.5	59.5	50.75	43.75	70
	Total			137.75	163.5	140.25	168.25	120	105.5	145.5	119.75	98.5	132.25

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