PROVIMI PRODUCTS FUNDED PROJECTS

Evaluating the efficacy of HERBOLIV+ to control wild animal intrusion in farmland and its effect on Crop and Soil

REPORT

Submitted by

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CONTENTS

EXPERIMENT DETAILS

Evaluating the efficacy of HERBOLIV+ to control wild animal intrusion in farmland and its effect on Crop and Soil

Evaluation of the efficacy of Herboliv[+] in farmland was carried out to assess the level of wild animal incidence and to quantify the degree of damage inflicted by the wild animals after the application of Herboliv[+] and its impact on the crop and soil.

OBJECTIVES

1. To evaluate the efficacy of the HERBOLIV[+] (Wildlife repellent) to repel the wild animals.
2. To evaluated the influence of the HERBOLIV[+] on Crop and Soil.

I. STUDY AREA

Herboliv[+] was tested in Sirumugai range of Coimbatore forest division, Tamil Nadu state, India. Farmers field where the agricultural crops being cultivated in the forest fringe areas which are prone to wildlife damage were identified and selected for the experimental trials.

Table 1. Geographical Location

S. No.	Crop	Location	GPS Points	Above Mean Sea Level
1	Sugarcane	Vedarcolony, Sirumugai Range	$11^0$20' N $76^0$58' E	292 m
2	Banana	Uppupallam, Sirumugai Range	$11^0$19' N $76^0$56' E	310 m
3	Fodder grass	Vilvamarathukuttai, Sirumugai Range	$11^0$22' N $76^0$58' E	330 m

2. Environmental conditions

Sirumugai range receives an annual rainfall of 830 mm. The mean maximum and minimum temperature is 32.2 ^{0}C and 23.2 ^{0}C, respectively. The climatic factors comprising of mean maximum and minimum temperature, quantum of rainfall, number of rainy days, and relative humidity which prevailed during the experimental period were recorded and is presented in Table 2.

Plate 1. Study Area

Plate 2. Sirumugai Range, Coimbatore Forest Division

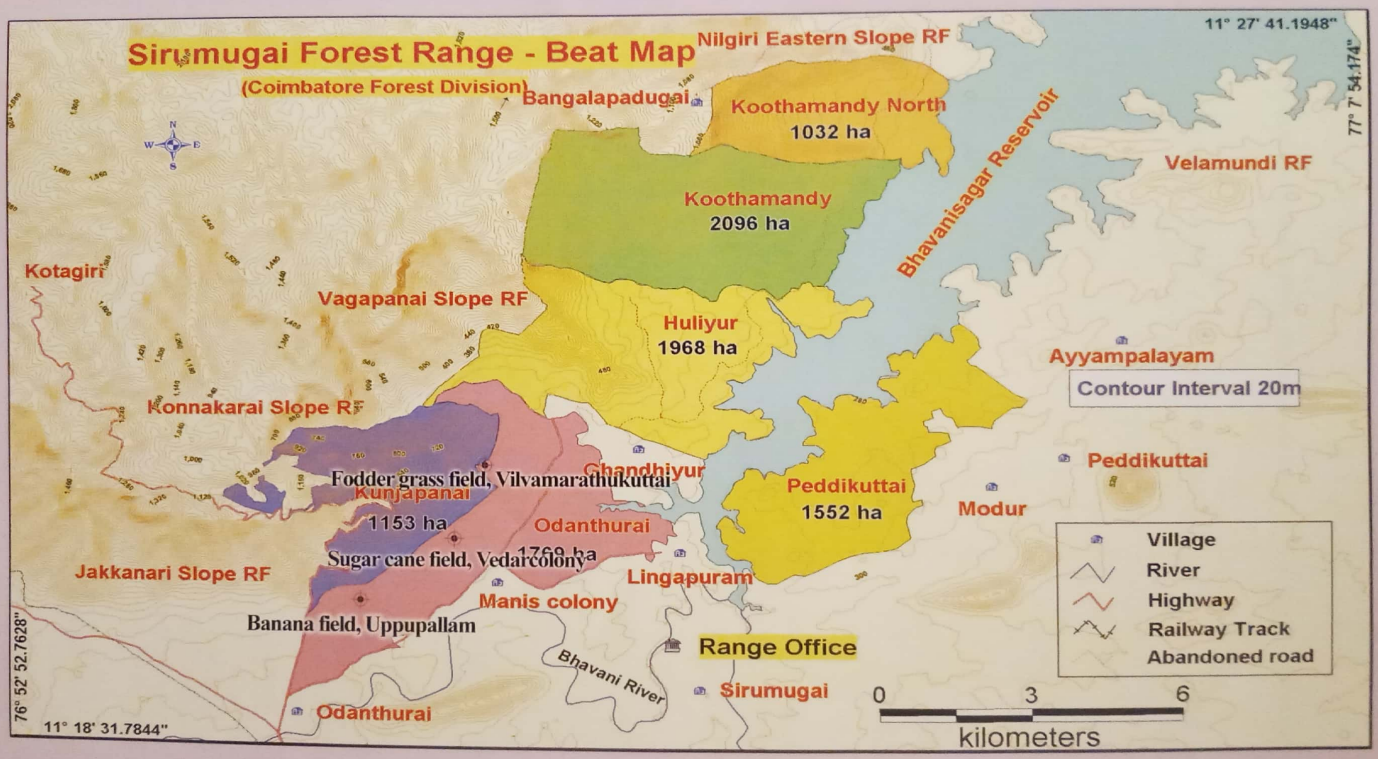


Table 2. Weather data recorded during the experimental period (September 2012 – April 2013)

Month/Year	Temperature (^{0}C)		Relative humidity (%)		Rainy days	Rainfall (mm)
	Min.	Max.	Min.	Max.		
Sep-12	21.9	33.9	52.0	86.5	1	34.6
Oct-12	21.5	32.9	63.0	86.4	11	367.6
Nov-12	19.4	32.1	58.7	83.7	1	17.5
Dec-12	17.5	32.0	55.0	83.5	1	16.9
Jan-13	16.1	33.3	42.7	81.5	NIL	NIL
Feb-13	19.4	34.0	48.6	81.1	1	90.2
Mar-13	20.2	36.0	45.9	72.0	1	57.0
Apr-13	24.0	38.4	47.0	71.8	3	61.0
(Source: Meteorological Observatory, FC&RI, Mettupalayam)						

3. Edaphic factors

The soil was found to be non-calcareous, red sandy loam (*Typic Ustropept*) and the chemical and biological properties of the soil are given in Table 3.

Table 3. Chemical and biological properties of the soil

S. No.	Particulars	Sugarcane	Banana	Fodder grass	Method adopted and reference
I. Chemical properties					
1	Soil pH	7.23	7.53	7.66	pH meter (Piper,1956)
2	Electrical conductivity (dSm^{-1})	0.16	0.26	0.14	Conductivity Bridge (Jackson,1973)
3	Available nitrogen (kg ha^{-1})	248.70	235.60	277.33	Alkaline permanganate method (Subbaiah and Asija, 1956)

4	Available phosphorus (kg ha^{-1})	13.16	13.80	11.47	Olsen's method (Jackson,1973)
5	Available potassium (kg ha^{-1})	287.70	326.90	321.00	Flame photometer (Jackson,1973)
II. Biological properties					
1	Bacterial population	54.3×10^{6}CFU's /g soil	72.3×10^{6} CFU's /g soil	38.3×10^{6} CFU's / g soil	Soil dilution and plate count method (Pramer and Schmidt,1964)
2	Fungal population	20.7×10^{5} CFU's / g soil	35.7×10^{5} CFU's /g soil	20.7×10^{5}CFU's /g soil	
3	Actinomycetes population	46.8×10^{3} CFU's / g soil	42.3×10^{3}CFU's /g soil	58.0×10^{3}CFU's /g soil	

II. EXPERIMENT DETAILS

The study was undertaken at wildlife prone agriculure field of Sirumugai range in Coimbatore district located in Tamil Nadu.

Table 4. Experimental design

Design	:	Randomized Block Design (RBD)
Treatment	:	8
No. of replication	:	Three
Period of the study	:	8 Months
Agricultural Crops	:	Sugarcane, Banana, and Fodder grass
Targeted Animals	:	Elephant, Deer, and Wild Boar
Area of the field	:	One hectare of each crop

Table 5. Treatment details

Sl.No.	Treatments
T_1	Spraying of Herboliv$^+$ – (1 litre in 10 litres of water – 10%)
T_2	Drenching of Herboliv$^+$ – (2 litres in 10 litres of water – 20%)
T_3	Soil application of Herboliv$^+$ – (5 litres in 10 litres of water – 50%)
T_4	Spraying + Drenching of Herboliv$^+$ – (10 % spraying + 20 % drenching)
T_5	Spraying + Soil Application of Herboliv$^+$ – (10 % spraying + 50 % soil application)
T_6	Drenching + Soil Application of Herboliv$^+$ – (20 % drenching + 50 % soil application)
T_7	Spraying + Drenching + Soil Application of Herboliv$^+$ – (10 % spray + 20 % drenching +50 % soil application)
T_8	Control

3. Method and Frequency of application

1. Spraying – 7 days interval (The portable power sprayer was used to spray Herboliv$^+$).
2. Drenching – 3 days interval (Gunny bags were used for drenching and placed at an interval of 3m).
3. Soil application – monthly interval (The soil application was done by mixing with irrigated water).

4. Recording of Observations

Method of observation

The study was conducted during September 2012 - April 2013 in the three fields (Sugarcane, Banana, and Fodder grass) and the level of wild animal intrusion and percentage of damage was observed. The data collection was done by using both direct and indirect evidence, wherein the direct evidence indicates the visual observation. The indirect evidence involves the observation of foot print, damage to crops and browsing of foliage.

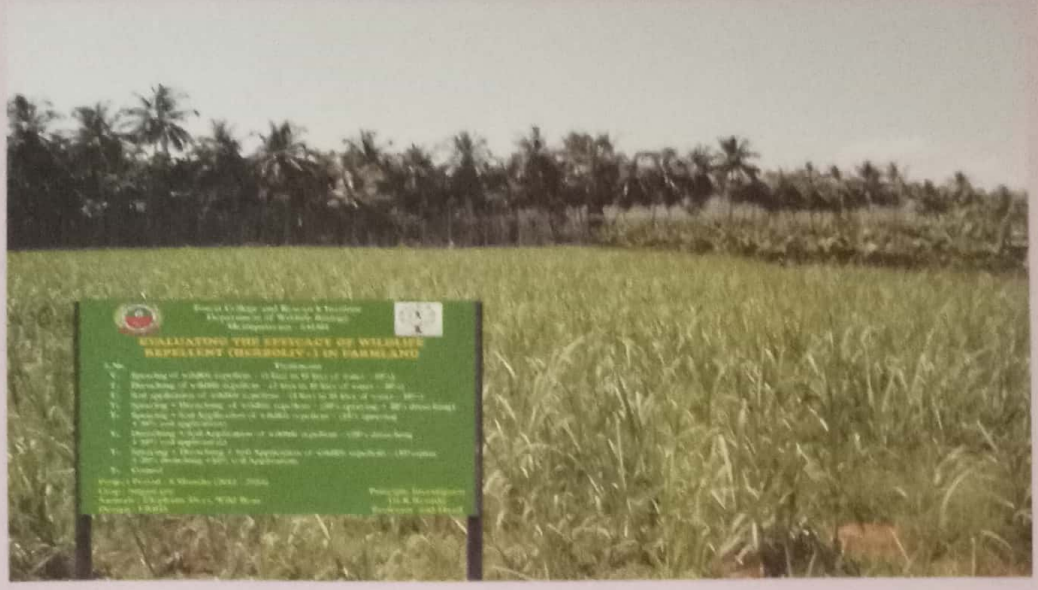
Plate 3. Materials used for the study

Herboliv+

Mixing of Herboliv+ with water

Power sprayer used for spraying Herboliv+

Plate 4. Overview of study trials



Sugarcane field at Vedarcolony

Banana field at Uppupallam

Fodder grass field at Vilvamarathukuttai

a. Crop raid by wild animals

The number of times the cultivated crops raided by the wild animals in Herboliv^{+} treated field were observed and recorded once in every 3 days.

b. Level of animal intrusion

The level of animal intrusion in Herboliv+ treated field were observed and recorded by measuring the length to which the animals has intruded.

$$\text{Level of animal Intrusion} = \frac{\text{Length to which animal has intruded in the field}}{\text{Total length of field}} \times 100$$

c. Quantification of crop damage

The percentage of crop damage in Herboliv+ treated field were observed and recorded by using the below formula in the different treatments.

$$\text{Percentage of crop damage} = \frac{\text{Area of crop damage}}{\text{Total area of field}} \times 100$$

d. Assessment of damage

The damage to the economic part of the crops, such as leaves, stems, roots, fruits by the wild animals and stage of the crop most vulnerable to damage in Herboliv^{+} treated field were observed and recorded for different treatments.

RESULTS OF THE EXPERIMENT

EFFECT OF HERBOLIV' ON THE INCIDENCE AND INTENSITY OF DAMAGE BY WILD ANIMALS

1. Level of wild animal incidence (Number of crop raid)

Wild animal incidence was assessed by observing the number of times the cultivated crops, viz; sugarcane, banana, fodder grass were raided by Elephant, Spotted deer and Wild boar.

Sugarcane field

Among the eight treatments, the total number of crop raid by Elephant, Spotted deer and Wild boar was 32, 99 and 71 respectively and it has occurred in all the months *viz.*, September, October, November, December, January, February, March and April (Table 6). The total number of crop raid by wild animal was minimum during the month of April which was 0, 4 and 5 times for Elephant, Spotted deer and Wild boar respectively. During the month of December, the damage to sugarcane by Elephant, Spotted deer and Wild boar was maximum and the total numbers of crop raid were 8, 17 and 15 respectively.

Banana field

The crop raid by the wild animals (Elephant, Spotted deer, and Wild boar) in the Herboliv' treated banana field is indicated in Table 7. The total number of crop raid by Elephant, Deer and Wild boar in the banana field was found to be 22,105 and 85 times, respectively during September 2012 to April 2013. Among the wild animals, the spotted deer raided the crop, maximum number of times followed by Wild boar and Elephant. The T_7 treatment (spraying + drenching + soil application) has shown the least number of crop raid by Elephant (once), spotted deer (five times) and wild boar (twice)

Fodder grass field

The crop raid by the wild animals (Elephant, Spotted deer, and Wild boar) in the Herboliv' treated fodder grass field is indicated in Table 8. The number of crop raid due to

Table 6. Number of crop raid by Elephant, Spotted deer and Wild boar in the Herboliv^{+} treated sugarcane field

Month	September			October			November			December			January			February			March			April			Total		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	2	1	1	-	2	-	1	1	1	1	1	1	1	1	1	-	1	1	-	1	-	-	-	-	5	8	5
T_2	-	2	1	1	3	1	1	3	1	1	3	2	-	2	2	1	1	1	-	1	1	-	1	1	4	16	10
T_3	-	1	1	1	1	1	-	1	1	1	2	2	1	1	1	-	2	1	-	1	1	-	-	-	3	9	8
T_4	-	2	-	-	1	-	1	1	1	1	1	1	-	1	1	-	1	-	-	-	1	-	-	1	2	7	5
T_5	-	1	1	1	2	2	-	2	1	-	2	2	-	1	2	-	1	2	-	1	-	-	-	-	1	10	10
T_6	1	3	1	-	2	1	1	3	1	1	2	1	1	2	1	1	1	1	-	1	1	-	1	1	5	15	8
T_7	-	1	-	-	1	1	1	1	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	1	5	2
T_8	1	5	2	2	4	3	2	4	3	3	5	5	1	4	3	1	3	2	1	2	3	-	2	2	11	29	23
Total	**4**	**16**	**7**	**5**	**16**	**9**	**7**	**16**	**9**	**8**	**17**	**15**	**4**	**13**	**11**	**3**	**10**	**8**	**1**	**7**	**7**	**0**	**4**	**5**	**32**	**99**	**71**

(Data has not been analysed statistically)

E - Elephant, **D** - Spotted deer, **W** - Wild boar, **(-)** No crop raid

Table 7. Number of crop raid by Elephant, Spotted deer, and Wild boar in the Herboliv* treated banana field

Month	September			October			November			December			January			February			March			April			Total		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	-	1	2	-	1	1	1	2	1	-	1	1	1	1	-	-	1	1	-	1	1	-	-	-	2	8	7
T_2	1	2	4	-	3	2	-	3	2	1	4	2	1	2	2	1	1	2	-	1	3	-	1	1	4	17	18
T_3	-	3	1	1	1	1	-	2	1	1	2	1	-	1	1	-	2	1	-	1	1	-	-	-	2	12	7
T_4	-	2	2	-	2	-	1	1	1	-	1	1	-	1	1	-	1	-	1	-	1	-	-	1	2	8	7
T_5	-	1	1	-	1	2	-	2	1	1	2	2	-	1	2	-	1	2	-	1	-	-	-	-	1	9	10
T_6	-	3	1	1	2	1	-	3	1	-	2	1	1	2	1	1	1	1	-	1	1	-	1	1	3	15	8
T_7	-	1	-	-	1	1	1	1	-	-	-	1	-	1	-	-	-	-	-	1	-	-	-	-	1	5	2
T_8	1	5	5	-	4	3	1	4	3	2	5	4	1	4	3	1	3	3	1	4	3	-	2	2	7	31	26
Total	**2**	**18**	**16**	**2**	**15**	**11**	**4**	**18**	**10**	**5**	**17**	**13**	**4**	**13**	**10**	**3**	**10**	**10**	**2**	**10**	**10**	**0**	**4**	**5**	**22**	**105**	**85**

(Data has not been analysed statistically)

E - Elephant, **D** - Spotted deer, **W** - Wild boar, **(-)** No crop raid

Table 8. Number of crop raid by Elephant, Spotted deer, and Wild boar in the Herboliv^{+} treated fodder grass field

Month	September			October			November			December			January			February			March			April			Total		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	1	5	1	2	3	3	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	10	6
T_2	3	9	4	3	6	5	2	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	19	13
T_3	1	3	2	1	2	1	2	1	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	6	5
T_4	2	5	2	1	1	1	-	3	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3	9	4
T_5	1	2	1	2	3	1	1	2	2	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	4	7	4
T_6	3	7	3	1	5	2	3	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	17	8
T_7	3	2	1	2	3	1	2	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	7	7	3
T_8	3	8	4	5	10	6	3	7	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	11	25	15
Total	**17**	**41**	**18**	**17**	**33**	**20**	**14**	**26**	**20**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**48**	**100**	**58**

(Data has not been analysed statistically)

E - Elephant, **D** - Spotted deer, **W** - Wild boar, **(-)** No crop raid

Elephant intrusion was found to be 17, 17 and 14 times during September, October and November.

Among all the 8 treatments the damage by the Spotted deer was 41, 33, 26, from September to November, respectively and the Wild boar damage to fodder grass was 18, 20 and 20 during the months of September, October and November respectively. The fodder grass was completely devastated due to Elephant, Spotted deer and Wild boar.

2. Level of wild animal intrusion

Sugarcane field

The level of Elephant, Spotted deer and Wild boar intrusion in the Herboliv^{+} treated sugarcane field is given in Table 9. From the table it is understood that the level of Elephant intrusion was found to be more in T_8 (control) with 66.4 per cent followed by T_2 (drenching) with 48.7 per cent, T_6 (drenching + soil application) with 46per cent and T_3 (soil application) with 43.3 per cent., whereas it was 20 per cent in T_7 (spraying + drenching + soil application). The level of Elephant intrusion was found to be maximum in December(305) followed by November(275).

The mean percentage of spotted deer intrusion was minimum in T_7 (spraying + drenching + soil application) with 23.0 percent and maximum in T_8 with 56.2 per cent. The level

Among the different months during the experimental trial the level of Wild Boar intrusion was found to be maximum in December followed by November and minimum in the month of April.

Banana field

The level of Elephant, Spotted deer and Wild boar intrusion in the Herboliv^{+} treated banana field is depicted in Table 10. From the table it is understood that the level of Elephant intrusion was found to be more in T_8 (control) and maximum during the month of January.

Similarly, the level of Spotted deer intrusion was found to be more in T_8 (control) with 61.2 per cent, and it was found to be maximum in the month of November followed by the

Table 9. Level of Elephant, Spotted deer, and Wild boar intrusion in the Herboliv[+] treated sugarcane field (%)

Month	September			October			November			December			January			February			March			April			Total			Mean		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	35	20	30	-	25	-	50	30	20	40	20	20	45	20	25	-	25	20	-	30	-	-	-	-	170	170	115	42.5	24.3	23
T_2	-	35	40	60	40	30	35	45	25	60	60	30	-	40	35	40	20	30	-	40	20	-	25	30	195	305	240	48.8	38.1	30
T_3	-	30	25	40	20	20	-	20	40	30	45	25	60	30	30	-	40	25	-	25	35	-	-	-	130	210	200	43.3	30.0	28.6
T_4	-	20	-	-	25	-	40	40	30	35	25	40	-	25	20	-	30	-	-	-	30	-	-	25	75	165	145	37.5	27.5	29
T_5	-	30	35	40	60	40	-	30	40	-	40	40	-	20	35	-	30	35	-	35	-	-	-	-	40	245	225	40	40.8	37.5
T_6	50	45	30	-	30	30	60	50	30	60	30	30	30	30	30	30	25	30	-	20	30	-	30	40	230	260	250	46	32.5	31.3
T_7	-	20	-	-	25	20	20	25	-	-	20	20	-	25	-	-	-	-	-	-	-	-	-	-	20	115	40	20	23.0	20
T_8	70	60	60	75	50	50	70	60	60	80	70	60	70	60	50	60	50	40	40	40	70	-	60	50	465	450	440	66.4	56.3	55
Total	**155**	**260**	**220**	**215**	**275**	**190**	**275**	**300**	**245**	**305**	**310**	**265**	**205**	**250**	**225**	**130**	**220**	**180**	**40**	**190**	**185**	**0**	**115**	**145**	**1325**	**1920**	**1655**	**344.5**	**272.5**	**254**

(Data has not been analysed statistically)

E - Elephant, **D -** Spotted deer, **W -** Wild boar, **(-)** No Intrusion

Table 10. Level of Elephant, Spotted deer, and Wild boar intrusion in the Herboliv' treated banana field (%)

Month	September			October			November			December			January			February			March			April			Total			Mean		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	-	25	30	-	40	25	40	30	30	-	40	40	45	25	-	-	45	20	-	30	30	-	-	-	85	235	175	43	33.6	29.2
T_2	40	60	40	-	65	40	-	65	65	60	60	50	75	60	45	50	50	40	-	60	60	-	45	40	225	465	380	###	58.1	47.5
T_3	-	40	25	30	20	30	-	45	40	40	45	30	-	35	30	-	40	45	-	25	35	-	-	-	70	250	235	35	35.7	33.6
T_4	-	30	35	-	45	-	30	40	30	-	35	40	-	25	40	-	35	-	40	-	30	-	-	35	70	210	210	35	35.0	35
T_5	-	25	25	-	30	40	-	50	40	30	40	35	-	40	35	-	30	35	-	45	-	-	-	-	30	260	210	30	37.1	35
T_6	-	45	30	50	60	30	-	60	30	-	30	30	60	50	30	30	45	40	-	30	40	-	40	50	140	360	280	###	45.0	35
T_7	-	20	-	-	25	25	40	45	-	-	-	20	-	25	-	-	-	-	-	40	-	-	-	-	40	155	45	40	31.0	22.5
T_8	60	70	60	-	50	50	70	80	70	75	70	80	70	60	50	60	50	60	50	60	70	-	50	50	385	490	490	###	61.3	61.3
Total	**100**	**315**	**245**	**80**	**335**	**##**	**180**	**415**	**305**	**205**	**320**	**325**	**##**	**320**	**##**	**140**	**295**	**##**	**90**	**290**	**265**	**0**	**135**	**175**	**###**	**2425**	**2025**	**350**	**336.8**	**299**

(Data has not been analysed statistically)

E - Elephant, **D** - Spotted deer, **W** - Wild boar, **(-)** No Intrusion

Plate 5. Wild animals in the study area

Asian elephant *(Elephas maximus)*

Chital *(Axis axis)*

Wild boar *(Sus scrofa)*

Plate 6. Spraying of Herboliv[+] in various experimental fields

Spraying in sugarcane field

Spraying in banana field

Spraying in fodder grass field

Plate 7. Drenching of Herboliv' in various experimental fields

Drenching in sugarcane field

Drenching in banana field

Drenching in fodder field

months of October and December. T_2 (drenching) registered the next highest level of Spotted deer intrusion with 58.1 per cent.

The level of Wild boar intrusion was found to be more in T_8 (control) with 61.2 per cent, and it was found to be maximum in the month of December. T_2 (drenching) and T_6 (drenching + soil application) has recorded the next highest level of intrusion by Wild boar. Among the different months during the experimental trial the level of Wild boar intrusion was found to be maximum in December followed by November and it was minimum in the month of April.

Fodder grass field

The level of Elephant, Spotted deer and Wild boar intrusion in the Herboliv$^+$ treated fodder grass field is indicated in Table 11. The table shows that the fodder grass was existing for a period of three months (September, October and November) only and by the end of November it was completely foraged by Wild Elephant, Wild deer and wild boar. The level of intrusion by Elephant, Spotted deer and Wild boar was found to be more in T_8 (control), followed by T_2 and T_6. The level of Elephant intrusion was 78.3% in T_8 (Control) and was found to be maximum in October followed by September and November.

The Spotted deer intrusion was found to be maximum(78.3%) in T_8 (control), followed by 75 % in T_6 ((20 % drenching + 50 % soil application).

The level of Wild boar intrusion was found to be maximum (75%) in T_2 (control), followed by T_8 (73.3% - control). Among the different months during the experimental trial the level of Wild Boar intrusion was found to be maximum in November followed by October.

3. Degree of crop damage

Sugarcane field

Crop damage by wild animals in Herboliv$^+$ treated field was expressed in percentage and depicted in Table 12. The table indicates that the crop damage due to Elephant, spotted deer and wild boar was maximum in T_8 (control). In contrast, the crop damage by Elephant was low (5 %) in T_7 (spraying + drenching + soil application) and T_5 (spraying + soil application). From the observations recorded during the different months the crop damage due

Table 11. Level of Elephant, Spotted deer, and Wild boar intrusion in the Herboliv® treated fodder grass field (%)

Month	September			October			November			December			January			February			March			April			Total			Mean		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	60	60	60	75	45	60	60	40	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	195	145	170	65	48.3	56.7
T_2	75	75	70	80	60	80	75	65	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	230	200	225	76.7	66.7	75.0
T_3	30	70	45	40	50	60	50	60	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120	180	165	40	60.0	55.0
T_4	50	60	60	50	35	50	-	70	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	100	165	180	50	55.0	60.0
T_5	40	50	75	40	60	70	75	60	60	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	155	170	205	51.7	56.7	68.3
T_6	60	75	60	70	70	60	60	80	50	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	190	225	170	63.3	75.0	56.7
T_7	45	40	40	35	50	50	40	45	70	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	120	135	160	40	45.0	53.3
T_8	75	80	75	90	75	70	70	80	75	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	235	235	220	78.3	78.3	73.3
Total	**435**	**510**	**485**	**480**	**445**	**500**	**430**	**500**	**510**	-	-	-	-"	-	-	-	-	-	-	-	-	-	-	-	**1345**	**1455**	**1495**	465	485.0	498.3

(Data has not been analyzed statistically)

E - Elephant, **D -** Spotted deer, **W -** Wild boar, **(-)** No Intrusion

Table 12. Degree of crop damage by Elephant, Spotted deer, and Wild boar in the Herboliv* treated sugarcane field (%)

Month	September			October			November			December			January			February			March			April			Total			Mean		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	6	1.5	2.5	-	2.5	-	8	1.5	1.5	5	1.5	2.5	5	2.5	1.5	-	1.5	0.5	-	1	-	-	-	-	24	12	8.5	6	1.7	1.7
T_2	-	4	1	5	1.5	2.5	8	5	1	12	5	3	-	3	2	8	1	1	-	2	0.5	-	1	1	33	22.5	12	8.3	2.8	1.5
T_3	-	2.5	1.5	4	1	1	-	1	2.5	6	3	1.5	8	1	2.5	-	3	1.5	-	2.5	1.5	-	-	-	18	14	12	6	2.0	1.7
T_4	-	0.5	-	-	1.5	-	5	2.5	1.5	5	2.5	1.5	-	1.5	0.5	-	1.5	-	-	-	1	-	-	0.5	10	10	5	5	1.7	1.0
T_5	-	1.5	0.5	5	2.5	0.5	-	1.5	0.5	-	1	0.5	-	1	1.5	-	0.5	0.5	-	3	-	-	-	-	5	11	4	5	1.6	0.7
T_6	6	3	1	-	1	1.5	8	3	2	6	2	2.5	5	2	2.5	5	1	2	-	1	1.5	-	0.5	1.5	30	13.5	14.5	6	1.7	1.8
T_7	-	0.5	-	-	0.5	0.5	5	0.5	-	-	0.5	0.5	-	0.5	-	-	-	-	-	-	-	-	-	-	5	2.5	1	5	0.5	0.5
T_8	10	12	5	15	8	8	12	12	8	10	15	10	15	8	5	10	5	3	10	5	5	-	8	3	82	73	47	11.7	9.1	5.9
Total	**22**	**26**	**12**	**29**	**19**	**14**	**46**	**27**	**17**	**44**	**31**	**22**	**33**	**20**	**16**	**23**	**14**	**8.5**	**10**	**15**	**9.5**	**0**	**9.5**	**6**	**207**	**158.5**	**104**	**53.0**	**21.1**	**14.8**

(Data has not been analysed statistically)

E - Elephant, **D** - Spotted deer, **W** - Wild boar, **(-)** No damage

Plate 8. Wild animal damages in the Herboliv' treated fields

Sugarcane field

Banana field

Fodder grass field

to Elephant intrusion was maximum in November (46 %) and least damage was observed in the month of March (10 %).

Similarly, the crop damage due to Spotted deer was high in T_8 (control) recording a value of 9.1 per cent followed by T_3 (50% - Soil application of Herboliv$^+$). The per cent crop damage due to Spotted deer was maximum in December (30.5 %) and least damage in the month of April (9.5 %).

The table shows that the crop damage due to Wild boar was maximum in T_8 (control) in the month of December and least in the month of February and April.

Banana field

The degree of crop damage by Elephant, Spotted deer and Wild boar in the Herboliv+ treated banana field is indicated in Table 13. From the table it can be predicted that the per cent crop damage was high in T_8 (control) and observed to be 16.6, 10.8, and 7.2 per cent due to elephant, spotted deer and wild boar, respectively. The per cent crop damage by wild elephant, spotted deer and wild boar was low in T_7 (spraying + drenching + soil application).

Fodder grass field

The degree of crop damage by Elephant, Spotted deer and Wild boar in the Herboliv+ treated fodder grass field is given in Table 14. The table indicates that the crop damage due to Elephant was maximum in T_8 (control) in the months of October followed by November.

The crop damage due to Spotted deer was maximum in T_8 (control) in the month of September and November.

The crop damage due to Wild boar was maximum in T_8 (9.1%) and minimum in T_3 (1.5%). The per cent crop damage due to Wild boar was maximum in the month of October and November (31 %) and minimum in September (27.5 %).

Table 13. Degree of crop damage by Elephant, Spotted deer, and Wild boar in the Herboliv^{+} treated banana field (%)

Month	September			October			November			December			January			February			March			April			Total			Mean		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	-	1.5	3	-	2.5	1.5	12	1.5	2.5	-	2.5	0.5	5	1.5	-	-	2.5	1.5	-	2.5	1.5	-	-	-	17	14.5	10.5	8.5	2.1	1.8
T_2	20	5	5	-	6	2.5	-	5	3	10	8	2.5	8	5	3	10	5	2.5	-	5	5	-	3	2.5	48	42	26	12	5.3	3.3
T_3	-	8	0.5	10	1	1.5	-	3	1.5	5	5	2	-	3	2.5	-	4	0.5	-	1	2	-	-	-	15	25	10.5	7.5	3.6	1.5
T_4	-	1.5	3	-	1.5	-	15	1	2.5	-	0.5	0.5	-	0.5	2.5	-	0.5	-	5	-	2.5	-	-	0.5	20	5.5	11.5	10	0.9	1.9
T_5	-	0.5	0.5	-	3	0.5	-	0.5	0.5	8	3	0.5	-	2	0.5	-	2.5	1.5	-	3	-	-	-	-	8	14.5	4	8	2.1	0.7
T_6	-	3	2	15	1	2.5	-	8	2	-	5	2.5	5	4	1.5	5	3	2	-	2.5	1.5	-	2.5	3	25	29	17	8.3	3.6	2.1
T_7	-	0.5	-	-	0.5	0.5	5	0.5	-	-	-	0.5	-	0.5	-	-	-	-	-	0.5	-	-	-	-	5	2.5	1	5	0.5	0.5
T_8	30	15	8	-	10	6	20	15	8	15	15	10	15	10	7	10	8	8	10	8	6	-	6	5	100	87	58	16.7	10.9	7.3
Total	**50**	**35**	**22**	**25**	**26**	**15**	**52**	**35**	**20**	**38**	**39**	**19**	**33**	**27**	**17**	**25**	**26**	**16**	**15**	**23**	**19**	**0**	**12**	**11**	**238**	**220**	**138.5**	**76**	**28.9**	**19.0**

(Data has not been analysed statistically)

E - Elephant, **D -** Spotted deer, **W -** Wild boar, **(-)** No damage

Table 14. Degree of crop damage by Elephant, Spotted deer and Wild boar in the Herboliv^{+} treated fodder grass field (%)

Month	September			October			November			December			January			February			March			April			Total			Mean		
	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W	E	D	W
T_1	10	5	2.5	10	3	5	5	2.5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	10.5	10	8.3	3.5	3.3
T_2	25	12	5	30	7.5	7.5	8	5	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	63	24.5	17.5	21.0	8.2	5.8
T_3	20	7.5	1.5	15	4	0.5	10	3	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	45	14.5	4.5	15.0	4.8	1.5
T_4	10	2.5	2.5	5	2.5	2	-	5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	15	10	7.5	7.5	3.3	2.5
T_5	10	3.5	3	10	3	2.5	5	2.5	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	25	9	8	8.3	3.0	2.7
T_6	15	10	5	15	10	3	20	8	5	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	50	28	13	16.7	9.3	4.3
T_7	15	2.5	0.5	12	0.5	0.5	15	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	42	5	1.5	14.0	1.7	0.5
T_8	30	15	7.5	40	12	10	35	15	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	105	42	27.5	35.0	14.0	9.2
Total	**135**	**58**	**27.5**	**137**	**43**	**31**	**98**	**43**	**31**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**370**	**144**	**89.5**	**126**	**47.8**	**29.8**

(Data has not been analysed statistically)

E - Elephant, **D** - Spotted deer, **W** - Wild boar, **(-)** No damage

IMPACT OF HERBOLIV^{+} ON THE CROP AND SOIL

1. Impact of Herboliv^{+} on crop growth and yield of agriculture crops

Sugarcane field

The effect of Herboliv^{+} on crop growth of sugarcane indicated an appreciable difference between the various treatments (Table 15). Significant differences were observed in plant height due to the application of Herboliv^{+}. Among the treatments T_7 treatment (spraying + drenching + soil application) increased the crop height in sugarcane registering a value of 2.04 m followed by T_5 (spraying + soil application) and T_6 (drenching + soil application) recording an average height of 1.98 m and 1.86 m respectively when compared to T_8 control which has registered a value of 1.42 m. The sugarcane growth was found to vary significantly due to the different treatments.

Similarly, the yield of sugarcane was found to be influenced due to Herboliv+ application among the different treatments. T_7 (spraying + drenching + soil application) increased the crop yield in sugarcane registering a value of 107 t ha^{-1} followed by T_5 (spraying + soil application) and T_6 (drenching + soil application) treatment registering a value of 104 t ha^{-1} and 98 t ha^{-1}, respectively, when compared to T_8 (control) recording a value of 85 t ha^{-1}. The sugarcane yield was found to vary significantly due to the different treatments and significant variation could be observed among the treatments.

Banana field

Significant differences were observed in plant height, due to different treatments which is depicted in Table 16. Among the treatments, T_7 (spraying + drenching + soil application) recorded a maximum height of 2.8 m which was highly significant followed by T_5 (spraying + soil application) recording a value of 2.6 m and T_6 (drenching + soil application) registering a plant height of 2.4 m when compared to control (1.7 m).

While considering the yield of banana T_7 treatment (spraying + drenching + soil application) recorded the highest yield registering a value of 8.2 kg tree^{-1} when compared to all other treatments which was significantly superior. T_5 (spraying + soil application) and T_6 (drenching + soil application) treatments registered a bunch yield of 7.6 kg tree^{-1} and 6.8 kg tree^{-1} respectively when compared to T_8 (control) which recorded the least yield of 5.4 kg tree^{-}

Table 15. Plant height and yield of sugarcane in the Herboliv^{+} treated field

S.No.	Treatments	Average plant height (m)	Yield (tones/hectare)
1	T_1 - Spraying (10 %)	1.76	93
2	T_2 - Drenching (20 %)	1.64	88
3	T_3 - Soil application (50 %)	1.83	92
4	T_4 - Spraying + Drenching (10 % + 20 %)	1.72	95
5	T_5 - Spraying + Soil Application (10 % + 50 %)	1.98	104
6	T_6 - Drenching + Soil Application (20 % + 50 %)	1.86	98
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	2.04	107
8	T_8 – Control	1.42	85
	SEd	0.01	5.4
	CD (.05)	0.02	11.58

Table 16. Plant height and yield of banana in the Herboliv* treated filed

S.No.	Treatments	Average plant height (m)	Bunch yield(Kg/tree)
1	T_1 - Spraying (10 %)	2.1	6.5
2	T_2 - Drenching (20 %)	1.9	6.2
3	T_3 - Soil application (50 %)	2.2	6.6
4	T_4 - Spraying + Drenching (10 % + 20 %)	2.3	6.3
5	T_5 - Spraying + Soil Application (10 % + 50 %)	2.6	7.6
6	T_6 - Drenching + Soil Application (20 % + 50 %)	2.4	6.8
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	2.8	8.2
8	T_8 – Control	1.7	5.4
	SEd	0.06	0.07
	CD (.05)	0.13	

Table 17. Yield of fodder grass in the Herboliv^{+} treated filed

S.No.	Treatments	Yield per (Kg/1m^2)	Yield (tones/hectare)
1	T_1 - Spraying (10 %)	0	0
2	T_2 - Drenching (20 %)	0	0
3	T_3 - Soil application (50 %)	0	0
4	T_4 - Spraying + Drenching (10 % + 20 %)	0	0
5	T_5 - Spraying + Soil Application (10 % + 50 %)	0	0
6	T_6 - Drenching + Soil Application (20 % + 50 %)	0	0
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	0	0
8	T_8 – Control	0	0

Plate 9. Performance of agriculture crop during application of Herboliv

8 months old sugarcane

10 months old banana

3 months old fodder grass

1. The banana yield was found to be influenced due to Herboliv^{+} application in combination and significant difference could be observed among the different treatments.

Fodder grass field

The influence of Herboliv^{+} on crop yield could not be estimated as the crop was completely foraged and damaged by the Wild Animals.

2. Impact of Herboliv+ on soil nutrients

The soil from the experimental site (sugarcane, banana, and fodder grass) was collected and was analyzed for their chemical properties (Table 3).

A. Physico-chemical properties of soil analysis (prior application)

Soil pH

The soil pH was found to be neutral and the value recorded were 7.23 in sugarcane field, 7.53 in banana field and 7.66 in fodder grass field, respectively.

Electrical conductivity (EC)

Electrical conductivity was found to be 0.26 dSm^{1} in banana field, 0.16 dSm^{-1} in sugarcane field and 0.14 dSm^{-1} in fodder grass field.

Available nitrogen

The initial analysis of soil revealed that the available nitrogen was found to be low in the fodder grass field (277.33 $kgha^{-1}$), low in banana field (235.60 kg ha^{-1}) and it was medium in sugarcane field (248.70 kg ha^{-1}).

Available phosphorus

The soil analysed for available phosphorus revealed to be high in banana field (13.80 kg ha^{-1}), low in fodder grass field (11.47 kg ha^{-1}) and medium in sugarcane field(13.16 kg ha^{-1}).

Available potassium

The available potassium from the soil analysis revealed to be high in the all three (sugarcane, banana and fodder grass) experimental sites. i.e. 287.70 kg ha^{-1} in sugarcane field, 326.90 kg ha^{-1} banana field and 321.00 kg ha^{-1} in fodder grass field.

B. Impact of Herboliv^{+} on the soil of sugarcane field

Soil pH

Herboliv+ did not influence much in the pH among different treatment as only less variation could be observed as depicted in Table. 18

Electrical conductivity (EC)

From the Table 18 it could be understood that there was no significant variation among the different treatments and Herboliv^{+} was not influential in bringing much changes in EC. Electrical conductivity ranged from 0.16 dSm^{-1} to 0.17 dSm^{-1}

Available nitrogen

The available nitrogen in the soil of sugarcane field indicated that there was no appreciable change between the various treatments (Table 18). However, T_7 treatment (spraying + drenching + soil application) registered the maximum available nitrogen value of 251.83 kg ha^{-1} when compared to T_8 (248.7 kg ha^{-1}) whereas T_5 (spraying + soil application) treatment registered a value of 249.38 kg ha^{-1}.

Available phosphorus

The soil available phosphorus was not significantly influenced by the treatments (Table 18). The highest value of available phosphorus was observed in T_7 treatment (spraying + drenching + soil application) with the value of 14.40 kg ha^{-1}, whereas the lowest available phosphorus was recorded in T_8 control (13.16 kg ha^{-1}).

Available potassium

The statistical analysis for available potassium in soil revealed that the different treatment has no significant effect due to the Herboliv^{+} (Table 18). From the table it was found that combination of the treatment (spraying + drenching + soil application) registered the

Table 18. Impact of Herboliv[+] on chemical properties of soil in sugarcane field

S.No.	Treatments	pH	EC(dSm-1)	Available nutrients (kg ha^{-1})		
				N	P	K
1	T_1 - Spraying (10 %)	7.24	0.16	248.87	13.93	289.2
2	T_2 - Drenching (20 %)	7.25	0.16	249.13	13.69	289.1
3	T_3 - Soil application (50 %)	7.22	0.17	248.85	13.71	288.63
4	T_4 - Spraying + Drenching (10 % + 20 %)	7.25	0.16	249	13.8	288.77
5	T_5 - Spraying + Soil Application (10 % + 50 %)	7.24	0.17	249.38	13.67	290.33
6	T_6 - Drenching + Soil Application (20 % + 50 %)	7.24	0.16	249.13	13.86	289.53
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	7.25	0.17	251.83	14.4	291.93
8	T_8 – Control	7.23	0.16	248.7	13.16	287.7
	SEd	0.03	0.011	6.027	0.391	4.076
	CD (.05)	NS	NS	NS	NS	NS

maximum available potassium value of 291.93 kg ha^{-1} and the lowest value was observed in T_8 (287.70 kg ha^{-1}).

C. Impact of Herboliv$^+$ on the soil of banana field

Soil pH

The statistical analysis of soil pH in the banana field has not showed significant variation among the different treatments (Table 19). The soil pH varied from 7.53 to 7.56 in Herboliv$^+$ treated banana field.

Electrical conductivity (EC)

The electrical conductivity varied from 0.24 to 0.27 dSm^{-1} in Herboliv$^+$ treated banana field (Table 19) which shows slight variations among the different treatments.

Available nitrogen

The available nitrogen in the soil of banana field indicated that there was no appreciable change among the various treatments (Table 19). From the table it is understood that T_7 treatment (spraying + drenching + soil application) recorded the maximum soil available nitrogen value of 240.93 kg ha^{-1} when compared to T_8 (235.60 kg ha^{-1}).

Available phosphorus

The available phosphorus in the soil was not significantly influenced by the treatments as revealed by statistical analysis that is indicated in Table 19. From the table it could be observed that T_7 treatment (spraying + drenching + soil application) was found to enhance the soil available phosphorus to a value of 14.97 kg ha^{-1} which was followed by T_6 (drenching + soil application) with soil available phosphorus of 14.93 kg ha^{-1} and T_3 (soil application) with a value of 14.83 kg ha^{-1}.

Available potassium

The statistical analysis for available potassium in the soil revealed that the different treatments have no significant influence due to the Herboliv$^+$ application as indicated in banana field (Table 19). However, it was found that T_7 treatment (spraying + drenching + soil

Table 19. Impact of Herboliv^{+} on chemical properties of soil in banana field

S.No.	Treatments	pH	EC (dSm^{-1})	Available nutrients ($kg\ ha^{-1}$)		
				N	P	K
1	T_1 - Spraying (10 %)	7.53	0.26	239.2	14.14	327.2
2	T_2 - Drenching (20 %)	7.53	0.24	237.1	14.19	327.5
3	T_3 - Soil application (50 %)	7.55	0.27	238.63	14.83	327.93
4	T_4 - Spraying + Drenching (10 % + 20 %)	7.54	0.25	236.77	14.6	327.63
5	T_5 - Spraying + Soil Application (10 % + 50 %)	7.56	0.27	239.53	14.57	328.4
6	T_6 - Drenching + Soil Application (20 % + 50 %)	7.55	0.26	236.57	14.93	326.93
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	7.55	0.27	240.93	14.97	329.5
8	T_8 – Control	7.53	0.26	235.6	13.8	326.9
	SEd	0.0172	0.013	6.599	0.526	3.966
	CD (.05)	NS	NS	NS	NS	NS

application) registered a maximum value of 329.50 kg ha^{-1} followed by T_5 (328.40 kg ha^{-1}) and T_3 (327.93 kg ha^{-1}). The least potassium value was recorded in T_8 (control) with a registered value of 326.90 kg ha^{-1}.

D. Impact of Herboliv$^+$ on the soil of fodder grass field

Soil pH

The soil pH value was not significantly influenced by the treatments. The Herboliv$^+$ did not influence the soil pH among different treatment as only less variation could be observed as depicted in Table 20 *viz.*, in T_1 (7.65), T_2 (7.63), T_3 (7.66), T_4 (7.64), T_5 (7.68), T_6 (7.66), T_7 (7.66) and T_8 (7.66).

Electrical conductivity (EC)

Herboliv$^+$ has not significantly enhanced the soil electrical conductivity and it differed with various treatments. The soil electrical conductivity differed with treatments of Herboliv$^+$ registering values of 0.14 dSm^{-1} in T_1, 0.13 dSm^{-1} in T_2, 0.14 dSm^{-1} in T_3, 0.13 dSm^{-1} in T_4, 0.14 dSm^{-1} in T_5, 0.13 dSm^{-1} in T_6, 0.14 dSm^{-1} in T_7 and 0.14 dSm^{-1} in T_8 (Table 20).

Available nitrogen

The statistical analysis for available nitrogen in the soil revealed that the different treatments have no significant influence due to the Herboliv$^+$ application as indicated in Table 20. T_7 treatment (spraying + drenching + soil application) registering the highest soil available nitrogen value of 282.69 kg ha^{-1} when compared to T_8 (277.33 kg ha^{-1}) followed by T_5 (spraying + soil application) and T_4 (spraying + drenching) treatment recording values of 281.06 kg ha^{-1} and 280.47 kg ha^{-1} respectively.

Available phosphorus

The soil available phosphorus was not significantly influenced by different treatments (Table 20). From the table it could be observed that T_7 treatment (spraying + drenching + soil application) was found to enhance the soil available phosphorus by 13.87 kg ha^{-1} when compared to T_8 (control) which recorded the least value of 11.47 kg ha^{-1} followed by T_5

Table 20. Impact of Herboliv[+] on chemical properties of soil in fodder grass field

Sl.No.	Treatments	pH	EC (dSm^{-1})	Available Nutrients ($kg\ ha^{-1}$)		
				N	P	K
1	T_1 - Spraying (10 %)	7.65	0.14	279.7	11.9	323.93
2	T_2 - Drenching (20 %)	7.63	0.13	279.3	11.53	323.43
3	T_3 - Soil application (50 %)	7.66	0.14	278.77	12.87	324.87
4	T_4 - Spraying + Drenching (10 % + 20 %)	7.64	0.13	280.47	12.4	323.99
5	T_5 - Spraying + Soil Application (10 % + 50 %)	7.68	0.14	281.06	13.17	323.67
6	T_6 - Drenching + Soil Application (20 % + 50 %)	7.66	0.13	280.13	12.47	324.4
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	7.66	0.14	282.69	13.87	325.73
8	T_8 – Control	7.66	0.14	277.33	11.47	321
	SEd	0.029	0.019	8.283	0.79	2.398
	CD (.05)	NS	NS	NS	NS	NS

(spraying + soil application) and T_3 (soil application) which registered a value of 13.17 kg ha^{-1} and 12.87 kg ha^{-1} respectively.

Available potassium

The statistical analysis for available potassium in the soil revealed that the different treatment had no significant influence on available potassium (Table 20). From the table it was found that T_7 treatment (spraying + drenching + soil application) recorded the highest value of 325.73 kg ha^{-1} of available soil potassium followed by T_3 (soil application) treatment and T_6 (drenching + soil application) which registered value of 324.87 kg ha^{-1} and 324.40 kg ha^{-1} respectively. T_8 (control) registered the least value of 321.00 kg ha^{-1} and it was varying among the other treatment values.

E. Impact of Herboliv$^+$ application on soil microbial population

1. Soil Microflora Estimation (prior application)

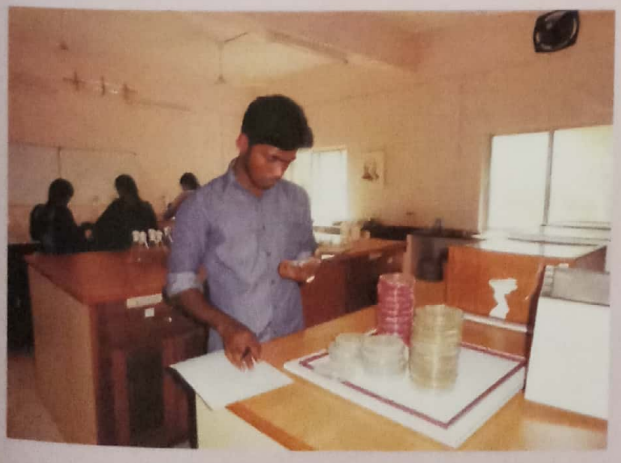
Soil from the experimental site (sugarcane, banana, fodder grass) was collected and analyzed for the soil biological properties viz., Quantification of population of soil microbes such as bacteria, fungi and actinomycetes which are depicted in Table 3. The microbial population status in the soil of sugarcane field was 54.3×10^6 CFU's $gram^{-1}$ of soil for bacteria, 20.7×10^5 CFU's $gram^{-1}$ of soil for fungi and 46.8×10^3 CFU's $gram^{-1}$ of soil for actinomycetes. In banana field the soil microbial status was 72.3×10^6 CFU's $gram^{-1}$ of soil for bacteria, 35.7×10^5 CFU's $gram^{-1}$ of soil for fungi and 42.3×10^3 $gram^{-1}$ of soil for actinomycetes. The soil microbial population in fodder grass field was 38.3×10^6 CFU's $gram^{-1}$ of soil for bacteria, 20.7×10^5 CFU's $gram^{-1}$ of soil for fungi and 58.0×10^3 CFU's $gram^{-1}$ of soil for actinomycetes.

2. Impact of Herboliv$^+$ on soil microbial population in sugarcane field

Bacterial population

The effect of Herboliv$^+$ on bacterial population of sugarcane soil has shown an appreciable change among the various treatments which is depicted in Table 21. Among the different treatment T_7 (spraying + drenching + soil application) has recorded the maximum bacterial population in the soil registering a value of 360.7×10^6 CFU's $gram^{-1}$ of soil, followed by T_5 (spraying + soil application) treatment (301.3×10^6 CFU's $gram^{-1}$ of soil) and T_6

Plate 10. Processing of microbial population study



(drenching + soil application) treatment (285.3 × 10^6 CFU's $gram^{-1}$ of soil) when compared to T_8 (control) which has registered a value of 62.0 × 10^6 CFU's $gram^{-1}$ of soil.

Fungal population

The effect of Herboliv$^+$ on fungal population of sugarcane soil has indicated an appreciable change between the different treatments as shown in Table 21. From the table it is understood that T_7 treatment (spraying + drenching + soil application) has recorded the maximum fungal population in the soil registering a value of 56.0 × 10^5 CFU's $gram^{-1}$ of soil, followed by T_5 (spraying + soil application) treatment recording the value of 42.0 × 10^5 CFU's $gram^{-1}$ of soil and T_6 (drenching + soil application) treatment registering a value of 35.3 × 10^5 CFU's $gram^{-1}$ of soil when compared to T_8 (control) with a least value of 23.7 × 10^5 CFU's $gram^{-1}$ of soil. Highly significant variation could be observed in the fungal population among the various treatments.

Actinomycetes population

The impact of Herboliv$^+$ on actinomycetes population of sugarcane soil indicated highly significant and appreciable changes between the various treatments as indicated in Table 21. From the table it can be understood that T_7 treatment (spraying + drenching + soil application) has recorded the maximum actinomycetes population in the soil registering the value of 210.0 × 10^3 CFU's $gram^{-1}$ of soil, followed by T_5 (spraying + soil application) treatment recording a values of 189.0 × 10^3 CFU's $gram^{-1}$ of soil and T_6 (drenching + soil application) treatment registering a value of 153.0 × 10^3 CFU's $gram^{-1}$ of soil, when compared to T_8 (control) which recorded the least value of 57.7 × 10^3 CFU's $gram^{-1}$ of soil. The actinomycetes population was found to possess highly significant variation among the various treatments.

3. Impact of Herboliv$^+$ on soil microbial population in banana field

Bacterial population

The effect of Herboliv$^+$ on bacterial population of banana soil has shown appreciable changes between the various treatments as indicated in Table 22. It was observed that T_7 treatment (spraying + drenching + soil application) had the highest bacterial population in the soil registering a value of 301.7 × 10^6 CFU's $gram^{-1}$ of soil when compared to the T_8 (control) with a population of 85.0 × 10^6 CFU's $gram^{-1}$ of soil. The bacterial population recorded due to T_5 (spraying + soil application) treatment was 264.7 × 10^6 CFU's $gram^{-1}$ of soil and due to T_6

Table 21. Impact of Herboliv[+] on the soil microbial population in sugarcane field (Cfu's/gram of soil)

Sl.No	Treatments	Bacteria ($x10^6$)	Fungi ($x10^5$)	Actinomycetes ($x10^3$)
1	T_1 - Spraying (10 %)	96.3	26.3	95.3
2	T_2 - Drenching (20 %)	82.7	23.7	71.3
3	T_3 - Soil application (50 %)	268.3	34.3	149.3
4	T_4 - Spraying + Drenching (10 % + 20 %)	127.3	26.7	145.3
5	T_5 - Spraying + Soil Application (10 % + 50 %)	301.3	42	189
6	T_6 - Drenching + Soil Application (20 % + 50 %)	285.3	35.3	153
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	360.7	56	210
8	T_8 – Control	62	23.7	57.7
	SEd	2.07	0.91	1.56
	CD (.05)	4.45	1.97	3.36

Table 22. Impact of Herboliv[+] on the soil microbial population in banana field (Cfu's/gram of soil)

Sl.No.	Treatments	Bacteria ($x10^6$)	Fungi ($x10^5$)	Actinomycetes ($x10^3$)
1	T_1 - Spraying (10 %)	114.7	63.3	92.3
2	T_2 - Drenching (20 %)	96.3	48.7	65.3
3	T_3 - Soil application (50 %)	128.7	69	117.3
4	T_4 - Spraying + Drenching (10 % + 20 %)	123.7	60	101.3
5	T_5 - Spraying + Soil Application (10 % + 50 %)	264.7	97.3	188.7
6	T_6 - Drenching + Soil Application (20 % + 50 %)	195.7	74	127.7
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	301.7	124.7	222
8	T_8 – Control	85	41	47.3
	SEd	2.69	2.54	2.34
	CD (.05)	5.79	5.45	5.03

(drenching + soil application) was 195.7 × 10^6 CFU's $gram^{-1}$ of soil. The bacterial population was found to vary significantly and the different treatment due to the Herboliv$^+$ had a significant influence in banana field.

Fungal population

The soil fungal population when subjected to statistical analysis showed significant variation among the different treatments as indicated in Table 22. Among the treatments T_7 treatment (spraying + drenching + soil application) recorded the highest fungal population in the soil registering a value of 124.7 × 10^5 CFU's $gram^{-1}$ of soil when compared to the T_8 (control) with a least value of 41.0 × 10^5 CFU's $gram^{-1}$ of soil. T_5 (spraying + soil application) treatment recorded a value of 97.3 × 10^5 CFU's $gram^{-1}$ of soil and T_6 (drenching + soil application) recorded a significant lower value of 74.0 × 10^5 CFU's $gram^{-1}$ of soil when compared to the combination of treatments.

Actinomycetes population

The effect of Herboliv$^+$ on Actinomycetes population of banana soil indicated an appreciable change among the various treatments (Table 22). T_7 treatment (spraying + drenching + soil application) registered a highest population of 222.0 × 10^3 CFU's $gram^{-1}$ of soil, followed by T_5 (spraying + soil application) treatment with a value of 188.7 × 10^3 CFU's $gram^{-1}$ of soil. A comparatively lesser population was recorded in T_6 (drenching + soil application) treatment (127.7 × 10^3 CFU's $gram^{-1}$ of soil) when compared to T_7. The other treatments registered values of 92.3 × 10^3 CFU's $gram^{-1}$ of soil in T_1, 65.3 × 10^3 CFU's $gram^{-1}$ of soil in T_2, 117.3 × 10^3 CFU's $gram^{-1}$ of soil in T_3 and 101.3 × 10^3 CFU's $gram^{-1}$ of soil in T_4 when compared to the combination of treatments (T_7).

4. Impact of Herboliv$^+$ on soil microbial population in fodder grass field

Bacterial population

The bacterial population status in fodder field when subjected to statistical analysis showed highly significant variation among the different treatments (Table 23). T_7 treatment (spraying + drenching + soil application) registered highest bacterial population in the soil with a value of 217.0 × 10^6 CFU's $gram^{-1}$ of soil when compared to T_8 control (47.0 × 10^6 $gram^{-1}$ of soil) whereas T_5 (spraying + soil application) treatment recorded a value of 166.0 × 10^6 CFU's

Table 23. Impact of Herboliv^{+} on the soil microbial population in fodder grass field (Cfu's/gram of soil)

Sl.No.	Treatments	Bacteria ($x10^6$)	Fungi ($x10^5$)	Actinomycetes ($x10^3$)
1	T_1 - Spraying (10 %)	88	24	67.3
2	T_2 - Drenching (20 %)	49	21.7	53.3
3	T_3 - Soil application (50 %)	114.3	26.3	86
4	T_4 - Spraying + Drenching (10 % + 20 %)	90	24.7	77.3
5	T_5 - Spraying + Soil Application (10 % + 50 %)	166	35.3	130.7
6	T_6 - Drenching + Soil Application (20 % + 50 %)	125.3	28.7	104.7
7	T_7 - Spraying + Drenching + Soil Application (10 % + 20 % + 50 %)	217	42.7	184
8	T_8 - Control	47	22.3	64
	SEd	1.8	1.93	1.54
	CD (.05)	3.86	4.14	3.31

gram^{-1} of soil and T_6 (drenching + soil application) registered a population status of 125.3 × 10^6 CFU's gram^{-1} of soil. The bacterial population in the remaining treatments registered values of 88.0 × 10^6 CFU's gram^{-1} of soil in T_1, 49.0 × 10^6 CFU's gram^{-1} of soil in T_2, 114.3 × 10^6 CFU's gram^{-1} of soil in T_3 and 90 × 10^6 CFU's gram^{-1} of soil in T_4 which were comparatively lesser than to T_7.

Fungal population

The effect of Herboliv$^+$ on fungal population in fodder grass field indicated an appreciable change among the various treatments which is given in Table 23. Among the different treatments T_7 (spraying + drenching + soil application) recorded the highest fungal population with a value of 42.7 × 10^5 CFU's gram^{-1} of soil followed by T_5 (spraying + soil application) treatment with a value of 35.3 × 10^5 CFU's gram^{-1} of soil and T_6 (drenching + soil application) recorded a value of 28.7 × 10^5 CFU's gram^{-1} soil. The fungal population status of T_8 was comparatively lesser when compared to other treatments *viz.*, T_1 (24.0 × 10^5 CFU's gram^{-1} soil), T_2 (21.7 × 10^5 CFU's gram^{-1} soil), T_3 (26.3 × 10^5 CFU's gram^{-1} of soil) and T_4 (24.7 × 10^5 CFU's gram^{-1} soil).

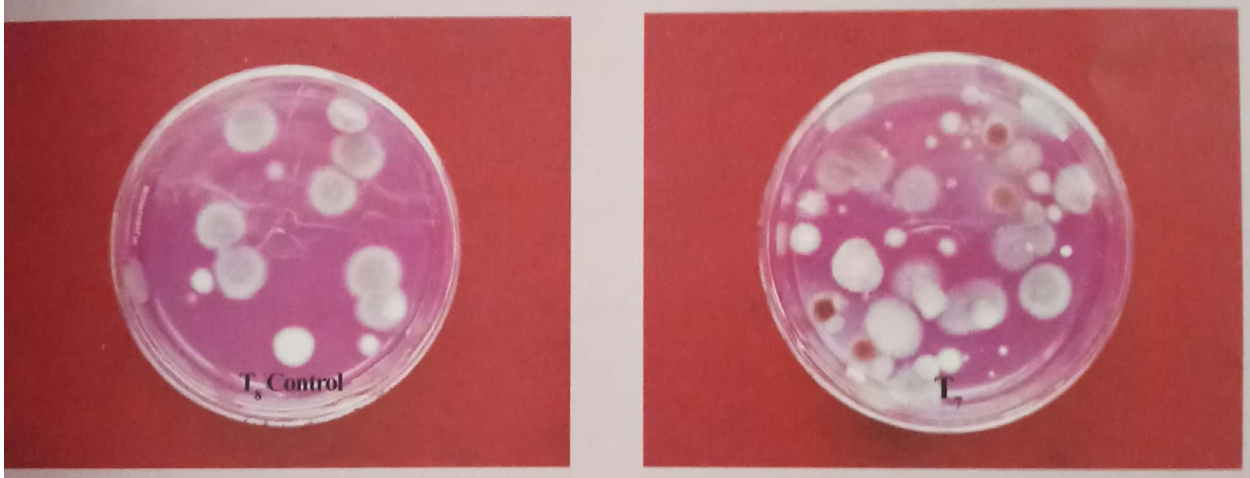
Actinomycetes population

The impact of Herboliv$^+$ on soil microbial population with respect to actinomycetes of fodder grass soil indicated an appreciable and significant change between the various treatments (Table 23). Among the various treatments T_7 (spraying + drenching + soil application) recorded the highest actinomycetes population registering a value of 184.0 × 10^3 CFU's gram^{-1} of soil when compared to the untreated control T_8 (64.0 × 10^3 CFU's gram^{-1} of soil). From the table it is understood that T_5 (spraying + soil application) treatment recorded a value of 130.7 × 10^3 CFU's gram^{-1} of soil and T_6 (drenching + soil application) treatment registered a population value of 104.7 × 10^3 CFU's gram^{-1} of soil. The statistical analysis on population status of actinomycetes revealed that there was a highly significant difference among the various treatments.

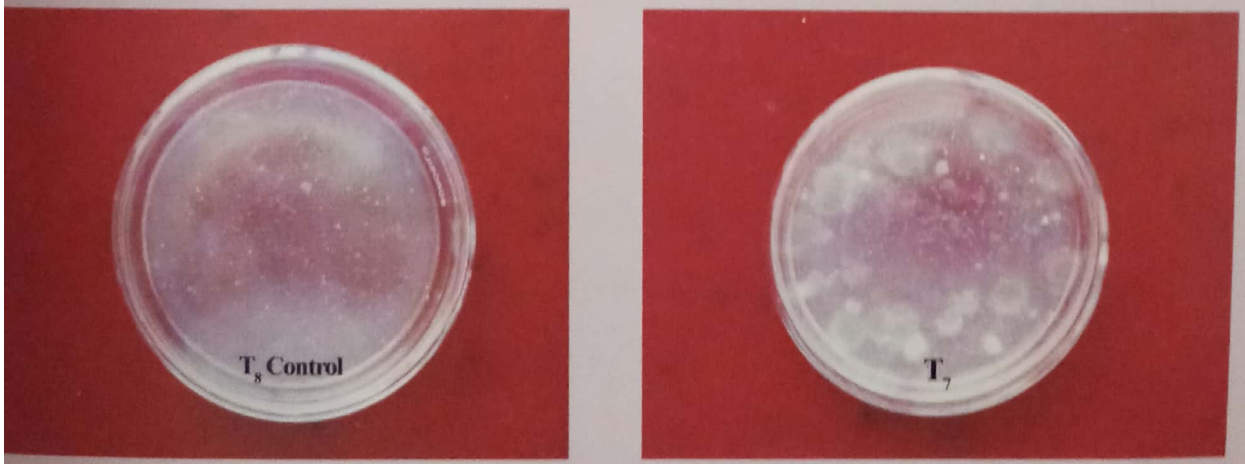
The increase in soil microbial population may be due to the positive effect of the constituents of Herboliv$^+$ on soil biological properties. Increase in microbial population would contribute to the Rhizosphere effect, which would have led to intense microbial activity in the Rhizosphere zone. This intense activity has a direct relation with the crop health.

Plate 11. Microbial population status in Herboliv' treated soil

Bacterial growth



Fungal growth



Actinomycetes growth

CONCLUSION AND RECOMMENDATION

As human populations encroachto wild animal habitats, natural wildlife territory is displaced. The population density of wildlife and humans overlaps increasing their interaction thus resulting in increased physical conflict. Potential solutions to these conflicts include electric fencing, land use planning, community based natural resource management, compensation, payment for environmental services, ecotourism, wildlife friendly products, or other field solutions. To reduce human animal conflict, Government of India has partnered with a number of organizations to provide solutions across the country. Having this as background, the present study was aimed to reduce human animalconflict by using organic product (Herboliv^{+}) in agriculture field, prone to wildlife damage. Towards realising the objectives enumerated in the introduction, experiments were carried out at Sirumugai range in 2012 to 2013. The salient findings of the investigations are reported under the following headings.

1. The number of crop raid and level of intrusion by wild animals in the agriculture field
2. Percentage of crop damage by wild animals in the study sites
3. Impact of crop growth and yield of Herboliv^{+} treated fields
4. Impact of Herboliv^{+} on soil nutrient status and microbial population

The observations recorded were for the experimental trial were, number of crop raid, percentage of crop damage, crop yield assessment, soil nutrient status and soil microbial status. Agriculture fields (sugarcane, banana and fodder grass) prone to wild animals attack and damage frequently selected for the experiment were treated with the Herboliv^{+} and studied for a period of 8 months. During the study the observations recorded, were analyzed, summarized and are concluded in this chapter.

The number of crop raid by wild animals (elephant, deer and wild boar) was observed maximum in the treatment T_8 (control) and minimal in the treatment T_7 (spraying + drenching + soil application) in sugarcane field. In banana field, the elephant crop raid was highest in T_8 (7) and lowest in T_7 (1) and a similar trend was observed due to deer and wild boar. The highest number of crop raid by wild animals in the fodder grass field was 51 in treatment T_8 and due to the Herboliv$^+$ treatment the number of crop raid was low in T_7 (17) treatment.

The level of wild animal intrusion in sugarcane field (elephant, deer and wild boar) was observed to be highest in treatment T_8 (66.4%, 56.25 % and 55 % -control) and lowest in treatment T_7 (spraying + drenching + soil application) with a result of 20 %, 23 % and 20 %. In banana field, the level of intrusion due to elephant was maximum in T_8 (64.1 %) and minimum in T_7 (40 %) and a similar pattern of crop raid was observed due to deer and wild boar. The highest level of intrusion by wild animals in the fodder grass field was 78.3 per cent, 78.3 per cent and 73.3 per cent respectively in treatment T_8 and due to the combination of Herboliv$^+$ treatment the number of crop raid was low in T_7 (40 %, 45 % and 53.3 %) treatment.

The degree of crop damage by wild animals (elephant, deer and wild boar) in sugarcane field was observed to be maximum in treatment T_8 (11.7 %, 9.1% and 5.8%) and minimum in treatment T_7 (spraying + drenching + soil application) with a result of 5 per cent, 0.5 per cent and 0.5 per cent. In banana field, the percentage of crop damage was maximum in T_8 (16.7 %, 10.9 % and 7.3 %) and minimum in T_7 (5 %, 0.5 % and 0.5 %). A similar trend was observed due to deer and wild boar damage. The highest degree of crop damage by wild animals in the fodder grass field was 35 per cent, 14 per

cent and 9.2 per cent respectively in treatment T_8 and due to the Herboliv$^+$ treatment degree of damage was low in T_7due to deer and wild boar(13 % and 2.5 %) whereas the damage by wild elephant was low in T_4 treatment.

Crop growth and yield of Herboliv$^+$ treated sugarcane field has shown a maximum plant height of 2.04 m and a maximum yield of 107.00 t ha^{-1} in T_7 treatment. The minimum growth and yield was recorded in T_8 treatment with a mean height of 1.42 m and yield of 85.00 t ha^{-1}. The banana plant height and yield was found to be influenced due to Herboliv+ application in different treatments, where T_7 treatment showed the maximum plant height (2.8 m) and bunch yield (8.2 kg $tree^{-1}$). In the fodder grass field, yield could not be estimated as the crop was completely damaged by the wild animals.

Impact of soil nutrient status in Herboliv$^+$ treated sugarcane field indicates that the soil pH was found to vary from 7.23 to 7.25. Electrical conductivity ranged from the 0.16 $dSm^{-1}$to 0.17dSm^{-1}. The soil available nitrogen was high in T_7 (251.83 kg ha^{-1}) and low in T_8 (248.70 kg ha^{-1}). Similarly available phosphorus and potassium was maximum in T_7 treatment (14.40 kg ha^{-1} and 291.93 kg ha^{-1}) and minimal in T_8 treatment (13.16 kg ha^{-1} and 287.70 kg ha^{-1}). The Chemical properties of Herboliv$^+$ treated banana field has shown that soil pH ranged from 7.53 to 7.56 in which T_7 recorded highest pH value,Electrical conductivity ranged from the 0.24 $dSm^{-1}$to 0.27dSm^{-1}. The maximum soil available nitrogen recorded was of 240.93 kg ha^{-1} in T_7 treatment followed by T_8 (239.53 kg ha^{-1}) and minimum in T_8 treatment (235.60 kg ha^{-1}). The available phosphorus ranged from 13.80 to 14.97 kg ha^{-1} in Herboliv$^+$ treated banana field. A

similar trend of result was observed in fodder grass field with reference to soil chemical properties

Microbial population in Herboliv^{+} treated agriculture field has shown highest bacterial population in sugarcane field, banana field and fodder grass field with values of 360.7 $\times 10^{6}$gram^{-1}of soil, 301.7 $\times 10^{6}$gram^{-1}of soil and 217.0 $\times 10^{6}$gram^{-1}of soil respectively in T_7 treatment and lowest bacterial population was recorded in T_8 treatment. The fungal population in sugarcane was maximum in T_7 treatment due to Herboliv^{+} with value of 56.0 $\times 10^{5}$gram^{-1}of soil and minimum in T_8 (23.7 $\times 10^{5}$gram^{-1}of soil), likewise in banana and fodder field a similar trend in fungal population was observed. Among the three Herboliv^{+} treated field, banana field has registered a maximum actinomycetes population of 222.0 $\times 10^{3}$gram^{-1}of soil followed by sugarcane field (210.0 $\times 10^{3}$gram^{-1}of soil) and fodder grass field (184.0 $\times 10^{3}$gram^{-1}of soil) in T_7 treatment and the lowest actinomycetes population was recorded in T_8 treatment with values of 64.0 $\times 10^{3}$gram^{-1}of soil, 57.7 $\times 10^{3}$ gram^{-1}of soil and 47.3 $\times 10^{3}$gram^{-1}of soil respectively in fodder grass field, sugarcane field and banana field.

The study results help to conclude that different mode of application of Herboliv^{+} treatment namely spraying, drenching and soil application has not helped to prevent wild animal intrusion in the treated agriculture field. Crop raid by wild animals and their eventual intrusion into the treated agriculture fields has also been observed. It is important to note that the wild animals made physical crop damage and has not consumed the crop in the Herboliv^{+} treated fields. Hence, it can be concluded that Herboliv^{+} can act as an antifeedant for wild animals but it cannot act as a repellent to prevent wild animal intrusion into the agriculture crops. It is observed that Herboliv^{+} has

contributed to the crop growth, yield and biological properties (soil) of agriculture crops (Sugarcane, Banana and Fodder grass) and did not have any significant effect in soil chemical properties.

ANNEXURE

Agriculture crops details

Sl.No	Crops	Variety	Spacing (m)	Potential yield/hectare
1	Sugarcane	CO.86032	1.5 m	100 - 130 tonnes
2	Banana	Nendran (*Musa* spp.)	2.0 x 2.0 m	50 - 60 tonnes
3	Fodder grass	*Pennistum purpureum*	Broad casting	35 - 40 tonnes

The level of intrusion by elephants in the Herboliv^{+} treated sugarcane field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Sheath	Tillering phase
2.	October	Sheath	Tillering phase
3.	November	Sheath	Ground growth period
4.	December	Canes	Ground growth period
5.	January	Canes	Ground growth period
6.	February	Canes	Ripening Phase
7.	March	Canes	Ripening Phase
8.	April	Canes	Final harvest

The level of intrusion by Deer in the Herboliv+ treated sugarcane field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Sheath	Tillering phase
2.	October	Sheath	Tillering phase
3.	November	Sheath	Ground growth period
4.	December	Canes	Ground growth period
5.	January	Canes	Ground growth period
6.	February	Canes	Ripening Phase
7.	March	Canes	Ripening Phase
8.	April	Canes	Final harvest

The level of intrusion by Wild boar in the Herboliv+ treated sugarcane field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Sheath	Tillering phase
2.	October	Sheath	Tillering phase
3.	November	Sheath	Ground growth period
4.	December	Canes	Ground growth period
5.	January	Canes	Ground growth period
6.	February	Canes	Ripening Phase
7.	March	Canes	Ripening Phase
8.	April	Canes	Final harvest

The level of intrusion by elephants in the Herboliv[+] treated banana field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Stems	Sucker
2.	October	Stems	Sucker
3.	November	Stems	Sucker
4.	December	Flower	Sucker
5.	January	Flower	Flowering
6.	February	Bunch/Fruits	Flowering
7.	March	Bunch/Fruits	Fruiting
8.	April	Bunch/Fruits	Fruiting

The level of intrusion by Deer in the Herboliv[+] treated banana field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Leaves	Sucker
2.	October	Leaves	Sucker
3.	November	Leaves	Sucker
4.	December	Flower	Sucker
5.	January	Flower	Flowering
6.	February	Bunch/Fruits	Flowering
7.	March	Bunch/Fruits	Fruiting
8.	April	Bunch/Fruits	Fruiting

The level of intrusion by Wild boar in the Herboliv^{+} treated banana field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Rhizome	Sucker
2.	October	Rhizome	Sucker
3.	November	Rhizome	Sucker
4.	December	Rhizome	Sucker
5.	January	Rhizome	Flowering
6.	February	Rhizome	Flowering
7.	March	Rhizome	Fruiting
8.	April	Rhizome	Fruiting

The level of intrusion by elephants in the Herboliv^{+} treated fodder grass field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Grass	Germination
2.	October	Grass	Flowering
3.	November	Grass	Flowering

The level of intrusion by Deer in the Herboliv^{+} treated fodder grass field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Grass	Germination
2.	October	Grass	Flowering
3.	November	Grass	Flowering

The level of intrusion by Wild boar in the Herboliv^{+} treated fodder grass field

Sl.No	Month	Economic part damaged	Stage of crop damage
1.	September	Grass/root	Germination
2.	October	Grass/root	Flowering
3.	November	Grass/root	Flowering