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Field Study For The Bioefficacy And Economics Of Herbal- *Lantana Camara* (L.) And Fungal- *Beauveria Bassiana* (Balsamo), Biopesticides Against *Helicoverpa Armigera* (Hubner) In South Rajasthan (India)

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Abstract— Recent researches have focused on the drawbacks of synthetic chemicals on ecosystem and advocates ecofrendly inclusions in pest management. The present investigation is an attempt to to compare the efficacy and feasibility of herbal and fungal bio pesticides with synthetic chemicals against a notorious pest *Helicoverpa armigera* (Hubner) infesting chick pea and tomato crops severely in South Rajasthan (India). When recommended doses of leaf and flower extracts of *Lantana camara* (L) and *Beauveria bassiana* (balsam) were applied in chick pea and tomato crops respectively in an Randomised Block Design with Endosulfan as standard check, the results were interesting. Percent infestations with highest dose of 1000ml per hectare of *Lantana camara* (L)were 9.11 and 8.51 on weight basis and 64.58 and 14.35 on number basis for leaf and flower respectively against 6.63 for Endosulfan .Similarly 32.35 (Weight basis)and 32.51(on number basis)percent infestations were observed against 20.75 with Endosulfan at highest doose of 400 ml /l/hectare with *Beauveria bassiana*(Balsamo). Bioeconomics again revealed that cost benefit ratio were 1:23.26 and 1:24.20 for leaf and flower of *Lantana camara*(L)respectively against 1:31.82 with Endosulfan at highest applied dose of 1000 ml /l/hectare .similarly cost and benefit ratio of entomopathogen was 1:52.60 against 1:62.37 for Endosulfan at highest applied dose of 400 ml/l/hectare.

Index Terms— *Helicoverpa armigera*, *lantana camara*, *Beauveria bassiana*, Endosulfan.

1 Introduction

Agriculture sector is vital for any nation and in India it is the principal source of livelihood for more than 58 per cent of the population. The goal of sustainable agriculture should be to maintain production at levels necessary to meet the increasing aspirations of an expanding world population without degrading the environment. In future, disease, insect resistant varieties and biological pest suppression will emerge as major component of the pest control activity. Biotechnological research has provided key developments in pest control agents, focusing on pathogens of insect pests and herbal products as formulated biological pesticides. Bio pesticides of plant and microbial origin will become an important inclusions being safe, cheap and cost effective in nature. These insecticides are especially valuable because their toxicity to non target animals and humans is extremely low compared to other commonly used insecticides.

Helicoverpa armigera (Hubner) is one of the most destructive and highly polyhagous insect pests of field crops worldwide. It causes severe damage and loss to a wide range of food, fiber, oil, fodder, vegetable, horticultural, ornamental, aromatic and medicinal plants. Losses solely due to this pest of up to Rs. 10,000 million have been reported in crops like cotton, pigeon pea, chickpea, groundnut, sorghum, pearl millet, tomato and many vegetable crops of economic importance [1].Our demand of vegetables will be 225 million tons by 2020 and 350 million tons by 2030. The major challenge, which lies ahead, is to develop technologies that enhance quality and productivity of vegetables under reducing land, declining natural resources and increasing biotic and abiotic stresses. Chemical pesticides that have alone proved to be effective till now to fight the war against pests but have made scientists helpless due to their3r"s (Residue, resurgence and resistance) and an immediate relief is being sought for.[2]

Hence in the present investigation, an attempt has been made to evaluate bio pesticides of plant origin and an entomopathogen of fungal origin in field trial to assess the feasibility of these eco safe plant protection measures in the field conditions. We have selected leaf and flower extracts of *Lanatana camara* (L) and different concentrations of *Beauveria bassiana*(Balsamo) against *Helicoverpa armigera* (Hubner)infesting chick pea and tomato crops severely in South Rajasthan(India).

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2 METHODOLOGY

Field experiments were done with chickpea (*Cicer arietinum,* L.)and tomato(*Lycopersicum esculantum*)by adopting Randomised Block Design (RBD) in the fields of Udaipur. In the trial there were four treatments including one control and one synthetic pesticide and each had four replications for leaf,flower extracts of *lantana camara*(L) and *Beauvera bassiana*(Balsamo). The plot size was 20 x7 meters and there were a total of 32 blocks. Each block of RBD measured 1 x 1 meter and a 2 x 2ft channel was running between two blocks. The distance between two plants in a row was 8 cm and the row to row distance was 30 cm (fig-A). The first spray was given one month after transplantation. By this time, incidence of *Helicoverpa armigera* (Hubner) was observed in the field. The sprays were repeated after every 15 days. The spraying of botanical pesticides were carried out during early morning hours or late during evening so as to avoid bright sunlight immediately after spray. Three sprayings were given during the complete experimental tenure. Hand compression sprayer was used for the spray. Since there is no commercial preparation of *Lantana camara* is available hence Neem product was taken as slandered for dose and cost. . The outcome of the experiments were on the basis of percent infestations on number and weight basis of fruits and cost benefit ratio taking Arjun (Endosulfan), the recommended pesticide for these crops for comparison

The total yield was assessed on the basis of total number of plant and their weight in each sampling units and the data were put into following formulas:

Percent infestation (on weight basis) =

$$\frac{\text{Weight of infested plant}}{\text{Total weight of plant}} \times 100$$

Percent infestation (on number basis) =

$$\frac{\text{Number of infested plant}}{\text{Total weight of plant}} \times 100$$

Fig-1.RBD design (details of doses applied in different blocks)

	R1		R2		R3		R4	
	T8		T1		T8		T1	
	T4		T5		T4		T5	
	T3		T6		T3		T6	
	T2		T7		T2		T7	
	T4		T5		T4		T5	
	T3		T6		T3		T6	
	T2		T7		T2		T7	
	T1		T8		T1		T8	

RBD design (details of doses applied in different blocks):

Where, R-Row

T1 = Endosulfan,(marketed as Arjuna,)
T2 = 500 ml per hectare of leaf extract
T3 = 750 ml per hectare of leaf extract
T4 = 000 ml per hectare of leaf extract
T5 = 500 ml per hectare of flower extract
T6 = 750 ml per hectare of flower extract
T7 = 1000 ml per hectare of flower extract
T8 = Control

The same sets were repeated four times.

Details of doses applied in different blocks of RBD:

T_1	Endosulfan	@400 ml /l/ h
T_2	*Beauveria bassiana*	@300mi/l /h
T_3	*Beauveria bassiana*	@350 ml/ l/h
T_4	*Beauveria bassiana*	@400ml/l/ h

3 EXPERIMENTAL FINDINGS (TABLE 1&2 AND FIELD VIEW)

The percent infestations at highest applied dose of 1000 ml per hectare were 9. 11 and 8. 51 on weight basis for leaf and flower extracts respectively against 30. 62 percent with no spray and 6. 63 percent with endosulfan. Whereas, percent loss on weight basis was only 14. 58 for both leaf and flower extracts at 1000 ml (highest dose) as compared to 10. 52 percent in Endosulfan. The result clearly revealed that both botanicals and Endosulfan are at par in their effects as far as check in percent infestations was concerned.When different formulated doses of entomopathogen were applied on tomato crop againt *Helicoverpa armigera*(Hubner),percent infestations on weight and number basis were 32.35 and 35.51 at highest applied dose of 400ml/l/hectareagainst 20.75 with Endosulfan at 400 ml/l/hectare and 75.00 percent in control where water was only sprayed.Other treatments also revealed similar trend.

The cost benefit analysis is the actual analysis where the bio economics of the botanicals were taken into account with the highest dose of leaf and flower (1000ml per hectare) extracts. It was 1:23. 26 and 1:24. 20 for leaf and flower extracts as compared to 1:31. 82 for Arjun (Endosulfan) at same dose level of 1000 ml per liter/hectare that was almost at par, but the fact that botanicals are not produced in large scale they are little costlier than the synthetic pesticide. Increase in yield was 89.48 quintal/hectare with highest applied dose of 1000 ml /l/hectare with flower extract as compared to 118.74 quintal/hectare with Endosulfan.The average increase in yield for *Beauveria bassiana* (Balsamo) was 237.50 quintal/hectare, and 284.50 and 340.00 quintal/hectare at 300,350and 400 ml/l/hectare respectivelyas compared to 426.50 quintals/hectare . The yield was minimum in case of control (97.00 quintals/hectare) when no spray was done. When 400 ml/lt/hectare was applied the cost benefit ratio was 1:52.60 against 1:6 2.37 with Endosulfan at the rate 400ml/l/hectare .Both the results were almost at par.

Table 1 Bioefficacy *of Lantana camara*(L)and *Beauveria bassiana* (Balsamo) against *Helicoverpa armigera* (Hubner) infesting chickpea and tomato crops

Treatment Number	Treatment	Dosage per hectare (ml/lt/hectare)	Infestation of tomato fruits on weight basis	Infestation of tomato fruits on number basis		
			Average weight (Kg)	Percent Infestation	Average	Percent Infestation
T1	Endosulfan	1000ml	325/4900	6. 63	5 of 48	10. 42
T2	Leaf	500ml	770/4385	17. 56	12 of 48	25. 00
T3	Leaf	750ml	665/4450	14. 94	10 of 48	20. 83
T4	Leaf	1000ml	410/4500	9. 11	7 of 48	14. 58
T5	Flower	500ml	725/4415	16. 42	11 of 48	22. 92
T6	Flower	750ml	550/4540	12. 11	8 of 48	16. 67
T7	Flower	1000ml	385/4525	8. 51	7 of 48	14. 58
T8	Control	-	1240/4050	30. 62	22 of 48	45. 83
CD at 1%				0.631		0.922
CD at 5%				0.855		1.250
SEM				0.19		0.40
CV				50.01		49.07
T_1	Endosulfan	400 ml/lt/hectare	3.75/18	20.83	75 of 276	27.17
T_2	*Beauveria bassiana*	300 ml/lt/hectare	9.5/14.25	66.67	139 of 276	50.36
T_3	*Beauveria bassiana*	350 ml/lt/hectare	7.25/15	48.33	117 of 276	42.39
T_4	*Beauveria bassiana*	400 ml/lt/hectare	5.50/17	32.35	98 of 276	35.51
T_5	Control	-	8.25/11	75.00	188 of 276	68.12
CD at 5%			1.28		32.86	
CD at 1%			1.77		45.43	
SEM			0.72		475.40	
CV				46.65%		34.97%

Table 2 Economics and cost benefit ratio of *Lantana camara* (L), *Beauveria bassiana* (Balsamo) and Endosulfan

S.No.	Treatment (per hectare)	No. of Application	Average total yield (quintals per hectare)	Increased yield over control (quintals per hectare)	Approx.sales price Rs./quintal	Value of increased yield(Rupees)	Approx.cost of insecticide + labor cost	Approx.net price + in Rs.per hectare	C:B Ratio
T2	Leaf Extract @500ml	3	243. 21	54. 16	1000	54157. 70	1650	52507. 70	1:31. 82
T3	Leaf Extract @750ml	3	254. 64	65. 59	1000	65594. 73	2660	62934. 73	1:23. 66
T4	Leaf Extract @1000ml	3	275. 16	86. 11	1000	86114. 10	3550	82564. 10	1:23. 26
T5	Flower Extract @ 500ml	3	248. 25	59. 20	1000	59203. 44	1650	57553. 44	1:34. 88
T6	Flower Extract @750ml	3	268. 43	79. 39	1000	79386. 44	2660	76726. 44	1:29. 84
T7	Flower Extract @1000ml	3	278. 53	89. 48	1000	89477. 93	3550	85927. 93	1:24. 20
T8	Control	----	189. 05	0. 00	----	0. 00			
T1	Endosulfan	3	307. 79	118. 74	1000	118743. 27	1950	116763. 27	1:59. 87
T1	Endoslfan 400 ml/lt/hectare	4	426.50	329.50	500.00	164,750.00	2,600.00	162,150.00	1 : 62.37
T2	*Beauveria bassiana* 300 ml/lt/hectare	4	237.50	140.50	500.00	70,250.00	1,634.00	68,616.00	1 : 41.99
T3	*Beauveria bassiana* 350 ml/lt/hectare	4	284.50	187.50	500.00	93,750.00	1,950.00	91,800.00	1 : 47.08
T4	*Beauveria bassiana* 400 ml/lt/hectare	4	340.00	243.00	500.00	121,500.00	2,267.00	119,233.00	1 : 52.60
T5	Control	4	97.00	0.00	500.00	-	-	-	-

Labour cost is Rs.250 per day ,hence 250x4= 1000/- for four sprays

4 Discussion

Looking into all drawbacks of chemical pesticides, inclusion of bio pesticides can be a welcoming step. With the increase in food grain production, pesticide consumption has also increased from 2000 tons a year in the fifties to over 80 thousand tons which includes consumption both in agriculture and public health [3]. Viewing the unacceptable negative consequences, like environmental pollution and damage to non target organisms, and widespread resistance to synthetic pesticides, the present situation has necessitated a re-evaluation of chemical pesticides as the final and comprehensive solution to pest and disease management[4]. Therefore it has become extremely important to turn on to safer mode by the use of pesticides that will not pose any threat to life..

Statistical analysis of data very well revealed that both the plant parts (leaf and flower extracts) were significantly superior over the control where no spray was done although their effects were dose dependent. Leaf and flower extracts at highest dose of 1000 ml brought 9. 11and8.51 percent infestations on weight basis respectively as compared to 6.63 percent in Endosulfan(almost at par).Similarly Percent infestations were also affected when considered on number of plants infested with leaf and flower extracts and compared with control and endosulfan blocks.

If average yield in quintals were observed the extracts were almost near to the yield obtained from Endosulfan.The average yield was 278.16 quintals for highest dose of 1000 ml per hectare for flower and leaf respectively as compared to 307.79 quintals per hectare in Endosulfan.

Increase in yield by the use of synthetic insecticides is reported by several authors.[4,5,6,7&8] But bio pesticides have also proved their worth in field treatments.

In a study ,leaf extracts of *Vitex negundo* L, *Synadenium grantii* Hook and *Prosopis juliflora* (SW) DC, and cake of *Azadirachta indica* A. were evaluated for their efficacy in reducing the population of the green leafhopper, *Nephotettix virescens* (Distant), and its transmission of rice tungro virus under field conditions. All four plant species tested reduced the population of the vector significantly in both the nursery and main field. The lowest population of the vector was recorded with application of neem cake at 5 kg/0. 032 ha of nursery, followed by foliar spray of Neem seed kernel extract at 5 percent in the main field[9]..

The efficiency of the botanical insecticide (BI) Neem Azal T/S (containing 1percent Azadirachtin A), on the basis of Azadirachtin applied in a dose of 20 g per ha^{-1} against Brassica pod midge (*Dasineura brassicae*).[10] The biological efficiency of BI was compared with the efficiency of some synthetic insecticides. It was ascertained that BI was very efficient in decreasing the number of damaged oilseed rape pods (ranging from 56. 5 to 85. 9percent compared to untreated plants) . The yield increase of Azadirachtin ranged between 9. 3 and 19. 4percent compared to the control sample. Azadirachtin showed the highest yield for the whole time of experimentation, and in some years the yield increase was significantly higher compared to some synthetic agents .Similarly reatment with *Lantana camara* (L.) extract (1percent) reduced the percentage of *H. armigera* infested plants and the intensity of cabbage damage. The intensity of cabbage damaged caused by *P. xylostella* was significantly lower in *Lantana camara* (L.) and *C. inerme* than control and Challenger[10]

Phytochemicals, especially botanical insecticides are currently of interest because of their successful application in plant protection as potential biocontrol agents. Biological activity of leaf aqueous extract of twenty five medicinal plants were evaluated by [11].They reported that against the VI instar larvae of gram pod borer *Helicoverpa armigera* (Hübner), (Lepidoptera: Noctuidae) and a significant larval mortality rate between 11. 8 and 78. 9 was exhibited after 24h of exposure to leaf aqueous extracts. The results imply that leaf aqueous extract of *M. azedarach*, *A. indica, S. trilobatum*, *A. paniculata, A. marmelos, A. lineata, S. surattrense, C. roseus*, A. *zeylanica, A. fruticosa* and *D. metal* can potentially be used as eco-friendly pest control agents against the larvae of *Helicoverpa armigera* (Hubner).

At last the economics that is the most important aspect for farmers, indicated that increase in yield per hectare was 86. 11 and 89. 48 percent for 1000 ml per hectare dose of leaf and flower extracts respectively as compared to 118. 74 percent with endosulfan at the same dose level and cost benefit analysis further supported the data with 1:23. 26 and 1:29. 84 as compared to 1:59. 81 with Endosulfan at the same dose level of 1000ml per hectare.

It was also interesting that lower doses of 500 ml per hectare the C:B ratio were respec 1:31. 82 and 1: 34. 88 for leaf and flower extracts respectively that were nearer to Endosulfan. However, Endosulfan treatment certainly gave better results as they are cheaper and more toxic but looking into other drawbacks and damage to human health little less yield can be compromised and if botanicals are also prepared commercially, further increase in C:B ratio is well speculated. It means that the cost of botanicals at higher doses played an important factor in determining cost benefit ratio. The increase in cost of botanicals against synthetic pesticides may be due to less production and general unawareness of the farmers as compared to later.

The entomopathogenic *B.bassiana* represent one of the beneficial fungi that is known in the field and semifield of biological control ([12] In a study it was found that *Earias insulana Pectinophora gosspiella* and *Heliothis armigera*, can be controlled in the field by *B.bassiana*.[13].

Overall results in all the randomized block design were quite effective as far as percent infestation of fruits on number basis was concerned. Comparable results were investigational when percent infestation on weight basis was compared with microbial pesticides *Beauveria bassiana* (Balsamo) and synthetic pesticide, Endosulfan it could be stated, that microbial pesticides were also quite efficient in controlling the infestation, since untreated plots observed 75.00 and 68.12 percent infestations on weight and number basis respectively. Successful field applications of safer microbial are being tried continuously in the field with greater success Control of the *S.lituralis* by the fungi gave good results in the laboratory as well as in field[14,15 and 16].Mycopathogens have proved superior for many important pests of economic importance.

Foliar application of *B. bassiana* could control two spotted spider mite on various crops. However, the level of control provided varied from one crop to another. Since the crops were individually used in separate experiments, it was not possible to make a conclusion as to which crop type had an effect on the efficacy of the biocontrol agent[16,17]. At the recommended dose of 1 x 10^7 and 1x10^8 spore/ml, bioassay of SBT # 27 and SBT # 28 isolates against *H .armigera* showed optimum larval mortality within 8 days after spraying. Initial mortality was observed within 6 days itself after treatment. The percentage of cumulative mortality of *H. armigera* larvae treated with 107and 108 conidia / ml of *M. anisopliae* formulation (SMB). Amongst the two isolates, BST # 27 strain caused 95% larval mortality, which was significant ($P < 0.01$) than the control[19]. Isolates of a fungus from different host insects have varying degrees of virulence as measured by percent mortality in Bioassays[20], broader host range and time taken for spore germination[20,21].

The cost benefit analysis is the actual analysis where the bio economics of the botanicals were taken into account with the highest dose of pathogen (400 ml/l/ hectare). In the present investigation when cost benefit ratio and bio economics were calculated T_1, (Endosulfan @ 400ml/ lt/hectare) gave 1:62.37 followed by 1:52.67 (T_4 @ 400ml/ lt/hectare), 1:47.08 (T_3 @ 350ml/ l/hectare) and 1:41.99 (T_2 @ 300ml/l /hectare).When increase in yield over control and total increased in yield in terms of rupees were taken into account it was 426.50 quintals with a price of Rs 162, 150.00 for Endosalfan (400ml/ l/hectare) and it was 340.00 quintals with an increase of yield (Rs/hectare) of 119.233.00 at 400/ml/ l/hectare (T_4) for *B.bassiana* (Balsamo).. Nevertheless, Endosulfan treatment definitely gave better results as they are cheaper and more toxic but looking into other drawbacks and damage to human health, little less yield can be compromised and if this microbials are also prepared commercially, further increase in C:B ratio is well considered. Similar report was given by [22,23]against bug *Scutella nobilis.*Two foliar sprays given at monthly interval revealed that lambda-cyhalothrin 5 EC at 25 g a.i. ha^{-1} and imidacloprid 17.8 SL 100 ml ha^{-1} were most effective treatments followed by Carbosulfan 25 EC at 250 g a.i. ha^{-1} and Monocrotophos 36 SL at 500 g a.i. ha^{-1}. Next effective treatments were Spinosad, endosulfan, *Beauveria bassiana*, *Metarhizium anisopliae* resulted in moderately reduction in pest population.

5 Conclusion

Hence, it is well proved that these bio-pesticides have great future and they are quiet effective both in terms of pest control as well as yield of crop (cost-benefit calculation).Only fact is that they are little costlier as their production is less and farmers are not aware of these microbial. If they are produced commercially and farmers are trained for their use there is no doubt that these eco-safe products can replace the hazardous chemicals of the field in coming days. Further the results if analyzed critically gives a clear indication of bright future prospects of microbial pesticides to be included in IPM.

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