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Research Article

ECOLOGICAL AND ECONOMIC PERSPECTIVE OF INTEGRATED PEST MANAGEMENT (IPM) IN PADDY (*Oryza sativa* L) ECOSYSTEM IN TAMIL NADU

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Abstract: A study was carried out in the district (two taluks) of Erode of Tamil Nadu; India to ascertain the variety of pesticides was used in the Paddy (*Oryza sativa* L.) ecosystem. One representing the IPM adopter and other representing non-IPM adopter were randomly selected from each taluk. The awareness about the IPM farm practices was very less in non-IPM farmers compared to IPM paddy growers. Important precautions like using masks and gloves were followed either by very few farmers. Use of carbofuran was 1.598 kg/ha in IPM and 3.131kg ha^{-1} in Non-IPM paddy growing sample farms. The highly hazardous chemical like phorate was used only in Non-IPM paddy at the rate of 2.5 kg ha^{-1}. The net return per ha was ₹.9815.62 in IPM and ₹.6617.15 in non-IPM paddy farms. Average cost of pesticides in IPM paddy was only ₹.212.42 and it was ₹.769.48 ha^{-1} in Non-IPM paddy. Eco-friendly bio control agents like *Bacillus thuringiensis* and Azardirctin were applied only in IPM paddy growing sample farms. The number of pesticides used and the application rate were less in IPM paddy compared to Non-IPM paddy. The Environmental Impact Quotient (EIQ) value of usage of chemicals in IPM paddy was less at 28.40 compared to Non-IPM paddy at 40.26. Most common health problems due to the use of pesticides reported by the sample respondents, were tiredness (58.33 %) followed by head ache (45.00 %). Allergic dermatitis and body pain were reported by 31.67 and 21.67 % of the sample farmers, respectively. Constraints in IPM adoption in paddy cultivation was high wage labour, non-availability of labour, lack of IPM inputs such as; *Azospirlillum, Tricoderma* sp., In Non -IPM paddy sample growers expressed lack of confidence in IPM measures.

Keywords: *IPM paddy, non-IPM paddy, EIQ, pesticides cost, awareness, heath problems*

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Introduction

Pesticides, besides being poisonous in nature to the targeted pests, there are the environmental costs and human health hazards associated with the use of pesticides. Per capita consumption of pesticides in India is 0.6 kg per hectare, compared to 13 kg per hectare and 7 kilograms per hectare in China and the US respectively [1]. In Asia, India has the largest area under the rice accounting for 28.5 % of the global rice area. Per capita consumption of crop protection chemicals in India is lower at 0.6 kg/ ha compared to 13 kg/ ha in China and as compared to the world average (3 kg/ha). The Present consumption is however around 288 g ha^{-1}, which is far below the level of consumption of 12000g ha^{-1} in developed countries [2]. Per hectare consumption of pesticides was the highest in Punjab (0.74 kg), followed by Maharashtra (0.57 kg) during the year 2016-17[3]. Farmers invest more money on crop protection chemicals in order to get maximum returns and they fail to take into account the health risk and medical expenditure associated with the pesticide use [4]. In India the crop losses due to pests were estimated as 15.7 % from 23.3 % in post – green revolution period [5]. India, being a tropical country, the non-uniform use of the plant protection chemicals in different regions, cropping systems and consumption pattern is also more skewed towards insecticides Monoculture and continuous cultivation of paddy led to decline in genetic base and have made that agro-ecosystem very susceptible to crop pests [6]. Indiscriminate use of pesticides apart from being occupationally hazardous is poisoning and a serious threat to human health in the developing world. All pesticide formulations that are broad spectrum and applied excessively would cause various environmental problems. Repeated use of the broad-spectrum pesticides may also affect the non-target organisms, some of which are beneficial, like; honeybees, lac insects, predatory and parasitic insects. These poisons slowly seep into our body and take years to show up as cancer, as immune system disorder or as hormonal or reproductive system disorders affecting even the foetus. To quote a few, the Bhopal Methyl Icocyanide (MIC) gas tragedy that occurred in the year 1984 is considered as the world's worst industrial disaster. Regard to different types of insecticides marketed, organophosphates dominate insecticide market with 36 % followed by pyrithroids with 25 %, carbamates with 21 %, organochlorines with eight % and others accounting for 10 % [7]. These often result in symptoms of toxic poisoning ranging from itching to headaches, eye irritation, vomiting, sleepiness, fever, stomach cramps and even death. These symptoms have been reported in cotton growing areas of Maharashtra and Andhra Pradesh in India. Exposure to organophosphates (OP) produced depression, a major risk factor in suicides. Research from Spain had shown that suicide rates were higher in areas of greater Organophosphates use [8]. Most of agricultural workers in India are prone to insecticide poisoning because of contaminated food and exposure to pesticides. Lack of knowledge about the hazards of insecticides adds to the problem. A research study conducted in Telangana state revealed that awareness of pesticide classification based on toxicity indicates in colour code triangle on the pesticide bottle was noted by 3.33% of open field and 14.29% poly house farmers indicated less awareness of farmers about pesticides [9]. The most common pesticide contaminants found in vegetable oils and oil seeds were DDT (1,1,1-trichloro-2, 2-bis (p-chlorophenyl) ethane) and HCH. Out of 12 brands of edible oil collected during 1992, six were contaminated with Hexa Chlorcyclo Hexane and DDT.

Most of the vegetable samples collected from Delhi, Haryana, Karnataka, Andhra Pradesh and Maharashtra had been found to be contaminated with DDT and HCH and few were contaminated with aldrin, heptachlor and endosulfan. Pesticides use has increased pushing up the cost of production besides aggravating environmental pollution. IPM technology training programmes were the support of Food and Agricultural Organization (FAO) and United Nation Development Programmes (UNDP) projects, to extension functionaries and farmers through Farmers Field School (FFS). Some of the state governments, *viz.*, Andhra Pradesh, Karnataka, and Tamil Nadu have conducted a few exclusive women FFS and a large number of mixed FFS from their own resources. Considering this, greater emphasis is given to reduce the extent of use of pesticides to reduce the extent of human risks and environmental pollution through Integrated Pest Management approach. Where the use of biological agents to manage crop pests is a key component as an alternative to ecological disruptive chemical control. In Tamil Nadu, among the total crops paddy is the major cultivated area and high consumption of pesticides next to cotton. The objective of the study is: (i) To study the awareness & adoption level of IPM technology in paddy (ii) To analyse the economics of pesticide use and its efficiency in paddy (iii) To assess the environmental damage potential of pesticide use in paddy.

Materials and Methods

Both primary and secondary data were collected for the study. The primary data were collected through personal contact of the respondents with the help of a pre-tested interview schedule. Erode district comprises of seven taluks. Subsequently two taluks each for paddy were chosen based on the proportion of area under these crops (the top two taluks) to the gross cropped area at the zonal level. In the second stage, two villages, one representing the IPM adopter and other representing non-IPM adopter were randomly selected from each taluk. In the third stage, 15 farmers were randomly chosen from each village, thus, forming a sample size of 60.

Cobb-Douglas Production Method

Production function analysis was carried out to examine the resource use efficiency in paddy production. The estimated values of the regression co-efficient were tested for statistical significance with the help of 't' test and the appropriateness of the model chosen was tested by 'F' test. All the co-efficient were tested at **P<0.01 and ***P<0.001 of significance. The functional form of is Cobb-Douglas type specified as given below:

$$\ln y = \ln a + b_1\ln X_1 + b_2\ln X_2 + b_3\ln X_3 + b_4\ln X_4 + b_5\ln X_5 + b_6\ln X_6 + b_7\ln X_7 + b_8\ln X_8 + e$$

Y	=	Yield of paddy (qtls/ha)
X1	=	Quantity of seeds used (kg/ha)
X2	=	FYM (tones/ha)
X3	=	N (kg/ha)
X4	=	P (kg/ha)
X5	=	K (kg/ha)
X6	=	Labour (man days) (Women days were converted to man days on the basis of wages)
X7	=	Expenditure on Plant protection chemicals (₹/ha)
X8	=	Dummy to account for damage by rain fall (affected -1, not affected -0) at harvest stage.
e	=	Error term

EIQ Technique

Developed a formula for determining the Environmental Impact Quotient (EIQ) of individual pesticides capturing the effects on farm worker, consumer and ecology [10]. It is explained below,

$$EIQ = \{C [(DT*5) + (DT*P)] + [(C*((S+P)/2)*SY) + (L)] + [F*R] + (D*((S+P)/2)*3) + (Z*P*3) + (B*P*5)]\}/3$$

Where,

DT	=	Dermal toxicity	D	=	Bird toxicity
C	=	Chronic toxicity	S	=	Soil half-life
Sy	=	Systemicity	Z	=	Bee toxicity
F	=	Fish toxicity	B	=	Beneficial arthropod toxicity
L	=	Leaching potential	P	=	Plant surface half-life.
R	=	Surface stress potential			

To account for different formulations of the same active ingredient and different use patterns, a simple equation called EIQ field use rating was developed.

Garrett's Ranking Technique

To study the constraints in adopting IPM and reason for non-adoption of IPM in paddy and cotton crops in the study area, the respondent's were asked to rank the factor and the % position was worked out using the following formula. The % position estimates were converted into score for each factor and the score of various farmers were added and the mean values were computed. The mean values were then arranged in descending order and the factor with highest value was considered as the most important one.

$$\% \text{ Position} = 100 (R_{ij} - 0.5) / N_j$$

Where, R_{ij} = Rank given for i^{th} factor by j^{th} individual

N_j = Number of factor₹ ranked by j^{th} individual.

Result and Discussion

Age Distribution of Heads of Sample Farm Households

The results are furnished in [Table-1]. It could be seen that majority (40.00 %) of the sample farmers adopting IPM in paddy cultivation, fall in the age group of 45-60 years, whereas most of the non-IPM sample paddy growers ranged between 30- 45 years of age. Considering the entire paddy growing sample farmers, they constituted 33.33 % each in the age group of 30- 45 years and 45- 60 years of age, respectively.

Table-1 Age distribution of heads of sample farm households (numbers)

SN	age group (years)	IPM paddy growers	non-IPM paddy growers
1	Up to 30	4(13.33)	5(16.67)
2	30-45	9(30.00)	11(36.67)
3	45-60	12(40.00)	8(26.67)
4	>60	5(16.67)	6(19.99)
5	Total	30(100.00)	30(100.00)

(Numbers in parentheses indicate % to total)

Educational Status of the Heads of Sample Farm Households

Educational status of the heads of the sample farm households is presented in [Table-2]. In both IPM and Non-IPM paddy sample households more than 50 % of the heads of households crossed high school level of education. Whereas for the combined sample, 33.33 % had undergone high school level of education followed by primary educated with 23.33 % and those completed higher elementary level constituted 20 %.

Table-2 Educational status of the heads of sample farm households (numbers)

SN	institutions	IPM growers	non-IPM growers
1	Primary level	6(20.00)	8(26.67)
2	Higher Elementary Level	7(23.33)	5(16.67)
3	High School Level	9(30.00)	11(36.66)
4	Higher Secondary Level	6(20.00)	3(10.00)
5	College level	2(6.67)	3(10.00)
6	Sample size	30(100.00)	30(100.00)

(Numbers in parentheses indicate % to total)

In all, considering both cotton and paddy sample growers, 31.6 % had crossed high school level of education, followed by 24.16 % with higher elementary level education, 19.16 % had primary level education, 15.84 % higher secondary level education and 19.17 % had college level education.

Experiences in Farming of Heads of Sample Farm Households

The results are furnished in [Table-3]. The analysis revealed that majority of IPM paddy growers (40.00 %) were having above 10 years of experience, whereas among non-IPM paddy growers, the experience in farming was comparatively higher. Nearly 43 % of the farmers were having more than 20 years of experience.

Table-4 Awareness and adoption of different pest control methods in IPM and non- IPM sample farm households (%)

SN	different pest control methods	IPM paddy				non-IPM paddy			
		aware	adoption*	aware but not adopted*	not aware and not adopted*	aware	adoption*	aware but not adopted*	not aware and not adopted*
1	Physical Control								
	i) Sanitation	88.90	41.22	47.68	11.1	46.00	23.00	23.00	54.00
	ii) Destruction of infested plants	74.00	67.55	6.45	26.00	48.76	35.00	13.76	51.24
	iii) Light traps	92.00	38.55	53.45	8.00	14.50	5.88	8.62	85.50
2	Cultural Control								
	i) Fallowing	90.16	25.55	64.61	9.84	62.33	12.55	49.78	37.67
	ii) Flooding	100.00	100.00	0.00	0.00	100.00	100.00	0.00	0.00
	iii) Mulching	100.00	100.00	0.00	0.00	100.00	100.00	0.00	0.00
	iv) Crop rotation (Paddy-Pulses-Paddy)	68.46	16.18	52.28	31.54	28.77	8.50	20.27	71.23
	v) Green Manuring (sunhemp)	59.18	28.19	30.99	40.82	25.44	4.00	21.44	74.58
	vi) Trap crops (pulses)	76.55	25.89	50.66	23.45	12.56	3.88	8.68	87.44
	vii) Seed treatment (*Azospirlillum*)	100.00	78.00	22.00	0.00	18.16	6.48	11.68	81.84
3	Use of Bio-Products								
	i) Neam oil	92.66	81.46	11.2	7.34	48.00	18.36	29.64	52.00
	Egg Parasities								
	i) *Tricoderma. sp*	94.48	46.50	47.98	5.52	8.52	2.45	6.07	91.48
4	Chemical Control								
	i) Organophosphorous	86.50	54.52	31.98	13.5	56.45	52.58	3.87	43.55
	ii) Pyrithroids	84.20	56.89	27.31	15.8	55.49	51.23	4.26	44.51
5	Number of sample households	30				30			

Table-6 Cost and returns of IPM paddy and non-IPM sample household

SN	Particulars	IPM paddy			non-IPM paddy		
		quantity	amount (₹)	% of total	quantity	amount (₹)	% of total
1	Seed (kgs)	77.38	1355.21	8.25	83.75	1409.53	8.15
2	Seed treatment with *Azospirillum. sp* (gms)	11.11	12.42	0.08	-	-	-
3	Manure (tones)	2.72	1375	8.37	1.81	1106.52	6.41
4	Mechanical control (physical removal)	-	177.84	1.08	-	-	-
5	Biological control	-	301.34	1.84	-	-	-
6	Fertilizers (N+P+K) (kgs)	142.98	1863.81	11.35	220.02	3413.04	19.76
7	Human labour (man days)	78.04	9478.62	57.74	68.01	8550.77	49.50
8	Bullock power (hou₹)	8.18	490.80	2.99	8.23	493.80	2.85
9	Tractor power	-	1150.74	7.01	-	1532.01	8.87
10	Plant protection chemicals (₹)	-	212.42	1.29	-	769.46	4.46
11	Total variable cost (₹)	-	16418.2	-	-	17274.6	-
12	Yield (kgs)	-	-	-		-	-
	Main product	3474.54	-	-	3126.26	-	-
	By product	2070.22	-	-	1926.65	-	-
13	Gross income (₹)	-	26233.82	-	-	23891.75	-
14	Net farm income over variable cost (₹)	-	9815.62	-	-	6617.15	-

Table-3 Experience in farming of heads of sample farm households (numbers)

SN	farming experience (years)	IPM paddy growers	non-IPM paddy growers
1	Up to 10	12(40.00)	9(30.00)
2	11-20	7(23.33)	8(26.67)
3	>20	11(36.67)	13(43.33)
4	Total	30(100.00)	30(100.00)

(Numbers in parentheses indicate % to total)

Awareness and Adoption of Different Pest Control Methods

The awareness and adoption levels of different pest control methods by IPM and non-IPM paddy sample farmers in the [Table-4]. The awareness and adoption were 100 % for practices like, flooding and mulching in both IPM paddy and non-IPM paddy cultivating sample households. Even though the awareness of other IPM measures were fairly higher (ranging from 59.18 to 94.48 %) among IPM paddy growers, the adoption level was less. It ranged between 16.18 and 81.46 %. Adoption rates were particularly higher at 81.46, 78.00 and 67.55 % in cases of application of neem oil, seed treatment with *Azospirillum* and destruction of infested plants. Among the Non-IPM paddy growers, the awareness about the IPM farm practices was very less compared to IPM paddy growers. It ranged between 14.50 and 56.45 % with the exception of flooding and mulching. The adoption rate of various IPM practices was also very less ranging from 2.45 to 52.58 with the exception of flooding and mulching.

Safety Measures Followed during and after Pesticide Application

The safety measures followed during and after pesticide application by the sample farmers are given in [Table-5]. The tabular analysis would show that the safety measures like washing hands with soap after pesticide application was followed by majority of the farmers. It was 86.67 % in case of paddy growers. The awareness about the colour and symbol of pesticide among the sample farmers was also more ranging between 73.33 and 86.67 %.

Table-5 Safety measures followed during and after pesticide application by sample farm households (numbers)

SN	Safety measures	IPM paddy growers	Non-IPM paddy growers
1	Pesticides measured by measurement jar	12(40.00)	11(36.67)
2	Aware of spray nozzle size	25(83.33)	9(30.00)
3	Washing hands with soap	27(90.00)	25(83.33)
4	Use mask	1(3.33)	0(0.00)
5	Use gloves	0(0.00)	0(0.00)
6	Awareness of color and symbol of pesticide	24(80.00)	22(73.33)
7	Sample size	30	30

(Numbers in parentheses indicate % to total)

However important precautions like using masks and gloves were followed either by none of the farmers or by a very few farmers.

This should be of great concern given the poisonous nature of the pesticides and implies the need to educate the farmers and strictly enforce following all safety norms in both handling and application of pesticides.

Cost and Returns in Sample Farm Households

The cost of cultivation for both IPM and Non-IPM paddy are given in [Table-6]. The cost of cultivation for both IPM and Non-IPM paddy remained more or less same (₹ 16418 and ₹ 17274 ha^{-1}, respectively). In sample IPM paddy farms the cost of fertilizer constituted 11.35 percent and in Non-IPM paddy sample farms it constituted 20 % of the total cost of cultivation. The use of plant protection chemicals constituted 1.29 % and 4.46 % in these farms. Cost of labour was ₹ 9478.62 ha^{-1} (57.74 %) in IPM paddy cultivation and ₹ 8550.77 (49.50 %) in Non-IPM paddy cultivation of the total variable cost. Average yield was 3474.54 kg and 3126.26 kg ha^{-1}, in respectively in these farms. The net return over variable cost per ha^{-1} was ₹ 9815.62 and ₹ 6617.15 respectively in IPM and Non-IPM paddy farms. The yield rate was higher, the cost per ha was lower and net return was higher in IPM paddy farms compared to Non-IPM paddy farms.

Usage of Different Pesticides in Paddy Cultivation

From the [Table-7], it could be inferred that the number of pesticides used and the application rate were less in IPM paddy compared to non-IPM paddy. The application rate of like monocrotophous and carbofuran designated as highly hazardous chemicals by the EPA (Environment Protection Agency, 1984) were used at the rate of 1.833 kg/ha and 1.598 kg/ha, respectively, in IPM paddy growing area, whereas in non-IPM paddy growing areas the use of monocrotophos and carbofuran was relatively higher at 2.064 and 3.131kg/ha. Phorate another highly hazardous chemicals, was used only in non-IPM paddy and cotton at the rate of 2.5 kg /ha and 6.34 kg/ha respectively. Average cost of pesticides in IPM paddy was only at ₹.212.42 compared to ₹.769.48 per hectare in Non-IPM paddy.

Table-7 Pesticides usage in sample farm households

SN	Pesticides	Application rate kg ha^{-1}	
		IPM paddy	non-IPM paddy
1	Alachlor*	1.235	-
2	Carbendazim**	-	0.632
3	Carbofuran***	1.598	3.131
4	Chloropyriphos**	-	1.390
5	Endosulfan**	1.933	2.200
6	Monocrotophos***	1.833	2.064
7	Quinolphos**	-	2.279
8	Triazole*	0.247	0.547
9	Phorate***	-	2.598
10	Azartirictin*	1.235	-
	Average cost of pesticidesha^{-1} (in ₹)	212.42	769.46

High risk ***, Medium risk**, Low risk* based Risk Assessment Guidelines of United States EPA(Environmental Protection Agency)

The use of carbofuran was 1.598 kg ha^{-1} in IPM and 3.131kg ha^{-1} in Non-IPM paddy growing sample farms. The highly hazardous chemical like phorate was used only in Non-IPM paddy at the rate of 2.5 kg ha^{-1}. Average cost of pesticides in IPM paddy was only ₹.212.42 and it was ₹.769.48 ha^{-1} in Non-IPM paddy. Eco-friendly bio control agents like Bacillus thuringiensis and Azardiractin were applied only in IPM paddy growing sample farms. The number of pesticides used and the application rate were less in IPM paddy compared to Non-IPM padd

Production Function Analysis

IPM Paddy

The Co-efficient of Multiple Determination, R^2 was 0.75. The independent variables like phosphorous and potassium significantly influenced yield at **P<0.01 and the variables like labour and the dummy for damage by rainfall significantly affected yield at ***P<0.001.

Table-8 Results of production function analysis of IPM paddy in sample farm households(ha)

Variables	Coefficients	Standard error
Constant	5.593***	0.332
Seeds (kg)	0.021	0.015
Organic manure (tone)	0.006	0.005
Nitrogen (kg)	0.175	0.020
Phosphorous (kg)	0.039**	0.020
Potassium (kg)	0.015**	0.007
Labour (Man day)	0.165***	0.05
Plant protection cost (₹)	0.008	0.006
Dummy to account for damage by rainfall (score)	0.206***	0.065
R^2	0.75	-
Adjusted R^2	0.65	-
'F' Statistic	7.688	-
Number of observations	30	-

*** Significant at P<0.001. ** Significant at P<0.01

Non-IPM Paddy

The Co-efficient of the Multiple Determination, R^2 was 0.83. The independent variables namely, seeds and the dummy for damage by rainfall-influenced yield significant at ***P<0.001, whereas, organic manure and nitrogen influenced yield significantly at ** P<0.01.

Table-9 Results of production function analysis of non-IPM paddy sample farm households

Variables	Coefficients	Standard Error
Constant	8.071***	0.609
Seeds (kg)	-0.325***	0.101
Organic manure (tone)	0.008**	0.003
Nitrogen (kg)	0.161**	0.058
Phosphorous (kg)	0.021	0.013
Potassium (kg)	-0.005	0.003
Labour (Man day)	0.033	0.042
Plant protection cost (₹)	-0.011	0.007
Dummy to account for damage by rainfall (dummy)	0.272***	0.057
R^2	0.83	-
Adjusted R^2	0.76	-
'F' statistic	13.069	-
No of observations	30	-

*** Significant at P<0.001, ** Significant at P<0.01.

Effect of Pesticide Exposure on Human Health

The Effects of pesticide exposure on health in IPM and non-IPM sample farm households were presented in [Table-10]. Most common health problems due to the use of pesticides reported by the sample respondents, were tiredness (58.33 %) followed by head ache (45.00 %). Allergic dermatitis and body pain were reported by 31.67 and 21.67 % of the sample farmers, respectively.

Table-10 Effects of pesticide exposure on health in IPM and non-IPM sample farm households

SN	*Health effects*	Number of respondents	
		IPM paddy	non-IPM paddy
1	Head-ache	12(40.00)	15(50.00)
2	Stomach-ache	4(13.33)	3(10.00)
3	Allergic Dermaties	6(20.00)	13(43.13)
4	Vomiting	2(6.67)	5(16.67)
5	Body pain	4(13.37)	9((30.00)
6	Tiredness	16(53.33)	19(63.33)
7	Sample size	30	30

(Numbers in parentheses indicate % to total)

Symptoms like allergic dermatitis and tiredness were reported by about 78.33 % and 80.00 % of sample cotton growers, respectively. More than 40 % of the sample cotton growers at the least reported other problems.

The analysis revealed that more farmers reported these problems among the Non-IPM growers in both the crops.

Environmental Impact Quotient (EIQ)

EIQ values of chemicals used in IPM and non-IPM sample farms were presented in [Table-11]. The cultivation of non-IPM paddy resulted in more EIQ values than IPM paddy. The EIQ value of usage of chemicals in IPM paddy was less at 28.40 compared to Non-IPM paddy at 40.26.

Table-11 EIQ values of chemicals used in IPM and non-IPM sample farm households

SN	EIQ values for		
	Crop	IPM	Non-IPM
1	Paddy	28.40	40.26

Constraints for Adoption of IPM Technology in Sample Farm Households

The predominant constraints in IPM adoption in paddy cultivation had been high wage labour non-availability of labour, lack of IPM inputs such as; *Azospirlillum*, *Tricoderma* sp, light traps, sexpheromones, and NPV, lack of extension follow-up, complex practices, inadequate training facilities and lack of assured irrigation besides being time consuming. In Non-IPM paddy sample growers expressed lack of confidence in IPM measures.

Conclusion

The awareness and adoption biological control was high among IPM farmers. In Non-IPM sample farmers use more fertilizers, pesticides and labour compared with IPM sample farmers resulting in lower productivity and net returns. Highly hazardous chemicals like monocrotophos, carbofuran and phorate application rate were high non-IPM farms. Symptoms like allergic dermatitis and tiredness were reported by more in Non-IPM growers. The constraints in IPM adoption were high wage and non-availability of labour, lack of IPM inputs and extension follow-up.

Application of research: Indiscriminate application of pesticides increase the cost of cultivation and also human health cost.

Research Category: Socio and Environmental Economics

Abbreviations:
IPM: Integrated Pest Management
EIQ: Environmental Impact Quotient

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Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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