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Feasibility of IPM in green gram: An economic analysis

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Abstract
The present investigation pertinent to this study entitled ‘‘Integrated Pest Management in Green gram in Parbhani District of Maharashtra state: An Economic Analysis’’ was conducted in Taroda and Sawali tehsils of Parbhani district of Maharashtra state. In a view to know the levels of adoption of IPM technology and feasibility to approach new technology. The data collected for the study was collected from the farmers through questionnaire and schedule of sample collection methods. A sample of 60 farmers were divided into three categories *viz*. Low adopters, medium adopters, high adopters, based on their levels of adoption. To assess the extent of adoption of various IPM technology of Green gram the concept of TAI was used.

Results shows that out of total 60 farmers 10 (16.66%) farmers were grouped in low technology adopters group and adopted the technology less than 53.60%, 32 (53.33%) farmers were grouped in medium technology adopter group whose technology adoption index was in the range of 53.60 to 73.91 percent and 18 (30%) farmers were grouped in high technology adoption group whose technology adoption index was greater than 73.91 percent. It is also revealed that, association between socio-economic characteristics such as age, IPM adoption level is inversely proportional whereas education was the most important factor in adoption of IPM technology.

Input gap of 3.07 kg of seeds in overall use of seed and there was an input gap of 3.28 kg of seeds by medium technology adopter against the recommended dose of 16 kg of seed, followed by a gap of 2.53 kg by high adopters. In the case of manure it is used excess in all the technology adopters. With respect to nitrogenous fertilizers it was observed that all technology adopter group nitrogen was used less by 3.6, 2.37 and 2 kg/ha respectively. In case of phosphorus fertilizer gap of 6.1 kg, 5.44 kg, and 1.18 kg was found among low, medium and high technology adopters group respectively.

The total cost of cultivation i.e. cost C2 at overall level of the technology adoption was worked out to Rs. 39451.44 and among the different technology adoption groups, cost C2 was Rs. 32239.82, Rs.36984.84 and Rs. 47842.99 on the farm of low, medium and high technology adoption groups respectively. It is depicted from the analysis that as the levels of technology adoption increases, cost of cultivation also increases. The output input ratio at cost C2 level was ranged in between 2.05 to 2.15 on low technology adoption group to high technology adoption group, while it was 2.33 at overall technology adoption level.

Keywords: IPM, green gram, economic analysis

Introduction
Integrated Pest Management (IPM) is a system that in the context of associated environment and the population dynamics of the pest species utilizes all suitable techniques and methods in as compatible manner as possible and maintains the pest populations at level below those causing economic injury (Food and Agricultural Organization, FAO, 1972). In IPM both crop and pest are seen as part of a dynamic agro-ecosystem. IPM is a sustainable approach to managing pests by combining biological, cultural, mechanical and chemical tools in a way that minimizes economic, health and environmental risks. The IPM concept is based on the principle that it is not necessary to eliminate all the pests but to suppress the pest population to a level at which these pests do not cause significant losses. An integrated strategy for crop pest management includes use of resistant varieties modifying agronomic practices to reduce pest incidence, biological control and other novel approaches for pest suppression and only need based judicious use of chemical pesticides (Handbook of Entomology, 2019).

Green gram is the third most important pulse crop in India after chickpea and pigeon pea. It has special importance in intensive crop production system of the country for its short growing period. It can also be used as a green manure crop in certain areas. Green gram generally grown as a rainfed crop during *kharif* season. (Dharwe *et al.*, 2018) [3]. The pulses have high protein contents (Average 20-25%). In addition to their value as food stuff, they are also important in cropping system.

Green gram may be grown twice a year i.e. in spring and autumn season also. This has opened avenues of intensifying crop production in the tribal dominated belt. Perhaps, because of these distinct features and higher economic returns, India is the world largest homeland of vegetarian and world leader in pulses production and import to provide protein supplement (Singh *et al.*, 2014) [9].

Materials and Methods

Methodology is concerned with the characteristics of the area chosen for study, the procedures used for sample selection, the nature and sources of data, and the numerous statistical tools and techniques applied in data analysis. For the present study 60 green gram growers who follows IPM technology were selected in consultation with KVK subject matter specialists, Officials of State Agriculture department and Extension Agronomists.

Further the sample of 60 farmers were divided into three categories *viz*., low adopters, medium adopters, high adopters, based on their levels of adoption. Survey method was adopted for the collection of data. A pre-tested schedule was prepared to obtain data from the selected farmers through, personal interview method.

Analytical techniques

To achieve the aim of the study analytical techniques are used, in accordance with every objective.

Technology Adoption Index (TAI)

The first objective i.e., to find out different levels of adoption is achieved by using Technology Adoption Index of each and every farmer using the following formula.

$$TAI = \frac{1}{K} X \left[\frac{AX1}{RX1} + \frac{AX2}{RX2} + \frac{AX3}{RX3} + - - - + \frac{AXK}{RXK}\right] X\ 100$$

TAI = Technology Adoption Index
K = No. of Technology
AXi = Actual use of selected Technology
RXi = Recommended use of selected technology

Categorizing the sample farmer

Taking into account the TAI, the sample farmers are grouped into low, medium and high adopters, by using the mean and standard deviation (SD) of the TAI obtained, which determines the level of adoption of the sample farmers.

Low adopters = Mean- SD

Medium adopters = Mean - SD to Mean SD High adopters = Mean + SD

Economic feasibility

The economic feasibility of green gram production which is cultivated with IPM technology was assessed by estimating cost and return from green gram cultivation. For estimation of the cost standard cost concepts provided by CACP New Delhi were used the standard concepts are described as below.

Cost concepts

Cost A1: It includes the following

1. Value of hired human labour
2. Value of hired and owned bullock labour
3. Value of hired and owned machine labour
4. Value of seed (farm and purchased seeds)
5. Value of manures (Owned and purchased) and fertilizers
6. Depreciation
7. Irrigation charges
8. Land revenue
9. Interest on working capital
10. Miscellaneous expenses

a) Cost A2: Cost A1 + rent paid for leased – in land
b) Cost B1: Cost A1 + interest on fixed capital (excluding land)
c) Cost B2: Cost B1 + rental value of owned land + rent for leased- in land
d) Cost C1: Cost B1 + imputed value of family labour
e) Cost C2: Cost B2 + imputed value of family labour
f) Cost C3: Cost C2 + 10 percent of cost C2 as management cost

Income measures

Gross income: GI = (Q m X Pm)

Where Q m = quantity of the main produce Pm = price of the main produce

Return over variable costs: RVC = Gross income – Cost A1

Farm business income: FBI = Gross income – Cost A2

Family labour income: FLI = Gross income – Cost B2

Net income: NI = Gross income – Cost C2

Returns to management: RM = Gross income – Cost C3

Monetary inputs

Land revenue

It contains the actual amount of revenue or any other tax paid by the producer farmer to government.

Interest on working capital

The working capital was estimated using the working expenditure i.e., the sum of all the costs incurred on hired human labour, seed, fertilizer, plant protection chemicals, excluding family labour. The interest on working capital was estimated at the rate of 6 percent per annum.

Interest on fixed capital

Interest on fixed capital was estimated at the rate of 10 percent of average values of all the permanent structures i.e., machinery, irrigation structure etc. excluding land of the sample farmers. It is further estimated for the required crop area.

Interest on fixed capital per hectare = 10 percent of average value of the fixed assets /average cropped area

Rental value of land

These are the charges for the usage of land, and it was charged at 1/6th value of the gross produce value.

Results and Discussion

Levels of adoption of Integrated Pest Management (IPM) Technology

The selected green gram growers were grouped as low,

medium and high IPM adopters on the basis of estimated mean and standard deviation of Technology Adoption Index, as prescribed in methodology and the results are shown in Table 1. It is observed from table that out of 60 sample farmers, only 30 percent were found to be adopting IPM technology at high level of adoption with Technology Adoption Index (TAI) ≥ 73.91 About 16.66 percent sample farmers adopted IPM at low level with TAI ≤ 53.60 while highest i.e. 53.33 percent farmers had adopted IPM technology at medium level of adoption whose TAI ranged between 53.60 to 73.91.

The Mean TAI and Standard deviation of TAI was 63.75 and 10.16 respectively.

The reason behind this fact could be clear from study of socio-economic status of the selected sample respondents.

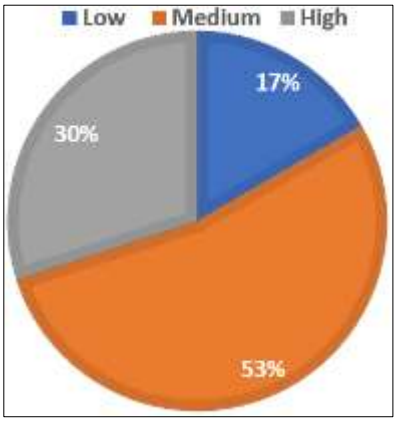

Fig 1: Levels of adoption of IPM technology

Table 1: Distribution of sample cultivators

Particulars	Technology adoption index	No. of farmers	Percentage
Mean (Technology Adoption Index)	63.75	-	-
Standard deviation (SD)	10.16	-	-
Low technology adaptors	≤ 53.60	10	16.66
(Mean-SD)			
Medium technology adaptors (Mean-SD to Mean+ SD)	≥ 53.60 to ≤ 73.91	32	53.33
High technology adaptors	≥ 73.91	18	30
(Mean + SD)			
Total		60	100

Economic feasibility of IPM technology

Economic feasibility is that advantage one achieve from any particular firm, with which are greater than the amount of costs that are incurred on the production.

Per hectare physical input use and output of green gram on sample farms

The information on per hectare input use and output on different groups of technology adoption are given in Table 2

Hired human labour

It is seen from the table that, use of hired human labour was more on high (18.48 man- days) IPM adoption group than medium (15.74 man-days) and low (11.48 man-days). At overall IPM adoption level, 15.86 man-days human labour were employed for green gram cultivation.

Bullock labour

In case of bullock labour, 1.5 pair-days were employed at overall IPM adoption group while use of machine labour in overall groups of IPM adoption was found to be 0.78 hrs per ha.

Seed

Seed rate per ha of the high technology adopter group was high i.e. 13.47 kg/ha as compared on medium and low technology adoption level: It was 12.72/ha kg and 12.65 kg/ha.

The overall seed rate is 12.93 kg/ha. Use of manure is increasing from low technology adopter group to high technology adopter group.

Table 2: Per hectare physical input use and output of green gram on sample farm

			Technology adoption groups		
	(10)		(32)	(18)	(60)
Physical inputs					
1. Hired human labour	man day	11.48	15.74	18.48	15.85
2. Family labour	man day	2.07	2.63	3.6	2.83
3. Bullock labour	hrs	1.3	1.44	1.59	1.46
4. Machine labour	hrs	0.6	0.78	0.84	0.76
5. Seed	kg	12.65	12.72	13.47	12.93
6. Manure	tons	15.6	16.31	23.67	18.39
7. Nitrogen	kg	8.4	9.63	10	9.53
8. Phosphorous	kg	23.9	24.56	28.28	25.56
9. Potassium	kg	14.4	15	15.78	15.13
10. Pheromone traps	No.	0	3.69	9.33	4.76
11. Nimboli extract	liter	1.1	3.92	4.67	3.67
12. Quinalphos	liter	0.16	0.16	0.12	0.16
13. Emamectin benzoate	gram	0	249.98	249.85	208.27
14. Flonicamid	gram	74.2	74.49	74.36	74.40
15. Dimethoate	liter	0	1.95	1.89	1.60
16. Thiodicarb	gram	0	0	649.95	194.98
Output					
Main produce	q	9.45	11.09	14.67	11.89

Manure

Use of manure was increasing from low to high technology adoption group. At overall level 18.4 t /ha manure was applied to soil.

Fertilizer

Use of nitrogen was found increasing from low to high technology adopter groups, the same trend was followed in phosphorous and potassium. It is observed that the use of phosphorous was high as compared to nitrogen and potassium, The overall use of N, P and K was 9.53, 25.57 and 15.12 kg/ha respectively.

Per hectare input gap on sample farms over recommended dose

It is seen from table that recommended seed rate of green gram is 12-16 kg/ha and it was optimally used on all level of technology adoption. Group wise analysis showed that on low, medium and high levels of technology adoption farms.

Regarding manure recommended dose of manure was 12 tons /ha. which was used excessively on all the farms. On high technology adoption farm manure was utilized twice of the recommended dose of nitrogen was 12 kg as against it was used deficiently by 3.6 kg, 5.4 kg and 1.18 kg on low, medium and high technology adoption farms.

Potassium was also used deficiently by 3.6, 3.0 and 2.22 kg/ha on the selected farm as against the recommended dose of 18 kg/ha with respect to the pheromone traps. It was found that 12 pheromone traps/ha were recommended in package of practices of IPM but except low technology adoption group, others medium and high technology adopters had installed less no. of traps by 8.31 and 2.67 respectively.

In the case of Nimboli extract the recommended dose was 5 litr/ha which was used deficiently by 3.9, 1.08 and 0.33 ltr on low, medium and high technology adoption farms. It is seen that the recommended dose of Quinalphos is 1 liter /ha and it was observed that there deficiently by 0.84, 0.84 and 0.88 liter/ha and in overall it is 0.85 liter. In the case of emamectin benzoate the recommended dose was 250 gms/ha. It is seen that only medium and high technology adopters was used emamectin benzoate and had deficient by i.e. 0.02 and 0.15 in medium and high technology adoption groups.

In flonicamid it was observed that the recommended dose was 75 gms/ha. It was found that the gap between all the level of adoption was 0.8, 0.51 and 0.64 gm/ha.

Likewise in dimethoate the recommended dose was 2 liter/ha, but it is found that the low technology adopter group did not use dimethoate and the gap between input is very less in medium and high technology adopter i.e. 0.05 and 0.11 liter/ha.

In the case of thiodicarb 650 gm was the recommended dose, it is found that only high technology adopters used thiodicarb and there was very less gap i.e. 0.05 gm /ha and in overall technology adopter it was 0.01, respectively.

Table 3: Per hectare input gap on sample farms over recommended dose

Particular	Unit	Recommended	Technology adoption groups			
			(10)	(32)	(18)	(60)
Seed	Kg	16	3.35	3.28	2.53	3.06
manure	Tons	12	-3.6	-4.31	-11.67	-6.39
Nitrogen	Kg	12	3.6	2.37	2	2.46
Phosphorous	Kg	30	6.1	5.44	1.18	4.27
Potassium	Kg	18	3.6	3	2.22	2.86
Pheromone traps	No.	12	12	8.31	2.67	7.23
Nimboli extract	Liter	5	3.9	1.08	0.33	1.32
Quinalphos	Liter	1	0.84	0.84	0.88	0.85
Emamectin benzoate	Gram	250	0	0.02	0.15	0.05
Flonicamid	Gram	75	0.8	0.51	0.64	0.59
Dimethoate	Liter	2	0	0.05	0.11	0.05
Thiodicarb	Gram	650	0	0	0.05	0.01

Cost of cultivation on the sample farm

For calculating per hectare cost of cultivation of green gram at different levels of technology adoption was calculated by using standard concepts and is presented in Table 3.

Per hectare cost of cultivation of green gram overall IPM technology adopters farm

From Table 3, it was clear that out of the cost C2 of all the sample farmers, major portion of cost was incurred on the total working capital (35.83%), followed by the rental value of the land (30.11%). A like trend was followed by individual groups of adopters as well.

The overall analysis showed that the cost A1 was 46.76 percent of the total cost. Cost C2 showed an increasing trend with the increase in level of adoption, i.e., ₹ 32239.82, ₹ 36984.84, ₹ 47842.99 for low, medium, and high adopter groups respectively.

With regard to working capital, hired human labour and bullock labour costs are revealed to be the major components, in all three categories of the farmers. With respect to the family labour, the overall cost of technology adoption was 4.64 percent of the total cost.

The production costs of medium and high adopter groups was comparatively higher than that of low adopters, yet the gross returns are more in case of high adopters followed by medium adopters and then low adopters.

Table 4: Cost of cultivation of green gram on sample farms (Rs./ha)

Particular		Technology adoption group		
	Low	Medium	High	Overall
1. Hired human labour	4592	6296	7392	6340.8
	(12.11)	(14.73)	(13.39)	(13.88)
2. Bullock labour	2080	2160	2385	2214
	(5.48)	(5.05)	(4.32)	(4.84)
3. Machine labour	1200	1404	1512	1402.4
	(3.16)	(3.28)	(2.74)	(3.07)
4. Seed	1897.5	1908	2020.5	1940
	(5.00)	(4.46)	(3.66)	(4.24)
5. Manure	780	815.5	1183.5	919.9
	(2.05)	(1.90)	(2.14)	(2.01)
6. Nitrogen	210	240.75	250	238.4
	(0.55)	(0.56)	(0.45)	(0.52)
7. Phosphorous	597.5	614	707	639.15
	(1.57)	(1.43)	(1.28)	(1.40)
8. Potassium	282.24	294	309.28	296.62
	(0.74)	(0.68)	(0.56)	(0.65)
Total	1089.74	1148.75	1266.28	1174.17
	(2.86)	(2.67)	(2.29)	(2.57)
9. Pheromone trap	0	92.25	233.25	119.17
		(0.21)	(0.42)	(0.26)
10. Nimboli extract	385	1372	1634.5	1286.2
	(1.01)	(3.21)	(2.96)	(2.81)
11. Dasparni ark	0	94.5	1011.5	353.8
		(0.22)	(1.83)	(0.77)
12. Quinalphos	327.6	330.33	343.2	333.73
	(0.86)	(0.77)	(0.62)	(0.73)
13. Emamectin Benzoate	0	5.93	36.94	14.24
		(0.01)	(0.06)	(0.03)
14. Flonicamid	255.45	150.5	189.57	179.71
	(0.67)	(0.35)	(0.34)	(0.39)
15. Dimethoate	0	47.25	93.33	53.1
		(0.11)	(0.16)	(0.11)
16. Thiodicarb	0	0	104.16	31.24
			(0.18)	(0.06)
17. Total working capital	12607.29	15825.01	19405.73	16362.93
	(33.25)	(37.03)	(35.16)	(35.83)
18. Interest on working capital @ 6%	589.86	666.93	773.96	686.19
	(1.55)	(1.56)	(1.40)	(1.50)
19. Land revenue	120	120	120	120
	(0.30)	(0.28)	(0.21)	(0.26)
20. Depreciation on farm assets	4260.97	3553.33	5270.33	4186.37
	(11.24)	(8.31)	(9.55)	(9.16)
21. Cost-A1 (∑ 17 to 20)	17578.12	20165.27	25570.02	21355.5
	(46.36)	(47.19)	(46.33)	(46.76)
22. Rent paid for leased in land	0	0	0	0
23. Cost - A2 (∑21 to 22)	17578.12	20165.27	25570.02	21355.5
	(46.36)	(47.19)	(46.33)	(46.76)
24. Interest on fixed capital @ 10% excluding land	2204.2	2028.74	2577.97	2222.7
	(5.81)	(4.74)	(4.67)	(4.86)
25. Cost-B1(∑21, 24)	19782.32	22194.01	28147.99	23578.2
	(52.18)	(51.94)	(51.00)	(51.63)
26. Rental value of land	10905	12818.33	16995	13752.44
	(28.76)	(30.00)	(30.79)	(30.11)
27. Cost B2 (∑ 22,25,26)	30687.32	35012.34	45142.99	37330.69
	(80.94)	(81.94)	(81.79)	(81.75)
28. Family labour	1552.5	1972.5	2700	2120.75
	(4.09)	(4.61)	(4.89)	(4.64)
29.Cost-C1(∑25,28)	21334.82	24166.51	30847.99	25699
	(56.27)	(56.55)	(55.89)	(56.27)
30. Cost-C2(∑27,28)	32239.82	36984.84	47842.99	39451.44
	(85.04)	(86.55)	(86.68)	(86.39)
31. Management Charges @ 10% of C2	5669.66	5743.46	7346.06	6211.94
	(14.95)	(13.44)	(13.31)	(13.60)
32.Cost -C3(∑30,31)	37909.48	42728.3	55189.05	45663.38
	(100)	(100)	(100)	(100)

Profitability in green gram production

Profitability in green gram production at different levels of costs along with output- input ratios is presented in Table 4.

It is seen from Table that the output-input ratio was increasing from low to high IPM technology adopter groups, it means profitability in green gram cultivation, on high IPM technology adopter groups was more than that of medium and low IPM technology adoption groups. It is depicted from Table that output-input ratio at cost A1 i.e., returns over variable cost (RVC), was 3.86 at overall level. It ranged from 3.8 to 4.0 on low technology adopters group to high technology adopters group. There by it is concluded that green gram cultivation under IPM technology was highly profitable at cost A1 on high technology adopters farm.

Profit at cost C2 (NI), was also found to be high on high technology adopters group. At overall level, output-input ratio in green gram cultivation was 2.10 whereas it was 2.05, 2.10, and 2.15 on low, medium and high IPM technology adopter groups.

These results are in support with the conclusions of Akter *et al.* (2016) [17], whose results showed that 2.2, 2.5 and 4.0 were the benefit cost ratios for wax gourd, okra and papaya cultivation of IPM adopters respectively, while the respected ratios of non-IPM adopters were 1.8, 2.1 and 3.0 in Bangladesh.

Table 5: Profitability in green gram production

Output-input ratio	Low adopters	Medium adopters	High adopters	Overall
Cost -A1	3.8	3.8	4.0	3.86
Cost-A2	3.8	3.8	4.0	3.86
Cost-B1	3.34	3.50	3.65	3.51
st-B2	2.16	2.22	2.27	2.22
ost-C1	3.10	3.21	3.33	3.22
Cost-C2	2.05	2.10	2.15	2.10
Cost-C3	1.74	1.82	1.86	1.81

Conclusion

The selected farmers were grouped into three categories i.e. low IPM adopters medium IPM adopters and high IPM adopters, by estimating Technology adoption index, It is observed that out of total 60 farmers 10 (16.66%) farmers were grouped in low technology adopters group and adopted the technology less than 53.60%, 32 (53.33%) farmers were grouped in medium technology adopter group whose technology adoption index was in the range of

53.60 to 73.91% and 18 (30%) farmers were grouped in high technology adoption group whose technology adoption index was greater than 73.91%.

All the inputs like hired human labour, machine labour, family labour, seed, NPK, plant protection chemicals an increasing trend with increase in the level of adoption. Inputs like Pheromone trap, Emamectin benzozte, Dimethoate and Thiodicarb were not used by low adopters. The output of green gram was highest among the high technology adopters with 14.67 quintals. The input gap on the sample farm of all the inputs expect manure showed a decreasing trend with increase in the level of IPM technology adoption. Manure was used in excess quantities among all the three adopters groups, with an excess of 3.6, 4.31 and 11.67 tons per hectare proportionately among low, medium and high technology adopters. The total cost of cultivation of low technology adopters was ₹ 37909.48, of medium technology adopters was ₹ 42728.3 and that of high technology adopters was ₹ 55189.05.

The profit at the total cost was observed to be highest among the high adopters with ₹ 47500.95. The output input ratio of the low adopters was 1. 74, that of medium adopters was 1.82, while that of high adopters was 1.86 Thus, it shows that adoption of IPM technology is economically feasible with output.

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