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A profitability analysis of the use of TNAU technology capsule for the maize fall armyworm in Erode district of Tamil Nadu

K Shanmuga Priya, T Samsai, S Selvam and K Mahendran

Abstract
Maize is the third most important crop in the world due to high source of nutrients and are used as food, feed and the raw material for multitude of industries. At present, maize farmers from all over the world are facing a serious issue due to fall armyworm attack which causes reduction in the quantity and quality of maize and increases the cost of plant protection chemicals. In order to tackle this worsening situation of maize growers, Tamil Nadu Agricultural University introduced an IPM technology capsule for management of the fall armyworm. In this context, the present study was undertaken to examine the profitability of adoption of TNAU technology capsule for maize fall armyworm in Erode district of Tamil Nadu. For this study, stratified random sampling methd was adopted. A total of 180 sample farmers which consists of 90 technology capsule adopters and 90 non-adopters were selected by using stratified random sampling. According to the results, it could be concluded that 44 per cent of farmers had high level of awareness followed by 40 per cent of farmers had medium level of adoption of TNAU technology capsule. More than 50 per cent of sample farmers partially adopted the TNAU technology capsule, while only around 20 per cent completely adopted the TNAU technology capsule. TNAU technology capsule adopter's of net revenue (Rs. 21895/ha) was higher than non-adopter's net revenue (Rs. 8464/ha). The farmers who used the TNAU technology capsule earned (Rs. 13042/ha) more profit than the non-adopted farmers. The high input costs, lack of proper knowledge of technology capsule, and lack of availability of subsidies for all inputs were the main constraints faced by the sample farmers for the adoption of TNAU technology capsule. The efforts like increasing the number of result demonstrations and awareness campaign to inform farmers of the profitability that can be earned by adopting TNAU technology capsule can be taken.

Keywords: Awareness, adoption, cost and returns, partial budgeting, constraints

Introduction

After rice and wheat, maize (*Zea mays* L.) is the third most extensively produced crop in the world. Maize is being praised as the "Queen of Cereals" since it has the highest yield potential among other cereal crops. Carbohydrates, protein, fibre, oil, sugar, and ash are all present in reasonable amounts in maize. Maize is a major source of food, animal feed, fodder, and are being used as fundamental raw material for many industries, including biofuel, food sweeteners, cosmetics, and alcoholic beverages. In India, maize is mainly used for the manufacturing of chicken feed and the extraction of starch.

India is the world's fourth largest area and seventh-largest producer of maize and accounting for two per cent of global production and four per cent of the world's total area. In India, Karnataka stands first in the area and production of maize and Tamil Nadu ranks first in productivity and fourth in production. Tamil Nadu had an area coverage of 0.4 million ha with a production of 2.56 million tonnes and the average productivity of maize was 6.4 t/ha in the year 2020-2021. In Tamil Nadu, Perambalur district stands first in both area and maize production, while Erode district stands first in productivity, covering 0.016 million ha and producing 0.15 million tonnes with an average productivity of 9.88 t/ha in the 2020-2021 (Season and Crop Report, 2020-2021).

Maize growers in India find difficulty in maintaining the crop on remunerative basis due to yield reduction resulting from Fall Armyworm insect (*Spodoptera frugiperda*) attack. Fall Armyworm (FAW) infestation is more in tropical and subtropical climate. FAW was first noticed in India in May 2018 in Karnataka and it soon spread over the entire maize fields in the country. The three hosts viz., maize, sorghum, pearl millet much favoured the growth and development of the *Spodoptera frugiperda* among many hosts (Sivaranjani *et al*, 2021) [7].

Though many insect species were reported to cause damage in maize, farmers gave less attention to plant protection until the infestation of fall armyworm, *Spodoptera frugiperda* in maize (Shylesha *et al.* 2018) [6].

The first occurrence of fall armyworm (*Spodoptera frugiperda*) was reported in sugarcane in Tamil Nadu, India (Srikanth *et al*, 2018) [9]. The fall armyworm incidence was observed in maize fields of Dharmapuri district in May 2018 which resulted in average yield loss of 20-30 per cent and from there it was spread to all other maize growing area. Farmers always prefer chemical methods of pest control for fall armyworm management. Though chemical insecticides provided managerial control, cases of resistance have been reported against some insecticides. FAW had emerged into a major threat to maize ecosystems which leads to rise in the cost of plant protection. Several strategies have been developed to control this voracious feeders overtime. The Tamil Nadu Agricultural University, Coimbatore, introduced an IPM technology capsule for maize fall armyworm control (Thilagam *et al*, 2020) [11].

Though majority of studies have focused on the use of IPM approaches for controlling fall armyworm in maize but only limited number of farmers are known about the economic benefits of adopting TNAU technology capsule. There hasn't been a detailed study in the economics about the IPM technology capsule developed by Tamil Nadu Agricultural University.

In the present study, attempt has been made to assess the profitability that can be availed through the adoption of TNAU technology capsule for fall armyworm control by comparing with that of other maize producers and suggested suitable policy implications for maintaining TNAU technology capsule practises for the control of maize fall armyworm.

Objectives

1. To study the TNAU technology capsule awareness and adoption of sample farmers.
2. To calculate the economics of maize production between TNAU technology capsule adopters and non-adopters.
3. To identify the constraints faced by the farmers for adoption of TNAU technology capsule.

Methodology

The incidence of fall armyworm was first reported in Erode and Karur districtsof Tamil Nadu in 2018. Erode district was purposively selected for this study because of high productivity of maize. In the present study, attempt has been made by the researcher to analyze the profitability gained by farmers by the use of TNAU technology capsule for the management of fall armyworm.

Three blocks in Erode district namely Anthiyur, Ammapettai, and Sathyamangalam which has the highest maize producing area were selected. Two villages were selected from each block, and from each village 30 maize farmers were selected. A total of 180 sample farmers which consists of 90 technology capsule adopters and 90 non-adopters were selected by using stratified random sampling. Primary data was collected for the study with the help of a well-structured interview schedule.

Tools and Analysis

Eleven components of recommended technology capsule practices such as summer ploughing, application of neem cake, seed treatment, spacing, inter row spacing, cover crops, pheromone trap, egg parasitoid, and insecticide application at vegetative stage, leaf whorl stage and tassel/ cob stage were selected and considered for determining the awareness and adoption level. The responses were taken as 'aware' and 'unaware', score 1 was given for aware and 0 was given for unaware of the recommended practices of the technology capsule. The response of farmers was recorded on three continuum scale – complete adoption, partial adoption and non adoption. The score of two was given for complete adoption, one for partial adoption and zero score for non adoption. Based on the total score obtained, the awareness and adoption of farmers were categorised into low, medium and high by using cumulative percentile.

Farmers those who have adopted the practices like summer ploughing, neem cake treatment, cover crops, and pheromone traps were identified as the technology capsule adopters. The cost and returns for both adopters and non-adopters of the technology capsule among maize producers were calculated using CACP. The net changes in income caused by the use of the technology capsule were investigated using partial budgeting. The constraints faced by the farmers in the adoption of the technology capsule were ranked by using Garrett's ranking method.

Cost of Cultivation

Based on the cost principle used by the Commission for Agricultural Costs and Prices, cost A1, A2, B1, B2, C1, C2, and C3 was selected for this study to estimate the cost of maize cultivation for both adopters and non-adopters of TNAU technology capsule.

a. Cost A1 includes all actual expenses in cash and kind incurred in the production by the farmer namely
    1. Value of hired human labour
    2. Value of owned and hired bullock labour
    3. Value of hired and owned machine labour
    4. Value of seeds
    5. Value of manure
    6. Value of fertilizers
    7. Value of insecticides and pesticides
    8. Depreciation on implements and machinery
    9. Irrigation charges
    10. Land revenue
    11. Interest on working capital
    12. Miscellaneous expenses
b. Cost A2 = Cost A1 + Rent paid for leased in land
c. Cost B1 = Cost A2 + Interest on fixed capital (excluding land)
d. Cost B2 = Cost B1 + Rental value of owned land
e. Cost C1 = Cost B1 + Imputed value of family labour
f. Cost C2 = Cost B2 + Imputed value of family labour
g. Cost C3 = Cost C2 plus ten per cent of Cost C2 as management cost

Partial Budgeting

To identify the partial changes in the farm, such as the use of new varieties, technologies, innovations, practises, equipment, or services, partial budgeting was employed. This approach was used to calculate the effect of new technology or variety utilisation on revenue generation. The approach of organising experimental data and information on the expenses and benefits of a change in the technologies being utilised on the farm is known as partial budgeting. Estimating the profit increase or decrease that will result from a modification in the farm plan is the goal.

In this study, the four components of partial budgeting were considered namely

1. Added cost due to the adoption of technology,
2. Reduced returns due to the adoption of technology,
3. Reduced cost due to the adoption of technology,
4. Added returns due to the adoption of the technology.

Net income from the change made in the farm organization by partial budgeting = (Total of added returns + reduced costs) – (total added costs + reduced returns)

Garrett's Ranking Technique

The major constraints faced by the sample farmers for the adoption of TNAU technology capsule were ranked by using Garrett's ranking technique.

$$\text{Percent position} = \frac{100 \text{ X } (R_{ij} - 0.5)}{N_j}$$

Result and Discussion

Technology-wise - Awareness about TNAU Technology Capsule

The recommended TNAU technology capsule practices were listed out and technology-wise awareness of TNAU technology capsule is presented in the Table 1.

Table 1: Technology wise awareness of TNAU technology capsule (n=180)

S. No	Recommended TNAU Technology Capsule Practices	Awareness	
		Number of Sample Sespondents	Percentage to Total
1.	Summer Ploughing	180	100
2.	Application of neem cake	124	68.89
3.	Seed treatment	132	73.33
4.	Spacing	126	70.00
5.	Inter row spacing	120	66.67
6.	Cover crops	134	74.44
7.	Pheromone trap	129	71.67
8.	Egg parasitoid	0	0.00
9.	Insecticide application – Vegetative stage	123	68.33
10.	Insecticide application – Leaf whorl stage	132	73.33
11.	Insecticide application – Tassel/ cob stage	126	70.00

It could be concluded from the above table that all the sample farmers in the study area were aware of summer ploughing (100 per cent). followed by cover crops (74.44 per cent), seed treatment (73.33 per cent), insecticide application sprayed during the leaf whorl (73.33 per cent), pheromone traps (71.67 per cent), insecticide application sprayed during the tassel/ cob stage (70 per cent), spacing (70 per cent), application of neem cake (68.89 per cent), insecticide application sprayed during the vegetative stage (68.33 per cent), and inter-row spacing (66.67 per cent). The sample farmers are unaware of the egg parasitoid (0 per cent) that is employed to control fall armyworm. Therefore, more than half of the farmers were aware about all the technology capsule methods used to manage the fall armyworm.

Technology-wise - Adoption of TNAU Technology Capsule

The level of adoption of TNAU technology capsule in the study area is presented in Table 2.

Table 2: Level of adoption of different TNAU technology capsule practices (n=180)

S. No	Recommended Technology Capsule Practices	Complete Adoption		Partial Adoption		Non-Adoption	
		No of Sample Respondents	% to Total	No of Sample Respondents	% to Total	No of Sample Respondents	% to Total
1.	Summer ploughing	27	15	153	85	0	0
2.	Application of neem cake	37	20.56	53	29.44	90	50.00
3.	Seed treatment	180	100	0	0	0	0
4.	Spacing	28	15.56	95	52.78	57	31.67
5.	Inter row spacing	25	13.89	87	48.33	58	37.78
6.	Cover crops	29	16.11	61	33.89	90	50.00
7.	Pheromone trap	25	13.89	65	36.11	90	50.00
8.	Egg parasitoid	0	0	0	0	180	100
9.	Insecticide application- Vegetative stage	25	13.89	155	86.11	0	0
10.	Insecticide application-Leaf whorl stage	45	25.00	135	75.00	0	0
11.	Insecticide application- Tassel/ cob stage	35	19.45	145	80.55	0	0

It could be inferred from the Table 2 that all the sample farmers had fully adopted the seed treatment practice (100 percent) because treated seeds were purchased and used for the maize cultivation. They were unaware of the egg parasitoid so the sample farmers had not adopted the egg parasitoid method. Less than 25 per cent of sample farmers fully adopted all the practices of TNAU technology capsule such as summer ploughing (15 per cent), the use of neem cake (20.56 per cent), spacing (15.56 per cent), inter-row spacing (13.89), cover crops (16.11), pheromone traps (13.89), and the application of insecticides at different stages for the control of fall armyworm (13.89 per cent at vegetative stage, 25 per cent at leaf whorl stage, 19.45 per cent at tassel/ cob stage).

More than half of the sample farmers partially adopted summer ploughing (85 percent), insecticide application at vegetative stage stages (86.11 per cent), insecticide application at tassel/ cob stage (80.55 per cent), insecticide application at leaf whorl stage (75 per cent) and spacing (52.78 per cent). More than one-fourth of sample farmers partially adopted the inter-row spacing, pheromone traps, cover crops and application of neem cake (48.33 per cent, 36.11 per cent, 33.89 per cent and 29.44 per cent, respectively). The results indicated that the majority of farmers in the study area partially adopted the technology capsule because of the high cost of inputs and lack of proper knowledge of TNAU technology capsule.

Overall Awareness and Adoption of TNAU Technology Capsule

By using cumulative percentile value, sample farmers were categorised into low, medium and high level of awareness and adoption of TNAU technology capsule. The awareness and adoption level of TNAU technology capsule is presented in Table 3.

Table 3: Level of awareness and adoption of TNAU technology capsule (n=180)

S. No	Category	Awareness		Adoption	
		Number of sample respondents	Percentage to total	Number of sample respondents	Percentage to total
1.	Low level	52	29.00	52	28.89
2.	Medium level	49	27.00	72	40.00
3.	High level	79	44.00	56	31.11
Total		180	100	180	100

It could be concluded from the above table that more than one third of the farmers had high level of awareness (44 per cent), while 29 per cent and 27 per cent of the farmers had low and medium level of awareness of TNAU technology capsule respectively.It showed that the majority of farmers were aware of the TNAU technology capsule employed for the management of fall armyworm.

With respect to the adoption of TNAU technology capsule, 40 per cent of the farmers had medium level of adoption whereas 31.11 per cent and 28.89 per cent of the farmers had high and low level of adoption respectively. The reason for the low level of adoption would be the high input cost, inadequate knowledge of the technology capsule such as application of neem cake, seed treatment, cover crops, pheromone trap and lack of subsidies for all the inputs.

Cost of Cultivation of Maize

CACP method was used for the estimation of cost of cultivation. The cost and returns of adopters and non-adopters of TNAU technology capsule are presented in Table 4.

Table 4: Cost of cultivation of TNAU technology capsule adopters and non-adopters (in Rs/ha)

S. No	Particulars	Adoption of Technology Capsule	Non adoption of Technology Capsule	Mean Differences
1.	**Cost A1**			
a.	Cost of hired human labour	23799 (33.12)	24150 (36.38)	-352^{NS}
b.	Cost of hired and owned machine labour	10484 (14.59)	10315 (15.54)	169^{NS}
c.	Cost of FYM	3238 (4.51)	3293 (4.96)	-55^{NS}
d.	Cost of seed	5959 (8.29)	5966 (8.99)	-6^{NS}
e.	Cost of fertilizers	3740 (5.20)	3859 (5.81)	-119^{NS}
f.	Cost of herbicide	582(0.81)	580 (0.87)	3^{NS}
g.	Cost of insecticides	4269 (5.94)	5869 (8.86)	-1600*
h.	Interest on working capital	1849 (2.57)	1688 (2.54)	161*
i.	Depreciation on fixed capital	257 (0.36)	220 (0.33)	37^{NS}
j.	Land revenue	26 (0.04)	26 (0.04)	0^{NS}
k.	Cost of neem cake	6314 (8.79)	-	6314*
l.	Cost of cover crops	789 (1.10)	-	789*
m.	Cost of pheromone trap	318 (0.44)	-	318*
	Total	61624 (85.75)	55964 (84.30)	5660*
2.	**Cost A2**			
a.	Rent paid for leased in land	0	0	0^{NS}
	Cost A2 = Cost A1 + Rent paid for leased in land	61624 (85.75)	55964 (84.30)	5660*
3.	**Cost B1**			
a.	Interest on fixed capital (excluding land)	1314 (1.83)	1495 (2.25)	-180*
	Cost B1 = Cost A2 + Interest on fixed capital (excluding land)	62938 (87.58)	57459 (86.55)	5479*
4.	**Cost B2**			
a.	Rental value of owned land	5742 (7.99)	5742 (8.65)	0^{NS}
	Cost B2 = Cost B1 + Rental value of owned land	68680 (95.57)	63201 (95.20)	5479*
5.	**Cost C1**			
a.	Imputed value of family labour	3182 (4.43)	3189 (4.80)	-7^{NS}
	Cost C1 = Cost B1 + Imputed value of family labour	66120 (92.01)	60648 (91.35)	5472*
6.	**Cost C2**			
	Cost C2 = Cost B2 + Imputed value of family labour	71861 (100)	66390 (100)	5472*
7.	Grain Yield (q/ha)	41.26	34.08	7.18*
8.	Returns from grains	99024	79327	19699*
9.	Straw Yield (q/ha)	9.12	7.65	1.47*
10.	Returns from straw	3010	2525	485*
11.	Gross income	102034	81852	20185*

12.	Net income	30173	15462	14713*
* -Significant at 1 per cent levelNS – Non-significant				

(Figures in the parantheses indicate percentage to total)

It could be concluded from the Table 4 that the independent t test showed the there exist a significant difference between the adopters and non-adopters of TNAU technology capsule for the variables namely cost of insecticides(-1600), interest on working capital (161), cost of neem cake (6314), cost of cover crops (789), cost of pheromone trap (318), interest on fixed capital (-180), cost A1 (5660), cost A2 (5660), cost B1 (5479), cost B2 (5479), cost C1 (5472), cost C2 (5472), grain yield (7.18), Returns from grains (19699), straw yield (1.47), returns from straw (485), gross income (20185) and net income (14713) which were significant at one per cent level.

The cost of cultivation of TNAU technology capsule adopted by sample farmers were estimated to be Rs. 71,861/ha and for non-adopters, it was estimated to be Rs. 66,390/ha. Cost A1 was calculated to be Rs. 61624/ha for technology capsule adopters which accounted for 85.75per centand Rs. 55964/ha for non-adopters, which accounted for 84.30per cent. Grain yields for adopters and non-adopters were 41.26 q/ha and 34.08 q/ha respectively. Because of the technology capsule adopted for the management of the fall armyworm, adopters have 7.18 q/ha more yield than non-adopters. The yield of straw was 9.12 q/ha for adopters and 7.65 q/ha for non-adopters.

Similar findings showed that the technology capsule developed by TNAU technology capsule reduced the population of fall armyworm thereby increasing the yield of maize was reported by Thilagam *et al*, 2020 [11]. The estimated gross income for adopters was Rs. 102034/ha, while the estimated gross income for non-adopters was Rs. 81852/ha. Net income for adopters was Rs. 30173/ha, whereas net income for non-adopters was Rs. 15462/ha. The production of maize was profitable in the research area for both adopters and non-adopters, but among them technology capsule-based cultivation was found to be more profitable.

Partial Budgeting

From the components of partial budgeting, the added returns in maize were attributed mainly through the increased productivity obtained in the adoption of technology capsule. The reduction in cost incurred was due to the cost of insecticides. However, the cost on neem cake, cover crops and pheromone traps contributed to the increase in cost of technology capsule adoption. The partial budget for the adoption of TNAU technology capsule for sample farmers is presented in Table 5.

Table 5: Partial budget of adoption of TNAU technology capsule for sample farmers

Debit	Cost (Rs/ha)	Credit	Cost (Rs/ha)
Added Cost		**Reduced Cost**	
Cost of neem cake	6314	Cost of insecticides	1600
Cost of cover crops	789		
Cost of pheromone trap	318		
Total	7421	Total	1600
Reduced Return		**Added Return**	
	Nil	Yield returns	20185
A. Total	7421	B. Total	21785
Net Increase in Income			
Credit – Debit (B-A)	14364		

It could be concluded from the above table that the additional return from adopting TNAU technology capsule for maize production was Rs. 20185/ha. The cost of insecticides was calculated to be Rs. 1600/ha which was the reduced cost for technology capsule adopters. The cost of neem cake, cover crops, and pheromone trap were the additional costs that the sample farmers faced by adopting TNAU technology capsule which was estimated to be Rs. 6314/ha, Rs. 789/ha, and Rs. 318/ha, respectively. Therefore, the total additional cost of adopting TNAU technology capsule for maize cultivation was Rs. 7421/ha.

It was found that the net increase in income per hectare for the cultivation of maize by technology capsule adopters was positive and calculated at Rs. 14364. This results clearly indicated that employing TNAU technology capsule was profitable and adopted farmers made more money than non-adopted farmers. Similar findings were found that the IPM farmers are more profit earners than non-IPM farmers was reported by Akhi and Islam 2020. The results from the partial budgeting analysis done for the adoption of SRI technique would provide an additional profit to the farmers was also reported by Devi et al, 2009.

Constraints

The constraints identified regarding the adoption of TNAU technology capsule were the high cost of inputs, lack of proper knowledge of technology, non-availability of subsidies for all inputs, non-availability of subsidy at the right time, lack of extension worker, non-availability of labour, difficult to adopt and non-availabilities of inputs. The constraints that the sample farmers encountered when adopting the TNAU technology capsule is presented in Table 6.

Table 6: Constraints for the adoption of TNAU technology capsule

S. No.	Constraints	Mean score	Rank
1.	High cost of inputs	62.26	I
2.	Lack of proper knowledge of TNAU technology capsule	57.47	II
3.	Non-availability of subsidy for all inputs	56.82	III
4.	Non-availability of subsidy at the right time	51.68	IV
5.	Lack of extension worker	51.47	V
6.	Non-availability of labour	44.22	VI
7.	Difficult to adopt	40.37	VII
8.	Non-availability of inputs	35.71	VIII

It was observed from the Table 6 that, out of the several constraints, the high cost of inputs ranks first followed by lack of proper knowledge of technology capsule, non-availability of subsidies for all inputs, non-availability of subsidy at the right time, lack of extension worker, non-availability of labour, difficult to adopt and non-availability of inputs regarding the adoption of TNAU technology capsule. So, there is need for financial assistance to farmers from the State Government by providing the subsidies regarding the high cost of inputs. The extension services must be improved to improve collaboration between extension workers and farmers to overcome the lack of proper knowledge of TNAU technology capsule. Government policies as well as rational decisions from farmers are much needed to overcome the constraints for the adoption of TNAU technology capsule.

Conclusion and Policy Recommendations

Wide disparity was observed between awareness and adoption level of TNAU technology capsule based on the descriptive evidence. The majority of sample farmers were aware of this package of practises used for TNAU technology capsule to manage the fall armyworm. More than half of the farmers in the study area partially adopted the TNAU technology capsule. Net returns per hectare of maize production were higher for technology capsule adopters than non-adopters. The partial budget analysis made clear that the net increase in income per hectare was positive for technology capsule adopters. The production of maize was profitable in the research area for both adopters and non-adopters, but among them technology capsule-based cultivation was found to be more profitable. The main constraints faced by the sample farmers were high input costs, lack of proper knowledge of technology capsule and a lack of subsidies for all inputs ranked first, second and third respectively. These limitations would force farmers for partial or no adoption of technology capsule.

The efforts like increasing the number of result demonstrations and awareness campaign to inform farmers of the profitability that can be earned by adopting TNAU technology capsule can be taken. And also, the state government may allocate more money from its annual budget for IPM technology capsule initiatives and deposit in the scheme for IPM program. As a result, more farmers may become motivated to use TNAU technology capsule techniques in the future. Additionally, the extension services must be improved to improve collaboration between extension workers and farmers. The government must pay greater attention to the cooperation between farmers and institutions and suitable promotion measures need to be taken to wide spread the adoption of TNAU technology capsule.

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