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RESEARCH PAPER

Economic effectiveness of different management practices for the control of sugarcane root grub

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Abstract: The primary objective of this study focuses on the economic effectiveness of various management practices for the control of sugarcane root grub. For the study we have selected Vijayapura district purposively and for the identification of sample snow ball techniques was employed. The study revealed that the farmers who have adopted cultural methods incurred an additional cost of ₹ 1,310 and added returns of ₹ 21,284. Farmers who have adopted mechanical method incurred an additional cost of ₹ 593 and realized additional returns of ₹ 17,211. The farmers who used *Metarizhium anisopliae* incurred an additional cost of ₹ 859 and added returns of ₹ 17695. Farmers who have adopted integrated approach incurred an additional cost of ₹ 7845 and realized additional returns of ₹ 43420. The study also revealed that during the management of root grub farmers were faced numerous problems especially non-availability of resistant varieties and unawareness about IPM.

Key words: Garett ranking, Integrated Pest Management, Root grub, Sugarcane

Introduction

Sugarcane is the primary source of crystallized sugar, with sugarcane accounting for approximately 70 per cent of global sugar production. In India, sugarcane is the sole contributor to sugar production. On a worldwide scale, India ranks second in both sugarcane area and production with the cultivated areaof 5.18 million hectares, an annual production of 439.42 million tonnes and the productivity was 84.90 tonnes per hectare (Indiastat, 2023). Sugarcane holds significant economic importance as a commercial crop in Northern Karnataka, primarily cultivated in the districts of Belagavi, Bagalkote, and Vijayapura which collectively accounts for 71.73 per cent of state's sugarcane area (Anon, 2022).

Sugarcane root grubs are widespread in sugarcane-producing countries like Brazil, India, Thailand, Australia, South Africa, the United States (Louisiana and Florida) and Southeast Asian nations (Viswanathan *et al.,* 2022). However, their distribution varies within these countries due to factors such as climate, soil conditions, and agricultural practices. Pest management strategies are region-specific, implemented by local authorities and farmers to monitor, control, and minimize damage caused by the grubs. Multiple species of root grubs exist, varying across regions based on the local insect populations (Long and Hensley, 1972).

Root grubs, also known as sugarcane white grubs, can cause significant damage to sugarcane crops. Root grubs directly harm sugarcane plants by feeding on their roots, leading to direct damage to the root system. The larvae's feeding activity disrupts the plant's ability to efficiently absorb water and nutrients from the soil, resulting in impaired nutrient uptake. This diminished nutrient availability causes stunted growth in infested plants, as the roots struggle to support optimal development (Pal, 1977).

Sugarcane plants infested with root grubs often display symptoms such as wilting and yellowing of leaves, indicating a compromised root system that struggles to supply sufficient water and nutrients. As a consequence, affected plants experience stunted growth, exhibiting reduced vigour compared to healthy counterparts. The damage inflicted by root grubs can also cause patchy or uneven growth patterns within sugarcane fields. Weakened root systems compromise the plants' anchorage making them more prone to lodging, where they topple or fall over due to weakened stability. In severe cases, root grub infestations can have a significant impact on sugarcane yields, resulting in reduced overall production levels (Madhusudhan *et al.*, 2021).

The present study focuses on the economic effectiveness of various management practices for the control of sugarcane root grub and to document the various constraints faced during sugarcane production, root grub management and the marketing of produce.

Material and methods

The present study employed a mixed-method sampling approach, where Vijayapur district in Northern Karnataka was selected purposively based on the recommendations of the Field Supervisors and Field Investigators from the Cost of Cultivation Scheme (CCS)at the University of Agricultural Sciences, Bengaluru. This district was chosen due to the severe impact of root grub infestation during 2021-22.

From the district, two tehsils were further selected in consultation with the officials of CCS, focusing on areas where the infestation was most prevalent. In the next stage, one village was selected from each tehsil. To identify respondents, the snowball sampling method was used, as there was no prior list of farmers whose sugarcane fields were affected by root grubs. Finally about 45 sample respondents were selected from each village, leading to a total sample size of 90.

To estimate the economic loss caused by the pest, data were collected from the same farmers during both the pre-infestation period (2020-21) and the post-infestation period (2021-22). In this study, data on various management practices of root grub infestation and various constraints in root grub

Table 1. Labour utilization pattern in the production of sugarcane (Per acre)

Operation	Before infestation				After infestation			
	M	W	BL	ML	M	W	BL	ML
Land preparation	-	-	2.06	2.50	-	-	2.06	2.50
FYM application	2.00	-	-	-	2.00	-	-	-
Planting	5.15	-	-	-	5.15	-	-	-
Chemical fertilizer application	2.17	1.46	-	-	2.17	2.19	-	-
Intercultural operation	-	9.00	-	1.61	-	8.00	-	1.61
Weedicide	0.50	-	-	-	0.75	-	-	-
Irrigation	5.00	-	-	-	5.00	-	-	-
Root Grub Management								
a. Cultural method	-	-	-	-	2.50	-	0.90	-
b. Mechanical method	-	-	-	-	2.00	-	-	-
c. Chemical method	-	-	-	-	2.50	-	-	-
d. Biological method	-	-	-	-	0.81	-	-	-
Total	14.81	10.46	2.06	4.11	22.90	10.19	2.96	4.11

Note: M= Men labour (Man days), W= Women labour (Man days), BL= Bullock labour (pair days) and ML= Machine labour (hrs.)

management and production and marketing of sugarcane were collected based on the recall information provided by the sample farmers. The data were gathered using a pre-tested and well-structured interview questionnaire during both the pre-infestation and post-infestation periods.

Economic effectiveness of root grub management was analysed using descriptive statistics such as mean, percentage, ratio and frequency distribution.

Added cost: These are the costs additionally incurred towards the adjustment made in the operations of controlling the root grub. Only paid out cost are considered. Added cost were taken from the farmers as an additional cost incurred towards various management practices to control the root grub.

Added return: These are the returns additionally obtained from the adjustment made in the operations. These are the returns obtained additionally by controlling the root grub.

Additional return was calculated by the assumption taken from the past studies that the yield loss due to root grub infestation was 40 per cent (Thirumurugan *et al.*, 2020). The difference in the yield due to root grub infestation with management practice and yield without root grub infestation was calculated (A1). The difference between the obtained yield (A1) and the returns of 40 per cent loss in yield was considered as added returns.

Garrett ranking

Garrett's ranking technique was used to identify constraints faced by sugarcane farmers during sugarcane production, root grub management and the marketing of produce. The determinants will be identified and prioritized by using Garrett's ranking technique by using following equation based on the primary data collected (Garret and Woodworth, 1969).

$$\text{Per cent position} = \frac{100*(Rij-0.50)}{Nj}$$

Where,

R_{ij} = Rank given for the i_{th} item by the j_{th} individual,

N_j = Number of items ranked by the j_{th} individual

Labour utilization pattern in the production of sugarcane

Comparative overview of labour utilization pattern in sugarcane cultivation on per acre basis before and after infestation has been analysed and presented in Table 1. It could be seen from the table that, land preparation required 2.06 pair-days of bullock labour and 2.50 hours of machine labour, while other operations such as FYM application and planting required 2 and 5.15 men labours were required for both before and after infestation of root grub, respectively. Chemical fertilizer application demanded 2.17 men and 1.46 women labour, while intercultural operations required 9 women labour and 1.61 machine labour. Weedicides application required 0.50 men labour, and irrigation demanded 5 men labour in before infestation of root grub and for after infestation of root grub it requires 2.19 women and 2.17 men labour for chemical fertilizer application, while intercultural operations required 8 women labour and 1.61 machine labour. Weedicides application required 0.75 men labour, and irrigation demanded 5 men labour. Root grub management require 2.50 men and 0.90 pair-days of bullock labour in cultural method, 2.00 men labours in mechanical method, for chemical method 2.50 men labours and for biological method 2.81 men labours are required.

Input use pattern in sugarcane cultivation

Input utilization pattern in sugarcane cultivation on per acre basis has been analysed and presented in Table 2. Before infestation, human labour amounted to 20.56 man-days, while bullock labour and machine labour was 2.06 pair-days and 4.11 hours per acre, respectively. The use of sets and farm yard manure remained constant at 2.83 tonnes and 3 tonnes per acre, respectively. Regarding chemical fertilizers, the input quantities for nitrogen, phosphorus, and potassium were 113.42, 81.52, and 106.33 kg per acre, respectively, before infestation. Weedicide, specifically Atrazine, required 0.75 kg per acre. Additionally, mechanical control components in the form of traps were used, totalling to the 2.38 traps per acre.

After infestation, the input quantities for human labour increased to 28.35 man-days because extra labours were used for mechanical and biological control, while bullock labour and machine labour remained the same at 2.96 pair-days and 4.11 hours per acre, respectively. Setts required to cultivate

Table 2. Input utilization pattern in sugarcane cultivation (Per acre)

Inputs	Units	Before infestation	After infestation
Human labour	Mandays	20.56	28.35
Bullock labour	Pair days	2.06	2.96
Machine labour	hrs	4.11	4.11
Sets	t	2.83	2.83
Farm yard manure	t	3.00	3.5
Chemical Fertilizers			
A.N	kg	113.42	121.34
B. P	kg	81.52	87.21
C.K	kg	106.33	113.76
Weedicides			
A.Atrazine	kg	0.75	0.75
Mechanical control components			
A.Traps	nos.	-	2.38
Bio pesticides			
A.*Metarizhium anisopliae*	kg	-	4
Plant protection chemicals			
A.Chloropyriphos	ltrs	-	2.5
B.Phorate 10G	kg	-	3.61
Irrigation	acre inch	160	180

sugarcane in one acre remains same. While, farm yard manure experienced slight increase (3.5 tonnes). Chemical fertilizers quantities for nitrogen, phosphorus, and potassium increased to 121.34, 87.21, and 113.76 kg per acre, respectively. Weedicides usage remained constant at 0.75 kg per acre. Notably, bio pesticides, specifically *Metarizhium anisopliae*, were introduced, with 4 kg per acre being used. Insecticides like Chloropyriphos and Phorate 10G were also applied, with quantities of 2.5 litre and 3.61 kg per acre, respectively. Irrigation increased from 160 acre inches to 180 acre inches after infestation this is mainly due to the flooding of sugarcane plots to control the root grub in the study area.

Various management practices followed by sample respondents

Various management practices followed by sample respondents in sugarcane cultivation in study area is depicted in Table 3. The farmers have followed different methods such as cultural, mechanical, chemical, biological and integrated methods for the management of root grub in the study area.

Table 3.Various management practices followed by sample respondents

Method	No of farmers	Percent of farmers
Cultural methods		
A. Deep ploughing	75	83.30
B. Flooding	90	100.00
Mechanical methods		
A.Trap	62	68.90
B.Collection of grub and shaking of host plant	90	100.00
Chemical methods		
A. Chloropyriphos 50EC	68	75.60
B. Phorate	65	72.20
Biological Method		
A. *Metarizhium anisopliae*	64	71.11
Integrated methods	57	51.30

Under cultural methods, the majority of respondents (83.3%) employed deep ploughing, while all of them used flooding techniques, indicating a high prevalence of these practices among the surveyed farmers. Mechanical methods included the use of traps and grub collection. A significant portion (68.9%) of farmers utilized traps, while all farmers practiced grub collection, highlighting the widespread adoption of these mechanical control measures. In chemical methods substantial proportion of farmers (75.6%) used Chloropyriphos 50EC, and 72.2 per cent farmers employed Phorate for pest management. In terms of biological method, *Metarizhium anisopliae* was adopted by 71.11 per cent of the sample respondents in the study area. Integrated method was adopted by 51.30 per cent of the sample respondents in the study area.

Effectiveness of various management practices among sample respondents in sugarcane cultivation

Data provided in Table 4 evaluates the effectiveness of various management practices among sample respondents in sugarcane cultivation, categorizing their responses into three levels: highly effective, moderately effective, and less effective.

Among cultural methods, about 83.33 per cent of respondents opined that flooding was predominantly considered as highly effective. In contrast, deep summer ploughing was found to be moderately effective as revealed by 29.30 per cent of respondents. In case of mechanical methods, about 62.22 per cent of respondents opined that collection of grubs and shaking host plants emerged as highly effective. On the other hand, 56.45 per cent of respondents revealed that Light traps were moderately effective, while 11.29 per cent respondents found them less effective.

Majority of respondents (70.59%) have adopted application of Chloropyriphos 50EC as management practice in chemical method. While, application of Phorate 10G received a moderate effectiveness rating from 53.85 per cent of respondents and it was also considered as less effective by 18.46 per cent of respondents. About 78.12 per cent of sample respondents have adopted application of *Metarizhium anisopliae* Dust in biological method as management practice and it was considered highly effective. About 87.71 per cent of respondents found integrated methods highly effective.

The results are in line with study conducted by Theurkar *et al.* (2013) wherein they reported that the larvae (grubs) and pupae stages, which primarily occur from August to April, are the most susceptible stages to control measures such as flooding, bio pesticides, or chemical interventions.

Added costs and added returns from sugarcane cultivation under different methods of root grub management

The farmers in the study area have adopted various methods for the management of root grub *viz*., cultural method, mechanical method, chemical method, biological method and integrated method. The farmers who have adopted cultural methods incurred an additional cost of ₹ 1,310 and added returns of ₹ 21,284 (Table 5). Farmers who have adopted mechanical method incurred an additional cost of ₹ 593 and realized additional returns of ₹ 17,211. Farmers have adopted two mechanical methods *i.e.,*

Table 4. Effectiveness of various management practices among sample respondents in sugarcane cultivation

Management practices	No. of farmers	Highly effective	Per cent	Moderately effective	Per cent	Less	Per cent effective
Cultural methods							
A. Flooding	90	75	83.33	10	11.11	5	5.56
B. Deep summer ploughing	75	43	57.33	22	29.3	10	13.33
Mechanical methods							
A. Light trap	62	20	32.26	35	56.45	7	11.29
B. Collection of grub and shaking host plants	90	56	62.22	24	26.67	10	11.11
Chemical methods							
A. Phorate 10G	65	18	27.69	35	53.85	12	18.46
B. Chloropyriphos 50EC	68	15	22.06	48	70.59	5	7.35
Biological method							
A. *Metarizhium anisopliae* Dust	64	50	78.12	10	15.62	4	6.25
Integrated methods	57	50	87.71	5	8.77	2	3.50

Table 5. Added costs and added returns from sugarcane cultivation under different methods of root grub management

Method	Number	Added Cost (AC)	Added Returns (AR)	AR-AC
Cultural methods	90	1310	21284	19974
Mechanical methods	90	593	17211	16618
Chemical methods	68	1881	20185	18304
Biological Method (*Metarizhium anisoplie*)	64	859	17695	16836
Integrated methods	57	7845	43420	35575

collection of grub and shaking of host plants and use of traps. The farmers who have adopted cultural methods incurred an additional cost of ₹ 1,881 and added returns of ₹ 20,185. The farmers who have used *Metarizhium anisoplie* for the control of root grub incurred an additional cost of ₹ 859 and added returns of ₹ 17695. Farmers who have adopted integrated approach *i.e.* all the four methods of root grub management incurred an additional cost of ₹ 7845 and realized additional returns of ₹ 43420. It is clear from the study that the integrated method approach is more beneficial as compared to adoption of individual methods to control root grub since, farmers who adopted integrated approach realized more added returns as compared to individual methods. The results are in line with study conducted by Lamani *et al*. (2017)

Constraints faced by sugarcane growers in management of root grub Constraints associated with root grub management in sugarcane production were depicted in Table 6. Among the nine constraints listed, non-availability of resistant varieties was ranked first with a mean garret score of 70.34, this might be due to lack of research and not available during planting. The unawareness about pest and IPM was ranked second with a mean garret score of 63.44, this was mainly due to lack of training to sugarcane growers regarding root grub management practices. The third most limiting factor was lack of irrigation water availability with a mean score of 57.16, this was due to irregular rainfall pattern in the study area. The Less effective of insecticides was ranked fourth with a mean score of 56.51, this was due to root grub infestation was soil borne and insecticides would be not effective. The non-availability of labour for pest control ranked fifth with a mean score of 46.71this was due this was due to scarcity of labour during peak period and high wage rate followed by Lack of guidance from concerned

Table 6. Constraints faced during management of root grub by sugarcane growers

Particulars	Mean Garret Score	Rank
Non-availability of resistant variety	70.34	I
Unawareness about IPM	63.44	II
Lack of irrigation water availability	57.16	III
Less effective of insecticides	56.51	IV
Non availability of labour for pest control	46.71	V
Lack of guidance from concerned officials	45.12	VI
Difficult to enter the field after six months	41.87	VII
More cost for different pest management practices	40.02	VIII
Efficacy of bio agent	32.82	IX

officials with a mean score of 45.12. The seventh constraint was difficult to enter the field after six months with a mean score of 41.87, because sugarcane will grow vigorously and movement in between the rows become difficult. The More cost for pest different management practices ranked eighth with mean score of 40.02 because of expensive pesticides, labour unavailability and more wage rate and efficacy of bio agent was ranked last with a mean score of 32.82. Similar results were reported by Furlan *et al*. (2006) wherein they reported that it is difficult to effectively use synthetic insecticides against soil pests due to problems of leaching, adsorption or rapid break down, and the impracticality of applying contact pesticides.

Constraints faced by sugarcane growers during production

The results of Garrett ranking analysis of problems associated with production of sugarcane are depicted in Table 7. Among eight factors listed, scarcity of labour and more wages was the major problem expressed by most of the farmers was ranked first with a mean Garett score of 69.11. In study area the labour scarcity was more and when labour was available, their wages were high and farmers also had to provide tea, meals and pan masala. So, this problem got assigned first rank. Insufficient irrigation water during peak period was ranked second with a mean Garett score of 63.82. Irrigation facilities were only available from the canal for a specific period and farmers had to use other sources of irrigation when there was no water in the canal. Thus, the insufficient irrigation water during peak period was ranked second. The pest and disease occurrence was ranked third with a mean Garett score of 56.77

Table 7. Constraints faced by sugarcane growers during production

Constraints	Mean Garret Score	Rank
Scarcity of labour and more wages	69.11	I
Insufficient irrigation water	63.82	II
Pest and disease occurrence	56.77	III
Lack of knowledge of scientific crop production	56.67	IV
High expenses on agricultural chemicals, fertilizers and insecticides	55.88	V
Limited and irregular supply of electricity	46.52	VI
Delayed harvesting	45.30	VII
Impact of weather	39.93	VIII

followed by lack of knowledge of scientific crop production (56.67), higher input prices *i.e*. high expenses on agricultural chemicals, fertilizers and insecticides (55.88). Limited and irregular supply of electricity (46.52) was the sixth constraint, as the electricity supply was irregular, and power cuts occurred during the day or night, creating problems for irrigation. The seventh limitation was delayed harvesting (45.30) in sugarcane cultivation farmers had to stop irrigation before harvesting of crop to prevent weight loss. Therefore, specific harvesting dates were assigned to farmers, but delayed in harvesting occurred due to a lack of labour. Finally unseasonal rains caused sugarcane flowering issues, leading to the Impact of weather (39.93). Similar results were reported by Chavhan *et al*. (2018) wherein they reported that, majority of respondents had problem of high cost of fertilizers and pesticides followed by, lack of knowledge on management of pests, Inadequacy of irrigation water at proper time and Irregular supply of electricity.

Marketing constraints faced by sugarcane farmers

Challenges encountered by sugarcane growers in the study area during marketing of produce were depicted in Table 8. It is

Table 8. Marketing constraints faced by sugarcane farmers

Particulars	Mean Garret Score	Rank
Price volatility	62.92	I
Limited market options for selling of sugarcane	50.64	II
Absence of on-farm weighing facilities	49.43	III
Higher transportation cost	39.00	IV

evident from the results that, price volatility was the foremost obstacle faced by sugarcane growers during marketing produce, which had the highest mean score of 62.92, signifying its primary hindrance. Limited opportunities to sell sugarcane in the study area were the second most significant impediment with mean score of 50.64. Absence of on-farm weighing facilities was ranked third with garret score of 49.43 followed by higher transportation costs (39.00). The results of Balas and Prajapati (2023) are in line with the current study wherein they reported that reduced sugarcane prices and elevated shipping expenses are the major marketing constraints faced by sugarcane growers.

Conclusion

The increased human labour was mainly due to higher labour usage for the control of root grub in sugarcane crop after the infestation. Farmers who have adopted integrated approach to control root grub realized more returns as compared to other control measures. Non-availability of resistant varieties, unawareness about IPM, lack of irrigation water availability and less effective of insecticides were major constraints faced by sugarcane growers during root grub management. Farmers need to be educated through trainings regarding preventive measures and early detection by government agencies, agricultural universities, and farmers' associations to create a robust support network for knowledge-sharing and resource access, so as to reduce the economic losses due to root grub infestation.

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