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IMPACT OF THE SUDDEN BAN ON CHEMICAL FERTILIZERS AND OTHER AGROCHEMICALS ON SMALLHOLDER TEA PRODUCTION IN THE RATNAPURA DISTRICT, SRI LANKA

PUNCHI HEWAGE NADEEKA KUMARI^{ID*}, SUDU HAKURUGE PUSHPA MALKANTHI^{ID}

Department of Agribusiness Management, Faculty of Agricultural Sciences, Sabaragamuwa University of Sri Lanka, Belihuloya, Sri Lanka

*Corresponding author: punchihewa.nadeeka@gmail.com



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SUMMARY

In April 2021, the government of Sri Lanka abruptly banned chemical fertilizers and other agrochemicals in a bid to safeguard the country's agricultural industry, particularly its farmers and consumers, from various health and environmental concerns. Therefore, it is critical to assess the impact of prohibiting chemical fertilizers and other agrochemicals on the smallholder tea production in the country. Additionally, understanding the smallholders' awareness of agrochemicals and their attitudes toward transitioning to organic farming is essential, as these factors hold significant importance for various aspects of the economy. The Ratnapura district was selected as the research area, owing to its extensive tea cultivation across numerous Divisional Secretary (DS) divisions. For this study, a sample of 120 tea smallholders was randomly chosen from three DS divisions (Balangoda, Opanayaka, Imbulpe), representing the entire district, who supply green leaves to the ABC tea factory in Balangoda. Research data were collected through a field survey conducted between September and November 2022. Descriptive statistics and paired t-tests were employed for data analysis. Additionally, the costs incurred for chemical fertilizers and other agrochemicals, the total cost of production, as well as tea production before and after the implementation of the fertilizer policy, were analyzed using paired t-tests. The results obtained indicate that the majority of tea smallholders possess a high level of education, with most owning tea lands ranging from 0.5 to 1.0 acre. Furthermore, a vast majority of them demonstrate understanding of both the positive and negative aspects of agrochemicals. Notably, the analysis reveals a significant increase in the cost of chemical fertilizers and other agrochemicals, as well as the total cost of production, following the implementation of the fertilizer policy. Conversely, tea production has shown a significant decrease. Moreover, farmers express willingness to transition gradually from conventional farming practices if suitable alternatives are available. However, they currently face a myriad of challenges due to the lack of effective alternatives for chemical fertilizers and agrochemicals. Consequently, there is a pressing need to identify and implement better alternatives to address their concerns.

Key words:

agrochemicals, chemical fertilizers, environmental pollution, organic farming, tea smallholders

Abbreviations:

DS - Divisional Secretariat; GND - Grama Niladari Divisions; GN - Grama Niladari; TSHDA - Tea Small Holding Development Authority

INTRODUCTION

Tea (*Camellia sinensis*) is an endemic plant in India. Tea cultivation was introduced to Sri Lanka in 1867 during the colonial period by James Taylor. Since then, tea, famously known as Ceylon Tea, has gained popularity worldwide. In Sri Lanka, tea is esteemed as one of the most vital commercial crops (Mohamed Ziyad & Zoysa, 2006). The commercial tea plantation was initiated in Sri Lanka by James Taylor, a Scotsman, in 1867, on a 19-acre plot of land in Loooleconda Estate, Hewaheta, to explore tea as a potential alternative crop for coffee (Sivapalan et al., 1986). For over a century, tea has been the leading sector contributing to job creation, export earnings, and government revenue since Sri Lanka gained independence in 1948. Tea, rubber, and coconut collectively accounted for over 92% of the country's total export earnings (Athukorala & Huynh, 1987). The tea industry plays a crucial role in the Sri Lankan economy by generating foreign currency, contributing to GDP, creating employment opportunities, and facilitating consumer spending. In 2019, the Sri Lankan tea production reached 300.1 million kilograms, representing 10% of all the agricultural value added, 0.7% of GDP, and 11.3% of the total export income (Central Bank of Sri Lanka, 2019). Small-scale tea farmers generally achieve higher yields compared to large-scale plantations, as they can frequently replant and rejuvenate old tea plantations with more productive plants (Central Bank of Sri Lanka, 2019). Smallholder farmers are the main contributors to tea production in Sri Lanka, producing 70% of the country's tea and generating significant export revenue (Bathige, 2022). Currently, smallholders cultivate 60% of the country's tea production area (Mohomad Esham et al., 2018). Various definitions of smallholder tea farms exist in Sri Lanka. Under the Tea Control Act of 1958, tea estates spanning less than 10 acres are classified as "Tea Small Holdings." Additionally, development activities involving 10 to 50 acres of land have been recognized as smallholder development by the Sri Lanka Tea Board. Sri Lanka exports 90% of its tea to the global market, with only 10% consumed domestically. Ceylon tea commands a premium price globally, primarily due to the high production costs in Sri Lanka, making Sri Lankan tea the most expensive to produce worldwide (Hilal, 2019). Smallholders play a pivotal role in Sri Lanka's tea industry, with approximately 500,000 small farmers contributing significantly to the production of Ceylon tea locally and internationally. Often referred to as the 'backbone' of the tea industry, smallholders cultivate 60% of all tea land and produce over 70% of all tea in Sri Lanka. According to the Tea Control Law, tea estates ranging from 20 perches to 10 acres are designated as "small tea estates" nationwide (Sri Lanka Federation of Tea Small Holders, 2020).

Chemical fertilizers are currently the primary fertilizers used in most countries, including Sri Lanka, due to their ease of handling, ability to provide precise amounts of nutrients, and efficiency in nourishing tea plants with minimal application. Fertilizer usage is largely influenced by the availability of direct distribution by the country and the longstanding practice of using organic fertilizers. It is crucial to educate smallholders on fertilizer utilization to enhance farm efficiency. However, smallholders who rely on fertilizers predominantly use zinc alone or a combination of zinc and copper (Perera, 2014). Among smallholders, T200, T750, U709, Urea, Kiserite, Zinc Sulfate, Dolomite, Epsom salt, and Magnesium sulfate are the most commonly utilized chemical fertilizers. It has been observed that the majority do not employ pesticides for their tea plantations. However, a limited number of pesticide users did not receive recommendations for any products classified by relevant authorities (Perera, 2014). The recommended pesticides for tea cultivation include Fipronil, Atabron, and Brunolium, whereas the recommended herbicides include Goal 2E, Dyrone, and MCPA.

In April 2021, the Import and Export (Control) Ordinance No. 07 of 2021 was issued, which prohibited the import of chemical fertilizers, pesticides, and herbicides. Subsequently, the requirement for chemical fertilizer import licensing replaced the import ban in 2021 (MONLAR, 2021). As of the time of writing this article, no licenses have been issued for the importation of chemical fertilizers, despite changes in legislation. Fertilizer subsidies, alongside other incentives, have contributed to increased food availability, export earnings, farm income, and food self-sufficiency in Sri Lanka. However, the substantial cost of these subsidies has diverted funds away from other government spending in the agricultural sector. In 2020, approximately \$218,851,000 (LKR 34,966,000,000) was spent on subsidizing fertilizers for food crops, constituting 53.6% of government spending in the agricultural sector (Finance Ministry of Sri Lanka, 2020). Consequently, farmers are increasingly transitioning to organic farming practices with the encouragement of the government.

Research Problem

The Sri Lankan government abruptly prohibited the importation of chemical fertilizers and other agrochemicals in April 2021. This measure aimed to save Sri Lanka \$300-400 million in foreign exchange, which the country spends annually on importing agrochemicals (MONLAR, 2021). By the end of 2021, Sri Lanka's tea smallholders estimated a 30% year-on-year drop in harvests, with further reductions in total output anticipated by March 2022 due to the lack of definitive measures to address drastic fertilizer deficits resulting from the controversial importation ban. The

Sri Lanka's total tea production exceeds 70%, with the small-scale tea sector comprising approximately 500,000 landowners spread across 138,900 hectares, 14 districts, 123 Divisional Secretariat Divisions (DSDs), and 3,692 Grama Niladari Divisions (GNDs). This sector is deeply intertwined with the country's economy, impacting over 5,000 villages and approximately 20% of the island's rural population (Dairy FT, 2021). The sudden implementation of the fertilizer policy has left farmers facing unexpected challenges related to soil nutrition levels, management practices, production costs, and the quantity and quality of tea yields. Accordingly, it is essential to explore the issues experienced by farmers due to the sudden prohibition of chemical fertilizers, particularly concerning the performance of tea smallholder production in Ratnapura district, Sri Lanka.

Therefore, this study attempts to address the existing gap in the literature by examining the following research questions:

1. What are the socio-economic characteristics shared by tea smallholders who use chemical fertilizers and other agrochemicals in the Ratnapura district?
2. What are the impacts of the sudden prohibition of chemical fertilizers and other agrochemicals in Sri Lanka on the cost of these inputs and the total cost of tea production before and after the prohibition?
3. What are the effects of the sudden prohibition of chemical fertilizers and other agrochemicals on the yield of tea smallholders?
4. What is the level of awareness among farmers regarding the effects of using chemical fertilizers and other agrochemicals?
5. What are the attitudes of smallholders toward the sudden prohibition of chemical fertilizers and other agrochemicals, and what is their inclination towards transitioning to organic farming?
6. What are the potential alternatives to chemical fertilizers and other agrochemicals currently used by tea smallholders, and how practical are they?

Research Objectives

The main objective of this study was to ascertain the impacts of the sudden ban on chemical fertilizers and other agrochemicals on the performance of smallholder tea production in the Ratnapura district. The specific objectives were as follows:

- examine the impact of the sudden ban on chemical fertilizers and other agrochemicals on the cost of chemical fertilizers and other agrochemicals, as well as the cost of production,
- assess the impacts of the sudden ban on chemical fertilizers and other agrochemicals on the yield of tea smallholders,
- determine the level of farmers' awareness of the impacts of the use of chemical fertilizers and other agrochemicals,
- identify the farmers' attitude towards the sudden ban on chemical fertilizers and other agrochemicals and their inclination towards transitioning to organic farming, and
- establish possible alternatives and evaluate their practicability for chemical fertilizers and other agrochemicals currently used by tea smallholders.

MATERIAL AND METHODS

Conceptual framework

According to the conceptual framework provided, the sudden ban on chemical fertilizers and other agrochemicals has resulted in several effects on smallholder tea growers. These effects include variations in the price paid for fertilizer and other agrochemicals, changes in the cost of production, fluctuations in tea production (yield), and the search for alternatives to chemical fertilizers and other agrochemicals. Furthermore, the transition to organic farming impacts farmers' socioeconomic factors, awareness of chemical fertilizers and other agrochemicals, attitudes towards the sudden ban, and the overall effects of banning chemical fertilizers and other agrochemicals.

Primary data were collected through a researcher-administered field survey conducted among tea smallholders who supply green leaves to the ABC tea factory in Balangoda. The objectives of the study were explained to the participants, and they were invited to participate in the research. Secondary sources, including research literature, articles, journals, theses, and websites, were also utilized.

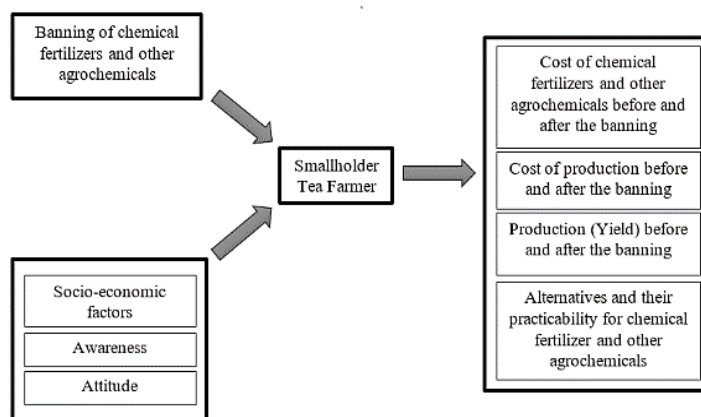


Figure 1. Conceptual framework

Official websites such as ABC Tea Factory, Sri Lanka Tea Board, Department of Census and Statistics, and Central Bank of Sri Lanka provided secondary data for the study. The target population comprised tea smallholders registered in the active supplier base of the ABC tea factory in Balangoda, totaling 5,400 suppliers. Due to time and budget constraints, a sample of 120 suppliers was randomly selected from this population. The selected suppliers were from three divisional secretariat divisions (Balangoda, Imbulpe, Opanayaka) in the Ratnapura District, where the study was conducted from September to November 2022.

Since the majority of tea smallholders are located in these three divisional secretariat divisions, the target population was effectively covered within these areas. To achieve the study objectives, both quantitative and qualitative research approaches were employed. Among the 5,400 tea smallholders, 120 were randomly selected for the survey, with 40 smallholders chosen from each division. Data analysis involved descriptive statistics and paired t-tests. Additionally, t-tests were utilized to analyze the cost of tea production and tea yield before and after the implementation of the fertilizer policy. Three pairs of hypotheses were formulated for the study.

The first pair of hypotheses was designed to contrast the cost of chemical fertilizers and other agrochemicals before and after the interdiction of chemical fertilizers and other agrochemicals:

H_0 : The difference between the cost of chemical fertilizers and other agrochemicals before and after the interdiction is equal.

H_1 : The difference between the cost of chemical fertilizers and other agrochemicals before and after the interdiction is not equal.

The second pair of hypotheses was designed to contrast the cost of production before and after the interdiction of chemical fertilizers and other agrochemicals:

H_0 : The difference between the cost of production before and after the interdiction is equal.

H_1 : The difference between the cost of production before and after the interdiction is not equal.

The third pair of hypotheses was designed to contrast the tea yield (production) before and after the interdiction of chemical fertilizers and other agrochemicals:

H_0 : The difference between the tea yield before and after the interdiction is equal.

H_1 : The difference between the tea yield before and after the interdiction is not equal.

RESULTS AND DISCUSSION

Socio-economic Factors of the Tea Smallholders

A descriptive analysis was conducted to collect background information on the tea smallholders considered. Consequently, the most significant socio-economic factors of the smallholders were examined, and the results are presented in Table 1.

Table 2. Socio-economic characteristics of the tea smallholders (n=120)

Socio-economic character		Frequency	Percentage (%)
Gender	Male	78	65
	Female	42	35
Age (years)	25-35	09	7.0
	36-45	32	27
	46-55	38	32
	56-65	34	28
	>66	07	7.0
Marital status	Married	102	85
	Unmarried	16	13
	Widowed	02	2.0
Education	Primary	03	3.0
	Junior Secondary	35	29
	Senior Secondary	64	53
	Diploma	13	11
	Graduate	05	4.0
	Postgraduate	00	0.0
	Other	00	0.0
Family size	<3	05	4.0
	3-5	91	76
	>5	24	20
Land size (Ac)	<0.25	03	3.0
	0.25-0.5	34	28
	0.5-1.0	72	60
	>1.0	11	9.0
Monthly income (LKR)	<25,000	03	3.0
	25,000-50,000	71	59
	50,000-75,000	35	29
	>75,000	11	9.0
Monthly tea income (LKR)	<25,000	37	31
	25,000-50,000	61	51
	50,000-75,000	18	15
	>75,000	4	3.0

In accordance with Table 1, the majority of those interviewed (65%) were male smallholders. Among them, 32% fell into the age group of 46-55, whereas 28% belonged to the 56-65 age group. Additionally, 27% were in the age category of 36-45 years. This indicates that young individuals are not shying away from tea cultivation, as they are engaged in similar proportions to their older counterparts. Most individuals engage in tea cultivation as an additional source of income. Regarding the marital status, the majority (85%) of the respondents were married. In terms of education, a significant proportion (53%) had completed their education up to the senior secondary level (grades 10-13, or age 15-18), whereas another substantial percentage (29%) had completed education up to the junior secondary level (grades 6-9, or age 10-14). Therefore, they possess a reasonable level of education. In relation to the family size, most respondents belonged to the category of 3-5 members. Consequently, many of them utilize family labor for tea cultivation and harvesting. Although farmers possess varying sizes of tea land, the majority (60%) have land ranging from $\frac{1}{2}$ to 1 Acre, with 28% owning land between 0.25 and 0.5 Acres. Turning to the monthly income, the data reveals that 59% of respondents received between 25,000 and 50,000 LKR per month, while 29% received between 50,000 and 75,000 LKR per month. Thus, the majority receive a relatively modest income per month, which may not be sufficient to meet their basic needs.

The impact of the sudden ban on chemical fertilizers and other agrochemicals on the cost of chemical fertilizers and other agrochemicals, cost of production, and tea yield

The table 2 details the cost of production for green leaves. Fixed costs are constant at 15.8, with a cost per kilogram at 4.0. Variable costs, including plucking, fertilizer application, and other cultivation, total 34.3. The overall cost of production (Total COP) combines these costs.

Table 2. Cost of production calculation

Operation	Worker requirement (Man days)	Worker cost	Material cost	Total cost	Cost/Kg Green leaves
Fixed cost	-	-	-	15.8	4.0
Variable cost	280.0			135756.0	34.3
Plucking	207.0	82753.0		82.8	20.9
Fertilizer application	1 Liter	4211.0	10508.0	14.7	3.7
Other field cultivation	62.0	26.7	4.4	38284.0	9.7
Total COP	280.0	113687.0	14952.0	151572.0	38.3

Table 3 indicates that the p-values for Pair 1 (the cost of chemical fertilizers and agrochemicals before and after the interdiction), Pair 2 (the cost of production before and after the interdiction), and Pair 3 (the tea yield before and after the interdiction) are all less than 0.01. Therefore, we can conclude that there is a significant difference between the cost of chemical fertilizers and other agrochemicals before and after the ban, the cost of production before and after the ban, and the tea yield before and after the ban. The mean differences in Pair 1 and Pair 2 (negative values) indicate a significant increase in the cost of chemical fertilizers and other agrochemicals and the cost of production after the ban. In Pair 3, the mean difference (positive value) indicates a significant decrease in tea yield after the banning of chemical fertilizers and other agrochemicals. Due to the unavailability of chemical fertilizers and other agrochemicals and their high prices, tea smallholder farmers have resorted to using various other organic fertilizers, weedicides, and pest control organic methods. This has led to an increase in the cost spent on inputs and production, while also resulting in a reduction in tea yield.

Table 3. Results of the Paired Sample Tests

		Paired Differences						t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference					
					Lower	Upper				
Pair 1	Cost of Agrochemicals Before Banning – Cost of Agrochemicals After Banning	-3635.02	1561.22	142.52	-3917.23	-3352.82	-9.15	119	.000	
Pair 2	Cost of Production Before Banning - Cost of Production After Banning	-70.14	32.81	2.99	-76.07	-64.21	-1.26	119	.000	
Pair 3	Yield Before Banning – Yield After Banning	84.65	44.95	4.10	76.52	92.77	2.03	119	.000	

Smallholders' awareness of the impact of chemical fertilizers and other agrochemicals

The level of awareness among smallholders regarding the positive and negative impacts of chemical fertilizers and other agrochemical products, as well as their sources of knowledge, was assessed. The findings are presented in Tables 4 and 5.

To assess smallholders' awareness of the impact of chemical fertilizers and other agrochemicals, eight statements were presented along with a 5-point Likert scale ranging from Strongly Agree to Strongly Disagree. Values were assigned to the Likert scale points as follows: 5 for Strongly Agree, 4 for Agree, 3 for Neutral, 2 for Disagree, and 1 for Strongly Disagree. The results are summarized in Table 4.

Table 4. Tea smallholder's awareness of the impact of chemical fertilizers and other agrochemicals

No	Statement	Mean	Std. Deviation	Remark
Level of awareness of the impact of using chemical fertilizers				
1	Chemical fertilizers enhance the yield.	4.81	.395	Strongly Agree
2	Chemical fertilizers adversely affect human health causing many diseases.	3.73	.501	Agree
3	Chemical fertilizers adversely affect the environment.	3.87	.448	Agree
4	Chemical fertilizers are mainly imported from other countries.	3.91	.367	Agree

Level of awareness of the impact of using other agrochemicals				
5	Other agrochemicals enhance the yield.	4.71	.456	Strongly Agree
6	Other agrochemicals adversely affect human health causing many diseases.	3.73	.530	Agree
7	Other agrochemicals adversely affect the environment.	3.84	.467	Agree
8	Other agrochemicals are mainly imported from other countries.	3.96	.474	Agree

According to Table 4, the smallholders' awareness regarding the impact of utilizing chemical fertilizers and other agrochemicals was evaluated. The first and fifth statements received very high mean values (>4), indicating strong agreement with these statements. Additionally, the smallholders generally agreed with the other six statements. Therefore, it can be concluded that the majority of the smallholders possess significant knowledge about the impact of using chemical fertilizers and other agrochemicals, including both advantages and disadvantages.

The sources of information regarding the impact of using chemical fertilizers and other agrochemicals by the smallholders were also evaluated. Data were collected using multiple response questions from the sample, and the results are presented in Table 5.

Table 5. Smallholders' sources of information (n=120, total cases= 220)

Factor		Responses		Percent of cases (%)
		N	Percent (%)	
Source	Tea instructor/inspector	96	45	80
	Agrochemical retail shops	50	23	42
	Mass media (Newspapers, Radio, Internet)	16	07	13
	Tea factory	33	15	28
	Other farmers	25	11	21
Total		220	100	184

According to the information presented in Table 5, various sources of information are available to tea smallholders in this region. The most common source is the tea instructor/inspector (80%), followed by tea smallholdings development societies, which are well-established in every Grama Niladhari (GN) division and are supported by the Tea Small Holdings Development Authority (TSHDA). Agrochemical retail shops (42%) also serve as significant sources of information, as they sell chemical fertilizers and other agrochemicals. Additionally, 28% of smallholders obtain knowledge from the tea factory (ABC Tea Factory) through monthly meetings conducted by the factory, which provides various services to its green leaf suppliers.

However, only 13% of smallholders have access to mass media sources such as newspapers, radio, and the internet for gaining knowledge. It is noteworthy that while agrochemical sellers provide cultivation information to small-scale farmers, this information may sometimes lack appropriate comprehension. Another significant factor is that farmers in the country still utilize fewer forms of mass media, particularly the internet.

The smallholders' attitude towards the sudden ban on chemical fertilizers and other agrochemicals, and the shift towards organic farming

The smallholders' attitude towards the sudden ban on chemical fertilizers and other agrochemicals, and the shift towards organic farming, was assessed using a 5-point Likert scale ranging from Strongly Agree to Strongly Disagree. Values of 5, 4, 3, 2, and 1 were assigned to the Likert scale points, respectively. The results are presented in Table 6.

Table 6. Smallholders' attitudes towards the sudden ban on chemical fertilizers and other agrochemicals, and the shift towards organic farming (n=120)

No	Statement	Mean	Std. Deviation	Remark
Smallholders' attitude towards the sudden ban on chemical fertilizers and other agrochemicals				
1	Aware of the chemical fertilizers and other agrochemicals importation ban	4.81	.395	Strongly Agree
2	Chemical fertilizers and other agrochemicals import ban is a good act	3.73	.501	Agree
3	Chemical fertilizers and other agrochemicals import ban will facilitate the control of human diseases	3.87	.448	Agree
4	Chemical fertilizers and other agrochemicals import ban facilitate the shift towards organic farming	3.91	.367	Agree
5	Chemical fertilizers and other agrochemicals import ban facilitate environmental protection	4.71	.456	Strongly Agree

6	Chemical fertilizers and other agrochemicals import ban reduces the yield	3.73	.530	Agree
7	Chemical fertilizers and other agrochemicals import ban causes farmers to shy away from farming	3.84	.467	Agree
Smallholders' attitude towards transitioning from inorganic farming to organic farming				
1	Organic farming is a successful method for tea cultivation	1.41	.804	Strongly Disagree
2	Prefer to cultivate 100% organically	1.28	.505	Strongly Disagree
3	Prefer to cultivate 50% organically and 50% inorganically	1.26	.476	Strongly Disagree
4	Prefer to cultivate 25% organically and 75% inorganically	3.60	1.133	Agree
5	Prefer to cultivate 75% organically and 25% inorganically	1.31	.719	Strongly Disagree
6	Not prefer to use organic farming	4.27	1.137	Agree

As shown in Table 6, the upper section consists of 7 statements concerning the farmers' attitudes toward the sudden banning of chemical fertilizers and other agrochemicals. The mean values for the first and fifth statements are notably high (>4). This indicates strong agreement among the farmers with these two statements, as reflected by the elevated mean values. Additionally, the farmers express agreement with the other 4 statements. Consequently, it can be inferred that the majority of the farmers possess a comprehensive understanding of the impacts associated with the sudden prohibition of chemical fertilizers and other agrochemicals, encompassing both advantages and disadvantages. From the farmers' perspective, the sudden ban is perceived as a less effective policy, despite its benefits for the farmers' health and the environment. Hence, the smallholders' attitudes towards transitioning from inorganic to organic farming were investigated, with the results outlined in Table 6. The remaining six statements in the lower segment of Table 6 pertain to the smallholders' attitudes regarding this transition. According to the findings, the mean values for four statements are notably low (<2). These low mean values indicate strong disagreement among the smallholders with those four statements, while agreeing with the other two. Consequently, it can be concluded that most of the smallholders consider the sudden transition to organic farming as ineffective and impractical, preferring a gradual shift towards organic farming.

Possible alternatives to chemical fertilizers and other agrochemicals currently used by the smallholders and their practicability

The study delved into alternatives to chemical fertilizers and other agrochemicals utilized by smallholders in tea cultivation, thoroughly examining their practicality. To ascertain the feasibility of these various alternative methods, the investigation centered on their potential and constraints concerning their implementation in tea plantations. The findings are elucidated in Tables 6, 7, and 8.

Alternatives to chemical fertilizers used by the tea smallholders

Table 7. Different alternatives to chemical fertilizers used by the smallholders

No	Alternatives for Chemical Fertilizer	Frequency	Percentage (%)
1	Compost	19	16
2	Cow Manure	06	05
3	Organic liquid fertilizer	15	12
4	Poultry Manure	07	06
5	Green Manure (Glyricidia leaves)	19	16
6	Using chemical fertilizers in small quantities mixed with compost	54	45

Most of the respondents (45%) utilized other available chemical fertilizers in small quantities mixed with compost. Meanwhile, a small percentage (16%) of the respondents employed compost and green manure in their tea lands. Additionally, they applied leaves of Glyricidia trees, cultivated as shade trees in their tea lands, as green leaf manure. Furthermore, 12% of the tea smallholder farmers utilized organic liquid fertilizer, whereas 6% utilized poultry manure, and a minimal percentage (5%) of the farmers employed cow dung as an alternative to chemical fertilizers. Some farmers prepared compost themselves, whereas others purchased it from agricultural retail shops. The convenience of preparation and purchase, the ability to utilize household waste, and the comparatively low price compared to chemical fertilizers were cited as the potential advantages of using compost instead of chemical fertilizers. However, the constraints to using this alternative included the requirement of large quantities per acre,

lack of facilities for preparing large quantities, the need for significant investment and labor when preparing in large quantities, and the risk of compost runoff from tea land with rainwater. The use of cow manure and poultry manure was noted as convenient and cost-effective. However, the constraints associated with employing these organic methods in tea lands included the need for large quantities per acre, difficulty in sourcing large quantities, the potential for nutrient loss through runoff, challenges in handling and storing, attraction and breeding of flies, attraction of feral swine-like animals to the field, and potential harm to tea bushes due to unpleasant odors. The smallholder tea farmers prepared organic liquid fertilizer by adding washed water from sprats, meat, fish, dried fish, etc., into a barrel, allowing it to stagnate by sealing it for nearly a month, and then applying this liquid fertilizer over the tea plants after plucking the tea leaves.

According to the smallholder tea farmers, this liquid fertilizer is more efficient than other methods as it accelerates the growth of immature tea leaves. The convenience in preparation and utilization of household kitchen waste as raw materials, and the potential for this method to be cost-effective are notable advantages. However, the constraints associated with employing these organic methods in tea lands include the need for large quantities per acre, difficulty in preparing large quantities, and the time-consuming nature of preparation. Additionally, high attraction of flies and feral swine-like pests due to the unpleasant odor are practical challenges of this method. The majority of the farmers utilize leaves of *Glyricidia* trees as green leaf manure, which are grown on their own lands as shade trees. The potential to utilize shade trees such as *Glyricidia* leaves in their tea lands, controlling weeds, acting as mulch, and providing a low-cost and environmentally friendly method to enrich soil are some of the advantages of this alternative method over chemical fertilizers. However, the constraints faced by the tea smallholder farmers when using this method include the requirement for large quantities per acre and difficulty in sourcing large quantities. According to the study, the majority of the tea smallholder farmers use chemical fertilizers in small quantities mixed with compost. They employ chemical fertilizers in this manner as they believe that organic fertilizers alone are insufficient to enhance productivity. From the smallholders' perspective, this mixed approach is deemed the most successful and effective method to achieve optimum tea production compared to other alternatives. The mentioned potentials of this method by the farmers include its low cost, reduced need for large quantities of compost, and its perceived effectiveness compared to other methods. However, challenges such as the time taken to prepare compost and the requirement for knowledge to determine suitable ratios are constraints associated with this method.

Alternatives to pesticides used by the tea smallholders and their practicability

Table 8. Different alternatives to pesticides used by the tea smallholders

No	Alternatives for Pesticides	Frequency	Percentage
1	Remove decayed/harmed plant parts and burn	82	68%
2	Remove eggs and destroying nests by hand	38	32%

Most of the respondents (68%) undertake the removal of decayed or harmed plant parts and either burn or bury them as a means to control pests in their tea lands. Meanwhile, 32% of the smallholder tea farmers manually remove eggs and destroy nests to manage pests in their tea plantations. It was observed that among the smallholder farmers surveyed, the majority abstain from employing pesticides to treat their tea plantations. Consequently, it can be deduced that the adoption of alternative pest control methods is less common in this area. The primary management practice involves meticulous pruning of tea bushes to remove damaged plant parts, eggs, and nests, followed by their proper disposal. These methods are deemed convenient, requiring no technical expertise, and easily implemented during pruning. However, a constraint of this method is that it may not entirely prevent pests from returning to the premises.

Alternatives to weedicides utilized by the tea smallholder farmers and their practicability

Table 9. Different alternatives to weedicides used by the tea smallholders

No	Alternatives for Weedicides	Frequency	Percentage
1	Use of a brush cutter machine	14	12%
2	Remove only harmful weeds	39	32%
3	Manual weeding	67	56%

Most of the smallholders (56%) employ manual weeding using "wisikaththa" and knives to control weeds in their tea lands (Tab. 9). Additionally, 32% utilize a method where only harmful weeds are removed from their tea lands.

Furthermore, 12% of the farmers mentioned that they use a brush cutter machine for weed control in their tea lands. Given that most smallholders own less than 1 acre of land, they tend to avoid using machines due to their high cost. Alternative weed control methods are less commonly utilized in this area. The brush cutter machine is lauded by the tea smallholders who use it for its lightweight design, convenience, and high efficiency in weed removal. However, the constraints associated with this alternative method include its higher operating cost, requirement for technical knowledge, and increased safety concerns compared to chemical weed control methods. Some smallholders opt to remove only harmful weeds in their tea lands due to the convenience of the method and its environmentally friendly approach. However, the constraints to this alternative method include its lower efficiency, higher labor requirements, impracticality for larger lands, and the necessity for comprehensive knowledge about weeds. Although manual weeding using "wisikaththa" and knives is prevalent among the smallholders, the advantages such as the removal of weeds without harming the environment and the fast recovery of weeds are noted. However, the constraints include the labor-intensive nature of the method, its ineffectiveness against woody and deep-rooted perennial weeds, and challenges such as scarcity of family labor, lack of spare time, rising labor costs, and physical strain. In summary, various factors, including the size of land holdings, costs, labor availability, and efficacy, influence the choice of weed control methods among the smallholder tea farmers in the region.

CONCLUSION

The results obtained indicate that the majority of tea smallholders among the respondents are male and are in their midlife. They tend to have a higher educational level, although the majority possess small tea plantations and earn extremely low monthly incomes. Most of them acquire knowledge about chemical fertilizers and other agrochemicals from the tea instructor of the division. The Tea Small Holding Development Authority (TSHDA) oversees the functioning of Tea Small Holdings Development Societies in every Grama Niladari (GN) division. At the grassroots level, the Tea Inspector/Extension Officer serves as the primary service provider within the TSHDA structure. It can be concluded that this area still benefits from a robust public tea extension service, as the majority obtain information from the tea inspector (45%), which is considered a formal source of information. However, reliance on informal sources such as agrochemical vendors and the media for information is less prevalent. According to the results of the study, the sudden banning of chemical fertilizers and other agrochemicals has had a detrimental effect on the performance of the tea smallholders. Statistical analysis reveals significant differences among the observed pairs. The results of the paired t-tests indicate that the cost spent on chemical fertilizers and other agrochemicals after the ban is higher. Moreover, the total cost of production post-ban is also higher based on the paired t-test analysis. However, the tea production has significantly decreased compared to before the ban. Regarding the farmers' attitudes, the majority demonstrate a profound understanding of the impact of using chemical fertilizers and other agrochemicals, as well as the consequences of their sudden banning.

The smallholders are inclined towards a gradual transition away from chemical fertilizers and other agrochemicals, preferring to adopt organic farming practices due to their awareness of the negative impacts associated with chemical inputs. Therefore, most tea smallholders do not favor the sudden banning of chemical fertilizers and other agrochemicals. Consequently, the farmers are currently grappling with several issues stemming from the abrupt ban on these inputs without providing suitable alternatives. Following the ban on chemical fertilizers and other agrochemicals, the farmers have turned to various chemical and organic farming methods. However, these alternatives have proven to be less effective compared to conventional chemical inputs. Consequently, the farmers resort to applying chemical fertilizers in small quantities mixed with compost, which they perceive to be somewhat more efficient than other methods. Nevertheless, the smallholders are now spending more on different chemical fertilizers and agrochemicals available in the market, leading to higher production costs for tea. Consequently, a significant number of the tea farmers report experiencing a pronounced reduction in both the quality and quantity of their tea production, alongside increased expenditure on chemical inputs. Therefore, it becomes imperative to introduce effective and efficient substitutes or integrated farming methods for tea smallholders to enhance tea cultivation practices in the future.

Based on the findings, several suggestions can be offered to three different stakeholders within the smallholder tea industry: smallholder tea farmers, researchers, and the government. For smallholder tea farmers, it is recommended to prioritize the adoption of sustainable cultural practices over chemical fertilizers and other agrochemicals, which pose risks to the environment and living organisms. This information can be disseminated to smallholders through various means such as training programs, educational seminars, workshops, and regular meetings. By enhancing their awareness and knowledge, smallholders can make informed decisions regarding their farming practices. Researchers, including tea inspectors, are encouraged to explore and develop better alternatives to chemical fertilizers and agrochemicals. They should focus on identifying feasible alternatives and assessing their practicality at

the smallholder level. Additionally, tea inspectors should provide appropriate training to smallholders on implementing Integrated Pest and Weed Management strategies, highlighting the benefits of sustainable control measures on tea lands. Developing programs and events to transfer technology for economically viable and environmentally friendly weed, pest, and fertilizer management practices is essential. Furthermore, smallholders should be incentivized by the government to adopt organic fertilizers, and researchers should be supported in conducting research to identify suitable substitutes. Immediate action is required to find comprehensive solutions through an integrated approach to safeguard the tea sector and the broader agriculture industry in the country. The government should prioritize conducting research in collaboration with relevant industry professionals and stakeholders to thoroughly assess the potential impact of policies before implementation. This approach will help mitigate the adverse effects of unsuitable policies and contribute to the sustainable development of the smallholder tea industry.

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