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Research Article:

Impact of the Fertilizer Import Ban in 2021 on Paddy Yield and Farm Economics in Polonnaruwa District, Sri Lanka: A Pooled Cross-Sectional Analysis

G.D.U.N.D. Garusinghe[1*], V.D.N. Ayoni[2], C.S. Wijetunga[1]

[1]*Department of Export Agriculture, Faculty of Animal Science and Export Agriculture, Uva Wellassa University, Badulla 90000, Sri Lanka*

[2]*Socio Economics and Planning Centre, Department of Agriculture, Peradeniya, Sri Lanka.*

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Abstract

High-yielding paddy varieties mainly depend on chemical fertilizers to enhance productivity. Since the introduction of the fertilizer subsidy policy in 1962, Sri Lanka has depended heavily on imported chemical fertilizers. However, the sudden fertilizer import ban implemented in May 2021 created significant challenges for agricultural production and raised concerns regarding food security and farmers' economic well-being. Although the ban was lifted in November 2021, the policy highlighted the vulnerability in the agricultural sector to abrupt changes in fertilizer availability. This study evaluates the impact of the fertilizer import ban in Polonnaruwa district, one of the country's major paddy-producing areas. Pooled cross-sectional data collected from 253 paddy farmers in both the Yala and Maha seasons by the Department of Agriculture between 2018 and 2023 were used for this study. Data were analyzed using the Cobb-Douglas production function, and paddy yield was used as the dependent variable, while independent variables included seed rate, machinery cost, weedicide cost, fertilizer cost, labour, and total chemical fertilizer used for paddy farming. A dummy variable was used to denote the ban period, allowing for an assessment of its impact on production outcomes. The study results indicate a 24.5% reduction in paddy yield during the period affected by the fertilizer ban. Additionally, the findings reveal that a 1% decrease in fertilizer usage causes a reduction in paddy yield by 0.43%. Further, the impact of gross margin and the benefit-cost ratio was also evaluated. Although production was reduced during the ban period, the highfarm-gateprice partially mitigated the economic impact on farmers. This study suggested that analogous policy interventions in the future be implemented through a phased and evidence-based approach, supported by rigorous scientific assessment and inclusive stakeholder engagement. Such an approach is essential to ensure policy coherence and to safeguard long-term economic stability, political feasibility, and social sustainability, while mitigating potential adverse impacts on the agricultural sector.

Keywords: Chemical fertilizer; Organic fertilizer; Polonnaruwa district; Rice varieties; Yield gap

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*Corresponding author: undgarusinghe@gmail.com

Postal address:Department of Export Agriculture, Faculty of Animal Science and Export Agriculture, Uva Wellassa University, Badulla 90000, Sri Lanka

1. Introduction

In the 20th century, agriculture was characterized by enhanced productivity, the replacement of human labour with machines, the use of chemical fertilizers and pesticides, and selective breeding (Singh and Surender Singh, 2013). Sri Lankan farmers have widely adopted these high-input agricultural practices (Bandara et al 2023). Chemical fertilizers are a major component of the food system, affecting food security both nationally and internationally (Nyamangara *et al*. 2020). However, the use of chemical fertilizers has many issues related to human health, the environment, and finance. In March 2021, the Sri Lankan government released a national agricultural policy proposing a shift to organic fertilizers from 1% to 30% in three years. (Research Institute of Organic Agriculture FiBL,2022).

On May 6, 2021, the Sri Lankan government made a sudden decision to prohibit the imports of chemical fertilizers, signalling a shift towards organic farming practices in the country's agricultural sector. This move was driven by concerns over the widespread health issues and environmental damage associated with the use of agrochemicals nationwide. Despite President Gotabaya Rajapaksa's previous commitment, outlined in his 2019 election manifesto "Vistas of Prosperity and Splendour," to provide Sri Lankans with food free from harmful chemicals, the implementation of the import ban took place unexpectedly and swiftly (Ghose *et al*., 2023). However, due to the food crisis, the ban on agricultural chemical inputs was completely lifted on 21st November 2021.

Banning chemical fertilizers and completely converting them to organic fertilizers irreversibly damaged many industries in many ways. Applying inorganic fertilizer cannot achieve 100% productivity from the present eroded soil, including agro-systems, when applying only organic fertilizer (Ulpathakumbura and Gunapala 2021).

Policymakers, government officials, farmers, and the public are concerned about the impact of agrochemical shortages on the 2021/22 Maha season's production. The 2020/21 Maha and 2021 Yala seasons were normal, benefiting from favourable climate conditions. In the 2020/21 Maha season, overall production of other field crops. Production increased by about 40%. However, despite no significant production increase in the 2021 Yala season, the high production in the 2020/21 Maha season boosted the overall year's output (Department of Agriculture, 2021/22 Maha season)

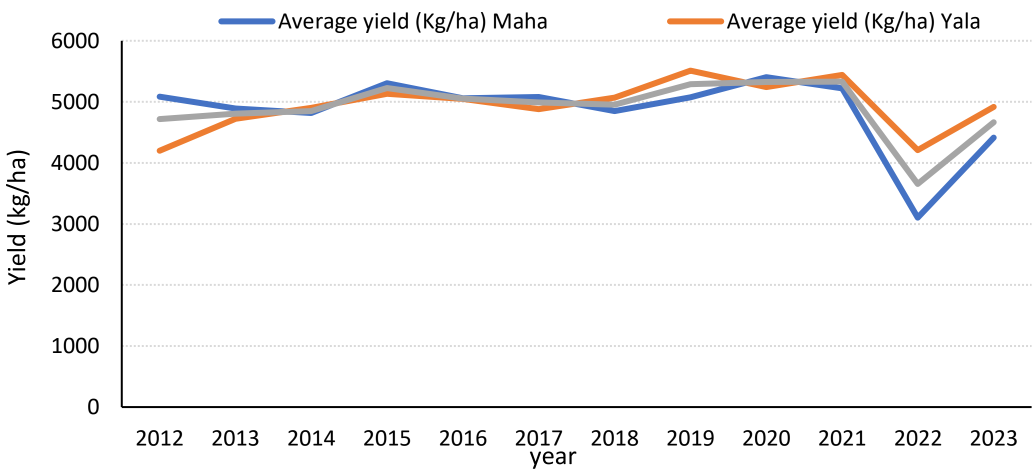

Figure 1: Average paddy yield 2012 -2023 in Polonnaruwa district (*Source: Department of Census and Statistics*)

Due to high agrochemical prices (Rs. 780–840 per kg) in late 2021 and early 2022, many farmers were reluctant to buy fertilizers. Different strategies emerged: some used available fertilizer mixtures, organic fertilizers produced at minimal or no cost, free Nano and organic liquid fertilizers, and leftover fertilizers at zero cost. Most farmers could not apply the recommended fertilizer dose due to high cost, leading to varied and generally lower yields. The cost of fertilizer applications was lower than expected since farmers used small amounts. Yield reductions varied, with many reporting around a 50% reduction compared to a normal season. District-specific situations were analyzed, comparing costs and prices to those of the previous Maha season, adjusted for inflation using the Colombo Consumer Price Index (CCPI) with 2013 as the base year (Department of Agriculture, Socio Economics & Planning Centre, 2021/22 Maha season). Due to the absence of agrochemical inputs in organic farming, nutrient access for plant growth is limited, and managing pests and diseases becomes more challenging; as a result, yields are lower compared to conventional agriculture (Bandara et al. 2023). There is no specific scientific research on the impact of the chemical fertilizer ban on paddy production using farm-level data in the Polonnaruwa district in Sri Lanka. This study fills this void by estimating the impact of the chemical fertilizer import ban on paddy production, comparing the periods with and without the chemical fertilizer import ban using farmer-level microdata from 2018 to 2023 for both the Yala and Maha seasons. Furthermore, when there is a yield reduction compared to normal seasons, an equilibrium point issue arises regarding demand and supply. Therefore, according to the basic production economic theories, when a production shortage increases, the market price increases (Debertin, 2002).

This study provide evidence-based insights into which factors most influence paddy yield in the context of a significant policy change. The study's findings will help bridge the gap between theoretical policy goals and practical agricultural outcomes, enabling the academic community to engage with contemporary challenges in agricultural sustainability.

The main objective of the study was to assess the impact of the ban on chemical fertilizer imports on paddy production in the Polonnaruwa district. Specific objectives are to: i. evaluate the influence of seed rate, chemical fertilizer used, labour usage, machinery cost, weedicide cost, and pesticide cost on paddy production in Polonnaruwa district; ii. analyze the impact of the chemical fertilizer import ban on the gross margin and benefit-cost ratio in paddy production in Polonnaruwa district; and iii. investigate the effect of the chemical fertilizer import ban on the yield gap for rice varieties BG 366 and BG 352 in the Polonnaruwa district.

2. Materials and methods:

The data on paddy cultivation in Polonnaruwa district were obtained from the primary surveys conducted by the Socioeconomics and Planning Centre of the Department of Agriculture (DOA 2018 – 2023) to estimate the cost of cultivation. Both the Yala season and Maha season were considered for the estimation of the production function. The sample size was 253 farmers. The dependent variable was paddy production, and the independent variables were seed rate, labour usage, fertilizer usage, weedicide cost, pesticide cost, and a dummy variable for the import ban period.

2.1 Production Function Analysis

Production function analysis was used to estimate the impact of the ban on chemical fertilizer on paddy production. The Cobb–Douglas production function was used to determine the factors and impact of various independent variables on yield due to its ease in computation and interpretation. A similar study has been conducted by Ahmad et al. (2005) to determine the various factors influencing carrot yield inPunjab. A similar study has been done using this function to analyze the regional differences in the productivity of potatoes in Sri Lanka (Ayoni et al. 2009).

The following Cobb – Douglas production function was considered in the general form.

$$\mathrm{Y_i} = \prod_{i=1}^{m} \mathrm{x_{ij}^{bi}} \mathrm{e^{ui}}$$

Were,
I = 1,2….., M are inputs
J = 1,2,……, N are the number of farmers
Yi = the output of the j[th] farmer
Xij = the level of input for the j[th] farmer
bi = the parameters to be estimated
ui = error term
e = the natural log exponent.

The above production function is in log-linear form.

$$\mathbf{In\ Y = A + \sum_{i=1}^{m} bi\ Inx_{ij} + \mu}$$

Applied Cobb–Douglas production function

$$\mathbf{InY_{ij} = In\beta_0 + \beta_1 InX_{1ij} + \beta_2 Inx_{2ij} + \beta_3 Inx_{3ij} + \beta_4 InX_{4ij} + \beta_5 InX_{5ij} + \beta_6 InX_{6ij}}$$

Yield (dependent variable)-$\mathbf{Y_i}$ (kg/acre)
Seed rate - $\mathbf{X_1}$ (kg/acre)
Labour usage-$\mathbf{X_2}$(man-days/acre)
Chemical fertilizer usage - $\mathbf{X_3}$ (kg/acre)
Weedicide cost $\mathbf{X_4}$(Rs/acre)
Pesticide cost $\mathbf{X_5}$ (Rs/acre)
Ban period $\mathbf{X_6}$ The dummy variable for a ban (without import ban =1, with import ban=0)

2.2. Gross Margin and Benefit-Cost Ratio
To analyze the gross margin, the average farm gate price, average cost of seeds, and average price for chemical fertilizer types are taken according to the cost of cultivation publication (DOA) related to each season. This is the method used for analyzing the gross margin in this analysis.

$$\text{Total Income} = \text{Total yield} \times \text{farm gate price}$$

$$\text{Total variable cost} = \text{Cost for seeds} + \text{labor cost} + \text{Machinery cost} + \text{Weedicide cost} + \text{Pesticide cost} + \text{Cost of chemical fertilizer}$$

$$\text{Gross margin} = \text{Total income} - \text{Total variable cost}$$

$$\text{Benefit Cost Ratio} = \frac{\text{Gross return}}{\text{Total cost}}$$

2.3 Yield Gap
Theoretical paddy yield is the maximum crop yield as determined by bio-physical limits to key processes, including biomass production and partitioning. Potential paddy yield is the yield of a current cultivar when grown in environments to which it is adapted, with nutrients and water non-limiting, and with pests, diseases, weeds, lodging, and other stress effectively controlled. (FAO ORG,2024). When analyzing the cultivated rice varieties in the selected data set, there are over 50 rice varieties. Among these varieties, the most popular rice varieties (BG 366 and BG 352) have been selected to analyze the yield gap. BG 352 Rice Variety is a white Nadu rice variety introduced in 1992 by the Rice Research and Development Institute (RRDI), Batalagoda. The average yield of BG 352 is 4.9t/ha (1,983 kg/acre). This rice variety has been cultivated in 36% of the observed sample. BG 366 Rice Variety is a white Nadu rice variety introduced in 1992 by Rice Research and Development Institute (RRDI), Batalagoda. The average yield of BG 352 is 6t/ha (2,428 kg/acre). This rice variety has been cultivated in 32% of the observed sample.

Yield Gap = Demonstrated plot average yield – BG 366 variety average yield (in Polonnaruwa district)
(Without chemical fertilizer ban impact and with the fertilizer ban impact)

Yield Gap = Demonstrated plot average yield – BG 352 variety average yield (in Polonnaruwa district)
(Without chemical fertilizer ban impact and with the fertilizer ban impact)

3. Results and discussion

Table 1: Results of the Cobb-Douglas production function

Variable	**Coefficient**	**Robust SE**	**T-value**	***p*-value**
Constant	6.502	0.896	7.26	0.000
LnSeedrate	0.292	0.746	3.91	0.000
Lnlabor	0.149	0.457	0.33	0.744
Lnmachinery	-0.602	0.769	-0.78	0.435
Lnweedicide	0.196	0.024	0.79	0.430
Lnpesticide	-0.271	0.006	-4.89	0.000
Lntotalfertilizer	0.432	0.176	2.46	0.015
D_ban	0.2445	0.083	2.95	0.004
Adjusted R^2				21.66
F value				10.99(p=0.000)

The Cobb-Douglas production function estimated the direction and the extent of various factors' influence on paddy yield. To assess the impact of the chemical fertilizer, import ban on paddy production in the Polonnaruwa district, was achieved by the dummy variable. Dummy variable for the ban (without import ban impact=1, with import ban impact=0). The coefficient for the dummy variable representing periods without the chemical fertilizer ban is 0.2445. This coefficient is statistically significant ($p = 0.004$), indicating that yields are higher during periods without the ban. This suggests that the chemical fertilizer ban \ harmed yield, highlighting the importance of policy interventions on agricultural productivity. On average, the yield is 27.7%, [100 × (exp(0.2445) − 1)], higher when there is no fertilizer import ban impact (d=1) compared to when there is a fertilizer import ban impact (d=0). This positive and significant coefficient suggests that the presence of a fertilizer ban has negative impact on yield. The coefficient for applied chemical fertilizer is 0.432, indicating that for every 1% increase in total fertilizer usage, yield increases by approximately 0.432 units, suggesting that increased fertilizer application positively impacts yield.

When comparing this result with the Rathnapura district, before the ban, the coefficient of the estimated equation is 8.647, and in the ban period, 4.810. (Rashikala and Shantha,2023). In this study, the calculated constant coefficient is 6.5020. In addition, a study done in Kiliveddy in Trincomalee district to find the impact of this fertilizer ban shows that the yield loss is nearly 60%(Perinparajah,2023). Nonetheless, this study finds that the chemical fertilizer import ban resulted in a 24.45% reduction in paddy production in Polonnaruwa district. The reasons for these different values: the researchers found that farmers from the Polonnaruwa District have a significantly lower probability of adopting organic fertilizer than the other districts. Farmers have applied to procure chemical fertilizers from the remaining stocks through private sellers, and some farmers already have remaining stocks from the previous season (Rosairo,2023). The soil test report in Polonnaruwa indicates that MOP and TSP are present in the correct amounts in the soil, though the fertilizer was not applied in this ban-impacted period. This might be the reason for the comparatively lower yield loss than in the other analysis.

3.1 Results of gross margin analysis

Table 2: Statistical model results of gross margin analysis

Variable	Coefficient	SE	t	$p > \|t\|$
Constant	0.3986	0.6476	6.15	0.000
D_Ban	0.1067	0.6477	1.52	0.131
Adjusted R^2				0.0091
F Value				2.30 (P=0.1308)

3.2 Results of benefit-cost ratio analysis

Table 3: Statistical model results of Benefit – cost ratio analysis

Variable	Coeffi-cient	SE	t	$p > \|t\|$
Constant	1.035	0.0059	173.51	0.000
D_Ban	0.012	0.0065	1.76	0.000
Adjusted R^2				0.0082
F Value				3.09 (P=0.0799)

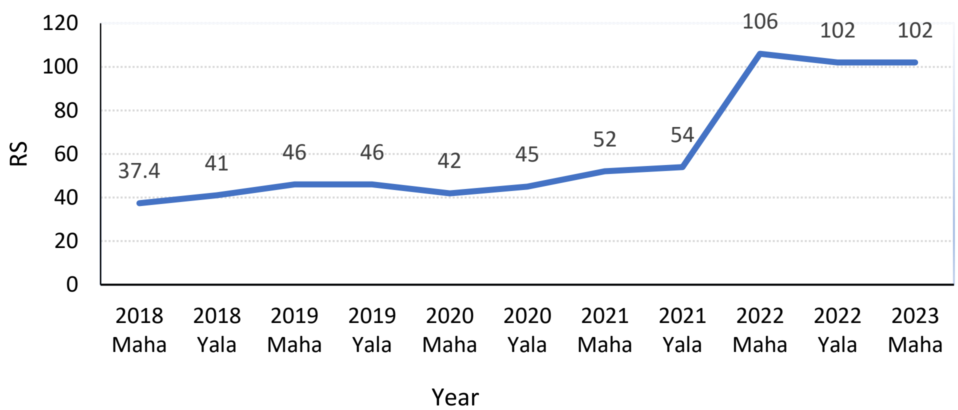

Figure 2: Farm gate price in Polonnaruwa District (2018-2023) (data *source: Department of Agriculture, Soci-oeconomics & Planning Centre)*

The accuracy of the above model is low due to the low variation of the independent variable with the dependent variable. The reason is that, through yield reduction, the farm gate price increase will be higher than 188% in 2022. (compared to the base year 2018). The increased farm gate price mitigated the negative economic impact on farmers in the Polonnaruwa district.

The graph shows the change in farm gate prices in Sri Lanka from 2018 to 2023 in both seasons (Maha and Yala). From 2018 to 2021, the prices increased gradually, with only slight fluctuations. However, there is a significant spike in farm gate prices, rising sharply to Rs. 106 during the 2022 Maha season and stabilizing around Rs. 102 in the subsequent seasons. This sharp increase coincides with the period of the synthetic fertilizer import ban, indicating that the farm gate price of paddy rose significantly, mitigating the economic impact on farmers in the Polonnaruwa district.

The chemical fertilizer subsidy was stopped from 1990 to 1994 due to rising international prices and currency depreciation. Despite this, fertilizer consumption did not decrease as much as expected, and farmers' gross margin remained stable due to guaranteed high farm gate prices (Ekanayake, 2006), (Weerahewa et al (2022). During the ban-impacted period, a similar situation was experienced in the gross margin and benefit-cost ratio. The increased farm gate price has mitigated the economic impact on the farmers. The benefit-cost ratio analyzed by Mufeeth (2019) in 2019 was 1.64 in the Ampara district. According to the study, B: C ratio in 2019 was 1.9. Therefore, cultivating rice in Polonnaruwa is more profitable than in the Ampara district. During the ban-impacted period, the B: C ratio was 1.6. Here, decreased farm-gate prices have also mitigated the economic impact on farmers.

3.3 Results of yield gap analysis

Table 4: Results of investigating the yield gap for variety Bg 352

Situation	Calculation	Results	Yield Gap
With the chemical fertilizer Import ban impact	$\frac{1790.3}{1982.96} \times 100$	90.28%	9.72%
Without chemical fertilizer Import ban impact	$\frac{1984.2}{1982.96} \times 100$	100%	0

Cultivating the Bg 352 variety with chemical fertilizer could yield like those demonstrated in the Research and Development Institute (RRDI), Batalagoda. In the ban-impacted period, the yield gap was 9.72%.

Table 5: Results of yield gap for variety Bg 352

Situation	Calculation	Results	Yield Gap
With the chemical fertilizer Import ban impact	$\frac{1659.3}{2428.11} \times 100$	68.33%	31.67%
Without chemical fertilizer import ban impact	$\frac{1927.7}{2428.11} \times 100$	79.39%	20.61%

Cultivating the BG 366 variety with chemical fertiliser had a 20.61% yield gap compared to the demonstrated plots in the Research and Development Institute (RRDI), Batalagoda. In the ban-impacted period yield gap increased the yield gap increased to 11.06%.

3.4. Limitations of the Study and Further Research

This study has some limitations related to the availability and quality of farm-level data, omitted factors, and the limited sample coverage, which may affect the generalizability of the findings. External factors such as weather conditions, irrigation, COVID-19, fuel shortages, and agricultural policy changes were not separately examined. Future studies should use larger and more representative samples, incorporate environmental and socioeconomic factors, and apply panel data and advanced econometric methods. Further research could also focus on sustainable and organic paddy production in Sri Lanka.

4. Conclusions

This study examined the impact of the chemical fertilizer import ban on paddy production in the Polonnaruwa district, which accounts for approximately 20% of national rice production. The results indicate a significant yield reduction of 24.45% during the ban period, demonstrating the high dependency of paddy on chemical fertilizer. This decline subsequently reduced marketable surplus, contributing to increased rice imports and upward pressure on retail prices. From a production economics perspective, the observed supply contraction is consistent with demand–supply theory, where reduced output leads to higher market prices. Although higher farm-gate prices partially offset farmer income losses, the overall production inefficiency highlights the vulnerability of the sector to abrupt input policy changes. The findings further suggest that varietal and input optimization, particularly the promotion of high-performing varieties such as BG 352 under recommended fertilizer regimes, can help reduce yield losses in similar policy environments.

Conflict of Interest

The authors declare that they have no conflict of interest

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Author contributions

G.D.U.N.D. Garusinghe: Data curation, formal analysis, conceptualization, methodology, writing – original draft, and writing – review & editing; V.D.N. Ayoni: Conceptualization, methodology, and supervision; C.S. Wijetunga: Supervision and writing – review & editing

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