Asian Journal of Research in Crop Science

Volume 8, Issue 4, Page 436-442, 2023; Article no.AJRCS.107535
ISSN: 2581-7167

Influence of Intercropping Green Gram with Two Paddy Varieties on Growth, Yield and its Components to Increase Economic Returns

P. O. P. Weerasinghe [a*], S. Sutharsan [a] and L. M. Rifnas [b]

[a] Department of Crop Science, Faculty of Agriculture, Eastern University, Sri Lanka.
[b] Department of Agro-Technology, University of Colombo Institute for Agro-Technology and Rural Sciences, Hambantota, Sri Lanka.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AJRCS/2023/v8i4224

Open Peer Review History:
This journal follows the Advanced Open Peer Review policy. Identity of the Reviewers, Editor(s) and additional Reviewers, peer review comments, different versions of the manuscript, comments of the editors, etc are available here: https://www.sdiarticle5.com/review-history/107535

Original Research Article

Received: 26/08/2023
Accepted: 01/11/2023
Published: 04/11/2023

ABSTRACT

A field experiment was conducted at the Faculty of Agriculture, Eastern University, Sri Lanka to investigate the effects of intercropping green gram on the growth and yield parameters of two varieties of paddy; Suwandel (traditional variety) and At 307 (improved variety) during the period of July to November 2022. The experiment was laid out in a 2 x 2 Factorial Randomized Complete Block Design with four treatments as monocropping Suwandel (T_1), intercropping Suwandel with green gram (T_2), monocropping At 307 (T_3) and intercropping At 307 with green gram (T_4), that were replicated five times. Significant differences in leaf area, shoot dry weight, 1000 seeds weight and grain yield were observed in the paddy-green gram intercropping system compared to the monocropping of paddy. Significant synergistic responses were also observed among the treatments, where the leaf area and shoot dry weight were the highest in Suwandel + green gram intercropping system and the 1000 seeds weight was the highest in At 307-green gram

**Corresponding author: E-mail: oshadeeweerasinghe@gmail.com;*

intercropping system. However, the cost-benefit analysis revealed that the net profit received from Suwandel + green gram intercropping system was 36.6% higher than the At 307-green gram intercropping system. Therefore, it was evident from the present study that the Suwandel + green gram intercropping system is an environmentally friendly sustainable approach to grow paddy without synthetic fertilizers.

Keywords: At 307; green gram; intercropping; paddy; sustainable; suwandel.

1. INTRODUCTION

Scientifically termed as *Oryza sativa*, paddy is grown in many countries around the world as it feeds over half of the world's population, with Asia accounting for 90% of the total production [1]. Rice, which is produced after the removal of husk and bran from paddy, is the staple food of Sri Lankans since ancient times. Its cultivation has a prominent role in the nation's politics, traditions and cultural identity [2]. Rice Fullfills 45% of the calorie and 40% of the protein requirement of an average Sri Lankan [3]. Paddy is cultivated in different parts of the country in two seasons namely, Maha (major) and Yala (minor) which are synonymous with the North-East monsoon and the South-West monsoon, respectively. Currently, it is estimated that roughly 708,000 ha of land is used exclusively for paddy cultivation in Sri Lanka and, the total production of paddy in 2021/2022 Maha season is 1,931,230 MT and in 2021 Yala season is 2,088,202 MT [4].

Rice has a wide range of grain characteristics that affect its quality and nutrient profiles, including length, colour, thickness, stickiness and aroma, which in turn have an impact on the preference of rice consumers from various geographic and cultural backgrounds around the globe [5]. Therefore, different varieties of paddy are grown by farmers to earn profits by meeting the consumer demand. In Sri Lanka, paddy is a crop with a significant genetic diversity, as majority of its germplasm which includes traditional varieties, exotic varieties, locally developed old varieties, locally developed new improved varieties and wild relatives have been preserved at the Plant Genetic Resources Centre (PGRC) at Peradeniya [6].

Early on, in the history of Sri Lankan paddy farming, only traditional varieties of paddy were grown [7] under entirely organic conditions and thereby it had no negative effects on the environment or people's health. Suwandel is one such traditional variety of rice with a rich milky taste and a fragrance [8] which makes it a highly demanded variety of rice by Sri Lankan consumers. Cultivating traditional varieties of paddy, with the application of organic manure such as green manure, cow dung, poultry manure etc., controlling weeds by hand weeding and managing the available water without causing moisture stress are some of the traditional techniques of farming practiced by farmers in Sri Lanka [9]. Since there was no usage of chemical fertilizers, herbicides or pesticides, such traditional techniques were successful in maintaining the environmental sustainability. However, these traditional paddy varieties disappeared from Sri Lankan farm lands around the 1960s, when the high-yielding, newly improved varieties were introduced [10]. At 307 is one such improved variety of paddy developed at the Rice Research and Development Institute – Ambalanthota, Sri Lanka. This variety is resistant to, blast disease and pests such as gall midge and brown plant hopper. It is a well-known fact that growing improved varieties is generally advantageous over traditional varieties due to their shorter life cycle, higher yields and resistance to pests and diseases etc. Therefore, it is evident that both traditional and improved varieties of paddy have their own benefits and drawbacks pertaining to agriculture.

Sri Lanka is currently facing a serious economic downturn in decades of the nation's history since independence. In consequence, the higher prices and, unavailability of chemical fertilizer and other agrochemicals including pesticides and herbicides is the major problem faced by Sri Lankan farmers. Therefore, in order to tackle these issues, the immediate and best option is the adoption of sustainable agricultural practices in paddy farms in Sri Lanka.

Out of several sustainable agricultural practices followed by farmers worldwide, intercropping can be pointed out as an important approach to maximize yield and improve productivity. By definition, an intercropping system is a method of farming which involves the simultaneous cultivation of two or more species of crops [11] in the same piece of land. Even though the component crops of an intercropping system do not have to be planted or harvested at the same

time, they should be grown together for the majority of their growth periods [12], which specifies the concept of intercropping.

Intercropping legumes with cereals are commonly practiced by Sri Lankan farmers. Typically, cereal crops are nutrient-exhaustive and utilize nutrients from the Upper soil layers [13] and legumes have the ability to fix atmospheric nitrogen. Being a short duration crop, green gram when intercropped with paddy has the potential to build up soil fertility and increase the overall productivity and income [14]. Therefore, the present study was undertaken with the objective of finding out the effects of intercropping green gram with improved and traditional varieties of paddy to improve the yield of paddy.

2. MATERIALS AND METHODS

2.1 Experimental Site

This study was conducted as a field experiment at the crop farm of the Faculty of Agriculture, Eastern University Sri Lanka, located in the Batticaloa district (situated in the eastern coast of Sri Lanka), falling under the low country dry zone (DL2) agroecological region of the country. The experiment was conducted during the period of July 2022 to November 2022. The experimental site is situated in the latitude of 7° 43' N and the longitude of 81° 42' E at an altitude of 10m above mean sea level.

2.2 Planting Materials

Suwandel; a popular traditional paddy variety (*Oryza sativa*) of Sri Lanka, At 307; an improved paddy variety (*Oryza sativa*) developed and released by the Department of Agriculture Sri Lanka, and Harsha variety of green gram (*Vigna radiata*) recommended by the Department of Agriculture Sri Lanka, were used as the planting materials of the experiment.

2.3 Treatments and Experimental Design

40 m^2 research plots were laid out in a 2 x 2 Factorial Randomized Complete Block Design with the 2 varieties of paddy (Suwandel and At 307) as the first factor and 2 different cropping systems for paddy (monocropping paddy and intercropping green gram with paddy) as the second factor. Collectively, these formed four treatment combinations as shown in Table 1. Each treatment was replicated five times.

2.4 Agronomic Practices

Seeds of both paddy varieties Suwandel and At 307 were sown in bubble trays filled with soil taken from the research plot. Spraying of water to the nursery trays was done three times a day. 12 days old seedlings were transplanted in the main field at a spacing of 25cm×25cm. Green gram seeds were sown in the research plots in between rows of paddy seedlings one week after transplanting paddy seedlings. After ploughing, a basal application of 2.5 t/ha compost, 4 t/ha cow dung, 2 t/ha poultry manure [15] and 1 t/ha green manure [16] was done to all the research plots. 4 weeks after transplanting paddy, 2 t/ha compost was applied [16] and 8 weeks after transplanting paddy 4 t/ha cow dung was applied. The research area was irrigated at 1-day intervals starting from two days after transplanting paddy seedlings. The irrigation schedule was discontinued on rainy days. Weeding was done manually in all the research plots in two-weeks intervals starting from 14 days after transplanting paddy. Green gram harvest was obtained 52-64 days after planting its seeds. The pods were then dried under direct sunlight for 2-3 days. Later, threshing was done to isolate the grains from straw. Paddy was harvested 93 days after transplanting.

2.5 Data Collection and Analysis

The observations for paddy were taken at weekly intervals starting from 4 weeks after transplanting paddy seedlings. The parameters measured for paddy were leaf area (cm^2), dry weight of shoot (g), grain yield (t/ha) and 1000 seeds weight (g). The parameter measured for green gram was the grain yield (t/ha). Collected data were subjected to Analysis of Variance (ANOVA) and mean separation (Tukey's test) using Minitab 17 statistical software at 5% significance level.

Table 1. Treatment combinations of the experiment

Treatment code	Treatment combination
T_1	Monocropping Suwandel
T_2	Intercropping green gram with Suwandel
T_3	Monocropping At 307
T_4	Intercropping green gram with At 307

3. RESULTS AND DISCUSSION

3.1 Leaf Area

According to the analyzed results shown in Table 2, Significantly positive interaction effects (P<0.05) were observed among the treatment combinations of the present study, with the maximum mean value recorded when Suwandel was intercropped with green gram. This result is in accordance with the findings Iwuagwu et al. [17] who reported that this might be due to a nutrient balance between the cereal (a crop that requires a lot of nitrogen) and the legume, which compensated the nitrogen taken up by the rice crop. A previous study conducted by Putra et al. [18] where rice intercropped with soybean also resulted in a higher leaf area when rice was grown in more or less equal quantities with the legume in the same plot, compared to the monoculture system of rice.

3.2 Shoot Dry Weight

Based on the analysis of variance, a significant interaction (P<0.05) was observed in between paddy variety and cropping system. A significantly higher mean value was obtained in the intercropping Suwandel with green gram. as shown in Table 2. The likely cause for this could be the higher dry matter accumulation in shoots achieved by increased rates of photosynthesis attributable to the higher mean leaf area [19] that was observed in intercropped plots.

3.3 1000 Seeds Weight

As per the analyzed results shown in Table 2, there was a statistically significant interaction (P>0.05) between the tested factors paddy variety and cropping system on 1000 seeds weight. Among the treatment combinations of the present study, with the highest mean value obtained when At 307 was intercropped with green gram. The results are in agreement with those of Mandal et al. [20], who observed that the 1000 seed weight of paddy increased when it was intercropped with legumes such as mung bean compared to sole cropping of paddy. Iwuagwu et al. [17] also found that the seed weight of rice was the highest when it was intercropped with a legume (soybean) and the lowest when it was grown alone.

3.4 Grain Yield

According to the analyzed results shown in Table 3, significant interactions were not observed (P>0.05); for the grain yield between the tested factors paddy variety and cropping systems. Further, there was no significant differences between the paddy varieties on grain yield but, there were significant difference between the cropping systems. A higher grain yield was recorded when paddy was intercropped with green gram compared to when paddy was grown as a monocrop. This is in agreement with Chu et al. [21] who found that the grain yield of paddy increased by 29-37% in the intercropping system compared to the monocropping system, and the credit for this was attributed to the improvement in nitrogen nutrition by the intercropped peanut. Iwuagwu et al. [17] also reported that the yield of paddy when it was intercropped with soybean (legume) was significantly higher than the system of monocropping paddy and that the reason for this might be due to the nutrient-balance relationship between paddy, a cereal crop with a strong reliance on nitrogen, and the supply of nitrogen provided by the legume crop (soybean).

Table *2*. Effect of different cropping systems on the growth and yield parameters of paddy

Paddy variety	**Cropping system**	**Leaf area (cm^2)**	**Dry weight of shoot (g)**	**1000 seeds weight (g)**
Suwandel	Monocropping	79.73 ± 2.61^{c}	5.63 ± 0.21^{b}	2.77 ± 1.99^{c}
	Intercropping	276.23 ± 5.42^{a}	12.08 ± 1.62^{a}	7.29 ± 0.62^{b}
At 307	Monocropping	93.67 ± 2.40^{b}	3.14 ± 0.28^{b}	9.37 ± 1.28^{b}
	Intercropping	86.63 ± 1.05^{bc}	5.14 ± 0.89^{b}	17.60 ± 0.93^{a}
	Sig.	*	*	*

Values represent mean ± standard error of five replicates. '' represents significant difference and 'ns' represents non-significant difference at 0.05 level of probability. According to Tukey's Test, means in the same column followed by dissimilar letter/s in superscripts indicate significant difference at 0.05 level of probability.*

Table 3. Effect of different cropping systems on the grain yield of paddy

Factors	Factor levels	Grain yield (t/ha)
Paddy variety	Suwandel	0.73 ± 0.22
	At 307	0.54 ± 0.18
	Sig.	**ns**
Cropping systems	Monocropping	0.27 ± 0.08^{b}
	Intercropping	1.00 ± 0.21^{a}
	Sig.	*****

Values represent mean ± standard error of five replicates. '' represents significant difference and 'ns' represents non-significant difference at 0.05 level of probability. According to Tukey's Test, means in the same column followed by dissimilar letter/s in superscripts indicate significant difference at 0.05 level of probability.*

Table 4. Cost-benefit analysis of the experiment

Treatments	Total yield (t/ha)		Cost (Rs. /ha)	Income (Rs. /ha)	Net profit (Rs. /ha)
	Paddy	Green gram			
T_1	0.33	-	285,069.2	165,000.0	-120,069.2
T_2	1.13	0.93	337,769.7	1,681,000.0	1,343,230.3
T_3	0.21	-	283,685.4	46,200.0	-237,485.4
T_4	0.87	0.94	336,385.9	1,319,400.0	983,014.1

3.5 Cost-Benefit Analysis

As shown in Table 4, the monocropping system for both the varieties of paddy is unprofitable. Although the yield under the intercropping system for At 307 and Suwandel were only marginally different from each other, the net profit from Suwandel-green gram intercropping system was 36.6% higher than the At 307-green gram intercropping system. This is because, being a highly demanded traditional paddy variety in Sri Lanka, the market price of Suwandel is much higher compared to At 307. The extra profit received from green gram in the intercropped plots also contributed to the higher income from these plots. In addition, since the experiment was done excluding the use of expensive chemical fertilizers, the cost of cultivation of paddy and green gram has been largely reduced. Therefore, it can be concluded from this result that intercropping is a good choice to increase the net profit received from paddy cultivation, especially in the traditional variety; Suwandel, grown using organic manure.

4. CONCLUSION

Intercropping paddy with green gram showed significant differences in leaf area, shoot dry weight, 1000 seeds weight and grain yield of paddy compared to paddy grown as a monocrop. In addition, synergistic effects of the treatment combinations were significant for the leaf area, shoot dry weight and the 1000 seed weight. Accordingly, the highest leaf area and shoot dry weight were observed in Suwandel-green gram intercropping system, and the highest 1000 seed weight was observed in At 307-green gram intercropping system. However, based on the cost-benefit analysis performed at the end of the experiment, the net profit received from Suwandel-green gram intercropping system was found to be 36.6% higher than the At 307-green gram intercropping system. Therefore, it can be concluded from the present study that Suwandel-green gram intercropping system is the best to grow paddy without synthetic fertilizers, which is an environmentally friendly sustainable approach to increase the yield of paddy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Devkota KP, Beebout SEJ, Sudhir-Yadav, Bunquin MA. Setting sustainability targets for irrigated rice production and application of the Sustainable Rice Platform performance indicators. Environmental Impact Assessment Review. 2022;92: 106697.
Available:https://doi.org/10.1016/J.EIAR.2021.106697
2. Ali RI, Awan TH, Ahmad M, Saleem MU, Akhtar M. Diversification of Rice-based Cropping Systems to Improve Soil Fertility, Sustainable Productivity and Economics.

The Journal of Animal & Plant Sciences. International Rice Research Institute. (2018). Sri Lanka and IRRI. 2012;22(1): 108–112.
Retrieved from https://www.irri.org/where-we-work/countries/sri-lanka (accessed Sep. 09, 2022

3. Department of Agriculture SL. Rice - The Staple Food - General Information. Available:https://doa.gov.lk/rrdi_rice_introduction-2/ (accessed Dec. 04, 2022)
4. Department of Census and Statistics, SL. Paddy Statistics. Available:http://www.statistics.gov.lk/Agriculture/StaticalInformation/rubpaddy (accessed Sep. 09, 2022)
5. Fukagawa NK, Ziska LH. Rice: Importance for Global Nutrition. Journal of Nutritional Science and Vitaminology. 2019;(65). Doi:10.3177/jnsv.65.S2
6. Gunasena PGSD, Wasala SK, Sumanasingha VA. Molecular characterization of accessions from a traditional rice cultivar, suwandel conserved at plant genetic resources centre, Sri Lanka. Tropical Agricultural Research. 2016;27(1). Doi:10.4038/tar.v27i1.8158
7. Rajapakse RMT, Sandanayake CA, Pathinayake BD. Foot prints in Rice Variety Improvement and its Impact on Rice Production in Sri Lanka. Annual Symposium of the Department of Agriculture. 2000;2:423-433.
8. Biodiversity for Food and Nutrition. Oryza sativa (Suwandel). Available:http://www.b4fn.org/resources/species-database/detail/oryza-sativa-suwandel/ (accessed Sep. 10, 2022)
9. Dharmasena. Traditional rice farming in Sri Lanka: Still viable with climate change; 2012. Available:https://www.academia.edu/38067206/Traditional_Rice_farming_in_Sri_Lanka_Still_viable_with_climate_change
10. Ginigaddara GAS, Disanayake SP. Farmers' willingness to cultivate traditional rice in Sri Lanka: A Case Study in Anuradhapura District. Rice Crop - Current Developments; 2018. DOI:https://doi.org/10.5772/intechopen.73082
11. BrookerRW, Bennett AE, Cong WF, Daniell TJ, George TS, Hallett PD, Hawes C, Iannetta PPM, Jones HG, Karley AJ, Li L, Mckenzie BM, Pakeman, RJ, Paterson E, Schöb C, Shen J, Squire G, Watson CA, Zhang C, Zhang F, Zhang J, White PJ. Improving intercropping: A synthesis of research in agronomy, plant physiology and ecology. New Phytologist. 2015;206 (1):107–117. Available:https://doi.org/10.1111/nph.13132
12. Lithourgidis AS, Dordas CA, Damalas CA, Vlachostergios DN. Annual intercrops: an alternative pathway for sustainable agriculture. Australian Journal of Crop Science. 2011;5 (4).
13. Ali RI, Awan TH, Ahmad M, Saleem MU, Akhtar M. Diversification of Rice-based Cropping Systems to Improve Soil Fertility, Sustainable Productivity and Economics. The Journal of Animal & Plant Sciences. 2012;22(1):108–112.
14. Lawrence H, Gohain T. Intercropping of greengram (*Vigna radiata* L) with upland Rice (*Oryza sativa* L) under rainfed condition of Nagaland. Indian Journal of Hill Farming. 2009;19:12-15.
15. Department of Agriculture SL. Parisara Hithakami Kabanika Wee Govithena Athpotha [Eco-friendly Organic Paddy Cultivation Handbook]. Ministry of Agriculture, Sri Lanka. Available:https://doa.gov.lk/wp-content/uploads/2020/05/OrganicB.pdf (accessed Nov. 27, 2022)
16. Liyanage GLVM, Pathirana SPGS, Rankoth LM, Wickramasinghe HKJP. Evaluation of growth, yield and nutritional characteristics of selected rice (*Oryza sativa* L.) Varieties Under Organic Farming Conditions; 2016. Available:https://www.researchgate.net/publication/334150939
17. Iwuagwu C, Umechuruba C, Ononuju C, Nwogbaga A, Salaudeen M, Onejeme F. Effect of Intercropping Rice with Maize and Soybeans on Disease Incidence, Severity and Yield of Rice in Abia State. International Journal of Agricultural Science. 2019;4:23-28. Available:http://iaras.org/iaras/journals/ijas
18. Putra FP, Yudono P, Waluyo S. Growth and yield of upland rice under intercropping system with soybean in Sandy Coastal Area. Ilmu Pertanian (Agricultural Science). 2017; 2(3):30. Available:https://doi.org/10.22146/ipas.25215
19. Patra B, Jena S, Mishra P, Kumar Sahoo H, Gantayat BP. Mangaraj S. Dry matter

partitioning of rice crop as influenced by date of planting and nutrient management; 2022.
Available:https://doi.org/10.21203/rs.3.rs-1526659/v1

20. Mandal BK, Dhara MC, Mandal BB, Das SK, Nandy R. Effect of Intercropping on the Yield Components of Rice, Mungbean, Soybean, Peanut and Blackgram. Journal of Agronomy and Crop Science. 1989; 162(1):30–34.
Available:https://doi.org/10.1111/J.1439-037X.1989.TB00684.X

21. Chu GX, Shen QR, Cao JL. Nitrogen fixation and N transfer from peanut to rice cultivated in aerobic soil in an intercropping system and its effect on soil N fertility. Plant and Soil. 2004;263(1): 17–27.
Available:https://doi.org/10.1023/B:PLSO.0000047722.49160.9E

Peer-review history:
The peer review history for this paper can be accessed here:
https://www.sdiarticle5.com/review-history/107535