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Effects of Mechanical Seeder Adoption in Rice Farming in Cagayan Valley Region, Philippines

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Abstract

Mechanical Seeder (MS) is a machine for planting rice. The Mechanical Seeder was initially introduced to rice farmers in Cagayan Valley Region, Philippines. This study was conducted to assess the benefits of the Mechanical Seeder in rice farming. The respondents in this study were the farmer-users of both the Mechanical Seeder and Manual Transplanting method in their neighboring or adjacent farms. All data were gathered through the use of an interview schedule. Data were analyzed using cost and return analysis and partial budget analysis to determine the economic benefits. Yield data was subjected to descriptive statistical analysis to get the yield differences. Major problems encountered by the respondents were also documented. Results revealed that the use of Mechanical Seeder in 2018 can significantly increase yield by 0.42 tons/ha for the first cropping and 0.39 tons/ha for the second cropping. The net returns of Mechanical Seeder in 2018 were higher than manual transplanting by PhP12727.16 for the first cropping and PhP12459.66 for the second cropping as a result of higher yield with a difference and reduced cost for seeds and planting. The cost per kilogram of rice production using Mechanical Seeder was lower than using the manual transplanting method by PhP1.90 per kilogram for the first cropping and PhP1.91 per kilogram for the second cropping. The major problems encountered by the respondents in using the MS were the susceptibility to weed infestation, high pests' infestation, hard to manage the irrigation and drainage system and water lodging which affected the germination of the seeds.

Keywords

Rice, Direct Seeding, Mechanical Seeder, Rice Farming, Rice Planting, Mechanization

1. Introduction

Rice farming in the Philippines is a labor-intensive endeavor, and enhancing the efficiency of key operations is essential for improving productivity. Traditionally, manual transplanting has been the dominant method for rice planting. However, this approach is not only physically demanding but also costly. As a response to these challenges, direct seeding has emerged as a viable alternative. In direct seeding, pre-germinated seeds are sown directly onto the soil surface, offering several advantages over transplanting, including reduced labor costs, earlier crop maturation, and lower expenses for crop establishment and management [1].

The introduction of the Mechanical Seeder (MS) in 2011, through the Korean Project on International Agriculture (KOPIA) in collaboration with the Philippine Rice Research Institute (PhilRice), marked a significant milestone in the mechanization of rice production in the country. Studies, such as those by Kumar [2], have highlighted the benefits of direct seeding over traditional puddled transplanting, including comparable yields, reduced irrigation and labor costs, increased net economic returns, and lower methane emissions. The adoption of precision seeders like the MS holds promise for small-scale farmers by improving productivity while reducing production costs [3]. Regalado *et al*. [4] even estimated that precision seeding could increase rice yields by approximately 10%.

In response to these potential benefits, the Department of Agriculture-Regional Field Office 2 (DA-RFO2) has begun promoting the Mechanical Seeder by distributing units to farmer cooperatives and organizations in the Cagayan Valley region. While some farmers have adopted the technology, others remain cautious, and uncertain about its practical benefits. To encourage wider adoption of the Mechanical Seeder, it is crucial to assess its impact on cost efficiency and yield outcomes. This study seeks to evaluate the effectiveness of the Mechanical Seeder in enhancing rice productivity and providing economic benefits to farmers in Cagayan Valley region, Philippines.

2. Methodology

2.1. Time, Respondents and Scope of the Study

The research was carried out in Cagayan Valley Region, Philippines in January 2019 to February 2020. The respondents of this study were the farmers using both Mechanical Seeder and manual transplanting of first and second cropping of 2018.

This research focused on all the sixty-seven (67) initial farmer-users of both Mechanical Seeders and Manual Transplanting methods in Cagayan Valley region to determine the benefits and challenges that affect the adoption of Mechanical Seeder technology. These farmers used both the Mechanical Seeder and Manual Transplanting techniques in their rice production across neighboring and adjacent farms, allowing for a comparative analysis of the two practices. The study specifically examined the benefits associated with the Mechanical Seeder in terms of yield, production costs, and income. However, it did not address other aspects

such as ecological, weather, personal experiences or social benefits, nor did it explore financial considerations related to acquiring and operating the Mechanical Seeder, or the technical performance, advantages and long-term sustainability of using the technology.

2.2. Research Framework

The framework of this study was based on the theory of change. A theory of change is a method that explains how a given intervention, or set of interventions, are expected to lead to a specific development change or result, drawing on a causal analysis based on available evidence [5]. The introduction and adoption of Mechanical Seeder realized results and benefits in rice production and these were documented in this study.

2.3. Research Instrument

An interview schedule was used in gathering information. The utilization and yield of farmers both using Mechanical Seeder and using manual transplanting in their rice farming were documented in this study. Primary data from farmers on cost incurred in rice production using Mechanical Seeder and using manual transplanting were collected. The actual yield of farmers both using Mechanical Seeder and using manual transplanting were also documented using a questionnaire.

2.4. Data Analysis

Data on yield gathered from the farmers using Mechanical Seeder and using manual transplanting were tabulated and analyzed using appropriate statistical analysis. Statistical analyses were done through Statistical Package for the Social Sciences (SPSS) system.

T-test was performed to compare the effects of Mechanical Seeder utilization and manual transplanting on the yield, for the first and second cropping of 2018 of the farms of respondents planted with both Mechanical seeder and manual transplanting. The t-test was used to determine whether the two practice namely the mechanical seeding and manual transplanting practice of are statistically different from each other.

Cost and return analysis were used to determine the return, costs of production and net income of farmers. The total cost represents the final value of all inputs (cash and non-cash) a farm uses in a given period. The return is the total revenue represents the total income that farmers receive from selling the rice per season. The cash costs were inputs like fertilizer, seeds, pesticides and other non-cash costs as well as the return (yield) items reflected in the "Using Mechanical Seeder" and "Using Manual Transplanting". Cost and return for 1st and 2nd cropping of 2018 were computed and compared to determine variances.

Partial budget analysis was also done to assess the net effect of a change in rice production practice of farmers particularly on the use of Mechanical Seeder versus the use of manual transplanting method of crop establishment. Calculations on

the four major sets of data for the Partial Budget were undertaken such as: a) Added costs (additional costs; b) Reduced return (reduction in income/return); c) Reduced costs (reduction in costs); and d) Added return (additional income/return). Partial Budget only considered the cost and or return items that were affected by the introduction of the Mechanical Seeder.

The cost was measured in Philippine pesos per hectare (PhP/ha), including all expenses related to planting, such as labor, seed, and equipment. Other data used in the determination of production cost and income were based on the following: a) Regular buying price of National Food Authority (NFA) in 2018 for clean and dry palay from farmers was Php17.00 per kilogram [6] and b) Land rental at Php2.19/kg and interest on capital at Php0.40/kg [7].

3. Results and Discussion

3.1. Yield Benefits

The use of Mechanical Seeder was expected to have an effect in rice yield. Rice yield is the amount of the produced rice in an area expressed is usually expressed in tons/hectare.

The yield differences of using the Mechanical Seeder and manual transplanting were documented. The average yield for the first cropping of 2018 using manual transplanting was 5.13 tons/hectare, and the yield with using Mechanical Seeder was 5.55 tons/hectare. For the second cropping season of 2018, the yield using manual transplanting was 5.05 tons/hectare and using Mechanical Seeder was 5.44 tons/hectare (Table 1).

Table 1. Benefits of Mechanical Seeder utilization on rice yield per hectare, 2018.

Year	Cropping	Average Yield, 14%MC (tons/ha)		Mean Difference	p-Value
		Using Mechanical Seeder	Using Manual Transplanting		
2018	1st cropping season	5.55	5.13	0.42	0.030*
	2nd cropping season	5.44	5.05	0.39	0.002**

**significant at 1% level significance; *significant at 5% level of significance.

The yield of farmer-respondents using Mechanical Seeder significantly increased for the first cropping season ($p < 0.05$) while a highly significant increase was recorded for the second cropping season ($p < 0.01$). For the first cropping season, there was a 0.42 tons/hectare increase in the yield, while for the second cropping season of 2018; there was a 0.39 tons/hectare yield increase when Mechanical Seeder was used.

The increase in yield due to the use of Mechanical Seeder conforms to the findings of Zhang [8] which observed a significantly improved crop growth population and increased yield due to increase density and precise distance in planting.

The average rice yield of all ecosystem of rice farm in Cagayan Valley region for the first cropping season was 4.51 tons/hectare [9]. This is lower than the recorded harvest of farmer respondents which was 5.13 tons/hectare using manual transplanting and 5.55 tons/hectare using Mechanical Seeder. However, the yields of the respondents with the use of Mechanical Seeder were comparable to the findings of Oli [3] which ranged from 5.18 to 7.97 tons/hectare.

The study of Kumar [2], however, observed similar yields on the use of direct seeding and puddled transplanting on rice production. He emphasized that yields may vary in some regions due to uneven and poor crop stand, poor weed control, higher spikelet sterility, crop lodging and poor knowledge on water and nutrient management.

The reason in the increase in yield on the use of Mechanical Seeder can be accounted from the improved rice population density for optimum yield and precise placement of seeds for better emergence and stability. The use of Mechanical Seeder also prevented transplanting shock to seedlings that could also contribute to better yields. This is consistent to the findings of Zhang [8] that mechanical direct rice seeding significantly improved the crop growth, population and effectively solved the problems of high frequency of disease and pests caused by the irregular distribution of rice seeds with manual broadcasting, and generally reduced seed usage and increased the yield as a result of higher density and precise distance in planting.

The yield increase of using Mechanical Seeder also supported by the study conducted by Gagelonia *et al*. [10]. She reported that the Korea's precision seeder attained higher yield than the PhilRice drum seeder due to better placement of seeds by the Korean precision seeder that resulted in good seedling emergence and crop growth. This was also confirmed by the report of IRRI [11] that plant spacing is an important factor in planting rice. Proper spacing can increase the yield by 25% - 40% over improper spacing. Straight rows also facilitate management practices such as hand or rotary weeding and application of fertilizers, herbicides, or insecticides, thereby saving money on inputs, labor, and materials. On the other hand, the study of Oli [3] also revealed that the yields when using mechanized precision seeder ranged from 5.18 to 7.97 tons per hectare. The yield of respondents using Mechanical Seeder and manually transplanted rice was comparable to the report of Oli [3].

3.2. Income and Cost Benefits

Table 2 shows the costs and returns of rice production using different method of planting for the first cropping of 2018 based from the data gathered from the farmer respondents. This analysis was prepared using the perspective of the farmers availing the services of Mechanical Seeder. Maintenance of the MS was already included in the cost of crop establishment.

The total return for rice production using Mechanical Seeder was PhP94,380.00 and for manual transplanting was PhP87278.00 per hectare at PhP17.00 per kilo-

gram buying price. The returns of Mechanical Seeder were higher by PhP7102.00 as a result of higher yield with a difference of 417.76 kgs.

Table 2. Costs and returns of rice production of different crop establishment method per hectare in Cagayan Valley Region, first cropping, 2018.

Items	Crop Establishment		
	Mechanical Seeder	Manual Transplanting	Difference
Returns	94380.00	87278.00	7102.00
Yield, kg/ha	5551.76	5134.00	417.76
Price, PhP/kg	17.00	17.00	0.00
Costs	54763.76	60388.92	−5625.16
Cash Costs	25233.35	31083.80	−5850.45
Seeds	1100.00	3300.00	−2200.00
Land preparation fee	6500.00	6500.00	0.00
Fertilizers	7600.00	7600.00	0.00
Herbicides	1285.00	432.00	853.00
Insecticides	615.00	615.00	0.00
Molluscicides	1260.00	1260.00	0.00
Crop establishment	3891.00	8500.00	−4609.00
Fertilizer and pesticide application	1755.00	1150.00	605.00
Drying Costs	1110.35	1026.80	83.55
Food expenses	917.00	1500.00	−583.00
Others/Non-Cash Costs	29530.40	29305.12	225.28
Caretaker's share	9438.00	8727.80	710.20
Combine harvester's share	7550.40	6982.24	568.16
Land rental (PhP1-2.50/kg of the total yield)	8000.00	8000.00	0.00
Interest in capital	4542.00	5595.08	−1053.08
Net Returns (Returns-Costs)	39616.24	26889.08	12727.16
Cost per kilogram	9.86	11.76	−1.90

The total cost of production of rice per hectare using the Mechanical Seeder was PhP54763.76 while using manual transplanting was PhP60388.92. The total cost consists of the cash costs and non-cash costs. The cash cost includes the seeds, land preparation fee, fertilizer, molluscicides, herbicides, drying cost and food expenses. The non-cash costs and other costs include the caretakers share, combine harvester's share, land rental and interest in capital. Other costs usually were being

paid based from the total return and usually paid after the harvest. The costs incurred for crop establishment using manual transplanting was PhP8500.00 which is higher than the crop establishment using Mechanical Seeder with PhP3891.00 with a difference of PhP4609.00.

Overall, the costs incurred for manual transplanting is higher than using Mechanical Seeder with a difference of PhP5625.16. The reduce costs when using the Mechanical Seeder were bought by the reduce use of seeds, costs for the crop establishments like reduced cost for planting using MS and the food expenses. There was also a reduced cost in the interest in capital when using the Mechanical Seeder due to lesser cash costs incurred. On the other hand, there was an increase in the cost of herbicides because of the high occurrence of weeds in the farms planted with Mechanical Seeder.

The net returns of rice per hectare using the Mechanical Seeder was PhP39616.24 and using manual transplanting was PhP26889.08. The net returns of Mechanical Seeder were higher than manual transplanting by PhP12727.16 as a result of higher yield with a difference and reduced cost for seeds and planting.

The cost per kilogram of rice production using the Mechanical Seeder was PhP9.86 and using the manual transplanting was PhP11.76. The cost per kilogram of rice production using Mechanical Seeder was lower than using the manual transplanting by PhP1.90 per kilogram.

Table 3 shows the costs and returns of rice production using different system of planting for the second cropping of 2018 based from the data gathered from the farmer-users and farmer-non-users.

Table 3. Costs and returns of rice production of different crop establishment method per hectare in Cagayan Valley Region, second cropping, 2018.

Items	Crop Establishment		
	Mechanical Seeder	Manual Transplanting	Difference
Returns	92548.00	85906.67	6641.33
Yield, kg/ha	5444.00	5053.33	390.67
Price, PhP/kg	17.00	17.00	0.00
Costs	53213.22	59031.55	−5818.33
Cash Costs	24198.80	30142.67	−5943.87
Seeds	1100.00	3300.00	−2200.00
Land preparation fee	6500.00	6500.00	0.00
Fertilizers	7230.00	7230.00	0.00
Herbicides	1383.00	479.00	904.00
Insecticides	648.00	648.00	0.00
Fungicides/Molluscicides	1310.00	1310.00	0.00

Continued

Crop establishment	3891.00	8500.00	−4609.00
Fertilizer and pesticide application	1453.00	945.00	508.00
Drying Costs	1088.80	1010.67	78.13
Food expenses	875.00	1500.00	−625.00
Other/Non-Cash Costs	29014.42	28888.88	125.54
Caretaker's share (10% of return)	9254.80	8590.67	664.13
Combine harvester's share and hauling (8% - 10% of the total return)	7403.84	6872.53	531.31
Land rental (PhP1-2.50/kg of the total yield)	8000.00	8000.00	0.00
Interest in capital (18% of the cash cost per/yr)	4355.78	5425.68	−1069.90
Net Returns (Returns-Costs)	39334.78	26875.12	12459.66
Cost per kilogram	9.77	11.68	−1.91

The comparison of the costs and return analysis for using the Mechanical Seeder and manual transplanting for the second cropping of 2018 had almost the same result for the first cropping season. The returns of Mechanical Seeder were higher than manual transplanting by PhP6641.33 as a result of higher yield with a difference of 390.67 kgs. In terms of total cost of production, manual transplanting incurred higher cost than the Mechanical Seeder with a difference of PhP5818.33.

The costs associated with manual transplanting are higher than those of using a Mechanical Seeder. The cost savings with the Mechanical Seeder stem from reduced seed usage, lower crop establishment costs (such as reduced planting expenses), and savings on food expenses. Additionally, the use of a Mechanical Seeder led to lower interest costs on capital due to fewer cash outflows. However, there was an increase in herbicide costs, as farms planted with the Mechanical Seeder experienced a higher occurrence of weeds.

The net returns of Mechanical Seeder were also higher by PhP12459.66 as a result of higher yield with a difference and reduced cost for seeds and planting. The cost per kilogram of rice production using Mechanical Seeder was lower than using the manual transplanting by PhP1.91 per kilogram.

Partial budget analysis was used to determine the income of farmers in using the precision seeder. The data used in the analysis was based on the information provided by the farmer-users. This was done to assess the net effect of a change in rice production practice of farmers particularly on the use of Mechanical Seeder versus the manual transplanting method of crop establishment. The gains or positive effects leading to increased farmer's income are the added returns and reduced costs.

Table 4 shows the partial budget of using Mechanical Seeder versus manual transplanting per hectare in Cagayan Valley. The total added returns and reduced

costs was PhP14494.00 and the total added cost and reduced returns was PhP1541.55. The net effect using Mechanical Seeder was PhP12952.45.

Table 4. Partial budget of using Mechanical Seeder versus manual transplanting, per hectare, in Cagayan Valley region for the first cropping season, 2018.

Gains/Positive Effects (A)		Costs/Negative Effects (B)	
Added Returns		Added Costs	
Yield increase		Crop care	
= 417.76 kgs X PhP17.00/kg = PhP7102.00	7102.00	Application of herbicide, insecticide, etc	605.00
		Additional herbicide	853.00
		Drying Cost	83.55
Total Added Returns	7102.00	Total Added Costs	1541.55
Reduced Costs		Reduced Returns	
Seed (2bags/ha @ PhP 1100.00/bag)	2200.00		
Crop Establishment	4609.00		
Food expense (for snacks of planting)	583.00		
Total Reduced Costs	7392.00	Total Reduced Returns	0
Total Added Returns and Reduced Costs	14494.00	Total Added Costs and Reduced Returns	1541.55
Net Effect (A-B)		12952.45	

The reduced costs cover lower seed requirement at 2 bags per hectare and the averted costs of seedling preparation, pulling, bundling, hauling and distribution of seedlings, tying and transplanting at the amount of PhP4,609.00. In addition, lower costs of meals and snacks are expected because of minimal labor requirement and faster completion of activities with the amount of PhP583.00. On the other hand, the negative effects are the added costs of crop care as herbicide application is generally higher amounting to PhP605.00, additional herbicide with the amount of PhP853.00 and additional cost for drying of PhP83.55.

Even if the use of Mechanical Seeder does not increase the yield, positive effect in the form of cost reduction makes the use of Mechanical Seeder advantageous at current service fee charged by MPS operators. The net effect without the yield effect was PhP5851.45. The substantial savings suggest that farmers are still better off using the Mechanical Seeder.

Table 5 shows the partial budget of using Mechanical Seeder versus manual transplanting per hectare in Cagayan Valley, for second cropping. The total added returns and reduced costs was PhP14075.33 and the total added cost and reduced returns was PhP1490.13.

The increase in yield using the Mechanical Seeder and the reduced in the use of

seeds had positive net effect at the amount of PhP12588.20. The net effect was a result of the yield increase by 390.67 kilograms per hectare amounting to PhP6641.33.

Table 5. Partial budget of using Mechanical Seeder versus manual transplanting, per hectare, in Cagayan Valley region for the second cropping season, 2018.

Gains/Positive Effects (A)		Costs/Negative Effects (B)	
Added Returns		Added Costs	
Yield increase = 390.67 kgs X PhP17.00/kg = PhP6641.33	6641.33	Crop care Application of herbicide, insecticide, etc	508.00
		Additional herbicide	904.00
		Drying Cost	78.13
Total Added Returns	6641.33	Total Added Costs	1490.13
Reduced Costs		Reduced Returns	
Seed (2bags/ha @ PhP 1100.00/bag)	2200.00		
Crop Establishment	4609.00		
Food expense (for snacks of planting)	625.00		
Total Reduced Costs	7434.00	Total Reduced Returns	0
Total Added Returns and Reduced Costs	14075.33	Total Added Costs and Reduced Returns	1490.13
Net Effect (A-B)		12585.20	

3.3. Problems Encountered by the Respondents

The problems identified by the respondents related to the utilization of the MS in rice production is presented in Table 6. Problems identified were susceptibility to weed infestation, high pest infestation, hard to manage the irrigation and drainage system, water lodging which affected the germination of the seeds, small and irregular farm size (not compatible with the capacity of the MS), and missing hills.

Table 6. Problems encountered by the respondents, 2018.

Problems	Farmer Respondents	
	No.	%
Susceptible to weed infestation	14	20.90
High pests' infestation	9	13.43
Hard to manage the irrigation and drainage system	9	13.43
Water lodging which affected the germination of the seeds	9	13.43

Continued

Small and irregular farm size	6	8.96
Missing hills using the MS	6	8.96
Inapplicable for seed production	6	8.96
No problems encountered	8	11.94

Twenty one percent (20.90%) of the respondents identified susceptibility to weed infestation as one of the major challenges in the use of the MS. Thirteen percent (13.43%) of the respondents had problems on the management of the irrigation system, high pest infestation and water lodging which affected the germination of the seeds. Almost nine percent (8.96%) of them had seen the problem that MS is not applicable for rice seed production, small and irregular size farms which resulted to incompatibility to the capacity of MS and missing hills. Moreover, 11.94% of the respondents have not experienced problems on utilizing the MS technology.

4. Conclusion

This study was conducted to assess the economic benefits and yield effects of the Mechanical Seeder in rice farming in Cagayan Valley region, Philippines. The use of Mechanical Seeder can significantly increase yield by 0.42 tons/ha for the first cropping and 0.39 tons/ha for the second cropping. The net returns of Mechanical Seeder were higher than manual transplanting by PhP12727.16 for the first cropping and PhP12459.66 for the second cropping of 2018 as a result of higher yield with a difference and reduced cost for seeds and planting. The cost per kilogram of rice production using Mechanical Seeder was lower than using the manual transplanting by PhP1.90 per kilogram for the first cropping and PhP1.91 per kilogram for the second cropping. The major problems encountered by the respondents in using the MS were the susceptibility to weed infestation, high pests' infestation, hard to manage the irrigation and drainage system and water lodging which affected the germination of the seeds.

Authors' Contributions

Each author made equal contributions to the study's conceptualization and design. All authors have reviewed and approved the final version of the manuscript for publication.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

References

[1] PhilRice (2016) Direct-Seeding Addresses High Labor Cost—Experts. https://www.philrice.gov.ph/direct-seeding-addresses-high-labor-cost-experts/

[2] Kumar, V. and Ladha, J.K. (2011) Direct Seeding of Rice: Recent Developments and Future Research Needs. In: *Advances in Agronomy*, Elsevier, 297-413. https://doi.org/10.1016/b978-0-12-387689-8.00001-1

[3] Oli, G. (2018) Technology Demonstration and Promotion of Mechanized Rice Farming in the Lowland Irrigated Areas in Region 02. Department of Agriculture-Regional Field Office 2.

[4] Regalado, M.J., Bautista, E.U., Tado, C.J., Gagelonia, E.C., Sicat, E.V., Canapi, G. and Panagsagan, J. (2015) Mechanization of Land Preparation and Crop Establishment Operations in Rice Farming in the Philippines. Asia Rice Foundation.

[5] UNDG (2018) Theory of Change: UNDAF Companion Guidance. United Nations Development Group. https://unsdg.un.org/sites/default/files/UNDG-UNDAF-Companion-Pieces-7-Theory-of-Change.pdf

[6] NFA (2019) Palay Buying Price. http://nfa.gov.ph/35-news/1297-palay-procurement

[7] Bordey, F., Moya, P., Beltran, J. and Dawe, D. (2016) Competitiveness of Philippine Rice in Asia. Science City of Muñoz (Philippines), Philippine Rice Research Institute, International Rice Research Institute.

[8] Zhang, M., Wang, Z., Luo, X., Zang, Y., Yang, W., Xing, H., *et al*. (2018) Review of Precision Rice Hill-Drop Drilling Technology and Machine for Paddy. *International Journal of Agricultural and Biological Engineering*, **11**, 1-11. https://doi.org/10.25165/j.ijabe.20181103.4249

[9] PSA (2019) 2019 Selected Statistics on Agriculture. Philippine Statistics Authority. https://psa.gov.ph/system/files/main-publication/Selected%2520Statistics%2520on%2520Agriculture%25202019.pdf

[10] Gagelonia, E.C. and Abon, J.O. (2013) Adaptation of Korea's Riding Type Seeder in Rice Seed Production. 10*th International Agricultural Engineering Week and Exhibition*, Tuguegarao, 22-26 April 2013. Philippine Society of Agricultural Engineers.

[11] IRRI (2019) Step by Step Rice Production: Planting. Knowledge Bank. http://www.knowledgebank.irri.org/step-by-step-production/growth/planting