Enhancing Food Security Using Rice Crop Manager (RCM) Technology (Geotagging) in Rice Production Systems in Bicol Region

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Abstract

RCM technology is an ICT science-based tool for best bet farming practices and crop management guidelines to increase yield and income of rice farmers. One of its components is geotagging which allows for a more precise fertilizer recommendation because it measures the actual field size and mapping of area. It was disseminated and applied locally in 2013 to date through regional orientation on the technology; conduct of field evaluation trials, deployment and monitoring; establishment of technology demonstration plots and precision rice farm clusters; and, capacitating of stakeholders on the software technology.

Verification trials showed 43.25% yield advantage of direct-seeded NSIC RC 222 with net benefit of Php 44,743.83 for rainfed rice and 24.60% yield advantage of direct-seeded NSIC RC 238 with net benefit of Php 44,481.80 for irrigated rice.

Precision rice farm clusters exhibited 7547.21 kg/ha and 7820.00 kg/ha for direct-seeded NSIC RC 302(DS) and 5736.43 kg/ha, 5991.98 kg/ha and 7404.65 kg/ha for direct-seeded NSIC RC 238 and NSIC RC 222 (WS). For the irrigated, significant yields obtained were 6302.43 kg/ha, 6343.93 kg/ha, 10914.58 kg/ha for direct-seeded NSIC RC 242(DS) and comparable yields of NSIC RC 222 with7810.00 kg/ha-9718.60 kg/ha (WS).

Deployment to 34,812 farmers and monitoring activities indicated milestones with increase of yields and income, more than the 8 bags and Php4,500.00 per hectare attainable with RCM. Initial ROIs obtained were:40.75% and 97.00%.

Therefore, RCM Technology is a sustainable productivity-enhancing, climate-resilient, inclusive ICT tool for transforming rice production in the rainfed and irrigated lowland ecosystems of Bicol.

Keywords: transforming, rice crop manager, rainfed, irrigated

Introduction

Bicol region has an aggregate area of 222,226 hectares of irrigated and 120,973 hectares of rainfed lowland areas with 872,206 MT and 371,035 MT production(Bicol Agricultural Profile) and rice sufficiency of 116.27%. However, the productivity level increase is only 2.33% per year compared to the population growth rate of 1.29% and an average yield of 3.41 t/ha to 3.83 t/ha from cy 2010 to cy 2015.

Crop management practices employed in maximizing rice yields have been disseminated through farmers field schools with local farmer technicians assisting the agricultural technicians in their technology transfer activities, rigorously capacitated by the extension program of the DA-ATI.

ICT-based tools have been developed to further expand the reach and reality of rice enhancing POTs. Among these is the Rice Crop Manager(RCM) which provides a unique way of bringing to the household/farmer level the rice cultivation practices with ease, precision and climate change resiliency.

RCM technology is a farmer-oriented, ICT science-based tool for best bet farming practices and crop management guidelines to increase income of farmers which could be accessed for free at the website www.webapps.irri.org/ph/rcm. It provides the opportunity for efficient, personalized and specific recommendations per cropping season and together with its advisory services, more profitable.

Field evaluation and deployment of the RCM technology would reduce vulnerability of rice production systems to climate change risks; enhance rice yields in the irrigated and rainfed lowlands; and, open opportunities for diversified farming systems in the rainfed lowlands because of more farming returns. The accelerated promotion and commercialization of the technology in both development zones will promote sustainable rice sufficiency and enhance food security in the rural communities.

Objectives:

1. Determine the local performance of the RCM technology;
2. Promote and commercialize the RCM technology;
3. Capacitate project stakeholders on the RCM software ; and,
4. Determine the cost and return analysis of the technology.

Review of Related Literature

Rice Situationer

Bicol region has an aggregate area of 222,226 hectares of irrigated and 120,973 hectares of rainfed lowland areas with 872,206 MT productions, a rice sufficiency of 116.27%, productivity increase of 2.33% per year and population growth rate of 1.29%. Likewise, productivity per hectare is only 3.83 t/ha (2015). Source: NRO 5-NEDA

Climate Change

It refers to events associated with the increase in global temperature, changes in precipitation pattern, occurrence of extreme events and increase in sea level. Examples of these are global warming, typhoons, El nino and La nina. The Intergovernmental Panel on Climate Change Fourth Assessment Report (2007) highlights that changes in Southeast Asia between 2010 and 2099 would include: increase in temperature from 0.72 C to 3.2 C; change in precipitation from -2% to 12%; and global rise in sea level from 18 cm to 59 cm. Philippine mean annual temperature increased by 0.61 C during the period 1951 to 2006 which resulted in significant increase in frequency of hot days and warm nights(PAG-ASA

DOST). Maps of the Manila Observatory generated during 1950 to 2000 indicate that northern, eastern and westernmost part of Luzon and most of Minadanao have less rains while, western Visayas have more rains.
Bicol has sustained rice damages of hundreds of million through the years because of typhoons, low pressure areas, flashfloods and dry spells.

Regional Rice R&D Agenda (2017-2022)

In 2016, regional and national consultations on different commodities with multi-stakeholders resulted to the updated Research, Development and Extension Agenda for the duration 2017-2022 for major commodities including rice.
This agenda, programs and projects would be the basis for short and long term interventions and financial investments of the Department of Agriculture for research activities.

Technology Commercialization

This is a component of technology management which refers to the process of marketing or selling a technology through 2 mechanisms, technology incubator and technology park. Technology incubator refers to the program which offers a full array of business assistance services tailored to the client company, whereas, technology park is a mechanism designed to stimulate the development of entrepreneurial, knowledge-based micro to small and medium size enterprises.
Meeting the challenge of sustaining available and affordable food for the rural communities necessities a strong technology transfer of research technologies from the generators to the adopters for a vibrant rural economy.
This continuum from research to transfer of technology/commercialization is necessary to translate research results into action at the farm level and allow free input from extension agents finetuning of the technology.

Rice Crop Manager

It is an ICT tool to facilitate the calculation and deployment of field-specific nutrient management and a comprehensive support tool for increasing yields and income of farmers. The generated output is a one page fertilizer application for the vegetative and reproductive stages. These precise recommendations facilitate the increase in yields at lower cost by providing the number of applications and what fertilizer in what amount to be applied at specific periods. As such, more farmers can be reached with opportunity for higher production and net benefits.

Methodology

I. Determination of the location specific performance of the RCM Technology

Conduct of Field Evaluation Trials

Verification trials were conducted in representative irrigated and rainfed ecosystems in WS 2013 and DS 2014 with 4 farmers, 3 using RCM and 1 using farmers practice (FP). These were laid out in a randomized complete block design, plot size of 3m x 4m, plant spacing of 20 cm x 20 cm, and 3 replications. Data on agronomic, parameters and yield components were collected and analyzed using the STAR Program of IRRI.

II. RCM Technology Promotion and Commercialization

Procurement and Distribution of IT Equipments

The RCM Technology requires a set-up of recommended hardware such as, laptop/tablet, pocket wi-fi and direct printer. IT equipments were procured and distributed to the LGU units.

RCM Deployment and Monitoring

From 2014 to 2017, dissemination of RCM technology was undertaken in the region, wherein, farmers were interviewed and provided with the 1 page output for application in their farms.

Monitoring of farmer enrollees was conducted to assess the adoption of the RCM-based recommendations together with the other crop management practices used such as: seeding rate, establishment method used, water management employed, chemical sprayings, variety used and specific ecosystem.

Establishment of Technology Demonstration Plots(TDP)

Ten (10) hectare TDP sites were established for both rainfed and irrigated ecosystems for DS and WS 2014 with farmers regularly monitored for the adoption of the RCM-based nutrient recommendations. Data collected were: previous season's yield, current season's target yield and actual yield.

Establishment of Precision Rice Farm Clusters (PRFC) with Georeferencing

Researcher-managed farm clusters with 8 to 10 farmers were established for both ecosystems for both dry and wet seasons in 2016. All farm lots were geotagged prior to the generation of the one-page output. Data collected were: agronomic traits and yield components. This were analyzed using the STAR Program of IRRI.

III. Capability-building activities of project implementers and local government units and technology briefings with farmers

Project implementers were involved in national project briefings which were conducted twice a year. Likewise, provincial, city and municipal local government units were regularly invited for participation in consultation meetings, technology briefings and hands on trainings.

The ATI was involved in fasttracking the dissemination of the RCM technology through their SMS texting and calling and conduct of Training of Trainers for the RCM coordinators from 2015 and onwards.

Results and Discussion

Field Evaluation Trials

Verification trials were conducted in the rainfed lowland in Ocampo, Camarines Sur and irrigated lowland in Minalabac for WS 2013 and DS 2014. Four (4) farmers were selected per site and RCM plots were superimposed in the farmers field wherein crop management practices undertaken were uniform except for the nutrient management practice. This specific practice followed the recommended fertilization input of RCM.

Rainfed Ecosystem (Gatbo, Ocampo)

Gatbo is one of the 25 barangays of Ocampo, belonging to the rural outlying areas with 2,168 residents. It is situated at the foot of Mt. Isarog divided into two areas, traversed by the gravitational waters for irrigation and the other side adversely affected by dry spells and drought periods. It has 189.50 hectares irrigated lowland and 36 hectares rainfed areas with 159 and 29 farmers, respectively.

Crop Management Practices

The rice variety used was NSIC Rc 222 and crop establishment used was direct seeding. Two (2) sites showed significantly promising yields of 6251.74kg/ha and 7668.80kg/ha in the RCM plots compared to FP practice with 3985.16kg/ha. Productive tiller count obtained were significantly high at a range of 33 to 40 compared to FP with only 15. Number of filled and unfilled grains and weight of 1000 grains significantly influenced the promising yields obtained with high values of 129-106, 53 and 30.8gms. (Table 1). Compared to the value under FP, only 89 filled grains and unfilled grains of 53 was corrected by the significantly high seed weight of 1000grains or the spikelets became heavier during the grain-filling period. With good weather condition and sustainable supply of nutrients,

good photosynthetic activity resulted to more number of filled and heavy grains. On the other hand, prolonged dry spell during the dry season affected the crop stand with only one (1) site obtaining significant yield of 5189.53 kg/ha with good tillering ability of 17, almost double the other values and taller plant height of 92cms. The panicles were longer at 26.6cms, more number of filled grains of 115 and heavier 1000 grains of 31.2gms. (Table 2 & Fig.1) Tayefe,M.et.al.,(2012), reported the significant effect of nitrogen of yield and yield components of rice. Furthermore, N contributes to spikelet production during early panicle formation stage, and contributes to sink size during the late panicle formation stage. It plays a role in grain filling, improving the photosynthetic capacity, and promoting carbohydrate accumulation in culms and leafsheaths (Mae,1997).

Net benefits obtained were Php38,531.86, Php62,621.88 and Php33,077.75, respectively.(Fig.2)

Table 1.Results of agronomic parameters and yield components of NSIC Rc222 in the rainfed ecosystem in Ocampo, Camarines Sur WS 2013.

Site/s	Plant Height (cm)		Tiller Count		Yield (kg/ha)		Total Weight of Grains		Panicle Length (cm)		No. of Filled Grains		No. of Unfilled Grains		Wt. Of 1000 Grains (g)		Net Benefits (Php)
Site 1	93.2	ns	40	**	3978.41	ns	139.6	ns	24.6	ns	86	ns	25	ns	26.3	ns	
Site 2	105.7	*	36	**	7668.80	**	245.4	*	24.5	ns	129	**	13	ns	27.9	ns	62,621.88
Site 3	99.2	ns	39	**	6251.74	**	163.7	ns	22.7	ns	106	*	53	**	30.8	*	38,531.86
Site 4	192.9	**	33	*	4315.93	ns	189.1	ns	25.2	ns	83	ns	35	ns	29.4	ns	
Site 5	98.0		15		3985.16		151.3		23.2		89		18		27.9		
%CV	**2.9**		**22.6**		**15.4**		**19.5**		**5.1**		**7.6**		**45.6**		**4.9**		

Table 2. Results of agronomic parameters and yield components in the rainfed ecosystem in Ocampo, Camarines Sur DS 2014

Site/s	Plant Height (cm)		Tiller Count		Yield (kg/ha)		Total Weight of Grains		Panicle Length (cm)		No. of Filled Grains		No. of Unfilled Grains		Wt. Of 1000 Grains (g)		Net Benefits (Php)
Site 1	77.80	ns	10	ns	3975.23	ns	85.2	*	26.3	**	89	**	17	ns	22.6	ns	
Site 2	75.59	ns	9	ns	3975.90	ns	52.5	ns	22.1	*	86	**	23	ns	25.3	*	
Site 3	92.00	n*	17	**	5189.53	**	102.6	**	26.6	**	115	**	26	ns	31.2	**	33,077.75
Site 4	72.40		9		3243.78		59.2		19.5		61		39		22.3		
% CV	**5.8**		**9.1**		**7.6**		**13.3**		**4.0**		**10.8**		**26.0**		**4.7**		

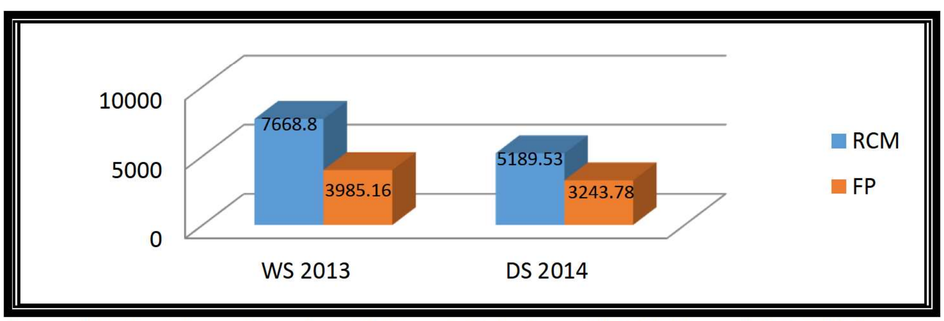


Fig.1.Yield obtained under RCM vs FP during WS 2013 and DS 2014

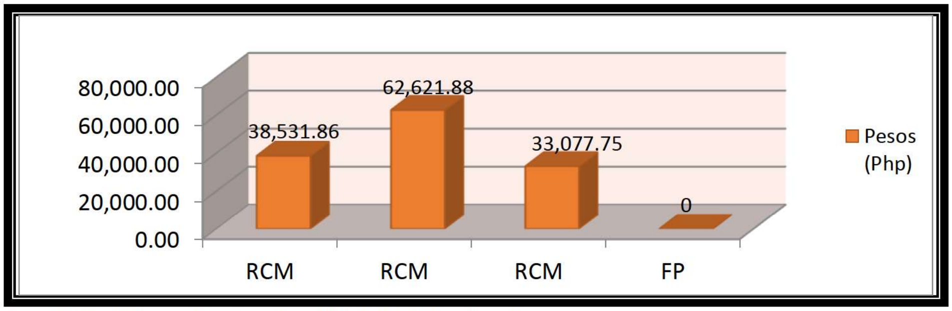


Fig.2 Net Benefits for the |Rainfed lowland

Irrigated ecosystem (Taban, Minalabac)

Taban is one of the 25 barangays of Minalabac in the outlying areas and considered rural with 1,023 residents in 2007. It is situated in the river basin area which is vulnerable to extreme and variable weather conditions.

Crop Management Practices

NSIC RC 238 was used and direct-seeded. Two RCM sites obtained significantly promising yields of 6507.61 kg/ha and 5802.79 kg/ha compared to the FP of 5052.20 kg/ha (Table 3 & Fig. 3)). Apparently, the significantly higher number of filled grains of 122 and 111(Table 3) resulted to higher yields, approximately double that of the FP value. The period was characterized by continuous heavy rains and the plants were submerged during the vegetative stage. During the dry season, three sites obtained significantly high yields of 4922.33 kg/ha, 5626.60 kg/ha and 5782.50 kg/ha(Table 4 & Fig 4).

The more precise fertilization technique could have sustained the nutrient availability from panicle initiation to flowering period. Likewise, the adequate nutrition resulted to taller plants with 91 cms to 103.8 cms, although only in two sites were the 1000 grain weight values significant at 25.9 gms and 29.7 gms. Only in one site were the values of total weight of grains, panicle length, number of filled grains, number of unfilled grains and 1000 seed weight, significant(Table 3). According to Barker and Dawe(2001) and Pingali et al(1997), current high yields of irrigated rice are associated with high applications of fertilizer. Likewise, it is the most yield-limiting nutrient in irrigated rice production around the world (Ladha and Reddy, 2003; Samonte et al 2006). Also, the capacity of soil to supply N may decline with intensive rice cropping under wetland condition; more than 50% of the N used by flooded rice receiving fertilizer N is derived from the combination of soil organic and biological nitrogen fixation by free-living and rice plant-associated bacteria; and, the remaining N requirement is normally met with fertilizer (Motior Rahman et al., 2009).

Net benefits obtained were Ph24,741.97, Php12,760.03 and Php23,116.26, Php35,088.85, Php37,739.15, respectively.(Fig.4)

Table 3. Results of agronomic parameters and yield components of NSIC Rc 238 in the irrigated ecosystem in Taban, Minalabac, Camarines Sur WS 2013.

Site/s	Plant Height (cm)	Tiller Count	Yield (kg/ha)	Total Weight of Grains (g)	Panicle Length (cm)	No. of Filled Grains	No. of Unfilled Grains	Wt. Of 1000 Grains (g)	Net Benefits (Php)
Site 1	105.6 ns	19 ns	6507.61 **	126.7 *	22.2 ns	122 **	9 ns	32.3 ns	24,741.97
Site 2	113.6 ns	18 ns	5802.79 *	108.9 ns	24.3 ns	111 **	51 **	30.4 ns	12,760.03
Site 3	100.2 ns	12 ns	5396.71 ns	86.6 ns	21.0 ns	86 ns	10 ns	32.6 ns	
Site 4	107.3	15	5052.20	94.8	21.6	66	19	31.4	
%CV	**6.6**	**17.0**	**4.9**	**11.8**	**11.5**	**13.5**	**42.6**	**7.1**	

Table 4. Results of agronomic parameters and yield components in irrigated ecosystem in Taban, Minalabac, Camarines Sur for DS 2014.

Practice/s	Plant Height (cm)		Tiller Count		Yield (kg/ha)		Total Weight of Grains (g)		Panicle Length (cm)		No. of Filled Grains		No. of Unfilled Grains		Wt. Of 1000 Grains (g)		Net Benefits (Php)
RCM	97.00	**	19	ns	4922.33	*	70.9	ns	20.9	ns	48	ns	14	*	24.9	ns	23,116.26
RCM	91.33	*	14	ns	5626.60	**	58.4	ns	21.4	ns	59	ns	8	ns	25.9	*	35,088.85
RCM	103.80	**	20	ns	5782.50	**	83.6	*	27.0	**	75	**	15	*	29.7	*	37,739.15
FP	80.67		17		3562.55		51.9		19.4		48		10		24.7		
% CV	**5.7**		**17.8**		**12.6**		**15.6**		**6.0**		**16.9**		**13.3**		**5.0**		

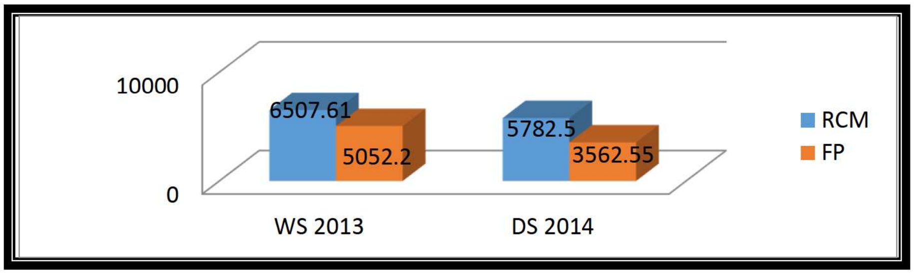


Fig.3. Yield obtained under RCM vs FP during WS 2013 and DS 2014

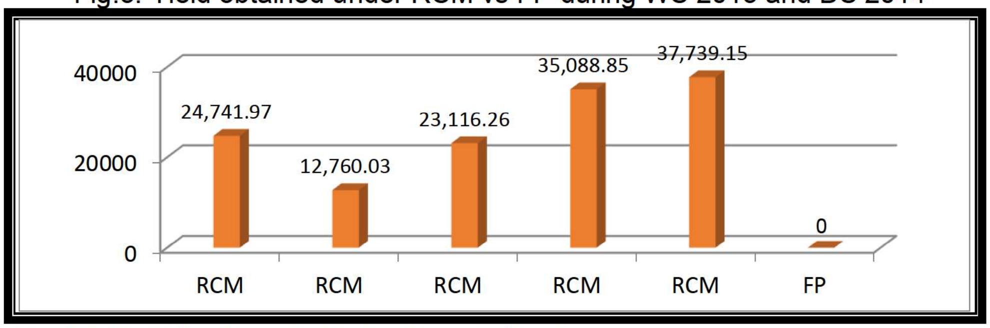


Fig.4 Added Net Benefits for the irrigated lowland

Figure 5. RCM research site in Minalabac

Figure 6. RCM research site in Ocampo

RCM Technology Promotion And Commercialization

121 IT equipments composed of laptops, tablets, pocket wifi and direct printers were procured and awarded to the different provincial, city and municipal LGUs under an agreement contract to facilitate the conduct of interview of farmers by the agricultural extension workers(AEWs).

RCM Deployment and Monitoring Activity. The strong collaboration with the LGUs and strong support of the local executives resulted to promising results. For the last 3 years (WS 2014 to DS 2017), approximately 34,812 farmers (Fig. 9) were interviewed and became RCM farmer enrollees in the different provinces, cities and municipalities. The involvement of the Field Operations Division in the implementation of the project this year is seen to further

boost the upscaling and outscaling of the technology because of the institutionalized support system for their extension services.

Farm monitoring activity was conducted last August 24, 2017 in Nabua with more or less 300 farmers, which indicated significant and promising results. The farmers were interviewed for their farming activities last May to December 2016 relative to their adoption of RCM technology. Although the questionnaires are still being processed, initial results showed positive indication for RCM adoption.

Figure 7. DA Staff (CBES & Operations) together with the Local Government of Nabua during the Farm Monitoring event in Macagang, Nabua, Cam. Sur

Figure 8. Mr. Elevado (AT) represents their MA to welcome the participants.

Figure 9. RCM deployment for the period 2014-2017

Region V	2014	2015	2016	2017
Farmer enrollees	7113	10,783	10,331	6585

Figure 10. Actual RCM interview in Minalabac

Figure 11. Sample RCM Recommendation

Technology Demonstration Plots and Monitoring Activity

Ten technology demonstration plots showing the technology were established in irrigated and rainfed ecosystems in Minalabac and Ocampo, Camarines Sur.

Table 5 showed that the farmers under rainfed conditions obtained higher yields during the wet season than during the dry season because of more soil moisture available, with the actual yields higher than their previous yields by 27 to 35 bags and 19 to 9 bags although the RCM target yields were not attained. The disparity in production would be attributed to deficient soil moisture, some pest infestation and plant nutrition. For the irrigated areas, actual yields were also higher than the previous yields by 25 to 35 bags and 9 to 15 bags although the RCM targets were not attained. The same factors affected the production

levels (Table 6). Thus, in Ocampo farmers obtained higher production through the use of RCM, both in the rainfed and irrigated areas. Likewise, in Minalabac farmers who used RCM obtained higher actual yields by 3 to 48 bags and 22 to 24 in the rainfed areas (Table 7). In the irrigated areas, the same trend was observed, with 28 to 30 bags and 11 to 15 bags differences for both seasons (Table 8).

The RCM questionnaire includes a target yield for the season, higher than the previous season's production. Thus, the nutrient recommendation is specific for this target. The additional 3 to 48 bags for the rainfed and 9 to 35 bags for the irrigated would be additional income of Php 2,397.00 to Php 38,352.00 and Php 7,195.00 to Php 27,965.00 for the farmers.

Table 5. Across sites in rainfed ecosystem at Ocampo, Camarines Sur DS/WS 2014.

Rainfed	Variety	Previous Yield	RCM target Yield	Actual Yield	Bags
10-Farmers (DS 2014)	NSIC Rc 222; NSIC Rc 238; NSIC Rc 194; PSB Rc10	45-65	85-95	80-92	35-27
10-Farmers (WS 2014)	NSIC Rc 222; NSIC Rc 238; NSIC Rc 194; PSB Rc 10	45-70	85-95	70-89	29-19

Table 6. Across sites in irrigated ecosystem at Ocampo, Camarines Sur DS/WS 2014.

Rainfed	Variety	Previous Yield	RCM target Yield	Actual Yield	Bags
10-Farmers (DS 2014)	NSIC Rc 276;NSIC Rc 274;NSIC Rc 222;NSIC Rc272;PSBRc 10;PSB Rc80	40-100	85-159	75-125	35-25
10-Farmers (WS 2014)	NSIC Rc 222; NSIC Rc 298;PSB Rc10;Blonde	45-70	85-95	70-89	15-19

Table 7. Across sites in rainfed ecosystem at Minalabac, Camarines Sur DS/WS 2014.

Rainfed	Variety	Previous Yield	RCM target Yield	Actual Yield	Bags
10-Farmers (DS 2014)	NSIC Rc 222; PSB Rc 10; Blonde	20-89	88-110	68-92	48-3
10-Farmers (WS 2014)	NSIC Rc 274; NSIC Rc 276; NSIC Rc 238; NSIC Rc 222; PSB Rc 10	45-70	88-110	69-92	24-22

Table 8. Across sites in irrigated ecosystem at Minalabac, Camarines Sur DS/WS 2014.

Rainfed	Variety	Previous Yield	RCM target Yield	Actual Yield	Bags
10-Farmers (DS 2014)	M-20; NSIC Rc 222; NSIcRc 238; NSIC Rc 274; NSIC Rc 276; NSIC Rc 272; PSB Rc 10	32-80	90-123	60-110	28-30
10-Farmers (WS 2014)	NSIC Rc 222; PSB Rc 10; Blonde	60-89	99-141	75-100	15-11

Table 9. Net Benefits obtained from monitored farmers DS 2014/WS 2014.

ECOSYSTEM	NUMBER OF BAGS	NET BENEFITS
Rainfed	3 - 48	P 2,397.00 - P 38,352.00
Irrigated	9 - 35	P 7,191.00 – P 27,965.00

Establishment of Precision Rice Farming Clusters in the Irrigated and Rainfed Lowlands with Georeferencing.

The georeferencing parameter was incorporated with the RCM Technology, to acquire a precise measurement of the fields of the RCM adopters. Their farmlots were measured using a global positioning system (gps) unit and incorporated in the questionnaire, consequently, nutrient recommendation computed was based on the actual field size resulting to more precise nutrient recommendations.

Irrigated and rainfed lowland cluster farms with 8 to 10 farmers were geotagged prior to generation of RCM recommendations (Fig. 6). In the irrigated cluster with direct-seeded rice, NSIC RC 216 obtained significantly higher yields with 6201.48 kg/ha to 10.914.58 kg/ha compared to the FV (DS) (Table10).For the WS, NSIC RC 222 obtained comparable yields with the FV at a range of 7810.0 kg/ha to 9718.6 kg/ha (Table 11). In the rainfed lowlands during the DS, NSIC RC 302 significantly out yielded the FV with 7547.21 kg/ha and 7820.0 kg/ha in 2 sites and showed comparable performances in the other sites with the FV at 6016.55 kg/ha (Table 12). For the WS in 3 sites, NSIC RC 238 significantly obtained 5736.43 kg/ha to 7404.65 kg/ha compared to the FP with 4496.12 kg/ha. (Table 13).

The RCM technology with georeferencing granted more precision in the personalized recommendations generated for fertilizer application. The actual measurement of the farm lots assured that the volume of fertilizer applied at the specific crop growth stage would result to a precise fertilizer recommendation and an optimized production output.

Table 10.Agronomic data of NSIC Rc216 for RCM PRF Cluster in the irrigated at Manapao, Minalabac, Camarines Sur for DS 2016

Site/s	Plant Height (cm)	Tiller Count	Yield (kg/ha)
Site 1	61.3 ns	437 ns	6343.93 *
Site 2	64.7 *	495 *	5863.29 ns
Site 3	65.2 *	488 *	5200.88 ns
Site 4	80.5 **	501 *	6201.48 *
Site 5	61.5 ns	482 *	6302.43 *
Site 6	87.5 **	519 **	10914.58 **
Site 7	86.0 **	487 *	5982.49 ns
Site 8	76.3 **	516 **	6160.18 ns
Site 9	58.8	402	5548.09
%CV	**4.0**	**6.0**	**17.3**

Table 11.Agronomic data of NSIC Rc222 for RCM PRF Cluster in the irrigated at Manapao,Minalabac Camarines Sur for WS 2016

Site/s	Plant Height (cm)	Tiller Count	Yield (kg/ha)
Site 1	98.9 ns	280 ns	8606.4 ns
Site 2	89.5 ns	515 ns	8164.6 ns
Site 3	106.3 ns	462 ns	8546.2 ns
Site 4	92.1 ns	510 ns	7810.0 ns
Site 5	100.1 ns	441 ns	8143.0 ns
Site 6	105.1 ns	486 ns	8979.5 ns
Site 7	103.9 ns	452 ns	8251.5 ns
Site 8	105.1 ns	582 ns	9522.2 ns
Site 9	94.6 ns	601 ns	9718.6 ns
Site 10	116.2	570	9071.2
%CV	**2.4**	**11.8**	**11.4**

Table 12. Agronomic data of NSIC Rc302 for RCM PRF Cluster in the rainfed at Gatbo, Ocampo, Camarines Sur for DS 2016

Site/s	Plant Height (cm)	Tiller Count	Yield (kg/ha)
Site 1	89.5 *	412 ns	7820.00 *
Site 2	86.3 ns	454 ns	6061.16 ns
Site 3	85.9 ns	378 ns	7105.12 ns
Site 4	88.7 *	369 ns	6609.30 ns
Site 5	85.6 ns	396 ns	6054.84 ns
Site 6	84.2 ns	431 ns	6448.22 ns
Site 7	85.7 ns	501 ns	6785.07 ns
Site 8	89.5 *	412 ns	7547.21 *
Site 9	84.7	399	6016.55
%CV	**2.4**	**17.0**	**9.5**

Table 13.Agronomic data of NSIC Rc222 for RCM PRF Cluster in the rainfed at Gatbo, Ocampo, Camarines Sur for WS 2016

Site/s	Plant Height (cm)	Tiller Count	Yield (kg/ha)
Site 1	86.7 ns	367 ns	5991.98 *
Site 2	88.5 ns	368 ns	5088.78 ns
Site 3	113.1 **	405 ns	7404.65 **
Site 4	92.8 ns	365 ns	5736.43 **
Site 5	101.3 *	707 ns	4668.60 ns
Site 6	77.5 ns	1056 **	4411.94 ns
Site 7	60.7 ns	374 ns	4518.60 ns
Site 8	92.7 ns	309 ns	5218.60 ns
Site 9	91.3	857	4496.12
%CV	**5.9**	**8.6**	**11.9**

Fig.12. PRF Clusters of Minalabac, Nabua and Ocampo

Innovations

Georeferencing activity of farmers fields was included in the RCM Technology. A total of 1,648 farmlots of RCM farmer enrollees have been measured. All encoded and uploaded data of all farmers are maintained in a database, the historical information of which would be available for future use by the region (Table 14).

Table 14. Number of geotagged farm lots in Bicol Region

Province	No. of Farmlots geotagged
Camarines Sur	1212
Camarines Norte	24
Albay	178
Sorsogon	226
Masbate	8
TOTAL	**1648**

To sustain the dissemination of the RCM technology professionalization of the agricultural extension system, wherein the AEWs (ATs (700), LFTs (200), Researchers, etc.) were registered and since this was on-line submission of information, identification cards would be generated per entry.

Capability Building Activities

For the successful implementation of the RCM Technology, hands on training activities, technology briefings, feedbacking mechanism were instituted to facilitate the capacitating of all stakeholders, project implementers, AEWs and other potential agents for technology dissemination. In the different strategies employed for the optimization of the deployment of the technology, limits were aptly addressed and challenges met (Table 16).

A series of orientation and hands-on-trainings were undertaken to capacitate researchers, extension workers(PLGUs and MLGUs), farmer cooperators, farmers and other stakeholders in the community (Table 15).

In partnership with the Agricultural Training Institute(ATI), in 2005 the different LGUs underwent a training of trainers to formally institutionalize the RCM Technology in their local agricultural development program. A local RCM team per municipality was created, responsible for the project implementation in their farming communities. ATI also conducted the RCM SMS which explored the cellphone, wherein, texting and calling of RCM farmer enrollees were done to remind them of their farm activity.

Table 15. List of capability-building activities during the duration of RCM implementation.

No. of Activities	ACTIVITIES / LOCATION
1	➢ Conducted Regional RCM orientation and hands on training at Avenue Plaza Hotel, Naga City last October 28-29, 2014 with PLGU/PAS & MLGU of Camarines Sur, Albay, Sorsogon, Camarines Norte & Masbate
36	➢ Conducted interviews and technology briefings at different MLGUs in Camarines Sur (Minalabac, Pamplona, Sipocot, Ocampo,Canaman; Gainza, Camaligan, Bula, Pili, Milaor)
4	➢ RCM meetings and distribution of RCM questionnaires (version 1.12) at PAS office (Albay)
1	➢ Conducted consultation meeting at Sorsogon (PLGU & MLGUs) represented by PA,MA/MAOs,ATs& LFT technicians
2	➢ Briefing on RCM protocol in SikatSaka Program (SSP) participated by 90 Irrigators Association Members both from communal and national irrigation system at Masbate
35	➢ Research component- trials and techno demos; located at San Jose(Nabua),Taban(Minalabac),Gatbo(Ocampo),Tarosanan(Camaligan) and Pili, Camarines Sur
4	➢ Briefing on Rice Crop Manager Project (February 12, 2014) ➢ Implementation of Rice Crop Manager (August 13-14, 2014) ➢ Rice Crop Manager Deployment Progress (February 13-14, 2015) ➢ Workshop on RCM implementers (IRRI, DA, PhilRice& ATI (May 4-8, 2015)
40	➢ Briefing Orientation Seminar on Rice Crop Manager (February 23, 2016) ➢ Provincial Orientation and Hands on Training on Geo-referencing/Farm monitoring on RCM (Camarines Norte; Camarines Sur; Sorsogon&Albay)

	➢ RCM Meetings & Dissemination (San Jose West, Canaman, Timbang, San Jose, Manapao, IrayangSolong, Bagongbong, Taban, Mataoroc, BaliuagNuevo, Minalabac&GatboOcampo (August – September 2016
25	➢ RCM Interview & Dissemination (Del Carmen, Manapao, Malitbog, San Jose Minalabac, Gatbo, Ocampo) February – April 2017 ➢ Cluster Retooling Workshop (July 18-21, 2017) ➢ Briefing Orientation on Geo-tagging (Nabua – July 25, 2017) ➢ Coordination with LGUs on Geo-tagging (Gainza,Canaman, Milaor, Minalabac, Ocampo, Nabua, Libmanan, Pili, Pamplona, Camarines Sur &Mobo, Masbate. (July 26-30, 2017) ➢ Regional Convention Cum Training for Local Farmer Technician (LFTs) – August 15-18,2017 ➢ Farm monitoring & evaluation activity of farmers uptake on Rice Crop Manager recommendation (August 24, 2017) ➢ Regional Agriculture and Fishery Extension Workers profiling workshop (August 30, 2017)

Table 16.Constraints/ Issues and Solutions

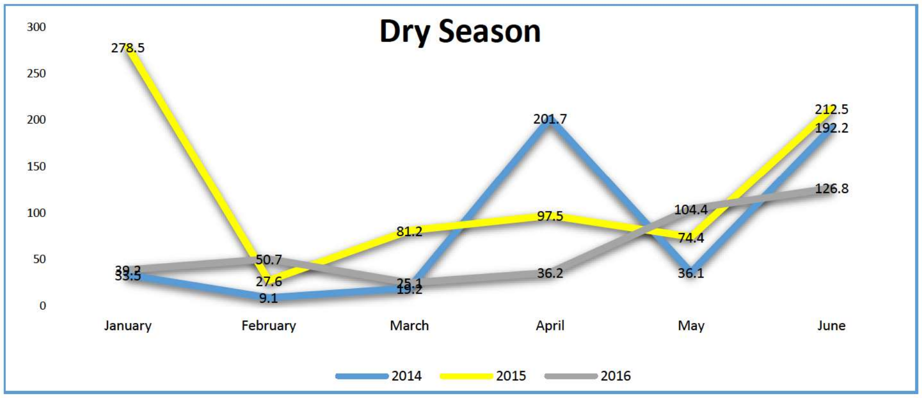
CONSTRAINTS/ISSUES	SOLUTIONS
➢ Lack of manpower within the municipality to disseminate the RCM	➢ Hiring of computer literate interviewer
➢ Weak internet connection	➢ Designate the provincial office as the RCM hub for uploading and printing of output ➢ Continuous printing & distribution of RCM questionnaire ➢ Bookmarking and RCM uploading which internet connectivity is available
➢ Slow deployment of RCM Protocol	➢ Sustained Integration of RCM protocol in Techno-Demos, LFT-FFS, Next-gen Project, Project HAYTA and other DA rice programs ➢ Involvement of FOGD ➢ Partnership with ATI
	➢ Awarding of IT equipment (Laptop/Tablet, direct printer & pocket wifi,) to PLGUs, PAS & MLGU's

Economic Analysis

Cost and return analysis of some RCM-based rice production activities was extracted from the farm monitoring activity conducted at Nabua. Two sets were determined, above and below the average yield of 80 cavans per hectare in a hectare rice production system. Return on investment (ROI) obtained were 40.75% and 97.00% (Appendix) which supported RCM as a viable technology for transforming rice production systems in both rainfed and irrigated lowlands from low and subsistence productivity levels to a level above the regional average rice yield.

Weather Condition

Dry seasons for all years of 2014, 2015 and 2016 had low rainfall except for the months of January, April and June. For the wet seasons rainfall was erratic and high.



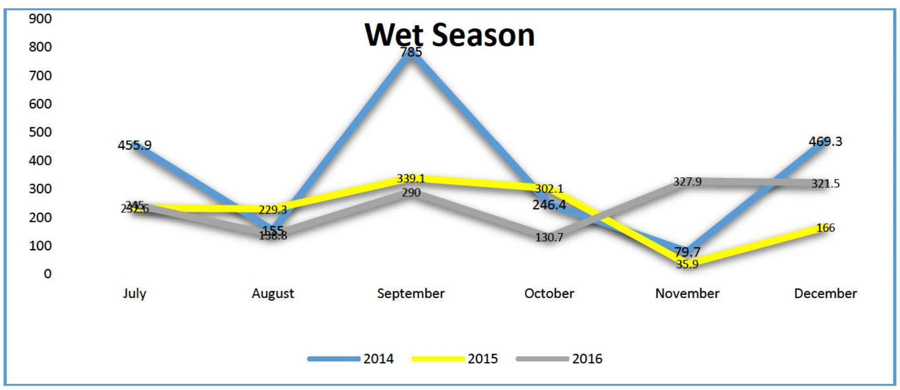


Figure 13. Rainfall pattern for CY 2014, CY 2015, CY 2016

Conclusion

The RCM Technology is a decision-making tool designed for use by extension workers, crop advisors, agricultural service providers and farmer leaders who use the internet to access RCM through the web browser of a personal computer, tablet or smartphone. The farmer is interviewed to obtain information of the farmers farming practices and conditions. The collected information is then transmitted via the internet to the RCM "calculator" on a cloud-based server, which automatically calculates and transmits a crop and nutrient management within moments back to the device used in the interview. The one-page recommendation is then provided to the farmer which advises them on how increase net income from rice production.

Verification trials showed 43.25% yield advantage of direct-seeded NSIC RC 222 in experimental plots using the RCM over the FP and net benefit of Php44,743.83 for rainfed rice and 24.60% yield advantage of direct-seeded NSIC RC 238 with RCM over the FP and net benefit of Php44,481.80 for irrigated rice. Technology demonstration farms obtained net benefits of Php38,352.00 and Php27,965.00 for the rainfed and irrigated lowlands.

In the precision rice farm clusters farmlots with RCM obtained exhibited 7547.21 kg/ha and 7820.00 kg/ha for direct-seeded NSIC RC 302(DS) and 5736.43 kg/ha, 5991.98 kg/ha and 7404.65 kg/ha for direct-seeded NSIC RC 238 and NSIC RC 222 (WS). For the

irrigated, significant yields obtained were 6302.43 kg/ha, 6343.93 kg/ha, 10914.58 kg/ha for direct-seeded NSIC RC 242(DS) and comparable yields of NSIC RC 222 with7810.00 kg/ha-9718.60 kg/ha (WS).

The increase in production and net benefits in the different field trials support the viability of the RCM Technology and its location-specific adaptation in the Bicol Region.

Recommendation

Sustain the institutionalization and adoption of the RCM Technology with the LGUs through strategies like: provision of appropriate IT equipments: enhancing awareness of local executives and extensions workers on the potential of the technology to increase rice production in their marginalized rice fields; inclusion of RCM Technology in the local agricultural program for adequate financial support.

Fortify the linkage of DA RFO 5 and ATI to accelerate RCM Technology dissemination and adoption as part of their training program and school on the air program. Also, activate the FITs Centers as generating stations for RCM Technology

Initiate linkage of DA RFO 5 and SCUs to accelerate RCM Technology dissemination and adoption as part of their curricular program.

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