IMPACT OF FARMERS' ADOPTION OF "ONE MUST AND FIVE REDUCTIONS" ON RICE PRODUCTION AND WATER USE IN AN GIANG, VIETNAM

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ABSTRACT

An individual farmer survey in An Giang province with 471 farmers in 2009 and 418 farmers in 2011, combined with farmer focus group discussions, showed that the model of 1M5Rs has increased rice production and benefit. Farmers have positive attitudes toward the water saving technology of Alternative Wetting and Drying (AWD). Farmers had their own indicators to know whether to do irrigation for the rice fields. However, collective pumping schemes does not facilitate farmers applying AWD perfectly. Thus, to convince the collective pump owners /managers it is necessary to request them to follow the principle of alternative wetting and drying in the contract.

Keywords: *Alternative wetting and drying, An Giang, farmer survey, One Must and Five Reductions, water use*

INTRODUCTION

A new innovation called "One Must and Five Reductions" (1M5Rs) is the integration of several technological components. It is developed from a previous technology called as "Three Reductions and Three Gains" (3R3Gs). These are the technologies to decrease rice inputs as reductions of seed rate, fertilizer (especially nitrogen), pesticide (especially insecticide), and reduction of water and post harvest loss. Farmers also must use certified seeds. The "Three Gains" were increase of rice production, quality and economics. The application of seed reductions by using row seeding was recommended in 3R3Gs and this was spreading out widely in Vietnam since 2003. However, rice farmers in the Mekong Delta still face several challenges from weather change, high cost of input from the markets, shortage of water in some months of the year and high floods and high tides in other months. Ensuring household food security requires farmers to adopt the best cultural practices as 1M5Rs together with selection of suitable rice varieties. The technological package of 1M5Rs was introduced in An Giang province in wet season 2009 and later, many more farmers have been trained to apply it. This paper aims to assess the adoption of 1M5Rs on rice production and water use as well as its consequence as a suitable strategies for spreading this best cultural practice to many farmers in the Mekong Delta and other regions.

METHODS OF DATA COLLECTION AND ANALYSIS

The first baseline survey with 471 farmers was conducted in 2009. A post survey of 418 farmers was conducted in 2011 with the same selected households in the same villages as in baseline survey. The farmers were classified as farmers who were trained and applied 1M5Rs in 2009, farmers in the same commune who were not trained and un-trained farmers in different communes from the trained farmers. Some of the un-trained farmers in 2009 may have participated in training after 2009. However, in this report, the farmers were classified according to their 2009 status for easy comparison with the previous survey. The sample size surveyed of 418 farmers in 2011 is presented in Table 1.

Table 1. Type of farmers in household survey

Type of farmers	No	%
- Participated in model	155	37
- All control group	263	63
+ Control within commune	100	24
+ Control outside commune	163	39
- Total	418	100

(Source: Analysis from data surveyed in 2011 in An Giang province)

Data were collected by direct interview with individual farmers by using a pre-tested structured questionnaire. The focus group discussions were conducted to supplement information from the survey.

The qualitative information from focus group discussion was summarized and incorporated in this report. The qualitative data from household survey was quantified and coded. The descriptive statistics was used to summarize the data in the forms of frequency, mean and percentage. T-test was used to compare rice outputs and inputs between farmers participated in the model of 1M5Rs and farmers outside (control farmers) and between farmers surveyed in 2009 and surveyed in 2011.

To calculate NPK in household survey data, we use the standard conversion factor to convert fertilizer quantity to nutrient equivalent. For example, urea has 46% N. Hence, 100 kg of urea contains (100*46%=) 46kg of N. This calculation is simple since urea contains only the nitrogen nutrient without oxides. Other types of fertilizers contain the elements with P and K in their oxide form as P_2O_5 (phosphate) and K_2O (potassium oxide), respectively. The compound P_2O_5 contains 44% P and the compound K_2O contains 83% K. To exclude oxygen in P_2O_5 and the element P is calculated by P = P_2O_5 kg x 44%. To exclude oxygen in K_2O and the element K is calculated by K = K_2O kg x 83%.

RESULTS AND DISCUSSION

Household income

Rice income is the most important income source, it contributes more than 80% of total household income. The other income sources included off-farm/non-farm and animal raising (Table 2).

Farm characteristics

More than one-third of the farmers had 1-2 ha of rice land, followed by less than 1 ha. The average area of rice land varied from 1.92 to 2.22 ha/ household. The most popular rice cropping system was rice-rice (67%), and the rest was rice-rice-rice system (33%). More than half of the farmers had one parcel of rice land, followed by 2 parcels, few of them had 3 parcels. The percentage of farmers with more than 3 parcels were negligible. Most of rice areas belonged to the household, few fields were rented in or mortgaged in to plant rice.

Table 2. Household income in 2010

Income source	Participated in model (n= 155)	Control within commune (n= 100)	Control outside commune (n=163)	All control group (n=263)	Total (n=418)
Income (1,000 VND/year)					
Rice income	187,156	160,110	177,687	171,004	176,994
Non- rice crop income	3,462	170	3,031	1,943	2,506
Animal income	2,981	2,745	5,959	4,737	4,086
Aquaculture income	266	500	1,580	1,169	834
Off-farm/non-farm income	19,440	17,180	26,950	23,562	21,940
Remittances	504	400	703	587	556
Total household income	213,810	181,106	215,910	203,002	206,917
Distribution of income (%)					
Rice income	88	88	83	84	86
Non- rice crop income	2	< 1	1	1	1
Animal income	1	2	3	2	2
Aquaculture income	< 1	< 1	1	1	< 1
Off-farm/non-farm income	9	9	12	12	11
Remittances	< 1	< 1	< 1	< 1	< 1
Total	100	100	100	100	100

(Source: Analysis from data surveyed in 2011 in An Giang province)

Impact of 1M5Rs on rice production and water use

The rice area was not different among the groups of the farmers. However, the rice yield and rice production of the farmers participating in the 1M5Rs model were higher than those of the control groups. Farmers participating in the 1M5Rs model also obtained higher price at sale, and higher rice income than control farmers. They use a lower seed rate (142 kg/ha) than control farmers (166 kg/ha). This indicated that the positive impacts of 1M5Rs are reducing seed rate and increase rice production and rice quality to sell at a higher price than other farmers. There was no difference in fertilizers used by farmers participating in model and control farmers. The 1M5Rs model reduced labor requirement. Farmers participating in model used less labor input than control farmers. Associated with seed reduction, the farmers who participated in the model spent less on seed than control farmers. The impact of 1M5Rs included reduction of insecticide and fungicide cost among farmers who participated in the model as compared with farmers in control groups. With water reduction in 1M5Rs, farmers who participated in model had significantly less expense on irrigation than control farmers. The analysis shows that the benefit cost ratio (BCR) of farmers participating in the model was higher than those of control farmers and thus, their net rice income was also higher (Table 3).

Table 3. Rice production and input use in Winter-Spring 2010-2011, An Giang

Item	Partici-pated in model (n= 155)	Control within commune (n= 100)	Control outside commune (n=163)	All control groups (n=263)	Total (n=418)	T- Value compared model with all control groups Sig. (2-tailed)
Rice area (ha)	2.02	1.74	2.07	1.94	1.97	0.4256
Rice production (kg/ha)	8,004	7,752	7,760	7,757	7,848	2.2761*
Rice price (1,000 VND/kg)	5.711	5.325	5.623	5.486	5.586	2.0532*
Rice income (1,000 VND/ha)	45,714	41,275	43,629	42,734	43,839	2.8082**
Rice yield (t/ha)	8.00	7.75	7.76	*7.76*	7.85	2.2761*
Seed rate (kg/ha)	142	158	170	166	157	-5.2943**
Nitrogen fertilizer (N kg/ha)	112	116	118	117	115	-1.6651
Phosphorous fertilizer (P kg/ha)	29	31	29	29	29	-0.1168
Potassium fertilizer (K kg/ha)	44	42	46	45	44	-0.0565
Total labors (person days/ha)	28	39	29	33	31	-2.5034*
+ Hired labors	14	16	14	18	14	-2.3826*
+ Family labors	15	24	14	15	17	-0.9237
Power cost (1,000 VND/ha)	2,673	2,602	2,681	2,651	2,659	0.1649
Irrigation cost (1,000 VND/ha)	718	1,003	857	912	840	-2.2154*
Seed cost (1,000 VND/ha)	1,161	1,069	1,410	1,280	1,236	-2.1969*
Fertilizer cost (1,000 VND/ha)	5,184	5,088	5,352	5,252	5,226	-0.4000
Hired labor cost (1,000 VND/ha)	2,132	2,215	1,780	1,946	2,015	0.9240
Imputed family labor cost (1,000 VND/ha)	1,085	1,242	1,155	1,188	1,150	-0.9237
Total pesticide cost (1,000 VND/ha)	1,662	2,183	2,067	2,111	1,945	-4525*
+ Insecticide	534	844	693	750	670	-4.2471**
+ Fungicide	642	798	898	860	779	-4.0116**
+ Herbicide	260	274	279	277	271	-0.7143
+ Molluscide & rodenticide	227	267	197	224	225	0.0951
Overall cost (1,000 VND/ha)	14,615	15,400	15,301	15,339	15,071	-1.7211
BCR	3.34	2.80	3.00	2.92	3.08	3.8201**
Net Income (1,000 VND/ha)	31,099	25,875	28,328	27,395	28,769	3.3197**

(Source: Analysis from data surveyed in 2011 in An Giang province),

Comparing the rice output and input between the 2009 and 2011 surveys shows that there were some changes in the land resource and inputs and outputs in rice production among

farmers in the sample of household surveyed. The rice area per household increased due to some of farmers in the sample buying some more parcels for rice cultivation. A few of the farmers in household sample surveyed in 2009 sold their lands and had left the villages by 2011. The mean of rice production per hectare as well as rice yield in the later year were higher than the previous year. This may be a result of the impact of the technologies as rice varieties and 1M5Rs about which the Plant Protection Department of the province as well as by the Plant Protection Station at district level continuously train the farmers. The seed rates in both years surveyed are acceptable because they are low when compared to farmers' custom practice with more than 200kg/ha. The use of fertilizer of the later year was lower than the previous year, especially nitrogen and phosphorus fertilizer. This proved that farmers were aware of reduction of fertilizer to reduce input cost. With new innovation as 1M5Rs, the input of labor was reduced in the later year. However, the power cost in the later year increased due to the increasing mechanization in harvesting as recommended in 1M5Rs and by the Agricultural Department. Most of farmers have used machines for land preparation and rice threshing for many years. Only recently the harvesting by machine has been trying to reach as much rice areas as possible to reduce post harvest loss. With water reduction message in 1M5Rs, irrigation cost of the later year was lower than the previous year. However, the seed cost of the later year was higher due to increase in using certified seeds which are costlier than the normal seeds. Using certified seeds is "A Must to Do" in 1M5Rs. The amount of fertilizer was reduced in the later year but its cost was higher because of the higher market price. The total pesticide cost in the later year was lower than the previous year and this indicated that farmers reduced pesticide to a certain extent. However, this reduction has not yet reached the requirement from the scientists because it occupied 16% in cost structure in 2009 and 13% in 2011. Benefit cost ratio and net return in the later year were higher than in the previous year (Table 4 and Figure 1 & 2).

In Winter-Spring 2010-2011, not all farmers irrigated before sowing because they could receive water by gravity. However, from sowing to flowering, farmers irrigated nearly 5 times. Farmers participated in 1M5Rs model reduced 1 time of irrigation as compared with control farmers in this stage of rice growth. From flowering to harvesting, the mean number of irrigation applications 1.4, and farmers participating in the 1M5Rs did irrigation 1.2 times in average compared to 1.6 times for control farmers. In general, farmers participating in the model of 1M5Rs reduced irrigation by 1.4 applications per season (Table 5).

Compared to the 2009 survey, farmers in the community as well as farmers participating in the 1M5Rs model reduced irrigation amounts. Farmers using the model reduced more dramatically than the farmers in control group. Some of the farmers in the control group may have received later training to follow the practices of 1M5Rs.

Average number of days between irrigations and the average depth of water for each irrigation were similar in 2009 and 2011

In 2011, farmers participating in the model expended less labor than control farmers for crop care from flowering to harvesting, gap filling, harvesting and post harvesting (Table 6).

The 2011 survey showed that labor investment in dry season (31.2 labor days/ha) was lower than in 2009 (45.2 labor days/ha) because farmers in the later year increased the use of mechanization in harvesting, and more farmers followed 1M5Rs to reduce labors.

Table 4. Comparison between rice production and input use in Winter-Spring 2010-2011 and Winter-Spring 2008-2009, An Giang

Item	Winter-Spring 2008-2009 (n=471)	Winter-Spring 2010-2011 (n=418)	T value
Rice area (ha)	1.64	1.97	-2.9547**
Rice production (kg/ha)	7,236	7,848	-6.5331**
Price rice (1,000 VND/kg)	4.000	5.586	-21.7585**
Rice income (1,000 VND/ha)	31,744	43,839	-19.8529**
Rice yield (t/ha)	7.00	7.85	-6.5331**
Seed rate (kg/ha)	145	157	-4.1671**
Nitrogen fertilizer (N kg/ha)	123	115	2.9510**
Phosphorous fertilizer (P kg/ha)	32	29	2.2279*
Potassium fertilizer (K kg/ha)	45	44	0.3228
Total labors (person days/ha)	45	31	9.5698**
+ Hired labors	30	14	11.0162**
+ Family labors	15	17	0.1416
Power cost (1,000 VND/ha)	1,614	2,659	-15.0167**
Irrigation cost (1,000 VND/ha)	1113	840	4.1690**
Seed cost (1,000 VND/ha)	881	1,236	-11.0921**
Total fertilizer cost (1,000 VND/ha)	4,872	5,226	-3.1207**
+ Granular fertilizer	4,650	5,016	-3.3032**
+ Foliar fertilizer	222	210	0.6368
Total pesticide cost (1,000 VND/ha)	2,258	1,945	3.0943**
+ Insecticide cost	1,005	670	4.1049**
+ Fungicide cost	713	779	-1.8916
+ Herbicide cost	335	271	3.0327**
+ Molluscide & rodenticide cost	206	225	-0.8852
Hired labor cost (1,000 VND/ha)	2,629	2,015	5.2796**
Imputed family labor (1,000 VND/ha)	1,015	1,150	-1.9163*
Overall cost (1,000 VND/ha)	14,382	15,071	-2.6515**
BCR	2.36	3.08	-10.9415**
Net Income (1,000 VND/ha)	17,362	28,769	-17.3305**

(Source: Analysis from data surveyed in 2009 and 2011 in An Giang province)

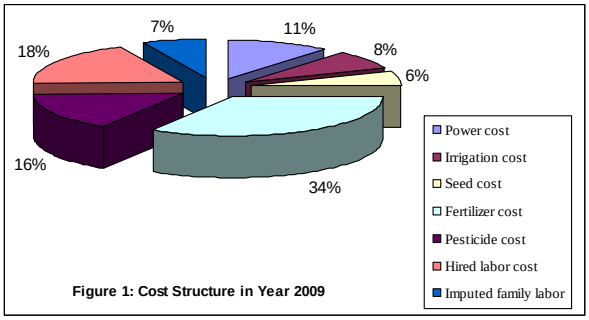

Figure 1: Cost Structure in Year 2009

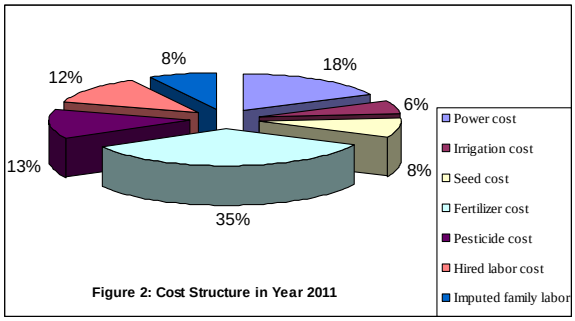

Figure 2: Cost Structure in Year 2011

Table 5. Irrigation practices, An Giang

Item	Participated in model	Control within commune	Control outside commune	All control group	Total
(Winter-Spring 2010-2011)	(n= 155)	(n= 100)	(n=163)	(n=263)	(n=418)
No. of irrigation before sowing/transplanting	0.4	0.6	0.6	0.6	0.5
No. irrigation from sowing/transplanting to flowering	4.0	5.3	4.7	4.9	4.6
No. irrigation from flowering to harvesting	1.2	1.7	1.5	1.6	1.4
Total irrigation number	5.7	7.5	6.8	7.1	6.6
Ave. number of day interval between irrigations	10.3	9.0	10.2	9.7	9.9
Ave. depth of water from soil surface for each irrigation (cm)	5.7	6.4	5.8	6.0	5.9
(Winter-Spring 2008-2009)	(n= 174)	(n= 109)	(n=188)	(n=297)	(n=471)
Number of irrigation before sowing/transplanting	0.7	0.6	0.7	0.7	0.7
Number irrigation from sowing/transplanting to flowering	4.9	5.1	5.0	5.0	4.9
Number irrigation from flowering to harvesting	1.5	2.0	1.9	1.9	1.8
Total number of irrigation	7.1	7.7	7.6	7.6	7.4
Ave. number of day interval between irrigations	9.8	9.4	9.6	9.5	9.6
Ave. depth of water from soil surface for each irrigation (cm)	7.2	7.5	7.0	7.2	7.2

(Source: Analysis from data surveyed in 2011 and 2009 in An Giang province)

Table 6. Comparison labor days/ha between model and control by activities in 2011

Item	Participated in model (n=155)	Control (n=263)	T-value between
Land preparation for seed bed	0.01	0.00	1.200
Land preparation for main field	0.89	1.11	-1.6
Irrigation for land preparation before sowing/transplanting	0.27	0.52	-1.600
Irrigation for crop care from sowing/transplanting to flowering	1.69	1.73	-0.2
Irrigation for crop care from flowering to harvest	**0.51**	**0.66**	-1.980*
Cleaning/repair of dikes	1.96	2.36	- 1.715
Seed preparation	0.80	0.70	0.690
Sowing/transplanting	1.17	0.84	1.874
Gap filling/replanting	**3.37**	**4.33**	-2.291*
Hand weeding, removing off types	2.46	1.99	0.989
Fertilizer application	2.12	2.04	0.378

Item	Participated in model (n=155)	Control (n=263)	T-value between
Foliar Fertilizer application	0.53	0.49	0.599
Herbicide application	0.67	0.73	-1.000
Insecticide application	1.30	1.38	-1.384
Fungicide application	1.31	1.46	-0.956
Rodenticide application	0.17	0.14	0.541
Molluscicide application	0.39	0.39	-0.001
Harvesting	2.33	2.26	0.153
Gathering	0.05	0.07	-0.528
Combine hand harvesting and gathering	**0.55**	**1.85**	-3.758**
Hauling	**0.08**	**0.19**	-1.636
Threshing	**0.23**	**0.68**	-3.953**
Transporting	**1.08**	**1.24**	-1.453
Drying	**4.39**	**5.89**	-2.961**
All activities	28.34	33.05	-2.503*

(Source: Analysis from data surveyed in 2011 in An Giang)

Farmers' access and attitude to training on water saving

Most of the farmers who did not participate in the model of 1M5Rs heard about water saving. Nearly half of them were trained on water saving technology (Table 7).

Among farmers surveyed in 2011, most had heard about AWD technology from technical staff, extension staff, plant protection staff during training and workshop, mass media (TV, radio, newspaper, bill board,..), research institute, university, Farmers' Association, farmer' cooperatives and neighbor/ other farmers. More than half of them were trained on AWD. This training was started many years ago. The earliest training was in 2000. From that year to 2011, 62% of the respondents were trained on AWD. Most of the trainings were from technical staff from extension and plant protection stations at district level, followed by provincial and commune levels. Other resource persons were from Can Tho University, Farmers' Association and pesticide company. However, pesticide company just combined AWD in the training mostly for pesticide advertisement (Table 8).

Table 7. Access to information and training by control farmers

Item	Control within commune (n=100)		Control outside commune (n=163)		All control group (n=263)	
	No.	%	No.	%	No.	%
Hearing about water saving						
+ Yes	84	84	146	90	230	87
+ No	16	16	17	10	33	13
Training on water saving technology						
+ Yes	43	43	70	43	113	43
+ No	57	57	93	57	150	57

(Source: Analysis from data surveyed in 2011 in An Giang province)

Table 8. Alternative wetting and drying (AWD) and information and training access

Item	Farmers participated in model (n=155)		All control farmers (=263)		Total (n=418)	
	No.	%	No.	%	No.	%
Hearing about AWD						
+ Yes	154	99	204	78	358	86
+ No	1	1	59	22	60	14
Attended training on AWD						
+ Yes	154	99	104	40	258	62
+ No	1	1	159	60	160	38

(Source: Analysis from data surveyed in 2011 in An Giang province

Attitude related to irrigation

Regarding to farmers' attitude on irrigation, almost farmers in all categories agreed that "Water is the food of the plants", "Leveling at land preparation is very important for irrigation", "Plants need to be in standing water for 1-2 weeks after planting to prevent weed infestation", "Even if there is no water on the surface, the plants may still get enough water", "If the soil has cracks, it has no more water for the plants", "Keeping low water level at tillering stage will result to more tillers and panicles", and "If the soil is allowed to dry for a while, the roots go deeper". Most of farmers did not agree that "The more water the better for the plants" and "Water should always be maintained above soil surface continuously from 7 days after sowing until to 2 weeks before harvesting". Two-third of the farmers did not agree that "Allowing the paddy field to get dry is always bad for the plants", "Less water can hurt the crop" but the extent of hurt was small (few percent), and "Farmers get scared when there is no standing water on the paddy surface". Water depth was around 5cm when the plant needs to have water in the field (Table 9).

Table 9. Farmers' attitude on irrigation

Item	Participated in model (n=155)					
	Agree		Disagree		No opinion	
	No.	%	No.	%	No.	%
Water is the food of the plants.	152	98	3	2	-	-
Leveling at land preparation is very important for irrigation.	152	98	2	1	1	1
Plants need to be water standing for 1-2 weeks after planting to prevent weed infestation	149	96	6	4	-	-
Allowing the paddy field to get dry is always bad for the plants	52	34	98	63	5	3
The more water the better for the plants	21	14	134	86	-	-
Less water can hurt the crop	49	32	97	63	9	6
Extent it can hurt the crop, if agree (%)	2.50					
Even if there is no water on the surface, the plants may still get enough water	137	88	16	10	2	1
If the soil has cracks, it has no more water for	143	92	9	6	2	1

Item	Participated in model (n=155)					
	Agree		Disagree		No opinion	
	No.	%	No.	%	No.	%
the plants.						
Farmers get scared when there is no standing water on the paddy surface	48	31	96	62	11	7
Keeping low water level at tillering stage will result to more tillers and panicles	140	90	15	10	-	-
Keeping water at low level at flowering stage always gives more yield	111	72	40	26	4	3
Water should always be maintained above soil surface continuously from 7 days after sowing until to 2 weeks before harvesting	26	17	129	83	-	-
What water depth must be when the plant needs to have water	5.02					
If the soil is allowed to dry for a while, the roots go deeper	145	94	3	2	2	1
Water is the food of the plants.	261	99	2	1	-	-
Leveling at land preparation is very important for irrigation.	262	100	1	< 1	1	< 1
Plants need to be water standing for 1-2 weeks after planting to prevent weed infestation	249	95	13	5	-	-
Allowing the paddy field to get dry is always bad for the plants	89	34	168	64	5	2
The more water the better for the plants	12	5	249	95	2	1
Less water can hurt the crop	87	33	164	62	11	4
Extent it can hurt the crop, if agree (%)	2.64					
Even if there is no water on the surface, the plants may still get enough water	230	87	27	10	5	2
If the soil has cracks, it has no more water for the plants.	233	89	24	9	4	2
Farmers get scared when there is no standing water on the paddy surface	105	40	136	52	21	8
Keeping low water level at tillering stage will result to more tillers and panicles	245	93	16	6	1	< 1
Keeping water at low level at flowering stage always gives more yield	206	78	48	18	8	3
Water should always be maintained above soil surface continuously from 7 days after sowing until to 2 weeks before harvesting	38	14	224	85	-	-
What water depth must be when the plant needs to have water	5.27					
If the soil is allowed to dry for a while, the roots go deeper	234	89	8	3	3	1

(Source: Analysis from data surveyed in 2011 in An Giang)

Farmers agreed that "Water is the food of the plants" with several explanations. They said that "Plant cannot survive without water, plant needs water. No water leads to yield loss and plant will die. With water, plants can grow. Water helps to dissolve fertilizer to give nutrition to plants. Water importance is at 1st rank, then 2nd rank is fertilizer". Farmers agreed that "Must have water to make rice plant cool", "Water assists the plant to uptake and translocate nutrients", "Water is a matter to help assimilation of nutrition, water helps to breakdown substances", "Fertilizer and pesticide applications require water in the field", "Flowering fast with water at flowering stage", "Water supply helps fast root development and is good for photosynthesis", "Water is food. Water is nutrition. Water provides nutrition", "Tillering stage needs water", "Water should be enough, no excess or no deficiency because too much water, plant is weak and easily attacked by pest". This indicated that farmers knew well about the role of water for the plant but should not apply excess water and knew that plants need water at certain stages.

Farmers agreed on "Leveling at land preparation is very important for irrigation" because it is easy to manage water on leveled land (irrigating in and drainage out by gravity); by maintaining water evenly water in the field, plants grow evenly, with good plant development (leading to less gap filling, less golden snail and rice disease), even flowering and maturing, even seed broadcasting. This is also easy in row seeding at low seed rate. It is easy for pumping water to suppress the weeds. It limits off-types to obtain more rice purity. With leveled land, farmers will have less cost, less labor and less time in pumping, less fuel cost, easy to apply water saving technology as AWD, easy in fertilizer and herbicide application.

Farmers had the reasons for agreement on "Plants need to be water standing 1-2 weeks after planting to prevent weed infestation". They said that water sinks the weeds. It inhibits photosynthesis of weeds so that the weeds die; weed seeds cannot germinate due to no oxygen under water or under aerobic condition. With water, the soil has no sunlight and weeds cannot grow. Thus it needs to maintain sufficient water for a few days to suppress weeds and off-types.

Farmers did not agree that "Allowing the paddy field to get dry is always bad for the plants" because they knew at what rice stage the field should be dry or wet. Dry field at certain stage causes the root system to penetrate deeper into the soil, the plant stands well. Drying hardens the soil and stiffens the stems, reducing lodging. Young plants need more water, later stages need less water but just need moisture. A dry field at harvest is easy for rice harvesting by machines.

Farmers did not agree that "The more water the better for the plants" because more water makes plant soft and weak, it causes rotted roots, the plant is easily infested by toxic substances and diseases. With more water, the root system cannot develop deeper into the soil, so the soil is soft, plants are easily lodged, produce less tillers and low yield. There are more golden snails and crabs, and plant may die due to submerge rice. Rice needs just enough water for plant development and this depends on plant stage.

Farmers have several ideas on "Less water can hurt the crop" as no water, plants are infested with insect pest/weeds/rats, experience slow development, cannot uptake nutrition, are stunted or wilted, produce less tillers. The plant cannot stand heat and dries up, with low yield.

Farmers' agree with the statement "Even if there is no water on the surface, the plants may still get enough water" because there is still existing of moisture in the soil. They say roots can grow deeper and stiffer to uptake water. Plants get water from soil moisture and mist in the night and develop normally. Water is still present below soil surface. Soil still has water at root zone. They also said that water moves up through capillary attraction. Farmers can monitor water level for plant up take by observing the AWD tube, or observing the plant, soil, looking at the leaves, or looking at the water level in the internal field ditches. If the leaves become yellow, that means lack of water in the soil for plant to take up. They also base observations on the rice growth stage. If there is

no water in the soil surface at the young stage, young plants cannot get enough water while older plants can (maybe roots already develop deeper). If the soil is too dry, plants lack water. Some farmers did not agree due to plant cannot get water.

Farmers also expressed several reasons for believing "If the soil has cracks, it has no more water for the plants". Most of farmers said that if the soil surface cracks, roots are broken down which causes damage to the plant; the root system cannot uptake water; roots cannot develop and thus cannot absorb water. They say the plant is wilted and collapsed, plant development is slow and with yellow leaves, the plant is spoiled and dead. No more water in soil. Soil cracks cause more weeds, dry plant, wilt plant. So dry soil with cracks mean no more water, water vapors, no more nutrition for plant. Water moved too deep under the soil.

Some farmers said below the soil surface there is still water even when the soil cracks. Roots go deeper to get water. Observating of plant, if plant is not wilted, that means it still has enough water. If there are water vapors in the day time, at night it may still have water. No water or not when soil cracks depending on time, soil types, and level of cracks .

Farmers did not get scared when there is no standing water on the paddy surface because when moisture is below soil surface for plant, plants still grow normally. Moisture can be checked by stepping with bare feet on the soil surface and feeling it. Water is still at the root zone. The soil surface is not cracked yet, and thus farmers did not worry. They did not get scared because they adopted water saving technology, using AWD tube to check water; they know when to have standing water and when to not have it, they know the rice stage needs wet and dry. Alternative wet and dry is good for roots developing deeper. They did not get scared because they had experience by observing soil surface and plant.

Some of the farmers get scared when there is no standing water on the paddy surface because they thought the plant maybe dead. When farmers saw no standing water, they got scared of low yield, poor plant development, weak plant, stunting, wilting, leaves becoming yellow, lack of nutrition to have filled grains, rat attacks, more weeds, stem borer and disease damage. They also cannot apply fertilizer and pesticide.

Many farmers said that keeping low water level at tillering stage will produce more tillers quickly. It will give more panicles later. Low water will stimulate rice development and does not cause rotted tillers. They say one should start to keep low water level from 12- 16 days after sowing (DAS) to stimulate strong plant development during 10-25 DAS. After 20 days, water should be drained out for good rice development and for roots growing deeper to uptake nutrition/fertilizer for tillering. It also makes stiff roots and plants, no lodging, more grains with less unfilled grains. Low water level will help plants absorb more sunlight. Low water at tillering stage reduces weeds for plant development. The best water level at tillering stage is 3-5 cm.

Farmers knew that high water level makes plants weak and reduces development of tillers and tillers are tall, thin and weak. More water causes effective tillers to be submerged, and the newly emerged tillers spoiled. With more water plants lose nutrition. Newly emerged tillers will be eaten by golden snail if there is more water.

Most of farmers said that at flowering stage, the plants need water at relatively low water for even flowering. Keeping a medium water level provides for enough nutrition uptake. One only needs 5 cm water level to kill rats, suppress weeds, develop the plants and limit lodging, create more panicles and more filled grains. Farmers understand that at the flowering stage, water should not be high or too low. Farmers said that more water at flowering stage can cause weak plants, and a weak plant base leading to lodging and low yield. Too low water resulted in unfilled grains, poor flowering, and difficulty in nutrition uptake.

Regarding maintaining water in the rice field, most of the farmers said that water should not be maintained continuously because keeping

water for a long time will lead to no tillering, more ineffective tillers, soft soil, no ventilation, weak rice plants, easy lodging (roots cannot grow deeply into the soil), difficult harvesting, especially harvesting by machine, slow ripening, and low yield. The plant also cannot uptake nutrition, acidity in soil cannot move down deeper, more golden snails attack. Keeping water continuously means there is no dry period for hardening the plant. Farmers also said that the plants need to be wet and dry alternatively depending on rice stage, it must be drained out and pumped in at right time for good tillering, well plant development and no lodging.

The average water depth was around 5cm when the plant needs to have water. According to farmers it is suitable and sufficient to ensure good plant development, ensure photosynthesis and respiration, keep roots cool, sufficient for nutrition uptake to feed the plant, more tillers and filled grains, producing high yield. This water level is sufficient to suppress weeds, uptake nutrient and to apply fertilizer and chemical when needed. Farmers experienced that more water makes plant weak, susceptible to lodging, slow root development, and less tillering. More water dilutes fertilizer and the plant cannot have sufficient nutrition. More water is wasted, costs are higher and net return is low.

Farmers agree on the statement "If the soil is allowed to dry for a while, the roots go deeper" because some plant stages need water and some stage do not need water on the soil surface. Draining the soil at suitable times increases root development deeper, hardens the plants, lessens lodging, tolerates insect pest, enhances soil mineralization to supply nutrition for plant, and reduces pumping cost. Letting the soil dry at certain level (not too dry) for the plant to absorb sufficient sunlight and soil can provide oxygen for roots. This also reduces toxic substances and acidity to develop new roots.

Aspects related to Alternative Wetting and Drying

Farmers had multiple responses related to sources of irrigation. Most sources of water for irrigation were from canals and rivers or branches of a river. In addition, they also obtain rain water during rainy season. Farmers also use gravity to get water in certain periods of the crop season depending on tides and the location of the rice fields. Most of the water distributed in main canals or field sub-canals by gravity was not continuously available. Average number of irrigations was highest in dry season (Winter – Spring) from 5-6 times/ crop season and lowest in Autumn – Winter (wet season-flooding period) from 1-2 times. Most of farmers had to pump water out of the field in Autumn – Winter season.

Most of the farmers did not keep their rice field flooded. Few of them had field flooded. Farmers said that if they keep the field flooded the rice will be easily attacked by brown planthopper, other insects and golden snail. It also leads to lodging rice, rotted rice, spoiled rice, damaged tillers, weak plants, no tillering, poor flowering, slow plant development, more unfilled grains and plants may die. Their fields only need enough water level to harden plant, produce more tillers and good plant development. Farmers also follow the new technology of AWD and model of 1M5Rs and they do not let the field remain flooded.

The other farmers had field flooded for reasons beyond their control. Their fields were relatively lower than other nearby fields, or there were more rains, typhoon effects and high tides which could not be drained out. Some of farmers let the field be submerged to kill brown planthopper, and mite (*Steneotarsonemus spinki*- belong to Arachnida order) and to suppress weeds. However, this submerging is also for a certain period, and after controlling pest, water level was kept at normal levels.

Most of farmers reported no case where "water for irrigation is not enough" and only few of them had this problem. This situation was commonly caused by a shallow canal that was not dredged or repaired often or by drought. Sometimes the co-operative did not pump in time, or distribution of water in the canal was not even. Farmers' actions to solve this problem included

pumping from canal, pumping the second time, transferring from this field to other field.

More than half of the farmers said that there was a time when there was too much water for irrigation. This was due to heavy rains continuously for few days, rains together with flood, or high tides. In the dry season, it was often caused by high tides in November (at early rice crop stage). In wet season (Summer – Autumn), water rose due to flood seasons and raining while their fields were relatively lower than other fields. In some cases, the pumping collective over pumped water into the farmers' fields. Farmers had to pump water out, or use gravity to drain water out. Most of farmers did not have water problem in dry season in An Giang province

Most of farmers (72% of farmers in the sample of survey in 2011) applied AWD technology. Only slightly more than one-fifth did not apply AWD. Few of them have applied since 1990. However, most of them applied from 2009 until now. Farmers applied AWD because they found it was effective from watching agricultural programs from television. They followed the guidance from technical staff, applied AWD after training in 1M5Rs or after training 3R3Gs. This technique was effective, in producing healthy plants, good plant development, no lodging, high yield, high return, saving water, and low pumping cost. It was good for the soil. Farmers also observed field demonstrations and other farmers who applied AWD effectively. Some were curious and want to try. Many of farmers want to apply but they cannot because of collective pumping. The other reasons were not having leveled land, not suitable for field conditions, or being un-trained.

Farmers understood AWD as pumping in at sufficient level about 3-5 cm and at right time or suitable time similar as their attitude to irrigation as presented above.

More than half of the farmers said that AWD was applicable. Farmers had their own indicators to apply alternative wetting and drying. The main indicators are the soil cracks as bird feet on soil surface, hard surface soil and feeling hurt a little when stepping on it, dry soil that falls down when crushed in the hand, dry soil that does not stick on the feet, dry soil that cannot be pressed by fingers, dry leaves/ or dried up leaf tips, leaves starting to yellow, no more smooth leaves, no water drops on the leaf tips in the evening, change of plant color, wilting plant in the middle of a sunny day. Farmers also look at the level of water in the internal field ditches and plastic tubes placed in the field. They also base decisions to apply wetting and drying on the rice stages. After farmers had experience in applying AWD, using a field water tube for one or two crop seasons, they did not use the tube any more. About half of the farmers participated in 1M5Rs model did not use a field water tube to check the level of water below soil surface. More than half of farmers in the control groups did not use it, either. More farmers participating in the 1M5Rs model (83%) than farmers in the control group (53%) noticed positive change from using AWD and they are willing to recommend that other farmers use AWD because it is easy to apply. The most significant change was no plant lodging, followed by higher rice yield, good plant and root system development, healthy plant, less insect pests. The irrigation cost and number of irrigations were reduced.

AWD is not applicable in some cases because of collective or cooperative pumping water, fields located far from the water source, soft soil, or soil that does not hold water well. In other cases there is no need to use AWD due to ease of gravity irrigation for water application and draining.

CONCLUSION

After implementing of the model of 1M5Rs in rice production in An Giang province, farmers increased their rice production and benefit. Farmers who participated in the 1M5Rs model had higher yield (8.0 t/ha) than control farmers (7.76 t/ha) and they also had higher income from rice production. They got a higher net return than control farmers resulted from lower labor invest, seed cost, irrigation cost, insecticide and fungicide cost. Therefore the

benefit cost ratio of farmers participating in 1M5Rs model (3.34) was higher than control farmers (2.92) They gained experience in applying water saving technologies by AWD. They had their own indicators to know when the rice field needed to be irrigated, and believed that the average water level in the field should be 5-7 cm. Farmers had a positive evaluation on the benefit of applying alternative wetting and drying and they are willing to continue to apply and recommend to other farmers.

RECOMMENDATION

The extension staffs of the province and district **s**hould increase farmers knowledge by training on 1M5Rs and water saving technologies such as as AWD.

The authority of provincial and district levels should convince the owners of pumping machines or manager of collective pump to apply the principle of alternative wetting and drying (not pump on a schedule as per old contracts but should allow flexible timing) and return the money to farmers if the pumping time is reduced.

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TÓM TẮT

Ảnh hưởng của áp dụng "Một Phải Năm Giảm" đến sản xuất lúa và sử dụng nước cho canh tác ở An Giang

Điều tra các thể 471 nông dân năm 2009 và 418 nông dân năm 2011 cùng với phỏng vấn nhóm nông dân ở An Giang cho thấy áp dụng "Một Phải Năm Giảm" làm tăng sản lượng lúa và lợi nhuận. Nông dân có quan niệm tích cực đối với kỹ thuật tiết kiệm nước như kỹ thuật tưới nước theo ướt khô xen kẻ (AWD). Nông dân có các tiêu chí để biết khi náo cần bơm nước vào ruộng. Tuy nhiên, bơm tập thể làm nông dân khó áp dụng AWD. Vì vậy, cần vận động chủ máy bơm hoặc người quản lý của bơm nước tập thể áp dụng bơm nước theo nguyên lý ướt khô xen kẽ trong hợp đồng bơm nước tập thể.