

Research Article

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Climate field schools to increase farmers' adaptive capacity to climate change in the southern coastline of Java

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Abstract: Demonstration plots (demo plots) have been used as participatory research methods to conduct Climate Field Schools (CFS) with farmers from May to October 2018. CFS aimed at improving the adaptive capacities of the farmers and obtaining appropriate technologies to be adopted in the two villages of Ciganjeng and Rawaapu. The demo plots were set up with a different treatment of organic manure ($T_1 = 10 \text{ ton ha}^{-1}$ of cattle compost; $T_2 = 10 \text{ ton ha}^{-1}$ of cattle compost + 10 ton ha^{-1} of *Azolla pinnata*; and $T_3 = 10 \text{ ton ha}^{-1}$ of cattle compost + 2 ton ha^{-1} of *Sesbania rostrata*) and different rice varieties. The farmers were fully responsible for the monitoring of the parameters (e.g., plant height, number of tillers, and grain yield). The demo plots results revealed that the application of organic manure T_2 has increased the soil C and N content by 64.6 and 40.00%, respectively, and rice yield by 27.8% compared to neighboring plots using inorganic fertilizers. The Mendawak variety at both CFS locations showed better performance compared to the other varieties. Moreover, the capacity of the research farmers involved in the CFS has been increased by 52.74% with a gain factor of 0.42 in Ciganjeng and 41.23% with a gain factor of 0.39 in Rawaapu moderately based on pretest and posttest results. It is concluded from the research process that farmers who built up their capacity on on-farm

show a high level of confidence and can convey comprehensive information to other farmers.

Keywords: climate field schools, farmers capacity, organic manure, rice varieties

1 Introduction

Climate change is one of the natural phenomena where there are changes in the value of climate elements naturally and accelerated due to human activities on the face of the earth. Currently, there is no longer a debate about the existence of climate change, but it has become a common problem between communities, between agencies, between countries, and even globally to get serious handling (Prayoga et al. 2020). Consequences of climate change are global warming, increasing climate variability, and more frequent and more severe weather events affecting people's livelihood, particularly in vulnerable areas, such as tropical Asia; one of them is Indonesia (Asian Development Bank 2017).

Indonesia is an archipelago consisting of 17,480 islands. It has a coastline of 91,000 km and is home to around 267 million people (around 50–60% of the population live along the coastal zone) predominantly depending on agriculture. Rice is an important agricultural crop in Indonesia with rice production in 2017 reaching 81 million tons of dry grain (National Development Planning Agency 2018). In Indonesia, climate change has severe impacts on rice farming and production. The changing frequency and intensity in rainfall, the increase in temperature, and the rise of sea levels have significantly contributed to a decline in rice productivity. The occurrence of extreme weather events such as floods and droughts is increasing and causes crop losses (Surmaini et al. 2018; Aryal et al. 2019; Owade et al. 2020). The decrease in rainfall and the increase in overall temperatures can lead to soil erosion. Soil erosion leads to sediment and runoff of clay, humus,

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and other soil particles that are rich in nutrients. This leads to a decrease in the physical, chemical, and biological quality of the soil and the overall soil fertility decreases (Simarmata et al. 2016; Stefanos and Dimitrios 2018).

Southern Coastline Java Island is an area prone to climate change impacts because it borders directly with the Indian ocean without any island being a barrier to sea waves. Wave height on the south coast can reach more than 6 m with sea level below 15 m (Handiani et al. 2019). On the Southern Coastline Java Island, the rise of the sea level caused by climate change has led to tidal floods in rice fields (Prayoga et al. 2018). Carrying salt particles, tidal flows increase the salinity level of the rice fields. High soil salinity affects plant growth by damaging plant cells, leading to the disruption of plant growth or even plant cell death (Aslam et al. 2017). Southern Coastline Java Island is also a place where rivers flow. The intensity of high rainfall can cause the river to overflow and flood the rice fields (Rostini et al. 2018).

The villages of Ciganjeng and Rawaapu are areas on the Southern Coastline Java Island which are prone to flooding. Floods in Ciganjeng village were caused by the overflow of the Citanduy river during very high rainfall, while floods in Rawaapu village were caused by overflowing seawater due to tidal water. This makes the two villages have different problems. The problem in Ciganjeng village is the low level of soil fertility due to frequent leaching of nutrients due to flooding from river floods, while the problem in Rawaapu village is the high level of soil salinity due to the lagging of salt particles due to tidal floods (Rostini et al. 2018). Therefore, the participatory technology approach for the two villages will differ according to the problems faced by farmers in the two villages.

Deterioration in soil quality due to climate change in Ciganjeng can be anticipated by adding green manure to the soil. Green manure can increase soil organic matter and nutrients in the soil, resulting in an improvement in the physical, chemical, and biological properties of the soil. This has an impact on increasing soil productivity (Lukas van Zwieten 2018). One of the good green manures for soil fertility is *Azolla pinnata*. The use of *Azolla* as green manure can increase soil fertility because it has a high nutrient content of N. *Azolla* symbiosis with *Anabaena* in binding free nitrogen in the air. The symbiosis between *Azolla* and *Anabaena* *Azolla* can bind to 100–170 kg N/ha per year (Soedharmono et al. 2016). *Azolla* which has undergone a process of decomposition forms humus so that it can increase the capacity of water stress on the soil to improve drainage and wateration in the soil (Swami and Singh 2019). Asifah et al. (2019)

suggest that the dosage of using *Azolla* as green manure is 5–10 ton ha⁻¹. This is in accordance with the results of the study of Prayoga et al. (2020) which explains that the addition of *Azolla* 10 ton ha⁻¹ can increase soil nitrogen content by up to 90% and increase rice production by 9%.

Besides *Azolla*, another plant that can be used as green manure is *Sesbania rostrata*. *Sesbania* is an ideal plant as green manure because it is fast-growing, easy to decompose, able to maintain soil moisture, and produces maximum organic matter and nitrogen in the soil. The potential of *Sesbania* as green manure is supported by its deep rooting properties and its many roots. *Sesbania* can be used to improve soil fertility, increase soil capacity to absorb nutrients, improve soil structure, and increase soil microbial activity. *Sesbania* aged 60 days produce 5.2 ton ha⁻¹ of dry matter which produces 135 kg N per hectare (Wabi et al. 2016). *S. rostrata* increases rice yield by increasing N content to 5% and increasing the efficiency of N and P absorption in the soil (Naher et al. 2019). Prayoga et al. (2020) explain that the addition of *Sesbania* 2 ton ha⁻¹ can increase soil N content by up to 50% and increase rice production by as much as 10%.

Technology in the effort to adapt to climate change in Rawaapu is a suitable variety. Understanding suitable variety is a variety that can adapt to environmental conditions due to the influence of climate change (Chaudhary et al. 2019). The impacts of climate change occurring in Rawaapu are tidal flooding and high levels of salinity. Therefore, the selection of varieties needs to be done to obtain the varieties with the best adaptability (tolerant of salinity stress). Universitas Padjadjaran, Humboldt Universitaet zu Berlin, and the members of the Indonesian Farmers Community Network (JAMTANI) have conducted participatory research as a joint project called CRAIIP (climate-resilient agriculture investigation and innovation project is aimed and used as a vehicle for technology transfer from the University to farmers). CRAIIP provides solutions for climate-resilient rice farming through experiments with the so-called climate field school (CFS). The farmers act as a subject of the research (farmer-oriented experiment), well-known as participatory research. This method enables to accelerate the process of technology transfer to farmers (Snapp et al. 2019).

Technology transfer for appropriate climate resilience takes into account local capabilities to adopt it (including adjusting materials, approaches, and processes) and in accordance with local conditions (Filho 2018). Rice farmers are advised to investigate climate-resistant cultivation techniques, such as the use of green manure and suitable rice varieties. Green fertilizer is expected to

substitute for inorganic fertilizers that have been used by farmers. The combination of green manure and rice varieties is expected to be able to improve the soil's health and increase rice productivity in sustainable ways. Participatory research methods have so far been used only a little. In general, universities conduct independent research without involving farmers and farmers only as objects of implementing technology that has been studied by the university. Therefore, research activities carried out jointly by universities and farmers are a new thing as a fast method of technology transfer.

2 Materials and methods

The study was designed in an integrated manner using mixed-methods. The mixed-method is a research step by combining two aspects of research, namely, qualitative and quantitative. In a mixed-method, researchers can give the same priority, weight, or status to quantitative and qualitative aspects or can give greater weight to one of these aspects (Creswell 2014). This research emphasizes quantitative dominance with three approaches, namely: (1) Participatory Action Research through focus group discussions (FGD) and farmer field schools; (2) descriptive qualitative through surveys and interviews; and (3) quantitative through participatory experimental design.

The study was conducted in two villages along the southern coastline of Java, namely, Ciganjeng village ($7^{\circ}34'44''\text{S}$, $108^{\circ}42'43''\text{E}$) and Rawaapu village ($7^{\circ}37'59.0''\text{S}$, $108^{\circ}45'51.5''\text{E}$) from May to October 2018. Following the Schmidt-Ferguson climate classification, the climate in both locations falls into category B, which is described as a subhumid ago-climatic zone. The soils in both demonstration plots (demo plots) are broadly classified as silty clay. Ciganjeng has an altitude of 12 masl (meters above sea level), while Rawaapu has an altitude of 4 masl (Rostini *et al.* 2018). The size of the experimental farm in Ciganjeng and Rawaapu was $1,000\text{ m}^2$. The selection of the two research sites is based on the group discussion results between researchers and farmer organizations, i.e., the Indonesian Farmers Community Network (Jamtani). The two locations have different impacts due to the tidal wave. Based on the effects of tides, Gandasmita *et al.* (2006) classified paddy fields into three zones. The first zone is paddy fields that were strongly influenced by tides, often referred to as “tidal wetlands”. The second zone is the rice field as part of the lower watershed, but its position is deeper inland or upstream. In this region, river energy, in the form of river flow movement towards the sea, meets with the tidal energy that is still quite dominant. The third zone is rice fields that are not affected by tides and are usually included in the middle river flow areas in large rivers. Based on the classification, Ciganjeng is classified as the third zone, while Rawaapu is classified as the first zone (Figure 1). The two villages

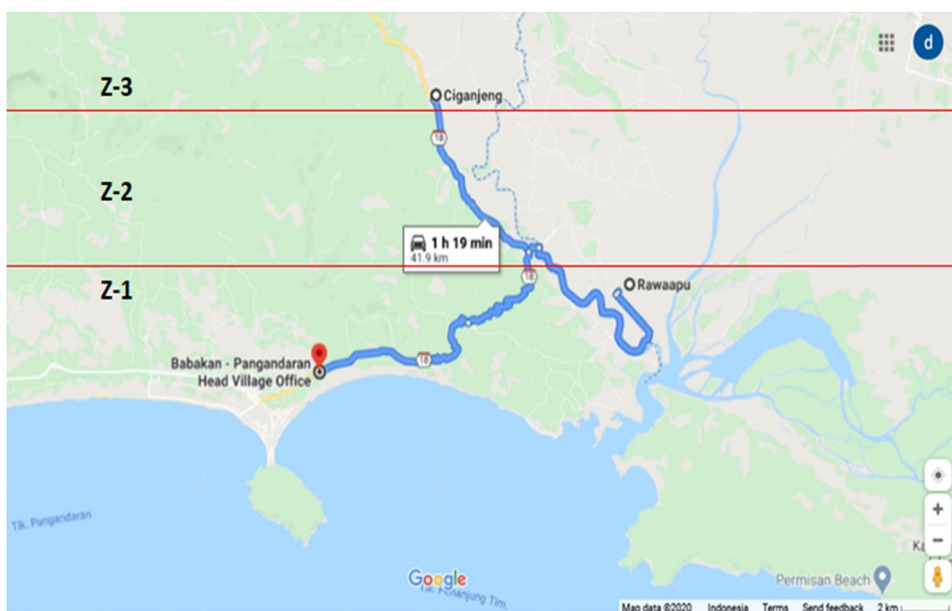


Figure 1: Distribution of research location zones.

encounter different agricultural productivity problems; Ciganjeng suffers from low soil fertility because nutrient leaching is often an effect of river flooding, while Rawaapu has high soil salinity levels due to tidal flooding.

The main problem in Ciganjeng village is low soil fertility because nutrient leaching is often an effect of river flooding, so the research conducted is the effect of green manure on soil fertility and rice production. Research in Ciganjeng village uses a factorial randomized block design. The organic manure was placed as the first factor for three treatments ($T_1 = 10 \text{ ton ha}^{-1}$ of cattle composts; $T_2 = 10 \text{ ton ha}^{-1}$ of cattle composts + 10 ton ha^{-1} of *Azolla pinnata*; and $T_3 = 10 \text{ ton ha}^{-1}$ of cattle composts + 2 ton ha^{-1} of *Sesbania rostrata*). The second factor is variety, namely, V1 = Ciherang as popular variety and V2 = Makeup as recommended variety/flood-tolerant variety. The composition of the treatment was determined based on the results of discussions with farmer researchers where most of the farmers in Ciganjeng provided 10 ton ha^{-1} of cattle composts as basic fertilizer. Determination of the additional dose of *Azolla* and *Sesbania* is based on literature in previous studies. Asifah et al. (2019) suggest that the dosage of using *Azolla* as green manure is $5\text{--}10 \text{ ton ha}^{-1}$ and Prayoga et al. (2020) recommend an additional 2 ton ha^{-1} of *Sesbania* to increase rice production. The main problem in Rawaapu village is high levels of soil salinity due to tidal flooding, so the research conducted is testing rice varieties that are tolerant of salinity stress. Research in Rawaapu village uses a randomized block design experiment that involved five treatments (varieties) with five repetitions. Rice varieties used were the saline-tolerant Inpari 34, Inpari 41, and Inpara Pelalawan, and the flood-tolerant Inpara 02 and Mendawak.

The results of the FGD also determine the four criteria for farmers who could get involved in the CFS or so-called farmer researcher. First, the farmers should own their paddy fields because ownership is essential in the sustainability of participatory research activities. The owners of paddy fields are expected to apply the technology that is learned in participatory activities. Also, in principle, farmers have full rights to their private paddy fields, in contrast to smallholder farmers who usually get interference from the paddy fields (Lestari and Mardiyanto 2017). The second criterion is that farmers should be able to read and write because, in participatory research, there is a learning module and note-taking in each meeting. The third criterion is that farmers have former participation in agricultural training activities. The CFS is more detailed than the general agricultural training, so experienced farmers would not have difficulties to follow through the CFS. The last criterion is that the farmers are willing

to participate in the CFS completely. Farmer researchers must follow the entire set of activities during the CFS to fully transfer information and technology and avoid misinterpretation during the field application.

Farmer researchers were selected by purposive sampling based on a survey conducted with 139 farmers in both villages. The number of farmer researchers in the two villages is 14 people. Determination of the number of farmers is based on the statement of Ernawati et al. (2015), which explains that farmer field schools will run effectively if followed by a maximum of 15 farmers. Farmer field school activities will not be effective if there are quite a lot of participants due to the limited education owned by farmers. The farmer researchers were directly involved in the research design, the selection of organic fertilizers and rice varieties, and routine observations. In addition, the farmer researchers received training on simple methods to measure climate parameters and soil fertility.

Overall, the success indicators of CFS are farmer researchers who have knowledge about climate change, rice cultivation techniques, organic agriculture, and research designs. This can be measured from the extent of the increase in scientific knowledge of farmers after participating in participatory action research. The increase in knowledge of the farmer researchers was tested using the One-Group Pretest-Posttest design method. The pretest aimed at determining the status quo of the participants' knowledge on climate-adaptive agriculture and was done before the farmer researchers began with the CFS. The posttests aimed at measuring the increase in farmer researchers' knowledge and were carried out after the end of the CFS. The magnitude of the increase in the pretest value to the posttest value was analyzed using the n -gain test (Diyanah and Firdausi 2018). The n -gain test formula is as follows (Hake 1998):

$$g = \frac{S_{\text{post}} - S_{\text{pre}}}{100 - S_{\text{pre}}}$$

where, g = factor gain value, S_{post} = average of posttest score, S_{pre} = average of pretest score. Factors g are further classified against the categories: $g \geq 0.7$ = high, $0.3 \leq g < 0.7$ = medium, and $g < 0.3$ = low. However, the g score could not explain the adoption of technology or knowledge obtained from CFS on their own field.

The farmers who were selected as researchers and involved in CFS activities in the two villages (28 people) were given a list of activities to conduct field observations. The observations on the demo plot were carried out by farmer researchers every morning at 8 AM. The farmer researchers were trained to perform field research tasks

following a standard research protocol. They collected, presented, and discussed observational data. The observed characteristics were plant height, the number of tillers, and grain yield. In demo plot testing, the productivity differences of the varieties were tested via an ANOVA posthoc analysis using the Tukey's honest significance test (Tukey's HSD). The data were computed using the PKBT stat software. For comparison, we contrasted the grain yield obtained by farmers involved in this research and attended the CFS with the surrounding farmers who did not participate in the field schools. Our (alternative) hypothesis is that the farmers who attend the CFS harvest significantly higher grain yield. The significance of grain-yield means between these two groups of farmers was tested using a one-sided *t*-test with a 95% significance level. We can reject the null hypothesis that both groups of farmers have a similar grain-yield means if the *t*-count > *t*-table.

Informed consent: Informed consent has been obtained from all individuals included in this study.

Ethical approval: The research related to human use has been complied with all the relevant national regulations, institutional policies and in accordance with the tenets of the Helsinki Declaration, and has been approved by the authors' institutional review board or equivalent committee.

3 Results and discussion

3.1 Participatory research in Ciganjeng village

A major problem in Ciganjeng village is poor soil health. Soil is an important factor in crop production. Healthy soil supports optimum production (Bitew and Melkamu 2017). In the CFS, farmers were trained on how to measure the level of soil health quickly and simply by looking at different indicators (structure, color, pH, and soil organic matter content). Before the research started, the soil health on the demo plot was examined. Low organic matter content indicated poor soil health. An analysis of soil samples at the Soil Fertility Laboratory validated this conjecture. Laboratory test results showed that the soil at the demo plot site was unhealthy (Table 1). In general, the use of organic manure can increase the content of organic carbon (C) and nitrogen (N) in the soil (Table 1).

Although the increase is not significant, this greatly supports the process of growth and development of rice. Organic carbon (C) in the soil is a source of nitrogen (N), and the carbon-to-nitrogen ratio (C/N ratio) in the soil is an important indicator of soil health and overall productivity. A lack of N is the main limiting factor of rice crop productivity. Soil with low organic matter content needs the addition of N from organic fertilizer so that the N-nutrient status of plants is sufficient to support rice productivity (Bado *et al.* 2018).

Increased organic carbon (C) and nitrogen (N) in the soil is a contribution of organic fertilizer. Mature organic fertilizer will easily decompose so that it can add total C and N in the soil. The C:N *Azolla* ratio ranges from 10 to 12, lignin <15%, and polyphenols <4% so that it will be easy to mineralize the nutrients (Yadav *et al.* 2014). Besides, decomposed *Sesbania* can produce N-containing compounds such as ammonium, nitrite, nitrate, and nitrogen gas (Latt *et al.* 2009).

On observing rice plants, it was concluded that the plant height character did not show significant differences between treatments and between varieties. Thus, it can be concluded that the appearance of the plant height of both varieties in each treatment is the same (Table 2). In the number of tiller characters, there are significant differences between varieties, but not significantly different in each treatment. The Mendawak variety has more number of tiller than the Ciherang variety (Table 3). The number of tiller correlates with grain yield; the more number of a tiller, the more grain yield is predicted. This is consistent with the results of the analysis in which the Mendawak variety has a higher grain yield than the Ciherang variety. The results of the statistical analysis also showed that there were no significant differences in each treatment, even though the treatment value of T₂ had the highest average grain yield compared to other treatments (Table 4).

Table 1: The improvement of chemical soil properties due to organic manure

Parameter	Initial soil analysis	Organic manure (ton ha ⁻¹)		
		T ₁	T ₂	T ₃
Organic carbon (%)	0.82	1.66	1.35	1.66
Nitrogen (%)	0.10	0.23	0.14	0.14
C/N ratio	8.00	7.00	10.00	12.00

Note: T₁ = 10 tons/ha of cattle composts; T₂ = 10 tons/ha of cattle composts + 10 tons/ha of *Azolla pinnata*; and T₃ = 10 tons/ha of cattle composts + 2 tons/ha of *Sesbania rostrata*.

Table 2: Plant height (cm)

Varieties	Treatments			Average of varieties
	T ₁	T ₂	T ₃	
Ciherang	94.43	94.52	87.62	92.19 ^a
Mendawak	96.91	95.24	87.38	93.18 ^a
Average of treatments	95.67 ^a	94.88 ^a	87.5 ^a	

Note: numbers followed by the same letter are nonsignificant ($P < 0.05$).

In treatment 2, more organic carbon was absorbed than in the other treatments. Table 1 shows that the remaining organic carbon in the soil is 1.35%. This relates to the C/N ratio, as treatment 2 had an ideal C/N ratio (10). Treatment 1 had a low C/N ratio (7), which meant that organic matter was more easily decomposed. Treatment 3 had a C/N ratio that was too high (12), slowing down the decomposition of organic matter. As a result, nutrients in the soil are not maximally utilized by plants. A high C/N ratio indicates the presence of relatively large weathered soils (e.g., cellulose, fat, and wax). Based on these observations, it can be said that *Azolla* (treatment 2) is the most effective organic fertilizer.

The treatments in the CFS did not use synthetic chemicals. Therefore, data from nearby farmers were collected to compare the grain yield after the application of organic manure with the grain yield after the application of chemical fertilizers. The average grain yield of farmers using chemical fertilizers was 4.97 ton ha⁻¹ (Table 5). The results of the statistical analysis show that the t_{count} is greater than the t_{table} , so it can be concluded that the treatment in the demo plot using organic manure has a higher grain yield than the conventional treatment using chemical fertilizers (Table 5).

Farmers who participated in the CFS (farmer researchers) have seen and learned firsthand how the application of organic manure improves soil health and subsequently

Table 4: Grain yield (ton/ha)

Varieties	Treatments			Average of varieties
	T ₁	T ₂	T ₃	
Ciherang	5.74	6.30	5.72	5.92 ^b
Mendawak	6.70	6.40	5.51	6.21 ^a
Average of treatments	6.22 ^a	6.35 ^a	5.62 ^a	

Note: numbers followed by the same letter are nonsignificant ($P < 0.05$).

increases yields. Farmer researchers are expected to practice the use of organic manure in their respective paddy fields and to provide information on the benefits of organic manure to other farmers who did not participate in the CFS. However, the most important step after this activity is the multiplication of *Azolla* and *Sesbania* so that in the future when farmers need to fertilize, the two materials are available.

3.2 Participatory research in Rawaapu village

The main problem of the CFS in Rawaapu village is the high level of soil salinity. Soil salinity is measured periodically using electrical conductivity (EC) meter. There are five soil salinity criteria, i.e., very low (<1 ds/m), low (1–2 ds/m), medium (2–3 ds/m), high (3–4 ds/m), and very high (>4 ds/m) (Smit 1975). Farmer researchers were trained on using the EC. During the study period, the soil salinity level in the demo plot ranged from low (1.49 ds/m) to very high (7.36 ds/m) (Figure 2).

Salinity is a form of abiotic stress that greatly affects crop productivity and quality, especially in the tidal land area. The closer an agricultural plot is located to a salt-water source, the more likely salinity will affect crop productivity (Filho 2018). High soil salinity inhibits nutrient

Table 3: Number of tillers

Varieties	Treatments			Average of varieties
	T ₁	T ₂	T ₃	
Ciherang	19.95	19.76	20.13	19.95 ^b
Mendawak	22.38	24.76	21.24	22.79 ^a
Average of treatments	21.17 ^a	22.26 ^a	20.68 ^a	

Note: numbers followed by the same letter are nonsignificant ($P < 0.05$).

Table 5: Grain yield comparison of organic manure and conventional

Treatment	Grain Yield (ton/ha)		Std. deviation	t_{count}	t_{table}
	Organic manure	Conventional			
T ₁	6.22 ⁽⁺⁾	4.97	0.67	4.58	2.57
T ₂	6.35 ⁽⁺⁾		0.34	10.01	
T ₃	5.62 ⁽⁺⁾		0.20	8.05	

Note: (+): higher than farmers around.

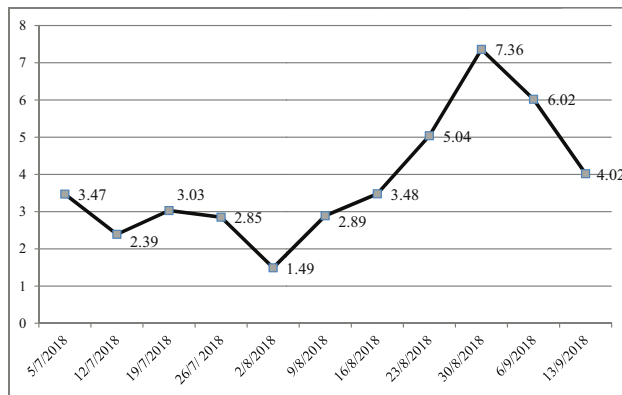


Figure 2: Soil salinity level during observation (ds/m).

absorption, and the metabolic imbalance caused by ion poisoning (Na^+) and nutrient deficiency (N, P, and K) affects the growth of roots, stems, and leaves (Aslam *et al.* 2017). If salt concentrations in the soil are higher than in root cells, the soils absorb water from the roots and stems. As a result, the plant will wither and die. This is a basic principle of how salinization affects crop production. Salts that cause plant stress include NaCl , Na_2SO_4 , CaCl_2 , MgSO_4 , and MgCl_2 dissolved in water (Setiawati *et al.* 2018).

The rice varieties used in the CFS are tolerant of salinity. The observations show that plant growth was normal and there were no symptoms of plant stress. The average plant height of the five varieties was 82.71 cm and the average number of tillers was 20.79 (Table 6). Nevertheless, the process of filling and ripening grain indicated the presence of salinity stress. This can be deduced from the average grain yield of 3.72 ton ha^{-1} , whereas the five varieties have a potential grain yield of more than 5 ton ha^{-1} (Agricultural Research and Development Agency 2015).

Plant sensitivity to salinity stress (salt tolerance) varies (Aslam *et al.* 2017). Some plants can overcome

high salt levels in the soil, while others cannot. Plant species that only tolerate low salt concentrations are included in the glycophyte group of plants, and plant species that tolerate high salt concentrations are included in the halophytes plant group. The statistical analysis shows that the grain yield of all promoted varieties on the demo plots is higher than the grain yield of the Ciherang variety which is used by farmers around the demo plot (except Pelalawan; Table 7). The Ciherang variety is a widely-introduced and popular variety used by farmers around the Rawaapu area, even though it belongs to the glycophyte group of plants and is salt-intolerant. Ciherang seeds are easy to obtain and have a good grain shape and good taste; this makes the variety very popular with farmers.

The grain yields of the Mendawak and Inpari 41 varieties are the highest compared to other varieties (Table 6). Seeing the good appearance of the Mendawak and Inpari 41 varieties, it is suspected that the two varieties were able to adapt to salinity stress conditions. The two varieties will be introduced to other farmers who were not involved in CFS as an effort to adapt to salinity stresses caused by rising sea levels due to climate change.

3.3 Farmer researchers scientific improvement

In Indonesia, participatory action research is generally carried out through a field school approach. Field schools are participatory in nature, thus opening up space for farmers to choose, create, develop, and practice techniques that are produced from the farming community itself and produced by innovators so that farmers will gradually be able to determine their farming business management strategies. Participatory action research is innovation and apt strategy in an effort to increase

Table 6: Average of each observation characters

Varieties	Plant height (cm)	Number of tillers	Grain yield (ton)
Mendawak	77.94 ^a	23.71 ^a	4.32 ^a
Inpari 41	73.20 ^a	23.26 ^a	4.28 ^a
Inpari 34	113.03 ^a	17.86 ^a	3.98 ^b
Inpara 02	77.51 ^a	21.71 ^a	3.08 ^{bc}
Pelalawan	71.86 ^a	17.40 ^a	2.95 ^c
Average	82.71	20.79	3.72

Note: numbers followed by the same letter are nonsignificant ($P < 0.05$).

Table 7: Grain yield comparison of demoplot and farmer treatment

Varieties	Grain yield (ton/ha)		Std. deviation	t_{count}	t_{table}
	Demoplot	Farmer treatment			
Mendawak	4.32 ⁽⁺⁾	2.37	0.62	7.07	2.78
Inpari 41	4.28 ⁽⁺⁾		0.66	6.50	
Inpari 34	3.98 ⁽⁺⁾		0.76	4.73	
Inpara 02	3.08 ⁽⁺⁾		0.35	4.53	
Pelalawan	2.95		0.58	2.21	

Note: (+): higher than farmers around.

production and productivity of farming. Adoption of technology by farmers takes place through a Learning Process that at the field level includes Seeing-Analyzing-Proving-Implementing (Musyafak and Ibrahim 2005).

Successful agricultural technology transfer requires the active participation of farmers. Farmer involvement is facilitated through CFS activities aimed at increasing the capacity of farmers to adapt to climate change. The CFS conducted in the two villages involved 28 farmer researchers (14 in each village). The farmer researchers were trained in climate-resistant cultivation techniques through the use of organic manure and the selection of alternative rice varieties. The CFS concept integrates crop management with local wisdom, awareness-building, and guidance directed towards environmentally friendly agriculture (Emawati et al. 2015).

The increased capacity of farmers is reflected in the increase in farmer knowledge. To examine the increase in farmers' knowledge, a pretest was conducted. The pretest aimed at determining the level of farmer researchers' knowledge on sustainable climate-resilient agriculture before the start of the CFS, so that the selection of the training material could be adjusted to their needs (Diyanah and Firdausi 2018). After the CFS, a posttest examines whether farmer researchers' knowledge has increased.

The results of the pre- and posttest show an increase in farmers' knowledge. The posttest results in Ciganjeng showed an increase in farmers' knowledge of 52.74%, while in Rawaapu an increase of 41.23% (Table 8). Increased knowledge of farmers in field school activities is related to age and education level. The productive age for farmers is 30–50 years. At that age, farmers will be more active and have great curiosity (Seran et al. 2011). In this field school activity, there were 7 farmers in productive age in Ciganjeng and Rawaapu (Figure 3).

The level of education affects the ability of farmers to understand and receive information at CFS. Farmer researchers with low education certainly have limited knowledge, so it tends to be more difficult to accept new technological information. The level of education can also influence the decision process for technology adoption (Lestari and Mardiyanto 2017). The education

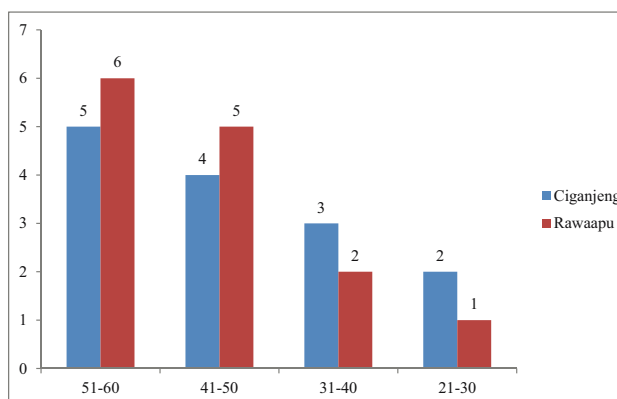


Figure 3: Age distribution of farmer researchers.

level of farmers participating in CFS is mostly Junior High Schools (JHS). In Ciganjeng, the level of education of farmers was 5 Elementary Schools (ES), 8 JHS, and 1 Senior High Schools (SHS), while in Rawaapu there were 6 ES, 7 JHS, and 1 SHS (Figure 4).

The magnitude of the increase was analyzed using the *n*-gain test. The *n*-gain test results show that in both Ciganjeng and Rawaapu village, the magnitude of knowledge increase is moderate with *n*-gain values of 0.42 and 0.39, respectively (Table 8). In general, the improvement of farmers' capacities during CFS is not maximal. However, it is quite encouraging and needs to be appreciated given that half of the farmer researchers are not in the productive age and most are poorly educated.

Farmers' capacity increase can also be seen from the ability of farmers to submit their findings while participating in the CFS for local farmers. A total of 4 farmer researchers in Ciganjeng and 6 farmer researchers in Rawaapu became agricultural instructors in other villages after receiving CFS. Equipped with theoretical and practical knowledge, farmer researchers can be more

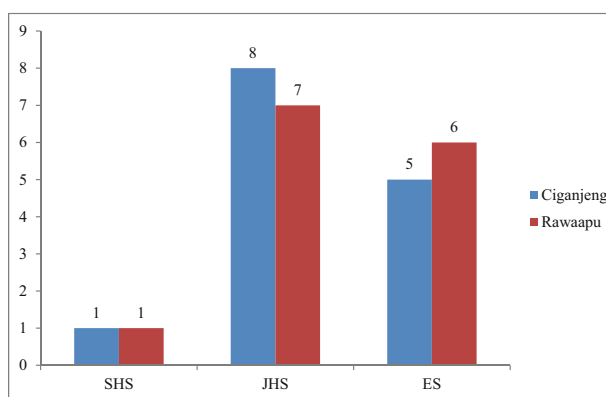


Figure 4: Level of education distribution of farmer researchers.

Table 8: Pretest and posttest results of farmer researchers

Location	Average of		Increase (%)	Factor <i>g</i>	
	Pretest	Posttest		Value	Criteria
Ciganjeng	44.29	67.64	52.74	0.42	Medium
Rawaapu	48.86	69.00	41.23	0.39	Medium

confident in conveying environmentally friendly agricultural technology to other farmers. In addition, after the CFS activity, farmer researchers also began to receive technology that was received during CFS.

According to Rogers and Shoemaker (1983), conceptually, the process of adopting technology by farmers consists of several stages, namely, awareness (aware of the innovations offered), interest (growing interest is marked by the desire to ask questions or know more about innovations offered), evaluation (assessment of the good/bad or the benefits of known innovations), trial (trying on a small scale to be more convincing before applying on a broader scale), and adoption (accepting/implementing with confidence based on the assessment and trials that have been conducted/observed alone). The Farmer researcher has passed all of these stages and will now enter the stage for disseminating information to other farmers.

The participatory action research jointly conducted by farmer researchers and the university researchers accelerates the process of technology transfer for the following reasons. Field testing of organic manure and varieties in demo plots allow farmers to see and adjust the results directly on their farm. Through participatory research, the capacity of farmers on sustainable climate-resilient agriculture can be improved. Observations and recording of results carried out jointly with farmers allow increasing the independence of farmers. This research reveals that farmer researchers are seen as risk-takers and innovators and increasingly serve as a point of orientation for farming decisions to be taken by the community.

4 Conclusion

Organic manure can increase organic carbon 64.63–102.44% and also increase total N 40–130% in the soil. The application of organic fertilizer gives a higher yield ($T_1 = 6.22 \text{ ton ha}^{-1}$, $T_2 = 6.35 \text{ ton ha}^{-1}$, $T_3 = 5.62 \text{ ton ha}^{-1}$) compared to conventional methods (4.97 ton ha^{-1}) using chemical fertilizers. Mendawak Varieties are varieties selected by farmer researchers to be developed because they have high yields (Ciganjeng = 6.21 ton ha^{-1} , Rawaapu = 4.32 ton ha^{-1}), and based on grain shape, taste, and stem strength characters, are considered better than other varieties. The knowledge of farmer researchers involved in CFS increased by 52.74% in Ciganjeng and 41.23% in Rawaapu compared to the pretest that farmers have not gained knowledge from CFS. The gain factor analysis was classified as moderate criteria (Ciganjeng: $g = 0.42$; Rawaapu: $g = 0.39$).

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