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Large Scale Demonstration of Rice Production Technology in North-Western Ethiopia

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Abstract

Currently, rice is one of the major prioritized crops in Ethiopia. More than 30 improved rice varieties have been released by national research system. However, there is productivity variability across rice producing areas. The objectives of this activity were to minimize the variability in yield; enhance productivity of rice and record farmers' perception on cluster farming approach. The demonstration was conducted in purposively selected high potential rice producing areas in North western Ethiopia. For this purpose three improved rice varieties (Pawe-1, Nerica-3 and Nerica-4) were selected and planted on 250ha of land. For the perception assessment, a total (397) targeted farmers, 212 farmers were from the established clusters and 185 were non-cluster. From non-cluster participant 54.6% was selected from Jawe and the remaining 45.4% was from pawe district. In both district non-cluster participant was selected by simple random sampling and the site was selected purposively. According to the result of descriptive statistics, all the demonstrated varieties Pawe-1, Nerica-3 and Nerica-4 varieties have a yield advantage over the local varieties 47.6%, 42.9% and 47.06% respectively. Based on farmers perception assessment, 99 percent of cluster farming participants agreed on the importance of cluster farming. Only 24 percent of non-cluster farming participants agreed on the importance of cluster farming. Therefore, the result highlights the scaling of improved rice verities (Pawe-1, Nerica-3 and Nerica-4) in similar agro ecology. In addition, as the number of farmers who perceive the cluster farming as an important approach was low, the finding implies for additional awareness creation among farmers.

Keywords: *Cluster farming, demonstration, improved variety, productivity, rice*

1. Introduction

In Ethiopia the cluster farming initiative primarily focuses on facilitating the transition of smallholder farmers from subsistence to semi-subsistence farming production (Dureti et al., 2023). Cluster approach first of all a new managerial knowledge which allows to increase competition (Zhukenov, 2014). The approach is also important for the implementation of new agricultural technologies due to repeated collaboration of farmers each other (Joffre et al., 2019). A cluster work can also help to create social capital by conveying stakeholders together to determination of common problems (USAID, 2008).

Rice is one of the most staple crop in the world and accounts for more than 21% of caloric requirements (Mohidem et al., 2022). Since non-industrial nations depend on rice as a food sources in the last 30 years, the interest in rice increased by 70% (Desta et al., 2022). According to (USDA) the total amount of rice produced worldwide in 2020/2021 cropping season reaches 503.1 million metric tons. China, India, Bangladesh, Indonesia, and Vietnam ranked one up to five with the production quantity of 148,300,000, 120,000,000, 35,300,000, 34,900,000, and 27,100,000 metric tons, respectively. For the period 2020/21, the world's rice consumption reached 697.09 Mt (Mohidem et al., 2022). In Sub-Saharan Africa, 14.5 million metric tons of rice is produced annually which covers 15% of the region's cereal production. Due to its contribution in improving the economic growth, in creating jobs and capital, contributing on food security and social stability, the rice industry in the region is considered as an engine (Seck & Diagne, 2012).

In Ethiopia the first adapted rice variety was gained in Fogera by introducing the genotype from North Korea by a team of experts with a project entitled "Ethio-jigna development project"(Tilahun, 2020). The fact that rice has recent history in Ethiopia; it becomes one of the most strategic crops for addressing food security and income earnings. According to the ministry of Agriculture and Rural Development Report MoARD, (2010) the potential land for rice production in the country is estimated about 39,354,190 hectares. From these potential areas, 5,590,895 ha are estimated to have high potential areas for rice production most of the potential areas for rice is available in the western parts of the country (Anteneh et al., 2020).

In Pawe district the introduction of rice is interrelated with the resettlement program of the Dergue regime and the formation of pawe agricultural research center in 1985 (Alemu et al., 2018). The district covered by 60% verty soil which is suitable for rice production (PWANR, 2021). Currently, the crop is widely cultivated in the pawe district and distributed to Dangur district of Benishangul Gumuz and Jawe districts of the Amhara region by the efforts of the Pawe Agricultural Research Center. The existence of the pawe agricultural research center contributes to adapting and demonstrating new improved rice variety in the areas. For the last 30 years more than 40 improved rice varieties, which have better productivity were released by the Ethiopia institute of agricultural research and other collaborative research centers including regional agricultural research institutes. Despite the availability of improved rice varieties, most farm households still use local rice varieties which have low productivity. Even, those farmers who have improved rice varieties cultivate in small scale bases, a minimum of 0.25 and a maximum of not greater than two hectares and low uses of agricultural inputs which results in low productivity. To tackle this low productivity problem, Pawe Agricultural Research Center conducts pre-extension demonstration of adapted improved rice varieties namely, pawe-1, Nerica-4, Nerica-3, Hidasie, Abay, Erib, and X-jigna. From these varieties, pawe-1, Nerica-4 and Nerica-3 varieties were the most productive varieties preferred by farmers during field events. Therefore, this study was initiated to demonstrate the yield advantage of improved rice varieties and to investigate the perception of farmers towards cluster farming approach in Pawe and Jawe districts. .

2. Materials and Methods

2.1. Description of the study area

Pawe districts: is located in the north-western parts of the Metekel zone which has a distance of 575 km away from Addis Ababa. Pawe district is located at Latitude; 110 09' N Longitude; 360 03' E. It has the mean altitude of 1120 m.a.s.l. According to PARC metrology data, Pawe has an average temperature of 32.7 0C and rainfall of 1582 mm/year over the last 30 years. According to pawe woreda agricultural and natural resource office; the district has a total area of 64,300 ha. From this, 50.4 % is arable land. In the 2021 cropping season a total of 24,670 ha of land was covered by different crops. In the district 20 kebeles are available; out of 20 kebele, 18 kebeles are potential areas to produce rice. In 2022 a total of 9,829 farmers produce rice for their consumption and market purposes. Of the total rice producers, 8,610 were male headed and the rest 1,219 are female-headed household (PWANR, 2022).

The other site which rice large scale demonstration was conducted at Jawi districts of Awi zone Jawi is found at 602 Km to North West direction far away from Addis Ababa with geographical location at 36029'17.58'' longitude and latitude of 11033'22.68''. Fendika is the capital city of the Jawi district. It covers an area of 515,400 hectares with an estimated population of 122,259 (53.08% male) inhabitants (JWAO, 2018). The farming system of the district is characterized as mixed crop-livestock farming system dominated by cereal and pulses crops. The district is bounded in the East by the Dangla district, in South by the Dangur and pawe district, in the West by Quara districts and in the North by the Alefa Taqusa district. It is characterized as warm humid low land area with high rainfall. The district has 25 kebeles and the climate of the area is hot humid and characterized by unimodal rainfall patterns with high and heavy rainfall that exceeds from May to October. The area receives mean annual rainfall of 1250 mm and its altitude ranges from 700 to 1500 m.a.s.l. Pawe and Jawe districts were selected purposively to conduct large-scale demonstrations due to their agro-ecological suitability for rice production.

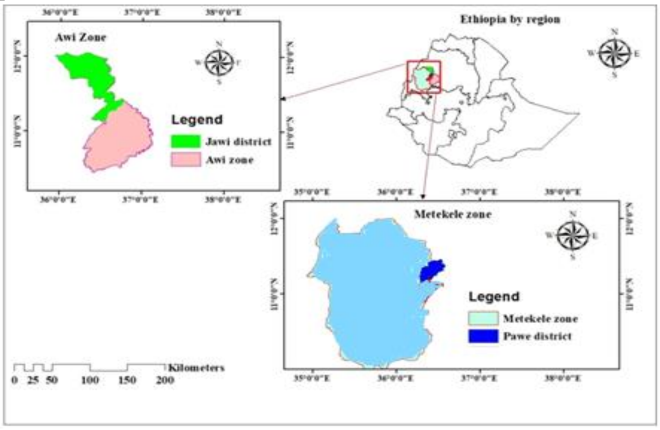

Figure 1. Map of the study area

2.2. Site and farmer selection techniques

Pawe district from Metekel and Jawi district from Awi zone were purposively selected to conduct cluster farming considering their rice potential. From the two districts a total of six kebeles were also selected purposefully taking in to account the potential of rice production. In addition to cluster land, all the required agricultural inputs including improved seed, fertilizer, and herbicides were identified and applied accordingly. For participant farmers rice varieties (pawe-1 Nerica-3 and Nerica-4) were delivered from the Pawe Agricultural Research Center. All the variety used is conducted with the recommended agronomic practice for cluster participants. A follow up team from different disciplines to monitor, supervise and evaluate the overall cluster implementation

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processes starting from site selection to the completion of the cluster farming was organized. In the overall activity implementation processes, agricultural extension research process took a leading role and the team run the tasks at different stages of the crop by taking correction measures and directions were given on the spot to development agents and farmers.

2.3 Sampling procedures

In this study, participant farmers were selected by the criteria of having adjacent land to form a cluster and produce the same type of crop. From the total six kebeles, a total of six cluster and 212 farmers were participate in the cluster farming from 2020 – 2022 cropping season. Farmers were selected in collaboration with district experts and village extension workers based on the criteria of having a willingness to share their experience with other farmers, availability of cultivated land, and having an adjacent site. Parallel to cluster participant, non-cluster participants were selected from the area which, there is no intervention of any cluster farming and have no knowledge of on it. From the two districts a total of 185 non cluster participant sample farmers were selected by simple random sampling and the site for non-cluster participant farmers were selected purposively.

2.3. Sample size determination

By using (Yamane, 1973) formula, the required sample sizes were selected with the accuracy/precision level of 7% from each sample kebele. Since almost all farmers in both districts are rice producers, have similar farming system, agro ecology and there is no high degree of variability regarding rice production among farmers. This is the reason that the precision level lies on 7%. There for by using the above formula the required sample size for non-cluster participant was calculated as follows;

$$n = \frac{N}{1+N(e^2)} \quad = \quad n = \frac{2056}{1+2056(0.7^2)} = 185$$

Where, n= the required sample size N= the total population size e = the level of precision

Table 1; - Sample size determination

Districts	Household no.	Sample Size	Proportion
Pawe	930	84	45.4
Jawe	1126	101	54.6
Total	2056	185	100

2.4. Input delivered

During the implementation of cluster based large scale rice demonstration, inputs like improved seed, fertilizer (NPS and UREA), and both selective and non-selective herbicides were applied by the farmers. The recommended amount of improved rice varieties seed rate of 80 kg ha-1 was delivered to those participant farmers. Pawe-1, Neria-3 and Nerica-4 varieties were the material used in cluster production. From the total 250ha of land 218 (87.5%) of land was covered by Pawe-1 variety. The remaining Nerica-3 and Nerica-4 varieties were takes the share of 4% and 8.5% respectively. In the overall three years 19.664 ton of improved rice seed was delivered to farmers. All seeds were supplied by Pawe Agricultural Research Center and fertilizers were gained from district cooperatives/Unions. To control weed infestation, farmers apply different types of herbicides for both broad leaf and grass family weeds.

Table 2 variety used, seed rate and participant of LSD

Varieties used	Seed used (ton)	Land size (ha)	Benefici aries	Percent
Pawe-1	16.536	218.30	182	85.90
Nerica-3	0.751	10.00	7	3.30
Nerica-4	1.720	21.25	23	10.80
Total	190.07	249.55	212	100.00

Source: Own data, 2020-2022

2.5. Methods of data collection and analysis

All necessary data such as: training participants, amount of input delivered to cluster participants, total farmers who participate in cluster farming, the total area covered by rice cluster, total production gained from cluster, total field day participant, and their perception on the cluster farming were collected through checklist. In addition to cluster participants, data were collected by household survey from 185 non-cluster participant farmers for comparison with cluster participants. The quantitative data were analyzed by descriptive and inferential statistics. The qualitative data also analyzed through Likert scale and narratives. Standard deviation, mean, percentage, maximum, and minimum were employed as descriptive statistics. Accordingly, t-tests and chi square test were conducted as inferential statistics.

2.6. Yield advantage

The yield advantages of the demonstrated varieties such as (Pawe-1, Nerica-3 and Nerica-4) were estimated by the following formula:

$$\%\ \text{of yield advantage} = \frac{\text{yield of new variety} - \text{yields of local variety}}{\text{yields of local variety}} * 100$$

3. Results and Discussion

3.1. Demographic characteristics of participant and non-participant farmers

The demographic characteristics of rice cluster participant and non-participant were presents in table 2. From the total 212 participants in rice cluster 96.23% male and the rest 3.77% was female. Among non-cluster participant farmers about 9.19% was female-headed households and the rest 90.82% of non-participant was male-headed. Participation of female households on cluster farming was not as expected. The value of chi-square ($\chi 2$*=4.91) is an evidence for the presence of positive and significance association between sex and cluster participants at 5%.* In addition to sex, when looking at the education level of the households, from the total 185 non-cluster participant, 29.2% 16.8% 45.4%, and 8.6% were illiterate, read and write, primary school complete and above respectively. On the other side among rice cluster participant farmers 40.56%, 37.26%, 15.2%, and 7.07% were illiterate, read and write, primary school complete and above respectively. The chi-square value ($\chi 2$ =49.99) is evidence for the presence of positive and significance association between education and cluster participant households.

Table 3. Sex and level of education

Varia bles	Category	Participant (N = 212)	Non-participant (N = 185)	All cases	$\chi 2$
Sex	Female	8	17	25	4.91**

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	Male	204	168	372	
Education	Illiterate	86	54	140	49.99***
	Read & write	79	31	110	
	Primary school completed	37	84	116	
	Secondary school & above	15	16	31	

Source: Own data, 2020-2022

3.2. Training and field day participants

Rice production and management training was provided to development agents, district and zone experts, farmers, and other stakeholders. The instruction addressed site selection, post-harvest handling practices, and various pest and disease control approaches. This was done to guarantee that all participants could apply the concepts they had learnt properly. Both theoretical and practical training was provided to 81 experts and 178 targeted farmers. Furthermore, development agents, district and zone experts, and farmers who can read and write were given technical production manuals and printed extension materials. These materials serve as a technical guidance to assist in the successful implementation of the intended activity. Field day activities are organized in selected clusters throughout all districts to share experiences among cluster-based farming system participants and non-participants. Host and non-host farmers, experts, and officials from the (district, zone, regional, and federal) levels attend the event (Figure 2). During field day activities and throughout the implementation processes, overall successes, difficulties encountered, intervention opportunities, shared experiences, and lessons learned were reviewed.

Figure 2. Field day event program at Pawe district

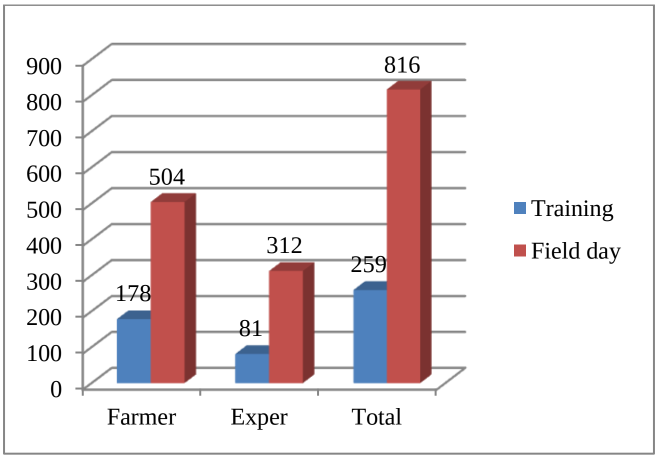

Figure 3. Training and field day participant farmers and experts

According to the table-3, the mean age of farmers who are participated on the rice cluster is 43.16 and those who do not participated on rice cluster is 45.9 with the standard deviation of 9.38 and 9.82 respectively. In this regard, the value of t= -2.843*** is evidence for the presence of significant mean difference between participant and non-participant groups in terms of age. According to this result, the mean family size of the household who are participating in rice cluster was 4.51 and 4.82 is the mean value of family size for non-cluster participants. The result of t-value = -1.83 shows that there is a statistical mean difference between rice cluster participants and non-participants farmers. The average land for farmers in cluster participants is 1.17 and for non-cluster participants is 1.41 with the standard deviation of 1.53 and 0.76 respectively. The t-value -1.875 is represents that, participants of cluster farming allocates less farm land for rice production. This is because; in cluster approach the probability of getting more plots of land for a particular crop is less due to less access of adjacent land ownership. The mean seed rate of rice cluster farmers was 76.2 kg/ha and for the non-cluster participants, the average seed rate used for 1ha was 105.3kg with a standard deviation of 2.14 and 26.75 respectively. In this, the higher the standard deviation indicates the variation among individuals in terms of seed rate/ha. The result of t-test= -15.71 presents that there is a statistically significance mean difference between cluster participant and non-cluster participants. The negative sign shows that farmers who participate on cluster farming use less amount of seed rate than the non-cluster participant. This is because that, rice cluster participant used the recommended amount of seed rate per hectare with a better-germinated seed. Non-cluster participant farmers used their seed which has a germination problem. Due to this reason non cluster participant uses much amount of seed rate than cluster participants. There is a significant mean difference between participants and non-participants in terms of yield gained from. The mean yield of cluster participants is 3.32ton/ha and the mean yield of non-cluster participants is 2.25 ton/ha. The value of (t=12.97) is evidence for the presence of mean difference between the two groups. This is because cluster participants use the recommended amount of inputs, get experience on rice production and management, and can get close follow up those results in good productivity.

Table 4 Continuous variable with cluster participant and non-participant

Variables	Category	Participant (N = 212)	Non-participant (N = 185)	t-value
Age of household head	Mean	43.16	45.9	-2.843***
	SD	9.38	9.82	
Family size	Mean	4.51	4.82	-1.830*
	SD	1.58	1.71	
Rice farm land (ha)	Mean	1.17	1.41	-1.875*
	SD	1.53	0.76	
Seed rate (kg ha-1)	Mean	76.2	105.3	-15.79***
	SD	2.14	26.75	

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Yield (ton/ha)	Mean	3.32	2.25	12.97***
	SD	8.9	7.2	

Source: Own data, 2020-2022

3.3. Yield variation and performance of the varieties

In the study the yields of both rice cluster participants and non-participants was identified. According to the findings of the study, 3.32 ton/ha and 2.25 ton/ha is the mean yield of cluster participant and non-cluster participant respectively. Production of crops on cluster has a yield advantage over the control groups which has a total of 1.07 ton/ha yields variation. On the other hand, this study shows the yield performance of varieties demonstrated on the cluster. The mean yields of 3.32, 3.31 and 3.22 ton/ha recorded from Pawe-1, Nerica-4 and Nerica-3 varieties respectively. Although the highest mean grain observed from Pawe-1 variety, all the varieties used in the cluster showed significant yield increment over the local varieties. Pawe-1 variety preferred by farmers not only due to its great mean grain yield, but also its good tillering capacity and not easily damaged by birds.

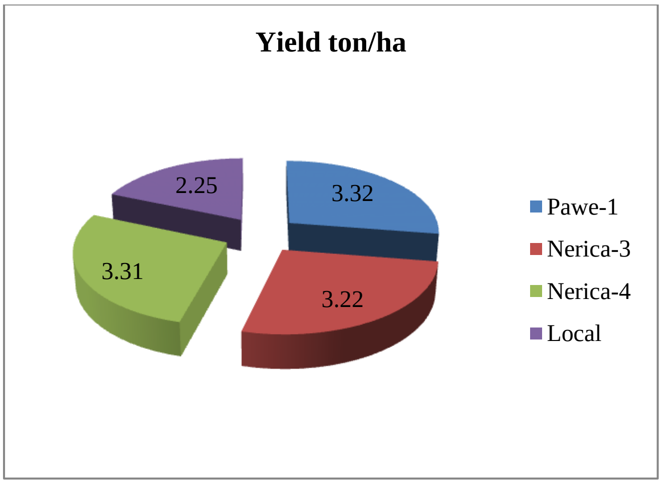

Figure 4. Performance of the varieties /productivity

Figure 5. Rice production at commercial level using LSD seeds/outreach of extension/ Jawi district

3.4. Farmers' perception on cluster farming

Overall feedbacks and perception of the demonstrated rice varieties and cluster farming were collected at different stage of the crop both from cluster and non-participants. From the three improved rice varieties namely, Pawe-1, Nerica-3 and Nerica-4 varieties, farmers preferred Pawe-1 due to high tillering capacity, resistance to weed, and resistance to bird attack. However, this variety has some drawbacks like the skein being light, and shattering problem during harvesting. The rest Nerica-3 and Nerica-4 varieties relatively have heavy skeins when compared to the Pawe-1 variety. Mostly these varieties have a problem with being attacked by birds, less resistance to weeds due to low amount of tillering capacity.

Farmers' perceptions are crucial for expanding cluster farming to unaddressed areas with similar environmental conditions to the study locations. As a result, data on crop output in clusters was collected from both cluster and non-cluster growers immediately following the completion of cluster production. According to the study's findings, the majority of cluster producers positively perceived and decided to continue cluster farming since it allows them to communicate with themselves, development agents, and experts on a regular basis. According to the findings, 42.45% and 47.64% of cluster producers strongly agree and agree on the importance of cluster production respectively. On contrast to this, the majority (76.22%) of non-cluster producers disagree on cluster production. The result of chi-square test ($\chi2$ = 267.998) tells the presence of a positive and significant association between cluster participation and farmers' perception on cluster farming. In these regards, cluster participant farmers get frequent visit and on farm advice from different stakeholders. Moreover, farmers in cluster production system can get training on crop production and management system; weed control, disease and pest protection mechanisms and post-harvest handling system of the crop. These helps to understand and increase the perception of farmers' towards the importance of cluster production systems.

Table 5. Perception of farmers on cluster production

Categories	Participant (N = 212)	Non-Participant (N = 185)	All cases	$\chi2$
Importance of cluster farming				
Strongly agree	90(42.45%)	3 (1.62%)	93 (23.43%)	267.988***
Agree	101(47.64%)	23 (12.43%)	124 (31.23%)	
Moderately agree	20 (9.43%)	18 (9.73%)	38 (9.57%)	
Not at all	1(0.47)	141(76.22%)	142 (35.77%)	

Source: Own data, 2020-2022

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4. Conclusion and Recommendation

The findings of the study revealed that cluster farming is the most acceptable approach to promote and enhance new agricultural technologies for a wider community. According to the results of the study, the yield variation of participant and non-participant records a significance difference due to practical intervention on the side of cluster participants when compared with the local practice. Due to having a number of advantages on sharing experiences on the production and managements of rice technology, cluster farming should be strengthened. The participation of female headed households on rice cluster farming is very limited, so that it is important to improve the participation of female-households on cluster farming. Depending on the study the majority of 54.6% of non-cluster participant was at Jawe district when compared to 45.4% at pawe district, there for intervention should be needed in Jawe district to promote the technology. On the other hand, it is better to enhance the clustering approach for other crops and an addressed area.

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