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Effects of Good Agricultural Practice for Sustainable Rice Production in North Western, Ethiopia.

Christian Tafere*

Fogera National Rice Research and Training Center

Corresponding Authors:** ***Christian Tafere, *Fogera National Rice Research and Training Center*

Abstract: *Good Agricultural Practice is vital for rice production by integrating different technologies which is very easy to implement for sustainable use. Field experiment was conducted to evaluate the impact of introduction a basket of GAP and farmers current production practice and to assess about potential adoption of component technologies in a GAP basket. Five rice producing villages and 4 farmers in each village were selected and the GAP components were implemented on a total of 20 farmers' field. To introduce a new basket, farmer's received inputs (Fertilizer, improved rice variety seeds) and GAP component contains improved rice variety (Ediget), land preparation, nutrient management, optimum seed density, timing of drainage, optimum harvesting time applied on 200m2 area land. Conventional farmer's practice was compared with the GAP components and good adoption rate was observed. Seven GAP components were highly feasible and selected for future use. Filled grain weight was not significantly affected by location. Dead heart disease was highly observed at heading stage where as sheath rot disease infestation was sever at harvest. However, components were highly compatible with current farmer's practice for sustainable use. GAPs are principles and codes of practice that promote the achievement in sustainable production of rice and improves food safety and quality for rice producing farmers.*

Keywords: *GAP component, Crop establishment, Compatibility, Productivity*

1. Introduction

Rice belongs to the family of Gramineae and the genus Oryza. Oryzae contains about 20 different species of which only two are cultivated: *Oryza sativa* L. (Asian rice) and Oryza *glaberrima Steud*. (Africa rice). (Matsuo et al, 1995). Greater than 3.5 billion people worldwide relied on rice food. Rice is one of the key crops in Africa as the evident from the continent's largest consumption growth rate in the world. In developing countries, approximately 60 % of total calories consumed are derived directly from cereals with values exceeding 80 % in the poorest countries (Awika Jm et al, 2011). A rice value chain study is indicating that a better understanding of the market, improved timeliness of operations, and better crop management have the potential to double returns to farmers and thus reduce the import bill by increasing productivity (Rosemary et al., 2010).

Production technology for rice in the world is advancing (Shoichi Ito,2019). Maintenance of native soil fertility intensively cultivated regions of the country is the preconditions of maintaining and improving the current crop yield levels. The basic principle of maintaining the fertility status of a soil under high intensity crop production system is to annually replenish nutrients that are removed from the field and proper agronomic management practices. Sustainable farm practices and the proper farm management represent the answer to all challenges of rice production.

In Ethiopia, rice is grown under three ecologies; irrigated, rain-fed lowland and upland ecologies with the production area coverage of about 10,000 ha in 2006 has increased to over 63,000 ha in 2018 (CSA 2019). Appropriate technologies are emerging to boost the production and productivity sustainably. Suitable agronomic management practice application is an important management principle to improve soil fertility and production of rice (Maneesh et al. 2018). GAP is an agricultural system of certification for a specific procedure and implemented for sustainable use to attain food security by enhancing productivity. GAPs in rice production enhance the production to become safe and good quality food. These practices are usually environmentally safe and ensure that the final product is appropriately handled, stored, and transported (Sara et al., 2013). Science-based solutions such as the use of appropriate stress-tolerant varieties, matched with good agronomic or management practices, will double yield. GAP is a set of practices that address environmental, economic and social sustainability for on-farm processes (Takahiro & Sarah 2014). Growers who adopt good agricultural practices can go through a voluntary auditing process to verify that they follow the standards.

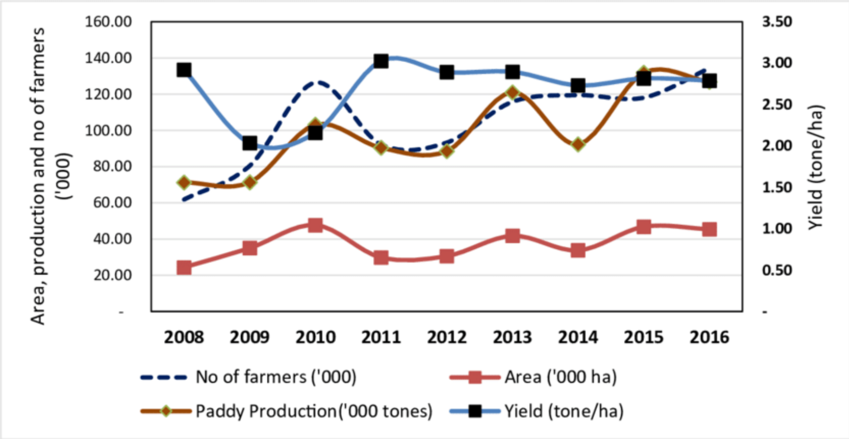


Fig1. *Trends of rice cultivation and production in Ethiopia (Hannington Odame et al., 2018).*

This is a quality assurance program for food safety that applied to the farm. The application of a certification system for agricultural production processes that use advanced, environmentally friendly, and sustainable technology (FAO 2015).

2. Materials and Methods

2.1. Description of the study area

Fogera area is the most well-known in Amhara region having high rice cultivation potential. Among the three rice producing districts (Fogera, Dera and Libokemkem) in the region, Fogera has huge rice production potential. In Fogera districts five villages and in each village, four farmers were selected to conduct the GAP technology. The area is located between 11^0 57' N and 12^0 30'N latitude and 37^0 35' E and 37^0 58'E longitude. The study area has a very flat land, which is known by Fogera plan, adjacent to the eastern coast of Lake Tana. The mean annual rainfall is 1430mm and mean monthly values varies between 0.6mm (January) and 415.8mm (July), which indicates poor temporal distribution of rainfall. The mean monthly temperature of the area is about 19^0C, monthly mean maximum temperature is about 27.3^0C, and monthly mean minimum temperature is 11.5^0C. Selected villages, to implement the GAP basket shown in map below in Fig.1.

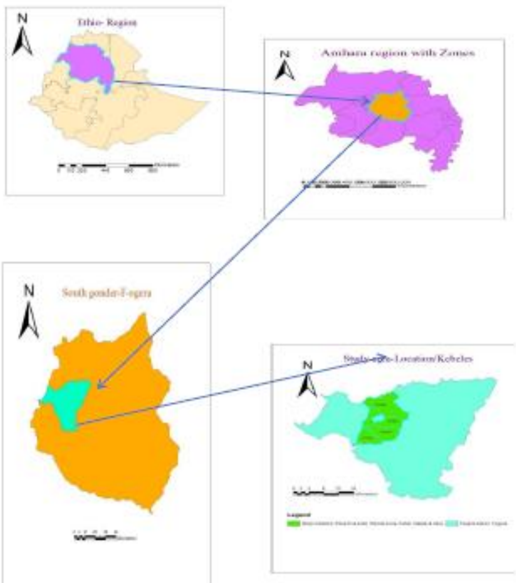


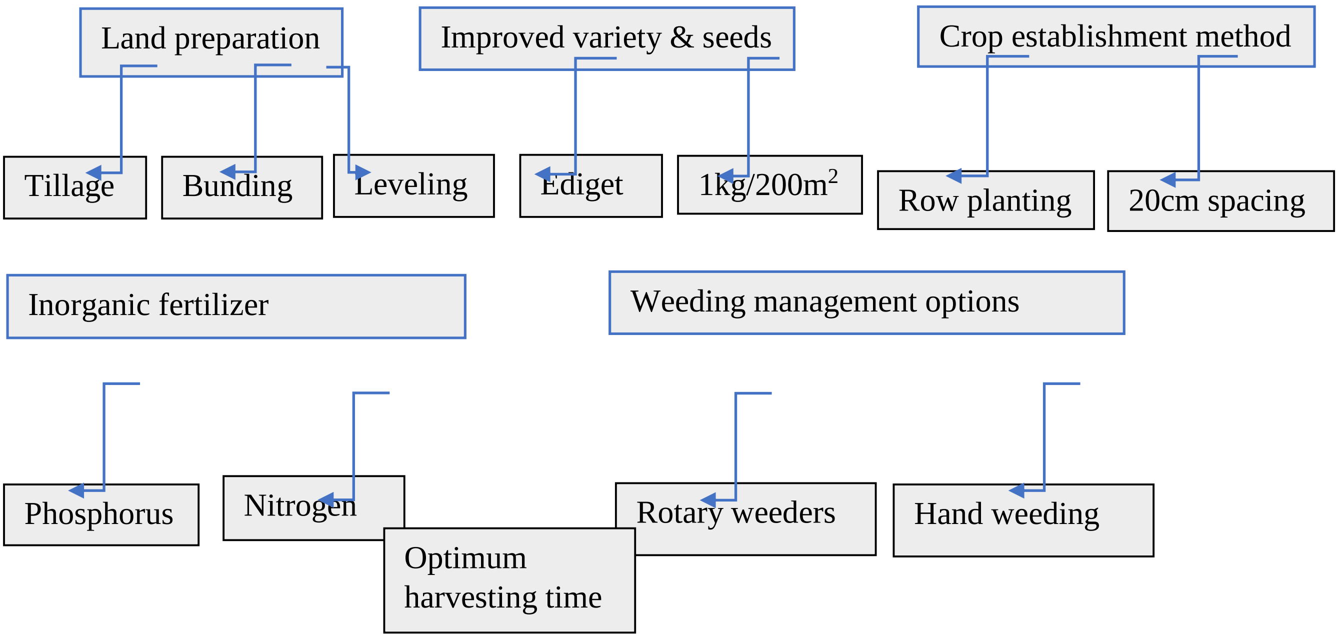
Fig2. *Location map of the study area where the GAP technology was implemented within Fogera district.*

2.2 Treatments, Design and GAP components management

A total of 20 on-farm trials were conducted during the main rice cropping season. GAPs in rice production comprised a package of technologies, these were improved variety, weeding and pest management, nutrient management, water management, and timely and proper harvesting. The experiment carried out on-farm field covering a plot size of 200m^2 on 5 villages. Relevant and easily implemented technologies preferred based on the farmers practice and the method of rice cultivation. Improved rice variety Ediget selected and 1kg/200m^2 area land received to farmers during planting time. In addition to improved rice variety Ediget, farmers also received 1kg DAP/200m^2 and urea fertilizer 2.609kg/200m^2 for the specified plot area. Total amount of DAP was applied once at planting and 2.609 kg/200m^2 urea applied as three split applications.

2.3 GAP Components

The prominent GAP technologies introduced were land preparation (Tillage, Bunding &Leveling), Improved variety and Seeds (Ediget variety and 1kg/200m^{2}seed), Crop establishment method (direct seeding and row planting at 20cm spacing), Inorganic fertilizer application (N and P_2O_5) recommended rate of P_2O_5 applied at planting, 1/3rd of N at planting, 1/3rd at panicle initiation and 1/3rd at heading), weeding management options (Rotary weeders & hand weeding). Farmers current practices, use of local rice varieties, un leveled and bunded field, broad cast crop establishment method, too much number of seed, only urea fertilizer applied once at tillering stage, manual (hand weeding).



After the component technologies and farmers selection, group training organized about improved land preparation and sowing methods, tillage, leveling & bunding. Different visiting's were conducted together with the selected farmers before and after land preparations, bunding, leveling and at different rice growth stages. However, the first visit was before land preparation, 2nd visit around sowing, 3rd visit around PI, 4th visit around heading and 5th visit at harvest for yield measurement conducted. Rice growth stages determined by crop establishment method and crop duration of a specific rice variety following the crop calendar. The farmers selected to implement the GAP technology, provided codes by village (01-020) as defined below in Table 1.

Table1. *List of farmers, codes and production system to implement GAP technology.*

Code	Village's name	Rice production system	Rice Variety	Seed source	Plot land
01	Kuhar Michael	Rain-fed lowland	Ediget	Researchers	200m^2
02	Kuhar Michael	Rain-fed lowland	Ediget	Researchers	200m^2
03	Kuhar Michael	Rain-fed lowland	Ediget	Researchers	200m^2
04	Kuhar Michael	Rain-fed lowland	Ediget	Researchers	200m^2
05	Kuhar Abo	Rain-fed lowland	Ediget	Researchers	200m^2

06	Kuhar Abo	Rain-fed lowland	Ediget	Researchers	200m^2
07	Kuhar Abo	Rain-fed lowland	Ediget	Researchers	200m^2
08	Kuhar Abo	Rain-fed lowland	Ediget	Researchers	200m^2
09	Woreta Zuria	Rain-fed lowland	Ediget	Researchers	200m^2
010	Woreta Zuria	Rain-fed lowland	Ediget	Researchers	200m^2
011	Woreta Zuria	Rain-fed lowland	Ediget	Researchers	200m^2
012	Woreta Zuria	Rain-fed lowland	Ediget	Researchers	200m^2
013	Tehuazana Kena	Rain-fed lowland	Ediget	Researchers	200m^2
014	Tehuazana Kena	Rain-fed lowland	Ediget	Researchers	200m^2
015	Tehuazana Kena	Rain-fed lowland	Ediget	Researchers	200m^2
016	Tehuazana Kena	Rain-fed lowland	Ediget	Researchers	200m^2
017	Abuana Kokit	Rain-fed lowland	Ediget	Researchers	200m^2
018	Abuana Kokit	Rain-fed lowland	Ediget	Researchers	200m^2
019	Abuana Kokit	Rain-fed lowland	Ediget	Researchers	200m^2
020	Abuana Kokit	Rain-fed lowland	Ediget	Researchers	200m^2

Data collection

Data were collected around/21 Days after sowing, around Panicle initiation (PI), Heading, harvesting and after harvesting to get feedback from farmers and the GAP adoption. Following the GAP protocol at different crop growth stages according to the cropping calendar. Score of leaf color chart, Visual score of the canopy cover, weed score above and below the canopy, Water or irrigation level, soil condition, hydrological level, disease and insect pest, shattering incidence, bird and rat damage, filled grain weight, moisture content data were recorded during the experimentation period.

Data analysis

Data analysis done by using the SPSS. Mean separation was done by using LSD at 5 % and 1% probability level.

3. RESULTS AND DISCUSSION

From demonstrations, farmers gained ample experience for sustainable use of GAP technologies. Ediget improved rice variety was not appropriate for their rice production and will not incorporate for further use. Implementing the technology be able to characterize all the components and pertinent components selected for sustainable production. Ediget rice variety, it was not performed well in a submerged water level, weak response for fertilizer, very weak weed competitiveness and cracked during milling. When the standing water level was increased the growth and vegetative performance of the variety becomes poor. Fertilizer 1kg /200m^2 of DAP (23kg/ha P_2O_5) and three splits of 2.609kg/200m^2 UREA (138kg/ha N) were applied but the response obtained from the variety was not good. Beyond the variety, the adoption of GAP technology was very good.

Land preparation and Crop establishment method

Visual observations and field visiting’s were conducted together with the farmers for the assessment of farmer’s practice and the GAP technology. The bunding and water conservation measures were good compared to the usual farmer’s practice. The field was tilled properly in terms of depth. The crop establishment method was direct seeding at 20cm spacing than 25-30cm conventional practice of farmers oxen ploughing and sowing was done following the crop calendar. Interview was made with farmers and N fertilizer was applied at basal and within three weeks as top-dressing.

Observation around/ after panicle initiation stage

After panicle initiation stage, visual score for rice canopy cover was above 60% of ground cover. However, the weed score above rice canopy was less than or equal to 10%. On the other hand, the weed score below rice canopy was less than or equal to 10%. During the study, the hydrological level was selected and it was ponded water. Soil related problems such as salinity or iron toxicity was recorded and not observed during the experimentation period. Level of insect pest and disease infestation was assessed at panicle initiation stage of rice and offered in Table 2.

Observation around /after heading stage

At the heading stages of rice, field observation was done and third application of N fertilizer application was not conducted. On the other hand, Chemicals against disease and insect pest was not applied. Off-types identification was conducted by the variation in heading date and the level of occurrence was low (less than or equal to 10%). Disease and insect pest frequency was chronicled and shown in Table 2.

Table2. *Weed, Disease, Insect pest and hydrological level frequency and percentage in different growth stages of rice*.

Parameters measured	Growth stages of rice: PI		Heading		At harvest	
Weed score above rice canopy	**Frequency**	**Percent**	**Frequency**	**Percent**	**Frequency**	**Percent**
No weeds	10	50%	8	40%	9	45%
Weed cover less than or equal to 10%	5	25%	7	35%	3	15%
Weed cover more than 10% and less than or equal to 30%	5	25%	1	5%	2	10%
Weed cover more than 30% and less than or equal to 60%			4	20%	5	25%
Weed cover more than 60%					1	5%
Weed score below rice canopy						
No weeds	1	5%			2	10%
Weed cover less than or equal to 10%	12	60%	7	35%	4	20%
Weed cover more than 10% and less than or equal to 30%	7	35%	9	45%	10	50%
Weed cover more than 30% and less than or equal to 60%			4	20%	4	20%
Dominant disease oberevd						
Absence	13	65%	4	20%	3	15%
Leaf blast	2	10%				
Brown spot	1	5%				
Narrow brown spot	1	5%				
Leaf scaled	3	15%				
Sheath rot			10	50%	12	60%
Others			6	30%	5	25%
Stress level of disease						
Minor	20	100%	18	90%	17	85%
Moderate			2	10%	3	15%
Dominant insect oberevd						
Abscence	7	35%	12	60%	12	60%
Deadhearts	12	60%				
Leaf beetles	1	5%				
White heads			7	35%	7	35%
Lepidoptoures leaf feeders			1	5%		
Others					1	5%
Stress level of Insect pest						
Minor	18	90%	17	85%	19	95%
Moderate	2	10%	2	10%	1	5%
Sever			1	5%		
Hydrological level						
Submerged	6	30%	2	10%		
Ponded	14	70%	12	60%		
Wet soil			6	30%		

Scores of Leaf Color Chart (LCC)

LCC provides guidance when to apply nitrogen fertilizer and how much quantity of N is to be applied to get better yield of rice. As the analysis of variance revealed that LCC was highly significantly ($P \leq 0.01$) affected between locations at heading stage but non-significant ($P \leq 0.05$) variations were chronicled around sowing and PI stage as presented in table 3. At the heading stage the highest LCC mean was recorded from Abuana Kokit (1.75) followed by Kuhar Michael (1.5) but similar results of LCC was found from Kuhar Abo, Woreta Zuria and Tehuazana Kena (1.0). Kuhar Abo two farmers field and Woreta Zuria were found similar results of LCC around /after heading stage of rice. However, LCC at PI stage was not shown significant difference between locations except code 03 and 04 at Kuhar Michael village. Furthermore, 21 days after sowing values of LCC were the same between locations.

Table3. *Means of LCC at different growth stages in the rice producing villages according to 11 GAP components.*

	LCC around sowing		LCC around PI		LCC around heading	
Village name	**Mean**	**STD**	**Means**	**STD**	**Means**	**STD**
Kuhar Michael	1.5	0.58	1.5	0.58	1.5	0.58
Kuhar Abo	1.92	0.63	2.2	0.9	1	0.13
Woreta Zuria	1.92	0.63	1.7	0.6	1	0.13
Tehuaza Kena	1.5	0.58	2.1	0.87	1	0.13
Abuana Kokit	1.89	0.61	2.5	1	1.75	0.5
LSD (0.05)	Ns		Ns		**	

5.5. Compatibility of GAP components

Of the 11 GAP components land preparation (tillage, bunding, leveling), Inorganic fertilizer (DAP & Urea), Weeding management options (hand weeding), Optimum harvesting time and 1kg/200m^2 seeds were perceived to be compatible with their current farming practices. However, Improved rice variety (Ediget), Crop establishment method (Row planting & 20cm spacing), Weeding management options (rotary weeder) farmer's perception on compatibility was low on these four component technologies of GAP.

5.6 Yield assessment

Yield assessment was evaluated at harvest and after harvest as it shown in Table 4 and Table 5. However, Off-types were identified by basal leaf sheath color before rice canopy closure, variation in plant height before or around flowering, variation in flowering (heading) date and grain size and color. The frequency was higher (9 of the 20) at heading stage and 14 of the 20 at harvest which accounts 45% and 75% respectively. Filled spikelets were identified by pressing the spikelets with finger and fertile spikelets (75-89%) were accounted 85% and highly field spikelets (>90%) covered 10%. However, partially filled spikelets (50-74%) were accounted 5%. Lodging was not observed with in all the experimental plots. However, the shattering incidence was recorded on one farmer's field which covered 5%. Rat damage was higher on one experimental plot field which was 5%, four farmer's field were accounted 20% and for fifteen farmers covered 75% was not observed.

Table4. *Assessment of yield related factors at heading and harvest stages.*

Parametrs measured	Growth stages of rice: Heading		At harvest	
	Frequency	Percent	Frequency	Percent
Off-types identified				
No off-types	5	25%	4	20%
Off-types less than or equals to 10% (low)	9	45%	14	70%
Off-types more than 10% and less than or equal to 30% (Moderate)	6	30%	2	10%
Bird Damage at harvest (No)			20	100%
Rat Damage at harvest				
No damage observed			15	75%
Less than or equals to 5%			4	20%
6-25%			1	5%
Fertile spikeletes identifed by pressing the spikeletes with finger				
Highly fertile(>90%)			2	10%
Fertile (75-89%)			17	85%
Partly sterile (50-74%)			1	5%
Percentage of plants lodged at harvest				
<25%			20	100%
Shatering incidence				
Yes			1	5%
No			19	95%

The analysis of variance revealed that filled grain weight was not affected by locations. Similarly, moisture content was attained non-significant variation between locations as it presented in Table 5.

Table5. *Mean comparisons of filled grain weight and Moisture content of rice*

	Filled Grain Weight (kg/200m^2)		Moisture content (%)	
Village name	**Means**	**STD**	**Means**	**STD**
Kuhar Michael	4.24	0.93	17.82	0.87
Kuhar Abo	3.09	0.61	17.87	2.29
Woreta Zuria	2.98	0.64	16.44	1.16
Tehuaza Kena	3.7	0.74	16.51	0.85
Abuana Kokit	3.87	1.23	18.58	1.39
LSD (0.05)	Ns		Ns	

.Adoption of GAP components

The majority of GAP components were highly feasible and adopted for further use by incorporating with their conventional practices. After harvesting time, interview was made to get farmers feedback and adoption. Those farmers who were implemented the GAP components delivered their perspective and adoption rate to use it in the future as described in Fig.3 below.

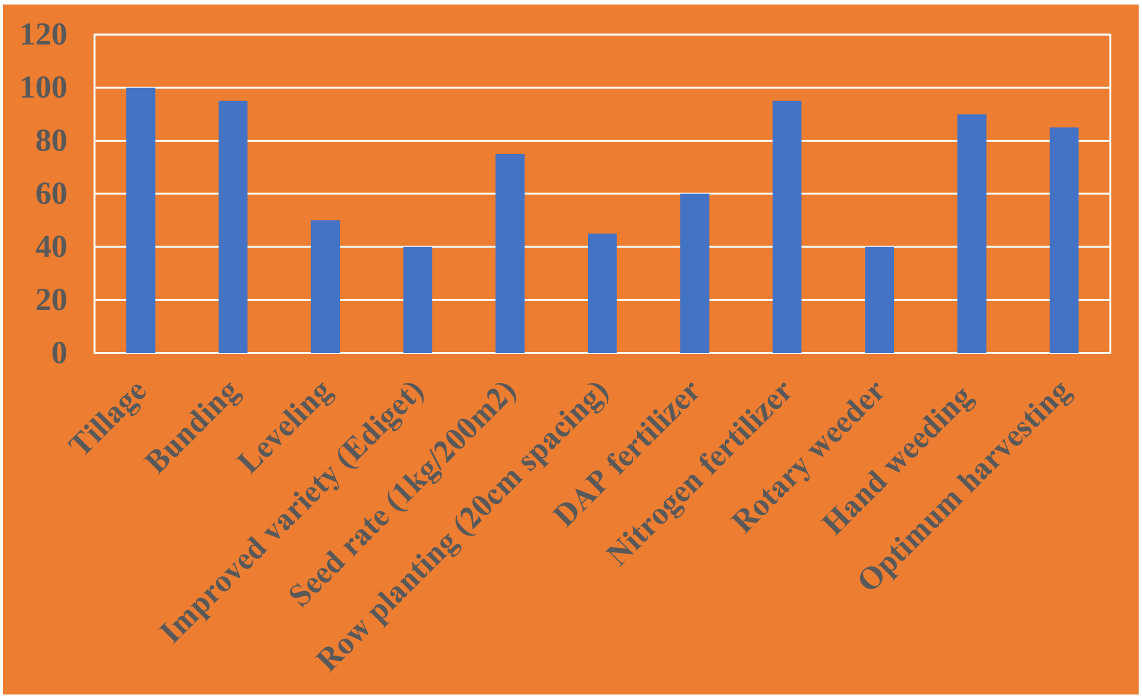


Fig3. *Adoption rate of GAP implemented farmers in percentage after harvesting*.

4. Conclusions and Recommendation

The national average yield of rice in Ethiopia is about 2.8 t ha-1, which is lower compared to the world average productivity of 4.6 tones ha-1. Land preparation, crop establishment methods, soil nutrient deficiencies, fertilizer application time and doze and occurrence of disease are among the major causes of low productivity of rice. Based on the results of the present study 7 GAP components are highly compatible for sustainable use and recommended for rainfed low land rice production in the study area. GAPs are principles and codes of practice that promote the achievement in sustainable production of rice and improves food safety and quality for rice producing farmers. Extreme interest to apply the GAP components perceived from farmers for sustainably use and to advance their knowledge and enhance the production of rice.

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