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Participatory upland rice (*Oryza sativa* L.*)* seed rate determination for row method of sowing under irrigated eco-system

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A field experiment was conducted in 2013 cropping season at Bedloale and Werer sites in Amibara district, Afar Regional State, to determine optimum seeding rate for row method of sowing for productivity of rice (*Oryza sativa* L.) under irrigated ecosystem. The experiment was conducted with five levels of seed rate treatments (50, 60, 70, and 80 kg ha^{-1} and local practice) laid out in a randomized complete block design (RCBD) with three replications. The results of agronomic analysis showed that there was no statistical difference for all parameters at Bedolale site. However, at Werer site total number of tillers per plant, number of productive tillers per plant, total biomass and grain yield were significantly affected by seed rate. Compared to the control, 50 and 60 kgha^{-1} seed rates have shown a grain yield and superior performance in total biomass yield advantage. Moreover, the partial budgeting analysis results showed that sowing of 60 kg ha^{-1} NERICA-4 seed yielded positive gross margin at Werer site. While at Bedolale site, the two least cost treatments, that is, 50 and 60 kg ha^{-1} could be economically viable. In general, from the results of this study, it can be concluded that 60 kg ha^{-1} drilling is optimum seed rate for row method of sowing.

Key words: Seed rate, rice productivity, NERICA-4, sowing method, row planting.

INTRODUCTION

Rice (*Oryza sativa* L.) is an important staple food and grown across the world. It is the second most widely consumed cereal in the world next to wheat (Kumari et al., 2014). Rice is becoming increasingly popular in Africa with about 16 million metric tons of annual consumption and 14 million tons of production, creating a deficit of 2 million metric tons, which is filled by imports (Somado et al., 2008).

Introduction of the crop dates back to recent decades; evidences have indicated that cultivation of the crop in

Ethiopia was first started at Fogera and Gambella plains in the early 1970s (MoARD, 2005). In Ethiopia, research in rice was started informally by Tana Beles project and by the Koreans who were in Ethiopia for a different mission. Nowadays, production of rice is expanding as the hot to warm moist climates are potentially suitable for rice culture as they fulfill all the requirements of the crop and produced mainly by small scale farmers in many parts of the country and with large scale farmers in few places (MoARD, 2010).

Low land areas of Ethiopia are dominantly settled by pastoral or agro-pastoral peoples who are seasonally moving in search of pasture and water for their animals. Recently, the government of Afar implemented permanent settlement program for agro-pastoralists. This program is benefiting agro-pastoralists who are just starting crop production. Rice is the staple food for Afar peoples and one of the potential crops suitably grown in the region. Although the crop is staple food for the people of the region, almost all the consumption demand is fulfilled by buying rice like other consumption goods, rather than satisfying their demand via cultivating the crop. However, now a day's agro-pastoralist has started production of the crop due to the opportunities that have been created by the state government settlement program.

Soil nutrient application rates, schedule of nitrogen fertilizer application, irrigation amount and scheduling, seeding rate and planting methods are among the major agronomic practices, which limit rice productivity and production. Seeding rate is one of most important agronomic aspect which need due attention. When the plant density exceeds an optimum level, competition among plants for light above ground and nutrients below ground becomes severe (Baloch et al., 2002). Consequently, plant growth slows down and the grain yield decreases. However, very low plant density may not enable to attain the yield plateau.

Given to the fact that rice is a recently cultivated crop in Ethiopia, to the best of our knowledge, very few studies so far have been conducted with regard to optimum cultural practices' determination for the rice producing areas of Afar region particularly in Amibara Woreda. This urges that a lot has to be done on rice agronomic experiments so as to have appropriate rice crop management recommendations.

This research was therefore, initiated to elucidate the effect of seeding rate on rice yield and yield components for row method of sowing under irrigated condition with reasonable economic return to be recommended and disseminated to farmers.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted on farmer's field and on-station (Werer) during the main cropping season at Werer and Bedolale Kebeles in Amibara district of Afar Region, Ethiopia. Geographically, the experimental site was located at 09° 60' N latitude and 40° 09' E longitude and at an elevation of 740 m.a.s.l. The total rain fall during 2013 cropping season was 516.3 mm. The major portion of the total annual rainfall was received between July and October. The total rainfall received between these months in the 2013 cropping season was 306.8 mm which was 59.42% of the total rainfall in the year. The average yearly minimum and maximum temperatures were 31.2 and 39.4°C, respectively. The annual evapotranspiration (2796.9 mm) of the area was much more exceeded than annual rain fall (516.3 mm) which resulted 2280.6 mm deficit (Table 1) owing to this the area is fully irrigated. The soil of the experimental site was Vertisol. The map of the Woreda where the experimental sites was located is as shown in Figure 1.

Soil sampling, preparation and analysis

Composite soil sample per replication, each made from three sub-samples was collected in a diagonal pattern from 0 to 30 cm soil depth for Werer site. Likewise, in the same manner three sub-samples from each replication for each treatment was collected and composited into one sample per treatment for Bedolale site before planting to assess physico-chemical properties of the soil under study. Uniform slices and volumes of soils were obtained in each sub-sample by vertical insertion of an auger. The samples were air-dried, ground to pass through a 2 mm sieve, except for analysis of organic carbon and nitrogen, where the samples were passed through 0.5 mm sieve. Working samples were obtained from each submitted samples and analyzed for selected physico-chemical properties such as texture, soil pH, EC, organic carbon, total N, available phosphorus, and available potassium using standard laboratory procedures.

Total N in the soil was determined by the Kjeldahl method (Dewis and Freitas, 1975). Organic carbon content of the soil was determined by reduction of potassium dichromate by organic carbon compound and determined by reduction of potassium dichromate by oxidation reduction titration with ferrous ammonium sulfate (Walkley and Black, 1934). The organic matter was calculated by multiplying the organic carbon using the factor 1.724. Particle size distribution (texture) was determined by hydrometer method (differential settling within a water column) using particles less than 2 mm diameter (FAO, 2008). This procedure measures percentage of sand (0.05 - 2.0 mm), silt (0.002 - 0.05 mm) and clay (<0.002 mm) fractions in soils. Available P was determined following the method of Olsen and Dean (1965). The pH of the soil was measured in 1:2.5 (weight/volume) soil samples to $CaCl_2$ solution ratio using a glass electrode attached to digital pH meter (Page et al., 1982). The soil analysis was carried out by soil and water laboratory of Werer Agricultural Research Center.

Treatments and experimental details

A participatory trial was conducted in one selected agro pastoralist field at Bedloale Kebele and Werer experimental site in Amibara district. As to the team formation three (Farmer's Research Groups, FRGs) were formed and training was organized on FRG concept and rice production techniques for FRG member agro-pastoralists.

Four seeding rates (50, 60, 70, and 80 kgha[-1]) and one control (60 kgha[-1] broadcasting/local practice) was laid out in a randomized complete block design (RCBD) with three replications using a total plot size of 20 m[2] (4 m width and 5 m length) with a spacing of 2 m and 3.6 between plots and blocks, respectively and no spacing between plants (drilling). NERICA-4 variety of rice was used as a

Table 1. Average rainfall, average temperature, evapotranspiration and relative humidity for the year 2013.

| Month	R.F. (mm)	Temperature (°C)		R.H. (%)	Evap. (mm)
		Min.	Max.		
January	14.5	12.7	32.5	52	199.9
February	3.4	16.4	34.2	37	223.5
March	85.7	21.4	36.4	49	251.2
April	79.2	22.7	36.8	50	228.2
May	8.1	23.8	38.0	43	277.5
June	9.5	26.4	39.4	37	313.3
July	161.9	22.0	34.8	58	212.4
August	75.1	22.3	33.7	63	192.1
September	22.6	22.3	35.4	55	212.9
October	47.2	19.6	34.4	50	282.9
November	9.1	17.6	32.6	56	222.6
December	0.0	13.3	31.2	49	180.5
Total	516.3				2796.9
Mean	43.0	20.0	35.0	49.9	233.1
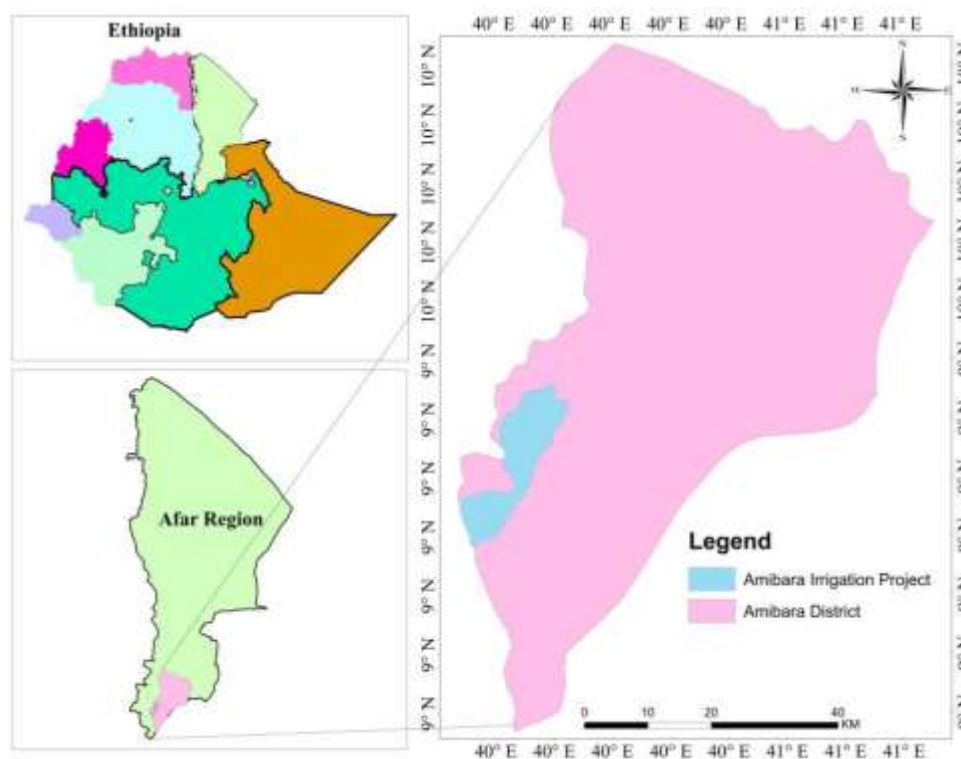
Figure 1. Geographical map of the study sites.

test crop. Each plot received uniform doses of 100 kgha^{-1} Urea and 50 kgha^{-1} di-ammonium phosphate (DAP) fertilizers. Urea was applied in two equal splits, at tillering and at panicle initiation stage; whereas full dose of DAP was applied at sowing. As to the seeding rate, it was used as per the treatment. Besides, necessary compensations were made to the seed rate amount based on the germination rate obtained by the germination test conducted before sowing. All necessary management was carried out as per the

Table 2. Selected chemical properties of the experimental soil.

Seed rates (kgha⁻¹)	Bedloale site					
	pH	EC_e (ds/m)	%OC	%OM	%TN	AP (ppm)
50 (drilling)	8.3	0.402	0.397	0.684	0.034	8.280
60 (drilling)	8.3	0.505	0.494	0.852	0.043	9.655
70 (drilling)	8.4	0.394	0.462	0.796	0.040	8.155
80 (drilling)	8.4	0.408	0.631	1.087	0.054	10.405
60 (broadcasting)	8.4	0.457	0.585	1.009	0.050	8.280
	Werer site					
50 (drilling)	8.3	0.463	0.254	0.437	0.022	17.279
60 (drilling)	8.4	0.409	0.306	0.527	0.026	14.655
70 (drilling)	8.4	0.439	0.273	0.471	0.024	14.030
80 (drilling)	8.5	0.512	0.137	0.235	0.012	21.841
60 (broadcasting)	8.4	0.502	0.338	0.583	0.029	18.311

EC_e=Electrical conductivity, OC=Organic carbon, OM=Organic matter, NT=Total Nitrogen, AP=Available Phosphorus.

research recommendations. Eventually, field visit at Bedloale and Werer sites was organized to show the experience of the team (FRGs).

Data collection

At maturity, number of tillers (productive and total), panicle length and plant height was taken per plant basis from randomly selected six plants. While biomass yield and grain yield were taken per plot base and then converted in to per hectare basis. Grain yield was adjusted to 12% moisture content and biomass yield/ha was determined after sun drying to bring moisture content to near minimum level. Exceptionally, for broadcasting/control 1 m × 1 m quadrat was used for biomass and grain yield determination. However, for row method of sowing a dimension of 2.4 m length and 3 m width (7.2 m²) was considered as net harvested plot size. Thousand-grain weight was recorded by counting 1000 grains of representative seeds samples collected from each plot. It was also adjusted to 12% moisture content and weighed using an electronic balance.

Economic analysis

The economic analysis of an on-farm experiment begins with partial budget analysis[1]. This partial budget analysis was conducted to find out which seeding rate is economically feasible (Table 5). Dominance analysis was carried out to eliminate treatment which was not considered by agro-pastoralists' (Table 6). Moreover, marginal analysis was performed to consider the increase costs

[1] Partial budgeting is a method of organizing experimental data and information about the costs and benefits of various alternative treatments. In partial budgeting only those costs that are affected by the alternative treatments are being considered and not all production costs are included. In this instance costs which vary among treatments are seed and weeding costs. Therefore, seed and weeding cost for the control and seed cost for the rest treatments were considered as a variable cost for the analysis. Tables 5 and 6 are the steps involved in partial budgeting analysis. For interpretation, marginal rate of return (Table 7) is considered.

(Table 7). Although the calculation of net benefits accounts for the costs that vary, it was necessary to compare the extra (or marginal) costs with extra (or marginal) net benefits. Higher net benefits may not be attractive if it requires very much high costs.

Statistical analysis

Analysis of variance (ANOVA) was performed using SAS software version 9.1 (SAS Institute, 2004). Fisher's least significant difference (LSD) test at 5% probability was used for mean separation (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Physical and chemical properties of the experimental soil

The result of the physical and chemical properties of the soil of the study sites is presented in Table 2. The soil used for the experiment was silt clay loam and clay in texture for Bedolale and Werer sites, respectively. Soil pH of the Bedolale site was 8.3 to 8.4, which is moderately alkaline according to Jones (2002). However, the Werer site had pH which ranges from moderately alkaline to strongly alkaline (8.3-8.5) (Ibid.). The electrical conductivity values of saturation extract have ECe value ranging from 0.394 to 0.512 dS m⁻¹, these values can be rated as normal since it is less than 4 dS m⁻¹ for both locations. The organic carbon content of the soil ranges from 0.397 to 0.631%, which is low in accordance with Landon (1991) at Bedolale site. Likewise for the Werer site which it ranges from 0.254 to 0.338%. Also, organic matter contents of the experimental sites ranges from very-low to low for both sites in accordance with Tadesse (1991). Total nitrogen of the present soil was low (<0.05%)

Table 3. Effect of seeding rate on yield and yield components of upland rice variety NERICA-4 at Bedolale, 2013.

Seed rates (kgha^{-1})	TNTPP	NPTPP	PL (cm)	PH (cm)	BY (tha^{-1})	GY (kgha^{-1})	TSW (g)
50 (drilling)	7.3	6.7	20.3	91.1	17.4	4415.0	25.3
60 (drilling)	7.4	6.9	20.4	88.2	17.8	4434.1	25.5
70 (drilling)	6.0	5.9	20.7	87.8	18.0	4293.5	25.4
80 (drilling)	6.8	6.5	18.5	84.3	16.4	3774.3	24.8
60(broadcasting)	5.7	5.5	20.3	88.8	15.7	3793.9	24.3
LSD (0.05)	ns	ns	ns	ns	ns	ns	ns
CV (%)	22.8	23.0	7.5	5.6	13.3	14.3	2.1

ns = Not significant, TNTPP = total number of tillers per plant, NPTPP = number of productive tillers per plant, PL = panicle length, PH = plant height, BY = biomass yield, GY = grain yield, TSW = thousand seed weight.

Table 4. Effect of seeding rate on yield and yield components of upland rice variety NERICA-4 at Werer, 2013.

Seed rates (kgha^{-1})	TNTPP number of tillers/plant	NPTPP	PL (cm)	PH (cm)	BY (tha^{-1}) Yield tha^{-1}	GY (kgha^{-1}) (yield kgha^{-1})	TSW (g)
50 (drilling)	6.0^{ab}	5.3^{ab}	18.5	68.2	12.7^{a}	2739.3^{a}	24.1
60 (drilling)	6.6^{a}	6.0^{a}	19.3	70.3	13.1^{a}	2960.6^{a}	23.7
70 (drilling)	5.4^{bc}	4.9^{abc}	18.1	69.8	11.8^{ab}	2650.4^{ab}	23.5
80 (drilling)	4.7^{c}	4.1^{c}	17.5	65.2	9.7^{c}	2156.1^{b}	23.5
60 (broadcasting) control	4.9^{bc}	4.3^{bc}	18.6	63.0	10.2^{bc}	2152.1^{b}	23.2
LSD (0.05)	1.1	1.2	ns	ns	1.9	527.6	ns
F-probability	*	*	-	-	*	*	
CV (%)	11.3	12.9	5.5	5.3	9.3	11.5	1.4

*, **, *** significant at P ≤ 0.05, p ≤ 0.01 and p ≤ 0.001 probability levels, respectively; ns= not significant. Means in a column followed by the same letters are not significantly different at p > 5% level of significance.

for Werer site and it ranges from low to medium (0.034-0.054%) for Bedolale site according to Tekalign (1991). Regarding on available P, it was medium (10 - 25 ppm) for Werer site and ranges from low to medium (8.155 - 10.405 ppm) for Bedolale site based on the classification (Horneck et al., 2011). This indicated that P is limiting nutrient for optimum crop growth and yield in the experimental sites. In general, the properties of the experimental soil in both sites were conducive, albeit there was an evidence suggesting replenishment of nutrients such as nitrogen and phosphorus for proper growth of the crop.

Bedloale site

The analysis of variance exhibited that seed rate had brought no significant effect on all parameters considered in this study (Table 3). None of the parameters were significantly (P > 0.05) affected by seeding rate implying the treatments considered in this particular site was not high enough to encounter yield loss due to competition of above and below ground resources. In addition, compared

to other row sown treatments, broadcasted control has given statistically similar result which is difficult to justify. Therefore, based on the result, we recommended 50 kg ha^{-1} seeding rate since it permit to save unnecessary usage of extra seeds.

Werer site

The yield components and other parameters, viz. panicle length, plant height and thousand grain weight were not significantly (P > 0.05) influenced by seed rate (Table 4). Since the result obtained from aforementioned parameters was non-significant, thus it is not logical to compare such figures because the analysis of variance revealed statistically non-significant difference among the treatments considered in this study.

Total and productive tillers per plant

In this study, total number of tillers and productive tillers (Table 4). Higher total number of tiller per plant was

Table 5. Calculation of partial budget.

Site		Seeding rates (kgha⁻¹)				
		50 kgha⁻¹ Drilling	60 kgha⁻¹ Drilling	70 kgha⁻¹ Drilling	80 kgha⁻¹ Drilling	60 kgha⁻¹ (Broadcasting)
Bedolale site	AY (kgha⁻¹)	4415.00	4434.10	4293.50	3774.30	3793.90
	AY* (kgha⁻¹)	3752.75	3768.99	3649.48	3208.16	3224.80
	GB (ETB ha⁻¹)	37,527.50	37,689.85	36,494.75	32,081.55	32,248.15
	CS (ETB ha⁻¹)	600.00	720.00	840.00	960.00	720.00
	WC (ETB ha⁻¹)	-	-	-	-	200.00
	TVC (ETB ha⁻¹)	600.00	720.00	840.00	960.00	920.00
	NB (ETB ha⁻¹)	36,927.50	36,969.85	35,654.75	31,121.55	31,328.15
Werer site	AY (kgha⁻¹)	2739.3	2960.6	2650.4	2156.1	2152.1
	AY* (kgha⁻¹)	2328.92	2516.51	2252.84	1832.69	1829.29
	GB (ETB ha⁻¹)	23289.15	25165.10	22528.40	18326.85	18292.85
	CS (ETB ha⁻¹)	600.00	720.00	840.00	960.00	720.00
	WC (ETB ha⁻¹)	-	-	-	-	180.00
	TVC (ETB ha⁻¹)	600.00	720.00	840.00	960.00	900.00
	NB (ETB ha⁻¹)	22689.15	24445.15	21688.40	17366.85	17392.85

Costs other than seed cost were kept constant because of an assumption that all treatments received the same management practices except 60 kg ha⁻¹ broadcasted which had incurred additional 200 and 180 Birr ha⁻¹ for weeding (labor cost) for Bedolale and Werer site, respectively. CS: Seed cost is 1200 Birr/100kg; Grain price is 1000 Birr/100kg; GB=gross benefit without deduction of costs; VC=variable cost/costs that vary; TVC=Total variable cost; NB=net benefit = GB-TC; AY=average yield; AY*=adjusted yield, 15% is adjusted for analysis (literature recommends 5-30%). All the monitory value were stated in Ethiopian birr (ETB)

obtained from 60 kg ha⁻¹ seeding rate which was drilled while the lowest was observed from 60 kg ha⁻¹ broadcasted (control). Compared to the control seeding rate other than, 60 kg ha⁻¹ which was drilled was statistically at par with the control. Likewise, number of productive tillers per plant was consistent with the total number of tillers. Thus, the higher number of productive tillers was recorded from 60 kg ha⁻¹ seed rate which was drilled whereas the lowest was observed from 60 kg ha⁻¹ seed rate which was broadcasted (control). Total number of tillers per plant and number of productive tillers per plant from 60 kg ha⁻¹ seed rate found to be increased by 34.69 and 39.53%, respectively compared with the control.

Among yield components, productive tillers are very important because the final yield is mainly a function of the number of panicles bearing tillers per unit area and number of grains per panicle (Chatterjee and Maiti, 1985). In this trial, maximum number of tillers per plant and productive tillers per plant were achieved from 60 kg ha⁻¹ seed rate which was row sown. Concomitant with the present finding, Angassa (2017) had reported higher total and productive number tillers per plant from using lower (40 kg ha⁻¹) seed rate compared to higher seed rate under irrigated condition. On the other hand, Tekle and Wedajo (2014) had reported higher total number of tillers and productive tillers from using 100 kg ha⁻¹ seed rate under rainfed condition.

Biomass yield (t ha⁻¹)

Statistical analysis of data showed significant difference ($P \leq 0.05$) due to the effect of seed rate on biomass yield of rice (Table 4). Significantly, the highest biomass was observed from 60 kg ha⁻¹ seed rate followed by 50 kg ha⁻¹ seed rate while the lowest biomass yield was observed from 80 kg ha⁻¹ seed rate. Lower seeding rate (50 and 60 kg ha⁻¹) gave higher biomass yield. Comparatively, lower seeding rate have shown superior performance over higher seed rate and the broadcasted control. Lower seed rates (50 and 60 kg ha⁻¹) have 24.51 and 28.43% biomass yield advantage, respectively, over the control. Concurrent with the result of this study, Angassa (2017) had reported higher biomass yield with lower seeding rates (40 and 60 kg ha⁻¹). In addition, it has been reported that biomass yield was found to decrease as seed rate increase beyond 60 kg ha⁻¹.

Grain yield (kg ha⁻¹)

The result indicated that seeding rate had significant ($P \leq 0.05$) effect on grain yield of rice (Table 4). Maximum yield was obtained from lower seeding rates (50 and 60 kg ha⁻¹) which were not statistically different. The lowest grain yield was observed from 60 kg ha⁻¹ broadcasted

Table 6. Dominance analysis.

Seeding rates (kgha^{-1})	Bedolale site		Werer site	
	TVC (ETB)	NB (ETB)	TVC (ETB)	NB (ETB)
50 kgha^{-1} drilling	600.00	36,927.50	600.00	22689.15
60 kgha^{-1} drilling	720.00	36,969.85	720.00	24445.15
70 kgha^{-1} drilling	840.00	35,654.75	840.00	21688.40
80 kgha^{-1} drilling	960.00	31,121.55*	960.00	17366.85*
60 kgha^{-1} (broadcasted)	920.00	31,328.15	900.00	17392.85

*The dominated treatment that was eliminated. VC is variable costs that are considered (the seed costs that vary only keeping other production costs constant)

Table 7. Marginal analysis.

Seed rates kgha^{-1}	TVC	MC	NB	MNB	MRT
Bedolale site					
50 kgha^{-1} drilling	600.00	-	36927.50	-	-
60 kgha^{-1} drilling	720.00	120	36969.85	42.35	0.3529
70 kgha^{-1} drilling	840.00	120	35654.75	-1315.1	-10.9591
60 kgha^{-1} (broadcasting)	920.00	80	31,328.15	-4326.6	-54.0825
Werer site					
50 kgha^{-1} drilling	600.00	-	22689.15	-	-
60 kgha^{-1} drilling	720.00	120	24445.10	1755.95	14.63
70 kgha^{-1} drilling	840.00	120	21688.40	-2756.70	-22.97
60 kgha^{-1} (broadcasting)	900.00	60	17392.85	-4295.55	-71.59

MC=Marginal cost (ETB); NB=net benefit (ETB); MNB=marginal net benefit (ETB); MRT=marginal rate of return (ETB).

(control). The lower seeding rate 50 and 60 kg ha-1 which was drilled have shown superior performance over the control with 27.28 and 37.57% yield advantage, respectively. The result is in agreement with findings of Angassa (2017) who reported higher grain yield with lower seeding rates (40 and 60 kg ha^{-1}).

Result of economic analysis

Bedolale site

The agronomic data evaluation and the statistical analysis result of this particular on-farm experiment reveal that there is no yield difference among treatments. The yield differences between different seed rate treatments [50, 60, 70, 80 and 60 kg ha^{-1} (broadcasted)] were statistically non-significant. It is needless to show the economic analysis of such statistically non-significant treatments, rather it is advisable to consider the least cost treatment. However, for this experiment though the treatments are non-significant there is still a room to have

a positive return of using either of the two least cost treatments. Sowing of 60 kg ha^{-1} NERICA-4 seed yielded 35% profit (if Agro-pastoralists incur 1 birr they will cover their 1 birr and got additional 35 cents profit). Therefore, it is up to the agro-pastoralists to choose among the two least cost treatments, that is, 50 and 60 kg ha^{-1}.

Werer site

As revealed by statistical result, grain yield was significantly affected by different seed rate. Sowing of 60 kg ha^{-1} NERICA-4 seed resulted in positive return. Besides, using of seeding rate which exceed 60 kg ha^{-1} was encountered loss. In fact, still it is up to the agro-pastoralist to choose between two least cost treatments. Nonetheless, from economic point of view it would be better if they made a choice of 60 kg ha^{-1} which was drilled, since using of 60 kg ha^{-1} seed rate yielded 1463% profit (if agro-pastoralists incur 1 birr they will cover their 1 birr and got additional 14.63 birr profit), which is far above the acceptable level (Table 7). Therefore, it is advisable to use 60 kg ha^{-1} seed rate at Werer site.

Conclusion

This experiment follows a participatory approach by which agro-pastoralists were involved from problem identification to final decision of the research output. Thus, the recommendations to be made are farmer oriented. Farmers' and/or agro-pastoralists' assessments have been carried out to gain their opinions about the treatments they have seen in their fields. Besides, agronomic evaluation and statistical data analysis have also been done ahead of economic analysis.

Statistical analysis declared yield difference among the seed rate for Werer site whereas at Bedolale site no yield difference was observed. Economic analysis dictated that using of 60 kg ha^{-1} yielded profit compared to other seed rate considered at Werer site. However, for Bedolale site, since the test was non-significant, it was needless to show economic analysis for such result. Hence, it is up to agro-pastoralists to choose between the two least cost treatments (50 and 60 kg ha^{-1}). Therefore, based on the choice of the agro-pastoralist's, statistical and economic analysis, it can be concluded that the seed rate of 60 kg ha^{-1} is advisable and could be appropriate for rice production in the test area even though further testing is required to put the recommendation on a strong basis.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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