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Effect of Seed Rate and Row Spacing on Yield and Yield Component of Rainfed Lowland Rice Variety (Ediget) at Assosa, Western Ethiopia

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Abstract: Rice is one the newly introduced crop in western Ethiopia (Assosa). However, the yield is far below its genetic potential. Lack of proper management practice on seed rates and row spacing are one of the problems limiting. Field experiment was conducted to investigate the effect of seed rate and row spacing on yield and its traits of lowland rice The treatment consisted of seven levels of seed rate (40, 60, 80, 100, 120, 140, and 160 kg ha^{-1}) and four levels of row spacing (15, 20, 25, 30cm). The experiment was laid out as a Randomized Complete Block Design in a factorial arrangement and replicated three times. From the analysis of variance, all the parameters except filled grain were not significantly affected by seed rate and row spacing. The maximum plant height (90.38cm) was observed at seed rate of 40 kg ha^{-1} and the lowest was observed at seed rate of 160 kg ha^{-1}. The highest panicle length (16.77cm), tiller per plant (3.37) and filled grain (86.93) was observed at seed rate of 40 kg ha^{-1}. Filled grain was highly significant and the highest filled grain was observed at 40 kg ha^{-1} (86.93) and at 15cm spacing (70.07). The highest grain yield (3.93 t ha^{-1}) was obtained at a seed rate of 60 kg ha^{-1} and 20cm row spacing. The economic analysis indicated that a seed rate of 60 kg ha^{-1} and row spacing of 20cm is the most profitable treatment with mean net benefit of 86,110 Birrha^{-1}. Therefore it can be concluded that a seed rate of 60 kg/ha and row spacing of 20cm is preferable and recommended for rain fed lowland rice production areas in the study areas.

Keywords: Rice, Edigat, Row Spacing, Seed Rate, Yield, Yield Component

1. Introduction

In Ethiopia rice is a recently introduced crop and its area and production have been increasing. Ethiopia has a huge potential in both rain-fed and irrigated areas for rice production, which is, estimated about thirty million ha [1, 2]. From this 3.7 million hectare of land are suitable for irrigation. In the farming systems of the country, the production area of rice were lower than other cereals (teff, sorghum, maize and wheat) [3]. According to [4], rice is the second among cereals in terms of average national yield (2.8 t ha^{-1}) next to maize (3.7 t ha^{-1}).

Benishangul-Gumuz Regional State (BGRS) is one of the potential regions in Ethiopia with ample rainfall i.e. for six months and conducive environment which are suitable for rice production. It is estimated to be 4.9 million hectare of land is potential for rice production [1]. About two million hectare is highly suitable and the rests are suitable and moderately suitable both for upland and low land rice ecosystems. But the region could not use this immense potential to secure food security due to some problems.

Production of rice depends on several factors: climate, physical conditions of the soil, soil fertility, water management, sowing date, cultivar, seed rate, weed control, and fertilization [5]. Different row spacing affected significantly most of the rice parameters per square meter. Wider row spacing reduces the crop's competitive ability with weeds because it increases the space available for the weeds between the rows and decreases the competitive ability of the crop [6].

To alleviate these factors rice research activity has been conducted in the region for the past few years and some promising varieties have been adopted. Among the released NERICA varieties, NERICA-4 had better yield advantage over others under on-station and on-farm conditions (Assosa ARC, Completed activity 2014 unpublished). But still no rice agronomic practices concerning with row spacing and seed rate was done to improve rice production in the areas. Therefore, the objective this study was aimed at determining the optimum seed rate and row spacing of rice in the target area and areas with the same ecology and soil types.

2. Materials and Methods

2.1. Location of the Study Area

Trial was conducted at the Assosa Agricultural Research Center at Assosa, during 2017 and 2018 cropping seasons. The center is located at latitude of 10°02’ N and longitude of 34°34’ E in western Ethiopia. It is characterized by altitude ranging from 1553 m.a.s.l. and mean annual rainfall of 1275 mm. The rainy season extends from April to October and maximum rain is received in the months of June to August. It has a warm humid climate with mean maximum and minimum temperatures are 32.0°C and 17.0°C, respectively. The soil of the area is characteristically reddish, brown, Nitosol.

2.2. Treatments and Experimental Design

The treatments consist of 4x7 factorial combinations of row spacing (15, 20, 25, and 30cm) and seed rate (40, 60, 80, 100, 120, 140, 160 kg ha^{-1}). The treatments were arranged in a randomized complete block design (RCBD) with three replications, making a total of 84 experimental plots.

2.3. Experimental Materials

A rice variety Ediget was used for the experiment.

2.4. Experimental Procedures and Field Management

The experimental land was ploughed, disked and harrowed and rows were prepared manually with traditional hoes. The plot size was 2 m x 2.5 m. There were 10 rows in each plot with 0.2m between rows and distance of 0.75 m and 1 m between plots and blocks respectively. The net area of the plot was 4 m^2 (2.5 m x 1.6 m). A constant water layer of 6-8cm was maintained during the whole cropping season under the continuous flooding regime depending on the growth stages of the crop. Other crop management was carried accordingly as the recommended package of the crop. At crop physiological maturity stage, rice was harvested, and grain yields were determined in each plot and adjusted to a standard moisture content of 14%.

2.5. Data Collection and Analysis

The whole agronomic parameters like plant height, panicle length, number of filled grain, number of productive tiller per plant, and yield per hectare were recorded and were subjected in to SAS (Statistical Analysis software version 9.2) and the treatment differences which showed significance were separated using LSD at 5% level of significance. The mean grain yield data was adjusted by 90% and economic analysis was carried out by following the procedure of CIMMYT (1988) by taking all variable costs invested for the treatment. The prevailing cost of inputs and out puts in year 2020 considered for the analysis. The cost of rice grain was Birr 25 at the year. Total costs that varied for price of seed and planting cost for each treatments was calculated and treatments were ranked in order of ascending total variable cost (TVC) and dominance analysis was used to eliminate those treatments costing more but producing a lower net benefit than the next lowest cost treatment. To estimate economic parameters, sweet potato tuber was valued at an average open market price of Birr 25.00 birr kg^{-1}.

The prices of the inputs that were prevailing at the time of their use were considered for working out the cost of cultivation. Net returns per hectare were calculated by deducting cost of production per hectare from gross income per hectare. A treatment which is non-dominated and having the highest net benefit is said to be economically profitable (CIMMYT, 1988).

3. Result and Discussion

The analysis of ANOVA showed that the plant height did not show significant difference between row spacing and seed rates ($P<0.05$). Zewdineh Melkie [7] reported that the main effect of row spacing and two and three factor interaction of varieties, row spacing and N application rates did not show significant effect on plant height. Rao, P. U.’s research report [8] also revealed that seed rate had brought no significant effect on plant height of rice. The highest plant height (90.38cm) was observed at the lowest seed rate of 40 kg ha^{-1} which was 86.67cm) [8].

From the experiment, it was observed that as the seed rate increased, the plant height was decreased. The highest plant height was observed at the lowest seed rat and wider spacing and this result agrees with the findings of [9] who reported that increase in the seeding rate resulted in decreasment in the heights of the plants. This might be due to by increasing seed rate per unit area, the inter competition for space, nutrient, moisture and sun light increases which results in shortest plant height.

Seed rate had no significance effect on panicle length. In [10], wheat research reported that varieties have different genetic potential regarding the spike length So it can be concluded from these research results that panicle length is genetic characters of a given variety, which is less influenced by agronomic practices. The maximum number of tillers per plant (3.37) and the minimum (2.21) were recorded from the seed rate of 40 kg ha^{-1} and 140 kg ha^{-1}. On the other hand, the minimum and maximum tillers per plant were observed at row spacing of 15cm (2.02) and 30cm (3.01) respectively (Table 1).

From the result, it can be concluded that as the seed rate increased, the number of tillers showed decreasing tendency and as the row spacing increased, the number of tillers increased but as the row spacing decreased the number of tillers decreased. This result agreed with the findings of [11] that they explained that it could possibly be due to the enhanced tillering capacity of the existing plant population associated with the adequate availability of soil nutrients for the lower population resulted from the decreased seed rate.

Table 1. *Effect of seeding rate and row spacing on yield and yield components of rain fed lowland rice (Ediget) variety at Assosa in 2017 and 2018 main cropping season.*

Treatments	Plant Height (cm)	Panicle Length (cm)	Tiller number Per plant	Filled grain	Yield (t ha^{-1})
Seeding rates (kg ha^{-1})					
40	90.38	16.77	3.37	86.93^{a}	3.06
60	90.18	16.40	3.26	83.48^{ab}	3.928
80	88.63	16.11	2.83	78.52^{abc}	3.26
100	88.51	15.86	2.41	74.99^{bcd}	3.37
120	88.39	15.76	2.81	73.43^{ab}	3.5
140	87.47	16.06	2.35	68.83^{d}	3.48
160	86.67	15.58	2.21	77.78^{cd}	3.38
Sig. difference	Ns	Ns	Ns	***	Ns
SE ±	2.75	0.49	0.24	3.67	1.85
Row spacing (cm)					
15	89.79	15.84	2.02	70.07^{b}	3.44
20	89.41	15.74	2.11	73.85^{b}	3.93
25	88.17	16.25	2.99	83.45^{a}	3.39
30	87.79	16.47	3.01	84.03^{a}	3.20
Mean	88.84	16.07	3.03	77.85	3.32
Sig. difference (5%)	Ns	Ns	Ns	***	Ns
SE ±	2.1	0.37	0.18	2.78	1.39
CV (%)	10.73	10.66	27.01	19.29	19.25

CV Coefficient of variation SE Standard error.

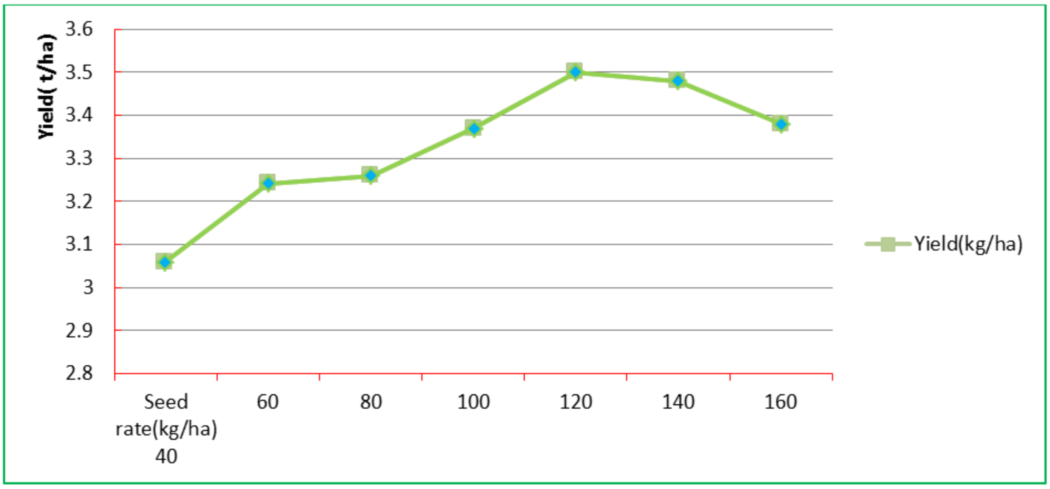

Figure 1. *Effect of seed rate on yield of rice (Ediget) at Assosa, western Ethiopia.*

The analysis of variance showed that the main effect of seed rate and row spacing had significantly ($P < 0.01$) affected filled grain. The highest (86.93) filled grain was observed at seed rate of 40 kg ha^{-1} and the lowest (68.83) was observed at seed rate of 140 kg ha^{-1} (Table 1). From the result, it can be concluded that filled grain showed decreasing tendency with increasing seeding rate and the maximum filled grain was attained lower rate of seeding. This result is in line with [12]. He concluded from his wheat research findings that increasing the rate of seeding from 100 to 150 kg ha^{-1} decreased the number of grains per spike from 32.02 to 29.60 at the seed rate 100 and 150 kg ha^{-1} respectively. Moreover, [13] reported that the number of kernels per spike decreased with an increase in seeding rate. Also the highest filled grain (84.03) was observed at wider spacing (30cm) and the lowest (70.07) at narrower spacing (15cm). This may be due to increased plant population with higher seed rate which increased the inter plant competition for space, nutrient, moisture and sun light which results in lower filled grain, but at wider spacing and lower seed rate, there were enough spacing which decreased inter plant competition for nutrient, moisture and sunlight to fill the grain.

The analysis of variance showed that the main effect of seed rate and row spacing had no significant effect on grain yield. Even though there were no significant differences between the treatments. The maximum grain yield (3.93 t ha^{-1}) was obtained at seed rate of 60kg seed ha^{-1}. However, it was statistically at par with the result obtained at seed rate of 140 kg ha^{-1} which gave 3.48 t ha^{-1}. But as the seed rate increased, the yield was being started decreasing (Figure 1). This might be due to the large population which brought competition for space nutrient and other necessary materials for better yield. The lowest yield (3.02 t ha^{-1}) was obtained at seed rate of 40kg seed ha^{-1} (Table 1). The increase in yields with increasing seeding rate is due to more panicle being produced as results of more plants population were established but at the certain population limit. The current result agreed with those of [14, 15], who reported that grain yield increased as seed rate increased. In addition, as the spacing between rows increased, the yield was getting decreased and at the optimum spacing (20cm) better plant population was established and better yield (3.93 t ha^{-1}) was obtained (Figure 1). The current finding is also agreed with result reported by [16] who reported that narrow row spacing give greater yields than wide row spacing.

4. Conclusion and Recommendation

Production of rice using optimum row spacing and seed rate has a vital role to increase production which in turn alleviates food security problem. Since rice crop is newly introduced crop in the western region especially in Benishangul Gumuz region, the agronomic management of the crop is not yet studied properly. In view of that, the research work was initiated to investigate the effect of seed rate and row spacing on yield and yield components of irrigated edigat rice variety.

From the analysis of variance, all the parameters except filled grain were not significantly affected by seed rate and row spacing. The maximum plant height (90.38cm) was observed at seed rate of 40 kg ha^{-1} and the lowest was observed at seed rate of 160 kg ha^{-1}. The highest panicle length (16.77cm), tiller per plant (3.37) and filled grain (86.93) was observed at seed rate of 40 kg ha^{-1}. Filled grain was highly significant and the highest filled grain was observed at 40 kg ha^{-1} (86.93) and at 15cm spacing (70.07). The highest yield was observed at seed rate of 60 kg ha^{-1} and 20cm spacing (3.93 t ha^{-1}). The lowest yield was observed at seed rate of 40 kg ha^{-1} and spacing of 30cm. Marginal rate of grain yield analysis was performed on non-dominated treatments to identify treatments with the optimum return to the farmers' investment. In order to consider a treatment as worthwhile option to farmers, 100% marginal rate of return (MRR) is minimum acceptable rate of return [17]. MRR at seed rate of 60 kg ha^{-1} + 20cm spacing gave a value that was higher., indicating that 60 kg ha^{-1} + 20cm spacing used in this study was the economic optimum rate for the crop. Therefore, even though further testing is required, it can be concluded that the use of seed rate at 60 kg ha^{-1} and spacing of 20cm is advisable and could be appropriate for rice production in the testing area.

Table 2. *Partial budget analysis of grain yield for seed rate by row spacing of low land rice at Assosa.*

Trt	SR	RS	GYt/ha	AGY (t/ha)	TVC (Birr/ha)	GB (Birr /ha)	NB (Birr/ha)	MRR (%)
1	40	15	2.31	2.08	2230	52,000	49,770	D
2	60	15	3.25	2.93	2550	73,250	70,700	
3	80	15	3.48	3.13	2870	78,250	75,380	
4	100	15	3.28	2.95	3190	73,750	70,560	D
5	120	15	3.29	2.96	3510	74,000	70,490	D
6	140	15	3.01	2.71	3830	67,750	63,920	D
7	160	15	2.93	2.64	4150	66,000	61,850	D
8	40	20	3.27	2.94	1820	73,500	71,680	
9	60	20	3.93	3.54	2140	88,500	86,110	
10	80	20	3.13	2.82	2460	78,250	75,790	D
11	100	20	3.24	2.92	2780	73,000	70,220	D
12	120	20	3.12	2.81	3100	70,250	67,150	D
13	140	20	3.43	3.10	3420	77,500	74,080	
14	160	20	2.62	2.34	3740	65,500	61,760	D
15	40	25	2.57	2.32	1620	58,000	56,380	D
16	60	25	3.40	3.10	1940	85,000	83,060	
17	80	25	3.50	3.15	2260	78,750	76,490	D
18	100	25	3.18	2.86	2580	71,500	68,920	D
19	120	25	3.43	3.10	2900	77,500	74,600	
20	140	25	2.73	2.46	3220	61,500	58,280	D
21	160	25	3.23	2.91	3540	72,750	69,210	
22	40	30	2.78	2.50	1460	62,500	61,040	D
23	60	30	3.14	2.83	1780	70,750	68,970	
24	80	30	2.49	2.24	2100	56,000	53,900	D
25	100	30	2.78	2.50	2420	62,500	60,080	
26	120	30	3.23	2.91	2740	72,750	70,010	
27	140	30	3.06	2.73	3060	68,250	65,190	D
28	160	30	2.84	2.56	3380	64,000	60,620	D

RS=Row spacing (cm); SR=seed rate (kg ha-^{1}); TVC=Total variable cost (Birr ha^{-1}) GY, Average grain yield (t ha^{-1}) AGY=Adjusted grain yield (ton ha^{-1}); D=Dominance, GB=Gross benefit (Birr ha^{-1}); NB=Net benefit (Birr ha^{-1}).

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