Global Scientific JOURNALS

GSJ: Volume 8, Issue 8, August 2020, Online: ISSN 2320-9186
www.globalscientificjournal.com

Influence of seed rate and row spacing on Yield and yield Components Upland ecosystems rice (*Oryza sativa* L.) **in western Ethiopia**

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1. ABSTRACT

One adapted variety in the upland ecosystem Nerica-4 were evaluated using randomized complete block design with different plant population (spacing, 20, 30 and 40 cm) between rows and three seed rates (50, 60 and 70 kg^{-}ha^{1}) which is factorial combined along with one control treatment (80kg/ha broadcasting) used as comparison for grain yield and yield contributing parameters. Increase in spacing contributes to vigorous plant growth as well as increased the number of panicles per hill, grain yield per hill, filled grains per panicle and 1000-grain weight. As the seed rate increased there was a proportional increment on the number of tillers per plant. Seed rate and row spacing significantly affected grain yield and plant height. The grain yield obtained from the seed rate of 60 kg /ha at spacing of 20cm gives an average two years yield of (6.523 t ha-1) higher by 20.41% compared to the seed rate of 80 kg ha-1 (5.2643 t ha-1) and in the year 2015 (3.1 t ha-^{1} higher by 44.23%) than the standard check.

Keyword; *population, rainfed, upland rice, seed rate, row spacing*

2. INTRODOCTION

Although rice has just been recently introduced to Ethiopia, recognizing its importance as a food security crop and a source of income and employment opportunities, the government of Ethiopia has named it the "millennium crop," and has ranked it among the priority commodities of the country. The national rice research and development strategy (NRRDS) for 2010-19 has been prepared to tackle rice-related progress in rice value chain, postharvest, grain quality, and marketing issues. The rice sector in the country saw a phenomenal growth from 2005 to 2016. Three rice ecosystems exist in the country, including upland rice, rainfed lowland rice, and irrigated lowland rice. The introduction and expansion of rice production in suitable agro-ecologies could be an option to achieve food security and self-sufficiency. Even though rice is not a traditional staple food in Ethiopia, it is considered a high potential emergency and food security crop .Since crop management is one of the factor for crop to achieve their optimum yield, some factors should be considered essential to increase yield and economic
Profitability.

Factors temperature, solar radiation, moisture and soil fertility affects crop plants growth and nutritional requirements. A thick population crop may have limitations in the maximum availability of these. Therefore, it is, necessary to determine the optimum population per unit area for obtaining maximum yields. Many scholars have reported that optimum population of a critical level of rice plant population in field was necessary to maximize grain yields. Counce (1987) suggested that population density ranging from 159 to304 plants per m^2 could produce maximum yield under a dry seeded and flooded in rice production systems. The seeding rates from 50 to 168kg/ha were necessary for obtaining maximum yields under direct seeded cultures depending upon planting dates (Jones and Synder, 1987a),spacing between hills and rows (Bari *et al*., 1984; Bisht *et al*., 1999)panicles per m2 (Miller *et al*., 1991; Gravois and Helms, 1992). Number of panicles per unit area is the most important component of yield and contribute 89 % of the variations in yield. Kenneth *et al*., (1996) reported similar results for an optimum plant stand in producing high rough rice yield, head rice and total milled rice. Jones and Synder (1987b), however, reported that panicles per m^2 accounted for only 34% of yield variations in direct seeded rice crop and 85% of the yield variations in ratoon rice crop. The effect of plant density on kernel dimension also identified during different panicle development stages (Senanayake*et al*., 1991; Karim *et al*., 1992; Banik *et al*., 1997; Wang and Luo, 1998; Gopal *et al*., 1999). The present studies were, therefore to determine the optimum plant density for getting the maximum yield in rice. This study aimed to evaluate the response of upland rice to different spacing and seed rates.

3. MATERIALS AND METHODS.

3.1. Description of the Study Area

The experiment was conducted for two consecutive years(2014 and 2015) at the Experimental Farm of Kamashi sub center located at latitude of 09º31.463' and 'longitude of 035º53.227. kamashi is situated in north western Ethiopia of benshangul gumuz regional state at about 657 kms from the capital Addis Ababa, and about 200m from the regional city Asosa to the East at an altitude of 1219 meters above sea level (masl). The long-term weather data of the annual rainfall varies from 800 to 2000 mm.

3.2. Treatments and Experimental Design

Treatments were prepared from four levels of seed rate (50, 60, 70, 80(as check in broadcasting) kg ha-1). The new rice for Africa (Nerica 4) created by crossing (O.glaberrima and O. sativa) had been used as test crop for its` potential yield. This rice display heterosis, the phenomenon in which the progeny of two genetically different parents grow faster, yield more, or resist stresses better than either parente (Oryza sativa L.) i.e., Basmati 370, Jajai 7.The experiment consisted of ten treatments with a total of thirty plots. Spacing of 20cm, 30 cm and 40cm between rows were kept for growing the crop and one broadcasting used as check and a seed rate of 50kg/ha, 60kg/ha and 70 $kg^{-}ha^{1}$ were used to identify their effect on grain yield parameters. The field design laid out in randomized block design (RCBD) with three replication. It sown in same day June 24 in both year (2014 and 2015). The area of each plot was 3 x $4m^2$. Seed drilled in a row in rectangular method of planting. The fertilizer in the form of urea and diammonium phosphate (DAP) was applied at the rate of 46 N and 46 P_2o_5 (kg/ha) being urea applied in two split. The basal dose of 23 N (kg/ha) was applied at sowing time while the remaining 23 N (kg/ha) was applied as top dressing at tillering stage. Standard cultural practices carried out until the crop was mature.

3.3. Data Collection

Phenological Parameters

Phenological parameters such as days to emergence, days to flowering and days to maturity recorded. Days to emergence was recorded when 50% the plants per plot emerged while days to flowering was recorded by counting the number of days after emergence when 50% of the plants per plot had the first open flower. Days to maturity were recorded when 90% of heads/spikes per plot.

Growth Parameters

At mid flowering stages, fifteen plants from each of the plots selected randomly and uprooted carefully to determine crop growth parameters such as plant height and number of tillers.

3.3.1. Grain Yield and Yield Components

3.3.1.1. Determination of grain yield.

Grain yield adjusted to 12.5% moisture content. Fifteen plants randomly selected from the six central rows to determine yield and yield components, which consisted of number of tillers per plant, number of seeds per spike and thousand seeds weight. Spike number per plant was determined by counting spikes of the ten randomly selected plants while number of seeds per spike recorded by counting the total number of seeds in a spike from ten randomly sampled spikes taken from the fifteen randomly selected plants. Seed weight was determined by taking a random sample of 1000 seeds and adjusted them to 12.5% moisture content. Total biomass yield measured from the six middle rows when the plant reached harvesting maturity. Harvest index calculated as the ratio of seed yield to total above ground biomass yield.

3.4. Statistical Analysis

The data on paddy yield per plot and yield parameters i.e., panicle height, stand count at harvest m^2 ,thousand seed weight (gram) ,number of grains per panicle, number of panicle (m2) ,number of tillers (m2), plant height in (cm) ,grain yield in kg/ha were recorded and analyzed using SAS 9.1 system ;mean values were compared by DMR test.

3.5 Soil laboratory result

Soil sample has randomly collected from the trial field and subjected to for laboratory analysis, the result obtained looks like in the table.

Table.1 soil analysis result of the trail area

factor	units problem	level
pH =	PH-meter	6.025
Salinity (water) – ECW	dS/m =mmol/cm	2.145
Salinity (soil) – ECS		3.214
TDS	dS/m	445.253
specific ion toxicity		
Sodium – SAR	no units	2.934
Chloride	me/l	6.849
Boron	mg/l	0.725
Bicarbonate HCO_3-2	me/l	4.665

4. RESULTS AND DISCUSSION

The analysis of variance resolved that the yield performance of different spacing between row and the seed rate as well as the interactions between the sources of variation. The performance of each years with respect to Panicle height, Stand count at harvest m^2 ,thousand seed weight (gram) ,number of grains per panicle, plant height in (cm) ,grain yield in kg/ha were significantly different at ($P<0.01$and $P<0.05$). However, the row spacing of 20cm and seed rate of 60kg/ha gave the highest average grain yield (46.07 kg/ha)followed by seed rate 60kg/ha with spacing of 40cm (44.94 kg/plot) and seed rate 50kg/ha with 20cm (44.91 kg/ha). Stand count at harvest of broadcasting with seed rate 80kg/ha (76 pollution per m^2) were highly significant than the other seed rate and spacing under study. This may be the higher seed rate that have used resulted in poor in number of seed per panicle and seed quality with higher population density.

Table 2-.The average ANOVA result of grain and grain yield components for spacing and seed rate over years (2014-2015).

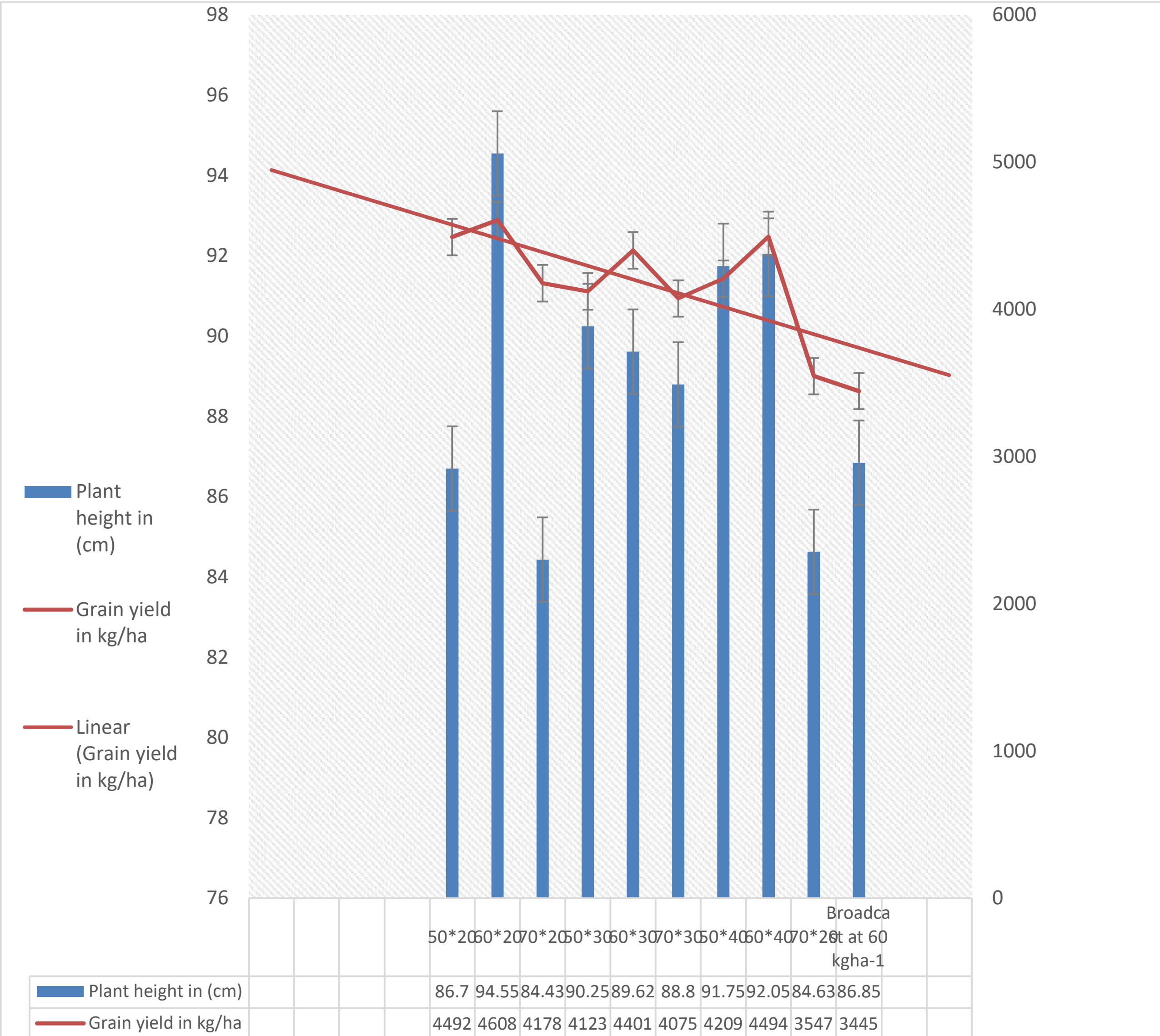
treatments		parameters							
Kg/ha	cm	Panicle height	Stand count at harvest m2	Thousand seed weight (gram)	Number of grains per panicle	Number of panicle (m2)	Number of tillers (m2)	Plant height in (cm)	Grain yield in kg/ha
50	20	22.9333^{a}	47.333^{b}	23.000^{ab}	133.47^{a}	226.67^{a}	249.33^{a}	86.703^{bc}	4491.8^{ab}
60	20	23.3167^{a}	60.000^{b}	24.333^{a}	132.87^{a}	281.10^{a}	297.87^{a}	94.550^{a}	4607.7^{a}
70	20	20.5167^{c}	58.667^{b}	21.333^{ab}	125.87^{a}	260.00^{a}	268.57^{a}	84.433^{c}	4177.9^{ab}
50	30	22.3667^{a}	45.667^{b}	22.000^{ab}	121.40^{a}	229.33^{a}	244.77^{a}	90.250^{abc}	4122.8^{ab}
60	30	22.1167^{ab}	48.000^{b}	23.000^{ab}	131.27^{a}	262.53^{a}	281.87^{a}	89.617^{abc}	4401.3^{ab}
70	30	22.6000^{ab}	44.000^{b}	22.667^{ac}	124.87^{a}	227.70^{a}	230.77^{a}	88.800^{abc}	4074.6^{ab}
50	40	22.6167^{ab}	46.667^{b}	23.000^{ab}	131.07^{a}	260.33^{a}	265.80^{a}	91.75^{ab}	4209.3^{ab}
60	40	22.5167^{ab}	52.667^{b}	22.333^{ab}	137.00^{a}	281.10^{a}	280.20^{a}	92.05^{ab}	4494.0^{ab}
70	40	21.8667^{abc}	56.000^{b}	21.667^{ab}	131.60^{a}	260.53^{a}	277.90^{a}	84.63^{c}	3546.7^{ab}
broadcast		21.233^{bc}	75.667^{a}	19.333^{b}	110.60^{a}	257.77^{a}	273.80^{a}	86.850^{bc}	3445.1^{b}
F value		2.42	4.18	1.13	0.71	0.64	0.79	1.96	1.28
Sign. (P<0.05)		*	**	*	*	*	*	*	*
CV		4.352545	15.25	9.24	12.37	17.64	14.62	4.16	13.91

** = Highly significant at P < 0.01 probability level; * = Significant at P < 0.05 probability level; Ns = non-significant at P < 0.05 probability level; LSD = least significant difference; and CV = Coefficient of Variation.

Table 3: Influence of seed rate and row spacing on Yield and yield Components of Upland Rice at two different season (NERICA – 4) at Kamashi 2014 and 2015

Treatment		2014			2015		
Seed rate kg^{-} ha	Row spacing	Panicle length (cm)	Plant height cm	Yield kg/ha	Panicle length cm	Plant height cm	Yield kg/ha
50	20	21.7	99.2	6748.5	24.27^{ab}	84.67^{ab}	2868.7^{ab}
60	20	21.7	92.6	6523.7	21.73^{cd}	79.33^{bc}	3167.7a
70	20	19.3	92.8	6874.9	21.33^{d}	76.07^{c}	2033.3^{b}
50	30	21.3	98.2	6515.3	23.67^{abc}	82.27^{abc}	2307.0^{ab}
60	30	21.0	98.5	6736.3	23.27^{abcd}	80.733^{abc}	2655.0^{ab}
70	30	20.7	95.4	6323.6	24^{ab}	82.200^{abc}	2419.3^{ab}
50	40	19.7	96.5	6187.9	24.67a	87.000^{a}	2908.3^{ab}
60	40	23.7	101.2	7264.9	22.73^{abcd}	82.867^{abc}	2315.3^{ab}
70	40	21.0	90.4	5709.1	21.80 ^{cd}	78.87^{bc}	1941.7^{b}
Broadcast at 80 kgha^{-1}		20.3	95.3	5264.3	22.47^{bcd}	76.067^{c}	18.0^{ab}
F value		0.38	0.84	1653.7	0.012	0.0726	0.1861
Sign. (P<0.05)		*	*	*	*	*	*
CV		10.4	5.1	15.0	4.70	4.63137	22.6686

Grap. 1. The average interaction effect of seed rate and spacing



Results indicated that wider spacing had linearly increasing effect on the performance of individual plants. The plants grown with wider spacing have more area of land around them to draw the nutrition, had more solar radiation to absorb for better photosynthetic process, and hence performed better as individual plants. The reason for deviation of this linearity in case of grain yield per plot is that the yield does not entirely depend upon the performance of individual plant but also on the total number of plants per plot and yield contributing parameters within plant .The data indicates that the effect of spacing of yield and yield parameters seed rate (Table 1). There is a significant interaction between seed rate and spacing. This reveals that crop requires giving its optimum yield at appropriate seed rate and spacing. The effect of spacing within entries was also significantly different. This also makes intelligible explanation that spacing modify the components that influence the final yield. Ennus and Sadeque (1974) found that the number of panicles per plant and straw yield increased with increased spacing in transplanted rice. Shahi *et al*. (1976) studied.

5. SUMMARY AND CONCLUSION

Growing rice by using optimum seed rate and spacing could make an important contribution to increase agricultural production and productivity in areas like Kamashi where there is low practice of using improved agronomic practices such as optimum seed rate. To this end, applying optimum seed rate could be one of the alternatives to improve productivity by small farmers. However, the agronomic management regarding seed rate is not yet studied in the area. Thus, this research work is initiated to investigate the impact of seed rate on the performance of rice. Study on seed rate and spacing was conducted at Kamashi under rainfed 2014and 2015. The objective of the study was to determine the optimums seed rate that will improve rice production. The experiment was carried out using the randomized complete block design (RCBD) with three replications. Four levels of seed rate (50, 60, 70, 80(check in broadcasting kg ha-1) and 3 level of spacing (20, 30,40cm) combined factorally and become ten total treatments. According to the results of analysis of variance, growth parameters except stand count per m^2 were significantly affected by seed rate. The maximum number of tillers per plant and the highest plant height were noted from the seed rate of 50 and 60 kg ha-1 with the spacing of 20cm for each. Grain yield and total biomass weight were significantly affected by seed rate whereas; seed rate had brought no significant effect on the yield components such as 1000 seeds weight and number of tillers per plant. The highest grain yield of (4.6077 t /ha-1) were obtained from the seed rate of 60kg ha-1.Therefore, it can be concluded that the seed rate of 60 kg ha-1 is with spacing of 20cm recommended and could be appropriate for rice production in the test area even though further investigations is required.

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