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Response of an Up-Land Rice (NERICA-4) Variety for Row Spacing and Nitrogen FertilizerRate in Pawe Area, North western Ethiopia

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Abstract

An experiment was conducted at Pawe research station and on farmers field in two cropping seasons (2016 and2018), to investigate the effect of row spacing(RS) and nitrogen (N) fertilizer rate on yield and yield component and to determine economically optimum row spacing and N fertilizer rate for an upland rice variety (NERICA-4). The experiment had three row spacing(20, 25 &30 cm) and four N-rates (0, 32, 64 and 96 k ha^{-1}) totally twelve treatments.It was laid out in RCBD with factorial arrangement andthree replications. Analysis of variance was highly significant (P<0.001) difference due to treatment effect for 90% physiological maturity, plant height, No of tiller per 0.5m row length, Aboveground biomass yield (BY), Grain yield (AGY) and Thousand kernels weight. The highest BY (9677 kg ha^{-1}) was produced by 20 cm RS with application of 96 kg N ha^{-1},but at par with 25 and 30 cm row spacing and 96 kg N ha^{-1}.The highest AGY (4704.6 kg ha^{-1}) was produced by RS of 20 cm and 96 kg N ha^{-1}. But, it was at par with of 25 and 30 cm row spacing with application of 96 kg N ha^{-1}. The marginal rates of return(MARR) 295.95 % was the optimum profitable rate in the current finding, because it was well above MARR, 100% and produced an additional mean seed yield advantage of 194.12% over control. Hence, the economic analysis suggests that marginal benefits of rice would be

higher, if fertilizer and row spacing is used at 30 cm row spacing and a rate of 96 kg N ha^{-1}, because it gave the highest net benefit, 28358.68 EB/ha.

Introduction

Rice is the second largest produced cereal after wheat in the world. The majority of rice cultivated in the world is under flooded conditions (Prasad, 2011). It is one of the most strategic crops in Africa and particularly in Ethiopia (Meron, 2016). Ethiopia has tremendous potential to increase the area under rice and is looking for partnerships to make use of rice production areas (EUCORD, 2012). In 2017 about 48,418.09 ha of land was cultivated with the total production of 136,000.726 tons (FAOSTAT, 2017). Rice production and productivity are mainly affected by both biotic and abiotic factors.

The enhanced soil productivity and assured sustainability are the two major issues of concern in order to feed the increasing population of the world. Improvement of thus issues especially nutrient retention practice in the soil, use of optimum rate of nitrogen fertilizer and other nutrients; effective row and plant spacing are considered to be the major determinants of yield of rice. Row spacing affected significantly the number of fertile tillers and total tillers per square meter. Wider row spacing reduces the crop’s competitive ability with weeds because it increases the space available for the weeds and decreases the competitive ability of the crop (Martin *et al*., 2010). It is, therefore, necessary to determine the optimum plant population per unit area and spacing to obtaining high yield (Rasool *et al*., 2013, Sultana *et al.*, 2012).

Ethiopia is more sensitive to shortage of major fertilizer nutrients especially nitrogen and phosphorus, because the fertilizer input in is less and expensive than its demand. Determination of an appropriate dosage of application will be both economical, enhance productivity and consequent profit of the grower. Nitrogen is the most essential element that is applied most frequently and with high amount in rice production. But application of nitrogen fertilizer either in excess or less than optimum rate affects both yield and quality of rice (Shukla*et al*., 2015).

Pawe is a major rice producing area and the above agronomic practices are also major limiting factors to increase rice production and productivity. At present the rice farmers used blanket recommended fertilizer rates (100 kg urea and 100 kg DAP)across thecountry for most cerealcrops and soil types and 20 cm row spacing.This recommendation fails to address the current fertility status of the soil and specific crop needs and High-yielding rice cultivars needs large amount of nitrogen to achieve acceptable grain yields.The farmers also planted traditional ploughing by using oxen and donkey plough; with this 20 cm row planting is not easily important specially wetted soil type. Therefore, the objectives of this study were:-to investigate the effect of Row Spacing and nitrogen fertilizer level on grain yield and yield component of upland rice NERICA-4 variety andto determine economically feasible Row Spacing and nitrogen fertilizer application for upland rice NERICA-4 variety.

2. MATERIALS AND METHODS

2.1. Description of the Study Area

The field experiment was conducted in Pawe district, Northern western Ethiopia during the main crop growing season on- research station and farmers field (2016 and 2018). The geographical location is between 11° 15′ North latitude and 36° 30′ East longitudes. The altitude of the area is 1100-1200 m.a.s.l. The area has a univocal rainfall pattern that extends from May to October. The annual rain fall was 1336.9and 1515.5mm in 2016 and 2018 cropping season, respectively. The mean annual minimum temperature was 16.9 and 17.1 ^{0}C in 2016 and 2018, respectively. The means annual minimum and maximum temperature was 32.8and 33.2^{0}Cin 2016 and 2018 respectively (Pawe meteorological unpublisheddata).

2.2. Experimental Design and Treatment arrangements

The experiment had two factors: - three row spacing (20, 25 and 30 cm) and four nitrogen rates (0, 32, 64, 96 kg ha^{-1}).Urea (46% N) and triple supper phosphate (TSP) (46% P_2O_5) were used as source of N and P respectively.The experiment was laid out in randomized complete block design in factorial arrangement with three replications. The gross plot size was 3 m length and 1.8 m width (5.4 m^2) for 20 cm and 30 cm and 3 m x 1.75 m (5.25 m^2) for 25 cm row spacing. The path between experimental plots was 0.75 m and replications 1.5m. The net plot areas which excluded the outer one row of each side of the gross plot of each treatment unit were used to collect all the relevant data. Before planting, composite soil sample from ten random spot each from depth of 0-20 cm were collected as X-shape soil sampling method by using auger for analysis of soil physical and chemical properties (Texture, pH, OC, total nitrogen and available phosphorus.

Table1. Treatment combination

Row spacing (cm)	Nitrogen rate			
	0 kg/ha	32 kg/ha	64 kg/ha	96 kg/ha
20	1	2	3	4
25	5	6	7	8
30	9	10	11	12

2.3. Experimental Procedure and Field Management

The experimental field plots were ploughed two times using tractor mounted moldboard plough to 30 cm soil depth on station and oxen ploughed on farmer's field. Subsequent tilling operations wouldbe done by harrowing to about 5 cm depth tillage. Seeding was done by hand drilling using the recommended seed rate of 60 kg ha^{-1}. All agronomic field management practices were done as required. N fertilizer was applied in three equal splits viz., one-third at planting, one-third at tillering (at 3-4 tillering stage) and remaining one-third at panicle initiation. Basal application of Phosphorus fertilizer (46% P2O5) and the initial N fertilizer rate was at sowing, whereas the two split of N rate (one-third at tillering and one-third at panicle initiation) were side dressed.

2.4. Data Collection and Analysis

Data on number of Days to heading and Physiological maturity were recorded for each treatment by counting number of days from sowing till 50% of the plants in each plots initiated heads, and 90 % maturity respectively. Plant height and panicle length was measured from five randomly taken plants.Number of tillers was the average number of tillers from 0.5 m row length of three randomly taken rows of net plot area at harvesting.Number of filled grains per panicle was taken from the main panicle at harvest from average of five and ten randomly taken plants in 2016 and 2019 respectively.. Above ground dry biomass yield per hectare (ABY kg ha^{-1}) was harvested from the net plot, sun dried for 72hours andmeasured in kg per plot, and then converted in hectare.Thousandkernel weight (TKW) was recorded in gram with sensitive balance which was taken from bulked grains of each plot and adjusted to 14% seed moisture level. Grain yield per hectare (GY kg ha^{-1})was measured from net plot of each plot and converted to kilograms per hectare at 14% moisture content.Harvest index (%) was calculated with the formula;

$$Harvest\ index = \frac{Grain\ yield}{Biomass\ yield} \times 100$$

Data analysis was carried out for the collected and measured parameters following statistical procedures appropriate for the experimental design using SAS version 9.3 (SAS, 2014) and significant means were separated done using the least significant difference (LSD) test at 5% levels of probability.

The partial budget analysis was done as described by CIMMYT (1988) where the variable cost that vary included the cost of inputs (N-fertilizer) as well as the cost involved in their application. For price of the crop, the cost earned for threshing, winnowing, packing and transportation was added to the variable input cost. The Paddy grain and straw yields were subjected to partial budget analysis. Net benefit was calculated as the amount of money left when the total variable costs for inputs (TVC) are deducted from the Gross benefit (GR).

The yield was adjusted downward by 10% before calculating the gross return to have an idea of how much benefit can be obtained based on variable cost. Any treatment that has higher TVC but net benefits that are less than or equal to the preceding treatment (with lower TVC but higher net benefits) is dominated treatment(marked as "**D**"). **The Marginal Rate of Return (MRR):** is used to assess relative profitability among alternative treatments. MRR was calculated as the ratio of change in return of the average of each replicated treatment to the change in total cost with regard to the control.

3. RESULT AND DISCUSSION

3.1. Soil Physico-Chemical Properties of the Experimental Site

The best suitable soil for rice production is considered with a pH range of 5.5 to 6.6, but it is tolerant to a range of soils with pH from 4.5 to 8.5 and can be grown successfully on saline or sodic soils (Anonymous, 2002).

Table.2soil PHYSICO-chemical properties and soil textural classes of the soils before planting. sampled before planting on station.

Soil sample Year	pH (1:1) H_2O	Av. P (ppm)	OC (%)	TN (%)	Sand (%)	Silt (%)	Clay (%)
2016	5.33	7.36	2.154	0.177	5	14	81
2018	5.09	4.569	0.435	0.056	43	6	51

Av.P= Available Phosphorus, OC=organic carbon and TN=total nitrogen

3.2. Plant Phenology,Growth and Yield Parameters

The combined analysis showed the main effects of row spacing and nitrogen application, and interaction of RS and N rates did not show significant difference on days to 50% of heading (DH)(Table 3).However, panicle length (PL), fertile grain per plant (FG)and harvesting index (HI)werehighly significant ($P<0.001$) and significant ($p<0.015$) difference due to the Nitrogen rate level,But the main effects of row spacing and interaction of RS and N rates did not show significant difference (Table 3).

Table 3. Effect of nitrogen on days to heading, panicle length, fertile grain per plant, and harvesting index of rice (2016 & 2018)

Nitrogen Rate	DH	PL	FG	HI
0 kg/ha	79.7	18.5b	89.1b	50.6a
32 kg/ha	79.9	18.91ab	90.8b	48.1c
64 kg/ha	79.7	19.34a	93.6ab	49.9ab
92 kg/ha	79.2	19.41a	102a	48.6bc
LSD(5%)	**NS**	**0.61***	**8.7****	**1.77****
CV(%)	**2.35**	**5.98**	**17.17**	**6.63**

**, ** = significant at 0.05 and 0.01 probability levels respectively; NS = not significant; and means with the same letter are not statistically different; DH=Days to 50% heading; PL=Panicle length; FG =fertile grain per plant; HI=harvesting Index.*

The combined analysis of variance showed highly significant ($P<0.001$) difference due to main effect of nitrogen rate andinteraction of N rate and row spacing for days 90% of physiological maturity (DM)and plant height (PH)(Table 4).However, row spacing was not significant effectin both components. The Longest days of maturity was recorded with no N application and 30 cm row spacing, but it was at par withinteractioneffect of 25 cm row spacing and 0 kgha^{-1} N rate. In other ways the shortest days of maturity was found with interaction effect of 20 cm row spacing and 96 kg N rate. Increasing N rate from 0 to 96kg/ha,Maturity days decreases in all spacing. This showed that amount of N fasten the Physiological maturity of rice plant.Sewenet (2005) also reported that Application of higher levels of N (69 kg ha^{-1}) induced early maturity in rice.

The shortest plants (73.6 cm) were recorded due to the control N (0 kg ha^{-1}) and 30cm row spacing(Table 4). But, it was at parwith plant height due to treatment 1, 2 and 5. This might be due to encouraging effect of N on various physiological process including cell elongation and cell division of the plant in rice. Alam *et al*. (2014); Ali*et al.* (2011); and Rahman *et al*. (2007) also indicated the positive effect of N on plant height.

Table 4.Interaction effect of nitrogen and row spacing on Days to Maturityand plant height of rice (NERICA-4) (2016 & 2018)

Treatments	DM				PH (cm)			
	2016	**Loc 1**	**Loc 2**	**Com**	**2016**	**Loc 1**	**Loc 2**	**Com**
1	124.3	134.7^{c}	130^{a}	129.7^{bc}	79.3f	74.75^{cd}	75.2	76.4^{cd}
2	122.7	135^{bc}	129.33^{ab}	129^{cd}	80.9^{cdef}	75.96^{cd}	73.5	76.8^{cd}
3	122.7	136.3^{bc}	129^{abc}	129.3^{c}	84.5^{a}	80.8^{ab}	73.2	79.5^{abc}
4	122	134.7^{c}	127.67^{c}	128.1^{d}	83.1^{abcd}	77.5^{bc}	77.7	79.4^{abc}
5	124.3	137.7^{ab}	130^{a}	130.7^{ab}	76.1^{g}	77.3^{bc}	76.3	76.6^{cd}
6	123.3	137^{bc}	128.33^{bc}	129.6^{bc}	80.5^{def}	79.9^{abc}	73.1	77.8^{bc}
7	122.3	135.3^{bc}	128.67^{abc}	128.8^{cd}	81.4^{bcde}	85.3^{a}	79.6	82.1^{a}
8	123	136.3^{bc}	128.33^{bc}	129.2^{cd}	83.9^{abc}	80.3^{abc}	77.6	80.6^{ab}
9	123.3	140.3^{a}	130^{a}	131.2^{a}	79.9^{ef}	69.458^{d}	71.4	73.6^{d}
10	123	136.7^{bc}	129.33^{ab}	129.7^{bc}	84.2^{ab}	76.8^{bc}	77.7	79.5^{abc}
11	123	135^{bc}	128b^{c}	128.7^{cd}	82.6^{abcde}	82.8^{ab}	77.4	80.9^{ab}
12	122.3	135.3^{bc}	128b^{c}	128.6^{cd}	79.7^{ef}	84.9^{a}	77	80.5^{ab}
LSD (5%)	**NS**	**2.67**	**1.5***	**1.99****	**3.06****	**2.678**	**NS**	**3.38****
CV (5%)	**0.83**	**1.16**	**0.69**	**0.99**	**2.22**	**4.92**	**4.23**	**4.57**

*, ** = significant at 0.05 and 0.01 probability levels, respectively; NS = not significant; and means with the same letter are not statistically different; DM=Days to maturity; PH=Plant height; Loc1and Loc2= on station and on farmers field 2018 respectively; and Com=combined effect of the 3 site.

The combined analysis showed, number of tillers per 0.5m row length was highly significant (P<0.001) on main effect of row spacing, nitrogen rate and interaction effect of row spacing and N-rate. The highest number of tillers was recorded on 25 cm and 30 cm row spacing with 96 kg/ha N-rate. But the lowest one was recorded on 20 cm row spacing with no N application, But it was at par with 20 cm row spacing with 32 kg/ha N-rate. Chang and Su, (1977) studied number of tillers per hill at 50 days after transplanting increase with increasing rate of applied N and decreases with decreasing in spacing.Awan *et al*. (2011) and Uddin *et al.* (2013) found similar results. Aboveground biomass yield(BY)also highly significant(P<0.001) affected bymain effect of Nitrogen rate andthe interaction of row spacing and nitrogen rate, But main effect of row spacing was not significant on combined analysis. The result revealed that the highest BY (9677 kg ha^{-1}) was produced by 20 cm row spacing with application of 96 kg N ha^{-1}. This treatment was at par with treatments combination of 25 and 30 cm row spacing and 96 kg N ha^{-1} (Table 5). In general increasing N-rate from zero to 96 kg in all row spacing, Biomass yield also increased. Increasing the rate of N also increased dry mater weight of rice by enhancing N up take. Such increase in dry matter accumulation of rice actually accentuated from increase in growth of leaves in terms of number and size, elongation of stem/tillers and panicles or in general increased vegetative growth of plants (Kumbhar and Sonar, 1980). The results are in conformity with the finding of Alam *et al*. (2014) who reported that interaction of row arrangement and nitrogen levels had significant effect on biomass yield ha^{-1}.

Table 5. Interaction effect of nitrogen and row spacing on Number of tiller per 0.5 m row lengthand above ground biomass yield per hectare of rice (NERICA-4) (2016 & 2018)

Treatments	SCT/0.5m				BMY (kg/ha)			
	2016	**Loc 1**	**Loc 2**	**Com**	**2016**	**Loc 1**	**Loc 2**	**Com**
1	24.2^{h}	17.8^{d}	21.73^{d}	21.9^{f}	5032.1^{f}	3730.2^{f}	5238.1^{def}	4666.8^{e}
2	28.7^{g}	18.5^{d}	22.8^{bcd}	23.3^{ef}	8558.7^{cd}	6507.9^{cde}	6507.9^{cd}	7191.5^{cd}
3	37.7^{d}	25.9^{abc}	29.6^{abcd}	31.1^{bc}	8758.1^{d}	7381^{abcd}	6825.4^{bcd}	7654.8^{c}
4	41.7^{c}	26.5^{ab}	29.9^{abcd}	32.3^{b}	12049.2^{a}	8412.7^{ab}	8571.4^{a}	9677^{a}
5	31.3^{fg}	19.4^{cd}	27.3^{abcd}	$26d^{e}$	5272^{f}	4888.9^{ef}	4888.9^{ef}	5016.6^{e}
6	33.8^{ef}	$24b^{cd}$	28.3^{abcd}	28.7^{cd}	7316.2^{e}	6133.3^{cde}	5688.9^{de}	6379.5^{d}
7	36.3^{de}	29.1^{ab}	30.4^{abc}	31.9^{bc}	8973.5^{cd}	7822.2^{abc}	8266.7^{ab}	8354.1^{bc}
8	45.3^{ab}	27.1^{ab}	34.7^{a}	35.7^{a}	10818.1^{ab}	8444.4^{ab}	8266.7^{ab}	9176.4^{ab}
9	35.6^{de}	22.5^{bcd}	22.4^{cd}	26.9^{d}	5925.2^{f}	4907.4^{ef}	3796.3^{f}	4876.3^{e}
10	36.2^{de}	28.2^{ab}	34.5^{a}	33^{b}	7662.4^{de}	5833.3^{de}	5833.3^{de}	6443^{d}
11	42.9^{bc}	24.3^{bcd}	28.5^{abcd}	31.9^{bc}	8865.2^{cd}	6759.3^{bcde}	7777.8^{abc}	7800.7^{c}
12	48.7^{a}	32.5^{a}	30.9^{ab}	37.4^{a}	10197.2^{bc}	8703.7^{a}	8425.9^{a}	9108.9^{ab}
LSD (5%)	3.49	6.83	8.32*	4.11**	1341.8**	1902.3*	1594.4**	1169.5**
CV (%)	5.59	16.37	17.3	12.95	10.85	16.95	14.11	17.28

**, ** = significant at 0.05 and 0.01 probability levels, respectively; NS = not significant; and means with the same letter are not statistically different; STC=Tiller number; BMY=Aboveground biomass yield; Loc1and Loc2= on station and on farmers field 2018 respectively and Com=combined of three location.*

Grain yieldalso highly significantly ($P<0.001$) affected by Nitrogen rate andthe interaction of row spacing and N-level, But main effect of row spacing was not significant. The combined analysis of the three location showed, the highest grain yield (4704.6 kg ha^{-1}) was obtainedby row spacing of 20 cm and 96 kg N ha^{-1}. But it was at par with25 and 30 cm row spacing withapplication of 96 kg N ha^{-1}(Table 6).The lowest grain yield was due to 20,25 and 30 cm row spacing with no nitrogen application (Table 6). The numbers of effective tillers m^{-2}, number of grains per panicle and seeds weight might be attributed to the final grain yield increment.

As the N level was increased from 0 to 96 kg ha^{-1},rice grain yield also increased linearly in all row spacing. This showed that N is the main nutrient and plays important role for increasing yield of rice variety. Yordanos *et al*. (2013) indicated similar resultthat the grain yield of rice increased linearly with the increased in nitrogen application rates. Therefore, the higher the number of tillers, especially fertile tillers, and seeds per panicle, the more would be the yield. DAOFW, (1999) indicated thatgrowth and development of cereal crop was determined by row spacing and nitrogen levels.As Rahman*et al,* (2007a) reported, nitrogen level positively influenced grain and straw yield that is turn increased biomass yield.

Thousand kernels weight (TKW) also highly significant (P<0.001) influenced by interaction effect of row spacing and N rate. But the main effect of row spacing and N-rate have not significant on 1000 kernel weight.The highest number of TKW was measured from 20 cm row spacing and 32 kg N ha^{-1} rate (Table 6), but there was no significant difference in interaction effect of 20 cm*64 kg N ha^{-1}, 25 and 30 cm with no N application, and 30 cm with 32kg N ha^{-1}.The smallest TKW was recorded, in treatment 20 cm RS and 96 kg Nha^{-1}, but it was at par with almost all treatment. With increasing N rate from 0 to 92 kg/ha, the seed weight decreased in all row spacing. This might be duo to sink distribution in the seed.Hasegawa *et al.* (1994) reported that increased number of Spikelet's and vigorous growth of rice due to high N application induced competition for carbohydrate available for spikelet formation and grain filling.

Table 6. Interaction effect of nitrogen and row spacing on adjusted grain yield per hectareand thousand kernels weigh of rice (NERICA-4) (2016 & 2018)

Treatmen ts	**AGY(kg/ha)**				**TKW (g)**			
	2016	**Loc 1**	**Loc 2**	**Com**	**2016**	**Loc 1**	**Loc 2**	**Com**
1	2705.2^{g}	1856.4^{d}	2464.2^{cd}	2342^{f}	22.8^{abc}	27.23	26.12^{ef}	25.18^{bcd}
2	4733^{c}	3435.7^{abc}	2688.7^{c}	3619.1^{cd}	24.03^{a}	26.8	26.97^{bcde}	26.08^{a}
3	5041.9^{bc}	3689^{ab}	2888^{bc}	3873^{bc}	23.53^{ab}	26.7	27.28^{abcd}	25.71^{ab}
4	6129.2^{a}	4205.3^{a}	3779.2^{a}	4704.6^{a}	22.13^{bcd}	26.67	26.57^{cdef}	24.56^{d}
5	2841.6^{fg}	2505.1^{cd}	2336.8^{cd}	2561.2^{ef}	23.17^{a}b	26.67	27.85^{ab}	25.95^{ab}
6	3473.6^{ef}	2940.7bcd	2536^{c}	2983.4^{e}	22.47^{bcd}	26.6	25.62^{f}	24.82^{cd}
7	4541.4^{cd}	4157.4^{a}	3729.1^{a}	4142.6a^{bc}	21.2^{d}	26.37	26.30^{def}	24.73^{d}
8	5565.6^{ab}	4261.7^{a}	3652.2^{ab}	4493.1^{ab}	21.17^{d}	26.33	27.66^{abc}	25.19^{bcd}
9	3476.2^{ef}	2357.8^{cd}	1710.7^{d}	2514.9^{ef}	24.27^{a}	26.33	26.49^{cdef}	25.67^{ab}
10	3913de	2885.8^{bcd}	2569.3^{c}	3122.7^{de}	22.07^{bcd}	26.23	28.4^{a}	25.61^{abc}
11	4641.4^{c}	3432.2^{abc}	3652.9^{ab}	3908.8^{bc}	21.53^{cd}	25.03	27.45^{abcd}	24.62^{d}
12	5441.1^{b}	4498.8^{a}	3508.4^{ab}	4482.8^{ab}	22.1^{bcd}	24.87	26.86^{bcdef}	25.2^{bcd}
LSD(5%)	**640.8*** **	**1175.3**	**774.7** **	**631.51** **	**1.5*** **	**NS**	**1.26** **	**0.78** **
CV (%)	**9.87**	**20.7**	**15.46**	**18.85**	**3.94**	**3.11**	**2.76**	**3.31**

**, ** = significant at 0.05 and 0.01 probability levels respectively; NS = not significant; and means with the same letter are not statistically different; AGY=adjusted grain yield per hectare; TKY=thousand kernel weight in gram; Loc1and Loc2= on station and on farmers field 2018 respectively and Com=combined of the three location.*

3.2. Partial budget analysis

Partial budgetand dominance analysis were also carried out taking mean grain paddy rice yield, straw yield and prices of input and output from the nearby Pawe market (Table 7). The partial market price of input and net benefit were calculated each year with each location and combinedto once. Marginal acceptable rates of return(MARR) were calculated and compared with minimum acceptable rate of return(MARR) to see most profitable treatment. For treatments to be considered worthwhile option, MARR need to be at least between 50 and 100% (CIMMYT, 1988). The price of paddy rice yield was 6.3 birr kg^{-1}in 2017 and 9 birr kg^{-1}in 2019 and straw yield price was 750 birr ton^{-1}in 2017 and 1154 birr ton^{-1}in 2019at Pawe in January and February used for economic analysis**.**

Under both price assumptions, therefore, the treatment 30 cm RS with 96kg ha^{-1}, resulted in optimum net benefit showing the strength of the treatment. The marginal rates of return(MARR) 295.95% was the most profitable rate in the current finding, because it was well above MARR, 100% and produced an additional mean seed yield advantage of 194.12% over the lowest grain yield. Hence, the economic analysis suggests that marginal benefits of rice was higherin 30 cm row spacing and a rate of 96 kg N ha^{-1}, because it gave the highest net benefit, 28358.68EB/ha. However, that optimal fertilizer rates determined on an economic basis are smaller than those required to produce maximum crop yields.

Table7. Partial budget analysis for on-station and on farm trial on up land rice (NERICA-4) (2016 and 2018)

Treatment	**AGY (10%)**	**STY (10%)**	**TVC (Et birr)**	**GB (Et Birr)**	**NB (Et Birr)**	**MARR (%)**
1 (20 cm RS*0 kg N/ha)	2189.475	2.09	3810.428	18410.36	14599.93	D
2(20 cm RS*32 kg N/ha)	3507.84	3.27	5731.546	28900.29	23168.75	307.49
3(20 cm RS*64 kg N/ha)	3748.68	3.39	6568.211	30847.12	24278.91	D
4(20 cm RS*96 kg N/ha)	4554.653	4.69	8114.751	37879.32	29764.57	218.51
5 (25 cm RS*0 kg N/ha)	2368.148	2.2	3771.626	19962.45	16190.82	D
6 (25 cm RS*32 kg N/ha)	2795.378	3.16	4793.56	23882.25	19088.69	D
7 (25 cm RS*64 kg N/ha)	3818.093	3.84	6461.08	32470.35	26009.27	343.69
8 (25 cm RS*96 kg N/ha)	4285.148	4.34	7481.016	35860.77	28379.75	9.32
9 (30 cm RS*0 kg N/ha)	2479.703	2.15	3645.8	20123.62	16477.82	.
10 (30 cm RS*32 kg N/ha)	2988.248	3.09	4778.815	25017.97	20239.16	331.97
11 (30 cm RS*64 kg N/ha)	3682.778	3.58	6099.468	30865.88	24766.41	434.24
12(30 cm RS*96 kg N/ha)	4250.115	4.19	7254.933	35613.61	28358.68	295.95

AGY = Adjusted grain yield (kg/ha)
ASTY=Adjusted straw yield (Ton/ha)
GB = Gross field benefit (EB/ha)
TCV = Total cost that vary (EB/ha)
MARR= Marginal acceptable rate of return (%)
D = Dominated treatment
NB = Net benefit (EB/ha)
EB = Ethiopian Birr

Conclusions

From the results discussed, the yield and yield components of upland rice (NERICA-4) variety were affected by nitrogen rate, row spacing and its interaction. It can be concluded that in areas like Pawe with humid-tropical type of climate and abundant precipitation, farmers can apply 96 kg Nha^{-1} with the row spacing of 30 cm gives maximum grain yield (4428.8 kg ha^{-1}). As can be seen from the partial budget analysis, under all price assumptions the interaction of 96 kg N $ha^{-1}$with 30 cm gave highest MARR, 295.95% suggesting that it was the most profitable fertilizer rate under the current finding, and gave an additional grain yield advantage of 194.12% compared controlled treatment (2189.47 kg ha^{-1}).

The higher seed yield advantage and higher economic benefit from the application of 96kg Nha^{-1}at 30 cm, however, this was not necessarily the economic optimum level for rice production as nutrient response curve was not obtained. In other words, if more than 96kg nitrogen ha^{-1} was applied during the experiment that higher level of N still might have resulted in the higher net benefit. Therefore, it is important to do further research's with increasing rate of nitrogen tothe above recommendationconsidering rice crop's wider ecological adaptation and nitrogen management which needs special attention. Better timing, placement methods and nitrogen formulation with other nutrients like phosphorus should be given in the future investigations.

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