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# Economics of direct seeding methods of upland rice production in the Northern Guinea Savanna

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## Abstract

This study assessed the economic impacts of direct seeding of rice as an alternative crop establishment method for farmers in Samaru, Zaria in the Northern Guinea Savanna of Nigeria. Specifically, it examined the changes in farmers' inputs (labour and inputs) and level of productivity and incomes among direct-seeded methods such as broadcasting, drilling and dibbling and measured the economic returns on investment in direct seeding. Analyses included cost and return, and economic surplus framework. The economic analysis of upland rice production at both locations indicated that production of NERICA 8 and JAMILA by either broadcasting or drilling method at the seed rate of 80 kg $ha^{-1}$ gave the highest gross margin as well as return on investment. The result revealed that NERICA 8 and JAMILA sown by broadcasting method at 80 kg $ha^{-1}$ was the most profitable with gross margin of ₦246, 166.50 with return on investment of ₦6.72. This was followed by broadcasting JAMILA at 120 kg $ha^{-1}$ seed rate which gave a gross margin of ₦194, 583.50 and return on investment of ₦4.32. However, the least gross margin of ₦61, 249.85 was observed when NERICA 4 was dibbled at 120 kg $ha^{-1}$ which brought a loss of ₦16, 716.50 and ₦ 0.62k was lost per every naira invested.

**Keywords:** Economics, Direct Seeding, Upland Rice, Production

## Introduction

Rice is the world's most important crop and is a staple food for more than half of the world's population. Worldwide, rice is grown on 161 million hectares, with an annual production of about 678.7 million tons of paddy (FAO, 2009). About 90% of the world's rice is grown and produced (143 million ha of area with a production of 612 million tons of paddy) in Asia (FAO, 2009). Rice provides 30–75% of the total calories to more than 3 billion people (Khush, 1997; Von Braun and Bos, 2004). To meet the global rice demand, it is estimated that about 114 million tons of additional milled rice need to be produced by 2035, which is equivalent to an overall increase of 26% in the next 25 years (Yamano et al., 2016). The possibility of expanding the area under rice in the near future is limited. Therefore, this extra rice production needed has to come from a productivity gain. The major challenge to achieve this gain is less water, labour and chemicals (Hira, 2009)

A major reason for farmers' interest in direct seeding is the rising cost of cultivation and decreasing profits with conventional practice. Farmers likely prefer a technology that gives higher profit despite similar or slightly lower yield. Studies shows that various methods of direct seeding reduced the cost of production by US$9125 $ha^{-1}$ compared with conventional practice of transplanting (Inayat-Ali et al., 2012; Santhi et al., 1998). The largest reductions in cost occurred in practices in which zero tillage was combined with direct seeding. These cost reductions

were largely due to either reduced labour cost or tillage cost or both under direct seeding method. In areas where wages are high the labour cost savings in rice establishment can reach US$50 $ha^{-1}$ (Kumar et al., 2009).

The conventional method of rice growing is not only water-guzzling but also cumbersome and laborious. Rice transplanting requires 200-250 man-hour $ha^{-1}$, which is 25% of the total requirement for the rice crop production (Anoop et al., 2007). The problem has further been intensified with the timely unavailability of labour. Delay in transplanting beyond optimum time due to labour scarcity is creating a reduction in rice yield. Further, reduced labour availability is increasing the cost of transplanting and squeezing the farmer's profit as the cost of transplanting is increasing continuously. Paddy transplanting by labour also results in low and non-uniform plant population due to which crop yields are reduced (Mahajan et al., 2009). The productivity and sustainability of rice-based systems are threatened because of the inefficient use of inputs; increasing scarcity of resources, especially water and labour; changing climate; the emerging energy crisis and rising fuel prices; the rising cost of cultivation and emerging socio-economic changes such as urbanization, migration of labour, preferences of non-agricultural work, concerns about farm-related pollution (Kumar and Ladha, 2011). Conventional tillage and crop establishment by transplanting is the most input intensive process in crop production and, therefore, more efficient alternatives are urgently needed. Potential solutions is a shift from manual transplanting to direct seeded rice. Direct seeded rice with zero tillage system performed as well as the conventional practice but with significant savings in water and labour use (Bhusan et al., 2007). Direct-seeding is cost-effective, can save water through earlier rice crop establishment (Ladha et al., 2003a; Singh et al.,, 2003). With alternate wetting and drying cycles in direct seeding, the crop is subjected to greater weed competition than transplanted rice because weeds emerge before or at the same time as the rice (Chuhan, 2012). Therefore, heavy weed infestation is a major problem in direct seeded rice and its success lies in effective weed control measures (Singh et al.,, 2003; Rao et al.,, 2007), as failure to eliminate weeds may result in low or no yield (Estorninos and Moody, 1988). Therefore, the study aimed at evaluating the economics of direct seeding methods of upland rice varieties with a goal for finding most suitable ones with a potential to cover large area with similar agro ecological conditions.

## Materials and Methods

The field trials were conducted on the experimental farm of the Institute for Agricultural Research, Ahmadu Bello University Samaru, Zaria and on the Research Farm of the Kaduna State Agricultural Development Programme, Maigana in 2011 and 2012 cropping seasons. Samaru is on the Latitude $11^{o}11^{1}$ N and Longitude $7\ ^{o}38^{1}$ E and is 686 m above sea level while Maigana is located on Latitude $11^{o}11.06^{1}$ N and Longitude $7.54^{o}$ $7.58^{1}$ E both in the Northern Guinea Savannah Agro ecological zone of Nigeria. Random samples of soils were taken at depth of 0-30cm from the experimental sites using an auger of 10 cm diameter before land preparation and were analysed for physical and chemical properties.

The treatments consisted of three seeding methods (broadcasting, drilling and dibbling), three seed rates (40, 80 and 120 kg $ha^{-1}$) and three upland rice varieties (NERICA 4, 8 and JAMILA). The treatments were laid out in a split plot design with the combination of sowing methods and seed rates in the main plots and three rice varieties in the sub plots measuring 3 m x 3 m with a net plot of 2 m x 2 m and were replicated three times. The main plots were separated by a distance of 1 m and the sub plots by 0.5 m. Pre-planting herbicides, glyphosate (round up) was applied to the experimental sites at the rate 2 kg active ingredients $ha^{-1}$ two weeks before land preparation in each year of the study in order to control the prevalent weeds on the field. Thereafter, the field was harrowed twice to ensure fine tilth of the soil and the soil levelled manually.

Seeds of each variety were treated with Apron star as seed dressing chemical at the rate of 1.0 g of metalaxy to 3.0 kg seed to prevent pest attack and the three rice varieties were planted on 13th July 2011 and 9th June 2012 at Samaru while at Maigana, the varieties were planted on 30th July 2011 and 12th June 2012 when the rains were fully stabilized using direct seeding such as broadcasting, drilling and dibbling methods. Also hand pulling methods of weed control was used to control the weeds that later emerged at four and eight weeks after sowing. Fertilizers were applied at the recommended rate of 100 kg N $ha^{-1}$, 50 kg $P_2O_5$ $ha^{-1}$ and 50 kg $K_2O$ $ha^{-1}$. The nitrogen fertilizer were applied as split, half of the nitrogen fertilizer together with 50 kg $P_2O_5$ and 50 kg $K_2O$ $ha^{-1}$ were applied once

at two weeks after sowing using NPK (15:15:15) while the second half of the nitrogen were applied at panicle initiation stage using urea (46% N). Economics and energy analysis was done by taking pooled data of both the years. The economic analysis was measured using the partial budget procedure to determine the economic return. The data obtained was subjected to economic analysis where the returns and variable costs were calculated and gross margin (GM) and return on investment (ROI) was also determined. This depended on the prevailing market prices of inputs, labour and outputs. This was computed as:

GM=TR-TVC (Olukosi and Erhabor, 1988).

Where;
TR= Total revenue per hectare.
TVC=Total variable cost (sum of labour and material input cost) per hectare.

ROI =Net return /TVC X 100/1

Where; Net return = Total revenue (yield x output price) – TVC

## Results and Discussion

The physical and chemical properties of the soil used during the experimental periods at Samaru and Maigana are summarized in Table1. In 2011 at Samaru, the physico-chemical properties of the field on which the experiment was conducted showed that the soil was clay loam, slightly acidic with moderate total nitrogen and available phosphorus and low potassium and CEC and high organic carbon. In 2012 cropping season the soil was silt loam, slightly acidic with high total nitrogen; available phosphorus and potassium were moderate while organic carbon and CEC were low. At Maigana in 2011, the soil was silt clay loam, slightly acidic with high total nitrogen and organic carbon while available phosphorus, potassium and CEC were low. In 2012, the soil was sandy loam, slightly acidic with high total nitrogen while available P, K was moderate and organic carbon was high

The cost and return analysis per hectare on investment of growing upland rice varieties using different sowing methods and seed rates in 2011, 2012 wet seasons and the combined at Samaru and Maigana are presented in Tables 3 to 8. At Samaru in 2011, the result revealed that NERICA 8 sown by broadcasting method at 80 kg ha$^{-1}$ was the most profitable with gross margin of ₦129, 793.25 and Return on Investment of ₦3.02 which implied that for every ₦1.00 invested ₦2.02 was realized. Similarly, it was followed by NERICA 8 sown by broadcasting method at 120 kg ha$^{-1}$ seed rate which gave a gross margin of ₦95, 787.65 and Return on Investment of ₦2.23 which implied that for every ₦1.00 invested ₦1.23 was realized. However, the sowing of JAMILA with dibbling method at 120 kg ha$^{-1}$ brought a loss of ₦17, 932.50 and ₦ 0.34k was lost per naira invested.

In 2012, the use of broadcasting method to sow JAMILA at 80 kg ha$^{-1}$ seed rate was the most profitable with gross margin of ₦198, 750.00 and return on investment of of ₦4.42 indicating that for ₦1.00 invested ₦3.42 was realized. This was followed by broadcasting JAMILA at 120 kg ha$^{-1}$ seed rate which gave a gross margin of ₦194, 583.50 and return on investment of ₦4.32. There was no loss incurred during this year's production. However, the least gross margin of ₦61, 249.85 and return on investment of ₦1.11 was observed when NERICA 4 was dibbled at 80 kg ha$^{-1}$ seed rate.

The combined economic analysis indicated that broadcasting NERICA 8 at 80 kg ha$^{-1}$ seed rate was the most profitable with gross margin of ₦ 146, 215.00 and return on investment of ₦4.32 which indicated that for every ₦1.00 invested, ₦ 3.32 was realized. This was closely followed by either drilled NERICA 8 or JAMILA at 80 kg ha$^{-1}$ seed rate which gave a gross margin of ₦141, 194.30 and return on investment of ₦3.88.The least gross margin of ₦35, 467.65 and return on investment of ₦1.66 was observed when NERICA 4 was dibbled at 120 kg ha$^{-1}$ seed rate. Net returns in broadcasting was at par with drilling method and were higher than dibbling method. Kumar (2011) also observed similar findings and found higher B:C ratio in direct seeding as compared to manual puddled transplanted rice .

At Maigana in 2011, the result indicated that the highest gross margin of ₦119, 581.50 and return on investment of ₦3.85 was achieved by broadcasting NERICA 8 at 80 kg ha$^{-1}$ seed rate. This was followed by drilled NERICA 8 at 80 kg ha$^{-1}$ which gave a gross margin of ₦30, 832.50 and return on investment of ₦1.73. However, dibbled JAMILA at 120 kg ha$^{-1}$ brought a loss of ₦16, 716.50 and 0.62k was lost per every naira invested.

In 2012 and the combined, the result indicated that the highest gross margin was by drilled JAMILA at 80 kg ha$^{-1}$ seed rate. The gross margin of 2012 and the combined were ₦246, 166.50 with return on

investment of₦ 6.72 and ₦182, 874.00 with return on investment of ₦5.30 respectively. This was followed by drilled JAMILA at 120 kg $ha^{-1}$ seed rate with gross margin of ₦198, 666.50 and return on investment of₦ 5.62, gross margin of ₦98, 547.50 and return on investment of ₦3.32 for 2012 and the combined data. However, the least gross margin was observed when NERICA 8 was dibbled at 40 kg $ha^{-1}$ seed rate in 2012 and the combined were ₦24, 375.15 with return on investment of ₦1.54 and ₦11, 187.50 with return on investment of ₦1.25. In paddy, a labour saving of 95-99 percent in broadcasting or drilling methods were observed as compared to bibbling method during both years of the study and total labour use mainly depends on the weed management. In present study we made two hand weeding to cope up with weeds as the herbicide used were not so effective, which ultimately resulted in more labour use and higher cost of production. In overall, broadcasting and drilling methods had more percent labour saving as compared to dibbling method in both years of the study. Sehrawat et al. (2010) also observed 13-16% labour saving in direct seeding as compared to manual puddled transplanted rice.

Economic analysis is the ultimate yard stick to recommend a production technology. The loss incurred at both locations in 2011 was due to low rainfall recorded in that year.

Generally, throughout the study, increase in total revenue resulted an increase in gross margin in all the three sowing methods used in the study. In 2011 at Samaru, the maximum gross margin obtained from broadcasting method was due to the fact that crops established with these methods matured early than drilling and dibbling method. This helped the crops to escape the stress as a result of late planting as well early cessation of rainfall in that year and thereby resulted in highest yield. Despite the higher cost of production in 2012 wet season and the combined at Samaru, the highest gross margin obtained from broadcasting and drilling method were due to higher grain yield as a result of better rain fall recorded in that year at the experimental sites. Generally, dibbling method consistently produced the least gross margin throughout the study at both locations. This was due to the low yield recorded when rice was sown using this method throughout the study period. In 2011 at both locations, the lowest gross margin was recorded as well as the loss incurred was due to low yield as a result of late planting. However, the highest gross margin in that year was obtained from the broadcasting method at 80 kg of NERICA 8. The differences in gross margin in the two years at both locations could be attributed to the differences in cost of production as well as the market price. In this country it was discovered that prices of materials at different locations increase as the years passed by without necessarily increase the price of the farm produce. In this study, the cost of production at Maigana was far cheaper than Samaru especially the cost of labour and as well as some inputs such as fertilizers.

In both locations, the cost of labour such as weed control in broadcasting and drilling methods were lower than that of dibbling method. The highest difference in labour cost was in crop establishment. This reduced need for labour not only saves time and money of farmers but also allows greater flexibility so that farmers can attend other activities either in farm or at home. Higher expenditures on seeds were expected in direct seeding methods because higher seeding rates are required for direct seeding relative to transplanting. Farmers who practiced direct seeding were more reliant on herbicides simply because they cannot rely on flooding to suppress weeds during the crucial initial period of crop establishment (Johnson 2006). On the other hand, expenditures on fertilizers, and rent in land preparation were lower for direct seeding than transplanting. This was because farmers were inclined to use more fertilizers as a treatment or preventive measure against transplanting shock.

Previous studies had found that direct seeding may obtain a lower yield due to the unstable establishment of rice seedlings and slow growth during the early growing stage (Kimio et al., 1999). Yield in direct seeding can be also reduced by weed problems. Yield losses (due to weeds) largely depend on season, weed species, weed density, rice cultivar, and growth rate and density of weeds and rice (Azmi et al., 2005). Another factor affecting yield in direct seeding is seed rate. A seed rate higher than the recommended rate can result in lower yield of direct seeding since it may lead to nitrogen deficiency, thus reducing tillering and increasing the proportion of ineffective tillers, to attacks of brown plant hoppers, and to crop lodging. However, yield of direct seeding is not always lower than that of transplanting. Rice yields of wet- or dry-seeded crops have been higher than those of transplanted crops, provided weeds are adequately controlled (Johnson et al., 2003) .Higher rice yield resulting from direct seeding is due to the shorter time it takes for direct seeding rice to reach maturity. This

allows for on-time planting, thus saving farmers from a 1 percent (or more) reduction in yield per day (Hobbs 2001).

Rainfall at Samaru during the experimental period was 945.2 and 1333.3mm in 2011 and 2012 respectively (Table 2). Rain started in 2011 on 16th April and ended on 11th October with a total of 73 rainy days. In 2012, rain commenced on10th April and terminated on 24tth October with a total of 76 rainy days. Rainfall at Maigana during the experimental period was 636.6 and 762.9 in 2011 and 2012 respectively. Rain started in 2011 on 25th April and ended on 12th October with a total of 67 rainy days. In 2012, rain commenced on 17th April and ended on 22nd October with a total of 70 rainy days. Generally, rainfall was not evenly distributed during the conduct of this research. Rain was low at both locations in 2011 with Maigana recording lower rainfall in the two years of this study when compared with Samaru.

**Table – 1: Physical and Chemical Properties of soil (0-30cm) collected from the Experimental Sites**

| | Samaru | | Maigana | |
|---|---|---|---|---|
| **Soil Properties** | **2011** | **2012** | **2011** | **2012** |
| **Physical Properties** | | | | |
| Sand (g/kg) | 222.00 | 240.00 | 192.00 | 520.00 |
| Silt (g/kg) | 474.00 | 540.00 | 504.00 | 380.00 |
| Clay (g/kg) | 304.00 | 220.00 | 304.00 | 100.00 |
| Textural Class | Clay loam | Silt loam | Silty Clay loam | Sandy loam |
| **Chemical Properties** | | | | |
| pH in 0.01M $CaCL_2$ | 4.28 | 5.98 | 4.35 | 4.55 |
| Organic Carbon (g/kg) | 13.6 | 2.10 | 16.00 | 20.40 |
| Total Nitrogen (g/kg) | 1.70 | 9.00 | 2.20 | 10.10 |
| Available P mg/Kg | 3.05 | 1.42 | 4.48 | 2.84 |
| **Exchangeable Cation (cmol/kg)** | | | | |
| K | 0.15 | 0.22 | 0.17 | 0.22 |
| Mg | 0.59 | 2.00 | 0.63 | 1.76 |
| Ca | 0.59 | 3.00 | 0.61 | 5.00 |
| Na | 7.32 | 1.60 | 9.10 | 1.60 |
| CEC | 4.28 | 5.20 | 4.35 | 2.90 |

**Table – 2: Rainfall Distribution at Samaru and Maigana during 2011 and 2012 Cropping Seasons**

| | Samaru | 2011 | 2012 | | Maigana | 2011 | 2012 | |
|---|---|---|---|---|---|---|---|---|
| **MONTHS** | **Amount of Rainfall** | **Rainy days** | **Amount of Rainfall** | **Rainy days** | **Amount of Rainfall** | **Rainy days** | **Amount of Rainfall** | **Rainy days** |
| January | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| February | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| March | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| April | 27.8 | 4 | 7.3 | 3 | 36.4 | 1 | 21.1 | 4 |
| May | 123.3 | 11 | 263.4 | 15 | 63.4 | 8 | 109.6 | 14 |
| June | 162.5 | 12 | 120.7 | 8 | 102.5 | 15 | 145.7 | 13 |
| July | 223.9 | 14 | 165.3 | 12 | 113.2 | 12 | 150.4 | 15 |
| August | 239.9 | 16 | 426.7 | 16 | 165.2 | 16 | 130.5 | 19 |
| September | 113.8 | 12 | 270.3 | 17 | 89.1 | 19 | 191 | 18 |
| October | 54 | 4 | 79.6 | 5 | 66.8 | 5 | 14.6 | 3 |
| November | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| December | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| TOTAL | 945.2 | 73 | 1333.3 | 76 | 636.6 | 76 | 762.9 | 86 |

**Table – 3: Economic analysis of cost and return on investment of growing upland rice varieties using seed rate and sowing method at Samaru in 2011 wet season.**

| Variety | Sowing method | Seed rate (kg ha$^{-1}$) | Total yield (Kg ha$^{-1}$) | No. of bags (100kg) | Average Price/bag 100kgha[1] ₦ | Total revenue (TR) (₦ ha$^{-1}$) | Total variable cost (TVC) (₦ ha$^{-1}$) | Gross margin (TR- TVC) (₦ ha$^{-1}$) | Return on investment (ROI) ₦ |
|---|---|---|---|---|---|---|---|---|---|
| NERICA 4 | Broadcasting | 40 | 1088.67 | 10.89 | 4500 | 48990.15 | 43000 | 5990.15 | 0.14 |
| NERICA 4 | Broadcasting | 80 | 2413.08 | 24.13 | 4500 | 108588.60 | 43000 | 65588.60 | 1.53 |
| NERICA 4 | Broadcasting | 120 | 1395.77 | 13.96 | 4500 | 62809.65 | 43000 | 19809.65 | 0.46 |
| NERICA 4 | Drilling | 40 | 1517.92 | 15.18 | 4500 | 68306.40 | 48000 | 20306.40 | 0.42 |
| NERICA 4 | Drilling | 80 | 1710.75 | 17.11 | 4500 | 76983.75 | 48000 | 28983.75 | 0.60 |
| NERICA 4 | Drilling | 120 | 1895.43 | 18.95 | 4500 | 85294.35 | 48000 | 37294.35 | 0.78 |
| NERICA 4 | Dibbling | 40 | 1565.17 | 15.65 | 4500 | 70432.65 | 53000 | 17432.65 | 0.33 |
| NERICA 4 | Dibbling | 80 | 1699.48 | 16.99 | 4500 | 76476.60 | 53000 | 23476.60 | 0.44 |
| NERICA 4 | Dibbling | 120 | 1101.33 | 11.01 | 4500 | 49559.85 | 53000 | -3440.15 | -0.06 |
| NERICA 8 | Broadcasting | 40 | 1666.58 | 16.67 | 4500 | 74996.10 | 43000 | 31996.10 | 0.74 |
| NERICA 8 | Broadcasting | 80 | 3839.85 | 38.40 | 4500 | 172793.25 | 43000 | 129793.25 | 3.02 |
| NERICA 8 | Broadcasting | 120 | 3084.17 | 30.84 | 4500 | 138787.65 | 43000 | 95787.65 | 2.23 |
| NERICA 8 | Drilling | 40 | 2289.02 | 22.89 | 4500 | 103005.90 | 48000 | 55005.90 | 1.15 |
| NERICA 8 | Drilling | 80 | 2994.75 | 29.95 | 4500 | 134763.75 | 48000 | 86763.75 | 1.81 |
| NERICA 8 | Drilling | 120 | 2757.83 | 27.58 | 4500 | 124102.35 | 48000 | 76102.35 | 1.59 |
| NERICA 8 | Dibbling | 40 | 1876.5 | 18.77 | 4500 | 84442.50 | 53000 | 31442.50 | 0.59 |
| NERICA 8 | Dibbling | 80 | 2537.92 | 25.38 | 4500 | 114206.40 | 53000 | 61206.40 | 1.15 |
| NERICA 8 | Dibbling | 120 | 1279.67 | 12.80 | 4500 | 57585.15 | 53000 | 4585.15 | 0.09 |
| JAMILA | Broadcasting | 40 | 917.33 | 9.17 | 5000 | 45866.50 | 43000 | 2866.50 | 0.07 |
| JAMILA | Broadcasting | 80 | 1342.16 | 13.42 | 5000 | 67108.00 | 43000 | 24108.00 | 0.56 |
| JAMILA | Broadcasting | 120 | 969.58 | 9.70 | 5000 | 48479.00 | 43000 | 5479.00 | 0.13 |
| JAMILA | Drilling | 40 | 868.01 | 8.68 | 5000 | 43400.50 | 48000 | -4599.50 | -0.10 |
| JAMILA | Drilling | 80 | 1080.83 | 10.81 | 5000 | 54041.50 | 48000 | 6041.50 | 0.13 |
| JAMILA | Drilling | 120 | 1094.85 | 10.95 | 5000 | 54742.50 | 48000 | 6742.50 | 0.14 |
| JAMILA | Dibbling | 40 | 967.85 | 9.68 | 5000 | 48392.50 | 53000 | -4607.50 | -0.09 |
| JAMILA | Dibbling | 80 | 1014.55 | 10.15 | 5000 | 50727.50 | 53000 | -2272.50 | -0.04 |
| JAMILA | Dibbling | 120 | 701.35 | 7.01 | 5000 | 35067.50 | 53000 | -17932.50 | -0.34 |

Calculation of total revenue was based on market prevailing prices of ₦4,500.00 and ₦5000.00 per 100 kg bag of NERICAs and JAMILA respectively at Samaru and environs.

**Table – 4: Economic analysis of cost and return on investment of growing upland rice varieties using seed rate and sowing method at Samaru in 2012 wet season.**

| Variety | Sowing method | Seed rate kg ha$^{-1}$ | Total yield Kg ha$^{-1}$ | No. of bags (100kg) | Average Price/bag ₦ | Total revenue (TR) ₦ ha$^{-1}$ | Total variable cost (TVC) ₦ ha$^{-1}$ | Gross margin (TR- TVC) ₦ ha$^{-1}$ | Return on investment (ROI) ₦ |
|---|---|---|---|---|---|---|---|---|---|
| NERICA 4 | Broadcasting | 40 | 3125.00 | 31.25 | 4500 | 140625.00 | 45000 | 95625.00 | 2.13 |
| NERICA 4 | Broadcasting | 80 | 3500.00 | 35.00 | 4500 | 157500.00 | 45000 | 112500.00 | 2.50 |
| NERICA 4 | Broadcasting | 120 | 2833.33 | 28.33 | 4500 | 127499.85 | 45000 | 82499.85 | 1.83 |
| NERICA 4 | Drilling | 40 | 3541.67 | 35.42 | 4500 | 159375.15 | 50000 | 109375.15 | 2.19 |
| NERICA 4 | Drilling | 80 | 4208.33 | 42.08 | 4500 | 189374.85 | 50000 | 139374.85 | 2.79 |
| NERICA 4 | Drilling | 120 | 4208.33 | 42.08 | 4500 | 189374.85 | 50000 | 139374.85 | 2.79 |
| NERICA 4 | Dibbling | 40 | 2708.33 | 27.08 | 4500 | 121874.85 | 55000 | 66874.85 | 1.22 |
| NERICA 4 | Dibbling | 80 | 2583.33 | 25.83 | 4500 | 116249.85 | 55000 | 61249.85 | 1.11 |
| NERICA 4 | Dibbling | 120 | 2875.00 | 28.75 | 4500 | 129375.00 | 55000 | 74375.00 | 1.35 |
| NERICA 8 | Broadcasting | 40 | 3083.33 | 30.83 | 4500 | 138749.85 | 45000 | 93749.85 | 2.08 |
| NERICA 8 | Broadcasting | 80 | 4666.67 | 46.67 | 4500 | 210000.15 | 45000 | 165000.15 | 3.67 |
| NERICA 8 | Broadcasting | 120 | 3750.00 | 37.50 | 4500 | 168750.00 | 45000 | 123750.00 | 2.75 |
| NERICA 8 | Drilling | 40 | 3583.33 | 35.83 | 4500 | 161249.85 | 50000 | 111249.85 | 2.22 |
| NERICA 8 | Drilling | 80 | 5458.33 | 54.58 | 4500 | 245624.85 | 50000 | 195624.85 | 3.91 |
| NERICA 8 | Drilling | 120 | 3958.33 | 39.58 | 4500 | 178124.85 | 50000 | 128124.85 | 2.56 |
| NERICA 8 | Dibbling | 40 | 4125.00 | 41.25 | 4500 | 185625.00 | 55000 | 130625.00 | 2.38 |
| NERICA 8 | Dibbling | 80 | 4125.00 | 41.25 | 4500 | 185625.00 | 55000 | 130625.00 | 2.38 |
| NERICA 8 | Dibbling | 120 | 3000.00 | 30.00 | 4500 | 135000.00 | 55000 | 80000.00 | 1.45 |
| JAMILA | Broadcasting | 40 | 3208.00 | 32.08 | 5000 | 160400.00 | 45000 | 115400.00 | 2.56 |
| JAMILA | Broadcasting | 80 | 4875.00 | 48.75 | 5000 | 243750.00 | 45000 | 198750.00 | 4.42 |
| JAMILA | Broadcasting | 120 | 4791.67 | 47.92 | 5000 | 239583.50 | 45000 | 194583.50 | 4.32 |
| JAMILA | Drilling | 40 | 4875.00 | 48.75 | 5000 | 243750.00 | 50000 | 193750.00 | 3.88 |
| JAMILA | Drilling | 80 | 4208.33 | 42.08 | 5000 | 210416.50 | 50000 | 160416.50 | 3.21 |
| JAMILA | Drilling | 120 | 5150.00 | 51.50 | 5000 | 257500.00 | 50000 | 207500.00 | 4.15 |
| JAMILA | Dibbling | 40 | 3458.33 | 34.58 | 5000 | 172916.50 | 55000 | 117916.50 | 2.14 |
| JAMILA | Dibbling | 80 | 4833.33 | 48.33 | 5000 | 241666.50 | 55000 | 186666.50 | 3.39 |
| JAMILA | Dibbling | 120 | 3625.00 | 36.25 | 5000 | 181250.00 | 55000 | 126250.00 | 2.30 |

Calculation of total revenue was based on market prevailing prices of ₦4,500.00 and ₦5000.00 per 100 kg bag of NERICAs and JAMILA respectively at Samaru and environs.

**Table – 5: Combined economic analysis of cost and return on investment of growing upland rice varieties using seed rate and sowing method at Samaru in 2011 and 2012 wet seasons**

| Variety | Sowing method | Seed rate (kg ha$^{-1}$) | Total yield (Kg ha$^{-1}$) | No. of bags (100kg) | Average Price/ bag ₦ | Total revenue (TR) ( ₦ ha$^{-1}$) | Total variable cost (TVC) (₦ ha$^{-1}$) | Gross margin (TR- TVC) (₦ ha$^{-1}$) | Return on investment (ROI) ₦ |
|---|---|---|---|---|---|---|---|---|---|
| NERICA 4 | Broadcasting | 40 | 2106.83 | 21.07 | 4500 | 94807.35 | 44000 | 50807.35 | 2.15 |
| NERICA 4 | Broadcasting | 80 | 2956.54 | 29.57 | 4500 | 133044.30 | 44000 | 89044.30 | 3.02 |
| NERICA 4 | Broadcasting | 120 | 2114.55 | 21.15 | 4500 | 95154.75 | 44000 | 51154.75 | 2.16 |
| NERICA 4 | Drilling | 40 | 2529.79 | 25.30 | 4500 | 113840.55 | 49000 | 64840.55 | 2.32 |
| NERICA 4 | Drilling | 80 | 2959.54 | 29.60 | 4500 | 133179.30 | 49000 | 84179.30 | 2.72 |
| NERICA 4 | Drilling | 120 | 3051.88 | 30.52 | 4500 | 137334.60 | 49000 | 88334.60 | 2.80 |
| NERICA 4 | Dibbling | 40 | 2136.75 | 21.37 | 4500 | 96153.75 | 54000 | 42153.75 | 1.78 |
| NERICA 4 | Dibbling | 80 | 2141.41 | 21.41 | 4500 | 96363.45 | 54000 | 42363.45 | 1.78 |
| NERICA 4 | Dibbling | 120 | 1988.17 | 19.88 | 4500 | 89467.65 | 54000 | 35467.65 | 1.66 |
| NERICA 8 | Broadcasting | 40 | 2374.96 | 23.75 | 4500 | 106873.20 | 44000 | 62873.20 | 2.43 |
| NERICA 8 | Broadcasting | 80 | 4226.54 | 42.27 | 4500 | 190215.00 | 44000 | 146215.00 | 4.32 |
| NERICA 8 | Broadcasting | 120 | 3694.92 | 36.95 | 4500 | 166275.00 | 44000 | 122275.00 | 3.78 |
| NERICA 8 | Drilling | 40 | 2936.18 | 29.36 | 4500 | 132128.10 | 49000 | 83128.10 | 2.70 |
| NERICA 8 | Drilling | 80 | 4226.54 | 42.27 | 4500 | 190194.30 | 49000 | 141194.30 | 3.88 |
| NERICA 8 | Drilling | 120 | 3358.08 | 33.58 | 4500 | 151113.60 | 49000 | 102113.60 | 3.08 |
| NERICA 8 | Dibbling | 40 | 3000.75 | 30.01 | 4500 | 135033.75 | 54000 | 81033.75 | 2.50 |
| NERICA 8 | Dibbling | 80 | 3331.46 | 33.31 | 4500 | 149915.70 | 54000 | 95915.70 | 2.78 |
| NERICA 8 | Dibbling | 120 | 2139.83 | 21.40 | 4500 | 96292.35 | 54000 | 42292.35 | 1.78 |
| JAMILA | Broadcasting | 40 | 2062.83 | 20.63 | 5000 | 103141.50 | 44000 | 59141.50 | 2.34 |
| JAMILA | Broadcasting | 80 | 3066.92 | 30.67 | 5000 | 153346.00 | 44000 | 109346.00 | 3.49 |
| JAMILA | Broadcasting | 120 | 2922.29 | 29.22 | 5000 | 146114.50 | 44000 | 102114.50 | 3.32 |
| JAMILA | Drilling | 40 | 2871.51 | 28.72 | 5000 | 143575.50 | 49000 | 94575.50 | 2.93 |
| JAMILA | Drilling | 80 | 3804.58 | 38.05 | 5000 | 190229.00 | 49000 | 141229.00 | 3.88 |
| JAMILA | Drilling | 120 | 3122.43 | 31.22 | 5000 | 156121.50 | 49000 | 107121.50 | 3.19 |
| JAMILA | Dibbling | 40 | 2213.09 | 22.13 | 5000 | 110654.50 | 54000 | 56654.50 | 2.05 |
| JAMILA | Dibbling | 80 | 2923.94 | 29.24 | 5000 | 146197.00 | 54000 | 92197.00 | 2.71 |
| JAMILA | Dibbling | 120 | 2163.18 | 21.63 | 5000 | 108159.00 | 54000 | 54159.00 | 2.002 |

Calculation of total revenue was based on market prevailing prices of ₦4,500.00 and ₦5000.00 per 100 kg bag of NERICAs and JAMILA respectively at Samaru and environs.

**Table – 6: Economic analysis of cost and return on investment of growing upland rice varieties using seed rate and sowing methods at Maigana in 2011 wet season.**

| Variety | Sowing method | Seed rate (kg ha$^{-1}$) | Total yield (Kg ha$^{-1}$) | No. of bags (100kg) | Average Price/ bag ₦ | Total revenue (TR) (₦ ha$^{-1}$) | Total variable cost (TVC) (₦ ha$^{-1}$) | Gross margin (TR- TVC) (₦ ha$^{-1}$) | Return on investment (ROI) ₦ |
|---|---|---|---|---|---|---|---|---|---|
| NERICA 4 | Broadcasting | 40 | 718.67 | 7.19 | 4500 | 32340.15 | 40000 | -7659.85 | -0.81 |
| NERICA 4 | Broadcasting | 80 | 1451.20 | 14.51 | 4500 | 65304.00 | 40000 | 25304.00 | 1.63 |
| NERICA 4 | Broadcasting | 120 | 946.10 | 9.46 | 4500 | 42574.50 | 40000 | 2574.50 | 1.06 |
| NERICA 4 | Drilling | 40 | 1199.73 | 11.10 | 4500 | 53987.85 | 42000 | 11987.85 | 1.29 |
| NERICA 4 | Drilling | 80 | 1372.73 | 13.73 | 4500 | 61772.85 | 42000 | 19772.85 | 1.47 |
| NERICA 4 | Drilling | 120 | 732.80 | 7.33 | 4500 | 32976.00 | 42000 | -9024.00 | -0.79 |
| NERICA 4 | Dibbling | 40 | 818.72 | 8.19 | 4500 | 36842.40 | 44000 | -7157.60 | -0.84 |
| NERICA 4 | Dibbling | 80 | 1621.83 | 16.22 | 4500 | 72982.35 | 44000 | 28982.35 | 1.66 |
| NERICA 4 | Dibbling | 120 | 1119.62 | 11.20 | 4500 | 50382.90 | 44000 | 6382.90 | 1.15 |
| NERICA 8 | Broadcasting | 40 | 1143.77 | 11.44 | 4500 | 51469.65 | 40000 | 11469.65 | 1.29 |
| NERICA 8 | Broadcasting | 80 | 3231.63 | 32.32 | 5000 | 161581.50 | 42000 | 119581.50 | 3.85 |
| NERICA 8 | Broadcasting | 120 | 637.02 | 6.37 | 4500 | 28665.90 | 40000 | -11334.10 | -0.72 |
| NERICA 8 | Drilling | 40 | 1246.91 | 12.47 | 4500 | 56110.95 | 42000 | 14110.95 | 1.34 |
| NERICA 8 | Drilling | 80 | 1618.5 | 16.19 | 4500 | 72832.50 | 42000 | 30832.50 | 1.73 |
| NERICA 8 | Drilling | 120 | 634.83 | 6.35 | 4500 | 28567.35 | 42000 | -13432.65 | -0.68 |
| NERICA 8 | Dibbling | 40 | 933.33 | 9.33 | 4500 | 41999.85 | 44000 | -2000.15 | -0.95 |
| NERICA 8 | Dibbling | 80 | 1253.13 | 12.53 | 4500 | 56390.85 | 44000 | 12390.85 | 1.28 |
| NERICA 8 | Dibbling | 120 | 810.13 | 8.10 | 4500 | 36455.85 | 44000 | -7544.15 | -0.83 |
| JAMILA | Broadcasting | 40 | 691.83 | 6.92 | 5000 | 34591.50 | 40000 | -5408.50 | -0.86 |
| JAMILA | Broadcasting | 80 | 873.33 | 8.73 | 5000 | 43666.50 | 40000 | 3666.50 | 1.09 |
| JAMILA | Broadcasting | 120 | 1000.00 | 10.00 | 5000 | 50000.00 | 40000 | 10000.00 | 1.25 |
| JAMILA | Drilling | 40 | 674.17 | 6.74 | 5000 | 33708.50 | 42000 | -8291.50 | -0.80 |
| JAMILA | Drilling | 80 | 1380.97 | 13.81 | 5000 | 69050.00 | 42000 | 27050.00 | 1.55 |
| JAMILA | Drilling | 120 | 808.57 | 8.09 | 5000 | 40428.50 | 42000 | -1571.50 | -0.96 |
| JAMILA | Dibbling | 40 | 873.00 | 8.73 | 5000 | 43650.00 | 44000 | -350.00 | -0.99 |
| JAMILA | Dibbling | 80 | 978.80 | 9.79 | 5000 | 48940.00 | 44000 | 4940.00 | 1.11 |
| JAMILA | Dibbling | 120 | 545.67 | 5.46 | 5000 | 27283.50 | 44000 | -16716.50 | -0.62 |

Calculation of total revenue was based on market prevailing prices of ₦4,500.00 and ₦5000.00 per 100 kg bag of NERICAs and JAMILA respectively at Samaru and environs.

**Table – 7: Economic analysis of cost and return on investment of growing upland rice varieties using seed rate and sowing method at Maigana in 2012 wet season.**

| Variety | Sowing method | Seed rate (kg ha$^{-1}$) | Total yield (Kg ha$^{-1}$) | No .of bags (100kg) | Average Price/ bag ₦ | Total revenue (TR) (₦ ha$^{-1}$) | Total variable cost (TVC) (₦ ha$^{-1}$) | Gross margin (TR- TVC) (₦ ha$^{-1}$) | Return on investment (ROI) ₦ |
|---|---|---|---|---|---|---|---|---|---|
| NERICA 4 | Broadcasting | 40 | 2500.00 | 25.00 | 4500 | 112500.00 | 41000 | 71500 00 | 2.74 |
| NERICA 4 | Broadcasting | 80 | 2916.67 | 29.17 | 4500 | 131250.15 | 41000 | 90250.15 | 3.20 |
| NERICA 4 | Broadcasting | 120 | 3916.67 | 39.17 | 4500 | 176250.15 | 41000 | 135250.15 | 4.30 |
| NERICA 4 | Drilling | 40 | 1666.67 | 16.67 | 4500 | 75000.15 | 43000 | 32000.15 | 1.74 |
| NERICA 4 | Drilling | 80 | 2625.00 | 26.25 | 4500 | 118125.00 | 43000 | 75125.00 | 2.75 |
| NERICA 4 | Drilling | 120 | 3425.00 | 34.25 | 4500 | 154125.00 | 43000 | 111125.00 | 3.58 |
| NERICA 4 | Dibbling | 40 | 2075.00 | 20.75 | 4500 | 93375.00 | 45000 | 48375.00 | 2.08 |
| NERICA 4 | Dibbling | 80 | 1750.00 | 17.50 | 4500 | 78750.00 | 45000 | 33750.00 | 1.75 |
| NERICA 4 | Dibbling | 120 | 1875.00 | 18.75 | 4500 | 84375.00 | 45000 | 39375.00 | 1.88 |
| NERICA 8 | Broadcasting | 40 | 2000.00 | 20.00 | 4500 | 90000.00 | 41000 | 49000.00 | 2.20 |
| NERICA 8 | Broadcasting | 80 | 4166.67 | 41.67 | 4500 | 187500.15 | 41000 | 146500.15 | 4.57 |
| NERICA 8 | Broadcasting | 120 | 3375.00 | 33.75 | 4500 | 151875.00 | 41000 | 110875.00 | 3.70 |
| NERICA 8 | Drilling | 40 | 1625.00 | 16.25 | 4500 | 73125.00 | 43000 | 30125.00 | 1.71 |
| NERICA 8 | Drilling | 80 | 3000.00 | 30.00 | 4500 | 135000.00 | 43000 | 92000.00 | 3.14 |
| NERICA 8 | Drilling | 120 | 3458.33 | 34.58 | 4500 | 155624.85 | 43000 | 112624.85 | 3.62 |
| NERICA 8 | Dibbling | 40 | 1541.67 | 15.42 | 4500 | 69375.15 | 45000 | 24375.15 | 1.54 |
| NERICA 8 | Dibbling | 80 | 2416.67 | 24.17 | 4500 | 108750.15 | 45000 | 63750.15 | 2.42 |
| NERICA 8 | Dibbling | 120 | 2375.00 | 23.75 | 4500 | 106875.00 | 45000 | 61875.00 | 2.38 |
| JAMILA | Broadcasting | 40 | 2583.33 | 25.83 | 5000 | 129166.50 | 41000 | 88166.50 | 3.15 |
| JAMILA | Broadcasting | 80 | 4333.33 | 43.33 | 5000 | 216666.50 | 41000 | 175666.50 | 5.28 |
| JAMILA | Broadcasting | 120 | 3541.67 | 35.42 | 5000 | 177083.50 | 41000 | 136083.50 | 4.32 |
| JAMILA | Drilling | 40 | 2291.67 | 22.92 | 5000 | 114583.50 | 43000 | 71583.50 | 2.66 |
| JAMILA | Drilling | 80 | 5783.33 | 57.83 | 5000 | 289166.50 | 43000 | 246166.50 | 6.72 |
| JAMILA | Drilling | 120 | 4833.33 | 48.33 | 5000 | 241666.50 | 43000 | 198666.50 | 5.62 |
| JAMILA | Dibbling | 40 | 2916.67 | 29.17 | 5000 | 145833.50 | 45000 | 100833.50 | 3.24 |
| JAMILA | Dibbling | 80 | 3041.67 | 30.42 | 5000 | 152083.50 | 45000 | 107083.50 | 3.38 |
| JAMILA | Dibbling | 120 | 4375.00 | 43.75 | 5000 | 218750.00 | 45000 | 173750.00 | 4.86 |

Calculation of total revenue was based on market prevailing prices of ₦4,500.00 and ₦5000.00 per 100 kg bag of NERICAs and JAMILA respectively at Samaru and environs.

**Table – 8: Combined economic analysis of cost and return on investment of growing upland rice varieties using seed rate and sowing method at Maigana in 2011 and 2012 wet seasons**

| Variety | Sowing method | Seed rate (kg ha$^{-1}$) | Total yield (Kg ha$^{-1}$) | No. of bags (100kg) | Average Price/bag ₦ | Total revenue (TR) ( ₦ ha$^{-1}$) | Total variable cost (TVC) (₦ ha$^{-1}$) | Gross margin (TR- TVC) (₦ ha$^{-1}$) | Return on investment (ROI) ₦ |
|---|---|---|---|---|---|---|---|---|---|
| NERICA 4 | Broadcasting | 40 | 1609.33 | 16.09 | 4500 | 72419.85 | 40500 | 31919.85 | 1.79 |
| NERICA 4 | Broadcasting | 80 | 2233.93 | 22.34 | 4500 | 100526.85 | 40500 | 60026.85 | 2.48 |
| NERICA 4 | Broadcasting | 120 | 2431.38 | 24.31 | 4500 | 109412.10 | 40500 | 68912.10 | 2.70 |
| NERICA 4 | Drilling | 40 | 1433.20 | 14.33 | 4500 | 64494.10 | 42500 | 21994.00 | 1.52 |
| NERICA 4 | Drilling | 80 | 1998.87 | 19.99 | 4500 | 89949.15 | 42500 | 47449.15 | 2.12 |
| NERICA 4 | Drilling | 120 | 2078.90 | 20.79 | 4500 | 93550.50 | 42500 | 51050.50 | 2.20 |
| NERICA 4 | Dibbling | 40 | 1446.86 | 14.47 | 4500 | 65108.70 | 44500 | 20608.70 | 1.46 |
| NERICA 4 | Dibbling | 80 | 1685.92 | 16.86 | 4500 | 75866.40 | 44500 | 31366.40 | 1.70 |
| NERICA 4 | Dibbling | 120 | 1497.31 | 14.97 | 4500 | 67378.95 | 44500 | 22878.95 | 1.51 |
| NERICA 8 | Broadcasting | 40 | 1571.88 | 15.72 | 4500 | 70734.60 | 40500 | 30234.60 | 1.75 |
| NERICA 8 | Broadcasting | 80 | 2773.82 | 27.74 | 4500 | 124821.90 | 40500 | 84321.90 | 3.08 |
| NERICA 8 | Broadcasting | 120 | 2006.01 | 20.06 | 4500 | 90270.45 | 40500 | 49770.45 | 2.23 |
| NERICA 8 | Drilling | 40 | 1435.95 | 14.36 | 4500 | 64617.75 | 42500 | 22117.75 | 1.52 |
| NERICA 8 | Drilling | 80 | 2309.25 | 23.09 | 4500 | 103916.25 | 42500 | 61416.25 | 2.45 |
| NERICA 8 | Drilling | 120 | 2046.58 | 20.47 | 4500 | 92096.10 | 42500 | 49596.10 | 2.17 |
| NERICA 8 | Dibbling | 40 | 1237.50 | 12.38 | 4500 | 55687.50 | 44500 | 11187.50 | 1.25 |
| NERICA 8 | Dibbling | 80 | 1834.90 | 18.35 | 4500 | 82570.50 | 44500 | 38070.50 | 1.86 |
| NERICA 8 | Dibbling | 120 | 1592.57 | 15.93 | 4500 | 71665.65 | 44500 | 27165.65 | 1.61 |
| JAMILA | Broadcasting | 40 | 1637.58 | 16.38 | 5000 | 81879.00 | 40500 | 41379.00 | 2.02 |
| JAMILA | Broadcasting | 80 | 2207.50 | 22.08 | 5000 | 110375.00 | 40500 | 69875.00 | 2.73 |
| JAMILA | Broadcasting | 120 | 2666.67 | 26.67 | 5000 | 133333.50 | 40500 | 92833.50 | 3.29 |
| JAMILA | Drilling | 40 | 1482.92 | 14.83 | 5000 | 74146.00 | 42500 | 31646.00 | 1.74 |
| JAMILA | Drilling | 80 | 4507.48 | 45.07 | 5000 | 225374.00 | 42500 | 182874.00 | 5.30 |
| JAMILA | Drilling | 120 | 2820.95 | 28.21 | 5000 | 141047.50 | 42500 | 98547.50 | 3.32 |
| JAMILA | Dibbling | 40 | 1894.83 | 18.95 | 5000 | 94741.50 | 44500 | 50241.50 | 2.13 |
| JAMILA | Dibbling | 80 | 2010.23 | 20.10 | 5000 | 100511.50 | 44500 | 56011.50 | 2.26 |
| JAMILA | Dibbling | 120 | 2460.33 | 24.60 | 5000 | 123016.50 | 44500 | 78516.50 | 2.76 |

Calculation of total revenue was based on market prevailing prices of ₦4,500.00 and ₦5000.00 per 100 kg bag of NERICAs and JAMILA respectively at Samaru and environs.

## Conclusion

In this study, direct seeding of rice practice was evaluated and it is clear that direct seeded rice practices may not perform similarly in all agro ecological conditions because of rainfall distribution. At both location, the result indicated that the highest gross margin was by drilled JAMILA at 80 kg ha$^{-1}$ seed rate. The economic analysis of upland rice production at both locations indicated that production of NERICA 8 and JAMILA by either broadcasting or drilling method at the seed rate of 80 kg ha$^{-1}$ gave the highest gross margin as well as return on investment. The result revealed that NERICA 8 and JAMILA sown by broadcasting method at 80 kg ha$^{-1}$ was the most profitable with Gross margain of ₦246, 166.50

with return on investment of ₦6.72. This was followed by broadcasting JAMILA at 120 kg $ha^{-1}$ seed rate which gave a gross margin of ₦194, 583.50 and return on investment of ₦4.32. However, the least gross margin of ₦61, 249.85 was observed when NERICA 4 was dibbled at 120 kg $ha^{-1}$ which brought a loss of ₦16, 716.50 and ₦ 0.62k was lost per every naira invested. The data presented in the study shows that broadcasting and drilling method can also be a viable solution under scarcity of labour and water. but, there is need to develop proper weed management practices and requires further study to access the long term effects of herbicides on soil, water and development of weed flora.

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