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# Partial Economic analysis of Irish Potato Production under the Kebbi State Agroecological Conditions

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**ABSTRACT**- Field trials were conducted during the 2009-12 dry seasons at the Teaching and Research Farm of the Kebbi State University of Science and Technology located at Jega in the Sudan savannah zone of Nigeria. The aim was to evaluate the yield performance of three Irish potatoes (*Solanum tuberosum* L.) varieties and the economics of production under different irrigation intervals and NPK rates in the study area. Treatments consisted of three irrigation intervals (3, 6 and 9 days), four rates of NPK (20:10:10) fertilizer (0, 300, 600 and 900 kg NPK ha-1) and three varieties of potato (Bertita, Diamant and Nicola). Factorial combinations of irrigation intervals and fertilizer rates were allocated to the main plots, while varieties were assigned to the sub-plots in a split-plot design, replicated three times. The size of each sub-plot was 4.5 x 3m (13.5 m). Result of the cost-benefit analysis revealed that the revenue per naira invested (RNI) was highest when 600 kg NPK ha-1 was applied under 6 days irrigation interval (₦ 5.45), followed by 900 kg NPK ha-1 under 6 days irrigation interval (₦ 5.24), while the least RNI (₦ 2.44) was by the untreated control under 3 days irrigation schedule. From the result of this study, the use of 600 kg NPK ha-1under 6 days irrigation scheduling proved best for high tuber yield and economic returns.

**Key-Words:** Partial, Economic analysis, Irish potato, Production, Kebbi State

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## INTRODUCTION

Potato (*S. tuberosum* L.), popularly known as Irish potato originated in the high plains of the Andes Cordillera, Peru, where it is largely cultivated for food. The Spanish, who conquered Peru, discovered the crop and introduced it to Spain and the west of Europe in the mid 16th century (Fergeria *et al*., 1991; Rolot, 2001). In Africa, it was not until the end of the 19th century that potato was imported from Europe by the missionaries and the colonial administration (Rolot, 2001) Potato was introduced to Nigeria in 1920 by Europeans involved in tin mining on the Jos Plateau (Rhodes *et al.*, 2002). Production was limited to small garden plots until the Second World War, when the British colonial government encouraged potato cultivation to provide food for the servicemen in West Africa (Ifenkwe, 1989; Okwonko *et al*., 1995; Rhodes *et al*., 2002; Ugonna *et al*. 2013).

In tropical Africa, Malawi, Kenya, Ethiopia, Rwanda, Cameroon and Nigeria are the main potato producing countries and the crop is grown in high altitude which provides suitable temperature and photoperiod for growth (Harris, 1992; Okonkwo *et al.*, 1995; Rolot, 2001). The high yield potential of potato, combined with reasonable yields even under stressful growing conditions, encourages its production, which is rapidly expanding in Africa (Rolot, 2001). Under normal growing conditions, potato yields are in the range of 40 – 60 t $ha^{-1}$ (Rolot, 2001). In Nigeria,

 

potato is the most efficient tuber crop in terms of yield and days to maturity (Okonkwo *et al*., 1995). It matures in about 80 – 90 days as compared to 9 and 12 months for yam and cassava, respectively. Potato production in Nigeria in the year 2009, stood at 1.14 million tonnes cultivated on 145,680 hectares of land. Farmers yield was about 7.8 t $ha^{-1}$ (Ugonna *et al.* 2013; Anonymous, 2012).

The most important area of potato production in Nigeria is the Jos Plateau, which accounts for 85% of production in Nigeria. Biu and Mambila plateaus are two other areas where potato can be grown both in the dry and rainy seasons (Alhassan *et al*., 2004). In the low land areas of the northern states such as Kebbi, Kano, Kaduna, Borno, Sokoto and Adamawa, potato can be produced only during the harmattan period (November–February), when temperatures are sufficiently low (Okonkwo *et al*., 1995).

The most important factors that limit potato production in any region in Nigeria are insufficient water supply (rainfall or irrigation) and unfavorably high temperatures (Okonkwo *et al.*, 2009). In Nigeria, while the high altitude regions of Jos, Mambila and Biu plateaus experience relatively low temperatures that are conducive for potato production in both rainy and dry seasons, the period of harmattan (dry and dusty wind blowing over West Africa between the end of November and middle of March) in the lowland northern states such as Kebbi provides low temperatures that support potato production, provided irrigation facilities are available (Okonkwo *et al.*, 2009). It has been observed that almost all the potatoes consumed in the country are from the Jos plateau and Zaria areas. However, preliminary studies by the Kebbi State Agricultural Development Authority (KARDA) have revealed a huge potential for potato production in this axis of the Sudan Savannah. Incidentally, the cost of the commodity in the state is high, such that the crop is often considered as food for the rich, mainly because of the present restricted area of production. There is need to exploit other potential areas of production. The aim of this study was to evaluate the yield performance of some promising Irish potato varieties and the economics of production in the study area.

## MATERIALS AND METHODS

The experiments were conducted during 2009/10, 2010/11 and 2011/12 dry seasons at the Teaching and Research Farm of the Kebbi State University of Science and Technology, Jega (lat. $12^0$ 11' N; long. $4^0$ 16' E) in the Sudan savanna ecological zone of Nigeria. The climate of the area is semi-arid with an average rainfall of about 550mm- 650mm per annum. The relative humidity ranges from 21–47% and 51–79% during the dry and rainy seasons, respectively. The temperature ranges between 14-30$^o$C during the dry season and 27–41$^o$C during the rainy season (Anonymous, 2012).

The treatments consisted of three irrigation intervals (3, 6, and 9 days), four rates of NPK (20: 10: 10) fertilizer (0, 300, 600 and 900kg/ha) and three potato varieties (Nicola, Bertita, and Diamant). The treatments were laid out in a split-plot design with three replications. Irrigation intervals and fertilizer rates were combined and allocated to the main plots while variety was assigned to the subplots. The planting material (seed tubers) for the three varieties was sourced from the Potato Program Unit of the National Root Crop Research Institute (NRCRI) sub-station Vom, Jos, Plateau State. The seed tubers were pre-sprouted for six weeks before planting. The seed tubers were dressed with fungicide (Muncozeb powder) a day prior to planting. Planting was done manually with whole or cut tubers of approximately 30 g weight per hill at intra-row spacing of 30cm and a depth of 8–10cm. Plots of 3.0x4.5m (13.5$m^2$) were marked out, leaving a 1m space between main plots. Each subplot was made into six ridges, 75cm apart. Water channels were constructed for effective supply of water to each furrow during irrigation. The net plot area consisted of the two middle rows (3.0x1.5 m) (4.5 $m^2$).

The source of water was a tube well. Water pump machine

 

was used to draw water from the source to the field through the constructed water channels. Irrigation was scheduled according to the treatments, at 3, 6 and 9 days interval. The whole field, irrespective of the irrigation treatment, was watered 3 days before and after planting. The irrigation treatment was imposed after the crop has fully emerged [within 3 weeks after planting (WAP)]. Compound fertilizer (NPK 20: 10: 10) was used at the variable treatment rates of 0, 300, 600 and 900kg NPK/ha. These rates were applied according to the treatments in two split doses; the first and second doses were applied at planting and at 4WAP, respectively. The fertilizer was applied at about 10cm away from plant stand and 5cm deep and covered. Weeds were controlled manually using hand-hoe at 4 and 7 WAP. Karate (*Lambda cyhalothrin*) was sprayed at $4mlL^{-1}$ of water against insect pests. The crop was harvested on 16th February, 2010; 12th February, 2011; and 11th February, 2012; for the 2009/10, 2010/11 and 2011/12 trials, respectively. A light irrigation was given to all plots a day before harvesting irrespective of the irrigation treatment to facilitate easy lifting of tubers. Data generated were subjected to analysis of variance and means found to vary significantly were separated using Duncan's Multiple Range Test (DMRT). The economics of potato production based on treatments imposed in the study area was estimated using Gross Margin (GM) analysis. The model is represented as:

Total Gross Margin (TGM) = Total Revenue (TR) - Total Variable Cost (TVC)

Total Variable Cost (TVC) per hectare was estimated at the rate of ₦1, 000.00 per man-day, ₦110.00 per kg of NPK (20:10:10) fertilizer, ₦150.00 per kg of seed potato, ₦100.00 per liter of petrol and ₦ 550.00 per liter of engine oil.

The items of cost that made up the total cost of production include:

i. Seed tubers: Total of 1500kg of seed tuber was used per hectare, making ₦225, 000.00.
ii. Fertilizer (NPK 20:10:10): Cost of fertilizer according to treatment were ₦0.00, ₦33,000.00, ₦66,000.00 and ₦99,000.00 for rates of 0, 300, 600 and 900kg NPK $ha^{-1}$, respectively.
iii. Fuelling and servicing of water pump: Total of 30 litres of petrol was used per hectare at each irrigation day, making ₦3,000.00. 48 litres of engine oil was used for servicing water pump throughout the season, which amounted to ₦8,800.00.
iv. Chemicals: Fungicide (Muncozeb) and insecticide (lambdacyhalothrin) cost ₦3,000.00 and ₦4,200.00, respectively making ₦7,200.00.

Labour:

- Land preparation including ploughing, harrowing, ridging and construction of water channels consumed 72 man-days, making ₦72, 000.00.
- Preparation of seed tubers for planting which in cluded cutting and dressing required 5 man-days, making ₦10,000.00.
- Irrigation used up to 4 man-days per irrigation, making ₦8,000.00.
- Fertilizer application (2 split application) used up to 4 man-days each, making 8 man-days, amounting to ₦8,000.00.
- Weeding (2 times) used up to 10 man days each, making 20 man-days, amounting to ₦20,000.00.
- Fungicide and insecticide spraying (2 times) used up to 2 man-days each, making ₦4,000.00.
- Harvesting used up to 20 man days, making ₦20,000.00.

The cost-benefit analysis was based on the interaction of irrigation and fertilizer of each trial and the combined data. Variety was not considered in the cost analysis because the cost of seed tubers of the three varieties was the same.

 

## RESULTS AND DISCUSSION

The significant interaction between irrigation interval and fertilizer rates on fresh tuber yield for all seasons and the combined data is presented in Table 1. In 2009/10, the NPK untreated control gave similar fresh tuber yield with all the three irrigation intervals. With NPK rates of 300 kg $ha^{-1}$, 6 and 9 days intervals gave similar fresh tuber yield, with 9 days being lower than 3 days. With 600 and 900 kg NPK $ha^{-1}$, fresh tuber yield consistently decreased with widening irrigation interval from 3–9 days. On the other hand, at 3 days irrigation interval, fresh tuber yield was higher with 600 – 900 kg NPK $ha^{-1}$ than with 300 kg NPK $ha^{-1}$ and in turn lower with the untreated control. With 6 days interval, yield was higher with 600- 900 kg NPK $ha^{-1}$ than 300 kg NPK $ha^{-1}$ and the untreated control. With 9 days interval, NPK rates did not show significant effect on fresh tuber yield.

In 2010/11, the NPK untreated control gave higher yield with 3 and 6 days than with 9 days. With 300 kg NPK $ha^{-1}$, fresh tuber yield was similar with all the three irrigation intervals. With 600 kg $ha^{-1}$ rate, 3 and 6 days irrigation intervals gave higher fresh tuber yield than 9 days interval. With 900 kg NPK $ha^{-1}$, fresh tuber yield was higher by 3 and 6 days than by 9 days irrigation intervals. However, at irrigation interval of 3 days, NPK rate of 600 and 900 kg $ha^{-1}$ gave higher fresh tuber yield than the untreated control. With 6 days interval, fresh tuber yield was higher with 600–900 kg NPK $ha^{-1}$ than 0 and 300 kg NPK $ha^{-1}$. With 9 days interval, NPK rates of 300–900 kg $ha^{-1}$ gave similar and higher fresh tuber yield than the untreated control.

In 2011/12, the NPK untreated control gave similar fresh tuber yield with all the three irrigation intervals. With NPK rates of 300 kg $ha^{-1}$, 3 days intervals gave higher yield than 9 days. With 600 and 900 kg NPK $ha^{-1}$, irrigation at 6 days interval gave higher fresh tuber yield than 9 days. On the other hand, with 3 days interval fresh tuber yield was not affected by irrigation interval. With 6 days interval, tuber yield was higher with 600 -900 kg NPK $ha^{-1}$ than 0 and 300 kg NPK $ha^{-1}$. With 9 days interval, tuber yield was not affected by NPK rate.

In the combined data, the NPK untreated control and 300 kg NPK $ha^{-1}$ each gave similar fresh tuber yield with all the three irrigation intervals. With 600 - 900 kg NPK $ha^{-1}$, 3 and 6 days irrigation interval gave higher fresh tuber yield than 9 days. On the other hand, with 3 and 6 days irrigation intervals, 600–900 kg NPK $ha^{-1}$ gave higher yield than the untreated control. With 9 days interval, NPK rate did not affect fresh tuber yield.

Table 2 and 3 present the costs of producing potato and revenue per naira invested for each treatment during the three trials and the combined data. Apart from the costs of fertilizer, irrigation and engine fueling, all other costs incurred in the course of production were the same for each treatment combination. Therefore the costs of fertilizer were ₦0/ha, ₦ 33,000, ₦ 66,000 and ₦ 99,000 for 0, 300, 600 and 900kgNPK/ha, respectively; those for irrigation were ₦ 240,000, ₦ 156,000 and ₦ 128,000 for 3, 6 and 9 days intervals, respectively and those for engine fuelling were ₦ 90,000 ₦ 58,500 and ₦ 48,000 for 3, 6 and 9 days intervals, respectively. Another item of cost was the labour for fertilizer application which was also ₦0/ha for all treatments, with no fertilizer.

The total cost of production (TCP), the total revenue (TR), the total gross margin (TGM) and revenue per naira invested (RNI) are presented in Table 68. In 2009/10, the highest RNI was (₦5.00) obtained when 900kgNPK/ha with 3 days irrigation schedule was employed, followed by 600kgNPK/ha with 3 days intervals (₦ 4.93); and the smallest was in the NPK untreated control with 3 days intervals (₦ 1.85). In 2010/11, treatment with 600kgNPK/ha under 6 days irrigation intervals gave the highest RNI (₦ 5.26), followed by 900kgNPK/ha with 6 days intervals (₦ 5.02); ); and the smallest was in the NPK

 

untreated control with 9 days intervals (₦ 2.19). In 2011/12, treatment with 900kgNPK/ha under 6 days irrigation intervals gave the highest RNI (₦ 6.29), followed by 600kgNPK/ha with 6 days intervals (₦ 6.28); and the smallest was in the NPK untreated control with 3 days intervals (₦ 3.28). For the mean of the three trials, RNI was highest when 600kgNPK/ha was applied under 6 days irrigation interval (₦ 5.45), followed by 900kg NPK/ha under 6 days irrigation interval (₦ 5.24), while the least RNI (₦ 2.44) was by the untreated control under 3 days irrigation scheduling.

**Table 1:** Irrigation x NPK interaction on fresh tuber yield (t $ha^{-1}$) in 2009-12 dry seasons and the combined data

| NPK rates (kg $ha^{-1}$) | Irrigation interval (days) | | |
|---|---|---|---|
| | **3** | **6** | **9** |
| | **2009/10** | | |
| 0 | 8.88d | 8.84d | 10.53d |
| 300 | 20.51bc | 14.51cd | 13.48d |
| 600 | 26.11a | 20.88b | 14.27d |
| 900 | 27.57a | 20.94b | 14.00d |
| SE± | 1.82 | | |
| | **2010/11** | | |
| 0 | 10.53fg | 11.44efg | 9.12h |
| 300 | 17.77bcd | 16.27cde | 14.72def |
| 600 | 23.09ab | 23.80a | 16.26cde |
| 900 | 20.33ab | 23.79a | 18.43cd |
| SE± | 1.63 | | |
| | **2011/12** | | |
| 0 | 15.74c | 15.34c | 16.40c |
| 300 | 21.89abc | 21.22cd | 16.40c |
| 600 | 22.63abc | 28.40ab | 18.94bc |
| 900 | 22.93abc | 29.82a | 17.17c |
| SE± | 2.96 | | |
| | **Combined years** | | |
| 0 | 11.72c | 11.88c | 12.02c |
| 300 | 20.06ab | 17.34bc | 14.87bc |
| 600 | 23.94a | 24.65a | 16.49bc |
| 900 | 23.61a | 24.85a | 16.54bc |
| SE± | 1.77 | | |

Within a year, means followed by the same letter(s) are not significantly different using DMRT at 5%

 

**Table 2:** Costs of potato production under different fertilizer and irrigation levels for the average of the three trials at Jega, Sudan savanna, Nigeria

| Treatments | Seed potato (₦) | Ferti-lizer (₦) | Irriga-tion (₦) | Eng. Fuel (₦) | Eng. Mant. (₦) | Seed prep. (₦) | Land prep. (₦) | Spray (₦) | Plant-ing (₦) | Weed-ing (₦) | Fert appl (₦) | Harvesting (₦) | Total cost (₦) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No fert+3days | 225,000 | 0 | 240,000 | 90,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 0 | 20,000 | 719600 |
| No fert+6days | 225,000 | 0 | 156,000 | 58,500 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 0 | 20,000 | 604100 |
| No fert+9days | 225,000 | 0 | 128,000 | 48,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 0 | 20,000 | 565600 |
| 300kg+3days | 225,000 | 33000 | 240,000 | 90,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 760600 |
| 300kg+6days | 225,000 | 33000 | 156,000 | 58,500 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 645100 |
| 300kg+9days | 225,000 | 33000 | 128,000 | 48,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 606600 |
| 600kg+3days | 225,000 | 66000 | 240,000 | 90,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 793600 |
| 600kg+6days | 225,000 | 66000 | 156,000 | 58,500 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 678100 |
| 600kg+9days | 225,000 | 66000 | 128,000 | 48,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 639600 |
| 900kg+3days | 225,000 | 99000 | 240,000 | 90,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 826600 |
| 900kg+6days | 225,000 | 99000 | 156,000 | 58,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 710600 |
| 900kg+9days | 225,000 | 99000 | 128,000 | 48,000 | 26,400 | 5000 | 72,000 | 11,200 | 10,000 | 20000 | 8000 | 20,000 | 672600 |

 

**Table 3:** Revenue per naira invested on potato production under different fertilizer and irrigation levels for the 2009/10, 2010/11, 2011/12 and three-year mean data at Jega, Sudan savanna, Nigeria

| | Total cost (₦) | Total revenue (₦) | | | | Total gross margin (₦) | | | | Revenue per Naira Invested | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Treatments** | | 2009/10 | 2010/11 | 2011/12 | Mean | 2009/10 | 2010/11 | 2011/12 | Mean | 2009/10 | 2010/11 | 2011/12 | Mean |
| No fert+3days | 719,600 | 1,332,000 | 1,579,500 | 2,361,000 | 1,758,000 | 612,400 | 859,900 | 1,641,400 | 1,038,400 | 1.85 | 2.19 | 3.28 | 2.44 |
| No fert+6days | 604,100 | 1,326,000 | 1,716,000 | 2,301,000 | 1,782,000 | 721,900 | 1,111,900 | 1,696,900 | 1,177,900 | 2.19 | 2.84 | 3.8 | 2.94 |
| No fert+9days | 565,600 | 1,579,500 | 1,368,000 | 2,460,000 | 1,803,000 | 1,013,900 | 802,400 | 1,894,400 | 1,237,400 | 2.79 | 2.41 | 4.34 | 3.18 |
| 300kg+3days | 760,600 | 3,076,500 | 2,665,500 | 3,283,500 | 3,009,000 | 2,315,900 | 1,904,900 | 2,522,900 | 2,248,400 | 4.04 | 3.5 | 4.31 | 3.95 |
| 300kg+6days | 645,100 | 2,176,500 | 2,440,500 | 3,183,000 | 2,601,000 | 1,531,400 | 1,795,400 | 2,537,900 | 1,955,900 | 3.37 | 3.78 | 4.93 | 4.03 |
| 300kg+9days | 606,600 | 2,022,000 | 2,208,000 | 2,460,000 | 2,230,500 | 1,415,400 | 1,601,400 | 1,853,400 | 1,623,900 | 3.33 | 3.63 | 4.05 | 3.67 |
| 600kg+3days | 793,600 | 3,916,500 | 3,463,500 | 3,394,500 | 3,591,000 | 3,122,900 | 2,669,900 | 2,600,900 | 2,797,400 | 4.93 | 4.36 | 4.27 | 4.52 |
| 600kg+6days | 678,100 | 3,132,000 | 3,570,000 | 4,260,000 | 3,697,500 | 2,453,900 | 2,891,900 | 3,581,900 | 3,019,400 | 4.62 | 5.26 | 6.28 | 5.45 |
| 600kg+9days | 639,600 | 2,140,500 | 2,439,000 | 2,841,000 | 2,473,500 | 1,500,900 | 1,799,400 | 2,201,400 | 1,833,900 | 3.34 | 3.81 | 4.44 | 3.86 |
| 900kg+3days | 826,600 | 4,135,500 | 3,049,500 | 3,439,500 | 3,541,500 | 3,308,900 | 2,222,900 | 2,612,900 | 2,714,900 | 5 | 3.68 | 4.16 | 4.28 |
| 900kg+6days | 710,600 | 3,141,000 | 3,568,500 | 4,473,000 | 3,727,500 | 2,430,400 | 2,857,900 | 3,762,400 | 3,016,900 | 4.42 | 5.02 | 6.29 | 5.24 |
| 900kg+9days | 672,600 | 2,100,000 | 2,764,500 | 2,575,500 | 2,481,000 | 1,427,400 | 2,091,900 | 1,902,900 | 1,808,400 | 3.12 | 4.11 | 3.82 | 3.68 |

## CONCLUSIONS

Based on the findings of this research, it could be concluded that production of Irish potato in the study area is profitable and the best results are obtained under irrigation interval of 6 days with 600kg NPK $ha^{-1}$.

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