AGRONOMIC AND ECONOMIC EVALUATION OF POPCORN VARIETIES GROWN UNDER DIFFERENT NPK FERTILIZER RATES AND IRRIGATION LEVELS IN SUDAN SAVANNA ZONE OF NIGERIA

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Abstract

Three field trials were conducted during the dry seasons of years 2000, 2001 and 2002 at Irrigation Research Station Kadawa (1 1"39'N latitude, 08" 02'E longitude and 500m above sea level) in the Sudan savanna ecological zone of Nigeria to study the effect of NPK fertilizer rates (0:0:0; 60:13:25; 120:26:50 and 180:40:75), varieties (Yellow Composite and Ashland) and irrigation levels (5, 10, 15, and 20-days interval) on popcorn production. Factorial combination of varieties and irrigation levels were assigned to the main-plots and fertilizer was allocated to sub-plot in a split-plot design and replicated three times. Analyzed results showed that each increase in Nl'K fertilizer rates was accompanied with a significant increase in grain yield and gross margin. Yellow composite popcorn variety significantly outyield Ashland variety. The 15-day irrigation interval produced significantly higher grain yield and gross margin compared to other irrigation levels.

Key **words:** Agronomic, Economic, Fertilizer, Irrigation, Popcorn Varieties

Introduction

Popcorn *{Zea mays L.)* belongs to the family Poeceac and it is believed to have originated in the New World along with other sub-species of *Zea mays L.* such as *Zea mays* indentata (Dent), *Zea mays* indurate (Flint), *Zea mays* saccliarala (Sweet corn) and *Zea mays* aniylacca (Flour). The corn is now grown in many parts of the world including Nigeria. Here in Nigeria, the demand for the crop has increased sharply from mid-seventies stimulating production of the crop in some areas of the savanna around Zaria, Jos, Ilorin and few other towns (Iken, 1993).

In Zaria, popcorn production has been transformed from subsistence level for local consumption to a commercial one for food industry in the preparation of snack foods. Its production has taken over most of the cash crops of the area including some of the food crops. Dhuyvetter et al, (1991); D'Croz-Mason and Waldren (1990); and Ziegler el al, 1985) reported that popcorn is an alternative crop with production, harvest, storage and equipment requirements and practices similar to those for field or dent corn.

The required PH is 5.5 to 8 and does not do well in acid soils. The best climate are those which receive an annual rainfall of 600 to 100mm except where the crop is irrigated. For good growth and yield, maize needs a lot of sunshine and warmth. Average temperatures of 20-24C" arc ideal, temperature above 26" accelerated the growth of the crop loo much, so that yield will fall and with temperature over 30C°lhe susceptibility to diseases increased (Hunter et al, 1974).

Increased intensity of cropping in Nigeria has resulted in nutrient mining of the soil by the continued removal of nutrients in the grain and straw of crops and by soil erosion without compensatory replacement with fertilizers or other sources of nutrient, thus the need to apply fertilizer to the crop became imperative if any reasonable yield is to be obtained (Elemo, 1993). In order to do this, fanners used different fertilizer combinations to boost the yield of the crop but this practice may lead to the development of nutrient imbalance in the soil which may affect the productivity of the soil (Hussaini and Chiezey, 1995). The use of compound fertilizer (NPK) which supply the required nutrients for good growth and yield of the crop becomes imperative. Lombin et al (1991) reported that optimum conditions of soil, climate and farm management produce maximum yields provided the crops received a balanced and adequate nutrients supply. But the yield decreased sharply when the growing conditions are less favourable, e.g. due lo frost, drought, excessive rainfall, etc. In this case abundant supply of K together with optimum rates of N.P. Mg and other nutrients can limit the extent of the damage. Increasing N-rates up to 225 kg N/ha gave the highest grain yield of 4.6 t/ha while P. application increased grain yield up to 17.6 kg I'/ha and K application did not produced any direct measurable effect on grain yield (Hussaini and Chiezey, 1995).

Improved hybrid popcorn variety had an advantage over open pollinated variety in terms of yield, standing ability, time of maturity, resistance to diseases and insect pests, apart from producing product of appreciably high popping expansion than previously available (Iken, 1993).

Until recently most of the cereal production system in this part of the country apart from those involving wheat and barely have been restricted to the wet season. However, with the increased expansion of irrigation facilities through the construction of dams, reservoirs and the development of 'fadamas', the ever-increased human population coupled with favourable prices have necessitated the need for increased food production and cultivation of maize during the dry season (Hussaini, 1999). Sandy soils with low water holding capacity, irrigation at interval of one week or less may be necessary during the peak use (Doss et al, 1964); and liner textured soil hold more available moisture to sustain the crop for a longer period between irrigation.

Materials and Methods

The study was conducted at the Institute for Agricultural Research Station, Kadawa (11° 39'N lattude, 08°02'E longitude and 500m above sea level) in Sudan savanna ecological zone of Nigeria during 2000, 2001 and 2002 dry seasons (February to June); to study the effect of NPK fertilizer rates (0:0:0, 60:13:25, 120:26:50 and 180:40:75), varieties (Yellow composite and Ashland) and irrigation levels (5, 10 15 and 20-days interval). Variety and irrigation levels were assigned to main plots and NPK fertilizer rates was assigned to sub-plots in a split-plot design and replicated three times.

Yellow composite popcorn variety belongs to the pearl group, it has a short, thick kernel which was either rounded or flattened but always round at the crown. Ashland popcorn variety on the other hand belong to the rice group, it is flattened, round or rather long and slender but have a sharp pointed crown sometimes ending in hook or beak (lken, 1993).

The soil of the experimental site was sandy loam, well drained, slightly acidic and low in organic carbon, total nitrogen, exchangeable cations and moderately high in available phosphorus (Table 1).

Table 1: Physico-Cheinical Properties of Soil at the Experimental Sites During 2000, 2001 **and 2002 Dry Seasons at Kadawa**

Soil physical characteristic (%)	2000	**2001**	**2002**
Sand	53	51	54
Silt	31	28	32
Clay	16	20	22
Texture class	Sandy loam	Sandy loam	Sandy loam
Chemical Composition			
PH in **H_20** (1:2.5)	6.2	6.2	6.4
PHinO.l $CaCl_2$	6.0	5.9	6.1
Organic carbon (%)	0.87	0.49	0.56
Total nitrogen (%)	0.30	0.16	0.18
Available phosphorus (ppm)	28.9	8.3	10.8
Exchangeable **Bases** (cmol/kg)			
Ca	28.5	2.0	2.20
Mg	1.60	1.30	1.40
K	0.95	0.07	0.09
Na	0.47	0.26	0.28
CEC	8.9	7.10	7.40
H+Al	0.10	0.10	0.10

Each sub-plot measured 5m x 4.5m (6 ridges). The net plot area was 3m **x** 3m (4 ridges). Four seeds were sowed on ridges 75cm apart at intra-row spacing of 20cm. Thinning to one plant per stand was done at 2 weeks after sowing (WAS). Weeds were controlled using hand hoe at 3 and 6 WAS and

earthened up at 9 WAS. Fertilizers were supplied as per the treatments by drilling the seeds. The crop was harvested at physiological maturity when the leaves and cars turned brown (90-100 days).

Results and Discussion

Effects of NPK fertilizer rates, varieties and irrigation levels are shown in Table 2. Each increase in NPK fertilizer rates was accompanied with a significant increase in popcorn grain yield. Similar observation was reported by Jlussaini and Chiezey (1995) that increased N-rates up to 225 kg N/ha gave the highest grain yield of 4.6 t/ha while P application increased grain yield up to 17.6kg P/ha and K application did not produce any direct measurable effect on grain yield. Similarly, Falaki and Miko (1999) reported grain yield increase of 78.1% increasing nitrogen rates from 0 to 80kg N/ha and 15.8% when applied N was increased from 80 to 260kg N/ha. The increase in yield was attributed to the favourable effect of nitrogen on leaf number, leaf size, dry matter production, length and number of ear/plant, kernel weight and kernel depth which a11 have direct bearing on the final grain yield of maize.

Yellow composite popcorn variety significantly oulyield Ashland popcorn variety. The higher yield of yellow composite variety could be attributed to genetic make-up of that variety which made it possible to produce bigger ears, 2 or more ears/plant as well as production of tillers which ultimately ended up with productive ears (Iken, 1993).

The interval of 15-days irrigation significantly gave higher yield in 2001, 2002 and combined analysis while 10-day irrigation interval resulted in high popcorn grain yield in 2000 dry season. The higher yield of popcorn recorded with moderate irrigation interval of 10 to 15 days interval could be ascribed to the type of soil (sandy loam) as well as higher aquifer (water table) of the area. This provided favourable moisture conditions for food growth and yield of the crop with rapid photosynthetic capacity and overall plant growth. Besides shallow rooting which the moderate irrigation might have induced, could have enabled the plants to have access to irrigation water throughout the reproductive period. Similar effects, were reported by Doss et al. (1964) that moderate irrigation interval of 7 and 14 days provided more favourable growth conditions during pollination and fertilization in terms of water availability within the effective root of the crop. In practice, small soil moisture deficits are allowed to accumulate before irrigation is recommended as this reduces the frequency of application and avoid water wastage.

Table 2: Effect of NPK Rates, Varieties and Irrigation Levels on Popcorn Grain Yield

	Grain Vield (kg/ha)			
Treatments	2000	2001	2002	Combined
NPK Rates (kg/ha) 0:0:0	395. Id	6H).8d	568. Id	524.7d
60:13:25	590.7c	801.8c	1114.0c	835.5c
120:26:50	769.9b	1094.3b	1349.8b	1071.3b
180:40:75	904.6a	1264.6a	1669.4a	1279.5a
SE(±)	21.3	26.1	60.8	36.0
Varieties	723.0a	980.9a	1235.6a	979.8a
Yellow composite	654.9b	904.9b	1114.1b	891.3b
SE(±)	43.1	27.9	55.3	42.1
Irrigation Levels (Day Interval)	572.0c	874.6c	875.0d	773.9c
5-day	848.1a	956.4b	1204.4b	1003.0b
10-day	728.1 b	1151.2 a	1581.2a	1154.0a
15-day	512.0c	789.7d	I040.()c	781.0c
20-day	48.5	39.4	78.2	55.4
SE(+)				
Interaction	NS	NS	NS	*
Ix V	NS	NS	NS	**
IxF	NS	NS	NS	NS
Vx F	NS	NS	NS	NS
I x V x F				

Mean followed by the same letler(s) in a column are not significant statistically at 5% level of probability (P =.05) using DMRT.

Economic Evaluation

The cost of four variable inputs (seed, fertilizer, water and labour) constituted the total variable costs. The revenue from popcorn was obtained as product of price of one kilogramme of popcorn and the total measured in kilogramme. The farm gate price of N83.33/kg was used in computing the revenue. Gross margin which measured profitability was estimated as revenue less the total variable cost.

In this study, cost of seed remained the same for the treatments as same quantity of seed was used at same price. In Table 3, the cost of labour varied between the two varieties of popcorn. This was attributable to difference in yields which resulted to different labour requirement for harvesting and threshing. Higher gross margin of N40.413.00 per hectare was observed for yellow composite variety of popcorn in consonance to the variety's high yield recorded. The Ashland popcorn variety had the gross margin of 1435,258.00 per hectare.

Table 3: Average Costs and Returns Per Hectare for Production of Two Different Varieties of popcorn in Dry Season

Variety	Seed Cost (»)	Fertilizer Cost (N)	Irrigation Cost *(N)*	Labour Cost (N)	Total Variable Cost (N)	Revenue (W)	Gross Margin ***m***
Yellow composite	3000	4374	4500	29360	41234	81647	40413
Ashland	3000	.4374	4500	27130	39014	74272	35258

Table 4 shows economic performance of dry season popcorn production under different rates of NPK fertilizer application. The total variable cost increased from zero fertilizer application to the 180:40:75 NPK fertilizer rate. The increase in both fertilizer and labour costs were responsible for the increasing trend of the total variable cost. It was discovered that the gross margin in popcorn production increased in consonance to fertilizer rate; as such as highest NPK fertilizer rate (180:40:75).

Table 4: Average Costs and Returns Per Hectare for Popcorn Production at Different NPK Fertilizer Rates

N.P.K. Fertilizer (kg/ha)	Seed Cost (W)	Fertilizer Cost («)	Irrigation Cost (N)	Labour Cost (N)	Total Variable Cost (N)	Revenue *(X)*	Gross Margin (W)
0:0:0	3000	0	4500	19300	26800	43723	16923
60:13:25	3000	2916	4500	24460	34876	69622	34746
120:26:50	3000	5832	4500	32900	46232	89271	43039
180:40:75	3000	8748	4500	35820	52068	106621	54553

In Table 5, the cost of irrigation with increase in the interval of days for the irrigation. The interval of 15 days irrigation for popcorn production recorded maximum total variable cost, revenue and gross margin of N44,954.00, N96,163.00 and N51,209.00 per hectare respectively. This implies that irrigation at 15 days interval for popcorn production was the optimum. Therefore, less than 15 days interval could result to over-utilization of water and hence high cost of irrigation. On the other hand, more than 15 days interval could result to underutilization of water, low yield and poor economic performance of popcorn production.

Table 5: Average Cost and Returns Per Hectare for Popcorn Production at Different Irrigation Levels

Irrigation levels (days Interval	Seed Cost (N)	Fertilizer Cost (N)	Irrigation Cost (IN)	Labour Cost (N)	Variable Cost (N)	Revenue (N)	Gross Margin (N)
5 days	3000	4374	7200	23160	37734	64489	26755
10 days	3000	4374	5400	30880	43654	83580	39926
15 days	3000	4374	3600	33980	44954	96963	51209
20 days	3000	4374	1800	23340	32514	65081	32567

Conclusion

Both physical and economic returns in dry season popcorn production were influenced by the fertilizer rates, irrigation levels and types of variety. The yellow composite popcorn variety performance better than the Ashland variety. Intervals of 15 days irrigation allowed the utilization of water at optimal level for the popcorn production. Popcorn required substantial amount of nutrients or fertilizer to give reasonable yields.

This study, therefore, recommended the following for improvement in popcorn production:

i. High yielding varieties such as yellow composite should be extended to farmers and supplied to them at affordable rates,
ii. Farmers should be enlightened and trained through workshops and field demonstration on how to efficiently use fertilizer and water for popcorn production,
iii. Fertilizer should be supplied to farmers timely and at affordable rates through their cooperative societies,
iv. Irrigation facilities should be provided and effectively maintained to enable production of crop like popcorn during the dry season.

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