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Productivity of Apple as Influenced by Rates of Nitrogen, Phosphorus and Irrigation Interval

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Abstract
Field experiment was conducted on an established orchard of the Kaduna State Agricultural Development Project (KADP) at Maigana during the 1998- 2001 to evaluate the effect of nitrogen, phosphorus and irrigation interval on some selected growth attributes of apple. The treatments consisted of four levels of nitrogen (0, 60, 120 and 180 kg N h $^{-1}$, three levels of phosphorus (0, 22 and 44) and irrigation intervals (3, 5 and 7 days). Treatments were laid out in a split plot design with factorial combination of nitrogen and irrigation interval allocated to main plots and phosphorus assigned to sub-plots and replicated three times. The result showed that application of nitrogen up to 180 kg N ha $^{-1}$ resulted to taller plants with more branches and wider canopy as well as thicker stem and heavier fruit yield. Likewise, applications of phosphorus up to 44 kg P ha $^{-1}$ resulted to taller plants, more branches, wider canopy, thicker stem and heavier fruit yield. There was inconsistency in response of the parameters to irrigation interval, however the yield responded up to 7 days irrigation interval. It can be concluded that for proper apple growth, application of 180 kg N ha $^{-1}$ plus 44 kg P ha $^{-1}$, with 7 days irrigation interval should be adopted.
Keywords: fruit yield, nitrogen, phosphorus, irrigation and nitrogen content

Introduction

Apple is one among the most important and widely cultivated fruit crop most especially in the temperate regions and sub tropical. Production of the crop in tropical environment is possible eventhough yield and quality is some how low compared to cooler environment. It has been observed that the apple can grow well at temperature of 37 ^{0}C. The crop growth require deep well drained loamy soils with optimum pH between 6.5 and 6.8. It is popularly consumed as dessert, baked, roasted, stewed and boiled product. The fine grain apple hard wood is used in the manufacture of furniture, shoe lasts, small oogwheels' buttons etc.

There is paucity of information on the fertilizer and irrigation requirement of this crop in Nigeria. However, there were extensive studies carried out elsewhere, although the reports show variable results even within the same environment. Nitrogen is undoubtedly the most limiting nutrient particularly in the Nigeria Savanna zone, where the soils are characteristically low in organic matter. It has the most profound influence be ensuring healthy plant growth which is manifested by increased vigor, size and colouration. Research work by Herrera (2001) showed that nitrogen deficiency resulted to reduced leaf size and overall stunted growth. Phosphorus is one of the major limiting nutrients in most agricultural soil in the humid and semi humid tropic. Phosphorus is required in cellular energy transfer and storage; nucleid acid component or regulator co-factors (Garcia et al., 1998). According to Herrera (2001), when deficiency occurs in apple, the shoot growth appears slender. The same researcher reported that applying 90.7 kg of muriate of potash about every two years improves apple vegetative growth. Irrigation is one of the important cultural practices required for successful production of apple in dry climate. Adequate moisture is especially critical during the early growing stages (Anon., 2000). Irrigation was observed to consistently increase new shoot growth compared to un-irrigated treatments (Hipps, 1996). Likewise, Makariw (1981) observed that increase water supply to apple crop induced vigorous growth by increasing shoot length and trunk diameter over the un-irrigated control.

Judicious use of these nutrients and water will be useful for the production of this tree crop that can also be a means for fight against desert encroachment. The study was undertaken to determine the optimum N and P levels and best irrigating interval for good growth of apple.

Materials and Methods

Field experiment was conducted on an established apple orchard of the Kaduna State Agricultural Development Project (KADP) at Maigana during the 1998/ 99, 1999/ 2000 and 2000/ 2001 dry seasons. The experimental site lies in the Northern Guinea Savanna ecology of Nigeria (Longitude 11^0 11'N, Latitude 07^0 38'E and 686 m above sea level).

Treatments consisted of four nitrogen rates (0, 60, 120 and 180 kg N/ ha), three levels each of Phosphorus (0, 22 and 44 kg P) and irrigation intervals (3, 5 and 7 days) arranged in a split plot design with factorial combination of N and irrigation allocated to main plot and phosphorus assigned to sub-plots. Each sub-plot consisted of four crop trees. The treatments were replicated three times. Data were collected on apple plant height, number of branches, canopy spread, stem girth and yield these were subjected to analysis of variance (ANOVA) and means

were separated using Duncan Multiple Range test (Duncan, 1955).

Results and discussions

The analysed soil physical and chemical characteristics are presented on Table 1. The soil was loamy in nature in 1999 and 2001years while in 2000 it was clay loam. The soil nitrogen as well as the exchangeable basses was low in all the years.

Response of plant height, number of branches and canopy spread, stem girth and yield to levels of nitrogen, phosphorus and irrigation interval is presented on Table 2 and 3 respectively. Varying the nitrogen rate from the control up to 180 kg N ha $^{-1}$ resulted to a corresponding increase in plant height (at all except 2001), number of branches (only in 2001), canopy spread, stem girth and fruit yield ha $^{-1}$.While the increase in plant height in 2001 and branches in 1999 and 2000 was only up to 120 kg N ha $^{-1}$. Beyond which a significant decrease in height and branches was recorded in 2001 and 1999.

The significant response of this crop to applied nitrogen rates was not surprising because nitrogen is undoubtedly the most limiting nutrient in Nigeria savanna soil, also, it play a major role in growth and development in plants as well as ensuring healthy plant growth which is manifested by increased vigor, size and colouration. The increment in plant height and number of branches due to the applied nitrogen could be due to the role nitrogen play in increasing cellular cell division for vegetative growth in crops. The taller and highly branched plant with wider canopy spread means higher interception for light. This in turn means higher assimilate production use for the formation and development of these important growth attributed. This positive response of plant height, more number of branches, wider canopy, thicker stem and heavier yield to applied nitrogen could also, be attributed to the low soil nitrogen level of the experimental site. As such the applied nitrogen enriched the soil be providing the required nutrients needed for the plant growth. Similar findings were reported by Mengel and Kirby in 1982, also, Herrera (2001) who observed stunted growth in apple with nitrogen deficiency. However, the response to nitrogen was in most time up to the highest nitrogen rate of 180 kg ha $^{-1}$ indicating the possibility of having greater response at much higher dose.

Each increase in the level of applied phosphorus led to a significant increase in height, branches, canopy spread, stem girth and fruit yield ha $^{-1}$ in the three years with highest values attained at 44 kg P ha $^{-1}$.

This positive response due to application of phosphorus could be due to the fact that P is of major limiting nutrients in most agricultural soil in the humid and semi humid tropic and is required in cellular energy transfer and storage. The increase in these above ground parameters could be attributed to the rolephosphorusplay in root development and enhancement of nitrogen uptake from the soil for crop utilization. This in turn led to taller plants, with more branches and larger canopy spread for effective capture and utilization of available active photosynthetic radiation, thereby heading to enhance assimilate production thus translocated to the heavier fruit yield recorded. The low phosphorus level in the soil could also be another contributing factor for the positive response of these parameters to application of phosphorus. Garcia (et al., 1998) and Herrera (2001), research work reported that phosphorus is required for apple shoot growth. The response of these vegetative and yield character up to the highest P rate indicate that more P may enhance these parameters.

Table 1:physic-chemical properties of the soil at the experimental site at Maigana

Soil properties	**1999**	**2000**	**2001**
			Soil depth (cm)
	30	**0- 30**	**0- 30**
Physical properties			
Sand	210	230	220
Silt	360	330	350
Clay	430	440	430
Textural class	loam	Clay loam	Clay
chemical properties			
pH (H_20)	**6.00**	6.20	7.00
pH (0.01 M $CaCl_2$)	5.80	6.00	6.80
Total nitrogen (g kg $^{-1}$)	0.02	0.05	0.07
Available phosphorus	3.13	4.15	4.33
Calcium	**2.30**	2.20	1.25
Potassium	0.10	0.13	0.16
Magnesium	0.67	0.88	0.76
Sodium	0.08	0.08	0.13
CEC	6.80	5.20	5.90

Table 2: Effects of nitrogen, phosphorus fertilizers and irrigation interval on plant height (m) and numberofbranches of apple tree at Maigana

	19992000	2001		19992000	2001	
	Plant height			Number of branches		
Treatments	12 Week after pruning (WAP)			12 Week after pruning (WAP)		
Nitrogen (kg N/ ha)						
0	2.47d	2.67d	2.54c	3.44d	3.56c	5.19c
60	2.75c	2.36c	2.55c	3.78c	4.89b	5.89b
120	2.96b	3.77b	2.86a	4.59a	5.04a	6.11b
180	3.40a	4.02a	2.41b	4.00b	5.07a	7.52a
SE±	0.008	0.008	0.022	0.037	0.045	0.142
Phosphorus (kg P/ ha)						
0	2.81c	3.35c	2.77c	3.56c	4.53b	5.92b
22	2.89b	3.46b	2.85b	4.08b	4.53b	6.08b
44	2.98a	3.55a	2.89a	4.22a	4.86a	6.53a
SE±	0.007	0.007	0.019	0.032	0.039	0.123
Irrigation interval (days)						
3	2.85c	3.43c	2.65c	4.00a	4.47c	6.33
5	2.94a	3.47a	2.85b	3.89b	4.61b	6.11
7	2.89b	3.46b	3.02a	3.97a	4.83a	6.08
SE±	0.007	0.007	0.019	0.032	0.039	0.123
Interaction						
N x P	*	NS	NS	NS	NS	NS
N x I	**	**	NS	NS	NS	NS
P x I	NS	NS	NS	NS	NS	NS
N x P x I	NS	NS	NS	NS	NS	NS

Means within a column of any set of treatments followed by different letter are significantly different at 5 % level using DMRT.
** = Significant at 1 %. NS = Not significant

Table 3:Effects of nitrogen, phosphorus fertilizers and irrigation interval on canopy spread (m), stem girth (cm) and fruit yield per apple tree at Maigana

	19992000	2001		19992000	2001		Combined
	Canopy spread			Stem girth			Fruit yield (kg/
Treatments	12 WAP			12 WAP			ha)
Nitrogen (kg N/ ha)							
0	1.41c	1.76d	1.90d	7.07d	11.48c	9.14d	6.59d
60	1.63b	2.00c	2.26c	8.23c	14.74b	12.37b	9.19c
120	1.44c	2.45b	2.43b	8.92b	14.67b	11.91c	10.99b
180	1.97a	2.49a	2.60a	10.04a	15.56a	13.46a	13.58a
SE±	0.015	0.009	0.023	0.106	0.090	0.017	0.116
Phosphorus (kg P/ ha)							
0	1.49c	2.11c	2.21c	7.90c	13.67c	11.38c	9.75c
22	1.64b	2.18b	2.30b	8.60b	14.03b	11.73b	10.06b
44	1.71a	2.24a	2.38a	9.19a	14.64a	12.07a	10.44a
SE±	0.013	0.008	0.020	0.092	0.079	0.015	0.101
Irrigation interval (days)							
3	1.58b	2.17	2.26b	8.42b	13.83c	11.42c	8.55b
5	1.65a	2.17	2.25b	8.41b	14.50a	11.66b	8.44b
7	1.61b	2.18	2.38a	8.88a	14.00b	12.09a	13.26a
SE±	0.013	0.008	0.020	0.092	0.079	0.015	0.101
Interaction							
N x P	NS	NS	NS	NS	NS	NS	NS
N x I	NS	NS	NS	NS	NS	NS	**
P x I	NS	NS	NS	NS	NS	NS	NS
N x P x I	NS	NS	NS	NS	NS	NS	NS

Means within a column of any set of treatments followed by different letter are significantly different at 5 % level using DMRT.
NS = Not significant

Increase in irrigation interval from 3 to 5 days resulted to taller plants further delay to 7 days increased plant height only in 2001. Irrigation interval was observed to significantly influenced number of branches only in 1999 and 2000, where more branches was recorded by 7 days irrigation interval that was at par with 3 days interval only in 1999. In 1999 and 2000, irrigating at 3 and 5 days interval resulted to the least number of branches respectively. Irrigation interval significantly influenced canopy spread only in 1999 and 2001 where, irrigating at 5 and 7 days interval resulted to wider canopy respectively compared to the least recorded by other irrigation interval. Widest girth was observed with 7 days irrigation in 1999 and 2001 and 5 days interval in 2000. The thinnest stem was consistently by 3 days irrigation interval which in turn was at par with that of 5 days irrigation interval only in 1999. Irrigating at 7 days interval resulted to highest fruits yield when compared to the least recorded by other irrigating interval that were statistically similar

Irrigation is one of the important cultural practices required for successful production of apple in dry climate. The taller plant recorded at 5 and 7 days interval indicates that their was better utilization of the applied nutrients, which might be attributed to good soil aeration, adequate moisture that resulted to more branches, wider canopy cover with thicker stem needed for the plant support, thus resulted to heavier fruits yield. This could also be attributed to the soil textural class that was clay and loamy clay in 2000 and 2001, this might have assisted in retaining more water for longer period that is required for it production. It was not surprising that 3 days interval had the thinnest stem which could be due to the effect of water logging and poor aeration thus low nutrient absorption. Makariw (1981) observed that increase by increasing shoot length and trunk diameter over the un-irrigated control. Hipps (1996) and Anon. (2000) also found that water supply to apple crop to induced vigorous growth.

Conclusion

Based on the research conducted it can be concluded that higher vegetative growth of apple was attained at 180 kg N + 44 kg P ha $^{-1}$ and irrigating at 7 days.

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