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EFFECT OF WATER HARVESTING METHODS, NITROGEN-PHOSPHORUS FERTILIZER AND VARIETY ON LEAF TISSUE N, AND P, AND SOIL MOISTURE CONTENT OF DATE PALM (*PHONIX DACTYLIFERA* L.)

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ABSTRACT

A field experiment was conducted to study the effects of water harvesting methods, Nitrogen-Phosphorus fertilizer rate and variety on leaf tissue N, and P, and soil moisture content of date palm plants over a period of 32 months (May 2004- December 2006). The trial was sited at the Date palm Research Sub-station of the Nigerian Institute for Oil palm Research (NIFOR) Dutse (11^o 50'N, 09^o 25'E) in the Sudan Savanna ecological zone of Nigeria. The treatments consisted of six water harvesting methods (standard 30cm radius basin, single side pit, double side pits, perimeter square basin, side square basin and double square basin). Six NP-fertilizer rates (control, which is zero level fertilizer, 20g N + 10g P, 40g N + 20g P, 60g N + 30g P, 80g N + 40g P and 100g N + 50g P) and six date palm varieties (Palm 300, Tirgal, Dan Mali, Deglet Noor, Shuwarin C and Shuwarin B) arranged in a Latin square design. Two plants per experimental plot were sampled for plant tissue N, and P analysis, and soil moisture evaluation giving a total of 72 plants. Results from this study revealed that double square basin and double side pits proved more effective in enhancing more soil moisture and promoted plant tissue P. The application of NP- fertilizer at the rates of 80-100g N and 40- 50g P/ plant significantly enhanced plant tissue N and P. Deglet Noor and Dan Mali out performed other varieties in terms of soil moisture exploitation and are safely recommended for better date palm production especially within the Sudan ecological zone of Nigeria where this experiment was conducted.

Key words: Water harvesting method, Nitrogen-Phosphorus fertilizer, Date palm variety, Leaf Tissue N and P, and Soil moisture content.

INTRODUCTION

Date palm (*Phoenix dactylifera L.*) is one of the oldest cultivated crops of the world. It is a dioecious tree plant that produces the economically popular fruits called 'dates' that are eaten as dessert. Its origin is not quite certain but it is said to be around the Mesopotamia or the Gulf region (Wrigley, 1995; Sanderson, 2001).The world production has increased from 2.8million tons in 1985 to 6.8million tons in 2004 with Iran, Saudi Arabia and Iraq contributing almost half of world's production area. During 1996, about 322,000 tons of dates were exported with a total value of US $258 million (FAO, 2002). The date palm growing regions of Nigeria lies within the northern semi area between latitudes 10 - 12^o N (Omamor *et al.,* 2000). The area under date palm cultivation in Nigeria was estimated over 1,466.00 ha, and an estimated annual production of nearly 20,000.00 tones date fruits per annum (Bakshi, 1997). According to Harbo and Isyaku (2007), an average fruiting female palm can produce 60 – 80kg fruits/year which translates to 12 – 16tons date fruits ha^{-1} using a plant population of 200 trees ha^{-1}. A date takes in more water with an estimated water requirement of 250m^3/palm/year (FAO, 1993). The maximum average annual uptake of water occurs within the soil profile between 0.30 – 1.50 m depth, depending on the variety (Pillsbury, 1941; Furr and Armstrong, 1956). Increased in moisture supply enhanced plant growth (Nagre and Bathal, 1978; Javert *et al.*,1980). The amount of fertilizer needed by palm tree depends on soil type, kinds of inter crops grown under, variety and age of the tree (Ahmad, 2008). Klain and Zaid (2000) recommended the use of 262g N, 138g P and540g K for palm younger than four years, and 525g N,138g P and 540g k for palms four years and above. The general recommendation for a matured fruiting palm according to Latifa *et al* (2007) is 1.0kg N, 500g P and 800g K and1.50-3.00kg N, 0.50kg P and 2-3.00kg k (Ahmad, 2008). El-Deeb *et al* (2000) reported that, application of 465g N+310g P +500g k and olive pomace on mature 20year Hayany variety in Egypt enhanced growth, leaf N, P, K, Mn and Zn content and the pattern of mineral uptake and distribution in the palm was found to differ among varieties. However, Isyaku *et al* (2009) observed that, the amount of fertilizer needed by the palm is related to the sex and age of the palm while male palm performed well with the application of little fertilizer, the female palm needed more fertilizer for increased yield.

Total N and P in leaf pinnae was found to be related to the amounts added and the optimum N and P in the leave tissue of matured female fruiting palm is 2.0 - 2.5 and 0.10 - 0.30% respectively (Bose, 1985).

The growth, gestation period, yields and fruit quality of the crop is enhanced by adequate supply of soil moisture and nutrition. Differences among genotypes influence crop responses to moisture conservation and nutrition treatments. In adequate soil moisture and nutrition constitute production constraint and reasons for low yield. Information and research work on water harvesting method which is a rudimentary form of irrigation as well as appropriate Nitrogen and Phosphorus levels which are vital for crop establishment, growth and proper moisture utilization and retention under Nigerian conditions have been lacking. To reduce the gestation period of 5-7 years to 4-5 years and increase fruit yield from 60 - 80kg fruit/palm to 120 - 140kg fruit/palm, research on Nitrogen-Phosphorus fertilizer and moisture retention technique on the improved and Nigerian date varieties under Nigerian conditions have to be carried out to advantage, it is with this view that this research has been carried out with the objective of evaluating the effects of water harvesting method, Nitrogen-Phosphorus rates and variety on Leaf Tissue N, and P, and soil moisture content of young date palm plants in the drier Sudan ecology of Nigeria.

MATERIALS AND METHODS

A field experiment was conducted to study the effects of water harvesting methods, NP - fertilizer rate and variety on Leaf Tissue N, and P, and Soil moisture content of young date palm plants over a period of 32 months (May 2004- December 2006).The trial was sited at the Date palm Research Sub-station of the Nigerian Institute for Oil palm Research (NIFOR) Dutse (11^{o}50'N, 09^{o}25'E) in the Sudan Savanna ecological zone of Nigeria. The location has mean annual rainfall of about 600mm spread over five months and average minimum and maximum temperatures of 23 and 25^{o} C respectively (Appendix 1). Soils of the experimental area are generally sandy loam (Appendix II).

The treatments consisted of six water harvesting methods (standard 30cm radius basin, single side pit, double side pits, perimeter square basin, side square basin and double square basin). Six NP-fertilizer rates (control, 20g N + 10g P, 40g N + 20g P, 60g N + 30g P, 80g N + 40g P and 100g N + 50g P) and six date palm varieties (Palm 300, Tirgal, Dan Mali, Deglet Noor, Shuwarin C and Shuwarin B) arranged in a Latin square design. Two plants per experimental plot were sampled for leaf tissue N and P analysis and soil moisture evaluation giving a total of 72 plants. NP – fertilizer rates were derived from Urea (46%N) and Single superphosphate (18%P_2O_5) fertilizers. The characteristics of the date palm varieties are as follows:

Palm 300: This is late ripening and soft fruits date variety, it is a NIFOR sub-station locally improved material. The average fruit length and weight are 4.0cm and 50g, respectively. A mature female palm produces an average of 10 – 12 bunches and fruit yield of 80kg/plant/year.

Tirgal: This is a dry fruit variety, it is an exotic variety imported from Algeria. The average fruit length and weight are 4.0cm and 35g, respectively. A mature female palm produces an average of 8 bunches and fruit yield of 60kg/plant/year.

Dan-Mali: This is a semi - dry fruit variety. It is an exotic variety imported from Mali. It has average fruit length and weight of 4.0cm and 60g, respectively. A mature female palm produces an average of 10 bunches and fruit yield of 80 – 90kg/plant/year.

Deglet Noor: This is a semi - dry fruit, medium to late ripening date palm variety. It is an exotic variety imported from Algeria. It has average fruit length of 3.5cm and average fruit weight of 40g. A mature female palm produces an average of 12 bunches and fruit yield of 80kg/plant/year.

Shuwarin C: This is a dry fruit variety locally sourced from Shuwarin village around Dutse area. It has average fruit length and weight of 5.0cm and 55.0g, respectively. A mature female palm produces an average of 6- 8 bunches and fruit yield of 50 – 60kg/plant/year.

Shuwarin B: This is a soft fruit variety locally sourced from Shuwarin farmers around Dutse area. It has average fruit length of 4.0cm and average fruit weight of 40g. A mature female palm produces an average of 7 bunches and fruit yield of 50kg/plant/year.

The land was cleared and ploughed before field layout. The field was marked out with planting positions spaced at a 7m x 7m triangular arrangement (197 palm ha^{-1}) using surveying tools: calibrated chain, ranging poles and pegs and the planting holes were dug for transplanting. Nine month old date palm seedlings were transplanted on the 15^{th} May 2004. Furadan (Carbofuran 25%) was mixed with the soil for transplanting at the rate of 0.02kg per planting hole at the time of transplanting. The water harvesting structures were prepared on the 16^{th} and 17^{th} May each of years 2004, 2005 and 2006; ten kilograms of farmyard manure/ plant were applied on the 14^{th} June of each year 2004, 2005 and 2006 as a uniform requirement within the water harvesting structures. The inorganic NP fertilizers were applied in a 4 split doses in the month of August, November, February and May of each year 2004, 2005 and 2006 at the rate that varied with the treatments. The experimental field was kept free of speargrass (*Imperata cylindrica*) by manual hoeing 4 times each year during the rainy seasons of the experimental period. The incidence of Beetle (*Oryctes rhinoceros*) was observed in the year 2005 and controlled by the used of Decis (25% Deltametrin) spray at the rate of 2ml/l and by physically killing the insect with a sharp stick wherever found. Graphiola leaf spot was also observed in the year 2006 and was controlled by the use of Benlate(50% Benomyl) fungicide spray at the rate of 50g l^{-1}. Plants were largely sustained by rainfall and irrigated with 10 liters of water per plant in the first year and 10 liters morning and evening of each year 2005 and 2006 starting from December to the beginning of the rainy season.

Leaf tissue N: N was determined by micro-kjeldahl gunning method (AOAC, 1980). One matured leaf per plant was sampled in December of each 2005 and 2006 (Broschat, 1997; Robert *et al.*, 2004).

Leaf tissue P: P was determined color metrically by stannous Chloride method (Tolth and Prince, 1948). One matured leaf per plant was sampled in December of each 2005 and 2006 (Broschat, 1997; Robert *et al.*, 2004).

Soil samples were taken from within the 100cm-perimeter of ground around individual plants with auger to the depth of 0-30cm.The moisture content of these soils were determined as described by Michael (1999). The sampling was done on 15th December each year. Soil samples were weighed fresh and then oven- dried at 150 0^c for 3 hours to obtain the total moisture content.

Thus, **S.M.C (% by weight**) =

$$\frac{\text{Weight of moist sample - weight of oven dried sample}}{\text{Weight of oven dried sample}} \times 100$$

Data collected was subjected to analysis of variance for a Latin square design, to test the significance of treatment effects as described by Snedecor and Cochran (1967), the treatment means were separated using Duncan's Multiple Range test (Duncan, 1965).

RESULTS

Leaf tissue N and P of date palm during 2005 and 2006 seasons

Table 1 presented tissue N and P of date palm as affected by water harvesting method, NP-fertilizer rate and variety in 2005 and 2006 sampling periods. The effect due to water harvesting on tissue N was not significant in 2005 and 2006. However, the effect due to water harvesting on leaves tissue P was significant in both seasons. In 2005 and 2006, double square basins significantly produced higher leaves tissue P than all other treatments but at par with single side pit. The control, double side pits and side square basin were at par. The effects due to NP-fertilizer rates on leaves N and P was significant in both 2005 and 2006. In 2005, rates 80g N + 40g P and 100g N + 50g P significantly recorded higher tissue N which was at par with rates 60g N + 30g P and 20g N+ 10g P. The control and 40g N + 20g P produced the least tissue N. In 2006, rates 100g N +50g P and 80g N +40g P significantly recorded the highest tissue N which was at par with rate 60g N + 30g P. In 2005 rate 100g N +50g P significantly recorded highest tissue P followed by rate 80g N + 40g P which was at par with rate 60g N +30g P In 2006, rate 100g N + 50g P significantly recorded higher P than all other applied NP-rates except 80g N + 40g P which were at par.

The effect due to variety on tissue N was not statistically significant in 2005. However, in 2006, Tirgal, Dan Mali and Shuwarin C significantly recorded higher leaves tissue N which was at par with Shuwarin B and Palm 300. In 2005, Deglet Noor and Shuwarin C recorded higher tissue P which was statistically similar with other varieties except Palm 300. In 2006, Deglet Noor significantly recorded highest tissue P comparable with Dan Mali.

Soil moisture content (%) during 2004, 2005 and 2006 seasons

Table 2 presents mean percentage of soil moisture content of date palm varieties as affected by water harvesting method and NP-fertilizer rate during 2004, 2005 and 2006. The effect due to water harvesting on soil moisture was significant in all the years except in 2004. In 2005, DSB significantly retained more moisture than SSP, SSB and PSB but was at par with DSP and the Control water harvesting system. In 2006, DSB retained more moisture than SSB; SSP and PSB but at par with DSP and the Control.The effect due to NP- fertilizer application on soil moisture was only significant in 2005 when rate 40g N + 20g P significantly retained the highest soil moisture than all applied NP- fertilizer rates except 60g N+ 30g P which were at par. The effect of variety on soil moisture was significant in all the three years. In 2004, Palm 300 significantly retained the highest soil moisture which was at par with all other varieties except Tirgal. In 2005, all the varieties recorded statistically similar soil moisture except Tirgal which had the lowest soil moisture. In 2006, Deglet Noor, Palm 300 and Shuwarin B significantly recorded the highest soil moisture and were statistically similar with Shuwarin C and Dan- Mali. Tirgal recorded the lowest soil moisture.

DISCUSSION

In this study, varying water harvesting method produced no statistical difference in the tissue N of date palm. This may be attributed to the low rate of N used in this experiment as well as low soil N in the field where this experiment was conducted. However, varying water harvesting method produced significantly different tissue P in 2005 and 2006.This may be attributed to the low solubility of P and moderate level of soil P in our experimental field (Appendix II). The applied P in 2004 might not have dissolved completely; the combined effect of the applied P in 2004, 2005 and 2006 resulted in statistically different tissue P with double square basin producing significantly higher tissue P. The effect of NP-fertilizer on tissue N and P in 2005 and 2006 was statistically significant. The highest rate 100g N + 50g P produced significantly higher leaves tissue N and P compared to other rates in 2004 and 2006, but did not produce the required tissue N and P for enhanced plant growth (Hussein, 1983). Varieties also differ in their tissue composition of N and P with Deglet Noor recording significantly higher tissue N in 2005 and higher tissue P in 2006 while Tirgal recorded higher N in 2006, suggesting a difference in the uptake of N and P according to variety (Al – Whaibi, 1983).

Percentage Soil Moisture Content as affected by Water harvesting method, NP fertilizer and Variety 2004, 2005 and 2006.

In 2005 and 2006, DSB recorded the highest moisture level although comparable with the Control. This may be attributed to the relative size of DSB in harvesting the rain water and the efficiency of the control water harvesting system to utilize the harvested water.

40 g N + 20 g P recorded higher moisture although comparable with rate 60 g N + 30g P. This indicates that, medium NP- fertilizer rate conserved more soil moisture than higher rate at suitable temperature that minimizes surface evaporation (Appendix I). Varieties also differ in their ability to exploit soil moisture(Aref and Sam, 2005), and might be attributed to the differences in the thickness of the girth as thicker girth favours the concentration of the primary roots which allow the palm to benefit from underground moisture and consequently resist water stress and drought conditions(FAO,2002).

Conclusion

The results from this study revealed that double square basin and double side pits proved to be more effective in enhancing more soil moisture and promoted plant tissue P. The application of NP-fertilizer at the rates of 80- 100g N and 40- 50g P/ plant significantly enhanced plant tissue N and P. Deglet Noor and Dan Mali out performed other varieties in terms of soil moisture exploitation and are safely recommended for better date palm production within the Sudan ecological zone of Nigeria where this experiment was conducted.

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Table 1: Leaf Tissue N (%) and P (mgkg^{-1}) of date palm as affected by water harvesting method, NP- fertilizer rate and variety at Dutse, Nigeria.

Treatments	N (%)		P (mg/kg)	
	2005	2006	2005	2006
Water Harvesting Methods				
Control	0.046	0.071	0.050bc	0.060bc
Single side pit	0.050	0.064	0.054ab	0.063ab
Double side pits	0.048	0.059	0.049bc	0.060bc
Perimeter square basin	0.045	0.059	0.043c	0.055c
Side square basin	0.046	0.063	0.046bc	0.056bc
Double square basin	0.054	0.062	0.060a	0.068a
SE+	0.0052	0.0047	0.0029	0.0025
NP-fertilizer rates (g/plant/year)				
Control	0.036b	0.047c	0.033d	0.040d
20g N + 10g P	0.045ab	0.056bc	0.048c	0.050c
40g N + 20g P	0.040b	0.057bc	0.048c	0.059b
60g N + 30g P	0.045ab	0.069ab	0.050bc	0.060b
80g N + 40g P	0.060a	0.072a	0.060b	0.074a
100g N + 50g P	0.060a	0.078a	0.070a	0.080a
SE+	0.0052	0.0047	0.0029	0.0025
Varieties				
Palm 300	0.046	0.059ab	0.044b	0.054d
Tirgal	0.045	0.072a	0.048ab	0.055cd
Dan-Mali	0.047	0.067a	0.051ab	0.064ab
Deglet Noor	0.054	0.057b	0.055a	0.069a
Shuwarin C	0.048	0.060a	0.054a	0.063bc
Shuwarin B	0.044	0.059ab	0.049ab	0.058bc
SE+	0.0052	0.0047	0.0029	0.0025

Means followed by the same letter (s) are not statistically different at 5% level of significant using DMRT.

Table 2: Soil Moisture Content (%) (0-30 cm depth) of date palm varieties as affected by Water harvesting methods and NP-fertilizer rates during 2004, 2005 and 2006.

Treatments	2004	2005	2006
Water harvesting methods			
Control	7.88	11.91a-c	11.40ab
Single side pit	10.62	9.47c	9.85b
Double side pits	13.49	13.33ab	13.03a
Perimeter square basin	14.29	9.74c	10.39b
Side square basin	9.68	9.71c	9.13b
Double square basin	16.82	14.41a	13.73a
SE+	3.925	1.114	0.868
NP-fertilizer rates (g/plant/year)			
Control	11.12	10.83b	10.81
20g N + 10g P	18.60	10.73b	11.14
40g N + 20g P	10.70	14.06a	10.98
60g N + 30g P	11.64	11.92ab	12.09
80g N + 40g P	10.89	10.70b	11.57
100g N + 50g P	9.83	10.34b	10.95
SE+	3.925	1.114	0.868
Varieties			
Palm 300	19.55a	11.65a	11.98a
Tirgal	8.16b	8.41b	9.22b
Dan-Mali	10.96ab	12.92a	10.88ab
Deglet – Noor	11.45ab	11.51a	12.36a
Shuwarin C	11.70ab	12.00a	11.34ab
Shuwarin B	10.94ab	12.09a	11.73a
SE+	3.925	1.114	0.868

Means followed by the same letter (s) are not statistically different at 5% level of significant using DMRT.

Appendix I: Meteorology cal data showing air temperature (0^{c}), rainfall (mm) and day length (hours) in the years 2004, 2005 and 2006 at NIFOR, Dutse.

Month	Temp. 2004		Temp. 2005		Temp. 2006		Rainfall			Day length		
	Max.	Min.	Max.	Min.	Max.	Min.	2004	2005	2006	2004	2005	2006
January	19.0	18.12	19.27	17.23	18.58	17.55	Nil	Nil	Nil	165.23	170.21	173.48
February	22.63	20.14	25.89	23.98	18.23	18.04	Nil	Nil	Nil	160.55	159.45	169.24
March	24.71	23.87	28.82	28.23	25.11	24.27	Nil	Nil	Nil	186.30	190.00	183.90
April	29.12	26.31	32.32	30.75	28.75	27.00	Nil	Nil	Nil	259.62	281.50	277.99
May	33.61	31.00	32.45	31.05	33.06	29.42	72.80	5.10	54.80	274.18	269.44	275.55
June	31.00	27.16	30.60	29.34	30.46	27.88	21.50	109.4	86.80	273.19	270.00	287.19
July	30.78	28.19	27,26	24.79	30.30	27.95	146.8	119.0	143.2	289.14	290.32	288.18
August	21.31	20.14	20.26	18.36	20.90	18.22	242.4	226.7	352.4	241.44	235.12	238.92
September	23.89	22.41	21.29	19.72	27.22	25.00	53.0	54.7	129.2	254.92	266.35	279.92
October	27.12	26.32	24.34	22.77	29.67	28.13	22.6	Nil	Nil	250.17	268.44	270.14
November	24.43	20.38	21.88	18.92	20.82	19.52	Nil	Nil	Nil	381.70	230.00	211.19
December	19.98	18.20	20.32	18.29	18.30	17.61	Nil	Nil	Nil	195.77	188.28	200.31
TOTAL	**307.6**	**282.2**	**304.7**	**283.4**	**301.4**	**280.6**	**559.1**	**514.9**	**776.4**	**2888.68**	**2819.12**	**2856.01**

Source: Meteorological unit, NIFOR Date palm Research Sub - station, Dutse.

Appendix II: Physical and chemical properties of soils (0 – 15 and 15 – 30cm) December 2004, 2005 and 2006 at NIFOR, Dutse.

	December 2004		December 2005		December 2006	
	0-15	15-30	0-15	15-30	0-15	15-30
Particle Size (%)						
Clay	14.00	19.00	14.00	17.00	15.00	16.00
Silt	16.00	13.00	16.00	13.00	16.00	15.00
Sand	71.00	68.00	71.00	68.00	71.00	68.00
Soil Textural Class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam
Chemical Properties						
pH in Water	6.60	6.50	6.60	7.20	6.30	7.00
Organic Carbon (%)	0.16	0.13	0.15	0.11	0.16	0.13
Total Nitrogen (%)	0.01	0.01	0.01	0.01	0.01	0.01
Available P (ppm)	18.00	21.00	16.00	18.00	18.00	21.00
Exchangeable bases (meq/100g)						
Mg+Ca	1.55	2.10	1.55	1.35	1.55	2.10
K	0.45	0.40	0.45	0.40	0.45	0.40
Na	0.50	0.50	0.50	0.50	0.50	0.50
$H+Al^{+}$	1.10	1.35	1.10	1.35	1.10	1.35
CEC	2.75	2.65	2.75	2.65	2.15	2.00

Analysed by: Jigawa Research Institute's Laboratory, Kazaure.