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# EFFECT OF WATER HARVESTING METHODS, NITROGEN AND PHOSPHORUS FERTILIZER ON LEAF LENGTH OF DIFFERENT DATE PALM (*Phoenix d-*) VARIETIES

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***ABSTRACT***

***A field experiment was conducted to study the effects of water harvesting methods, NP - fertilizer rate and variety on leaf length 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° 50'N, 09° 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 fertilizer level, 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 the measurement of leaf length, given a total of 72 plants. Results from this study revealed that double square basin, the control, the perimeter square basin and side square basin methods proved more effective in enhancing more soil moisture and produced longer leaves. The application of NP- fertilizer at the rates of 80- 100g N and 40- 50g P/ plant to young date plant of about three years significantly enhanced leaf length. Deglet Noor and Dan Mali produced longer leaves and are likely to be more productive. The combination of either double square basin or the control or the perimeter square basin or side square basin water harvesting method treatments, with 80- 100g N and 40- 50g P/ plant and either Deglet Noor or Dan Mali may be recommended for better date palm production within the Sudan ecological zone of Nigeria where this experiment was conducted, following further studies.***

***Key words: Water harvesting method, Nitrogen-Phosphorus fertilizer, Date palm variety, Leaf length***

## INTRODUCTION

Water harvesting can be defined as the trapping of run-off for productive use. (Anon, 1997, Pacey and Cullins, 1999). The principle of water harvesting involves diverting run-offs from uncultivated (catchments areas) to the cultivated areas where the crops are grown. The run-off is collected in the cultivated area using soil moisture conservation methods, which allow the water to infiltrate into the soil and become available to the roots of the crops (FAO, 1991). This technology is essential in arid and semi arid regions where rainfall is accompanied by a large amount of surface run-off and high rate of moisture evaporation in the growing season. Generally sandy soils of arid and semi arid regions cannot retain the amount of water, which falls in such a short time, surface run-off can therefore be harvested which will lead to greater reliability of production even in a year of severe droughts (Anon, 1997). Literature on the effects of water harvesting methods on date palm growth are not available, but many authorities reported an increase in crop yield in water harvesting systems compared to non- water harvesting systems in other crops. The use of water harvesting in strawberry reduced pumping of water from aquifer for irrigation by more than 50% (Zuzueta, 1986). Mulching with maize Stover increased the moisture conservation and significantly increased grain yield in wheat (Sharma, 1991). Also, maize sown in furrows, a moisture trapping measure, recorded yield increased compared to that on a flat seedbed (Sharma, 1991). Zhu qiang, (2005) reported an increased grain yield of 20.50% in maize grown under water harvesting compared with that in non water harvesting system. The growth, yield and fruit characteristics of the varieties vary significantly with the local conditions. Sourial *et al.*, (1983) reported a yield of 136.2kg/palm of Hellawy (Iraqi cultivar) when grown under the condition of barrage region of Egypt. Chohant *et al.*,(1972) reported a yield of 66kg/palm of the same Hellawy palms grown in Abohar , India while Nixon,(1978) reported that Hellawy palms grown at Coachella valley gave 68.1-90.8kg date fruits/palm/year. Growth of leaf and production of inflorescence are essential for increased yield in date palm, the longer and wider the leaf, the higher the yield obtained from the palm. (FAO, 2002). The vegetative growth characters do vary with the cultivars.

For example, Medjool variety with short to medium size leaves between 3.50-3.80m long has an average fruit yield of 80-120kg/year while Barhee variety with leaves 3.80-4.15m long has an average fruit yield of 200kg/year (FAO, 2002). Hussein and Hussein, (1983), reported longer daily leaf elongation in Nitrogen applied palms compared to non Nitrogen applied palm (Control). 250g N/palm/year, 500gN/palm/year, 750g N/palm/ year and 1000g N/palm/year produced leaf elongation of 2.67cm/ day, 3.67cm/day, 4.05cm/day and 4.21cml/day respectively against 2.31cm/day produced by the control. Approaches that are likely to enhance moisture supply and retention around the root zones of the tree satisfy crop Nitrogen and Phosphorus requirements and faster leaf development are necessary. Date palm research on these aspects under Nigerian conditions with Nigerian varieties has been lacking. Studies in water harvesting method which is likely to satisfy crop water requirements, appropriate Nitrogen - Phosphorus levels which are vital for crop establishment, and good leaf development with Nigerian and improved varieties can effectively 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 methods, Nitrogen – Phosphorus levels on leaf length of improved and Nigerian date varieties in the drier Sudan ecology of Nigeria.

**MATERIALS AND METHODS**

A field experiment was conducted to study the effects of water harvesting methods, Nitrogen –Phosphorus rate on leaf length of different varieties 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. Soils of the experimental area are generally sandy loam (Table 4). 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 measurement of leaf length given 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 a 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 peg 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 according to the specifications given under treatment. 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 WH structures. The inorganic NP fertilizers were applied in 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 length was measured and recorded at three months interval, starting from June 2004 to December 2006.

**Leaf length** refers to the length of leaf from the apex to the apparent point of attachment on the stem. This was measured on a sample of three to five central leaves/plant using measuring ruler. The average lengths of the leaves were recorded.

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

## RESULTS AND DISCUSSION

Tables 1, 2 and 3 show the effect of water harvesting methods (WHM), Nitrogen and Phosphorus fertilizer (NP-fertilizer) on leaf length of different date palm varieties in 2004, 2005 and 2006 respectively. Varying WHM resulted in variable leaf length but the differences were significant only during the month of March and between the months of September to December 2006. During this period, the double square basin (DSB) produced significantly longer leaves when compared with the single side pit and double side pit treatments but had statistically similar effects with the control, the perimeter square basin and side square basin methods. The leaf length was significantly increased by the DSB (because of its larger catchment area) and in some instances, by the standard control treatment when compared to the side pit methods. The control treatment proved more effective in utilizing the excess rain compared to the side pit methods mainly because of its relatively closer distance to the root system of the plant. These results seem to be in line with the findings of Zhu qiang, (2005), who observed that the larger area of water harvesting system that conserved 400 - 500m$^3$ of water produced higher yields of wheat over smaller structure that conserved only 200m$^3$ of water. The differences in leaf length in response to NP-fertilizer rates were significant only between June and September 2006. At this period, the rate 80g N + 40g P produced significantly longer leaves than that of 20g N + 10g P application and was statistically similar with other rates including the control non fertilizer plot. The lack of significant response to applied rates of N and P seem to suggest that the rates of NP-fertilizer evaluated in this experiment were less than the required level for optimum plant response. The variation in the leaf length in respect of the crop variety was significant between the months of June, 2004 - September 2005 and between September to December 2006. Except at the initial two months of the experiment and March 2005, the variety Dan Mali significantly recorded longer leaves than the other varieties. In June 2004, Deglet Noor significantly produced longer leaves than Palm 300 but statistically similar with the other varieties, while during the period September – December 2004, variety Dan Mali significantly recorded longer leaves than Palm 300 and was statistically similar with the other varieties. In the period between March and September 2005, Deglet Noor and Dan Mali had significantly longer leaves compared with that of Palm 300, Shuwarin C and Shuwarin B but were at par with Tirgal. Between September and December 2006, Dan Mali produced significantly longer leaves than all other varieties except Deglet Noor. Deglet Noor significantly produced longer leaves than Palm 300, and Shuwarin C only and was statistically at par with Tirgal and Shuwarin B. Effects of variety on leaf length were significant during the later periods of the experiment when the utilization of the harvested water and NP – fertilizer was more directed to vegetative growth. Deglet Noor and Dan Mali are likely to give higher yields of date's fruit since leaf length is associated with the productivity of the crop (FAO, 2002).

## CONCLUSION

The results from this study revealed that DSB, the control, the perimeter square basin and side square basin methods proved to be more effective in enhancing soil moisture and produced longer leaves. The application of NP- fertilizer at the rates of 80- 100g N and 40- 50g P/ plant to young date plant of about three years significantly enhanced leaf length. Deglet Noor and Dan Mali produced longer leaves and are likely to be more productive. The combination of either DSB or the control or the perimeter square basin or side square basin water harvesting method treatments, with 80- 100g N and 40-50g P/ plant and either Deglet Noor or Dan Mali may be recommended for better date palm production within the Sudan ecological zone of Nigeria where this experiment was conducted, following further studies.

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**Table 1: Effect of Water harvesting methods, Nitrogen and Phosphorus fertilizer on Leaf Length of Different Date palm (*Phoenix d*-) varieties between June – December 2004, at NIFOR Date palm Research Sub – station, Dutse**

| Treatments | Period in Month | | |
|---|---|---|---|
| | June | September | December |
| **Water Harvesting Methods** | | | |
| Control | 0.268 | 0.436 | 0.474 |
| Single side pit | 0.248 | 0.357 | 0.403 |
| Double side pits | 0.243 | 0.333 | 0.377 |
| Perimeter square basin | 0.248 | 0.392 | 0.476 |
| Side square basin | 0.243 | 0.403 | 0.466 |
| Double square basin | 0.286 | 0.435 | 0.540 |
| SE+ | 0.0234 | 0.0491 | 0.0579 |
| **NP-fertilizer rates (g/plant/year)** | | | |
| Control | 0.292 | 0.403 | 0.458 |
| 20g N + 10g P | 0.258 | 0.330 | 0.390 |
| 40g N + 20g P | 0.253 | 0.388 | 0.441 |
| 60g N + 30g P | 0.238 | 0.374 | 0.434 |
| 80g N + 40g P | 0.265 | 0.436 | 0.529 |
| 100g N + 50g P | 0.231 | 0.423 | 0.484 |
| SE+ | 0.0234 | 0.0491 | 0.0579 |
| **Varieties** | | | |
| Palm 300 | 0.216b | 0.333b | 0.380b |
| Tirgal | 0.260ab | 0.388ab | 0.442ab |
| Dan-Mali | 0.238ab | 0.496a | 0.582a |
| Deglet Noor | 0.297a | 0.450ab | 0.535ab |
| Shuwarin C | 0.267ab | 0.332b | 0.381b |
| Shuwarin B | 0.258ab | 0.358ab | 0.417ab |
| SE+ | 0.0234 | 0.0491 | 0.0579 |

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

**Table 2: Effect of Water harvesting methods, Nitrogen and Phosphorus fertilizer on Leaf Length of Different Date palm (*Phoenix d*-) varieties between March – December 2005, at NIFOR Date palm Research Sub – station, Dutse**

| Treatments | Period in Month | | | |
|---|---|---|---|---|
| | March | June | September | December |
| **Water Harvesting Methods** | | | | |
| Control | 0.531 | 0.563 | 0.815 | 0.870 |
| Single side pit | 0.448 | 0.480 | 0.649 | 0.693 |
| Double side pits | 0.447 | 0.498 | 0.652 | 0.690 |
| Perimeter square basin | 0.516 | 0.556 | 0.813 | 0.875 |
| Side square basin | 0.506 | 0.549 | 0.716 | 0.787 |
| Double square basin | 0.592 | 0.642 | 0.878 | 0.969 |
| SE+ | 0.0729 | 0.0718 | 0.0921 | 0.1005 |
| **NP-fertilizer rates (g/plant/year)** | | | | |
| Control | 0.497 | 0.533 | 0.779 | 0.827 |
| 20g N + 10g P | 0.465 | 0.513 | 0.639 | 0.684 |
| 40g N + 20g P | 0.499 | 0.547 | 0.767 | 0.821 |
| 60g N + 30g P | 0.469 | 0.500 | 0.703 | 0.764 |
| 80g N + 40g P | 0.573 | 0.611 | 0.793 | 0.897 |
| 100g N + 50g P | 0.538 | 0.582 | 0.842 | 0.892 |
| SE+ | 0.0729 | 0.0718 | 0.0921 | 0.1005 |
| **Varieties** | | | | |
| Palm 300 | 0.415c | 0.450c | 0.628c | 0.702 |
| Tirgal | 0.485a-c | 0.516a-c | 0.698a-c | 0.756 |
| Dan-Mali | 0.628ab | 0.684a | 0.910a | 0.977 |
| Deglet Noor | 0.631a | 0.678ab | 0.893ab | 0.958 |
| Shuwarin C | 0.421bc | 0.453c | 0.676a-c | 0.712 |
| Shuwarin B | 0.463a-c | 0.503a-c | 0.718a-c | 0.779 |
| SE+ | 0.0729 | 0.0718 | 0.0921 | 0.1005 |

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

**Table 3: Effect of Water harvesting methods, Nitrogen and Phosphorus fertilizer on Leaf Length of Different Date palm (*Phoenix d*-) varieties between March – December 2006, at NIFOR Date palm Research Sub – station, Dutse**

| Treatments | Period in Month | | | |
|---|---|---|---|---|
| | March | June | September | December |
| **Water Harvesting Methods** | | | | |
| Control | 0.902ab | 1.063 | 1.217ab | 1.497ab |
| Single side pit | 0.752b | 0.874 | 1.073b | 1.337b |
| Double side pits | 0.753b | 0.897 | 1.060b | 1.348b |
| Perimeter square basin | 0.967ab | 1.073 | 1.333ab | 1.513ab |
| Side square basin | 0.918ab | 1.029 | 1.186ab | 1.509ab |
| Double square basin | 1.064a | 1.183 | 1.347a | 1.638a |
| SE+ | 0.1063 | 0.1093 | 0.0945 | 0.0812 |
| **NP-fertilizer rates (g/plant/year)** | | | | |
| Control | 0.886 | 1.034ab | 1.183ab | 1.414 |
| 20g N + 10g P | 0.757 | 0.847b | 1.014b | 1.364 |
| 40g N + 20g P | 0.891 | 1.022ab | 1.193ab | 1.465 |
| 60g N + 30g P | 0.848 | 0.971ab | 1.161ab | 1.502 |
| 80g N + 40g P | 1.023 | 1.180a | 1.308a | 1.563 |
| 100g N + 50g P | 0.952 | 1.065ab | 1.257ab | 1.533 |
| SE+ | 0.1063 | 0.1093 | 0.0945 | 0.0812 |
| **Varieties** | | | | |
| Palm 300 | 0.786 | 0.932 | 1.099b | 1.419bc |
| Tirgal | 0.826 | 0.959 | 1.121b | 1.353c |
| Dan-Mali | 1.101 | 1.226 | 1.415a | 1.743a |
| Deglet Noor | 1.017 | 1.147 | 1.286b | 1.593ab |
| Shuwarin C | 0.773 | 0.905 | 1.075b | 1.353c |
| Shuwarin B | 0.854 | 0.950 | 1.119b | 1.380bc |
| SE+ | 0.1063 | 0.1093 | 0.0945 | 0.0812 |

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

**Table 4: 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 | 5-30 | 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.
Source: Meteorological unit, NIFOR Date palm Research Sub - station, Dutse.