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# THE RESPONSE OF RAINFED PEARL MILLET (*PENNISETUM glaucum L.*) TO NITROGENOUS AND PHOSPHATIC FERTILIZERS APPLIED OF SANDY LOAM SOIL

[33]

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## ABSTRACT

A field experiment was conducted for two Summer seasons (2000 and 2001) to investigate the effects of nitrogenous and phosphatic fertilization on growth and yield of rainfed pearl millet (*Pennisetum glaucum* L.) grown on sandy loam soil at University of Zalingei site, Western Darfur States, Sudan. The experimental design used was spilt plot design with five replications with N in the main plots and P in the subplots. Four nitrogen treatments (0, 30, 60 and 80kg N/ha) and four phosphorus treatments (0, 15, 30 and 60kg P/ha) were used; Urea (46% N) and triple superphosphate (48% $P_2O_5$) were used as sources of N and P, respectively. Triple superphoshate fertilizer was applied at sowing in bands while urea was applied in bands and split in two equal doses, the first dose was added four days after emergence and the second three weeks after sowing. Grain and stover yields were increased as a result of nitrogen application. Nitrogen fertilization gave a rise in grain yield of 32.6%-131.9% and in stover yield of 69.2% - 262.9% over the control. On the other hand, phosphorus, had a significant effect on plant height and leaf area index (LAI) in the first season while in the second season such effect was observed during early stages only. Highly significant correlations between the added fertilizers (N and P) and yield of millet (grain and stover) were obtained in both seasons.

**Keywords:** Pearl millet, Nitrogenus fertilizers, Phosphatic fertilizers, Sandy loam soils

## INTRODUCTION

Yield of most crops in Sudan is very low compared with those in many parts of the world. This may be attributed to the low soil fertility which should be corrected by fertilizers application. The use of fertilizers in Sudan is often limited to irrigated agriculture and rarely practiced under rainfed conditions. In Sudan, pearl millet is an important cereal crop, next to sorghum. It constitutes the stable food of

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the majority of inhabitants of Western part of Sudan (Darfur and Kordofan) where it occupies an area of 1.2-2.9 million hectares (**Abuelgasim & Jain, 1987 and FAO, 1999**). Most of the millet area is cultivated under traditional rainfed agriculture. In Western Sudan, normally, the farmers used to cultivate vast areas on traditional basis to produce very low yield per unit area. This is considered a waste of farmer's effort and land. Generally, rainfed agriculture in Sudan contributes significantly to the national economy by supplying the most important food crops, mainly cereals. In spite of this, very little research work was conducted in this sector compared with irrigated agriculture. In particular, pearl millet did not receive the appropriate attention, despite its importance as a food crop for a wide sector in Sudan. Therefore, this study was conducted in order to investigate the effect of nitrogen and phosphorus fertilization on growth and yield of rainfed pearl millet on a sandy loam soil under Western Darfur State conditions.

## MATERIAL AND METHODS

A field experiment was conducted for two Summer seasons (2000 and 2001) to investigate the effect of nitrogenous and phosphatic fertilizers on growth and yield of rainfed pearl millet (*Pennisetum glaucum*) at University of Zalingei Site, Western Darfur State (latitude 12° 45' N and longitude 23° 29' E with an attitude of 900m above mean sea level).

According to **Black *et al* (1969)**, the soil of the site is sandy loam (65% sand) slightly acid (pH 5.6-6.7) with low organic carbon (0.16-0.29%), soil nitrogen (0.029-0.035%), phosphorus (0.74-0.77 ppm). The used experimental design was spilt plot design replicated five times with nitrogen in the main plots and phosphorus in the subplots. Local pearl millet cultivar (Darmasa) was sown on the $12^{th}$ and $15^{th}$ of July in the first and second seasons, respectively. The subplot was 6 x 4m in area and consisted of 6 rows 70cm apart and an intrarow spacings of 70cm. Seeds were shown at seed rate of 5 seeds/hole and a depth of 5cm. Nitrogen treatments consisted of four N levels: 0, 30, 60 and 80kg N/ha designated as 0N, 1N, 2N and 3N, respectively, while phosphorus treatments consisted of four P levels: 0, 15, 30 and 60kg P/ha designated as 0P, 1P, 2P and 3P, respectively.

Triple superphosphate was applied at sowing in bands of 5cm depth and at a distance of 5cm from the seeds, while urea was split in two equal doses applied four days after emergence and three weeks after sowing by hand placement. Thinning was done when the plants were four weeks old to end up with three plants per hole. Weeding was done three times in the first season and twice in the second season. Growth parameters were measured at intervals of two weeks starting a month after sowing and continued to harvest. The crop was harvested at 120 and 112 days from sowing in the first and second seasons, respectively. Grain and stover yields were evaluated in an area of $6.25m^2$ in the centre of the middle three rows of each plot.

## RESULTS AND DISCUSSION

### Vegetative growth parameters

Nitrogen significantly affected plant height ($P \leq 0.05$) at all stages in both studied seasons (Table, 1). The differences in plant height at different used nitrogen

Table 1. Effect of nitrogen fertilizer on plant height (cm)

| Nitrogen level | Time (weeks after sowing) | | | | |
|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 |
| First season | | | | | |
| 0 N | 30.7b | 71.6$^{b}$ | 147.9 b | 177.6 b | 189.3 b |
| 1 N | 39.2a | 108.9 a | 200.5 a | 219.9 a | 220.7 a |
| 2 N | 38.2 a | 106.9 a | 205.1 a | 221.2 a | 221.9 a |
| 3 N | 37.2 a | 106.9 a | 200.9 a | 217.2 a | 219.2 a |
| S.E± | 1.92 | 5.50 | 10.47 | 8.42 | 6.20 |
| Second season | | | | | |
| 0 N | 44.1c | 66.8c | 109.9 b | 137.2 b | 140.9 b |
| 1 N | 48.3 b | 105.6b | 157.9 a | 174.9 a | 178.5 a |
| 2 N | 52.9 a | 113.9 a | 163.9 a | 177.5 a | 178.2 a |
| 3 N | 52.9 a | 116.5 a | 160.6 a | 176.7 a | 177.3 a |
| S.E± | 1.06 | 2.02 | 4.55 | 5.04 | 5.15 |

Means within the same column followed by the same letter are not significantly different at P≤0.05 according to Duncan's Multiple Test (DMRT).

0N = 0kg N/ha 1N = 30kg N/ha
2N = 60kg N/ha 3N = 80N/ha

rates were significant relative to the control, but this was not the case among the other N treatments. The average increase in plant height produced by nitrogen addition amounted to about 16.6% over the control. These results were in conformity with findings obtained by **Ibrahim, (1996)** who found that plant height of pearl millet increased significantly and linearly with increased nitrogen application. Nitrogen application had a significant effect (P<0.05) on LAI in both seasons (Table, 2). Such LAI being also increased with increasing nitrogen rate. This may be due to the favourable effect of nitrogen on vegetative growth compared with control. **Mourad *et al* (1986)** found that LAI values were significantly increased with increasing nitrogen rate up to 90 kg N/fed.

With regard to phosphorus, it affected plant height significantly in both seasons (P≤ 0.05) (Table, 3). However, at later stages in the second season, this significant effect disappeared. **Okalebo, (1984)** reported that millet height at maturity increased significantly with fertilizer application and he obtained a linear relationship between the applied phosphate and plant height. Likewise, phosphorus fertilizer increased LAI significantly (P<0.05) over the control in the first

Table 2. Effect of nitrogen fertilizer on leaf area index (LAI)

| Nitrogen level | Time (weeks after sowing) | | | |
|---|---|---|---|---|
| | 4 | 6 | 8 | 10 |
| First season | | | | |
| 0 N | 0.51b | 2.27b | 2.93c | 2.94b |
| 1 N | 0.85a | 3.66a | 4.16b | 3.17b |
| 2 N | 0.84a | 3.93a | 4.75a | 3.47a |
| 3 N | 0.81a | 4.46a | 5.19a | 3.68a |
| S.E± | 0.05 | 0.24 | 0.18 | 0.08 |
| Second season | | | | |
| 0 N | 0.61c | 1.14c | 1.07c | 0.49c |
| 1 N | 0.92b | 2.19b | 2.02b | 0.98b |
| 2 N | 1.28a | 2.64a | 2.22ab | 1.28a |
| 3 N | 1.23a | 2.75a | 2.34a | 1.42a |
| S.E± | 0.06 | 0.08 | 0.09 | 0.05 |

Means within the same column followed by the same letter are not significantly different at P≤0.05 according to Duncan's Multiple Range Test (DMRT). Symbols as shown in Table 1.
0N = 0kg N/ha 1N = 30kg N/ha 2N = 60kg N/ha 3N = 80kg N/ha

Table 3. Effect of phosphorus fertilizer on plant height (cm)

| Phosphorus level | Time (weeks after sowing) | | | | |
|---|---|---|---|---|---|
| | 4 | 6 | 8 | 10 | 12 |
| First season | | | | | |
| 0 P | 31.4b | 82.3b | 165.3b | 194.5b | 200.0b |
| 1 P | 38.2a | 102.9a | 195.8a | 211.1a | 213.7a |
| 2 P | 37.5a | 103.3a | 195.2a | 214.9a | 218.3a |
| 3 P | 38.2a | 105.9a | 198.0a | 215.4a | 219.1a |
| S.E± | 1.10 | 2.98 | 3.02 | 8.42 | 2.11 |
| Second season | | | | | |
| 0 P | 46.9b | 90.4b | 141.8a | 161.5a | 162.6a |
| 1 P | 49.7a | 102.3a | 147.4a | 169.1a | 171.7a |
| 2 P | 50.9a | 104.7a | 153.8a | 171.0a | 173.4a |
| 3 P | 50.6a | 105.4a | 149.5a | 164.8a | 167.3a |
| S.E± | 0.99 | 1.42 | 3.34 | 3.09 | 3.14 |

Means within the same column followed by the same letter are not significantly different at P≤0.05 according to Duncan's Multiple Range Test (DMRT).
0P = 0kg P/ha 1P = 15kg P/ha 2P = 30kg P/ha 3P = 60kg P/ha

season (Table, 4). In the second season, the effect of P was obvious early in the season ($4^{th}$ and $6^{th}$ week measurement), but later ($8^{th}$ and $10^{th}$ measurement) the effect of added phosphorus was not significant (Table, 4).

The data was statistically analysed by using ANOVA for split-plot design. Means were compared according to Duncan's Multiple Range Test (DMRT) **(Gomez and Gomez, 1984)**. The interaction of N X P exerted a non significant effect on most parameters, except plant height at the eighth and sixth week after sowing in the first and second seasons, respectively (Tables 5 and 6). Here, the combination of 2N X 3P gave the tallest plants in both occasions.

## Grain and Stover Yields

The highest yield obtained in the first season was attributed to favorable rainfall (778 mm) and its distribution throughout the growing season. In contrast, the rainfall was very low (421 mm) in the second season which adversely affected crop production. This was in line with the results recorded by **Batino *et al* (1989)**.

Simple regression analysis was performed to reveal the relationship between grain and stover yields and the fertilizers used. Highly significant correlation between nitrogen and grain yield was obtained ($P \leq 0.01$. $r^2 = 0.998$ and 0.984 for the first and second seasons, respectively) (Figs. 1 and 2). Nitrogen accounted for about 99.8% and 98.4% of the variability in grain yield for the first and second seasons, respectively. The stover yield was significantly correlated with nitrogen level ($P \leq 0.01$, $r^2 = 0.994$ and 0.987 for the first and second seasons, respectively) (Figs. 3 and 4). Nitrogen accounted for about 99.4% and 98.7% of the variability in stover yield for the first and second seasons, respectively. Nitrogen produced a substantial increase in both grain and stover yields of millet. Nitrogen fertilization gave an average rise of 32.7and 131.9% in grain yield in the first and second seasons, respectively. The respective increase in stover yield by N fertilization was 69.2 and 262.6% in the first and second seasons respectively. Many research workers **(Bationo *et al* 1990; Okalebo, 1984 and Maman *et al* 1999)** reported similar findings.

With regards to phosphorus, significant correlation between P and grain yield was obtained in both seasons ($P<0.05$, $r^2 = 0.939$ and 0.874 in the first and second seasons, respectively) (Figs. 5 and 6). The phosphorus accounted for about 93.9% and 87.5% of the variability. Results showed a significant correlation between phosphorus levels and stover yield ($P \leq 0.05$, $r^2 = 0.999$ and 0.892 in the first and second seasons, respectively) (Figs. 7 and 8). Phosphorus accounted for about 99.9% and 89.2% of the variability in stover yield for the first and second seasons, respectively. Phosphorus application significantly increased grain and stover yields over the control of 10.9% to 20.0% for grain yield and of 12.8-71.6% for stover yield for the first and second seasons, respectively. These results were in harmony with those obtained by **Okalebo (1984)**.

Table 4. Effect of phosphorus fertilizer on leaf area index (LAI)

| Phosphorus level | Time (weeks after sowing) | | | |
|---|---|---|---|---|
| | 4 | 6 | 8 | 10 |
| **First season** | | | | |
| 0 P | 0.54b | 2.93c | 3.76c | 3.10b |
| 1 P | 0.79a | 3.54 b | 4.28 b | 3.30ab |
| 2 P | 0.83 a | 3.76 a | 4.34ab | 3.36 a |
| 3 P | 0.85 a | 3.80 a | 4.56 a | 3.49a |
| S.E± | 0.04 | 0.05 | 0.09 | 0.08 |
| **Second season** | | | | |
| 0 P | 0.77 b | 1.95 b | 1.93 a | 1.04 a |
| 1 P | 1.08 a | 2.23a | 2.04 a | 1.11 a |
| 2 P | 1.11 a | 2.30 a | 1.91 a | 1.04 a |
| 3 P | 1.16 a | 2.25 a | 1.78 a | 0.99 a |
| S.E± | 0.04 | 0.07 | 0.01 | 0.10 |

Means within the same column followed by the same letter are not significantly different at P≤0.05 according to Duncan's Multiple Range Test (DMRT).
0P = 0kg P/ha 1P = 15kg P/ha 2P = 30kg P/ha 3P = 60kg P/ha

Table 5. Effect of treatments interaction on plant height (cm) at the Sixth week after sowing (2nd season)

| Phosphorus level | Nitrogen level | | | |
|---|---|---|---|---|
| | 0N | 1N | 2N | 3N |
| 0 P | 64.7f | 96.1e | 100.3cd | 100.5cd |
| 1 P | 68.9f | 105.4cd | 117.7ab | 117.4ab |
| 2 P | 66.7f | 109.6bc | 117.8ab | 124.6a |
| 3 P | 66.9f | 111.5bc | 119.7a | 123.4a |
| S.E±3.02 | | | | |

Means within the same column followed by the same letter are not significantly different at P≤0.05 according to Duncan's Multiple Range Test (DMRT).
0N = 0kg N/ha 1N = 30kg N/ha 2N = 60kg N/ha 3N = 80kg N/ha
0P = 0kg P/ha 1P = 15kg P/ha 2P = 30kg P/ha 3P = 60kg P/ha

Table 6. Effect of treatments interaction on plant height (cm) at the eighth week after sowing (1st season).

| Phosphorus level | Nitrogen level | | | |
|---|---|---|---|---|
| | 0N | 1N | 2N | 3N |
| 0 P | 110.77f | 177.96cd | 187.80bc | 184.80bc |
| 1 P | 165.43de | 206.60a | 209.10a | 202.17ab |
| 2 P | 156.83e | 211.30a | 20576a | 207.13a |
| 3 P | 158.33e | 206.04a | 217.50a | 209.87a |
| S.E±3.02 | | | | |

Means within the same column followed by the same letter are not significantly different at $P \leq 0.05$ according to Duncan's Multiple Range Test (DMRT).
0N = 0kg N/ha 1N = 30kg N/ha 2N = 60kg N/ha 3N = 80kg N/ha
0P = 0kg P/ha 1P = 15kg P/ha 2P = 30kg P/ha 3P = 60kg P/ha

Fig. 1: Effect of nitrogen on grain yield ( first season)

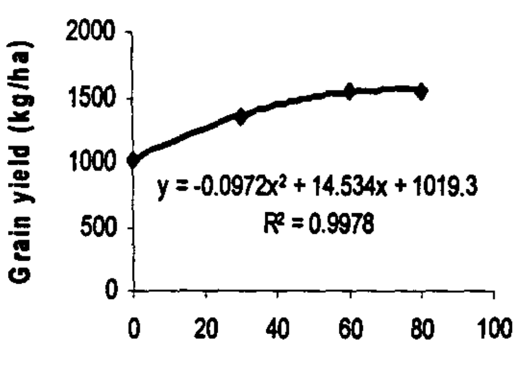


**Fig. 2: Effect of nitrogen on grain yield (second season)**

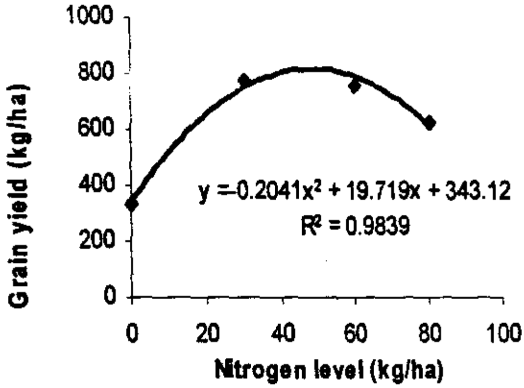
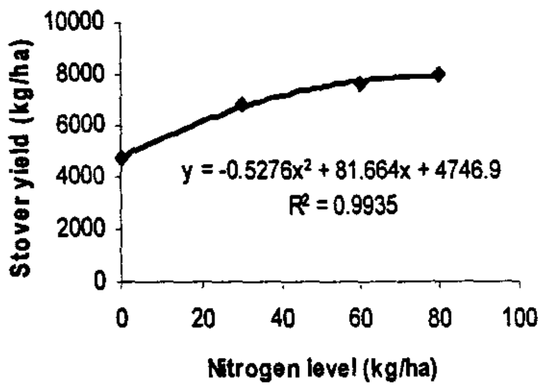



**Fig. 3: Effect of nitrogen on stover yield (first season)**



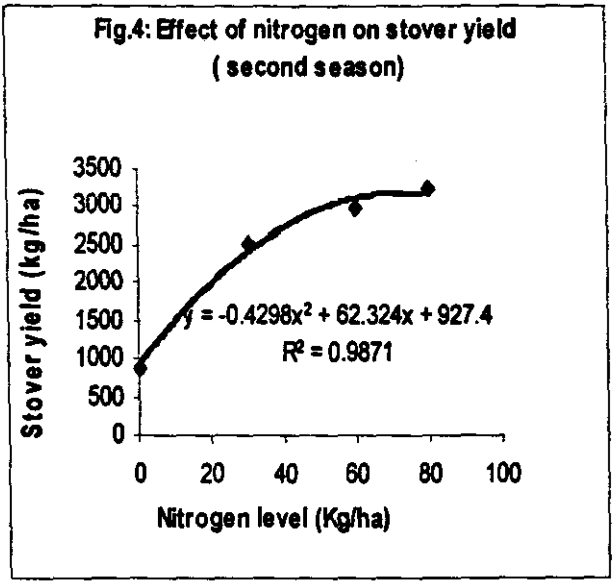


Fig.4: Effect of nitrogen on stover yield
( second season)
Stover yield (kg/ha)
3500
3000
2500
2000
1500
1000
500
0
0
20
40
60
80
100
Nitrogen level (Kg/ha)
y = -0.4298x² + 62.324x + 927.4
R² = 0.9871

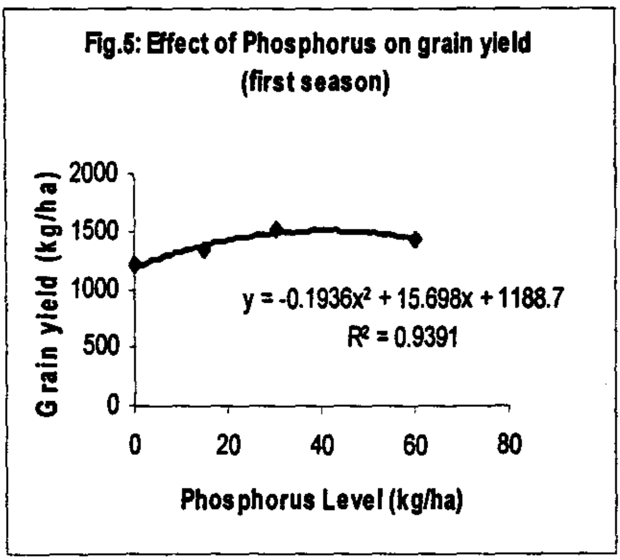


Fig.5: Effect of Phosphorus on grain yield
(first season)
Grain yield (kg/ha)
2000
1500
1000
500
0
0
20
40
60
80
Phosphorus Level (kg/ha)
y = -0.1936x² + 15.698x + 1188.7
R² = 0.9391

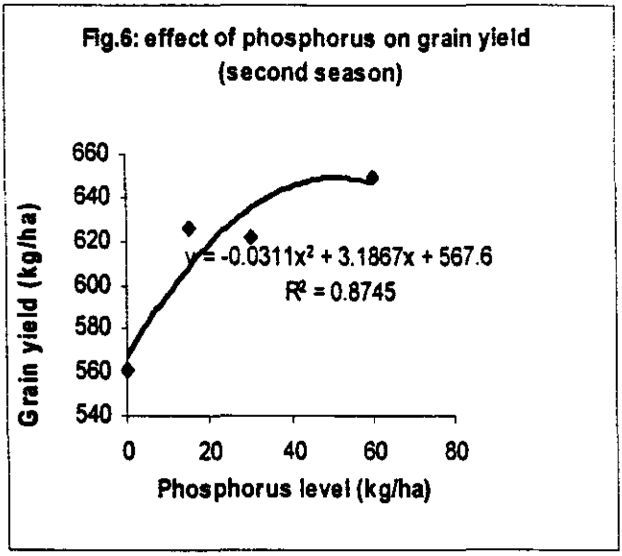


Fig.6: effect of phosphorus on grain yield
(second season)
Grain yield (kg/ha)
660
640
620
600
580
560
540
0
20
40
60
80
Phosphorus level (kg/ha)
y = -0.0311x² + 3.1867x + 567.6
R² = 0.8745

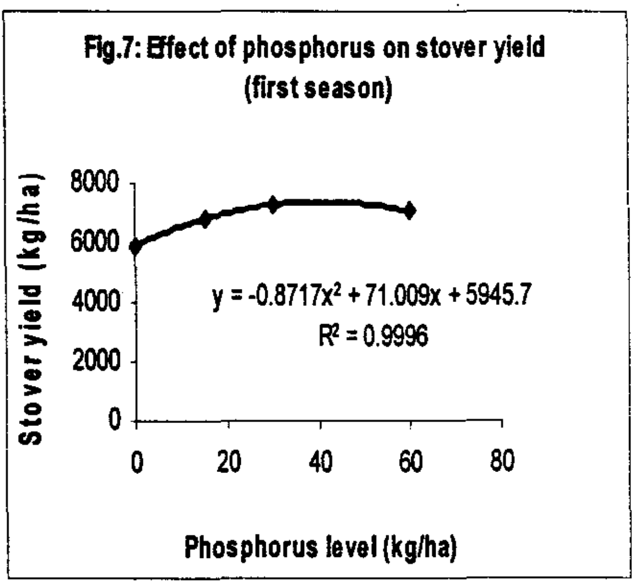
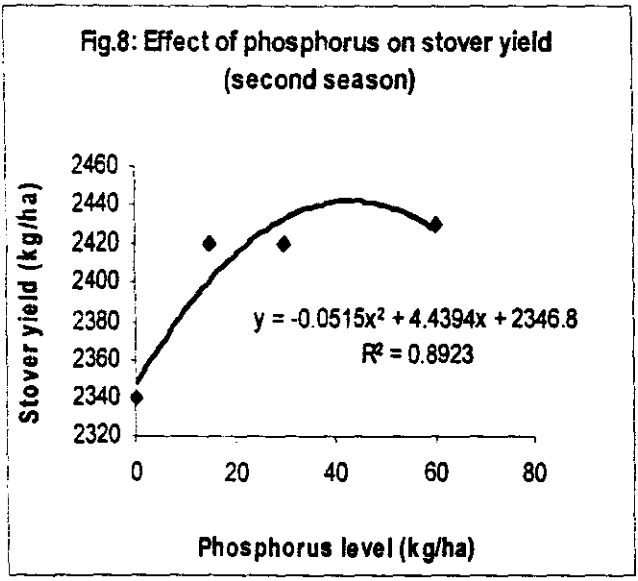


Fig.7: Effect of phosphorus on stover yield
(first season)
Stover yield (kg/ha)
8000
6000
4000
2000
0
0
20
40
60
80
Phosphorus level (kg/ha)
y = -0.8717x² + 71.009x + 5945.7
R² = 0.9996




## REFERENCES

**Abuelgasim, H.E. and R.P. Jain, (1987).** Breeding pearly millet for drought in the Sudan. Proceeding of the International Pearl Millet Workshop (7-11 April, 1986). *ICRISAT Center, India: 307-308.*

**Batino, A.; C.B. Christianson and A.U. Mokwunye, (1989).** Soil fertility management of pearl millet. Producing Sandy Soil of Sahelian West Africa: The Niger experience, Soil. Crop and Water management systems for rainfed agriculture in the Sudan Sahelian zone: Proceeding of International Workshop (11-16 Jan, 1989). *ICRISAT Sahelian Center Niame, Niger: 159-167.*

**Bationo, A.; C.B. Christianson and W.E. Baethgen, (1990).** Plant density and nitrogen fertilizer effects on pearl millet production in Niger. *Agron. J. 82: 290-294.*

**Black, C.A.; D.D. Evans; J.E. Ensminger; J.L. White and F.E. Clark, (eds.) (1969).** *Methods of Soils Analysis, Part 2.* Chemical and Microbiological Proprieties. Madison, Wisconsin, USA.

**FAO, (1999).** Food and Agricultural Organization of the United Nations. *Yearbook. 53, FAO, Rome.*

**Gomez, K.A. and A.A. Gomez (1984).** *Statistical Procedures for Agricultural Research. 2nd Edition.* **pp. 75-165.** John Wiley and Sons Inc. New York.

**Ibrahim, A.E.S. (1996).** Growth and forage yield of pearl millet (*Pennisetum americanum* L.) as affected by irrigation frequency, seed rate and nitrogen in the United Arab Emirates. *U.K.J. of Agric. Sci., 4(1): 45-60.*

**Maman, N.; C.M. Sephen; T. Galusha and M.D. Clegg, (1999).** Hybrid and nitrogen influence on pearl millet production in Nebraska: yield, growth, nitrogen uptake and nitrogen use efficiency. *Agron. J. 91(5): 737-743.*

**Mourad, S.B.; M.A. El-lakny.; A.I. El-Agamy and F.H. Soliman, (1986).** Response of some varieties of hybrids of maize to plant densities and nitrogen fertilization I. Growth and flowering traits. *Al-Azhar J. Agric. Res., 4: 401-411.*

**Okalebo, J.R. (1984).** Bulrush millet (*Pennisetum tyhoides*) responses to nitrogen and phosphorus fertilizers at Ithookwe, Kitui, Kenya. *East Afr. Agric. For. J. 49(3): 62-77.*

**Okalebo, J.R.; J.K.A. Keter and H. Sali (1989).** Response of sorghum to fertilizer nitrogen and phosphorus in semi-arid areas of Machakos and Kitui districts in Kenya. *East Afr. Agric. For. J. 54(3): 131-145.*

**Reddy, K.A. and R.S. Rao. (1971).** Effect of nitrogen and spacing on growth and yield of bajra (*Pennisetum typhoides* S. And H.) *Indian J. Agric. Res., 5: 105-108.*

مجلة حوليات العلوم الزراعية ، كلية الزراعة ، جامعة عين شمس ، القاهرة ، م٥٠ ، ع(٢)، ٤٩٩-٥١١ ، ٢٠٠٥

# تأثير إضافة السماد النتروجينى والفوسفاتى على نمو وإنتاجية محصول الدخن المزروع فى تربة رملية طمية فى الزراعة المطرية

**[٣٣]**

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أجريت تجربة حقلية لموسمين متتاليين (٢٠٠٠ و ٢٠٠١) بموقع جامعة زالنجى بولاية غرب دارفور لدراسة تأثير إضافة السماد النتروجينى والفوسفاتى على نمو وإنتاجية الدخن المزروع فى تربة رملية طمية فى الزراعة المطرية وتمت زراعة صنف محلى من الدخن (درسما) . وقد استخدمت أربعة معاملات من النتروجين هى صفر و ٣٠ و ٦٠ و ٨٠ كجم نتروجين للهكتار وأربعة معاملات من الفوسفور هى صفر و ١٥ و ٣٠ و ٦٠ كجم فوسفور للهكتار . وأستعمل اليوريا كمصدر للنتروجين والسيوبر فوسفات الثلاثى (٤٨% $P_2O_5$) كمصدر للفوسفور . وأتبع فى تنفيذ التجربة تصميم القطع المنشقة فى خمس مكررات وكانت معاملات النتروجين

في القطع الرئيسية ومعاملات الفسفور في القطع الفرعية ، وقد أضيف السماد الفوسفورى مع الزراعة في خطوط ، أما السماد النيتروجيني فقد أضيف على جرعتين الأولى بعد أربعة أيام من ظهور البادرات والثانية بعد ثلاثة أسابيع من الزراعة .

أوضحت النتائج أن إضافة النتروجين أدت إلى زيادة معنوية في طول النباتات ودليل مساحة الأوراق وإنتاجية الحبوب والقصب حيث تراوحت نسبة زيادة إنتاجية الحبوب بين ٣٢,٦ % - ١٣١,٩% بينما تراوحت نسبة الزيادة فى إنتاجية القصب بين ٦٩,٢% - ٢٦٢,٩% مقارنة بالشاهد ، أما الفسفور فقد كان له تأثير معنوى على طول النبات ودليل مساحة السطح الورقى في الموسم الأول أما في الموسم الثاني للزراعة فقد لوحظ تأثير السماد الفسفورى فى المراحل الولى للنمو . وقد دلت الدراسة على وجود إرتباط معنوى عالى بين الأسمدة المضافة (النيتروجينية والفوسفاتية) وإنتاجية الدخن من الحبوب والقصب في موسمى التجربة .

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