# Effects of nitrogen and phosphorous fertilizers on performance of four sunflower varieties

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*Abstract*

*Three sunflower hybrids (Pan 7351, DK 4040 and DKF 68-22) and one open pollinated variety (Sunfola) were grown with different fertilizer application rates in four locations of North eastern and Northern Uganda in 2004. The locations were Serere Agricultural and Animal Production Research Institute (SAARI) main station, and the Technology Verification Centres (TVCs) of Kumi, Kaberamaido and Ngetta. Ngetta is in northern Uganda while the other three are in the north east. Fertilizer treatments comprised the control (N0P0), 30 kg P/ha (N0P30), 30 kg N/ha (N30P0), 30 kg N/ha combined with 60 kg P/ha (N30P60), 60 kg N/ha combined with 30 kg P/ha (N60P30), 90 kg N/ha combined with 30 kg P/ha (N90P30) and 120 kg N/ha combined with 60 kg P/ha (N120P60). The four varieties did not significantly differ in height at each location but application of 120 kg N/ha and 60 kg P/ha (N120P60) at SAARI and Kaberamido increased height most. In three of the locations application of 30 kg N/ha combined with 60 kg P/ha (N30P60) significantly increased head diameter of all the varieties. The hybrid Pan 7351 performed best at Kaberamiado and Ngetta, and the best mean yield across the areas was attained by application of 30 kg N/ha and 60 kg P/ha (N30P60).*

Keywords: sunflower, *Helianthus annus L., fertilizers, nitrogen, phosphorous*

## Introduction

Sunflower *(Helianthus annus L.)* has become an important crop in Uganda, especially in the eastern and northern parts of the country. Although sunflower was widely grown in many parts of Uganda by the 1960s, no significant research had been conducted on this commodity. The Ministry of Agriculture did not even begin collecting national sunflower area and yield estimates until 1989. Interest in sunflower production has risen rapidly in recent years, and the area planted to sunflower has increased from less than 5,000 ha in the early 1980s to over 38,000 ha in 1991 (Rita Laker-Ojok, 1994). Yields per unit area, however have, remained low. The average yield in farmers' fields is about 750 kg per hectare, yet the yield potential of the crop is more than 2,500 kg per hectare.

One of the major causes of these low yields is decline in soil fertility in most of the areas where sunflower is grown. Sunflower is a heavy feeder with high nutrient requirements, especially for nitrogen (N), phosphorous (P) and potassium (K), although different reports exist regarding sunflower nutrient requirements. Putnam *et al* 1990 indicated that sunflower grows in a wide range of soil types from sands to clays with lower demands on soil macronutrients. They showed, however, that as with other non-leguminous grain crops, nitrogen is usually the first limiting factor for yield in sunflower. Although sunflower extracts a lot of nutrients from the soil, a small portion of these nutrients is removed with the seeds and the rest remains in the trash. Work in some places has shown that sunflower has modest fertility needs, but responds to nitrogen, and that animal manure or a legume cover crop can reduce or eliminate need for N fertilizer (http://www.jeffersoninstitute.org/sunflower.php**).** Other reporters stressed on the critical periods of nutrient requirements, saying that **s**unflower needs an adequate supply of nutrients at each developmental stage for optimum growth and that high yielding sunflower varieties remove greater amounts of nutrients from the soil (http://www.oznet.ksu.edu/library/crpsl2/sections/mf2384_body.pdf). It is therefore necessary to add adequate amounts of nutrients in sunflower fields.

Research on sunflower in Uganda has concentrated mainly on germplasm collection, genetic improvement and cropping systems (NARO, 1999). Not much has been done on nutrient requirements of sunflower and the little work done has not been well documented. Information on how inorganic fertilizers affect yield and quality factors of sunflower is scanty, and optimum fertilizer rates and combinations have not been established for sunflower in Uganda.

The way farmers manage sunflower trash seems to have contributed to the depletion of soil fertility as commonly reported by farmers. The trash from threshed heads is not returned to the fields and the stalks that remain in the fields are removed for firewood or for burning into soda ash used locally for cooking grain legumes. As a result of this, nearly all the nutrients extracted from the soil by the crop are removed from the field, leading to depletion of soil nutrients. There is therefore need to evaluate different management systems so as to find ways of reducing nutrients depletion by sunflower.

Inorganic fertilizer application to soils is one sure option of maintaining and enhancing soil fertility under various intensively cropped systems. In the forest-savanna transition zone of south-west Nigeria for example Olowe *et al* (2005) concluded that application of 60 kg N/ha and 30 kg P/ha (N60P30) resulted in optimum performance of sunflower, with N significantly ($P < 0.05$) increasing plant height, head weight, head diameter, and grain yields relative to the control. In Uganda, the problem sometimes arises from the high cost of fertilizers and lack of technical know-how. Sunflower, however, is a fairly highly paying crop, which could offset the cost of fertilizer use. The trend which the country is taking in the Plan for Modernization of Agriculture (PMA, 2005), in which research must put emphasis on development or importation, adaptation and adoption of improved high yielding, disease and pest resistant plant and stocking materials, puts sunflower in a good advantage. This requires that as many technologies as possible be made readily available, and includes fertilizer types and optimum application rates. Trials were therefore set up to evaluate fertilizer use in four sunflower varieties in Uganda.

The objectives of this study were to evaluate the effect of different rates and combinations of nitrogen and phosphorus fertilizers on growth and yield of sunflower under rain-fed conditions; and to determine the optimum rates and combination of nitrogen and phosphorus fertilizers for rain-fed sunflower in Uganda.

**Materials and methods**

Trials were planted at Serere Agricultural and Animal Production Research Institute (SAARI) main station, and the Technology Verification Centres (TVCs) of Kumi, Kaberamaido and Ngetta on 12$^{th}$, 14$^{th}$, 18$^{th}$ and 20$^{th}$ October 2004, respectively. The land was ploughed and re-ploughed with oxen at Kumi and Kaberamaido, and with a tractor at SAARI and Ngetta.

Four sunflower varieties (*Sunfola* an open pollinated variety and three hybrids, Pan 7351, DK 4040 and DKF 68-22) were used. They were planted at a spacing of 75x50 cm and thinned to one plant per hole. To each of these varieties, seven fertilizer treatments were applied. They were the control (N0P0), 30 kg P/ha (N0P30), 30 kg N/ha (N30P0), 30 kg N/ha combined with 60 kg P/ha (N30P60), 60 kg N/ha combined with 30 kg P/ha (N60P30), 90 kg N/ha combined with 30 kg P/ha (N90P30) and 120 kg N/ha combined with 60 kg P/ha (N120P60). Phosphorous was supplied in form of single super phosphate (ssp) while nitrogen in form of urea. The fertilizer was uniformly broadcast to the plots just before planting so that the subsequent planting procedure worked the fertilizers into the soil. The experiment was a split plot design replicated three times, with varieties in the main plots and fertilizer rates in the sub-plots. Plots measured 5x3.75 m.

Numbers of days to 50 % flowering and to maturity were recorded. Around the period of physiologic maturity measurements were taken for plant height, stem diameter and head diameter. At full maturity the heads were harvested, threshed, dried and weighed for yield data. Data for each location was analyzed separately using Genstat computer programme.

## Results and discussions

Results are presented for plant height, head diameter and yield only because no significant differences were seen for the other parameters.

## Plant height

Data on sunflower heights is presented in Table 1. Generally, sunflower was tallest at Kaberamaido and Ngetta TVCs than at SAARI, and shortest at Kumi. Unlike *Sunfola*, Pan 7351 and DK 4040, which showed some variations in height across locations, DKF 68-22 was uniform in three locations (Ngetta, SAARI and Kaberamaido) with a mean height of about 131 cm. At Kumi no difference was seen between the varieties. The four varieties did not significantly differ in height at each location. Any differences observed were due to error, as the trend was not maintained across the four sites.

Fertilizer application did not significantly affect plant heights at Ngetta and Kumi, but did so at SAARI and Kaberamido , where the biggest height was achieved by the highest rate of 120 kgN/ha and 60 kg P/ha (N120P60). However, at Kaberamaido and Kumi maximum height was even achieved through application of 30 kgN/ha with 60 kg P/ha (N30P60), while at SAARI only 30kg P/ha was sufficient to do this without any N. The response of individual varieties to fertilizer was highly varied at the 4 locations. At Kaberamaido all fertilizer rates caused dramatic and progressive increments in the height of DK 4040 compared to the no fertilizer control, and compared to the other 3 varieties. Soil analysis was not earlier done but these responses suggest that some locations had better fertility than others and this needs to be established.

## Head Diameter

The mean head diameter ranged from 11.6 cm at SAARI to 15.6 in Kumi (Table 2). The four varieties expressed their head diameter attribute differently in the four locations. Variety DK 4040 was the best in SAARI and Kaberamaido, and second best at Ngetta and Kumi. *Sunfola* was second best at SAARI and Kaberamaido but worst at Ngetta and Kumi. Pan 7351 was worst at Kaberamaido and Ngetta but third best at SAARI and Kumi. DKF 68-22 had the smallest head diameter in SAARI and Kaberamaido but best only at Kumi. Seed counts and weights were not taken but it has been reported that head diameter has a positive relationship with seed number and a negative relationship with seed weight (Michaud *et al*, 2007). Based on head diameter, therefore, these different varieties variously suit the different locations.

Fertilizer application had varying effects on head diameter of all the four varieties. In three out of the 4 locations, use of N30P60 gave the largest head diameter. These three locations SAARI, Ngetta and Kumi were also the sites where fertilizer application had an increase on head diameter. At Kaberamaido fertilizer application reduced head diameter. This was probably due to more nutrient accumulation to the stems than the heads.

## Yield

Sunflower yielded best at Kumi, out competing the on station trial at SAARI and the other two TVCs (Table 3). Except at SAARI where *sunfola* performed best, it was the worst at the three other locations. The hybrid Pan 7351 performed best at Kaberamiado and Ngetta but worst at SAARI. Variety DKF 68-22 maintained its good $2^{nd}$-$3^{rd}$ position at all the four locations. Performance of these hybrids compares well with results of trials conducted at Namulonge, in which average yields on-station were about 2000 kg/ha and at least 1300 kg/ha under farmer management (Rita Laker-Ojok, 1994).

Although big variations were seen in the response of the different varieties to fertilizer rates in the different locations, the best mean yield across the areas was attained by application of 30 kgN/ha and 60 kgP/ha (N30P60).

## Conclusions

1. Variety DKF 68-22 performed satisfactorily well at all locations and could be a more universal variety. More testing, however, is required.
2. Application of 30 kg N/ha of 60 kg P/ha was the best for all the varieties and all the locations used.


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God Almighty provided all we needed, including life and all glory go back to Him.


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**Table 1. Effects of fertilizer application on heights (cm) of four sunflower varieties at four locations in 2004**

| Location | | Variety | | | | |
|---|---|---|---|---|---|---|
| **SAARI** | **Fertilizer rate** | **Sunfola** | **Pan 7351** | **DK 4040** | **DKF 68-22** | **Mean** |
| | **N0P0** | 136.7 | 123.7 | 129.9 | 126.5 | **129.2** |
| | **N0P30** | 158.9 | 138.3 | 127.8 | 136.0 | **140.3** |
| | **N30P0** | 135.5 | 117.7 | 117.7 | 124.7 | **123.9** |
| | **N30P60** | 155.5 | 120.5 | 128.0 | 150.5 | **138.6** |
| | **N60P30** | 140.8 | 125.3 | 133.3 | 129.3 | **132.2** |
| | **N90P30** | 143.3 | 127.8 | 131.8 | 119.7 | **130.7** |
| | **N120P60** | 152.3 | 144.8 | 135.7 | 129.0 | **140.5** |
| | ***Mean*** | **146.2** | **128.3** | **129.2** | **130.8** | **133.6** |
| | **Cv (%)** | | | | | **7.8** |
| | ***Lsd*** | ***Varieties = 16.6; fertilizer rates = 8.6; Interaction = 21.4*** | | | | |
| **Kaberamaido** | | | | | | |
| | **N0P0** | 154.5 | 149.0 | 117.5 | 133.7 | **138.7** |
| | **N0P30** | 148.5 | 151.2 | 121.0 | 115.5 | **134.1** |
| | **N30P0** | 160.7 | 146.9 | 124.8 | 127.8 | **140.1** |
| | **N30P60** | 168.4 | 155.7 | 125.3 | 140.6 | **147.5** |
| | **N60P30** | 137.5 | 154.1 | 127.3 | 141.2 | **140.0** |
| | **N90P30** | 170.1 | 153.0 | 133.5 | 122.8 | **144.9** |
| | **N120P60** | 155.8 | 148.0 | 141.3 | 144.4 | **147.4** |
| | ***Mean*** | **156.5** | **151.1** | **127.2** | **132.3** | **141.8** |
| | ***Cv (%)*** | | | | | **9.0** |
| | ***Lsd*** | ***Varieties = 9.9; fertilizer rates = 13.0; Interaction = 26.1*** | | | | |
| **Ngetta** | | | | | | |
| | **N0P0** | 143.6 | 157.5 | 134.3 | 136.6 | **143.0** |
| | **N0P30** | 145.7 | 151.6 | 142.5 | 134.6 | **143.6** |
| | **N30P0** | 139.9 | 157.7 | 138.5 | 125.5 | **140.4** |
| | **N30P60** | 151.4 | 153.1 | 141.3 | 128.9 | **143.7** |
| | **N60P30** | 149.6 | 152.8 | 139.4 | 131.4 | **143.3** |
| | **N90P30** | 138.8 | 159.9 | 142.2 | 135.7 | **144.2** |
| | **N120P60** | 152.8 | 150.2 | 137.4 | 126.9 | **141.8** |
| | ***Mean*** | **146.0** | **154.7** | **139.3** | **131.4** | **142.8** |
| | ***Cv (%)*** | | | | | **5.9** |
| | ***Lsd*** | ***Varieties =192.5; fertilizer rates =87.9; Interaction =133.8*** | | | | |
| **Kumi** | | | | | | |
| | **N0P0** | 125.7 | 133.5 | 125.5 | 127.8 | **128.1** |
| | **N0P30** | 127.9 | 133.3 | 128.3 | 125.3 | **128.7** |
| | **N30P0** | 120.7 | 113.7 | 131.2 | 123.3 | **122.2** |
| | **N30P60** | 139.8 | 125.5 | 133.0 | 130.2 | **132.1** |
| | **N60P30** | 119.1 | 144.5 | 101.3 | 125.5 | **122.6** |
| | **N90P30** | 113.3 | 124.2 | 125.5 | 121.0 | **121.0** |
| | **N120P60** | 131.9 | 113.3 | 135.0 | 118.7 | **124.8** |
| | ***Mean*** | **125.5** | **126.9** | **125.7** | **124.6** | **125.7** |
| | ***Cv (%)*** | | | | | |
| | ***Lsd*** | ***Varieties = 61.7; Fertilizer rates = 111.5; Interaction = 215.5*** | | | | |

**Table 2. Effects of fertilizer application on head diameter (cm) of four sunflower varieties at four locations in 2004**

| Location | | Variety | | | | |
|---|---|---|---|---|---|---|
| **SAARI** | **Fertilizer rate** | **Sunfola** | **Pan 7351** | **DK 4040** | **DKF 68-22** | **Mean** |
| | **N0P0** | 11.1 | 10.8 | 13.8 | 8.9 | **11.2** |
| | **N0P30** | 14.0 | 12.2 | 13.2 | 10.2 | **12.4** |
| | **N30P0** | 10.3 | 10.2 | 11.1 | 8.3 | **10.0** |
| | **N30P60** | 13.3 | 11.5 | 11.7 | 11.6 | **12.0** |
| | **N60P30** | 11.9 | 10.6 | 15.3 | 10.4 | **12.1** |
| | **N90P30** | 13.2 | 11.5 | 13.6 | 6.0 | **11.1** |
| | **N120P60** | 13.4 | 12.8 | 13.5 | 9.7 | **12.3** |
| | ***Mean*** | **12.5** | **11.4** | **13.1** | **9.3** | **11.6** |
| | **Cv (%)** | | | | | **15.1** |
| | ***Lsd*** | *Varieties = 4.4; fertilizer rates = 1.4; Interaction = 4.8* | | | | |
| **Kaberamaido** | | | | | | |
| | **N0P0** | 14.4 | 16.9 | 12.4 | 14.4 | **14.2** |
| | **N0P30** | 11.5 | 13.2 | 13.1 | 11.5 | **12.1** |
| | **N30P0** | 14.2 | 15.6 | 12.7 | 14.2 | **13.6** |
| | **N30P60** | 14.5 | 14.6 | 11.0 | 14.5 | **13.5** |
| | **N60P30** | 11.3 | 15.6 | 12.7 | 11.3 | **13.3** |
| | **N90P30** | 14.6 | 16.2 | 12.7 | 14.6 | **13.8** |
| | **N120P60** | 14.0 | 12.1 | 14.7 | 14.0 | **13.6** |
| | ***Mean*** | **13.5** | **14.9** | **12.8** | **12.6** | **13.4** |
| | ***Cv (%)*** | | | | | **12.4** |
| | ***Lsd*** | *Varieties =5.1; fertilizer rates =1.7; Interaction =5.0* | | | | |
| **Ngetta** | | | | | | |
| | **N0P0** | 12.2 | 14.6 | 14.0 | 13.8 | 13.8 |
| | **N0P30** | 12.8 | 13.2 | 15.0 | 12.8 | 13.4 |
| | **N30P0** | 12.1 | 15.6 | 14.0 | 11.8 | 13.4 |
| | **N30P60** | 12.8 | 14.7 | 14.6 | 13.4 | 13.9 |
| | **N60P30** | 12.0 | 14.2 | 13.7 | 13.8 | 13.4 |
| | **N90P30** | 11.2 | 15.5 | 14.7 | 13.1 | 13.6 |
| | **N120P60** | 14.3 | 13.6 | 13.4 | 13.9 | 13.8 |
| | ***Mean*** | **12.5** | **14.5** | **14.2** | **13.1** | **13.6** |
| | ***Cv (%)*** | | | | | **10.8** |
| | ***Lsd*** | *Varieties =3.3; fertilizer rates =1.2; Interaction =3.7* | | | | |
| **Kumi** | | | | | | |
| | **N0P0** | 13.4 | 14.5 | 16.1 | 17.0 | **15.2** |
| | **N0P30** | 16.1 | 16.2 | 15.5 | 16.4 | **16.0** |
| | **N30P0** | 15.8 | 14.9 | 15.4 | 15.9 | **15.5** |
| | **N30P60** | 16.0 | 15.0 | 16.2 | 18.0 | **16.3** |
| | **N60P30** | 12.2 | 16.8 | 12.8 | 16.2 | **14.5** |
| | **N90P30** | 13.8 | 16.4 | 16.0 | 14.5 | **15.2** |
| | **N120P60** | 16.5 | 14.0 | 17.5 | 15.3 | **15.8** |
| | ***Mean*** | **14.8** | **15.4** | **15.6** | **16.2** | **15.5** |
| | ***Cv (%)*** | | | | | **14.2** |
| | ***Lsd*** | *Varieties =0.7; fertilizer rates =1.8; Interaction = 14.2* | | | | |

**Table 3. Effects of fertilizer application on grain yields (kg/ha) of four sunflower varieties at four locations in 2004**

| Location | | Variety | | | | |
|---|---|---|---|---|---|---|
| **SAARI** | **Fertilizer rate** | **Sunfola** | **Pan 7351** | **DK 4040** | **DKF 68-22** | **Mean** |
| | **N0P0** | 711 | 563 | 622 | 711 | 652 |
| | **N0P30** | 904 | 607 | 667 | 904 | 770 |
| | **N30P0** | 548 | 415 | 400 | 504 | 467 |
| | **N30P60** | 978 | 578 | 800 | 1052 | 852 |
| | **N60P30** | 741 | 281 | 607 | 770 | 600 |
| | **N90P30** | 741 | 326 | 356 | 800 | 556 |
| | **N120P60** | 859 | 874 | 844 | 637 | 804 |
| | ***Mean*** | ***783*** | ***521*** | ***614*** | ***768*** | ***671*** |
| | **Cv (%)** | | | | | ***35.7*** |
| | ***Lsd*** | ***Varieties =402.2; fertilizer rates = 196.8; interaction = 504.0*** | | | | |
| **Kaberamaido** | | | | | | |
| | **N0P0** | 563 | 625 | 500 | 469 | 539 |
| | **N0P30** | 469 | 525 | 594 | 500 | 547 |
| | **N30P0** | 531 | 500 | 531 | 500 | 516 |
| | **N30P60** | 719 | 594 | 531 | 844 | 672 |
| | **N60P30** | 500 | 813 | 594 | 563 | 617 |
| | **N90P30** | 563 | 531 | 469 | 563 | 531 |
| | **N120P60** | 313 | 781 | 813 | 813 | 680 |
| | ***Mean*** | ***522*** | ***638*** | ***576*** | ***607*** | ***586*** |
| | ***Cv (%)*** | | | | | ***38.7*** |
| | ***Lsd*** | ***Varieties =176.0; fertilizer rates =232.8; Interaction =465.6*** | | | | |
| **Ngetta** | | | | | | |
| | **N0P0** | 217 | 430 | 395 | 299 | 335 |
| | **N0P30** | 247 | 359 | 373 | 384 | 341 |
| | **N30P0** | 181 | 478 | 389 | 252 | 325 |
| | **N30P60** | 332 | 537 | 380 | 384 | 408 |
| | **N60P30** | 238 | 491 | 398 | 391 | 380 |
| | **N90P30** | 162 | 533 | 332 | 444 | 368 |
| | **N120P60** | 343 | 420 | 325 | 372 | 365 |
| | ***Mean*** | ***246*** | ***464*** | ***371*** | ***361*** | ***360*** |
| | ***Cv (%)*** | | | | | ***29.7*** |
| | ***Lsd*** | ***Varieties =192.5; fertilizer rates =87.9; Interaction =133.8*** | | | | |
| **Kumi** | | | | | | |
| | **N0P0** | 375 | 979 | 896 | 1208 | 865 |
| | **N0P30** | 500 | 1000 | 979 | 750 | 807 |
| | **N30P0** | 479 | 771 | 937 | 750 | 734 |
| | **N30P60** | 854 | 771 | 854 | 896 | 844 |
| | **N60P30** | 250 | 1208 | 458 | 1125 | 760 |
| | **N90P30** | 271 | 750 | 750 | 833 | 651 |
| | **N120P60** | 458 | 833 | 1063 | 854 | 802 |
| | ***Mean*** | ***455*** | ***902*** | ***848*** | ***917*** | ***781*** |
| | ***Cv (%)*** | | | | | ***35.0*** |
| | ***Lsd*** | ***Varieties = 61.7; Fertilizer rates = 111.5; Interaction = 215.5*** | | | | |