International Journal of Agriculture and Agricultural Sciences ISSN 1712-3496 Vol. 4(2), pp. 082-089 September, 2017. Available online at www.advancedscholarsjournals.org 

*Full length Research Paper*

# Influence of nitrogen fertilizer rates on growth and yield of fibre hemp cultivars in South Africa

***Francois de Klerk, Matthews Makeba and Winnie Gabriel Barnard**

Agricultural Research Council- Institute for Industrial Crops, Private Bag x 82075, Rustenburg 0300, South Africa.

Accepted 19 August, 2017

**Hemp (*Cannabis sativa* L.) has been grown in Southern Africa for medicinal purpose for many centuries, and in the past half century as an illegal drug crop marijuana, "dagga". It was however, noted that hemp has high fibre which can be used in formation of particle boards, textile products, paper and clothing. Field experiments were conducted during 2006/2007 and 2007/2008 seasons at Addo of Eastern Cape Province. The objective of the study was to determine the influence of nitrogen fertilizer rates; thus, 0, 50, 100 and 150 kg ha$^{-1}$ on growth and yield of fibre hemp cultivars, Kompolti, Felina 35 and Novosadska. In 2007/2008, Novosadska was used to replace Felina 35, whose fibre was very short. Trials were laid out in complete randomised block design with four replications and four nitrogen levels and two hemp cultivars. The results revealed that there were significantly higher fresh biomass yields, dry biomass yield, and fibre yield in the fertilized units than in the unfertilized control unit. The highest plant height, fresh and dry biomass yield were obtained with 100 and 150 kg ha$^{-1}$ of N fertilization were applied at Addo during 2006/2007. Higher nitrogen levels tended to produce higher yield and quality in both seasons. Kompolti performed better than Felina 35 and Novosadska. Kompolti had a higher fibre percentage and quantity than other cultivars in both seasons. It was therefore concluded that nitrogen application had a positive effect on growth and yield studied, and the optimum fertilization rate of nitrogen will be 100 and 150 kg ha$^{-1}$.**

**Key words:** Fibre hemp, cultivars, nitrogen fertilization, yield, quality.

## INTRODUCTION

Hemp (*Cannabis sativa* L.) is unknown to South African farmers as an industrial fibre crop. However, it has been grown in Southern Africa for medicinal purposes for many centuries, but cultivated during the past half-century as an illegal drug crop. This plant species was declared illegal in South Africa in 1928 due to its high cannabinoid

*Corrresponding Author. Email: dr.francois4@yahoo.com

content and potential psycho activity. Although hemp and marijuana are from the same plant family, they have different variations for different uses and physical characteristics (Dippenaar et al., 1996).

Hemp is generally referred to the fibre-producing strain of cannabis (Meijer, 1995). Most soils in Eastern Cape Province are depleted of nitrogen element as a result of mono cropping and leaching, ultimately crop yields and quality decline (Van der Werf, 1995). Brough et al. (2005) postulated that hemp declined yield rapidly when grown continuously in the same soil. Since, soil nutrients decline due to hemp plants uptake. This could be tackled by chemical fertilizers which are always costly and should be used in precise amounts to meet crop needs (Power et al., 1986). The objective of this study was to determine the influence of nitrogen fertilizer rates on growth and yield of fibre hemp cultivars, as well as to determine the best fertilizer rates for optimum yield of hemp cultivars grown in South Africa.

## MATERIALS AND METHODS

During 2006/2007 and 2007/2008 cropping seasons, trials were planted at the Agricultural Research Council's Addo experimental station in the Eastern Cape Province, which is situated at 33° 26" 46' S 25° 44" 45' E. The predominant soil type in the sites was a sandy loam classified by the South African classification system as a Hutton series (Soil Classification Working Group, 1991). An auger was used to take soil samples at 30, 60 and 90 cm depths for nutrients analysis.

### Trial design and treatments

The trial was laid out in randomized complete block design with four replications. Treatments were four nitrogen levels (0, 50, 100 and 150 kg/ha) and two hemp cultivars (Kompolti and Felina 35). The plot size was 4 m long and 1.5 m wide with an inter-row spacing of 0.25 m. There were six rows per plot in each trial. Along each row, a furrow of about 5 to 10 cm deep was made by hand and the seeds were drilled and covered by hand with soil. Hemp was planted at 600 000 plants/ha. The application of nitrogen fertilizer was split into three intervals, 50% of the required N was applied four weeks after planting since a crop requires more of N on early stages of growth, and 30% 8 weeks after planting and 20% after twelve weeks. However, in 2007/2008 Novosadska was used to replace Felina 35 whose height was rather too short and only produced a lot of seed.

### Data collection and analysis

The following data were collected from for two cropping seasons: wet biomass (kg/ha), dry biomass yield, stem diameter (mm), plant height (cm) and fibre percentage (%). Data collected was statistically analyzed using GenStat 5 for windows (7th edition) programme 2003 to develop analysis of variance (ANOVA). Means were separated and compared using a Tukey multiple regressions (Van Ark, 1995).

### Wet biomass (kg ha$^{-1}$)

All plants in the two middle rows of each plot were harvested (cut at about 20 cm above ground level). All the freshly harvested plants (one bundle) were weighed using a scale to achieve wet biomass in the field.

### Dry stem yield

From the plants harvested in the two middle rows, ten plants were selected at random and weighed for fresh biomass yield. Then, stem samples were oven dried at 60°C for 24 h. The weight obtained was converted to kg ha$^{-1}$.

### Stem diameter (mm)

The ten plants sampled earlier for dry stem yield were used to estimate stem diameter. Each plant was measure for stem diameter using Digital Caliper on the middle of the stem. The ten values obtained were averaged and recorded as stem diameter per plot.

### Plant height (m)

The mean height of the ten randomly selected plants was recorded as the plant height per plot. A meter stick was used to measure the plant heights.

### Fibre percentage

The following procedure was used to determine fibre percentage and fibre yield. Stem samples were oven dried at 60°C for 24 h. The dry mass of the samples was boiled in 2% NaOH in 1 L of water for 1 h. Bast fibre was manually removed after being dried for 60°C for 24 h. The weight (mass) of bast fibre and woody core was calculated to estimate the bast fibre and fibre yield.

### Method of conducting soil analysis in the laboratory

#### *Particle size distribution and soil texture*

According to the Handbook of Standard Soil Testing Methods for Advisory Purposes (1990), fifty grams soil was weight in a 500 ml glass beaker and 20 ml Calgon was dispensed in the beaker. 100 ml deionised water was added and it was stirred with a glass rod. The mixture was allowed to stand for 15 min and was transferred into a shake beaker of a high speed electrical mixing machine and was placed on the machine for 5 min. It was transferred into a 1000 ml glass cylinder and was allowed to stand overnight in a 22°C constant room. The following day as early as possible the samples were shaken by hand before taking the readings. The samples were read with the hydrometer exactly 5 min after being shaken. The readings acquired for sand, silt and clay were reported as percentages.

### pH ($H_2O$)

According to the Handbook of Standard Soil Testing Methods for Advisory Purposes (1990), soil pH was determined on a 1:2.5 soil:$H_2O$ ratio suspension with a glass electrode pH Meter. Ten grams of dried soil (2 mm) was placed in a 50 ml glass beaker. 25-cm$^3$ de-ionized water was added and the mixture was stirred rapidly for 5 s and was allowed to stand for 10 min.

pH was determined after 30 s with the electrode positioned in the supernatant. The pH meter was calibrated with commercially available buffer solutions at pH of 4.0, 7.0 and 8.0.

**Table 1.** Soil analysis results for hemp trial at Addo Experimental farm during 2006/2007.

| Description | 0-30 (cm) | 30-60 (cm) | 60-90 (cm) |
|---|---|---|---|
| **pH** | 7.87 | 7.92 | 7.89 |
| **Elements mg kg ha$^{-1}$** | | | |
| N | 2 | 2 | 3 |
| P | 255 | 125 | 140 |
| K | 455 | 291 | 525 |
| Ca | 1770 | 1830 | 4190 |
| Mg | 350 | 405 | 630 |
| Na | 143 | 213 | 378 |
| **Soil texture** | | | |
| % Sand | 60 | 66 | 70 |
| % Silt | 16 | 12 | 18 |
| % Clay | 24 | 22 | 12 |

### Extractable inorganic nitrogen

Extractable inorganic N in soils is defined as $NH^{4+}$, $NO^{3}$- and $NO^{2-}$ extractable at room temperature with a 1.0 mol $dm^{-3}$ KCL solution (Handbook of Standard Soil Testing Methods for Advisory Purposes, 1990). A 30 g soil sample was weight in a 250 ml wide mouth extraction bottle. 150 ml potassium sulphate was dispensed into the extraction bottle. The sample was shaken for 30 min in a reciprocal shaker at 180 oscillations per minute. The sample was allowed to stand for 30 min. It was filtered with a 2V filter paper until there was enough extract for analysis. The analysis was done with an Auto Analyzer.

### Extractable phosphorus

According to the Handbook of Standard Soil Testing Methods for Advisory Purposes (1990), the extraction of P by this procedure is based on the solubilization effect of H+ on soil P and the ability of F+ to lower the activity of $Al^{3+}$ and to lesser extent that of $Ca^{2+}$ and $Fe^{3+}$ in the extraction system. An 8 g of soil was placed in an Erlenmeyer flask. 60 ml Bray-2 solution (20°C) was added into the sample. The sample was shaken for 40 s by hand and was filtered immediately through a Whatman no. 2 filter paper into an extraction bottle. One-gram phosphorus free charcoal was added and the mixture was shaken by hand for 40 s. Two drops of flocculant was added and the extract was filtered through a Whatman no. 40 paper. P was determined within 24 h. The analysis was done with a continuous flow analyzer (e.g. Auto Analyzer).

### Extractable cations (K, Ca, Mg and Na)

According to the Handbook of Standard Soil Testing Methods for Advisory Purposes (1990), this method is used to determine extractable cations $Ca^{2+}$, $Mg^{2+}$, $K^{+}$ and $Na^{+}$ in soils, reflecting the nutrient status. 0.05 g air dried, ≤2 mm soil was placed in a 100 ml extraction bottle. 50 ml $NH_4OAc$ solution cooled to 20±2°C was added to the extraction bottle and was shaken horizontally on a reciprocating shaker at 180 oscillations per minute for 30 min. The extract was rapidly filtered through a Buchner funnel and collect filtrate. The elements K, Ca, Mg, and Na were determined on an atomic absorption spectrophotometer.

## RESULTS

### Rainfall distribution and temperatures readings

Rainfall distribution (Figure 1) and temperatures were recorded during the growing season, thus from October to July. At Addo, rain was evenly distributed in 2006/2007 and 2007/2008 compared to long-term average rainfall. Addo received the higher rainfall of 92 mm during the 2006/2007 season on March when compared with 2007/2008 and long term averages (Figure 1).

### Soil analysis

The results of the soil analysis taken before planting for 2006/2007 and 2007/2008 cropping season are presented in Table 1. The soil at Addo had a high pH and reasonably high potassium and low nitrogen content. Soils at 30 cm depth indicate high percentage of sand. Slight differences were found in soil texture for the three depths analyzed. Limited land in this experimental station dictated that the trial be planted in the same piece of land for 2006/2007 and 2007/08 growing seasons.

### Wet biomass yield

Wet biomass yield was significantly different between cultivar and nitrogen levels at P≤0.05 during 2006/2007 season. However, the Cultivar × Nitrogen interaction

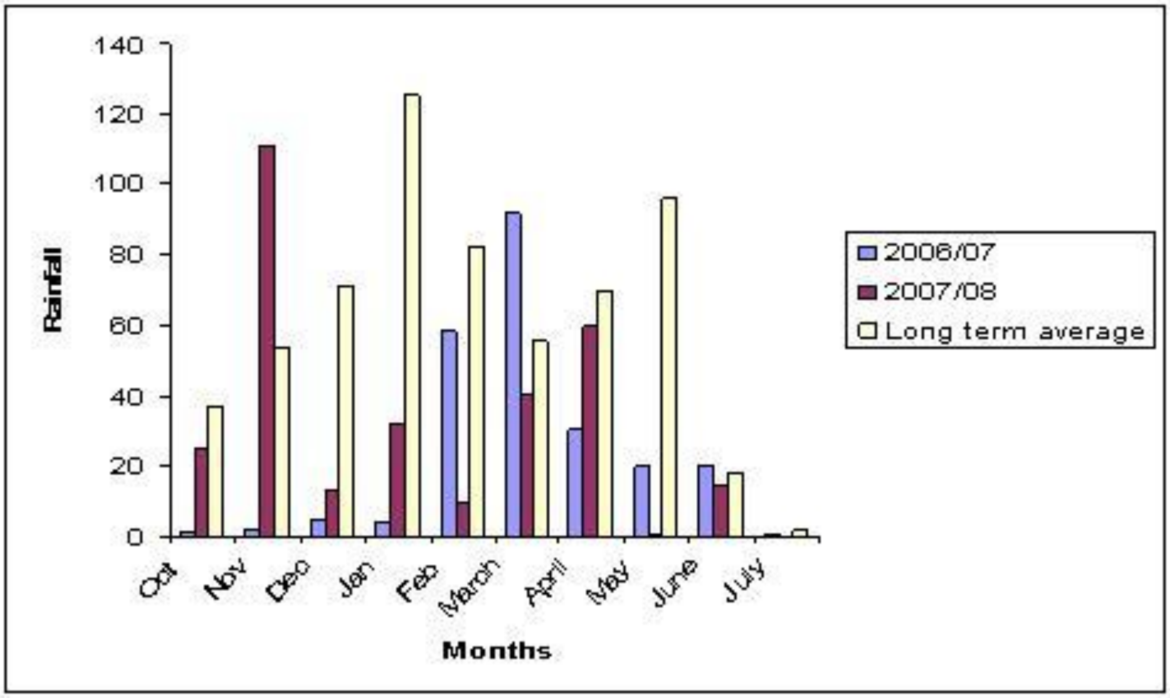


**Figure 1.** Monthly rainfall distribution (mm) from October to July during 2006/2007 and 2007/2008 growing seasons compared to long term averages at Addo.

**Table 2.** Wet biomass yield (kg ha$^{-1}$) for hemp cultivars grown at four different nitrogen fertilizer levels at Addo in 2006/2007 and 2007/2008 season.

| Nitrogen rates | 2006/2007 season | | Average | 2007/2008 season | | Average |
|---|---|---|---|---|---|---|
| | Kompolti | Felina | | Kompolti | Novosadska | |
| 0 kg ha-1 | 33375 cd | 15638 e | 25506 | 4111 b | 3031 b | 3571 |
| 50 kg ha$^{-1}$ | 52725 ab | 26963 de | 39844 | 6816 a | 6121 a | 6469 |
| 100 kg ha$^{-1}$ | 68550 a | 33375 d | 50963 | 7850 a | 7034 a | 7442 |
| 150 kg ha$^{-1}$ | 56175 ab | 40238 bcd | 48206 | 8712 a | 8691 a | 8702 |
| Average | 53206 | 29053 | 41130 | 6872 | 6219 | 6546 |
| CV% | | 16.05 | | | 22.5 | |
| LSD (0.05) Cultivars(C) | | 12449.2 | | | 2544 | |
| LSD (0.05) Nitrogen (N) | | 16950. | | | 3597 | |
| LSD (0.05) C × N | | 8451.1 | | | 1798 | |

Means within two cultivar columns followed by different letters are significantly different at LSD (0.05) Nitrogen.

component was not significant in the same season (Table 2). Kompolti produced higher wet biomass yield in both seasons than the other cultivars. Kompolti obtain high wet biomass at 100 kg ha$^{-1}$ N fertilization level when compared to other fertilization levels (Table 2). In 2007/2008, significant differences were found between cultivars and nitrogen fertilization levels with 0 kg ha$^{-1}$ having the lowest biomass weight. Although, from 50 to 150 kg ha$^{-1}$ N fertilization levels, the yield means did not vary between cultivars, a pattern of biomass increasing with N application rates was revealed (Table 2). Cultivar by nitrogen interaction was also not significant during 2007/2008 season.

## Dry biomass yield

In 2006/2007, mean dry biomass calculations were not done at Addo. Table 3 presents the means for dry biomass at Addo for 2007/2008. At 100 and 150 kg ha$^{-1}$ N fertilization levels, Kompolti gave the highest yield while cultivar by N fertilization interaction had no significant effect on dry biomass. However, the results showed evidence that there were significant differences between

**Table 3.** Mean dry biomass (kg $ha^{-1}$) for two hemp cultivars grown at four different nitrogen fertilizer levels at Addo in 2007/2008 season.

| Cultivar | Dry Biomass yield | | | | |
|---|---|---|---|---|---|
| | 0 kg N $ha^{-1}$ | 50 kg N $ha^{-1}$ | 100 kg N $ha^{-1}$ | 150 kg N $ha^{-1}$ | Average |
| Kompolti | $3222^{cd}$ | $6029^{ab}$ | $7314^{a}$ | $7000^{a}$ | 5891 |
| Novosadska | $2415^{d}$ | $4271^{bcd}$ | $5202^{ab}$ | $6359^{a}$ | 4562 |
| Average | 2819 | 5150 | 6258 | 6680 | - |
| CV% = 10.5 | | | | | |
| LSD (0.05) Cultivar = 1805 | | | | | |
| LSD (0.05) Nitrogen = 2553 | | | | | |
| LSD (0.05) Cultivar × Nitrogen = 1277 | | | | | |

Means within two cultivar row followed by different letters are significantly different at LSD (≤0.05) nitrogen.

**Table 4.** Stem diameters (mm) for hemp cultivars grown at four different nitrogen fertilizer levels at Addo in 2006/2007 and 2007/2008.

| Nitrogen rates | 2006/2007 season | | Average | 2007/2008 season | | Average |
|---|---|---|---|---|---|---|
| | Kompolti | Felina 35 | | Kompolti | Novosadska | |
| 0 kg ha-1 | $11.27^{a}$ | $5.70^{c}$ | 8.49 | $12.25^{ab}$ | $11.00^{a}$ | 11.63 |
| 50 kg $ha^{-1}$ | $10.56^{ab}$ | $5.70^{c}$ | 8.13 | $13.50^{a}$ | $8.83^{a}$ | 11.17 |
| 100 kg $ha^{-1}$ | $12.26^{a}$ | $6.65^{bc}$ | 9.46 | $14.25^{a}$ | $9.00^{a}$ | 11.63 |
| 150 kg $ha^{-1}$ | $11.72^{a}$ | $8.56^{abc}$ | 10.14 | $9.75^{a}$ | $11.75^{a}$ | 10.75 |
| Average | 11.45 | 6.65 | 9.05 | 12.44 | 10.15 | 11.30 |
| CV% | | 21.2 | | | 13.9 | |
| LSD (0.05) Cultivars (C) | | 2.84 | | | 2.27 | |
| LSD (0.05) Nitrogen (N) | | 4.02 | | | 3.21 | |
| LSD (0.05) C × N | | 2.01 | | | 1.23 | |

Means within two cultivar columns followed by different letters are significantly different at LSD (0.05) nitrogen.

N levels within cultivars. The 100 and 150 kg N $ha^{-1}$ tended to have higher dry biomass than the other levels.

### Stem diameter

During 2006/2007, only the cultivar effect was significant in stem diameter. Kompolti had significantly higher stem diameter compared to Felina 35 (Table 4). However, in 2007/2008, there were significant effects between cultivar by nitrogen level interaction (Table 4). As in 2006/2007, Kompolti showed a better performance in stem diameter as kg N $ha^{-1}$ level were applied. At 100 kg $ha^{-1}$ N fertilization, Kompolti gave the highest stem diameter than in other levels. Felina 35 showed no response to N levels applications. Also, Novosadska stem diameters means did not vary between N levels. However, at 150 kg $ha^{-1}$ stem diameter was at 11.75 mm, while the overall average for Novosadska was 10.15 mm during the 2007/2008 season; this was higher than that of Felina 35 which was 6.65 mm during 2006/2007. This is attributed for 53% higher than that of Felina 35's diameter.

### Plant height

In 2006/2007 growing season, there were significant differences in plant height between cultivars and N level (Table 5). The nitrogen levels and cultivar components had no significant interaction effect. In 2007/2008, there was a significant effect on cultivars only (Table 5). Furthermore, the cultivar by nitrogen levels interaction components also had no significant effect on plant height. In 2007/2008, both Kompolti and Novosadska (which replaced Felina 35) showed no response to nitrogen levels. However, it was noticed that Kompolti had slightly higher averages than Novosadska. During 2006/2007 season, there was no significant difference between N-

**Table 5.** Plant height (cm) for hemp cultivars grown at four different nitrogen fertilizer levels, at Addo in 2006/2007 and 2007/2008.

| Nitrogen rates | 2006/2007 season | | Average | 2007/2008 season | | Average |
|---|---|---|---|---|---|---|
| | Kompolti | Felina 35 | | Kompolti | Novosadska | |
| 0 kg $ha^{-1}$ | $167.0^{abcd}$ | $104.2^{d}$ | 168.4 | $171.5^{a}$ | $165.8^{a}$ | 168.4 |
| 50 kg $ha^{-1}$ | $190.8^{a}$ | $117.0^{cd}$ | 176.8 | $181.4^{a}$ | $172.3^{a}$ | 176.8 |
| 100 kg $ha^{-1}$ | $203.3^{a}$ | $131.0^{bcd}$ | 170.5 | $167.8^{a}$ | $173.3^{a}$ | 170.5 |
| 150 kg $ha^{-1}$ | $225.3^{a}$ | $178.0^{abcd}$ | 165.3 | $165.9^{a}$ | $163.^{a}$ | 165.3 |
| Average | 196.6 | 132.6 | 170.4 | 171.5 | 169.3 | 170.4 |
| CV% | | 23.4 | | | 5.8 | |
| LSD (0.05) Cultivars (C) | | 57.0 | | | 13.80 | |
| LSD (0.05) Nitrogen (N) | | 80.6 | | | 19.52 | |
| LSD (0.05) C×N | | 40.3 | | | 9.75 | |

Means within two cultivar columns followed by different letters are significantly different at LSD (≤0.05) Nitrogen.

**Table 6.** Fibre yield percentage (%) for hemp cultivars grown at four different nitrogen fertilizer levels at Addo in 2006/2007 and 2007/2008.

| Nitrogen rates | 2006/2007 season | | Average | 2007/2008 season | | Average |
|---|---|---|---|---|---|---|
| | Kompolti | Felina 35 | | Kompolti | Novosadska | |
| 0 kg $ha^{-1}$ | $41.50^{a}$ | $33.25^{abc}$ | 37.38 | $29.00^{a}$ | $28.50^{a}$ | 28.75 |
| 50 kg $ha^{-1}$ | $41.25^{a}$ | $27.50^{c}$ | 34.38 | $28.00^{a}$ | $29.75^{a}$ | 28.87 |
| 100 kg $ha^{-1}$ | $39.75^{ab}$ | $30.00^{abc}$ | 34.88 | $29.50^{a}$ | $27.25^{a}$ | 27.25 |
| 150 kg $ha^{-1}$ | $38.75^{abc}$ | $27.75^{bc}$ | 33.55 | $29.25^{a}$ | $28.75^{a}$ | 29.00 |
| Average | 40.31 | 29.62 | 34.97 | 29.03 | 29.00 | 29.02 |
| CV% | | 14.7 | | | 16.3 | |
| LSD (0.05) Cultivars(C) | | 7.62 | | | 6.94 | |
| LSD (0.05) Nitrogen (N) | | 10.78 | | | 9.82 | |
| LSD (0.05) C×N | | 5.39 | | | 4.91 | |

Means within a column followed by different letters are significantly different at P≤0.05.

levels and N-level × cultivar interaction components. Plant height only varied between cultivars: Kompolti and Felina 35 obtained their highest mean at 150 kg $ha^{-1}$ N fertilization, which were 225 and 178 cm, respectively. Generally, in 2006/2007, Kompolti and Felina 35 showed linear response; as nitrogen levels increased, the plant height also increased.

## Fibre percentage

In fibre percentage, the two cultivars were significantly different during 2006/2007 season (Table 6). In Table 7, Kompolti had a significantly higher mean fibre percentage when compared with Felina 35. In 2007/2008 growing season, no significant effect was observed for any of the variance components (Table 6). Also the nitrogen fertilizer levels and cultivar by nitrogen fertilizer interaction components had no significant effect on fibre yield. Means within N levels under both cultivars did not show any response to N levels. In 2006/2007, the two cultivars differed significantly of fibre percentage. However, in 2007/2008, when Felina 35 was replaced by Novosadska, there was no significant difference in fibre percentage (Tables 6).

## Fibre yield

In 2007/2008, there were variations in fibre between cultivar and cultivar by N fertilization interaction effects (Table 7). Also, there were significant differences among the fertilizer levels. In both cultivars there was a tendency for the fibre yield to increase as the nitrogen level increased (Table 7). Kompolti had significantly higher fibre yield (kg $ha^{-1}$) as compared to Novosadska across different nitrogen fertilizer levels. Kompolti accounted for 4392 kg $ha^{-1}$ average yield which was 69%

**Table 7.** Fibre yields (kg ha$^{-1}$) for two hemp cultivars grown at four different nitrogen fertilizer levels at Addo in 2007/2008.

| Cultivar | 0 kg N ha$^{-1}$ | 50 kg N ha$^{-1}$ | 100 kg N ha$^{-1}$ | 150 kg N ha$^{-1}$ | Average |
|---|---|---|---|---|---|
| Kompolti | 2082$^{f}$ | 3630$^{d}$ | 5003$^{b}$ | 6853$^{a}$ | 4392 |
| Novosadska | 906$^{h}$ | 1065$^{g}$ | 3606$^{e}$ | 4838$^{c}$ | 2604 |
| Average | 1494 | 2348 | 4748 | 5673 | |
| CV% = 67.9 | | | | | |
| LSD (0.05) Cultivar = 30.43 | | | | | |
| LSD (0.05) Nitrogen = 43.03 | | | | | |
| LSD (0.05) Cultivar x Nitrogen= 21.52 | | | | | |

Means within nitrogen columns followed by different letters are significantly different at P≤0.05.

higher than that of Novosadska.

## DISCUSSION

### Wet biomass yield and dry biomass

Comparison between two seasons showed that Kompolti had better yields than Felina 35 or Novosadska. This could have been due to variation in cultivar responsiveness to N fertilization and rain distribution in each season. Nitrogen fertilization had a significant effect on wet biomass production. An additional increase in nitrogen level tended to increase biomass yield. In this and related studies, higher nitrogen levels tend to be associated with higher wet biomass in hemp production (Van der Werf, 1991, Van Der Werf et al., 1994). For Addo, the nitrogen levels did not have any significant effect on the dry mass of both cultivars. This might have been due to the replacement of Felina 35 by Novosasdska. It is conceivable that both cultivars behaved in a similar manner in terms of dry biomass yield.

### Stem diameter and plant height

Stem diameter is one of the important traits that determine good yield in hemp production (Van der Werf, 1991). Generally, the greater the stem diameter, the higher the expected amount of fibre. It was noted that high stem diameter was produced at nitrogen level of 100 kg ha$^{-1}$ N fertilization. Since both Kompolti and Felina 35 had more or less the same stem diameter at 100 and 150 Kg N ha$^{-1}$, any of them could be planted at Addo, provided adequate nitrogen is applied. For high fibre yield, a combination of stem diameter and plant height is necessary. In this study, at both seasons and for both cultivars, plant height was associated with an increase in nitrogen level. General observation was that Kompolti grew taller than Felina 35. If the objective is to increase fibre yield, a better choice is Kompolti. Good stand of two hemp cultivars planted at Addo in 2006/2007 was observed at 100 kg/ha nitrogen fertilization. Kompolti was the taller cultivar and the shorter one was Felina 35. Good stand of hemp plants influences biomass yield and quality of fibre (Dewey, 2000). This is consistent with Meijer et al. (1995).

In N fertilization, the planting date is an important factor in successful hemp fibre production. The hemp plant is sensitive to day-length and the vegetative growth period must therefore, be prolonged. An early planting date (October to November in the Eastern Cape Province) resulted in taller plants with higher fibre yield. Later planting will result in early flowering and, therefore, poor fibre production (Van der Werf, 1991). The planting date for dry land hemp is determined by the availability of soil moisture. If irrigation water is inadequate, germination is limited (Meijer et al., 1995).

### Fibre percentage and fibre yield

In hemp production, a very important objective is high yield and quality fibre production. In both seasons, Kompolti out-performed Felina 35 in terms of fibre percentage. When no fertilizer had been applied, low and poor yields of fibre were obtained, especially if there is no added nitrogen fertilizer in some instances (Van der Werf et al., 1995). With hemp, the ultimate objective is to adopt the management practices that will eventually lead to high fibre yield. Such management practices will include appropriate choice of cultivars, fertilizer levels, and irrigation methods, planting depth, plant population, etc. In both seasons and cultivars, a high fibre yield tended to be associated with nitrogen levels. The optimum nitrogen fertilization level appeared to be between 100 and 150 kg ha$^{-1}$.

### Conclusions

Application of N fertilizer improved growth and fibre yield of hemp cultivars during 2006/2007 and 2007/2008 seasons at Addo Research Station. Nitrogen fertilizer rates at 100 and 150 kg N ha$^{-1}$ produced the best fibre yield in both growing seasons, and therefore, selected as the best optimum application rates. However, compared with the other examined cultivars, Kompolti showed higher potential as good cultivar for hemp fibre production. Kompolti was found to be well adapted to South African climatic conditions. Usage of correct recommended rates of fertilization could lead to better growth and fibre yields.

## Conflict of Interests

The authors have not declared any conflict of interests.

### REFERENCES


Brough C, Sotana M, Mhlontlo S (2005). Hemp (*Cannabis sativa* L.) production in South Africa, production guide, ARC-Institute for Industrial Crops. And Department of Agriculture Eastern Cape. pp. 12-24.

Dewey LH (2000). Article on Hemp. United States Department of Agriculture Yearbook.

Dippenaar MC, Du Toit CLN, Botha-Greef MS (1996). Response of hemp (*Cannabis sativa* L.) varieties to conditions in Northwest Province, South Africa. J. int. Hemp Association 3(2):63-66.

Handbook of Standard Soil Testing Methods for Advisory Purposes (1990). South African Society of Soil Sciences, South Africa.

Meijer WJM, Van Der Werf HMG, Mathijssen EWJM, Van Den Brink PWM (1995). Constraints to dry matter production in fibre hemp *(Cannabis saliva* L.). Eur. J. Agron. 4(1):109-117.

Power JF, Doran JW, Wilhelm WW (1986). Uptake of nitrogen from soil, fertilizer and crop residues by no-till corn and soybean. Soil. Sci. Soc. Am. J. 50:137-142.

Soil Classification Working Group (1991). Soil Classification: A taxonomic system for South Africa. Memoirs on the Agricultural Natural resources of South Africa No. 15, department of Agricultural Development, Pretoria.

Van Ark H (1995). Introduction to linear correlation and regression (1995). VSN international Ltd, Rothamsted, UK.

Van Der Werf HMG (1991). Agronomy and crop physiology of fibre hemp. A literature review. Centre for Agrobiological Research Report 142, Wageningen.

Van Der Werf HMG (1994). Crop physiology of fibre hemp (*Cannabis sativa* L.) Doctoral Thesis, Wageningen Agricultural University, Wageningen, the Netherlands: 153.

Van Der Werf HMG, Haasken HJ, Wijlhuizen M (1994). The effect of day length on yield and quality of hemp (*Cannabis sativa* L.). Eur. J. Agron. 3:117-123.

Van Der Werf HMG, Wijilhuizen M, De Schutter AA (1995). Plant density and self-thinning affect yield and quality of fibre hemp (*Cannabis sativa* L.). Field Crops Res. 40(3):72-86.