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**Full Length Research.**

# Response of Senna plant (*Cassia senna* L.) to Organic, Mineral and microbial Fertilization

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**A field experiment was carried out during the period 20\9\2007-20\2\2008 in the Experimental Farm of the Faculty of Agriculture at Shambat to investigate the response of Senna plant (*Cassia senna* L.) to organic, mineral and microbial fertilization.**

**Generally, the soil of the experimental site is non saline, non sodic and not expected to impose adverse impact on growth and development of Senna plant.**

**The application of almost all combination treatments consisting of chicken manure and biofertilizer substantially contributed to promoting production of green biomass increasing Senna plant vegetative growth parameters. The super phosphate applied in a single dose provided progressive increase in dry weight of plant, number and dry weight of pods. The super phosphate once being combined with urea reduced the plant dry weight.**

**The combination treatments ($CM_4$+ Bio), ($CM_3$+Bio) provided the highest increase in the contents of sennosides A and B in leaves as well as in pods, while super phosphate applied in a single dose or in combination recorded very low contents. The control almost invariably revealed the lowest values among all combination treatments including organic and inorganic fertilizers.**

**The study recommended application of organic manure combined with biofertilizer for the production of dry biomass, plant growth and yield parameters. For provision of sennosides A and B in leaves, super phosphate in a single dose or in combination could be avoided.**

**Key words:** Senna plant**,** Biofertilizer, Organic Fertilizers, Mineral Fertilizers, Sennosides

## Introduction

Senna is a medicinal plant that has been in use over a thousand years. It is a safe, harmless, and efficient remedy, it grows well and never does harm. (Light hall 2007).

*Cassia senna* (L) is widely distributed in Central Sudan (Hayati 2005). It is present in Western and Eastern Sudan, on the Nubian gravel desert, along the River Nile course from Khartoum to Dongla in Northern Sudan and it occurs on all types of soil with best yield on clay soils (Elamin 1990 and Vetaas 1993).

The demand for Senna as an herbal material is increasing to a great extent (Syamal 2008). The dried senna leaves and pods are exported mainly to America, European countries, Japan and Australia (Sharma 2004). Sudan and India are the largest producers and exporters of senna leaves, pods and total sennosides concentrates to the world market. The primary chemical constituents of Senna include anthraquinone glycosides (Sennosides, aloe– emodin, rhein), betasitosterol, flavones, tartaric acid, mucin, essential oil, mucilage, tannin and resin. The sennosides are irritating to the large intestine lining, causing peristaltic action and bowel evacuation. It also helps to temporarily prevent fluid from being absorbed from the large intestine, thus contributing to softer stools. It is used for biliousness, bad breath, colic, constipation, gallstone, gout, jaundice menstruation, mouth sores, obesity, boils, pimples, rheumatism, skin diseases and worms (Penelope 2007).

Very little research has been conducted in Sudan to study the many problems facing the production of Cassia crop under field conditions. Elamin (1999) studied the response of *C. senna* to nitrogen, phosphorus and potassium in the semi- arid zone of Central Sudan. Hayati and Yahia (2002) examined the relationships between soil mineral elements and uptake of these elements by *C. senna*. Hayati (2007) also studied the response of *C.* and *C. italica* to different levels of manganese. However, there is paucity of information concerning the nutrition of *C. senna,* particularly its response to organic and microbial fertilization, and their combined application.

## Materials and Methods

*Seeds:*

Seeds of Senna plant (*Cassia senna* L.) were secured from the Demonstration farm, of the Khartoum University – Sudan.

*Nitrogen – fixing, Phosphate and Potassium solubilizing bacteria*:

Mixed inocula of *Azotobacter vienlandii, Azospirillum barislense, Bacillus polymixa, B. megatherium* var. *phosphaticum and B. circulans* was kindly supplied by the National Centre for Research – Sudan. Meat peptone broth diluted medium was made by dissolving 2.5g NaCl, 2.5g meat extract and 5gm peptone in one liter of distilled water. Then 500 ml were taken and divided into 5 flasks. The media was then sterilized in the autoclave at temperature $121^0$C, at a pressure of 15 1b/in for 20 min. It was then left to cool. Every flask was then inoculated with the appropriate microorganism. It was then taken to a shaker for 24 hours, at room temperature. The liquid inoculum was then mixed with carrier at the rate of 400 ml per kg carrier (Tepper, *et al.*, 1993). Seeds were coated with the biofertilizer before sowing.

*Mineral and Organic Fertilizers:*

Nitrogen was applied in the form of urea at the rate of 50 kg urea/ feddan (0.42 ha) after 30 days from sowing. Phosphorus was added in the form of triple-super phosphate at the rate 100 kg TSP/ feddan before sowing. Four doses of chicken manure were tested: D1 (10 tons/ feddan), D2 (7.5 tons/ feddan), D3 (5 tons/ feddan) and D4 (2.5 tons/ feddan) at 15 days before sowing.

*Soil:*

The soil used in the field investigation was clayey in subsoil (50-75cm) underlying clay loams to sandy clay loams surface (0-25cm). The soil reaction is slightly alkaline in terms of pH values ranging from 7.1-8.2. The soil was none to slight salinity (1.0-7.2). CEC ranging from 32-58 mequ / 100 g soil. The exchange complex is almost saturated with cations such as $Ca^{++}$, $Mg^{+,}$ $K^+$ and $Na^+$ indicating moderate nutrient storage. The $K^+$ is very low compared to other cations in the exchange complex. Sodicity expressed in terms of exchangeable sodium percentage (ESP) varies from 2.6-6.4. Generally soils of this experimental site can be designated as moderately sodic / sodic. The formation of compacted sub surface layers is expressed by high (1.3g /$cm^3$) bulk density. Generally, the chemical parameters determined were designated the soil as none <4.0 to very slightly saline 4.6 and none sodic<15 to moderately (15- 20) sodic (FAO 1976).

*Field Experiment*:

The field experiment was conducted at the Demonstration farm of the Faculty of Agriculture Khartoum University at Shambat (Latitude 15̊ 40̊ N Longitude 32̊ 32̊ E, 375meters above sea level) during the period September 2007 and February 2008. The experiment included 9 fertilization treatments in addition to control with four replicates. The soil was deeply ploughed, using disc and disc harrow, cleared, leveled and divided into 40 plots (4, 0 x 4, 0 m), each with five ridges, oriented north – south direction. Seeds were soaked as recommended over night and then planted on September 20\ 2007 on the two sides of the ridge, at seed rate of 3-5 per hole with a spacing of 40 cm between holes. First irrigation was applied immediately after sowing and then intervals were kept at 7 to 15 days according to season till the end of the experiment. Thinning and weeding were carried out as practiced for leguminous crops. The crop was treated with pesticide (Colomit) against termites and fungicide (Sharpen) against *Fusarium*

*Harvesting*:

Three harvests were carried out during the course of the experiment by cutting the herb at 10 cm above the soil surface. The first cut was carried out on 20/12/2007, second on 20/1/2008 and third on 20/2/2008. Data were recorded for three plants, selected randomly from the middle row of each plot.

*Growth and Yield parameters*:

The following parameters were recorded based on properties of three plants: plant height (cm), Number of branches / plant, Number of leaves / plant, Dry weight of branches (g), Root length (cm), Dry weight of root system (g), Dry weight of leaves (g), Number of pods / plant, Dry weight of pods (g), Dry weight of Herb (g).

*Quality parameters:*

Sennoside content of leaves and pods was determined according to the method described by (El-Sawy and Pryde (2000).

*Statistical analysis:*

A Randomized Complete Block Design (RCBD) was followed. The findings were subjected to analysis of variance (ANOVA). Differences between means of treatments were compared by Duncan's Multiple Range Test (Gomez and Gomez 1984).

## Results and Discussion

*A. Growth parameters*

### *1. Plant height (cm)*

Data on plant height as affected by different kinds and rates of fertilizers at three harvests are shown in Table 1. Data pointed out that all treatments had no significant effect on plant height. The highest plant height obtained from the addition of combination of ($CM_4$+ Bio) 76.5, 76.9 and 94.3cm at different harvests respectively. The results of the plant height in response to poultry manure alone or combined with biofertilizer is in close agreement with those reported by Salem (2005), that plant height of Senna increased progressively by increasing the rate of chicken manure combined with biofertilizer under sandy soil or sandy loam soil of Giza. Elamin (1999) came to the conclusion that Senna plant height was not significantly affected by the mineral fertilizers and their combination under Shambat conditions which are on line with our findings.

**Table 1: Effects of different fertilizers on Senna plant height (cm)**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 49.6[a] ** | 51.8[a] | 60.6[a] |
| N | 51.2[a] | 52.4[a] | 61.6[a] |
| P | 54.6[a] | 61.5[a] | 69.4[a] |
| N + P | 53.5[a] | 58.5[a] | 63.9[a] |
| Bio | 61.1[a] | 65.8[a] | 71.1[a] |
| CM | 59.1[a] | 64.7[a] | 75.9[a] |
| $CM_1$+Bio | 54.7[a] | 65.1[a] | 68.8[a] |
| $CM_2$+Bio | 57.9[a] | 65.1[a] | 71.1[a] |
| $CM_3$+Bio | 73.2[a] | 76.1[a] | 91.0[a] |
| $CM_4$+Bio | 76.5[a] | 76.9[a] | 94.4[a] |
| LSD 0.05 | 26.826 | 32.476 | 38.242 |

Note: -
C* = Control, N = Urea, P = Super phosphate, N + P = Combination of Urea and Super phosphate, CM = 10 tons chicken manure, Bio = Biofertilizer, $CM_1$Bio = 2.5 tons chicken manure + biofertilizer, $CM_2$Bio = 5 tons chicken manure + biofertilizer, $CM_3$Bio = 7.5 tons chicken manure +biofertilizer
$CM_4$Bio = 10 tons chicken manure + biofertilizer
**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### *2. Number of branches/plant*

Significant responses resulted from the addition of organic manure, biofertilizer and mineral fertilizers in terms of number of branches were noticed at third harvest in all treatments Table (2). Also significant differences resulted from the application of ($CM_4$+ Bio), ($CM_3$+Bio), ($CM_2$+Bio) and (CM) at first and second harvests, while significant effect occurred at the first harvest only by the addition of biofertilizer, and phosphorus separately followed by the combination of nitrogen and phosphorus. The ($CM_4$+ Bio) treatment manifested the largest number of branches at three harvests 12, 14 and 15 respectively, followed by ($CM_3$ + Bio) and ($CM_2$ + Bio) treatments 12, 13, 14 then ($CM_1$ + Bio) 11, 12 and 12.

Less number of branches produced under the effect of mineral fertilizers P, NP and N respectively compared to other treatments. It seems that the fertilizers treatments increased branching at the expense of plant height.

The highest significant response of Senna plant to increasing number of branches due to organic fertilizers is in conformity with the finding of Salem (2005). Data about the effect of mineral fertilizers used separately or in combination are also in line with the findings of Elamin (1999).

**Table 2: Effects of different fertilizers on Number of branches/senna plant**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 4.0[c] ** | 8.0[d] | 9.0[c] |
| N | 8.0[abc] | 10.0[cd] | 12.0[b] |
| P | 10.0[ab] | 10.0[cd] | 12.0[b] |
| N + P | 10.0[ab] | 10.0[cd] | 12.0[b] |
| Bio | 10.0[ab] | 11.0[abc] | 12.0[b] |
| CM | 11.0[ab] | 12.0[abc] | 12.0[b] |
| $CM_1$ + Bio | 11.0[ab] | 12.0[abc] | 12.0[b] |
| $CM_2$ + Bio | 12.0[ab] | 13.0[ab] | 14.0[ab] |
| $CM_3$ + Bio | 12.0[ab] | 13.0[ab] | 14.0[ab] |
| $CM_4$ + Bio | 12.0[a] | 14.0[a] | 15.0[a] |
| LSD 0.05 | 4.341 | 3.312 | 2.677 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### 3. *Number of leaves/plant*

($CM_4$ +Bio) treatment was resulted in an average number of leaves per plant that are significantly different from other treatments, at the three harvests.

The highest number of leaves was recorded by the effect of ($CM_4$ + Bio) at the second harvest 479/plant followed by ($CM_3$ +Bio) at the same harvest 397/plant and then chicken manure only (CM) 334/plant. The "Least" number of leaves resulted from the application of mineral fertilizers separately or in combination. Data demonstrated in table (3) are in close agreement with findings of Salem (2005) and Elamin (1999).

**Table 3: Effects of different fertilizers on Number of leaves/ Senna plant**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 81.0$^{c}$ | 124.0$^{c}$ | 191.0$^{c}$ ** |
| N | 144.0$^{abc}$ | 191.0$^{c}$ | 209.0$^{bc}$ |
| P | 155.0$^{abc}$ | 262.0$^{bc}$ | 253.0$^{ab}$ |
| N + P | 145.0$^{abc}$ | 229.0$^{bc}$ | 248.0$^{ab}$ |
| Bio | 165.0$^{abc}$ | 270.0$^{bc}$ | 265.0$^{ab}$ |
| C.M | 246.0$^{abc}$ | 302..0$^{bc}$ | 334..0$^{ab}$ |
| $CM_1$ + Bio | 196.0$^{abc}$ | 273.$^{ab}$ | 289.0$^{ab}$ |
| $CM_2$ + Bio | 230.0$^{ab}$ | 290.0$^{ab}$ | 297.0$^{ab}$ |
| $CM_3$ + Bio | 261.0$^{ab}$ | 397.0$^{ab}$ | 373.0$^{ab}$ |
| $CM_4$ + Bio | 307.0$^{a}$ | 479.0.0$^{a}$ | 396.0$^{a}$ |
| LSD 0.05 | 145.540 | 199.87 | 173.747 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### 4. *Dry weight of branches (g)*

Table (4) showed that the dry weight of branches was significantly favored by the addition of ($CM_4$ + Bio) at the first and third harvests 58.7g/plant, 144.4g/plant respectively, and from the addition of ($CM_3$ +Bio) at third harvest 122.7 g/plant.

The other treatments resulted in high dry weight of branches compared to control. Relatively high value obtained at three harvests from chicken manure + biofertilizer ($CM_2$ + Bio), followed by (CM), ($CM_1$ + Bio), (Bio), P, NP, and the least value from nitrogen alone. The weight of dry branches showed trends similar to that recorded for fresh branches, but the combination ($CM_3$ + Bio) can be considered threshold likely indicating that at this combination, fertility storage produced material content high enough to meet plant requirement maintaining dry solids.

**Table 4: Effects of different fertilizers on dry weight of branches Senna plant (g)**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 20.3$^{bc}$** | 21.5$^{a}$ | 44.1$^{c}$ |
| N | 20.8$^{ab}$ | 43.5$^{a}$ | 62.6$^{bc}$ |
| P | 25.9$^{ab}$ | 47.1$^{a}$ | 71.9$^{ab}$ |
| N + P | 24.9$^{ab}$ | 34.59$^{a}$ | 65.7$^{ab}$ |
| Bio | 31.1$^{ab}$ | 57.3$^{a}$ | 73.9$^{ab}$ |
| CM | 34.7$^{ab}$ | 70. 5$^{a}$ | 81.7$^{ab}$ |
| $CM_1$ + Bio | 33.5$^{ab}$ | 63.8$^{a}$ | 75.1$^{ab}$ |
| $CM_2$ + Bio | 34.7$^{ab}$ | 71.1$^{a}$ | 101.7$^{ab}$ |
| $CM_3$ + Bio | 45.4$^{ab}$ | 82.1$^{a}$ | 122.7$^{ab}$ |
| $CM_4$ + Bio | 58.7$^{a}$ | 96.1$^{a}$ | 144.4$^{a}$ |
| LSD 0.05 | 35.067 | 76.833 | 72.733 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### *5. Root length (cm)*

Table (5) showed decreasing order of the root length starting from ($CM_4$ + Bio), NP to Urea the least.

Generally ($CM_3$ +Bio), ($CM_2$ + Bio) and ($CM_1$ + Bio) provided longer root length than the combination treatment ($CM_4$ + Bio).

Root elongation commenced from second to the third harvest showed significant length increase. This incidence occurred when combination of chicken manure and biofertilizer was added. The rate ($CM_3$ +Bio) seems to be the recommended level to cause maximum root length. However, this combination has provided nutrients, mostly nitrate- nitrogen used for assimilation of organic compounds during metabolic e.g. carbohydrate, protein to be mobilized in balance between root and aerial parts. Findings regarding the effect of different rates of chicken manure in combination with biofertilizer on root system length were in line with conclusions drawn by Salem (2005) for *C. senna*.

**Table 5: Effects of different fertilizers on root length of Senna plant (cm)**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 24.8$^{c}$ ** | 25.3$^{c}$ | 27.5$^{d}$ |
| N | 32.8$^{bc}$ | 35.8$^{bc}$ | 38.6$^{c}$ |
| P | 36.8$^{ab}$ | 39.7$^{ab}$ | 42.4$^{ab}$ |
| N + P | 36.7$^{ab}$ | 36.8$^{bc}$ | 39.8$^{b}$ |
| Bio | 37.3$^{ab}$ | 42.2$^{ab}$ | 45.2$^{ab}$ |
| CM | 38.9$^{ab}$ | 43.4$^{ab}$ | 46.4$^{ab}$ |
| $CM_1$ + Bio | 42.6$^{ab}$ | 45.4$^{ab}$ | 50.1$^{a}$ |
| $CM_2$ + Bio | 42.6$^{a}$ | 47.7$^{a}$ | 50.6$^{a}$ |
| $CM_3$ + Bio | 42.7$^{a}$ | 47.8$^{a}$ | 51.3$^{a}$ |
| $CM_4$ + Bio | 39.0$^{ab}$ | 44.0$^{ab}$ | 47.0$^{a}$ |
| LSD 0.05 | 9.859 | 9.758 | 9.953 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### *6. Dry weight of root system (g)*

Fertilizing Senna plants with ($CM_3$ +Bio) gave the highest significant value 31.5, 34.5 g/plant in both second and third harvests. Also significant differences were recorded by the addition of ($CM_2$ + Bio) at the third harvest 32.7g/plant. (Table 6).

The other treatments positively affected the dry weight of root system compared to the control. But among them there were no significant differences occurred. Such data were in conformity with those obtained by Salem (2005).

**Table 6: Effects of different fertilizers on dry weight of root system of Senna plant (g)**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 17.1$^{a}$ ** | 19.5$^{bc}$ | 19.5$^{bc}$ |
| N | 17.5$^{a}$ | 21.1$^{ab}$ | 22.1$^{ab}$ |
| P | 18.5$^{a}$ | 22.2$^{ab}$ | 25.2$^{ab}$ |
| N + P | 18.1$^{a}$ | 22.0$^{ab}$ | 23.0$^{ab}$ |
| Bio | 22.5$^{a}$ | 25.7$^{ab}$ | 28.7$^{ab}$ |
| C.M | 19.0$^{a}$ | 23.5$^{ab}$ | 26.5$^{ab}$ |
| $CM_1$ + Bio | 20.7$^{a}$ | 25.5$^{ab}$ | 28.3$^{ab}$ |
| $CM_2$ + Bio | 25.3$^{a}$ | 29.8$^{ab}$ | 32.8$^{a}$ |
| $CM_3$ + Bio | 26.5$^{a}$ | 31.5$^{a}$ | 34.5$^{a}$ |
| $CM_4$ + Bio | 20.3$^{a}$ | 25.3$^{ab}$ | 26.5$^{ab}$ |
| LSD 0.05 | 10.438 | 10.507 | 10.507 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

*B. Yield parameters*

***1. Dry weight of leaves (g)***

The higher significant mean leaf dry weight per plant produced by *Cassia senna* fertilized with ($CM_4$+ Bio) at all harvests and recorded 40.6, 55.5 and 74.9 g/plant respectively (Table 7).

Relatively less significant mean leaf dry weight was obtained by fertilizing with ($CM_1$+ Bio) at first and third harvests and reached 22.2, 36.3/plant respectively.

Chicken manure at the rate of 5 tons + biofertilizer gave less leaf dry weight in comparison with previous treatments, followed by (CM) alone, and then biofertilizer alone. The lowest yield obtained was with ($CM_1$+ Bio). However, all these results were not significant in comparison with the control.

Mineral fertilizers insignificantly increased the yield of leaf dry weight. Phosphorus gave more yield than the other mineral fertilizers treatments over control, followed by NP combination and then N fertilizer. These results are in agreement with the results reported by Elamin (1999), Pareek, *et al,* (1989) and Abu Zied (1986).

**Table 7: Effects of different fertilizers on dry weight of leaves of Senna plant (g)**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | $9.5^{c}$ | $15.4^{c}$ | $26.6^{c}$ |
| N | $17.6^{c}$ | $28.4^{c}$ | $30.9^{c}$ |
| P | $21.6^{abc}$ | $34.8^{abc}$ | $33.0^{abc}$ |
| N + P | $21.0^{abc}$ | $32.4^{abc}$ | $31.8^{abc}$ |
| Bio | $23.8^{abc}$ | $40.4^{abc}$ | $37.1^{abc}$ |
| C.M | $26.9^{abc}$ | $40.9^{abc}$ | $38.1^{abc}$ |
| $C.M_1$ + Bio | $22.2^{abc}$ | $38.3^{abc}$ | $36.3^{abc}$ |
| $C.M_2$ + Bio | $27.4^{abc}$ | $51.1^{abc}$ | $40.2^{abc}$ |
| $C.M_3$ + Bio | $38.5^{a}$ | $53.6^{abc}$ | $52.6^{a}$ |
| $C.M_4$ + Bio | $40.6^{a}$ | $55.5^{a}$ | $74.9^{a}$ |
| LSD 0.05 | 19.946 | 43.984 | 25.2 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

***2. Number of pods/ plant***

The data in Table (8) revealed that ($CM_4$+ Bio) and ($CM_3$+ Bio) significantly increased the plant number of pods in comparison with other treatments. The higher mean number of pods was obtained at the third harvest. The treatment ($CM_4$ + Bio) and $CM_3$ + Bio) produced 518 and 470 pods respectively.

($CM_2$+ Bio) significantly affected pods numbers and reached 429 pods /plant at the third harvest, where it exceeded the control by 165.5%, followed by (Bio) alone 153.2% over the control and then the chicken manure at the rate of 2.5 tons + biofertilizer ($CM_1$+ Bio) 135.9% over the control.

Mineral fertilizers increased the pods number per plant. Super phosphate gave similar effect as the treatment with organic fertilizers ($CM_2$+ Bio) 135.2% over the control followed by combined NP 10.4% over the control. The least number of pods obtained from the plants fertilized by nitrogen alone and recorded 39.6% over control.

Results about the effect of organic manure with or without biofertilizer agreed with Salem (2005) who reported that the number of pods per Senna plant was promoted significantly due to applying organic manure in high doses combined with biofertilizer. He reported also that fertilizing Senna plants with organic manures (with or without biofertilizer) gave better results than those obtained by mineral fertilizers.

Table (8) showed that Senna pods reach maturity at the end of growth cycle. However, sequential gradual pods increase was observed within the second and third harvests under all treatments. The combination ($CM_4$ + Bio) and ($CM_3$ + Bio) provided highest threshold being 518 and 470 pods /plant respectively. Treatment (CM), combination of ($CM_2$ + Bio), ($CM_1$+ Bio) are highly promising. On the other hand, the mineral fertilizers treatments of super phosphate improved pods yield close to that obtained from chicken manure fertilizers. The advantage of applying super phosphate is that phosphorus is one of the essential nutrient elements for crop production, contributing to vital biological functions in plants (Landon 1991).

**Table 8: Effects of different fertilizers on Number of pods/ Senna plant**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 10.0$^{c**}$ | 94.0$^{c}$ | 139.0$^{d}$ |
| N | 12.0$^{c}$ | 159.0$^{ab}$ | 194.0$^{c}$ |
| P | 31.0$^{abc}$ | 213.0$^{ab}$ | 326.0$^{abc}$ |
| N + P | 28.0$^{abc}$ | 213.0$^{ab}$ | 281.0$^{abc}$ |
| Bio | 43.0$^{abc}$ | 240.0$^{ab}$ | 352.0$^{abc}$ |
| CM | 49.0$^{abc}$ | 257.6$^{ab}$ | 369.0$^{abc}$ |
| $CM_1$ + Bio | 34.0$^{abc}$ | 224.0$^{ab}$ | 329.0$^{abc}$ |
| $CM_2$ + Bio | 54.0$^{abc}$ | 265.0$^{ab}$ | 429.0$^{abc}$ |
| $CM_3$ + Bio | 77.0$^{ab}$ | 280.0$^{ab}$ | 470.0$^{abc}$ |
| $CM_4$ + Bio | 86.0$^{a}$ | 384.0$^{a}$ | 518.0$^{a}$ |
| LSD 0.05 | 51.215 | 206.921 | 274.315 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### *3. Dry weight of pods (g)*

The data in Table (9) revealed that the combined application of ($CM_4$ + Bio), ($CM_3$ + Bio) and ($CM_2$ + Bio) significantly increased the dry weight of pods.

In the first, second and third harvests, the dry weight obtained by the application of chicken manure at the rate of ($CM_4$ + Bio) recorded 8.5-56.8 and 67.2g\plant compared to 0.9, 11.6 and 20.6 g\plant for control for three harvests respectively. Addition of chicken manure at the rate of ($CM_3$ + Bio) and ($CM_2$ + Bio) recorded dry weight at the third harvest, amounting to 190.2, 189.8% over control respectively. Application of combined chicken manures at the rate ($CM_1$ + Bio) as well as (Bio) and (CM) separately insignificantly increased the yield of dry pods at all harvests. Chicken manure at the rate ($CM_1$ + Bio) as well as (Bio) applied alone produced to some extent equal dry pods yield at all harvests. ($CM_1$ + Bio) recorded 5.6, 33.7 and 54.6g/plant at first, second and third harvests respectively, when (Bio) applied separately recorded 4.0, 33.6 and 53.7g/plant in the same sequence. On the other hand, the plant pods dry weight was not affected significantly with the addition of mineral fertilizers although they were considerably increased in comparison with control at all harvests.

The dry pods yield of *Cassia senna* when fertilized with super phosphate separately increased by 200.0, 164, 9 and 80, 6% at first, second and third harvest respectively over the control. Combined super phosphate with Urea increased the dry pods yield over the control by 192.9, 160.4, and 66.5% at the same sequence while the addition of Urea alone increased the yield over the control by 13.7, 102.1, and 30.5% at the above mentioned harvests. These finding confirmed the results reported by Salem (2005), Elamin (1999), Pareek, *et al.* (1989) and Abu Zied (1986).

($CM_4$ + Bio) gave the best result, constituting 27.2, and 57.6% at second and third harvests. The difference was significant in comparison with control. (Bio) applied alone as well as ($CM_3$ + Bio) was significantly different in this regard only at the third harvest when they both recorded 57.0, 56.7%. The other treatments gave more value in this regard compared with the control, but differences were insignificant. Phosphorus fertilizer treatment and combination of phosphorus + Nitrogen have recorded the highest (60- 61%) threshold, presiding over organic fertilizer treatments. The treatments of (Bio) and the combination treatments ($CM_4$ + Bio) and ($CM_3$ + Bio) revealed almost similar percentage weight, but, the combination treatments ($CM_2$ + Bio) and ($CM_1$ + Bio) are preferred as cost effective.

**Table 9: Effects of different fertilizers on dry weight of pods/ Senna plant (g)**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | 1.0$^{c}$ ** | 11.7$^{c}$ | 20.7$^{c}$ |
| N | 1.1$^{c}$ | 23.6$^{abc}$ | 26.0$^{c}$ |
| P | 3.0$^{bc}$ | 31.0$^{abc}$ | 43.0$^{abc}$ |
| N + P | 2.8$^{c}$ | 30.2$^{abc}$ | 34.5$^{abc}$ |
| Bio | 4.1$^{abc}$ | 33.6$^{abc}$ | 53.8$^{abc}$ |
| CM | 3.1$^{bc}$ | 31.8$^{abc}$ | 46.8$^{abc}$ |
| $CM_1$ + Bio | 5.6$^{abc}$ | 33.8$^{ab}$ | 54.7$^{abc}$ |
| $CM_2$ + Bio | 5.7$^{abc}$ | 42.3$^{ab}$ | 59.7$^{ab}$ |
| $CM_3$ + Bio | 7.5$^{ab}$ | 43.1$^{ab}$ | 59.9$^{ab}$ |
| $CM_4$ + Bio | 8.5$^{a}$ | 56.8$^{a}$ | 67.3$^{a}$ |
| LSD 0.05 | 4.760 | 26.771 | 36.250 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### *4. Dry weight of herb (g)*

In these treatments, variation in this parameter showed differences only in the third harvest (table 10). High significant differences appeared between control and combination treatment of ($CM_4$ + Bio), ($CM_3$ + Bio), ($CM_2$ + Bio) and single (Bio). Control recorded the lowest dry weight of plant.

The maximum threshold (250.0g) was recorded when combination treatment of ($CM_4$ + Bio) was applied, while that of ($CM_3$ + Bio) (243.0g), are very much close to threshold (250.0g), indicating that both combinations would accelerate concentration of dry solids.

**Table 10: Effects of different fertilizers on dry weight of herbs (g)**

| Treatment | Mean | | |
|---|---|---|---|
| | First harvest | Second harvest | Third harvest |
| C* | $59.3^{cd}$ ** | $42.7^{c}$ | $80.1^{d}$ |
| N | $59.5^{cd}$ | $88.2^{bc}$ | $130.9^{cd}$ |
| P | $66.5^{cd}$ | $114.0^{bc}$ | $149.6^{bcd}$ |
| N + P | $63.7^{cd}$ | $88.4^{bc}$ | $148.5^{bcd}$ |
| Bio | $76.0^{bcd}$ | $122.0^{bc}$ | $175.4^{abc}$ |
| CM | $80.1^{bcd}$ | $131.6^{bc}$ | $195.5^{abc}$ |
| $CM_1$ + Bio | $71.5^{bcd}$ | $118.2^{bc}$ | $150.7^{bcd}$ |
| $CM_2$ + Bio | $82.9^{bcd}$ | $137.4^{bc}$ | $196.6^{abc}$ |
| $CM_3$ + Bio | $70.1^{ab}$ | $138.6^{ab}$ | $243.6^{ab}$ |
| $CM_4$ + Bio | $135.2^{a}$ | $175.7^{a}$ | $250.4^{a}$ |
| LSD 0.05 | 66.453 | 105.198 | 95.114 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

*C. Quality parameters*

***Sennoside content***

The active constituent in Senna plant has been reported to be anthraquinon derivates. The leaves possess two crystalline glycosides, namely A and B as well as a third more potent glycoside having two additional glucose molecules, among other properties, namely Sennoside C and D.

### *A. Sennoside A (%) in leaves*

Statistical analysis showed significant differences in Sennoside A content in leaves (table 11). Combination treatments using Chicken manure and biofertilizer recorded from 0.24 to 0.48%. Combination treatments using inorganic fertilizers recorded from 0.13 to 0.18%, while the control recorded lowest value 0.03%.

### *B. Sennoside B (%) in leaves*

The data in Table (11) showed insignificant differences between treatments. ($CM_4$ + Bio), ($CM_3$ + Bio), ($CM_2$ + Bio) and ($CM_1$ + Bio) recorded (3.5-4.1%); (Bio) and (CM) separately recorded (2.7-2.9%); (NP) recorded (2.6%); (N) recorded (0.4%) and (P) recorded (0.5%). The control also recorded the lowest value (0.3%).

Assessed in percentages, combination treatment ($CM_4$ + Bio) showed significant contents (0.48%) compared to control and N treatments and relatively higher than that recorded by other doses ranging from 0.36-0.38 ($CM_3$+ Bio) ($CM_2$+Bio) for sennoside A. The single doses of (Bio), (CM) and combination of (NP) ranked second. These results were in line with findings obtained by other researchers (Mahfouz 2003 and Salem 2005) who reported about the positive response of Senna plant to the combined application of organic + biofertilizer and Urea + Super phosphate.

**Table 11: Effects of different fertilizers on Sennoside content of Senna leaves**

| Treatment | Sennoside A (%) | Sennoside B (%) |
|---|---|---|
| C* | 0.03b ** | $0.3^{a}$ |
| N | $0.07^{b}$ | $0.4^{a}$ |
| P | $0.13^{ab}$ | $0.5^{a}$ |
| N + P | $0.18^{ab}$ | $2.6^{a}$ |

Table 11 continues

| | | |
|---|---|---|
| Bio | 0.18[ab] | 2.7[a] |
| CM | 0.24[ab] | 2.9[a] |
| $CM_1$ + Bio | 0.32[ab] | 3.5[a] |
| $CM_2$ + Bio | 0.36[ab] | 3.8[a] |
| $CM_3$ + Bio | 0.38[ab] | 3.8[a] |
| $CM_4$ + Bio | 0.48[a] | 4.1[a] |
| LSD 0.05 | 0.36 | 5.2 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

### *C. Sennoside A (%) in pods*

Significant differences were obtained between combination treatments ($CM_4$+ Bio) (3.2%) and all other treatments including control (table 12). These differences varies from (0.7-1.1%) for ($CM_3$+ Bio), ($CM_2$+ Bio) and ($CM_1$+ Bio) and from (0.3-0.5%) for other treatments. Control revealed the lowest value (0.2%).

### *D. Sennoside B% in pods*

Significant differences were recorded between ($CM_4$+ Bio) and ($CM_3$+ Bio) (4.3 and 3.3% respectively and the control (0.4%) (table 12). Also there was a significant difference between combination treatments ($CM_4$+ Bio) and combination treatment of (NP), P and N single doses (0.9-1.0%).

The significant increase in percentage Sennoside B in pods represented threshold resulted from an integrated nutrient system created by applying the highest rate ($CM_4$+ Bio). These results are similar to those obtained by other researchers (Mahfouz 2003; Salem 2005; and Sundhariya and Subavasugi 2007).The magnitude of this increasing potential of percentages of Sennoside dropped as the amount of both organic and mineral fertilizers decreased. Hence this situation indicates that formation and development of Sennoside B requires substantial nutritional status enriched with almost all nutrients in balanced components and ratios.

**Table 12: Effects of different fertilizers on Sennoside content of senna Pods**

| Treatment | Sennoside A (%) | Sennoside B (%) |
|---|---|---|
| C* | 0.2[b] ** | 0.4[c] |
| N | 0.3[b] | 0.9[bc] |
| P | 0.3[b] | 0.9[bc] |
| N + P | 0.4[b] | 1.0[bc] |
| Bio | 0.5[b] | 1.7[abc] |
| CM | 0.5[b] | 1.8[abc] |
| $CM_1$ + Bio | 0.7[b] | 1.8[abc] |
| $CM_2$ + Bio | 0.7[b] | 2.2[abc] |
| $CM_3$ + Bio | 1.1[b] | 3.3[ab] |
| $CM_4$ + Bio | 3.2[a] | 4.3[a] |
| LSD 0.05 | 2.0 | 2.6 |

**Means followed by the same letter(s) in the same column do not differ significantly at P= 0.05, according to Duncan's Multiple Range Test.

## Conclusions

Medium textured soils of light clays and sandy clay loams having non saline and non sodic impacts, would favor satisfactory yields in terms of vegetative parameters and active ingredients.

For achieving progressive establishment and development of senna plants, as well as total dry solids, an integrated sources of combined organic- biofertilizer and inorganic fertilizers can be applied in order to maintain fertility status capable of replenishing and sustaining nutrient pool. The highest rates ($CM_4$+ Bio) ($CM_3$+ Bio) applied in this study are preferred.

The application of single doses from either chicken manure or biofertilizer separately did not contribute to an increase of yield of senna plant, therefore, can fairly be excluded from fertilization programme if mass production is targeted.

Super phosphate applied in single dose (P) is highly recommended for providing dry weight of plant avoiding Urea being combined with super phosphate as much feasible.

Prime consideration could be given to super phosphate applied in single dose (P) for increasing number and weight of pods.

For provision of sennoside A and B in leaves and pods, only ($CM_4$+ Bio) and ($CM_3$+ Bio) could be applied, but organic and inorganic fertilizers in single doses should not be considered.

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