



IMPACT OF CHICKEN MANURE AND SOWING METHODS ON ALFALFA (*MEDICAGO SATIVA L.*) GROWTH, FORAGE YIELD AND SOME QUALITY ATTRIBUTES

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Abstract

Purpose: A field experiment was carried out at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum at Shambat to investigate the effect of chicken manure and sowing methods on alfalfa (*Medicago sativa L.*) cultivar “Hegazi” growth, forage yield and some quality parameters.

Design/methodology/approach: The treatments consisted of four levels of chicken manure; namely, the control, 2.5, 5 and 10 tonne ha⁻¹, and two sowing methods, viz., flat plots and ridges. The chicken manure was applied three weeks before sowing and irrigation water was immediately applied. The experiment was laid out in a split-plot design with three replicates. Levels of chicken manure were assigned to the main plots and sowing methods to the sub-plots. Data were collected on plant height, stem diameter, leaf area index (LAI), forage fresh and dry yields, crude protein and fibre contents.

Findings: The results showed that chicken manure and sowing methods led to a significant ($P \leq 0.05$) positive effect on all studied parameters during at least one harvest, except for the effect of chicken manure on forage fresh yield. The treatment 5 tonne ha⁻¹ significantly ($P \leq 0.05$) increased plant height, stem diameter, LAI, forage dry weight and crude protein content. The flat sowing method was significantly ($P \leq 0.05$) superior over the ridge sowing method in stem diameter, LAI, and forage fresh and dry yields. The study



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indicated the importance of chicken manure for alfalfa, especially when the crop is grown in flat plots under environmental conditions similar to those in the Shambat area.

Keywords: Alfalfa, Forage yield, Quality, Chicken manure, Sowing methods

Paper type: Research paper

INTRODUCTION

The estimated livestock number in Sudan is about 168 million head (40 million cattle, 49 million sheep, 42 million goats and 37 million camel) (FMAR 2005). Due to degradation and desertification of rangelands in Sudan, the total dry matter production for livestock feeding is decreasing (Jindal *et al.*, 2008). To cope with the increased livestock numbers and the shortage in forage production in natural rangelands, expansion and improvement of irrigated forage have become a necessity. The irrigated forages in Sudan contribute to about 4 per cent of the total forage production (Abu-Suwar, 2004). They are mainly produced in the northern state (0.5 million tonne) as well as in Khartoum and eastern states (one million tonne).

Alfalfa (*Medicago sativa* L.) is a crop of high agricultural value (Jacobs, 1984; FAO, 1989) and good quality for all types of livestock because it (1) acts as a nitrogen source for rotational crops (it can provide 100–200 kg N ha⁻¹ for the subsequent crop) (2) improves soil physical properties such as soil tilth and prevent soil erosion, and (3) provides animals with a complete source of nutrients for the production of meat and milk. Abu-Suwar (2004) and Khair (1999) mentioned that alfalfa is considered the top ranking (94 per cent of the total cultivated forage crops) among irrigated forage crops in Sudan. The crop is exclusively grown under irrigation, particularly along the Nile from Khartoum state northwards. In the country, the crop is left to grow for two to four years, giving a cutting every three weeks on average. At the end of the third to the fourth year, the crop may be left to produce seeds during the hot dry period from March to May (Nayel and Khidir, 1995).

Although alfalfa is a leguminous crop that adds nitrogen to the soil through the N-fixation process, the application of fertilisers to the crop is still recommended to add other macro and micro elements to the soil to enhance crop growth, yield and quality (Ottman, 2010).

Chicken manure, which is produced in large amounts every year by the growing poultry industry in Sudan, can provide macro (e.g. 3.71% N and 0.003% P reported by Mohamed *et al.*, 2010) and micro elements to alfalfa fields and act as a soil amendment material (Elsheikh *et al.*, 2006). However, high doses of chicken manure increase soil acidity and some of the elements cause toxicity. Applying the optimal amount of chicken manure to alfalfa fields is therefore of paramount importance.

Alfalfa sowing methods, on the other hand, have effects on the establishment of the crop. Researchers have shown that different sowing methods result in alfalfa stands of different quantity and quality (Mustafa, 1996; Fadul, 2001) with varied weed infestation levels (Yazdani *et al.*, 2012). In Sudan, research results on alfalfa sowing methods are controversial and seem to be influenced by the location where the crop is sown.

The present study was therefore aimed at investigating the effect of chicken manure and sowing methods (flat and ridged plots) on alfalfa growth and forage yield and some quality attributes under conditions of clay soils in the Shambat area of Khartoum state, Sudan.

MATERIALS AND METHODS

The study area

A field experiment was carried out at the Demonstration Farm of the Faculty of Agriculture, University of Khartoum, Shambat, Sudan (latitude 15° 40' N and longitude 30° 32' E, elevation is 380 metres above sea level) from December 2010 to July 2011. The experimental site is located in a semi-desert zone. The soil of the experimental site is alkaline (pH 7.8 to 8) and cracking with about 50 per cent clay content. Other soil chemical and physical properties of the Shambat area were described by Suleiman *et al.* (2009) and Abdalla *et al.* (2012). The rainy season at Shambat is short with average annual rainfall of about 67.8 mm, with a peak in August.

THE TREATMENTS AND EXPERIMENTAL SETUP

The experiment consisted of eight treatments which were the combination of four levels of chicken manure *viz.*, the control, 2.5, 5 and 10 tonne ha⁻¹ (referred to as C₀, C₁, C₂, and C₃, respectively) and

two methods of sowing *viz.*, ridges and flat plots (referred to as R and F, respectively). The treatments were assigned as C₀R, C₀F, C₁R, C₁F, C₂R, C₂F, C₃R and C₃F.

The treatments were laid out in a split-plot design with three replicates. The main plots were allotted to the levels of chicken manure and the sub plots were allotted to the sowing methods. The study plots were 4 x 4 m each and ridges in the ridged plots were 70 cm apart. Dry broiler chicken manure was applied to the soil surface three weeks before sowing and the experimental site was then pre-watered using a surface irrigation system, which was the only irrigation system used throughout the study period. Hand weeding was done twice before sowing.

The seeds of alfalfa cultivar “Hegazi” were inoculated with rhizobium (*Rhizobium meliloti*) inoculums Tal 380 strain, which was supplied by the Agricultural Research Council (ARC) at Khartoum, Sudan, as a charcoal-based inoculum. The seeds were then immediately sown on December 20, 2010, by drilling the seeds on both sides of the ridges and by broadcasting them on the flat plots. A seeding rate of 22.50 kg ha⁻¹ was used. Irrigation water was applied immediately after sowing and a second irrigation was applied seven days later to facilitate the emergence of the seedlings. Subsequent irrigation was carried out at 7 to 10 day intervals depending on the weather conditions. Hand weeding was carried out one month after sowing and after the first cutting. The only major pest that infested the crop during the study period was aphid (*Aphis* spp.), which was controlled by applying Colmite at a rate of 2 ml L⁻¹.

The first cutting was taken 79 days after sowing when 50 per cent of the stand was in bloom. The other four cuttings were obtained at varying intervals (21 to 30 days) depending on the percentage of flowering or bud re-growth. A sickle was used for clipping plants 2 to 5 cm above ground.

PARAMETERS MEASURED

Data were collected on the following parameters; (i) plant height (cm): before each cutting, five plants were randomly selected from each plot and then plant height was measured from the soil surface to the apical meristem. Average plant height was recorded, (ii) stem diameter (mm): the stem diameter was measured from the same five plants that were randomly selected for the plant height using a digital vernier caliper

at a 5 cm height from the soil surface, (iii) leaf area index (LAI): this parameter was determined according to the Watson and Watson (1956) method. Three leaves were taken from each five randomly selected plants on each plot. Leaves were punctured using a puncture of 0.32 cm² and air dried for 20 to 30 days. The dry weight of the punctured discs was then determined using a sensitive balance. The leaf area was then calculated as follows:

$$\text{Leaf area} = \frac{\text{weight of leaf} \times \text{area of disc}}{\text{weight of disc}} \quad \text{Equation (1)}$$

Leaf area index was then determined according to the following formula:

$$\text{Leaf area index (LAI)} = \frac{\text{leaf area} \times \text{Number of leaves} / \text{plant} \times \text{plant density}}{\text{area of land occupied by leaves}} \quad \text{Equation (2)}$$

Plants in an area of 0.3 m² from the middle ridge of each plot and of 0.04 m² from the middle of the flat plots were counted to determine plant density (number of plants m⁻²), (iv) forage fresh weight (tonne ha⁻¹): the whole plot for each treatment was clipped and the fresh weight of the plants was immediately determined using a spring balance to find the fresh weight, which was then converted to tonne ha⁻¹, (v) forage dry weight (tonne ha⁻¹): plants within an area of 0.7 m² from the middle of the ridge plots and 0.09 m² from the flat plots were cut and air-dried for 30 days until a constant weight was reached, then re-weighed to determine their dry weight, which was then converted to tonne ha⁻¹, (vi) forage crude protein content (%): a subsample of 0.2 g was taken from each plot dry matter to estimate its crude protein content. Crude protein percentage was then estimated using the micro-Kjeldahl method as described by Pearson (1976), and (vii) forage fibre content (%): this quality parameter was determined using the Association of Official Analytical Chemists (AOAC, 1990) methods.

STATISTICAL ANALYSIS

The collected data of each sampling date were subjected to analysis of variance (ANOVA) appropriate for a split-plot method. Means of each parameter were compared using the least significant differences (LSD) test. Data on forage yields and some quality attributes were subjected to a

trend analysis to investigate changes in cumulative fresh and dry matter yields, as well as forage crude protein and fibre contents over time.

RESULTS

Plant height (cm)

There was great variability in plant height (cm) according to the chicken manure doses and sowing methods. Plant height was significantly ($P \leq 0.05$) affected by chicken manure in all cuttings, except cutting number 1 (Table 1). In all sampling occasions, C_2 (5 tonne ha^{-1}) was superior over all other chicken manure levels in respect to plant height (Table 1).

Although the sowing methods showed significant ($P \leq 0.05$) effects on plant height in the fourth sampling date only, the flat (F) sowing method produced higher alfalfa plants than the ridge (R) sowing method in all sampling dates, except during the fifth one (Table 1). The interaction between chicken manure rates and sowing methods did not significantly ($P \leq 0.05$) affect plant height in cuttings number 2, 3 and 5. With regard to other sampling occasions (1 and 4) there were some significant interactions (Figure 1).

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STEM DIAMETER (MM)

The results showed that applying 5 tonne ha^{-1} (C_2) of chicken manure to alfalfa produced thicker stems compared with the other chicken manure levels in four out of five sampling dates (Table 1). However, the C_2 dose significantly ($P \leq 0.05$) increased stem diameter as opposed to the control (C_0) during the last two cuttings only.

With respect to sowing methods, Table 1 shows that sowing the crop on flat (F) plots resulted in a larger stem diameter compared with sowing it on ridges (R). Notwithstanding, the significant ($P \leq 0.05$) differences between the two sowing methods were observed at the first sampling date only. The interaction between chicken manure doses and sowing methods was not significant ($P \leq 0.05$).

LEAF AREA INDEX (LAI)

Table 2 shows that the application of 10 tonne ha^{-1} (C_3) chicken manure to alfalfa produced significantly ($P \leq 0.05$) larger leaf area index compared with the control, 2.5 and 5 tonne ha^{-1} in two out of four cuttings.

Table I. Mean plant height (cm) and stem diameter (mm) of alfalfa as affected by chicken manure and sowing methods

Chicken manure	Plant height					Cutting number				
	1 st	2 nd	3 rd	4 th	5 th	1 st	2 nd	3 rd	4 th	5 th
C ₀	63.00 ^a	76.00 ^{ab}	71.56 ^{ab}	71.53 ^b	67.70 ^b	02.80 ^b	03.31 ^a	03.40 ^a	03.08 ^b	02.94 ^b
C ₁	63.00 ^a	72.90 ^{ab}	68.90 ^b	72.60 ^b	66.10 ^b	03.29 ^{ab}	03.38 ^a	03.52 ^a	03.21 ^{ab}	03.15 ^{ab}
C ₂	71.27 ^a	84.27 ^a	76.07 ^a	82.27 ^a	78.95 ^a	03.27 ^{ab}	03.75 ^a	03.63 ^a	03.47 ^a	03.35 ^a
C ₃	61.30 ^a	70.33 ^b	64.37 ^b	68.23 ^b	63.70 ^b	03.45 ^a	03.52 ^a	03.40 ^a	03.20 ^{ab}	03.11 ^{ab}
SE±	05.72	05.22	03.79	02.44	04.43	00.24	00.32	00.31	00.14	00.13
CV (%)	15.27	11.93	09.35	05.74	11.11	13.06	15.85	15.13	07.29	07.18
Sowing method										
F	66.03 ^a	76.38 ^a	70.32 ^a	74.93 ^a	68.69 ^a	03.35 ^a	03.53 ^a	03.51 ^a	03.30 ^a	03.19 ^a
R	63.70 ^a	76.37 ^a	70.13 ^a	72.38 ^b	69.63 ^a	03.06 ^b	03.44 ^a	03.50 ^a	03.18 ^a	03.08 ^a
SE±	01.13	01.53	01.48	00.65	01.28	00.12	00.07	00.06	00.06	00.05
CV (%)	04.28	04.95	05.17	02.19	04.55	09.46	05.54	04.56	04.57	04.12

C₀, C₁, C₂ and C₃ = 0, 2.5, 5 and 10 tonne ha⁻¹, respectively. F and R = flat and ridge sowing methods, respectively. F and R = flat and ridge sowing methods, respectively. CV = Coefficient of variation, SE = standard error. Means with the same letter(s) in the same column for each treatment (chicken manure and sowing method) were not significantly different (P ≤ 0.05) using least significant difference (LSD) test

Sowing alfalfa on flat plots yielded stands with higher LAI compared with sowing on ridges; however, the significant increment was during the first count only (Table 2). The interaction between chicken manure treatments and sowing methods on LAI was significant ($P \leq 0.05$) in all sampling occasions except during the second one (Figure 2).

FORAGE FRESH WEIGHT (TONNE HA⁻¹)

In this respect the results showed that chicken manure at a rate of 5 tonne ha⁻¹ (C₂) recorded the highest mean forage fresh yield in all cuttings compared with the control, C₁ and C₃. However, the differences in forage fresh yield among all levels of chicken manure were not significant ($P \leq 0.05$) (Table 3).

For the sowing methods, the results showed that the flat plots out-yielded the ridges in most of the harvests; however, a significant difference was observed during the fifth cutting only (Table 3). There were no significant interactions among the treatments on forage fresh weight.

FORAGE DRY WEIGHT (TONNE HA⁻¹)

The results showed that applying chicken manure at a rate of 5 tonne ha⁻¹ (C₂) significantly ($P \leq 0.05$) increased alfalfa forage dry weight in all sampling occasions, except sampling date number 2 (Table 3). The control (C₀) treatment exhibited the lowest forage dry yield in all cuttings; however, the differences among the control (C₀), C₁ and C₃ treatments were not significant ($P \leq 0.05$).

The flat (F) sowing method produced significantly ($P \leq 0.05$) higher forage dry yield in all sampling dates compared with the ridge (R) sowing

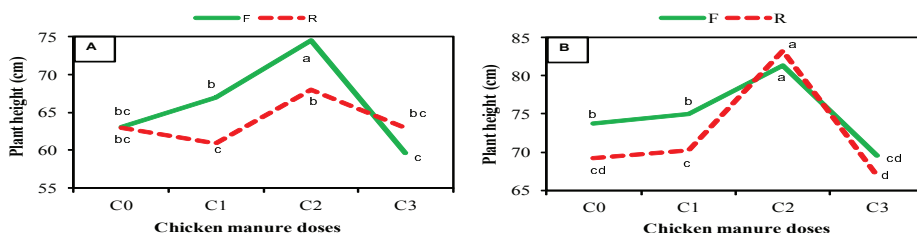


Figure 1. Interaction between chicken manure and sowing methods with respect to alfalfa plant height. A: 1st cutting, and B: 4th cutting. Points with the same letter(s) are not significantly different from each other at 0.05 level of probability using least significant difference (LSD) test

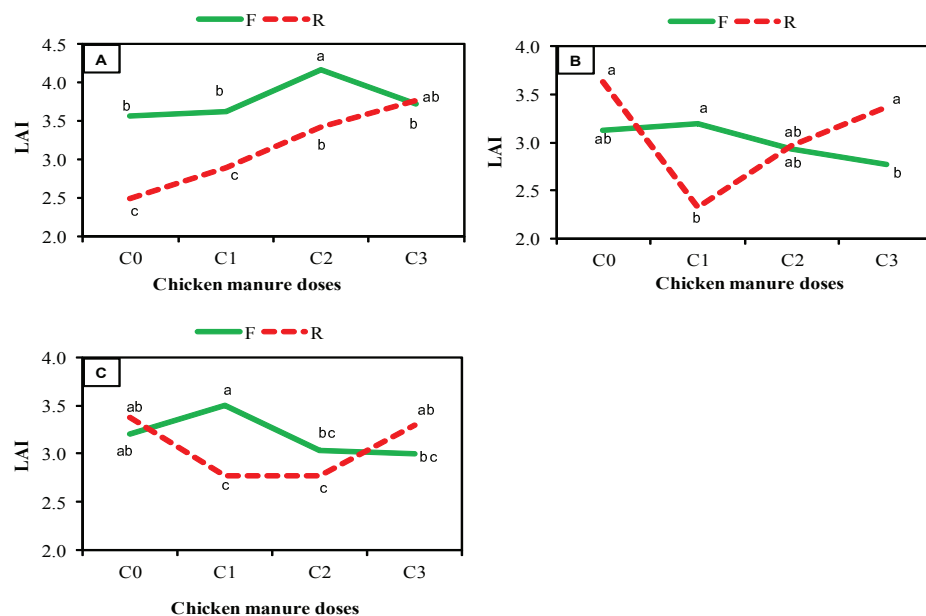
Chicken manure	Cutting number			
	1 st	2 nd	3 rd	4 th
	10/3/2011	12/4/2011	5/5/2011	28/5/2011
C ₀	03.03 ^b	03.25 ^a	02.77 ^b	02.90 ^a
C ₁	03.27 ^b	03.48 ^a	02.95 ^{ab}	03.13 ^a
C ₂	03.75 ^a	03.22 ^a	03.07 ^{ab}	03.28 ^a
C ₃	03.80 ^a	03.50 ^a	03.38 ^a	03.17 ^a
SE±	00.12	00.31	00.21	00.17
CV (%)	06.20	16.09	11.85	09.33
Sowing method				
F	03.78 ^a	03.52 ^a	03.08 ^a	03.18 ^a
R	03.15 ^b	03.21 ^a	03.01 ^a	03.06 ^a
SE±	00.10	00.17	00.16	00.10
CV (%)	06.72	12.63	13.39	07.79

C₀, C₁, C₂ and C₃ = 0, 2.5, 5 and 10 tonne ha⁻¹, respectively. F and R = flat and ridge sowing methods, respectively. CV = Coefficient of variation, SE = standard error
Means with the same letter(s) in the same column for each treatment (chicken manure and sowing method) were not significantly different ($P \leq 0.05$) using least significant difference (LSD) test

†During the 5th sampling date (that is, the last cutting) leaf samples for LAI were mistakenly disordered, and were therefore excluded from the analysis. Consequently, the results of only four sampling occasions are presented

Table 2. Mean leaf area index (LAI) of alfalfa as affected by chicken manure and sowing methods†

Figure 2. Interaction between chicken manure and sowing methods with respect to alfalfa LAI. A: first cutting, B: 3rd cutting, and C: 4th cutting. Points with the same letter(s) are not significantly different from each other at 0.05 level of probability using least significant difference (LSD) test



Chicken manure	Cutting number									
	Forage fresh weight					Forage dry weight				
	1 st	2 nd	3 rd	4 th	5 th	1 st	2 nd	3 rd	4 th	5 th
C ₀	12.96 ^a	13.26 ^a	14.66 ^a	16.16 ^a	15.50 ^a	04.27 ^b	05.46 ^a	04.68 ^b	05.24 ^b	05.16 ^b
C ₁	13.54 ^a	13.08 ^a	14.37 ^a	15.63 ^a	15.69 ^a	04.36 ^{ab}	05.76 ^a	05.63 ^{ab}	06.04 ^{ab}	05.60 ^b
C ₂	17.47 ^a	16.42 ^a	17.25 ^a	19.52 ^a	18.72 ^a	05.76 ^a	06.58 ^a	07.63 ^a	07.56 ^a	07.37 ^a
C ₃	12.99 ^a	11.53 ^a	12.95 ^a	14.17 ^a	14.31 ^a	05.26 ^{ab}	05.37 ^a	04.68 ^b	05.60 ^b	05.68 ^b
SE±	03.10	02.38	02.81	03.50	03.64	0058	00.91	00.86	00.77	00.66
CV (%)	37.76	30.39	32.83	37.05	39.27	20.37	27.24	26.44	21.83	19.10
Sowing method										
F	14.10 ^a	13.86 ^a	15.22 ^a	16.66 ^a	17.24 ^a	07.48 ^a	08.47 ^a	08.32 ^a	08.86 ^a	08.66 ^a
R	14.37 ^a	13.30 ^a	14.40 ^a	16.08 ^a	14.87 ^b	02.36 ^b	03.10 ^b	02.93 ^b	03.36 ^b	03.24 ^b
SE±	00.60	00.50	00.70	00.63	00.91	00.28	00.55	00.46	00.30	00.32
CV (%)	10.76	09.11	11.65	09.48	13.96	14.11	23.44	19.89	11.83	13.36

C₀, C₁, C₂ and C₃ = 0, 2.5, 5 and 10 tonne ha⁻¹, respectively. F and R = flat and ridge sowing methods, respectively. CV = Coefficient of variation, SE = standard error
Means with the same letter(s) in the same column for each treatment (chicken manure and sowing method) were not significantly different (P≤0.05) using least significant difference (LSD) test

Table 3. Mean forage fresh and dry weights (tonne ha⁻¹) of alfalfa as affected by chicken manure and sowing methods

method (Table 3). The highest alfalfa forage dry yield was observed during the fourth sampling date. The response of alfalfa forage dry weight to chicken manure was significantly ($P \leq 0.01$) affected by sowing methods during the third and fourth sampling dates (Figure 3).

FORAGE CRUDE PROTEIN CONTENT (%)

Table 4 shows that no single chicken manure treatment consistently recorded the highest crude protein content during the course of this study. However, C_2 and C_1 treatments were significantly ($P \leq 0.05$) superior over other treatments during cuttings number 3 and 4 respectively, and produced relatively better alfalfa forage crude protein content. Although the results showed no significant differences between sowing methods (F and R) with respect to alfalfa crude protein content, the ridge sowing method yielded relatively higher alfalfa crude protein content in all harvests except harvest number 2 (Table 4). The response of alfalfa crude protein content to chicken manure application was significantly ($P \leq 0.05$) affected by sowing methods on cuttings number 3 and 4 (Figure 4).

FORAGE FIBRE CONTENT

The results showed that significant ($P \leq 0.05$) differences among chicken manure levels with regard to fibre content were found in three out of five cuttings (Table 4). These were cutting numbers 3, 4 and 5. During sampling occasions 4 and 5, C_1 (2.5 tonne ha^{-1}) treatment exhibited significantly ($P \leq 0.05$) lower fibre content compared with the control.

The significant ($P \leq 0.05$) differences between sowing methods on fibre content were observed during the last sampling date only (cutting number 5). Sowing alfalfa on ridges lowered the fibre content in all sampling occasions, except during the second cutting (Table 4). There was no significant ($P \leq 0.05$) interaction between chicken manure rates and sowing methods with regard to alfalfa fibre content in all sampling dates.

CUMULATIVE ALFALFA FORAGE YIELDS AND SOME QUALITY ATTRIBUTES

Figure 5 shows that with time, the increment in alfalfa cumulative forage fresh and dry yields was not steady and these two attributes decreased

Chicken manure	Crude protein content					Cutting number					Fibre content				
	1 st	2 nd	3 rd	4 th	5 th	1 st	2 nd	3 rd	4 th	5 th	1 st	2 nd	3 rd	4 th	5 th
C ₀	26.11 ^a	26.54 ^a	17.92 ^b	19.49 ^b	18.15 ^a	28.82 ^a	35.23 ^a	35.47 ^a	42.31 ^a	34.42 ^a	28.82 ^a	35.23 ^a	35.47 ^a	42.31 ^a	34.42 ^a
C ₁	28.63 ^a	27.82 ^a	20.96 ^b	22.53 ^a	18.52 ^a	28.65 ^a	30.34 ^a	33.32 ^{ab}	35.87 ^b	31.78 ^b	28.65 ^a	30.34 ^a	33.32 ^{ab}	35.87 ^b	31.78 ^b
C ₂	28.36 ^a	27.93 ^a	25.71 ^a	19.58 ^b	19.27 ^a	31.32 ^a	33.49 ^a	30.76 ^b	38.38 ^b	33.46 ^a	31.32 ^a	33.49 ^a	30.76 ^b	38.38 ^b	33.46 ^a
C ₃	27.86 ^a	27.76 ^a	19.55 ^b	21.31 ^{ab}	19.69 ^a	29.86 ^a	31.42 ^a	31.63 ^b	36.20 ^b	33.72 ^a	29.86 ^a	31.42 ^a	31.63 ^b	36.20 ^b	33.72 ^a
SE±	01.70	02.36	01.71	00.89	00.95	01.54	02.09	01.45	01.54	00.52	01.54	02.09	01.45	01.54	00.52
CV (%)	10.55	14.88	14.09	07.49	08.78	09.01	11.09	07.64	07.00	02.69	09.01	11.09	07.64	07.00	02.69
Sowing method															
F	26.94 ^a	27.70 ^a	20.62 ^a	20.23 ^a	18.68 ^a	30.50 ^a	32.19 ^a	33.34 ^a	39.04 ^a	34.20 ^a	30.50 ^a	32.19 ^a	33.34 ^a	39.04 ^a	34.20 ^a
R	28.53 ^a	27.24 ^a	21.45 ^a	21.22 ^a	19.14 ^a	28.83 ^a	33.06 ^a	32.25 ^a	37.34 ^a	32.48 ^b	28.83 ^a	33.06 ^a	32.25 ^a	37.34 ^a	32.48 ^b
SE±	00.91	00.84	00.98	00.56	00.84	02.00	00.71	00.90	00.92	00.66	02.00	00.71	00.90	00.92	00.66
CV (%)	08.07	07.55	11.38	06.66	10.95	16.53	05.38	06.75	05.92	04.83	16.53	05.38	06.75	05.92	04.83

C₀, C₁, C₂ and C₃ = 0, 2.5, 5 and 10 tonne ha⁻¹, respectively. F and R = flat and ridge sowing methods, respectively. CV = Coefficient of variation, SE = standard error
Means with the same letter(s) in the same column for each treatment (chicken manure and sowing method) were not significantly different (P≤0.05) using least significant difference (LSD) test

Table 4. Mean forage crude protein and fibre contents (%) of alfalfa as affected by chicken manure and sowing methods

after the fourth harvest. The same trend was observed with regard to alfalfa cumulative crude protein and fibre contents, where the amount of protein was decreased and fibre was increased after four cuttings.

DISCUSSION

Effect of chicken manure and sowing methods on alfalfa growth parameters

Figure 3. Interaction between chicken manure and sowing methods with respect to alfalfa forage dry weight. A: 3rd cutting, B: 4th cutting. Points with the same letter(s) are not significantly different from each other at 0.05 level of probability using least significant difference (LSD) test

The significant effect of chicken manure on alfalfa growth may be attributed to its beneficial effect on soil structure, water uptake and root penetration; chicken manure also increases soil N, P and K contents (Holanda *et al.*, 1987). In addition, chicken manure has complexation properties which

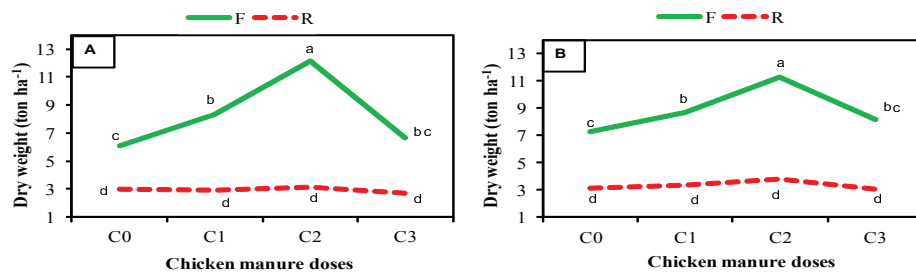
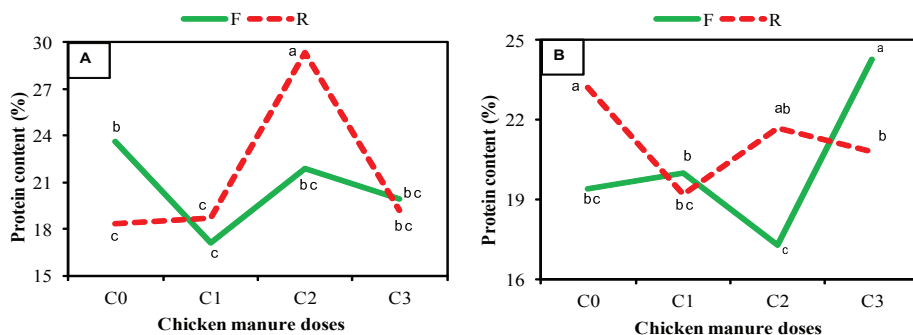


Figure 4. Interaction between chicken manure and sowing methods with respect to alfalfa crude protein content. A: 3rd cutting, B: 4th cutting. Points with the same letter(s) are not significantly different from each other at 0.05 level of probability using least significant difference (LSD) test



prevent depletion and fixation of many plant nutrients (Giarpini *et al.*, 1992). It also enhances protein synthesis (Giarpini *et al.*, 1992) which is a requirement of an efficient photosynthetic system. Elnesairy (1997) and Elsheikh *et al.* (2006) found positive significant effects of chicken manure on some alfalfa growth parameters (e.g., plant height). In addition, Eltilib *et al.* (1993) found that chicken manure has a positive effect on plant growth.

In the present study the results indicate that the flat sowing method significantly produced taller alfalfa plants than the ridge sowing method. This could be due to the increased competition between plants for light in flat plots as opposed to ridges. Consequently, the plants grew taller in the flat plots. Similar results were found by Fadul (2001) and Abu Elgasim (2006). However, this result was in contrast with that of Mustafa (1996) who reported that the relatively taller plants were those grown in ridges due to proper irrigation management using the furrow system, which prevents water logging. With regard to stem diameter and LAI, significant effects resulting from sowing the crop on flat plots were observed during the first cutting only. Due to the nature of these growth parameters, different sowing methods were not expected to produce positive effects. This finding was in accordance with the result of Fadul (2001), who reported insignificant differences between the two sowing methods (that is, flat and ridges) on alfalfa LAI.

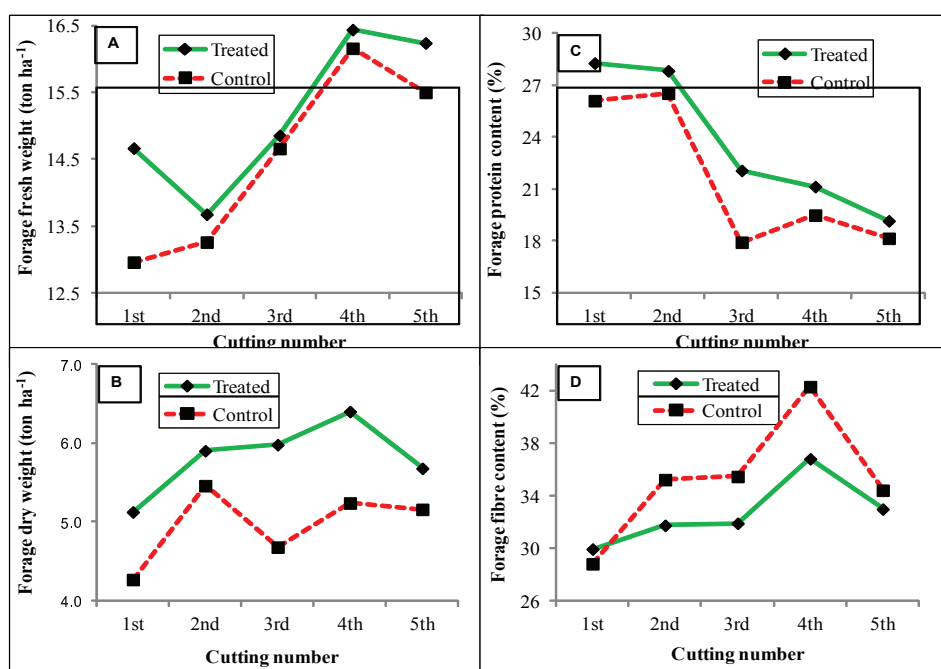


Figure 5. Changes in alfalfa forage yields and quality attributes over time. A: Cumulative forage dry yield, B: Cumulative forage fresh yield, C: Cumulative protein content, and D: Cumulative fibre content

Chicken manure did not have any significant effect on alfalfa forage fresh weight. During the course of the present study the crop was infested by the parasitic dodder plant *Cuscuta hyalina*. This parasitic plant might have confounded the effect of chicken manure on alfalfa forage fresh yield. This finding is in disagreement with that of Elnesairy (1997) and Elsheikh *et al.* (2006), who reported a significant effect of chicken manure on alfalfa forage fresh weight. In respect to forage dry weight, C_2 recorded significant differences during most harvests. When the plant materials were dried out, the confounding effect of dodder plants might have been reduced and consequently chicken manure showed positive effects on forage dry yield. This result was in agreement with that of Gabir (1984) and Elnesairy (1997), who found that chicken manure significantly increased alfalfa forage dry weight. Since chicken manure had enhanced forage dry weight it was expected that forage quality would also be improved. This finding concurs with those of Lim *et al.* (1994), Shin *et al.* (1996), Elnesairy (1997) and Elsheikh *et al.* (2006), who reported an enhancement in alfalfa forage crude protein content due to chicken manure application.

With regard to sowing methods, flat plots out-yielded ridge plots in terms of alfalfa forage fresh and dry weights. However, significant effects were recorded during the fifth harvest, and all harvests with respect to fresh and dry weights, respectively. This may be due to competition by dodder plants, which might have prevented the advantages of the sowing methods from having an effect on the forage fresh yield during the first four harvests. During the last harvest (the fifth sampling date), dodder plants were cleaned out and the sowing method had a significant effect on alfalfa forage fresh yield. When the plant materials were dried out, the confounding effect of plant moisture content on forage yield was reduced and therefore the flat sowing method significantly increased forage dry weight during all sampling dates. Similar results were obtained by Mustafa (1996) and Fadul (2001), who noted that flat plots were superior over the ridge sowing method with respect to alfalfa forage fresh yield. Sheaffer *et al.* (1988), Mustafa (1996), and Abu Elgasim (2006) also found that flat plots out-yielded ridge plots in terms of alfalfa forage dry yield.

In respect to forage quality, the ridges recorded relatively higher crude protein and lower fibre contents. This could be attributed to the fact

that the ridge sowing method improves root elongation and nodulation (Elsayed, 1994), which in turn improves plant water uptake and amount of fixed nitrogen. This might have resulted in alfalfa forage with relatively more crude protein and low fibre contents. This result is similar to that of Fadul (2001), who found an increased crude protein content as a result of sowing alfalfa on ridges. Nonetheless, Mustafa (1996) found relatively higher alfalfa nutritive value after sowing the crop on flat plots.

Effect of the interaction between chicken manure and sowing methods on growth, forage yield and some quality attributes of alfalfa

The results of the present study showed significant interactions between chicken manure and sowing methods with regard to alfalfa plant height, leaf area index, forage dry yield and crude protein content. The treatments C_1 (2.5 tonne ha^{-1}) and C_2 (5 tonne ha^{-1}) were the only doses that resulted in significant interactions with sowing methods. In contrast, sowing the crop on flat plots resulted in significant interactions with regard to leaf area index and forage dry yield, whereas the ridges contributed to the significant interactions regarding plant height and crude protein content. This trend was expected since these treatments significantly enhanced the specific parameters compared with the others when their main effects were compared, except the ridge method in respect of plant height. This implies that the response of alfalfa to chicken manure varies with different sowing methods when these attributes are considered.

Impact of chicken manure on alfalfa cumulative forage yield and some quality attributes over time

The results of the present study also present an opportunity to look at the effect of chicken manure on the ability of alfalfa to re-grow. The decrease in the cumulative alfalfa forage quantity and quality after cutting number four may be due to the fact that N and P contents on the Sudanese broiler chicken manure were relatively low: averaging 3.71 per cent N and 0.003 per cent P (Mohamed *et al.*, 2010). Thus, with time, these nutrients would have been depleted from the soil and the effect of chicken manure treatments on alfalfa would become very similar to the control. In addition, over time N is lost from chicken manure as ammonia (McCall, 1980) via volatilisation. It is also reported that chicken manure phosphorus may not all be available until the second season (McCall, 1980). It is worth noting that chicken manure in the present study was not incorporated into the soil and this might have caused nutrient loss via leaching.

CONCLUSIONS

From the results of the present study we conclude that:

- 1- Applying 5 tonne ha⁻¹ (C₂) chicken manure significantly increased alfalfa forage dry yield and crude protein content compared with the control (C₀), 2.5 (C₁), and 10 (C₃) tonne ha⁻¹. Therefore, it is advised that C₂ treatment can be used as a threshold to determine the optimal chicken manure rates for alfalfa production. Actual rates depend on the specific site, alfalfa nutrient requirements and soil fertility status, and
- 2- Sowing alfalfa on flat (F) plots significantly increased forage fresh and dry yields as opposed to growing the crop on ridges (R).

Overall, this study demonstrated the importance of chicken manure fertiliser for alfalfa production. This could offer an alternative/complementary environmentally friendly fertilisation protocol for alfalfa forage production. Future studies should look at the use of chicken manure as compost for fertilising alfalfa crops, and at the splitting of chicken manure doses. Methods of conserving (storing) and applying chicken manure should be followed carefully.

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