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Effect of Time Interval Between Sowing and Application of Nondigested/Digested Cattle Manure on Germination and Seedling Growth of Several Wheat Cultivars

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Abstract

Raw and digested animal manures are broadly used as trusted fertilizer in crop production. However, their effect on wheat seeds germination is poorly documented. Thus, the effect of raw (RM) and digested (DM) cattle manure alone or supplemented with urea on the germination and seedling growth of three wheat varieties (Slambo, Acsad, and Karim) was investigated. Seeds were sowing directly, 10, 20 and 30 days after soil fertilization with a rate corresponding to 350 kg Tot N ha^{-1}. The germinated seeds were counted during 14 days from which time to reach 50% germination ($T_{50\%}$), mean germination time (MGT), germination index (GI) and final germination percentage (FGP) were calculated. Seedling characteristics were also accessed as radicle length, plumule length and seedling dry weight. Results showed that sowing wheat directly or 10 days after fertilization with RM and DM, especially in combination with urea, delayed and reduced seed germination of wheat varieties. This effect was confirmed by high values of $T_{50\%}$ and MGT and low values of GI. As sowing close from fertilization reduced radicle length, plumule length and seedling dry weight. Our results revealed that extending the period between sowing and fertilization to 30 days would improve germination and seedling characteristics.

Keywords: Digested cattle manure; Germination characteristics; Raw cattle manure; Seedling characteristics; Urea

Introduction

Worldwide, large amounts of animal's manure are produced from farms that need to be handled and utilized in an appropriate way. The common way for sustaining animal wastes management is to use them as soil fertilizers [1] or in the bioenergy production such as biogas [2]. However, the utilization of animal's manure in bioenergy production also leads to the generation of a residue called digestate [3]. Digestate is known as plant nutrients rich material that can be used as fertilizers [4]. Recycling of organic wastes to arable soils as fertilizer has been shown to improve physical, chemical and biological properties of the soil as well as crop yield [5, 6]. Furthermore, the application of organic wastes in combination with mineral fertilizer will give even better results in terms of increasing crop yield [7, 8]. However, it has been reported in several studies that the application of nondigested and digested animal manures alone or in combination with urea will delay and reduce wheat seed germination if sowing is performed close from the fertilization time. Abubaker et al. [9] have stated that wheat seeds germination was delayed and reduced when sowing was performed two days after application of non-digested and digested of several manures' types represented by cattle, sheep and poultry manure. Moreover, in another study by El-Zeadani et al. [10], it was shown that sowing three wheat seeds varieties directly or 10 days from the application of raw or digested poultry manure reduced wheat seeds germination, plumule length, radicle length and seedling dry weight especially at the combination with urea. This adverse effect has been referred to the addition of growth-influencing substances such as ammonia and organic acids as observed by several researchers [11, 12]. Moreover, the application of urea increases the concentration of ammonia in the soil, which will reduce wheat seed germination and suppresses root hair formation [13]. However, El-Zeadani et al. [10] confirmed that the germination of wheat seeds can be enhanced if sowing is performed 20 to 30 days from the application of raw and digested poultry manure either alone or in combination with urea. It was assumed that by prolonging the period between application

and sowing, the adverse effect will be reduced. It is unclear if this method is applicable to all type of animal's manure, as there is no sufficient literature available to discuss or illustrate this area with respect to digested and nondigested organic wastes. Since the manures vary greatly in composition [14,15], it can be expected that each manure will behave differently when used as soil fertilizer. Several studies have reported that manures that generated from different animals are unlike in term of supporting crop growth and yield [9,16]. Due to the success in having high wheat yield can be affected by the percentage of seeds germination [17], it is important to find the suitable strategy for sowing that leads to increasing germination capacity. Consequently, the objectives of this study were first to investigate the effect of fertilization with raw and digested cattle manure alone or in combination with urea on wheat seeds germination and seedling characteristics. Secondly, to test the approach of extending the time between fertilization and sowing in improving wheat seeds germination and seedling characteristics. Thirdly, to identify the best wheat variety in term of germination and seedling growth.

Materials and Methods

Soil characteristics

Table 1: Properties of Soil that Used in the Experiment.

Parameters	Values
Physical properties	
Sand (%)	97
Clay (%)	1.3
Silt (%)	1.7
Water-holding capacity (%)	21.6
Chemical properties	
pHpaste	8
ECe (ds m-1)	2.99
OM (%)	0.5
Total N (%)	0.1
Total C (%)	1
P (g kg-1dw)	0.1
K (g kg-1dw)	0.04

Sandy soil in totally dry condition was collected from the desert located 10 km west of the Sabha city a southern part of Libya (22°30′ N and 30°00′ N and between the meridians of 10°E and 18°E). The land where the soil was collected has not been cultivated or fertilized before. The collected soil was thoroughly mixed, sieved (4-mm screen) and stored at lab temperature (+23°C) until use. The physical and chemical properties of the soil are shown in Table 1. The fractions of sand, clay and silt were determined according to Beretta et al. [18]. Soil water-holding capacity was measured according to the method described by Forster [19]. Soil pH was measured in the suspension at a soil-to-deionized water ratio of 1:2 using a pH meter 3030 (Jenway, Ltd., UK). Electrical conductivity (ECe) was determined in a 1:1 (v/v) water-to-soil suspension using the conductivity meter (model 4070, ELE, England). Organic matter (OM) in the soil was measured according to Ball [20]. Total nitrogen (Tot N) in the soil was measured using Kjeldahl technique modified by Bradstreet [21]. Total carbon (Tot C) in the soil was analysed by a loss-on-ignition method described by Dean [22]. Soil phosphorus (P) was extracted according to the method described by Chapman and Pratt [23] and determined using Cecil CE 202 spectrophotometer at 420nm (Super Aquarius, Cecil Instruments, Cambridge, England). Potassium (K) was measured using a flame photometer (Jenway, PFP7, UK) according to Protocol: P05-001A.

Fertilizers and characteristics

Cattle manure was collected from a farmyard located in Sabha city where animals are mainly fed with clover and barley straw. Approximately 20kg of raw manure was collected, cleaned and portioned into small burlap bags and stored at room temperature (+23°C) until use. Collected manure was nearly dry (% of water content was 1.2). A portion of collected manure was digested anaerobically according to Abubaker et al. [9]. The physical and chemical characteristics of raw and digested cattle manure are given in Table 2. Percentage of dry matter (DM) was determined after drying in the oven at 100°C for 24h as described by Windham et al. [24]. The pH was measured using a pH meter 3030 (Jenway, Ltd., UK) at a manure to-deionized water ratio of 1:6. Tot N was measured by the Kjeldahl method according to Bradstreet [21]. Tot C was measured by a loss-on-ignition method according to Dean (1974). Tot P was determined using Cecil CE 202 spectrophotometer at 420nm (Super Aquarius, Cecil Instruments, Cambridge, England) after extracted by HNO_3 according to the method described by Pungor and Horval [25]. Tot K was extracted by HCl (Protocol: P05-004A) and analysed by the flame photometer (Jenway, PFP7, UK). The urea ($CO(NH_2)_2$) used in the experiment consists of 46.6% N, 20% C, 26.6% O, 6.7% H.

Table 2: Characteristics of Raw and Digested Cattle Manure that used in the Experiment.

Parameters	Raw manure	Digested manure
DM (%)	98.8	17.3
pH	7.7	8.3
Tot N (g kg^{-1}dw)	13.8	14.2
Tot C (g kg^{-1}dw)	453	427
C/N	33	30
Tot P (g kg^{-1}dw)	5.9	5.9
Tot K (g kg^{-1}dw)	3.5	3.9

Experiment setup

The experiment was carried out at the faculty of agriculture, Sabha University, Libya. The experiment comprised three wheat varieties (*Triticum aestivum L.* cv. Slambo, cv. Acsad, and cv. Karim) and four sowing dates. Fertilizers used in the experiment were urea, raw manure and digested manures with and without combination of urea. The Germination experiment was carried out in

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plastic dishes (7.5cm diam. × 5cm height). The experiment was conducted in a randomized block design with four replicates and consisted of six treatments resulting in 60 dishes for each sowing date. Four sets of dishes were prepared in total 240 dishes + 12 unfertilized dishes as control (control was only run at the first sowing). The treatments used in the experiment are shown in Table 3. The fertilizers were applied with fixed N doses at a rate corresponding to 350kg Tot N ha^{-1}. At the start, 200g of pure soil was weighed into each dish after which mixed with the target fertilizer, gently packed into the dishes and watered with 15ml of distilled water by spraying. The combination with urea was done so that half of the added N originated from the manures and the other half came from the urea. The irrigation of dishes was done every other day by spraying.

Table 3: Treatments used in the Germination Experiment.

No.	Abbreviations	Treatments
1	C	No fertilization (control)
2	U	Urea
3	RM	Raw manure
4	RM+U	Raw manure (50% N) + urea (50% N)
5	DM	Digested manure
6	DM+U	Digested manure (50% N) + urea (50% N)

Sowing and germination characteristics

Four sets of dishes were prepared, of which the first set was sowed directly after amendment, while the second, third and fourth sets were sowed 10 days, 20 days and 30 days from amendment, respectively. Each dish was sown with 15 seeds at a depth of 1cm, i.e. corresponding to 170kg seeds ha^{-1} (broken and small seeds were avoided). Before the experiment, all wheat cultivars were tested for their vitalities according to Ellis et al. [26] and the results were 99 ±4, 89 ± 6 and 95 ± 3 for Slambo, Karim and Acsad, respectively. After sowing, all dishes were kept under lab conditions (i.e. 13h day, 11h night, temperature 20 ± 2°C and air humidity 34 %). The sowed dishes were checked daily and germination counts were made at days 4, 6, 8, 9, 12 and 14. The germination counts were used to calculate germination characteristics represented by time to reach 50% germination (T_{50}), mean germination time (MGT), germination index (GI) and final germination percentage (FGP). T_{50} was calculated according to the formula of Coolbear et al. [27] modified by Farooq et al. [28]. MGT, FGP and GI were calculated according to the formulas described by Dastanpoor et al. [29]. At the end of the experiment (day 14) seedling were carefully removed from the soil by placing them in flat pans of water where radicles could be freed from the soil particles with little injury. The length of plumule and radicle of each seedling was measured in all dishes besides seedling dry weight. Seedling dry weight was determined after drying at 75°C for 24h.

Statistical analyses

The data obtained from the germination experiment was analysed using the SPSS (WIN. Version 17) procedure GLM where three-way ANOVA (multi-factorial analysis) followed by Tukey (HSD) multiple comparison tests were used for repeated testing of paired differences between treatments regarding time to reach 50% germination ($T_{50\%}$), mean germination time (MGT), germination index (GI) and final germination percentage (FGP), plumule length, radicle length and seedling dry weight, where fertilizer type, wheat variety, sowing date, and the their interactions were considered as fixed factors. Differences considered significant at the level ($p < 0.05$) unless otherwise not stated.

Results

Germination characteristics

Time to reach 50% germination (T50%)

Table 4: Time to reach 50% Germination ($T_{50\%}$) of three Wheat Varieties (Salmbo, Acsad and Karim) at different Sowing Dates after Fertilization with Urea, Raw and Digested Cattle Manure with and without Combination with Urea. Values Represent the Average ± Standard Deviation (n = 4).

Fertilizer type	Wheat varieties	$T_{50\%}$ (days)			
		First sowing	Second sowing	Third sowing	Fourth sowing
C	Slambo	5.0 ± 0.2	-	-	-
C	Acsad	5.4 ± 0.5	-	-	-
C	Karim	4.6 ± 0.9	-	-	-
U	Slambo	7.6 ± 0.6	4.4 ± 0.8	5.0 ± 1.1	3.8 ± 1.1
U	Acsad	5.9 ± 1.3	5.5 ± 1.5	5.0 ± 1.1	3.8 ± 0.7
U	Karim	6.4 ± 0.6	5.6 ± 3.5	5.4 ± 1.2	4.7 ± 0.5
RM	Slambo	4.3 ± 0.3	4.6 ± 0.2	4.1 ± 0.2	3.0 ± 0.0
RM	Acsad	3.7 ± 0.3	3.6 ± 1.0	3.6 ± 1.0	3.8 ± 1.4
RM	Karim	4.6 ± 0.2	3.3 ± 0.6	4.0 ± 0.9	3.3 ± 0.6
RM+U	Slambo	8.8 ± 0.8	4.1 ± 1.0	3.8 ± 0.5	4.8 ± 0.8
RM+U	Acsad	10.3 ± 1.4	3.6 ± 1.0	3.6 ± 1.3	4.2 ± 0.6
RM+U	Karim	6.9 ± 2.8	4.4 ± 2.5	5.0 ± 0.9	4.1 ± 1.0
DM	Slambo	4.1 ± 0.5	4.2 ± 1.5	4.0 ± 0.9	3.0 ± 0.0

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DM	Acsad	3.8 ± 0.7	4.4 ± 1.3	4.6 ± 1.0	3.8 ± 1.4
DM	Karim	4.6 ± 1.0	3.6 ± 1.0	3.6 ± 1.0	3.3 ± 0.6
DM+U	Slambo	5.6 ± 2.3	5.1 ± 0.4	5.8 ± 0.3	3.8 ± 0.7
DM+U	Acsad	7.3 ± 1.8	7.0 ± 1.0	5.6 ± 1.3	4.6 ± 0.2
DM+U	Karim	6.5 ± 3.0	5.6 ± 1.3	5.7 ± 1.5	3.7 ± 2.9

(-) no control used in the second, third and fourth sowing.

Analysis of variance showed that $T_{50\%}$ was significantly ($p < 0.05$) affected by the time of sowing and fertilizer type and insignificantly affected by wheat varieties. However, the interactions effect of these treatments was not significant on $T_{50\%}$ with the exception the interaction of time of sowing * fertilizer type ($p < 0.05$). At first sowing, the $T_{50\%}$ was significantly ($p < 0.05$) higher in the treatments of U, RM + U and DM + U (ranged from 5.6 ± 2.3 to 10.3 ± 1.4) and it decreased at the second sowing where it reached its minimum at fourth sowing (ranged from 3.7 ± 2.9 to 4.8 ± 0.8) (Table 4). Moreover, treatments amended with RM and DM increased insignificantly $T_{50\%}$ at first sowing compared with the fourth sowing for most wheat varieties. However, in the first sowing RM and DM treatments gave low $T_{50\%}$ (ranged from 3.0 ± 0.0 to 4.6 ± 1.0) compared with RM +U, DM + U and U treatments (ranged from 3.6 ± 1.3 to 10.3 ± 1.4). Furthermore, the response of wheat varieties to the fertilizer type was fluctuating and this was confirmed by the analysis of variance where the interaction of fertilizer type*wheat varieties was insignificant. However, there was indication that Acsad and Slambo varieties have better germination in comparison with Karim. At fourth sowing, $T_{50\%}$ reached its minimum in all treatments compared with the first sowing and the control.

Mean germination time (MGT)

Analysis of variance displayed significant ($p < 0.05$) effect of the time of sowing, fertilizer type, wheat varieties and their interactions on MGT. Mean germination time varied among sowing dates, fertilizer type and wheat varieties (Table 5). At the first sowing, MGT was high in the treatments amended with U, RM + U and DM + U (ranged from 7.5 ± 1.1 to 11 ± 1.4) compared with fourth sowing (ranged from 5.2 ± 0.4 to 6.8 ± 1.0). Moreover, MGT was low in treatments of RM and DM compared with U, RM + U and DM + U. As there was no significant difference in MGT between RM and DM treatments at the first sowing and fourth sowing. In comparison to the first sowing and control, MGT was significantly ($p < 0.05$) low at fourth sowing in most treatments. Moreover, there was no significant different among wheat varieties in most treatments and at most sowing dates. However, MGT values indicated that Acsad and Slambo varieties have better germination in comparison with Karim.

Table 5: Mean Germination Time (MGT) to reach Final Germination Percentage of three Wheat Varieties (Salmbo, Acsad And Karim) at different Sowing Dates after Fertilization with Urea, Raw and Digested Cattle Manure with and without Combination with Urea. Values represent the Average ± standard deviation (n = 4).

Fertilizer type	Wheat varieties	MGT (days)			
		First sowing	Second sowing	Third sowing	Fourth sowing
C	Slambo	7.0 ± 0.1	-	-	-
C	Acsad	7.0 ± 0.4	-	-	-
C	Karim	6.7 ± 0.2	-	-	-
U	Slambo	9.2 ± 1.5	7.2 ± 0.3	5.8 ± 1.3	6.5 ± 0.7
U	Acsad	9.4 ± 0.9	6.4 ± 0.8	6.3 ± 0.2	6.6 ± 0.5
U	Karim	8.3 ± 1.8	7.8 ± 1.8	6.8 ± 0.3	6.8 ± 1.0
RM	Slambo	6.0 ± 0.0	5.5 ± 0.2	5.2 ± 0.3	5.1 ± 0.1
RM	Acsad	6.4 ± 0.4	5.9 ± 0.2	5.0 ± 0.2	5.8 ± 0.3
RM	Karim	6.2 ± 0.3	6.2 ± 0.3	5.4 ± 0.2	5.7 ± 0.3
RM+U	Slambo	10 ± 0.7	5.7 ± 0.3	4.9 ± 0.2	5.5 ± 0.5
RM+U	Acsad	11 ± 1.4	5.8 ± 0.3	5.0 ± 0.4	5.2 ± 0.4
RM+U	Karim	9.1 ± 1.0	6.8 ± 1.4	5.9 ± 0.9	5.7 ± 0.3
DM	Slambo	6.1 ± 0.2	5.9 ± 0.5	5.1 ± 0.2	5.6 ± 0.4
DM	Acsad	6.3 ± 0.5	5.9 ± 0.2	5.4 ± 0.5	5.5 ± 0.6
DM	Karim	6.2 ± 0.3	5.9 ± 0.1	5.4 ± 0.6	5.9 ± 0.2
DM+U	Slambo	7.5 ± 1.1	7.3 ± 0.6	6.2 ± 0.8	5.4 ± 0.5
DM+U	Acsad	9.5 ± 2.4	7.8 ± 1.0	8.2 ± 0.3	5.5 ± 0.2
DM+U	Karim	8.0 ± 1.8	7.1 ± 0.6	6.3 ± 1.2	6.6 ± 0.3

(-) no control used in the second, third and fourth sowing.

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Germination index (GI)

Analysis of variance showed that GI was significantly ($p < 0.05$) affected by the time of sowing, fertilizer type and wheat varieties. The interactions effect of these treatments was significant ($p < 0.05$) on GI with the exception the interaction of time of sowing * wheat varieties, which was insignificant. In the first sowing, all fertilizer types gave low GI values particularly in treatments amended with RW + U, DM + U and U (Table 6). In the second and third sowing GI increased significantly ($p < 0.05$) in most treatments and it reached its maximum at fourth sowing date. In the first sowing, amended with RM and DM, increased *GI* values (ranged from 10.8 ± 1.4 to 16.7 ± 0.0) significantly ($p < 0.05$) in comparison with treatments amended with RM + U and DM + U (ranged from 8.5 ± 2.0 to 12.5 ± 2.2). Moreover, *GI* values indicated that Acsad and Slambo varieties have better germination in comparison with Karim.

Table 6: Germination Index (GI) of three Wheat Varieties (Salmbo, Acsad And Karim) at different Sowing Dates after fertilization with Urea, Raw and Digested Cattle Manure with and without Combination with Urea. Values Represent the Average ± Standard Deviation (n = 4).

Fertilizer type	Wheat varieties	GI (% day -1)			
		First sowing	Second sowing	Third sowing	Fourth sowing
C	Slambo	13.8 ± 0.5	-	-	-
C	Acsad	14.3 ± 0.5	-	-	-
C	Karim	13.8 ± 0.6	-	-	-
U	Slambo	8.4 ± 2.0	11.7 ± 2.7	13.9 ± 0.8	15.3 ± 3.1
U	Acsad	7.5 ± 1.4	12.5 ± 0.8	11.8 ± 1.2	13.0 ± 2.0
U	Karim	10.6 ± 2.1	10.8 ± 3.0	13.0 ± 4.3	14.7 ± 2.9
RM	Slambo	16.7 ± 0.0	18.9 ± 1.0	17.2 ± 2.5	17.8 ± 1.9
RM	Acsad	14.7 ± 1.3	13.9 ± 4.2	20.0 ± 2.9	15.0 ± 1.7
RM	Karim	11.9 ± 1.7	14.2 ± 2.2	16.7 ± 2.9	16.1 ± 3.5
RM+U	Slambo	9.6 ± 0.7	15.6 ± 2.5	21.1 ± 1.0	17.5 ± 0.8
RM+U	Acsad	8.5 ± 2.0	13.9 ± 1.0	19.4 ± 1.0	20.0 ± 1.7
RM+U	Karim	10.0 ± 2.4	11.7 ± 1.7	16.7 ± 4.4	14.9 ± 0.1
DM	Slambo	16.4 ± 0.5	17.5 ± 1.4	20.6 ± 1.0	17.2 ± 3.5
DM	Acsad	16.1 ± 1.0	17.5 ± 0.8	17.8 ± 1.9	19.2 ± 2.2
DM	Karim	10.8 ± 1.4	16.1 ± 2.5	18.1 ± 3.4	16.1 ± 0.0
DM+U	Slambo	12.5 ± 2.2	14.2 ± 1.5	15.7 ± 1.5	17.8 ± 1.9
DM+U	Acsad	12.5 ± 2.9	10.3 ± 4.3	11.3 ± 1.6	18.9 ± 1.0
DM+U	Karim	11.6 ± 3.2	9.4 ± 2.3	17.0 ± 2.6	15.0 ± 1.4

(-) no control used in the second, third and fourth sowing.

Final germination percentage (FGP)

Analysis of variance displayed significant ($p < 0.05$) effect of time of sowing, fertilizer type and wheat varieties on FGP. The interactions effect of these treatments was significant ($p < 0.05$) on *FGP* with the exception the interaction of time of sowing * fertilizer type * wheat varieties, which was insignificant. At first sowing, treatments amended with RM and DM gave high *FGP* (ranged from 67 ± 12 to 100 ± 0) compared to treatments amended with U, RM + U and DM + U (ranged from 60 ± 0 to 93 ± 12) (Table 7). However, at fourth sowing FGP increased significantly ($p < 0.05$) for

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most wheat varieties in the treatments amended with U and DM + U (ranged from 83 ± 6 to 100 ± 0). In the same time treatments amended with RM and RM + U displayed low FGP at fourth sowing for all wheat varieties. Moreover, the results showed that Slambo variety reached maximum FGP (100 %) in most treatments and at most sowing dates.

Table 7: Final Germination percentage (FGP) of three Wheat Varieties (Salmbo, Acsad And Karim) at Different Sowing Dates after Fertilization with Urea, Raw and Digested Cattle Manure with and without Combination with Urea. Values Represent the Average ± Standard Deviation (n = 4)

Fertilizer type	Wheat varieties	FGP (%)			
		First sowing	Second sowing	Third sowing	Fourth sowing
C	Slambo	89 ± 1	-	-	-
C	Acsad	93 ± 3	-	-	-
C	Karim	87 ± 6	-	-	-
U	Slambo	67 ± 5	63 ± 15	93 ± 6	93 ± 12
U	Acsad	60 ± 0	73 ± 6	70 ± 10	83 ± 6
U	Karim	77 ± 6	70 ± 17	90 ± 17	90 ± 10
RM	Slambo	100 ± 0	100 ± 0	87 ± 12	87 ± 12
RM	Acsad	93 ± 12	80 ± 20	93 ± 12	87 ± 12
RM	Karim	73 ± 12	87 ± 12	87 ± 12	87 ± 12
RM+U	Slambo	93 ± 12	87 ± 12	100 ± 0	87 ± 12
RM+U	Acsad	93 ± 12	80 ± 0	93 ± 12	87 ± 12
RM+U	Karim	87 ± 23	80 ± 20	93 ± 12	87 ± 12
DM	Slambo	100 ± 0	100 ± 0	100 ± 0	93 ± 12
DM	Acsad	100 ± 0	100 ± 0	93 ± 12	100 ± 0
DM	Karim	67 ± 12	93 ± 12	93 ± 12	93 ± 12
DM+U	Slambo	87 ± 12	100 ± 0	93 ± 12	93 ± 12
DM+U	Acsad	93 ± 12	87 ± 23	87 ± 12	100 ± 0
DM+U	Karim	80 ± 20	73 ± 23	100 ± 0	93 ± 12

(-) no control used in the second, third and fourth sowing

4).**Seedling characteristics**

Plumule and radicle length

Analysis of variance displayed significant ($p < 0.05$) effect of time of sowing, fertilizer type, wheat varieties and their interaction on the length of plumule and radicle. At the first sowing, plumule and radicle length were reduced significantly ($p < 0.05$) in U, RM + U and DM + U treatments in comparison with the control (Figure 1). In the same time plumule and radicle length in the treatments of RM and DM were not significantly different from the control. However, plumule length has increased gradually in the treatments of RM + U and DM + U at the second sowing and increased more at the third sowing which after it reached its maximum on the fourth sowing insignificantly in comparison with the control. In the same time, a radicle length did not improve significantly at second, third and fourth sowing in all treatments in comparison with the control (Figure 1). At fourth sowing, DM and RM + U treatments gave the highest plumule length compared with other treatments. Moreover, there is indication that Slambo variety has high radicle length in comparison with othwheat varieties especially in the treatments amended with RM + U and DM + U.

Seedling dry weight

Analysis of variance confirmed that seedling dry weight was significantly ($p < 0.05$) affected by the time of sowing, fertilizer type and wheat varieties. However, the interactions effect of these treatments was not significant for seedling dry weight except that the interaction of time of sowing * fertilizer type ($p < 0.05$). Amending with U reduced seedling dry weight significantly ($p < 0.05$) of most wheat varieties in comparison with the control at all sowing dates (Figure 2). RM significantly ($p < 0.05$) reduced seedling dry weight of Slambo and Acsad in the first, second and third sowing. However, the combination with urea reduced seedling dry weight significantly ($p < 0.05$) in the first and the second sowing and increased insignificantly in the third and fourth sowing. Amended with DM and DM + U reduced seedling dry weight significantly ($p < 0.05$) in the first and the second sowing in comparison with the control especially for Slambo and Acsad. However, the results showed that Karim variety has high seedling dry weight in comparison with other wheat varieties.

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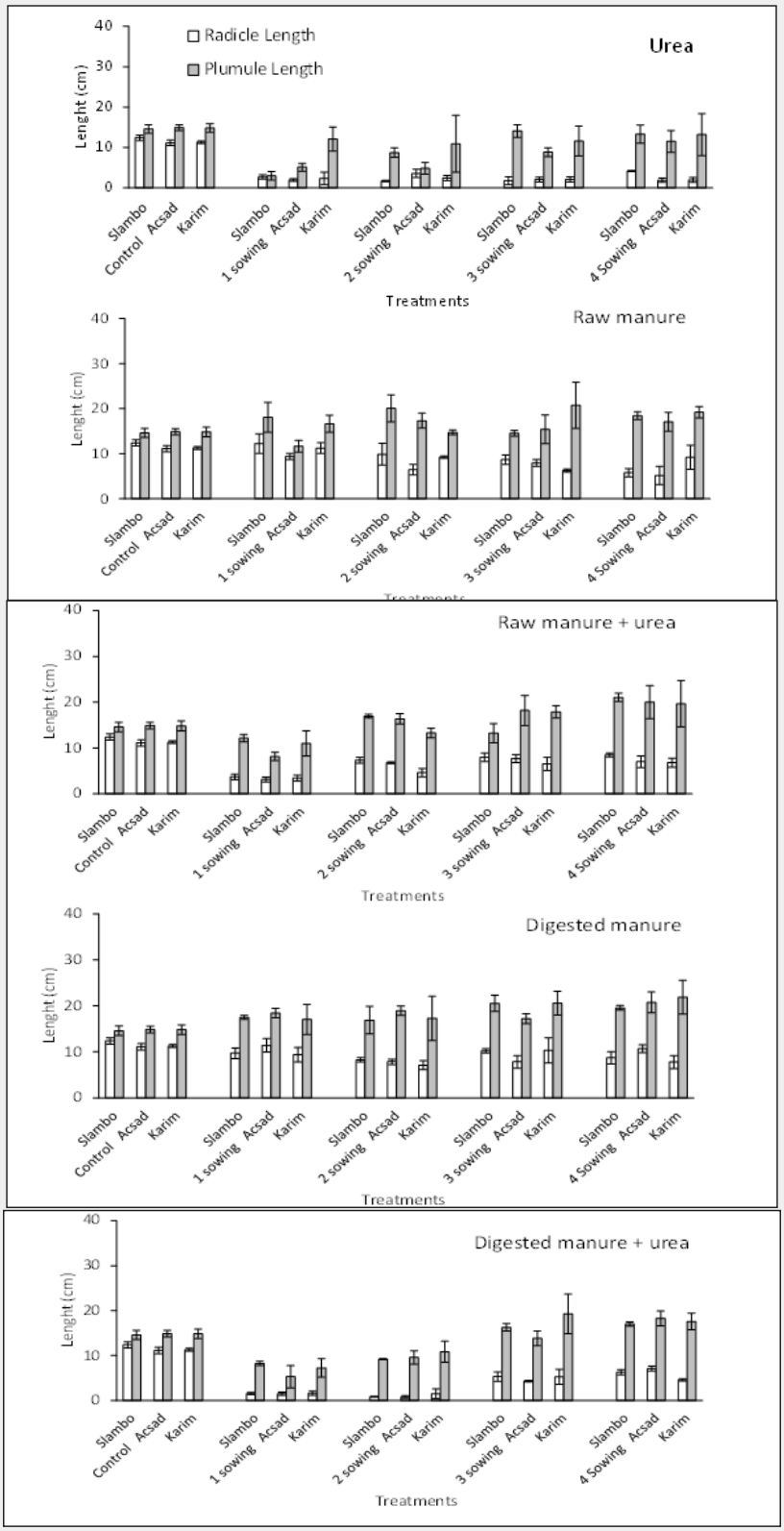

Figure 1: influence of fertilization with urea, raw and digested cattle manure with and without combination with urea on plumule and radicle length of three wheat varieties (Salmbo, Acsad and Karim) sowed in desert soil at different times from fertilization. Bars represent means ± standard deviation (n = 4).

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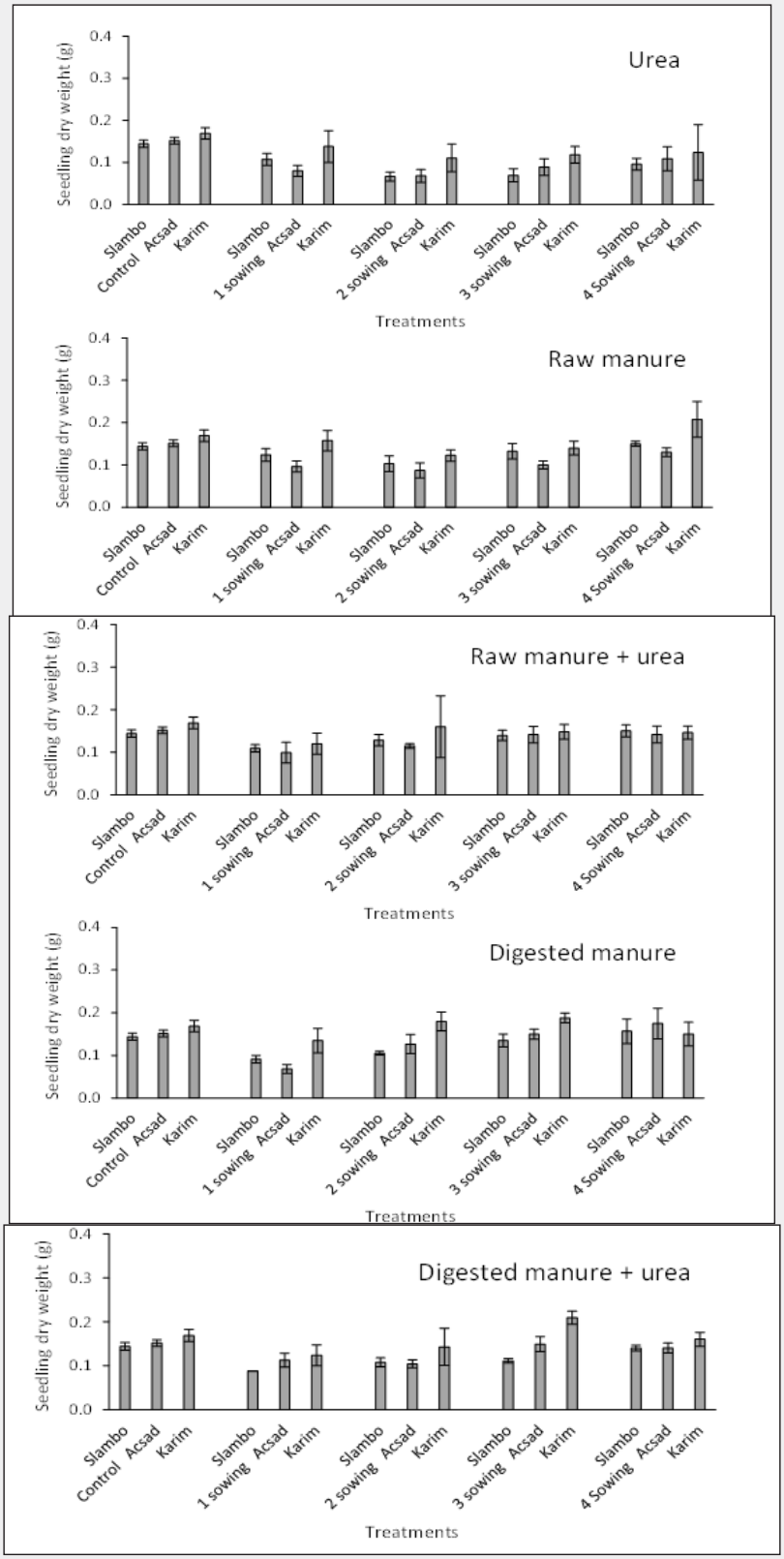

Figure 2: Influence of fertilization with urea, raw and digested cattle manure with and without combination with urea on seedling dry weight (plumule + radicle) of three wheat varieties (Salmbo, Acsad and Karim) sowed in desert soil at different times from fertilization. Bars represent means ± standard deviation (n = 4).

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Discussion

Germination characteristics

Sowing wheat directly or 10 days after the application of fertilizers reduced and delayed germination especially in the treatments where fertilizers combined with urea. This effect was confirmed by germination characteristics values, i.e. high values of $T_{50\%}$ and MGT and low values of GI. Where $T_{50\%}$ is the time to reach 50% of final germination and the MGT is a measure of the rate and time-spread of germination, high values of $T_{50\%}$ and MGT means slow germination and small values fast germination [30]. Whereas GI reflects the percentage of germination on each day of the germination period, higher values indicate higher and faster germination [31]. El-Zeadani et al. [10] have reported a similar effect on the same wheat cultivars at sowing directly or after 10 days from amendment with raw and digested poultry manures specifically at combination with urea. Furthermore, Abubaker et al. [9] have reported that germination of wheat cultivar Karim was reduced and delayed in comparison with the control when sowing was performed 2 days after application of raw and digested of animal manure alone or in combination with urea. This adverse effect has been referred to the formation of ammonia through hydrolysis of urea in the soil. Hydrolysis of urea occur by ureases enzyme that produce by soil microorganisms, which convert the urea to CO_2 and ammonia [32]. Wan et al. [13] have reported that percentage of wheat seeds germination reduced by 51-95 % at the application of urea due to ammonia that was generated from hydrolysis of urea. Furthermore, it has been reported that the application of urea in combination with organic material to the soil increases urea hydrolysis rates and ammonia volatilization [33,34]. This probably explains why treatments amended with raw and digested cattle manure in combination with urea have low germination since organic material in manure will stimulate hydrolysis of urea and increase ammonia diffusion in the soil. In addition, digested manure contains humic acids that were generated during anaerobic digestion processes, which has been shown to delay and reduce seeds germination [35,36]. At fourth sowing, i.e. 30 days from soil fertilization, seed germination was improved almost in all treatments and this was confirmed by low values of $T_{50\%}$, MGT and high GI values. Similar effect has been reported by El-Zeadani et al. [10] who found sowing wheat cultivars after 30 days from soil fertilization gave batter germination in comparison with sowing directly or after 10 days from fertilization. The explanation of these positive results might be related to the degradation of fertilizer components, such as organic acids, and the oxidation of ammonia by soil microorganisms in which reduced their negative effect on germination of wheat seed [12,37]. It has been reported that the concentration of most organic component such as phenolic substances in waste-treated soil decreased rapidly and reached that of the control on day 30 after waste disposal [38]. The present study showed that there was no significant difference among wheat varieties in most treatments; however, there was indication that Slambo variety has better germination. This finding agrees with what has been reported by El-Zeadani et al. [10]. This could be explained by high vitality of Slambo (99 ± 4%) in comparison with Acsad (95 ± 3%) and Karim (89 ± 6%).

Seedling characteristics

In the present study plumule length, radicle length and seedling dry weight decreased at sowing directly or 10 days after soil fertilization especially in the treatments of sole urea or in combination with urea. El-Zeadani et al. [10] have reported similar results when sowing was performed directly or 10 days from amendment with sole urea or with raw and digested poultry manure in combination with urea. It has been shown that the application of urea to the soil suppressed root hair formation and reduced radicle length [13] resulted in lowering seedling dry weight. Furthermore, the losses of urea in the form of ammonia through volatilization can decrease N availability in the soil to the plant and reduce crop biomass [39]. Moreover, several studies have reported that the application of urea in combination with organic fertilizer increases hydrolyses rate of urea and ammonia volatilization resulted in losing the nitrogen from the soil [33, 34]. Accordingly, the loss of N in the form of ammonia might have occurred in the treatments amended with raw and digested cattle manure in combination with urea resulted in having low plumule length in comparison with the treatments amended with raw and digested cattle manure. On the fourth sowing, plumule and radicle length as well as seedling dry weight were improved in most treatments compared with first and second sowing. Similar effect has been reported by El-Zeadani et al. [10] where they found that prolonging the period between soil amendments and sowing increased plumule and radicle length plus increasing seedling dry weight of three wheat varieties. They referred this improvement to the degradation and mineralization of organic components that will lead to the release of plant nutrients and enhance the growth of radicle and plumule resulted in increasing seedling dry weight.

Conclusion

Wheat seeds germination and seedling growth were negatively affected by application of raw and digested cattle manure in combination with urea when sowing was made directly or 10 days after fertilization. However, when sowing was made 30 days from the application all studied parameters have improved. The strategy of extending the period between amendments and sowing gave satisfying results especially at the combination with urea. The conception behind prolonging the period between amendments and sowing is to give enough time to soil microorganisms and chemical reactions in the soil to consume and reduce the germination-delaying substances that were added with the fertilizers. However, the strategy of prolongation may cause the loss of nutrients such as N in the form of ammonia resulted in reducing crop growth and yield. Therefore, to determine the value and benefits of this approach in supporting crop growth and yield further investigation is needed on a large scale. Moreover, focusing on selecting wheat varieties of high tolerance to the adverse effect caused by raw and digested organic waste maybe another future work.

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