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Forage Growth and Productivity of Pearl Millet as Affected by Soil Mulching, Planting Date under Salinity Conditions

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TWO FIELD experiments were carried out, at Ras Sudr Experimental Station, South Sinai Governorate, Egypt, during the two summer growing seasons 2011 and 2012. This work was conducted to study the effect of three sowing dates, *i.e.* 1st May, 15th May and 1st June and four soil surface mulching treatments *(i.e.* without, plastic sheet, one and two tons rice straw/fed) under two levels of saline water irrigation conditions, *i.e.* 4500 and 8000 ppm on some growth characters and forage yield of pearl millet [*Pennisetum glaucum* (L.) R. Br]. Obtained results showed that the growth characters and forage yield of pearl millet, *i.e.* plant height, number of tillers/plant, number of leaves/plant, leaf area index, leaves dry weight, stem dry weight and total plant dry weight reduced significantly by increasing saline water irrigation levels from 4500 to 8000 ppm. Early sowing date, at 1st May, produced the highest significant values of the most growth characters and the total forage dry weight. Meantime, the growth traits and forage dry yield were significantly affected by using 2 ton of rice straw/fed and plastic sheet soil mulching treatments which produced the highest values of leaves, stem and total dry weights/fed, compared to unmulching or using one ton rice straw/fed treatments.

Keywords: Pearl millet [*Pennisetum glaucum* (L.) R. Br] , Saline water irrigation, Sowing date, Soil surface mulching, Rice straw, Plastic sheet, Dry forage yield.

Pearl millet [*Pennisetum glaucum* (L.) R. Br] is one of the major cereal crops of the semi-arid regions of Africa and Asia and it is certainly the mainstay for millions of people in the Sahel. It's grown as grain and fodder crop (Blummel *et al*., 2003). In Egypt, pearl millet is not the staple food of rural populations as in the other countries of Africa, but using as summer fodder crop. South Sinai, as arid region with low rainfall and high evapo-transpiration (ET), brackish or saline groundwater is the main source of water for both domestic and agriculture use. The fodder demand is mostly faced by the local production of alfalfa and some annual forage cereals, as barley and sorghum, for feeding goats, sheep, cattle or camel. However, pearl millet is rated to be fairly tolerant to salinity (Krishnamurthy *et al*., 2007) and superiority over wheat, corn, and sorghum under dry and saline conditions in semi-arid land (Ferraris, 1973). Yakubu *et al*.

(2010) reported that, plant height, shoot and root dry weights of five pearl millet varieties were significantly decreased with increasing soil salinization. Also, Leila Radhouane (2013) used three levels of saline water irrigation, T_1 (1g NaCl/l as control), T_2 (4g NaCl/l) and T_3 (7g NaCl/l) for pearl millet plants, noticed that plant height of T_3 was 18% significantly lower than T_1 and 13% than T_2. The same findings were noticed by Abd El-Rahman *et al.* (2005), Hussein *et al*. (2010) and Siti Aishah *et al*. (2011) on sorghum.

Concerning sowing dates, Hancock & Greg Durham (2010), used five planting dates for pearl millet [*Pennisetum glaucum* (L.) R. Br.], found that the total DM yields were the highest in the late April planting and decreased linearly (by as much as 80lb/acre) for each day plantings were delayed past late April in 2008 and 2009 and quadratically during the extreme drought conditions of 2007. They added that late planting date influences the yield of pearl millet forage, staggered plantings are recommended to better distribute forage production throughout the growing season. Also, Maas *et al*. (2007) found that there was a significant decrease in grain yield, as well as plant height by delaying sowing dates. However, Wailare (2009) observed that sowing dates (2^{nd} week of July, 3^{rd} week of July, and 4^{th} week of July spaced at one week interval at Bagauda, Kano State, Nigeria) did not have significant influence on plant height of pearl millet.

Regarding soil mulching, Wang *et al*. (2001) found that covering the soil surface with plant residues can reduce soil evaporation. They added that wheat straw mulch reduced evaporation by 50% under winter wheat and this is equivalent to about 80 mm of water in the north China plain. Uwahm & Iwo (2011), used organic mulch rates (0, 2, 4, 6, and 8 t/ha) on maize productivity (*Zea mays* L.), found that soil moisture reserves, plant height and number of leaves/plant were highest at the 8 t/ha mulch rate, followed by 6 t/ha rate. Whereas, the unmulching as control plots had the lowest soil moisture reserves, shortest plants and least number of leaves/plant. Kobayashi *et al*. (2010) investigated how to apply pearl millet stalk for improving soil moisture condition for plant growth of pearl millet, using 3 irrigation intensities (the 1^{st} was irrigated at 3-6 mm/day as standard, the 2^{nd} was at 2/3 of standard as slightly water-saving, and the 3^{rd} was at 1/3 of standard as water-saving) and 3 treatments of stalk application (stubble mulching with pearl millet stalk residues, mixing soil with pearl millet stalk residues and non-treatment as control). They indicated that plant growth of pearl millet, above ground surface, did not show significant differences among the plants under the different irrigation intensities. Under non-treatment condition, pearl millet even in the 2/3 and 1/3 water-saving grew as well as that in the standard treatment. However, the fresh weights of non-treated was significantly lower than that of the other treatments, stubble mulching or mixing soil with pearl millet stalk residues. Additionally, there was a tendency for pearl millet growth of stubble mulching to higher than that of mixing soil with pearl millet stalk residues. This implies that mulching with pearl millet stalk residues can be more effective on plant growth.

Material and Methods

Two field experiments were conducted, at Ras-Sudr Experimental Station, South of Sinia Governorate, in two successive summer seasons, 2011 and 2012, to study the effect of saline water irrigation, sowing date and soil mulching on growth and forage yield of pearl millet (*Pennisetum glaucum* (L.) R.Br.) cv. Shandaweel 1. Each experiment included twenty four treatments, which were the combination between two levels, *i.e.* 4500 and 8000 ppm of saline water irrigation, three sowing dates, *i.e.* 1st May, 15th May and 1st June and four soil mulching treatments, *i.e.* without mulching, plastic sheet, 1 and 2 tons rice straw per fed. Each experiment was laid in a split-split plot design with three replicates. Saline water irrigation levels were arranged in the main plots, sowing dates were allocated in the sub plots, and soil mulching treatments were assigned in the sub-sub plots. The plot area was 10.5 m^2 (3m x 3.5m) and contained four furrows (3.5 m in length and 60 cm apart). Pearl millet seeds were sown, at the above mentioned sowing dates, in hills (about 5 seeds/hill, 20 cm apart) on the two ridges of furrows. Prior to planting, organic manure and calcium super phosphate (15.5% P_2O_5) were added at the rate of 20 m^3 and 200 kg per fed, respectively during the soil preparation. Nitrogen fertilizers were added at 60 kg/fed, as ammonium sulphate (20.5%) in three equal doses, the 1st dose was applied after 3 weeks from sowing dates, the 2nd and 3rd doses were applied after two weeks from the later cuts just before irrigation. The irrigation water was added as immersion in the two seasons. The lowest saline water irrigation level (4500 ppm) produced three cuts at the 1st and the 2nd sowing dates, and two cuts at the 3rd sowing date. On the other hand, the highest saline water irrigation level (8000 ppm) produced two cuts at the 1st and the 2nd sowing dates. Whereas, produced one cut at the 3rd sowing date. The 1st cut was taken after 60 days from sowing date, the 2nd cut was taken after 45 days from the 1st cut date and the 3rd cut was taken after 45 days from the 2nd cut date.

Physical and chemical analysis of the experimental field soil was determined as shown in Table 1. Mechanical analysis was carried out according to Jackson (1958). Chemical analysis was carried out according to Jackson (1958) and Chapman & Pratt (1961). The soil texture of this site was sandy loam containing calcium carbonate of 58.99 and 61.28% in the 1st and 2nd seasons, respectively. The mechanical, physical and chemical analysis of the experimental soil is shown in Table 1. The chemical analysis of saline water irrigation is shown in Table 2.

Data were subjected to the proper statistical analysis of variance and the combined analysis for the results of the two seasons was applied according to Steel & Torrie (1960). The treatment means were compared as showed by Waller & Duncan (1969).

TABLE 1. Mechanical, physical and chemical analysis of the experiment soil.
a: Mechanical and physical analysis.

Depth (cm)	Coarse sand (0.5–1.0 mm)	Fine sand (0.1–0.25 mm)	Silt (0.002 - 0.05 mm)	Total sand (0.1-1 mm)	Clay (<0.002 mm)	Class texture
1st season (2011)						
0-30	21.84	57.73	9.5	79.57	10.91	Sandy loam
30-60	22.17	63.45	6.987	85.62	7.39	Sandy loam
2nd season (2012)						
0-30	20.65	58.63	11.47	79.28	9.25	Sandy loam
30-60	23.21	61.53	7.86	84.74	7.40	Sandy loam

b: Chemical analysis

Depth (cm)	pH	EC (dS/m^{-1})	CaCO3 (%)	Saturation soluble extract (mg/100g)							Available nutrients (mg Kg^{-1})			
				Cations			Anions				N	P	K	Fe
				Ca^{++}	Mg^{++}	Na^{+}	CO_3^{-}	$HCO_3^{=}$	Cl^{-}	$SO_4^{=}$				
1st season (2011)														
0-30	7.7	8.60	58.99	24.5	5.2	57.1	0.0	6.0	61.5	22.2	26.0	5.1	51.5	4.2
30-60	7.9	7.35	52.48	16.7	3.7	49.5	0.0	3.5	49.0	19.5	18.5	3.3	35.3	3.4
2nd season (2012)														
0-30	7.8	8.82	61.28	25.1	5.7	57.8	0.0	6.2	61.7	23.4	26.2	5.2	51.5	4.3
30-60	7.9	7.50	55.71	17.3	4.2	49.8	0.0	3.7	50.1	20.3	18.6	3.6	35.4	3.6

TABLE 2. Chemical analysis of the irrigation water.

Wells	EC (ppm)	pH	Soluble anions (meq/l)				Soluble cations (meq/l)			
			$CO3^{=}$	HCO_3^{-}	$SO_4^{=}$	Cl^{-}	Ca^{++}	Mg^{++}	Na^{+}	K^{+}
1st well	4500	7.5	0.00	1.68	23.80	32.16	14.11	8.30	32.11	0.30
2nd well	8000	7.9	0.00	3.27	37.85	60.19	20.65	19.11	53.50	0.43

Results and Disscution

Results obtained in Table 3 showed that fresh and dry weight of pearl millet yield decreased significantly by increasing irrigation water salinity from 4500ppm to 8000ppm. These results could be due to the effect of high salinity of the irrigation water at 8000ppm which decreased all growth parameters, *i.e.* plant height, leaf area/m^2, leaf area index and number of tillers/m^2. In this respect, Zeinolabedin (2012) reported that, general symptoms of damage by salt stress are growth inhibition, accelerated development and senescence and death

during prolonged exposure. He added that growth inhibition is the primary injury that leads to other symptoms although programmed cell death may also occur under severe salinity shock. Yakubu *et al.* (2010) reported that germination percentage, plant height, shoot and root dry weights of some millet varieties were significantly decreased with increasing soil salinization. Also, Abd El-Rahman *et al*. (2005) studied the effect of salinity on productivity of some Sudan grass varieties (*Sorghum bicolor*) var. Sudanense. They noticed that all different traits, *i.e.* plant height, number of tillers/plant, number of leaves/plant, leaf area, fresh and dry weights of stem + sheaths/plant, stem + sheaths/blades ratio, fresh and dry weights of forage yield/fed were significantly decreased with increasing saline water irrigation levels from 3700 to 9200 ppm. Mean time, Siti Aishah *et al*. (2011) found an inverse relationship between increasing salinity and dry forage yield of sorghum.

TABLE 3. Effect of saline water irrigation levels on some growth characters and forage yield of pearl millet (average the two seasons 2011 and 2012).

Cutting No.	Saline water irrigation levels (ppm)			
	4500	**8000**	**4500**	**8000**
	Plant ht. (cm)		**No. of tillers/m^2**	
1st cut	99.44 a	90.84 b	119.8 a	67.47 b
2nd cut	118.2 a	64.54 b	91.79 a	27.06 b
3rd cut	78.84 a	0 b	19.84 a	0 b
	Leaves area (cm^2/m^2)		**Leaf area index**	
1st cut	77610 a	12720 b	7.761 a	1.272 b
2nd cut	61730 a	4127 b	6.173 a	0.413 b
3rd cut	8098 a	0 b	0.810 a	0 b
	Leaves dry wt. (t/fed)		**Stem dry wt. (t/fed.)**	
1st cut	0.474 a	0.260 b	0.313 a	0.228 b
2nd cut	0.406 a	0.138 b	0.354 a	0.159 b
3rd cut	0.107 a	0 b	0.113 a	0 b
	Total plant dry wt.(t/fed)		**Leaf/stem ratio**	
1st cut	0.787 a	0.489 b	1.558 a	1.156 b
2nd cut	0.760 a	0.298 b	1.152 a	0.595 b
3rd cut	0.222 a	0 b	0.631 a	0 b

ppm = part per milion, No.= number, ht.= height, wt. = weight, t = ton, fed = feddan.

Results in Table 4 indicated that sowing date had significantly effect in some growth characters and the dry weight of pearl millet under salinity conditions. Where, early planting date at 1st May produced a significant values of plant height, number of tillers, leaves dry weight, stem dry weight and the total dray weight per feddan in the 2nd and 3rd cuts. Whereas, sowing date at 1st June produced the high significant values of plant height and leaves dry weight at the 1st cut. These results were inharmony with Wailare (2009), who observed that sowing dates did not have significant influence on plant height, panicle weight, number of panicles per plot, panicle length, panicle diameter, and weight of 1000 grains but stover yield and grain yield per hectare were both significantly influenced by sowing date.

TABLE 4. Effect of sowing date on some growth characters and forage yield of pearl millet (average the two seasons 2011 and 2012).

	Sowing date					
Cutting No.	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**
	Plant ht. (cm)			**No. of tillers/m^2**		
1st cut	92.18 b	95.49 a	97.75 a	105.2 a	88.20 b	87.39 b
2nd cut	110.6 a	106.3 b	57.14 c	70.83 a	69.97 a	37.48 b
3rd cut	61.21 a	57.05 b	0 c	16.38 a	13.39 b	0 c
	Leaves area (cm^2/m^2)			**Leaf area index**		
1st cut	47220 a	39030 b	49250 a	4.722 a	3.993 b	4.925 a
2nd cut	50910 a	36610 b	11270 c	5.091 a	3.661 b	1.127 c
3rd cut	6332 a	5815 a	0 d	0.633 a	0.582 a	0 b
	Leaves dry wt. (t/fed)			**Stem dry wt. (t/fed)**		
1st cut	0.358 b	0.388 a	0.356 b	0.243 b	0.263 b	0.305 a
2nd cut	0.334 a	0.333 a	0.150 b	0.312 a	0.301 a	0.156 b
3rd cut	0.097 a	0.063 b	0 c	0.103 a	0.067 b	0 c
	Total plant dry wt.(t/fed)			**Leaf/stem ratio**		
1st cut	0.602 b	0.652 ab	0.661 a	1.451 a	1.466 a	1.153 b
2nd cut	0.646 a	0.636 a	0.305 b	1.040 a	1.094 a	0.487 b
3rd cut	0.204 a	0.130 b	0 c	0.477 a	0.469 a	0 b

Soler *et al.* (2008) found that the optimum planting date of some pearl millet varieties to obtain the maximum yield was between 13 and 23 May for variety Heini Kirei, while for the other varieties the planting dates were between 23 May and 2 June. Hancock & Greg Durham (2010) reported that the total DM yields of pearl millet were the highest in the late April planting and decreased linearly (by as much as 80 lb/acre) for each day plantings were delayed past late April in 2008 and 2009 and quadratically during the extreme drought conditions. Radhouane (2008) reported that the optimal planting time of pearl millet under Mediterranean environment conditions was between first May and early June. Whereas, he found that plant height was reduced in early and late planting dates. This may be due to changes in photoperiod which accelerated development towards reproductive stages and hence less time was available to vegetative growth. Low temperature during April and first weeks of May produced minimum plant height for early planting.

Data presented in Table 5 showed that there was significant difference among soil mulching treatments on the growth characters and the dry weight of pearl millet yield. Results indicated that soil mulching with plastic produced the high significant effect of the dry weight of the pearl millet yield at the 1^{st} cut. Whereas, soil mulching with 2t/fed, of rice straw produced the significant value of the dry weight of the pearl millet yield at the 3^{rd} cut. Mean time using plastic for soil mulching produced the high significant value of the accumulation dry weight for the three cuts of the pearl millet yield followed by using 2t /fed, of the rice straw. These results could be due to the positive correlation between the accumulation dry weight and plant height, number of tillers/m^2 and leaf area / m^2 as shown in Table 5.

It is known that the high temperatures and the high evaporation rate, enhancing of salt accumulation on soil surface subsequent to irrigations is inevitable unless using surface protection technique and this can be achieved by using soil surface mulching from cheaply materials and from crops residues.

Results presented in Table 6 showed the effect of the interaction between saline irrigation water levels and sowing date on pearl millet growth. Data showed that the growth and the dry yield of pearl mill significantly affected by the interaction between saline water irrigation and sowing date at the three cuts. Where, the high significant values of plant height, total yield of dry weight, leaves dry weight and stem dry weight were recorded at the third sowing date 1^{st} June under the low saline irrigation level (4500 ppm). Whereas, the significant values of the above characters were recorded for the first sowing date 1^{st} May under the low saline irrigation level (4500 ppm), On the other hand, the lowest significant values of all studied characters were obtained under the high salinity level (8000 ppm) and there was no re-growth of the pearl millet plants in the 2^{nd} cut under the high salinity level at the 3^{rd} sowing date of 1^{st} June. Meantime, there was no re-growth of the pearl millet plants under the low saline irrigation water level (4500 ppm) at the third sowing date 1^{st} June. These results may be due to the effect of the high temperature at the 3^{rd} sowing date 1^{st} June which caused high evaporation from the soil surface and negatively affected in the re-growth of the plants at the 3^{rd} cut time.

TABLE 5. Effect of soil mulching on some growth characters and forage yield of pearl millet (average the two seasons 2011 and 2012).

	Soil mulching				Soil mulching			
Cutting No.	**Without mulch**	**1ton/fed straw rice**	**2ton/fed straw rice**	**Plastic mulching**	**Without mulch**	**1ton/fed straw rice**	**2ton/fed straw rice**	**Plastic mulching**
	Plant ht. (cm)				**No. of tillers/m^2**			
1st cut	93.18 b	94.90 b	94.17 b	98.29 a	96.88 a	93.37 ab	89.57 b	94.62 a
2nd cut	88.99 b	87.14 b	94.08 a	95.18 a	54.67 b	63.28 a	60.82 a	58.93 ab
3rd cut	35.98 b	37.91 b	40.78 a	43.01 a	10.18 a	9.433 a	9.90 a	10.17 a
	Leaves area (cm^2/m^2)				**Leaf area index**			
1st cut	43800 ab	46190 ab	42240 b	48430 a	4.380 ab	4.619 ab	4.224 b	4.843 a
2nd cut	32280 b	36030 a	35290 ab	28120 c	3.228 b	3.603 a	3.529 ab	2.812 c
3rd cut	3646 b	4097 ab	4554 a	3900 ab	0.3645 b	0.4097 ab	0.4554 a	0.3900 ab
	Leaves dry wt. (t/fed)				**Stem dry wt. (t/fed)**			
1st cut	0.366 b	0.352 b	0.340 b	0.411 a	0.271 b	0.259 b	0.239 b	0.314 a
2nd cut	0.227 c	0.276 b	0.303 a	0.283 ab	0.216 c	0.249 b	0.279 ab	0.282 a
3rd cut	0.047 c	0.056 b	0.065 a	0.045 c	0.048 c	0.057 b	0.070 a	0.051 bc
	Total plant dry wt.(t/fed)				**Leaf/stem ratio**			
1st cut	0.637 b	0.611 b	0.579 b	0.726 a	1.351 a	1.350 a	1.414 a	1.313 a
2nd cut	0.443 b	0.527 a	0.582 a	0.563 a	0.857 ab	0.910 a	0.904 ab	0.823 b
3rd cut	0.095 c	0.115 b	0.138 a	0.096 c	0.330 a	0.328 a	0.311 a	0.293 a

TABLE 6. Effect of the interaction between saline water irrigation levels and sowing date on some growth characters and forage yield of pearl millet (average the two seasons 2011 and 2012).

Saline water irrigation	4500 ppm			8000ppm		
Planting date	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**
1st cut						
Plant height (cm)	95.72 bc	98.06 b	104.5 a	88.64 d	92.91 cd	90.96 d
No. of tiller /m^2	125.8 a	112.9 b	120.6 a	84.65 c	63.55 d	54.20 e
LA / m^2	79130 b	66690 c	87020 a	15310 d	11370 d	11480 d
LAI	7.913 b	6.669 c	8.702 a	1.531 d	1.137 d	1.148 d
Total plant dry (ton/fed)	0.725 b	0.769 b	0.868 a	0.480 c	0.535 c	0.453 c
Leaves dry weight (ton/fed)	0.455 a	0.472 a	0.496 a	0.260 c	0.305 b	0.215 d
Stem dry weight (ton/fed)	0.271 bc	0.297 b	0.372 a	0.215 d	0.230 cd	0.239 cd
Leaves/stem ratio %	1.699 a	1.607 a	1.368 b	1.203 c	1.326 bc	0.939 d
2nd cut						
Plant height (cm)	122.4 a	117.7 b	114.3 b	98.69 c	95.05 c	0 d
No. of tiller /m^2	106.8 a	93.65 b	74.95 c	34.87 e	46.30 d	0 f
LA / m^2	94620 a	68040 b	22540 c	7207 d	5173 d	0 e
LAI	9.462 a	6.804 b	2.254 c	0.721 d	0.517 d	0 e
Total plant dry (ton/fed)	0.848 a	0.823 a	0.609 b	0.444 c	0.449 c	0 d
Leaves dry weight (ton/fed)	0.476 a	0.442 a	0.300 b	0.192 c	0.224 c	0 d
Stem dry weight (ton/fed)	0.373 a	0.377 a	0.312 b	0.251 c	0.226 c	0 d
Leaves/stem ratio %	1.291 a	1.192 a	0.973 b	0.789 c	0.997 b	0 d
3rd cut						
Plant height (cm)	122.4 a	114.1 b	0 c	0 c	0 c	0 c
No. of tiller /m^2	32.75 a	26.78 b	0 c	0 c	0 c	0 c
LA (cm^2/m^2)	12660 a	11630 b	0 c	0 c	0 c	0 c
LAI	1.266 a	1.163 b	0 c	0 c	0 c	0 c
Total plant dry (ton/fed)	0.408 a	0.259 b	0 c	0 c	0 c	0 c
Leaves dry weight (ton/fed)	0.194 a	0.125 b	0 c	0 c	0 c	0 c
Stem dry weight (ton/fed)	0.205 a	0.134 b	0 c	0 c	0 c	0 c
Leaves/stem ratio	0.955 a	0.937 a	0 b	0 b	0 b	0 b

In addition to the above results, under high saline water irrigation level 8000ppm there was no any re-growth of the pearl millet plants in the three sowing dates, *i.e.* 1st May, 15th May and 1st June. This is may be due to the combine harmful effect of the high salinity of the irrigation water and the high temperature on the re-growth of the plants.

Results in Table 7 showed the effect of the interaction between irrigation water salinity and soil mulching on the forage yield and some growth characters of pearl millet. Obtained data showed that at the 1st cut using plastic soil mulching produced the significant values of plant height, number of tillers, leaves area/m^2, leaf area index, total plant dry weight, leaves dry weight, stem dry weight and leaves/stem ratio under the irrigation water salinity 4500ppm. Whereas, using plastic for soil mulching produced the lowest significant values of number of tillers, leaves area/m^2 and leaf area index under the high saline water irrigation 8000ppm.

At the 2nd cut results showed that, using 1 ton of rice straw for soil mulching produced the significant values of tillers number, leaves area/m^2 and leaf area index under the low saline irrigation water (4500 ppm). Whereas, using 2 ton of rice straw treatment produced the high significant values of the total plant dry weight, leaves dry weight, stem dry weight and leaves/stem ratio under the irrigation water salinity 4500ppm conditions. In the main time, the same soil mulching treatment produced the lowest significantly values of the total plant dry weight, leaves dry weight and stem dry weight under the irrigation water salinity 8000 ppm treatment.

At the 3rd cut there was no re-growth of pearl millet under the high saline irrigation water (8000 ppm). Results obtained showed that using plastic treatment produced the high significant values of plant height, number of tillers, total plant dry weight, leaves dry weight and stem dry weight under salinity irrigation water 4500 ppm treatment. Generally results indicated that the same soil mulching material or the amount of the material does not has the same effect on the pearl millet yield under different saline water irrigation levels. The results indicated that under the low irrigation water salinity using plastic for soil mulching is more efficiency than using rice straw, whereas, the reverse is true under the high irrigation water salinity conditions.

Results in Table 8 showed that at the 1st cut using plastic produced the significant values of plant height, total plant dry weight at sowing date 15th May, leaves area/m^2, leaf area index and stem dry weight at sowing date 1st June. The higher significant value of leaves/stem ratio was obtained by using 2 ton of rice straw at sowing date of the 1st May.

At the 2nd cut there were no significant differences among the soil mulching materials and amounts in the total plant dry weight at sowing date of 1st May and 15th May. On the other hand, using 2 ton of rice straw for soil mulching had the significant value of leaves dry weight at sowing date 15th May and the high stem dry weight at sowing date 1st May which produced the significant value of number of tillers at this sowing date.

TABLE 7. Effect of the interaction between saline water irrigation levels and soil mulching on some growth characters and forage yield of pearl millet (average the two seasons 2011 and 2012).

Saline water irrigation	4500 ppm				8000ppm			
Soil mulching	Without	1 ton/ fed straw	2 ton/ fed straw	plastic	Without	1 ton/ fed straw	2 ton/ fed straw	plastic
1st cut								
Plant height (cm)	99.11 ab	97.94 b	97.99 b	102.7 a	87.26 d	91.87 c	90.36 cd	93.86 c
No of tiller /m^2	121.9 ab	117.5 bc	113.1 c	126.5 a	71.87 d	69.20 d	66.07 de	62.73 e
LA (cm^2/m^2)	74340 bc	80110 ab	70890 c	85110 a	13260 d	12270 d	13580 d	11760 d
LAI	7.434 bc	8.011 ab	7.089 c	8.511 a	1.326 d	1.227 d	1.358 d	1.176 d
Total plant dry (ton/fed)	0.800 b	0.734 b	0.690 b	0.924 a	0.473 c	0.488 c	0.468 c	0.529 c
Leaves dry weight (ton/fed)	0.482 b	0.447 b	0.425 b	0.543 a	0.250 c	0.256 c	0.256 c	0.278 c
Stem dry weight (ton/fed)	0.319 b	0.287 bc	0.266 bcd	0.380 a	0.223 cd	0.230 cd	0.212 d	0.247 cd
Leaves/stem ratio %	1.567 a	1.573 a	1.623 a	1.470 a	1.136 b	1.126 b	1.205 b	1.156 b
2nd cut								
Plant height (cm)	116.4 b	111.5 c	120.7 a	124.0 a	61.55 e	62.82 e	67.42 d	66.38 d
No of tiller /m^2	80.17 c	101.5 a	94.97 ab	90.57 b	29.17 d	25.10 d	26.67 d	27.30 d
LA (cm^2/m^2)	60800 b	67440 a	65570 ab	53130 c	3762 d	4623 d	5011 d	3110 d
LAI	6.080 b	6.744 a	6.557 ab	5.313 c	0.376 d	0.462 d	0.501 d	0.311 d
Total plant dry (ton/fed)	0.663 b	0.773 a	0.832 a	0.772 a	0.223 d	0.282 cd	0.332 c	0.355 c
Leaves dry weight (ton/fed)	0.348 c	0.413 b	0.458 a	0.405 b	0.106 e	0.140 d	0.148 d	0.160 d
Stem dry weight (tan/fed)	0.316 b	0.355 ab	0.374 a	0.371 a	0.117 e	0.142 de	0.183 cd	0.193 c
Leaves/stem ratio %	1.101 b	1.166 ab	1.255 a	1.087 b	0.613 c	0.654 c	0.554 c	0.560 c
3rd cut								
Plant height (cm)	71.96 d	75.83 c	81.55 b	86.02 a	0 e	0 e	0 e	0 e
No of tiller /m^2	20.37 a	18.87 b	19.80 ab	20.33 a	0 c	0 c	0 c	0 c
LA(cm^2/m^2)	7291 b	8193 ab	9109 a	7799 b	0 c	0 c	0 c	0 c
LAI	0.729 b	0.819 ab	0.911 a	0.780 b	0 c	0 c	0 c	0 c
Total plant dry (tan/fed)	0.191 c	0.230 b	0.277 a	0.192 c	0 d	0 d	0 d	0 d
Leaves dry weight (tan/fed)	0.094 c	0.111 b	0.130 a	0.090 c	0 d	0 d	0 d	0 d
Stem dry weight (tan/fed)	0.097 c	0.114 b	0.140 a	0.102 c	0 d	0 d	0 d	0 d

Leaves/stem ratio %	0.659 a	0.656 a	0.622 ab	0.586 b	0 c	0 c	0 c	0 c

TABLE 8. Effect of the interaction between saline water irrigation levels and soil mulching on some growth characters and forage yield of pearl millet (average the two seasons 2011 and 2012).

Plant date	**1/5**				**15/5**				**1/6**			
Soil mulching	**Without**	**1ton/ fed straw**	**2ton/ fed straw**	**plastic**	**Without**	**1ton/ fed straw**	**2ton/ fed straw**	**plastic**	**Without**	**1ton/ fed straw**	**2ton/ fed straw**	**plastic**
1^{st} cut												
Plant height (cm)	85.15 e	94.92 bcd	94.59 cd	94.06 cd	95.47 bcd	92.68 d	92.93 d	100.9 a	98.92 abc	97.12 a-d	95.01 bcd	99.9 ab
No of tiller / m^2	126.0 a	95.05 c	104.6 b	95.35 c	92.45 c	84.55 d	80.05 d	95.75 c	72.20 e	100.5 bc	84.10 d	92.75 c
LA (cm^2/m^2)	47400 bcd	46020 b-e	49450 abc	46010 b-e	39930 cde	37720 de	36350 e	42120 cde	44080 cde	54830 ab	40910 cde	57170 a
LAI	4.740 bcd	4.602 b-e	4.945 abc	4.601 b-e	3.993 cde	3.772 de	3.635 e	4.212 cde	4.408 cd	5.483 ab	4.091 cde	5.717 a
Total plant dry (tan/fed)	0.594 bc	0.557 c	0.588 bc	0.670 abc	0.658 abc	0.599 bc	0.581 bc	0.770 a	0.658 abc	0.677 abc	0.568 c	0.740 ab
Leaves dry weight (tan/fed)	0.362 b	0.316 b	0.359 b	0.393 ab	0.394 ab	0.362 b	0.445 b	0.454 a	0.343 b	0.378 ab	0.317 b	0.385 ab
Stem dry weight (tan/fed)	0.233 b	0.240 b	0.229 b	0.270 b	0.264 b	0.238 b	0.236 b	0.316 ab	0.316 ab	0.299 ab	0.251 b	0.355 a
Leaves/stem ratio	1.510 ab	1.301 bcd	1.564 4 a	1.429 abc	1.459 abc	1.511 ab	1.455 abc	1.440 abc	1.085 d	1.237 cd	1.222 cd	1.070 d
2^{nd} cut												
Plant height (cm).	103.4 de	106.4 bcd	117.2 a	115.2 a	104.9 cde	100.7 e	109.2 bc	110.6 b	58.62 fg	54.36 g	55.83 fg	59.76 f
No of tiller / m^2	69.75 ab	74.40 a	75.45 a	63.70 b	68.45 ab	70.75 ab	69.90 ab	70.80 ab	25.80 d	44.70 c	37.10 c	42.30 c
LA (cm^2/m^2)	50100 b	58490 a	49780 b	45270 bc	37500 d	38040 d	42050 cd	28830 e	9236 f	11560 f	14040 f	10250 f
LAI	5.010 b	5.849 a	4.978 b	4.527 bc	3.750 d	3.804 d	4.205 cd	2.883 e	0.924 f	1.156 f	1.404 f	1.025 f
Total plant dry tan/fed	0.524 b	0.624 a	0.721 a	0.715 a	0.531 b	0.630 a	0.704 a	0.679 a	0.274 c	0.329 c	0.321 c	0.296 c
Leaves dry weight (tan/fed)	0.280 c	0.329 b	0.361 ab	0.365 ab	0.272 c	0.333 ab	0.371 a	0.354 ab	0.128 e	0.167 d	0.178 d	0.128 e
Stem dry weight (tan/fed)	0.244 d	0.296 bcd	0.361 a	0.347 ab	0.259 d	0.288 cd	0.333 abc	0.325 abc	0.146 e	0.163 e	0.142 e	0.174 e
Leaves/stem ratio	1.087 ab	1.080 ab	0.976 b	1.017 ab	1.045 ab	1.139 a	1.106 ab	1.088 ab	0.439 de	0.512 cd	0.630 c	0.365 e
3^{rd} cut												
Plant height (cm)	59.33 bc	58.09 bc	59.84 bc	67.57 a	48.60 d	55.64 c	62.48 b	61.47 b	0 e	0 e	0 e	0 e
No of tiller / m^2	17.60 a	14.90 c	15.90 ab	17.10 a	12.95 d	13.40 cd	13.80 cd	13.40 cd	0 e	0 e	0 e	0 e
LA(cm^2/m^2)	5872 abc	6926 a	6673 ab	5858 abc	5065 c	5365 bc	6991 c	5841 abc	0 d	0 d	0 d	0 d
LAI	0.587 abc	0.693 a	0.667 ab	0.586 abc	0.507 c	0.536 bc	0.699 a	0.584 abc	0 d	0 d	0 d	0 d
Total plant dry tan/fed	0.190 b	0.198 b	0.251 a	0.176 c	0.096 g	0.147 e	0.164 d	0.112 f	0 h	0 h	0 h	0 h
Leaves dry weight (tan/fed)	0.093 b	0.095 b	0.117 a	0.084 bc	0.048 d	0.073 c	0.078 c	0.052 d	0 e	0 e	0 e	0 e

Stem dry weight (tan/fed)	0.097 b	0.097 b	0.124 a	0.093 b	0.048 e	0.075 c	0.086 bc	0.060 d	0 f	0 f	0 f	0 f
Leaves/stem ratio	0.485 ab	0.493 ab	0.479 ab	0.452 ab	0.503 a	0.490 ab	0.454 ab	0.427 b	0 c	0 c	0 c	0 c

At the 3rd cut, results indicated that using plastic for soil mulching produced the significant of plant height, number of tillers and the leaves/stem ratio at the sowing date 1st May. Whereas, using 2 ton of rice straw for soil mulching had the significant values of the total plant dry weight, leaves dry weight and stem dry weight at the sowing date 1st May. Results showed that there was no re-growth of the peal millet plants at sowing date 1st June. This is may be due to the high temperature which cause high evaporation and led to increase soil salinity.

Results in Table 9 indicated that at the 1st cut using plastic for soil mulching produced the high significant values of the leaves area/m^2, steam dry weight and total plant dry weight at the sowing 1st June under the low saline irrigation water (4500 ppm). Whereas the lowest significant values of the total plant dry weight and steam dry weight were reduced by using 2 ton of rice straw for soil mulching at 1st June under the high saline irrigation water (8000 ppm).

At the 2nd cut using 2 ton ton of rice straw for soil mulching produced the high significant values of the total plant dry weight at the sowing 1st and 2nd sowing dates followed by using plastic for soil mulching under the low saline irrigation water (4500 ppm). This is may be due to the adequate amount of the rice straw for keeping the soil surface against the evaporation and save soil moisture. Whereas the lowest significant values of the total plant dry weight and steam dry weight were reduced by using without soil mulching at 1st May and 15th May under the high saline irrigation water (8000 ppm).

At the 3rd cut results indicated that using 2 ton of rice straw for soil mulching produced the high significant values of the total plant dry weight, steam dry weight and leaves dry weight at the sowing 1st sowing date under the low saline irrigation water (4500 ppm). Whereas, there was no re-growth of pearl millet at the 1st June sowing date under the low saline irrigation water (4500 ppm) and at the three sowing dates under the high saline irrigation water (8000 ppm) .

TABLE 9. Effect of the interaction between saline water irrigation levels, sowing dates and soil mulching on some growth characters and forage yield of pearl millet (average the two seasons 2011 and 2012).

	Plant height (cm)						**No. of tiller/m^2**					
	4500ppm			**8000ppm**			**4500ppm**			**8000ppm**		
Planting date	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**
Soil mulching	1st cut											
Without	91.63 def	97.58 bcd	108.1 a	78.67 g	93.37 def	89.75 ef	147.8 a	118.5 de	99.4 f	104.2 f	66.40 hij	45.00 k
1ton/fed straw	97.9 bcd	94.80 cde	101.1 abc	91.94 def	90.55 def	93.12 def	121.1 cd	99.9 f	131.6 bc	69.00 hi	69.20 hi	69.40 hi
2ton/fed straw	96.84 b-e	93.98 c-f	103.1 ab	92.33 def	91.87 def	86.88 f	131.1 bc	98.30 f	109.8 ef	78.00 gh	61.80 ij	58.40 ij
Plastic	96.5 b-e	105.9 a	105.8 a	91.62 def	95.87 b-e	94.10 c-f	103.3 f	134.7 b	141.5 ab	87.40 g	56.80 j	44.00 k
2nd cut												
Without	116.7 cde	115.3 de	117.2 cde	90.09 i	94.57 i	0 J	96.10 cde	92.80 cde	51.60 g	43.40 ghi	44.10 gh	0 k
1ton/fed straw	117.0 cde	108.7 fg	108.7 fg	95.75 i	92.72 i	0 J	110.5 ab	104.5 bc	89.40 de	38.30 hi	37.00 hij	0 k
2ton/fed straw	128.0 a	122.6 abc	111.7 ef	106.5 fg	95.73 i	0 J	118.9 a	91.80 cde	74.20 f	32.00 ij	48.00 gh	0 k
Plastic	128.0 a	124.4 ab	119.5 bcd	102.4 gh	96.77 hi	0 J	101.6 bcd	85.50 ef	84.60 ef	25.80 j	56.20 g	0 k
3rd cut												
Without	118.7 bc	97.20 e	0 f	0 f	0 f	0 f	35.20 a	25.90 d	0 e	0 e	0 e	0 e
1ton/fed straw	116.2 cd	111.3 d	0 f	0 f	0 f	0 f	29.80 bc	26.80 d	0 e	0 e	0 e	0 e
2ton/fed straw	119.7 bc	125.0 b	0 f	0 f	0 f	0 f	31.80 b	27.60 cd	0 e	0 e	0 e	0 e
Plastic	135.1 a	122.9 b	0 f	0 f	0 f	0 f	34.20 a	26.80 d	0 e	0 e	0 e	0 e

TABLE 9. Cont.

	LA(cm^2/m^2)						LAI					
	4500ppm			**8000ppm**			**4500ppm**			**8000ppm**		
Planting date	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**
Soil mulching	1^{st} cut											
Without	77920 bc	67850 cd	77250 bc	16880 e	12000 e	10900 e	7.792 bc	6.785 cd	7.725 bc	1.688 e	1.200 e	1.090 e
1ton/fed straw	76430 bc	65350 cd	98540 a	15620 e	10090 e	11110 e	7.643 bc	6.535 cd	9.854 a	1.562 e	1.009 e	1.111 e
2ton/fed straw	83990 b	60480 d	68200 cd	14900 e	12230 e	13620 e	8.399 b	6.048 d	6.820 cd	1.490 e	1.223 e	1.362 e
Plastic	78180 bc	73060 bcd	104100 a	13830 e	11170 e	10270 e	7.818 bc	7.306 bcd	10.41 a	1.383 e	1.117 e	1.027 e
2^{nd} cut												
Without	93140 b	70780 d	18470 g	7065 h	4222 h	0 h	9.314 b	7.078 d	1.847 g	0.707 h	0.422 h	0 h
1ton/fed straw	109200 a	69980 d	23110 fg	7772 h	6098 h	0 h	10.92 a	6.998 d	2.311 fg	0.777 h	0.610 h	0 h
2ton/fed straw	90260 b	78370 cd	28070 f	9299 h	5735 h	0 h	9.026 b	7.837 cd	2.807 f	0.930 h	0.574 h	0 h
Plastic	85850 bc	53030 e	20500 fg	4693 h	4637 h	0 h	8.585 bc	5.303 e	2.050 fg	0.4670 h	0.464 h	0 h
3^{rd} cut												
Without	11740 bc	10130 c	0 d	0 d	0 d	0 d	1.174 bc	1.013 c	0 d	0 d	0 d	0 d
1ton/fed straw	13850 a	10730 c	0 d	0 d	0 d	0 d	1.385 a	1.073 c	0 d	0 d	0 d	0 d
2ton/fed straw	13350 ab	13980 a	0 d	0 d	0 d	0 d	1.335 ab	1.398 a	0 d	0 d	0 d	0 d
Plastic	11720 bc	11680 bc	0 d	0 d	0 d	0 d	1.172 bc	1.168 bc	0 d	0 d	0 d	0 d

TABLE 9. Cont.

	Dry wt						**Dry wt leave**					
	4500ppm			**8000ppm**			**4500ppm**			**8000ppm**		
Planting date	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**	**1/5**	**15/5**	**1/6**
Soil mulching	1st cut											
Without	0.748 b-f	0.804 b-e	0.849 a-d	0.441 jk	0.511 g-k	0.467 ijk	0.480 abc	0.503 abc	0.464 abc	0.245 fg	0.284 efg	0.221 fg
1ton/fed straw	0.648 c-j	0.695 c-i	0.860 abc	0.466 ijk	0.503 h-k	0.493 h-k	0.390 cde	0.434 bcd	0.517 ab	0.242 fg	0.289 efg	0.238 fg
2ton/fed straw	0.703 c-h	0.630 d-k	0.738 b-g	0.473 h-k	0.531 f-k	0.399 k	0.456 a-d	0.383 cde	0.435 bcd	0.262 fg	0.306 efg	0.200 g
Plastic	0.801 b-e	0.945 ab	1.025 a	0.538 f-k	0.595 e-k	0.455 jk	0.494 abc	0.568 a	0.569 a	0.293 efg	0.340 def	0.200 g
2nd cut												
Without	0.728 bc	0.714 bc	0.547 d-g	0.320 h	0.348 h	0 i	0.414 cd	0.373 de	0.256 fg	0.146 i	0.172 hi	0 j
1ton/fed straw	0.820 ab	0.842 ab	0.658 cd	0.429 gh	0.417 gh	0 i	0.450 bc	0.455 bc	0.333 e	0.208 fgh	0.211 fgh	0 j
2ton/fed straw	0.940 a	0.915 a	0.641 cde	0.503 efg	0.493 fg	0 i	0.524 a	0.494 ab	0.357 e	0.197 ghi	0.248 fg	0 j
Plastic	0.905 a	0.819 ab	0.591 d-f	0.525 d-g	0.539 d-g	0 i	0.515 a	0.445 bc	0.256 fg	0.216 fgh	0.264 f	0 j
3rd cut												
Without	0.381 b	0.192 g	0 h	0 h	0 h	0 h	0.187 b	0.096 e	0 f	0 f	0 f	0 f
1ton/fed straw	0.397 b	0.294 e	0 h	0 h	0 h	0 h	0.189 b	0.145 d	0 f	0 f	0 f	0 f
2ton/fed straw	0.502 a	0.328 d	0 h	0 h	0 h	0 h	0.234 a	0.156 cd	0 f	0 f	0 f	0 f
Plastic	0.352 c	0.223 f	0 h	0 h	0 h	0 h	0.167 c	0.103 e	0 f	0 f	0 f	0 f

TABLE 9. Cont.

	Dry wt stem						Leave / stem ration					
	4500ppm			8000ppm			4500ppm			8000ppm		
Planting date	1/5	15/5	1/6	1/5	15/5	1/6	1/5	15/5	1/6	1/5	15/5	1/6
Soil mulching	1st cut											
Without	0.270 b-e	0.301 b-e	0.385 ab	0.196 e	0.227 de	0.246 de	1.783 ab	1.668 abc	1.249 d-h	1.238 e-h	1.250 d-h	0.920 hi
1ton/fed straw	0.258 cde	0.261 cde	0.343 a-d	0.222 de	0.214 e	0.255 cde	1.526 b-e	1.667 abc	1.527 b-e	1.077 f-i	1.355 c-g	0.947 hi
2ton/fed straw	0.247 de	0.247 de	0.303 b-e	0.211 e	0.225 de	0.199 e	1.885 a	1.556 a-e	1.428 c-f	1.244 e-h	1.354 c-g	1.016 ghi
Plastic	0.308 b-e	0.377 abc	0.456 a	0.233 de	0.255 cde	0.254 cde	1.603 a-d	1.537 b-e	1.269 d-h	1.254 d-h	1.343 c-g	0.871 i
2nd cut												
Without	0.314 b-e	0.342 a-e	0.291 c-g	0.174 i	0.177 i	0 j	1.319 a	1.106 abc	0.878 de	0.855 de	0.984 cd	0 g
1ton/fed straw	0.370 a-d	0.370 a-d	0.325 b-f	0.221 ghi	0.206 hi	0 j	1.219 ab	1.254 a	1.025 bcd	0.940 cd	1.023 bcd	0 g
2ton/fed straw	0.416 a	0.421 a	0.285 d-h	0.305 b-g	0.245 f-i	0 j	1.308 a	1.179 ab	1.260 a	0.645 f	1.015 bcd	0 g
Plastic	0.390 ab	0.374 abc	0.349 a-e	0.304 b-g	0.275 e-h	0 j	1.319 a	1.211 ab	0.731 ef	0.715 ef	0.965 cd	0 g
3rd cut												
Without	0.194 b	0.096 f	0 g	0 g	0 g	0 g	0.971 a	1.007 a	0 c	0 c	0 c	0 c
1ton/fed straw	0.193 b	0.149 d	0 g	0 g	0 g	0 g	0.986 a	0.980 a	0 c	0 c	0 c	0 c
2ton/fed straw	0.248 a	0.172 c	0 g	0 g	0 g	0 g	0.958 a	0.908 ab	0 c	0 c	0 c	0 c
Plastic	0.185 bc	0.121 e	0 g	0 g	0 g	0 g	0.904 ab	0.854 b	0 c	0 c	0 c	0 c

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تأثير تغطية سطح التربة ومواعيد الزراعة على نمو وإنتاجية الدخن تحت الظروف الملحية

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أجريت تجربتان ميدانيتان في مركز بحوث رأس سدر ، محافظة جنوب سيناء ، مصر خلال موسم صيف ٢٠١١ و ٢٠١٢. وقد أجريت هذه التجارب لدراسة تأثير أربعة معاملات التغطية (بدون تغطية لسطح التربة ، واحد طن قش الأرز / فدان ، ٢طن قش ارز /فدان ، التغطية بالبلاستك). وتم دراسة ثلاث مواعيد زراعة (الاول من مايو، ١٥ مايو ، الاول من يونيو) . على خصائص النمو و إنتاجية العلف من الدخن تحت مستويين من ملوحه مياه الرى (٤٥٠٠ و ٨٠٠٠ جزء في المليون). وأظهرت النتائج أن صفات النمو و إنتاجية العلف من الدخن إرتفاع النبات، وعدد الافرع / نبات ، عدد الأوراق / نبات ، دليل مساحة الاوراق ، الوزن الجاف لكل من للأوراق والسيقان و الوزن الجاف للنبات انخفض بشكل ملحوظ عن طريق زيادة ملوحة مياه الرى ٤٥٠٠-٨٠٠٠ جزء في المليون. وكان الفارق كبير نتيجه عملية التغطية وزاد محصول العلف الجاف بشكل كبير لمعامله تغطيه التربة بمعدل ٢ طن من قش الأرز / فدان ، والتغطية البلاستيك التي أنتجت قيم معنوية عالية لكل من الوزن الجاف للأوراق وللسيقان ومجموع الوزن الجاف / فدان بالمقارنة مع عدم التغطية (المرجعية) واستخدام طن واحد قش الأرز / فدان على التوالي . وأشارت النتائج أن ميعاد الزراعة المبكرة في الاول مايو اظهراعلى قيم معنوية لمعظم صفات النمو ومحصول العلف الجاف الكلى.