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THE INFLUENCE OF FOLIAR APPLICATION OF WHEY AND PERIODS OF CUTTING ON DRY MATTER YIELD AND FORAGE QUALITY IN SORGHUM (VAR.BOHOOTH 70)

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Abstract

A field experiment was carried out at the experimental farm, Faculty of Agricultural Engineering Science, University of Baghdad during summer seasons 2018 in order to study the influence of the foliar application of Whey and periods of cutting on dry matter yield and forage quality of Sorghum (var.Bohooth70). The experiment was designed according to Randomized Complete Block Design (R.C.B.D) using split-plot arrangement with three replicates, periods of cutting (45,55,65,and75)days after sowing were used as main plots ,while foliar application of Whey and nitrogen (control treatment ,nitrogen as recommended ,foliar application of Whey at conc. 50%and foliar application of Whey at conc.75%) referred to T_1,T_2,$T_3$and T_4 respectively. Three cutting were obtained during the growing season .Results showed that the late cutting period after 75 days from sowing caused significant increases in the percentage and yield of dry matter (13.65,10.41, and 6.31 t.ha^{-1}) and total (30.38) t.ha^{-1} and the yield of protein (1.33, 0.99, and 0,55 t.ha^{-1}) and fiber (3.7, 2.67 and 1.64t.ha^{-1}) while cutting the plant after 45 days from sowing significantly increases the percentage of protein(12.31, 12.11, and 12.49 %) for the three cutting respectively. The delay in cutting after 75 days from sowing resulted in a significant decrease in the protein percentage and an increase in the percentage of fibers for all three cutting. The treatment of N. fertilizer according to the recommendation was exceeded in the percentage and yield of dry matter and total, percentage, and yield of protein and yield of fiber for the three cutting respectively. There were no significant differences between Nitrogen fertilizer recommendation and foliar application treatment of Whey at concentration 75% in 1st cut only. As well as, the results showed that there was a significant interaction between Whey and periods of cutting for all the characteristics

Keywords: Sorghum, Whey, Periods of Cutting, Dry matter yield, Forage quality.

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is one of the important summer Gramineae crops locally and globally, and it is among the important crops that provide forage in suitable quantities during the summer and remains a longer period in the field, as it ranks the fifth after wheat, rice, maize, and barley in terms of importance and production as a cereal crop in the world. This crop has the potential to grow in a wide range of soil and climate conditions and to withstand high temperatures and droughts, as it gives good yield in semi-arid regions in addition to its tolerance to salinity (Khrbeet and Hashim, 2017). It is also considered one of the crops that have the ability to grow and branch after cutting, as well as its low fiber content, and its grains are used as food for humans in many poor countries after mixing with wheat flour at a percentage of about 50% (Al-Younes, 1993). Furthermore, it is used in animal feeding, where the percentage of protein in grains reaches more than 11% (Teutsch, 2002; Banks, 2005). However, forage crops are important in developing livestock in Iraq, as well as the stage and period of cutting are considered important factors in the yield of dry matter and the quality of forage, which determines the appropriate date for cutting the plant, and gives more number of cutting ranging from 3-4 cutting during the summer (Rahman *et al*., 2003). Studies indicated that the protein content reaches more at the early plant cutting and that the content of the dry matter and the fiber content in the plant increases with the delay of cutting (Al-Fahdawi, 2011; Jassim 2014). This crop is one of the stressful crops of the soil, which needs a high amount of nitrogen fertilizer, especially when planted for green forage, but there are caveats against the use of high doses of nitrogen, due to the increased toxic HCN concentration for the animal. In addition to the possibility of reducing the use of nitrogenous fertilizers that pollute the environment, focusing on alternatives from organic fertilizers and searching for safe nutritional sources in the environment for humans and animals that do not have negative effects. From these organic fertilizers used are (whey), which is considered a by-product of cheese making, one of the most important nutrients in foliar fertilization, because it contains water, a percentage of whey proteins, lactose, nutritional elements, and a few vitamins. Whey is added or sprayed as a supplement to the fertilization process in order to reduce the quantities of added chemical fertilizers that cause major environmental pollution to plants. Moreover, this material was used to improve wheat and soybeans when sprayed on the plant, as spraying helped to increase the growth speed and increase the ability of plants to absorb nutrients from the soil and increase the leaf content of protein and chlorophyll (Konar and Arioglu, 1987; Haroun and Ibrahim, 2003). Most recent studies and research indicate that spraying nutrients on the shoot is an effective way to supply the plant nutrients by absorbing them directly by plant tissues and compensation for the use of chemical fertilizers that pollute the environment. Therefore, the aim of the study was to provide forage along the season through the appropriate cutting stage, taking into consideration the safe quality for animal health, as well as the possibility of reducing the use of nitrogen fertilizers and compensating for it using the whey and determining its best concentration.

Materials and Methods

A field experiment was carried out at the experimental farm, Faculty of Agricultural Engineering Science, University of Baghdad during the summer seasons 2018 in order to study the influence of the foliar application of Whey and periods of cutting on dry matter yield and its quality of

Sorghum (var.Bohooth70) newly registered as the best variety for green forage in Iraq. The experiment was designed according to Randomized Complete Block Design (R.C.B.D) using a split-plot arrangement with three replicates. The main plots included periods of cutting (45, 55, 65, and 75) days after sowing, symbolized as (C_1, C_2, C_3, and C_4), respectively. The sub-plot included the concentrations of whey, which are (spraying with distilled water, nitrogen as recommended, foliar application of Whey at conc. 50% and foliar application of Whey at conc.75%) referred to T_1, T_2, $T_3$and T_4, respectively, at a rate of three sprayings per cut that its components and chemical properties are shown in Table 1. The period between one spraying to another was a week, and spraying was done according to the concentrations by diluting with distilled water, where spraying was done on the shoot after adding a surfactant such as liquid soap in a small percentage and in the early morning until full wetness after irrigating the experiment field before spraying one day to help open the stomata and increase the absorption process.

Table 1 : Components of whey and some chemical properties of nutrients

Whey components	pH	Water	Protein	N	fat	Lactose	Ash	P	K	Ca
%	6.2	93.3	1.14	0.18	0.1	4.42	0.52	455 ppm	1365 ppm	383.3 ppm

Table 2 : Physical and chemical properties of the soil before planting

Elements		Unit	Value
Soil texture		------	Silty clay
Soil separator	Sand	%	26.3
	Silt		35.5
	Clay		38.2
PH			7.12
Ec		$Ds.m^{-1}$	3.83
Ca		$Mg.l^{-1}$	18.70
Mg		$Mg.l^{-1}$	11.22
dissolved K		$Mg.l^{-1}$	32
Na		$Mg.l^{-1}$	8.82
Cl		$Mg.l^{-1}$	23.24
Co_3		$Mg.l^{-1}$	Nill
$Caco_3$		%	23.45
OM		%	0.52
NPK available	N	ppm	26
	P		13.38
	K		179.26

The experiment land was prepared from plowing, harrowing and leveling, then it was divided into five rows for each experimental unit, the distance between one row and another 40 cm, and the length of the row 3 m, the area of the experimental unit was 6 m^2 with dimensions (3 x 2 m). Furthermore, the seeding rates amounted to 48 $kg.ha^{-1}$, and the seeds were distributed inside the single row, and then covered well in the soil at a depth of 5 cm. A distance of meter was left between one replicate and another, and meter between the sub-plot, random samples were taken from the experiment land before sowing and at a depth of (0 - 30) cm to estimate some physical and chemical characteristics as shown in Table 2. The experiment was fertilized with phosphate fertilizer that mixed with the soil before sowing at a level of 100 kg $P.ha^{-1}$ as a triple superphosphate 45% (P_2O_5) in one batch. As for nitrogen fertilizer, it was added at the level of 200 kg $N.ha^{-1}$ in the form of urea (46% N) in batches, the first batch was added after two weeks of sowing, while the other batches were added after each cutting to ensure the restoration of growth after cutting (Hamdan, 2006). The experiment land was irrigated immediately after sowing to ensure that the seeds remained in the planting rows, while the other irrigation was given according to the need and the following characteristics were studied:

- **Percentage of dry matter%:** The percentage of dry matter was estimated for all treatments by taking plants from an area (1/4) m^2 of rows adjacent to the border rows and weighed directly and then dried under the sunlight until the weight constant, and the percentage of dry matter was calculated from the following equation:

$$\text{Percentage of dry matter} = \frac{dry\ sample\ \text{weight}}{wet\ sample\ \text{weight}} \times 100$$

- **Dry matter yield ($t.ha^{-1}$):** The dry matter yield for all treatments was calculated from the following equation:

$$\text{Dry matter yield} = \text{green forage yield} \times \text{percentage of the dry matter}$$

- **Qualitative Characteristics (Chemical Components)**: After calculating the percentage of the dry matter, the dried samples were crushed with a laboratory mill size of the sieve opening (1x1) mm, after that, it was kept in moisture-proof bags and the following chemical analyzes were performed:

1- **Protein Percentage%:** The percentage of crude protein was estimated using the Semi-micro kjeldal method according to A.O.A.C (1980).

2- **Crude protein yield ($t.ha^{-1}$):** The crude protein yield was calculated according to the following equation:

$$\text{Crude protein yield} = \text{dry matter yield} \times \text{percentage of crude protein}$$

3- **Percentage of crude fibers%:** The percentage of crude fibers was calculated by a (Tecator Fibeidec system heat Extractor 1010) according to the method described in A.O.A.C (1980).

4- **Crude fiber yield (t.ha^{-1}):** The crude fiber yield was calculated from the following equation:

Crude fiber yield = dry matter yield × percentage of crude fiber

Results and Discussion

Dry matter percentage (%)

It was observed from Table 3 that the cutting period after 75 days from sowing exceeded for all cutting and gave the highest average for this characteristic (31.0, 31.06 and 25.53), while the lowest average for this characteristic was at the cutting period after 45 days from sowing, which gave (25.27, 22.97 and 21.63%) for the first, second, and third cutting, respectively. The reason for increasing the percentage of the dry matter by increasing the cutting periods is due to the hardness of the stems (cellulose, hemicellulose, and lignin) and the accumulation of the dry matter with the age progress of plant, which leads to an increase in the amount and speed of absorption that in turn helped the accumulation of the dry matter. As well as, the decrease in the ratio of leaves to the stems with the age progress of plant compared with the earliest stages of growth in which plants may be soft and intact, these results are consistent with the results of (AL-Dulaimi *et al*., 2010; Ayub *et al*.,2002; Almozani and Al Ta'i 2014). Table 3 also showed that treatment (T_2) gave the highest percentage of dry matter compared to the rest of the treatments, but it did not differ from the treatment T_4, which gave (29.61, 27.62 and 24.89%) for all three cutting respectively. In addition, the treatment (T_1) gave the lowest percentage for this characteristic was (26.56, 23.95, and 21.53%) for the first, second, and third cutting respectively. The reason for the increase in the percentage of the dry matter of the plant in the treatment of (T_2) and (T_4) may be due to the increase in the hard parts of the plant to the soft parts, and this is due to the decrease in the ratio of leaves to the stems. As well as, an increase in the shoot and the height of the plant, which is reflected in increasing the dry matter, these results are consistent with (Hamad 1986; al-Rubaie 1995, Al-Ghalabi, 1988) in terms of the nitrogen influence, and (Haroun and Ibrahim 2003) in terms of the whey influence, where they indicate that adding nitrogen leads to an increase in the percentage of the dry matter.

Dry matter yield (t.ha^{-1})

Table 4 showed that the period of cutting after 75 days from sowing exceeded the rest of periods and gave the highest average for this characteristic of (13.65, 10.41 and 6.31 t.ha^{-1}) while cutting period after 45 days from sowing gave the lowest average of (5.8, 5.09 and 3.4 t.ha^{-1}) for all first, second and third cutting respectively. The reason for exceeding the cutting period after 75 days from sowing in increasing the dry matter yield to the increase in the green forage yield for the cutting period after 75 days from sowing and the percentage in the dry matter as shown in Table 3 resulted from the age progress of plant. Besides, the accumulation of the dry matter, which quickly accumulate to form (60-70%) of the final dry weight, moreover to the increases in roots number weight in the delayed stages of the plant life, these results are consistent with (Al-Fahdawi 2011; Al-Dulaimi 2012; Salama and Jassam 2014) findings. It was observed from Table 4, the treatment (T_2) exceeded in the dry matter yield over the rest of treatments and did not differ from the treatment (T_4), while it differed from the two treatments (T_1) and (T_3). As treatment (T_2) gave (11.01, 8.44 and 5. 73) t.ha^{-1} for all three cutting respectively, while the treatment (T_1) gave the lowest average for this characteristic, as it reached (7.73, 5.61 and 3.71) t.ha^{-1} for the three cutting, respectively. The reason for the increase in the dry matter yield in the treatment (T_2) and (T_3) and (T_4) is due to the increase in the yield of the green forage as well as the percentage of dry matter as shown in Table 3. These results are consistent with (Al Ghalabi, 1988; Al Rubaie 1995; Bakry *et al*., 2016; Abdel- Hameed 2009; Arnon, and Gupta 1995; Prasad *et al.,* 2000).

It was observed from Table 4 that there was a significant interaction between the two study factors and possibly it is due to the difference in the relative response to the cutting periods according to the different concentrations of foliar application of whey and fertilization, where an increase appears in the dry matter yield as far as the cutting periods delayed. In addition to that, this increase was more evident at the fertilizer recommendation treatment, as well as the treatment of the foliar application of Whey at a concentration of 75% with the same response, while the response was less evident at the treatment of spraying with distilled water and foliar application of Whey at concentration. 50% and the maximum response reached at cutting after 75 days from sowing.

Total dry matter yield (t.ha^{-1})

Table 5 showed that the period of cutting after 75 days of sowing exceeded the rest of the dates in this characteristic amounted to 30.38 t.ha^{-1}, while the period of cutting after 45 days of sowing gave the lowest average reached 14.3 t.ha^{-1}. The reason for this characteristic superiority was due to its superiority in the dry matter yield as shown in Table 4, where these results are consistent with (Al-Dulaimi, 2012 and Jasim 2014), by indicated that delaying the cutting stage leads to an increase in the dry matter yield. Also, from Table 5, it can observe that the treatment (T_2) is exceeded the rest of the treatments in this characteristic, as it gave the highest average of dry yield of 25.19 t.ha^{-1}, while treatment (T_1) gave the lowest average of 17.06 t.ha^{-1}, and the reason for the treatment (T_2) superiority is due to the increase in the dry matter yield and the percentage of dry matter as shown in Table 3. The results of Table 5 showed that there was a significant interaction between the two study factors and possibly it is due to the difference in the relative response to the cutting periods influence according to the difference in treatments of fertilizer and foliar application of Whey. An increase appears in the dry matter yield as far as the cutting periods delayed, and that this increase was more evident at the fertilizer recommendation treatment, as well as the treatment of the foliar application of Whey at a concentration of 75% with the same response, Similarly, the response was less evident at comparison treatment and foliar application of Whey at a concentration of 50%, and the maximum response reached at cutting after 75 days from sowing.

Protein Percentage (%):

The results in Table 6 showed that the period of cutting after 45 days from sowing exceeded the rest of periods and gave the highest protein percentage of (12.31, 12.11 and 12.49 %), while the period of cutting after 75 days gave the

lowest percentage reached (9.72, 9.48 and 8.73%) for the first, second and third cutting, respectively. The reason for the decrease in the percentage of crude protein with increasing the cutting periods may be due to the decrease in the ratio of leaves to stems with age progress of plant, which is accompanied by an increase in the percentage of fibers and carbohydrates over of the rest of protein. The protein content is more concentrated in the leaves compared to the stem, where this result is consistent with (Al-Dulaimi 2012; Ayub 2002; Al-Janabi and Al-Fahdawi 2014; Cakmakci *et al*., 1999), that indicated the protein content is high in vegetative growth stages and then decreases as the plant progresses towards maturity. The results of Table 6 indicated that there was a significant difference between the whey treatments, as the treatment (T_2) exceeded the rest of treatments, but it did not differ significantly from the treatment (T_4) and (T_3), but it differed significantly from the treatment (T_1) in the protein percentage.

As the treatment (T_2) gave the highest percentage of (11.81, 11.43, and 11.28%), while treatment (T_1) gave the lowest percentage for this characteristic reached (10.72, 10.23, and 10.55%) for the first, second and third cutting, respectively. The reason for the increase in the percentage of crude protein at treatment (T_2), (T_3) and (T_4) is due to the role of nitrogen, which increases the protein inside the plant by being from cyclic compounds such as adinin, which is one of the nitrogenous bases that contribute to the transmission of DNA. As well as, the formation of proteins, in addition to nitrogen being included in the protein synthesis (Isaa 1984), these results are consistent with the results of (Mahmud *et al*., 2003; Janabi and Fahdawi 2014; Ayub *et al.*, 2002) findings. They found that there was an increase in the protein percentage of Sorghum plants after the addition of nitrogen, these results are consistent with (Haroun and Ibrahim 2003) in terms of whey influence, which confirmed that whey leads to an increase in the protein percentage compared to not adding it. Table 6 indicates the presence of significant interaction between the two study factors, and the reason for this may be due to the different response of cutting periods with the difference in treatments of fertilizer and foliar application of Whey, where both of treatments (T_2) and (T_4) exceeded when cutting plants after 45 days of sowing. Furthermore, the protein percentage decreased whenever the cutting period delayed, but this decrease was less in the treatment of (T_2) and (T_4), while the comparison treatment was more decrease as the cutting periods increased.

Protein yield (t.ha^{-1})

It was observed from Table 7 that the cutting plants after 75 days from sowing has significantly exceeded the rest of the cutting periods in the protein yield characteristic and gave the highest average of protein yield reached (1.33, 0.99 and 0.55 t.ha^{-1}), while the plants cutting after 45 days gave the lowest average (0.71, 0.62 and 0.42t.ha^{-1}) for the first, second and third cutting, respectively. The reason for the superiority of cutting period after 75 days from sowing is due to the increase in the dry matter yield as a result of the age progress of the plant as shown in Table 4. Despite the decrease in the protein percentage with the age progress of plant as shown in Table 6, where these results are consistent with (Al-Fahdawi 2011; Jasim 2014; Al-Janabi and Al-Fahdawi 2011; Plucknett 1971). It was also observed from the same Table that the treatment (T_2) is superior to the rest of the treatments in the protein yield characteristic and did not differ from the treatment (T_4) in the first cutting only, and differed significantly in the subsequent ones significantly. However, the treatment (T_2) gave the highest average of this characteristic of (1.25, 0.94 and 0.62 t.ha^{-1},) while the treatment (T_1) gave the lowest average of (0.81, 0.55 and 0.38 t.ha^{-1}) for the first, second and third cutting, respectively. The reason for the superiority of treatments (T_2) and (T_4) is due to their superiority in the dry matter yield as shown in Table 4, and the increase in the percentage of crude protein as shown in Table 6. These results were consistent with (Al-Dahiri 2010; Al-Janabi and Al-Fahdawi 2014; Al-Ghalabi 1998; Haroun and Ibrahim 2003). The results in Table 7 showed that there was a significant interaction occurred between the two study factors in the characteristic of the protein yield. The reason may be due to the difference in the relative response to the cutting periods with the difference in treatments of fertilizer and foliar application of Whey where the response to the treatment of (T_1) and (T3) less evident, while it was more evident at the treatment of (T_2) and (T4). Finally, there was an increase in protein yield whenever delayed the cutting periods, but this increase was more evident than the treatment (T_2) and (T4) and reached its maximum at cutting after 75 days from sowing.

Percentage of crude fibers (%)

Table 8 showed that the cutting period after 65 days from sowing exceeded the rest of the other periods in the percentage of crude fibers, as it reached (25.9, 27.23 and 28.42%), while the plants cutting after 45 days from sowing gave the lowest percentage of (22.02 and 21.06 and 22.29%) for all three cutting, respectively. The reason for the increase in the percentage of fibers by increasing the cutting periods may be due to a decrease in the ratio of leaves to stems as a result of the age progress of plants. As the percentage of cellulose, hemicellulose, and lignin that are considered a component of the fibers, this result is consistent with (Khrbeet and Saleh 2003, Al-Mozani and Al-Ta'i, 2014; Al-Janabi and Al-Fahdawi, 2014). The reason for the low percentage of fibers in the late stages of maturing may be due to the fact that the percentage of fibers does not give an evident direction with increasing the cutting period or the cutting stage, as it remains constant or gets changes in terms of increase or decrease as the plant ages (El-Tekriti *et al*., 1987). Table 8 indicated that treatment (T_1) exceeded the rest of treatments in the percentage of crude fibers of (25.21, 26.12 and 27.05%), while the treatment (T_2) gave the lowest percentage of (22.97, 23.38 and 23.41%) in the first, second and third cutting, respectively. It was differed significantly from the rest of treatments, whereas the treatments (T_3) and (T_4) did not differ in the first and third cutting. The reason for the low percentage of crude fiber for the treatment (T_2) may be due to the fact that nitrogen promotes vegetative growth, as well as provides plant maturity and caused an increase in the ratio of leaves to stems, these results are consistent with (Ayub 2002; Janabi and Fahdawi 2014; Al-Ghalabi 1988). The results of the same Table indicated the presence of significant interaction between the two study factors and the reason may be due to the difference in the relative response to the cutting periods as a result of the difference in treatments of fertilizer and foliar application of Whey. This response was more evident at treatment (T_1) compared to the treatment (T_2), and less evident at treatments (T_3) and (T_4), and reached its maximum at plants cutting after 75 from sowing compared to cutting at 45 days from sowing.

The yield of crude fiber (t.ha^{-1})

The results of Table 9 indicated that the cutting period after 75 days from sowing exceeded the rest of other cutting periods and gave the highest average reached (3.7, 2.67 and 1.64 t.ha^{-1}), while the cutting period after 45 gave the lowest average was (1.21, 1.11 and 0.75t.ha^{-1}) for all three cutting, respectively. The reason for the increase in yield of crude fiber at the cutting period after 75 days from sowing is due to its superiority in the dry matter yield as shown in Table 4 and an increase in the percentage of crude fiber with the age progress of plant as shown in Table 8. These results are consistent with the results of (Khrbeet and Saleh 2003; Al-Mozani ad Al-Taei 2014; Saini, 2012), which they confirmed that the yield of crude fiber increases with the progress of cutting period or age progress of plant. It was observed from Table 9 the superiority of treatment (T_2) over the rest of other treatments, as it gave the highest average of fiber yield amounted to (1.99 and 1.37 t.ha^{-1}) for the second, and third cutting, respectively, while the treatment (T_1) gave the lowest average of (2.06, 1.42 and 1.01 t.ha^{-1}) for the three cutting, respectively. The reason for the increase in yield of crude fiber at treatment (T_2) and (T_4) is due to its superiority in the dry matter yield as shown in Table 4 with the age progress of plant despite the low percentage of fibers as shown in Table 8.

Finally, Table 9 showed that there was a significant interaction between the two study factors, and the reason for this interaction may be due to the difference in the relative response to the cutting periods with the difference in treatments of fertilizer and foliar application of Whey, as the Table showed an increase in the fiber yield whenever the cutting period delayed, and this increase was more evident and greater at the treatment (T_2) and (T_4), while the response was less evident at treatments (T_1) and (T_3).

Table 3 : The effect of foliar application of whey and periods of cutting and their interactions for the three cutting the dry matter percentage %.

Cutting	Whey and fertilization treatment	Cutting periods				Average
		C_1	C_2	C_3	C_4	
First cutting	T_1	22.87	24.87	27.77	30.73	26.56
	T_2	27.23	27.5	31.97	31.73	29.61
	T_3	24.13	26.1	29.13	30.63	27.5
	T_4	26.87	26.03	31.33	30.90	28.78
	L.S.D0.05	N.S				1.01
	Average	25.27	26.12	30.05	31.0	
	L.S.D0.05	0.70				
Second cutting	T_1	20.67	22.53	23.67	28.93	23.95
	T_2	25.23	25.97	25.93	33.33	27.62
	T_3	22.7	22.93	24.7	30.4	25.18
	T_4	23.27	24.27	23.97	31.57	25.77
	L.S.D0.05	N.S				0.99
	Average	22.97	23.93	24.57	31.06	
	L.S.D0.05	0.67				
Third cutting	T_1	20.07	20.73	22.2	23.1	21.53
	T_2	22.57	24.23	24.87	27.9	24.89
	T_3	21.7	22.07	22.5	25.13	22.85
	T_4	22.2	22.33	23.67	25.97	23.54
	L.S.D0.05	N.S				0.78
	Average	21.63	22.34	23.31	25.53	
	L.S.D0.05	1.76				

Table 4 : The effect of foliar application of whey and periods of cutting and their interactions for the three cutting on the dry matter yield ($t.ha^{-1}$)

Cutting	Whey and fertilization treatment	Cutting periods				Average
		C_1	C_2	C_3	C_4	
First cutting	T_1	4.91	6.18	9.02	10.82	7.73
	T_2	6.54	8.62	13.33	15.57	11.01
	T_3	5.28	8.79	9.87	13.33	9.32
	T_4	6.48	9.14	11.97	14.89	10.62
	L.S.D0.05	1.31				0.65
	Average	5.8	8.18	11.05	13.65	
	L.S.D0.05	0.43				
Second cutting	T_1	4.38	4.63	5.61	7.80	5.61
	T_2	5.56	7.12	8.61	12.47	8.44
	T_3	4.71	5.71	7.49	10.19	7.02
	T_4	5.70	6.18	6.52	11.19	7.40
	L.S.D0.05	0.92				0.46
	Average	5.09	5.91	7.06	10.41	
	L.S.D0.05	0.57				
Third cutting	T_1	2.85	3.56	4.08	4.34	3.71
	T_2	3.94	5.04	5.99	7.94	5.73
	T_3	3.20	4.39	4.96	6.13	4.67
	T_4	3.61	4.03	4.87	6.82	4.83
	L.S.D0.05	0.50				0.25
	Average	3.40	4.26	4.98	6.31	
	L.S.D0.05	0.50				

Table 5 : The effect of foliar application of whey and periods of cutting and their interactions for the three cuts on the total dry matter yield ($t.ha^{-1}$)

Whey and fertilization treatment	Cutting periods				Average
	C_1	C_2	C_3	C_4	
T_1	12.15	14.38	18.72	22.97	17.06
T_2	16.05	20.8	27.94	35.99	25.19
T_3	13.2	18.9	22.33	29.66	21.02
T_4	15.79	19.37	23.37	32.91	22.86
L.S.D 0.05	1.69				0.84
Average	14.3	18.36	23.09	30.38	
L.S.D 0.05	0.60				

Table 6 : The effect of foliar application of whey and periods of cutting and their interactions for the three cutting on the protein percentage (%)

Cutting	Whey and fertilization treatment	Cutting periods				Average
		C_1	C_2	C_3	C_4	
First cutting	T_1	11.21	11.20	11.07	9.42	10.72
	T_2	12.74	13.26	11.08	10.15	11.81
	T_3	12.55	12.12	10.76	9.37	11.20
	T_4	12.75	12.50	10.88	9.94	11.52
	L.S.D0.05	0.35				0.42
	Average	12.31	12.27	10.95	9.72	
	L.S.D0.05	0.24				
Second cutting	T_1	11.63	10.99	9.71	8.60	10.23
	T_2	12.76	11.82	10.89	10.23	11.43
	T_3	11.71	11.41	10.38	9.40	10.72
	T_4	12.33	11.54	10.35	9.68	10.97
	L.S.D0.05	N.S				0.28
	Average	12.11	11.44	10.33	9.48	
	L.S.D0.05	0.28				
Third cutting	T_1	11.7	11.02	10.52	8.95	10.55
	T_2	12.92	12.47	10.75	8.97	11.28
	T_3	12.52	11.98	10.39	8.34	10.80
	T_4	12.83	12.05	11.0	8.65	11.13
	L.S.D0.05	N.S				0.36
	Average	12.49	11.88	10.66	8.73	
	L.S.D0.05	0.42				

Table 7 : The effect of foliar application of whey and periods of cutting and their interactions for the three cutting on the protein yield ($t.ha^{-1}$)

Cutting	Whey and fertilization treatment	Cutting periods				Average
		C_1	C_2	C_3	C_4	
First cutting	T_1	0.54	0.68	0.99	1.01	0.81
	T_2	0.83	1.14	1.48	1.58	1.25
	T_3	0.66	1.06	1.06	1.25	1.01
	T_4	0.82	1.14	1.30	1.47	1.18
	L.S.D0.05	0.14				0.07
	Average	0.71	1.01	1.211	1.33	
	L.S.D0.05	0.09				
Second cutting	T_1	0.51	0.50	0.54	0.67	0.55
	T_2	0.71	0.84	0.94	1.27	0.94
	T_3	0.55	0.65	0.77	0.95	0.73
	T_4	0.70	0.71	0.67	1.08	0.79
	L.S.D0.05	0.12				0.06
	Average	0.62	0.67	0.73	0.99	
	L.S.D0.05	0.05				
Third cutting	T_1	0.33	0.39	0.43	0.38	0.38
	T_2	0.51	0.63	0.64	0.71	0.62
	T_3	0.40	0.52	0.51	0.51	0.48
	T_4	0.46	0.48	0.53	0.59	0.51
	L.S.D0.05	N.S				0.03
	Average	0.42	0.51	0.53	0.55	
	L.S.D0.05	0.05				

Table 8 : The effect of foliar application of whey and periods of cutting and their interactions for the three cutting on the percentage of crude fibers (%)

Cutting	Whey and fertilization treatment	Cutting periods				Average
		C_1	C_2	C_3	C_4	
First cutting	T_1	23.33	24.86	26.78	25.86	25.21
	T_2	19.73	21.53	25.38	25.26	22.97
	T_3	22.86	24.88	25.77	25.73	24.81
	T_4	22.16	24.90	25.70	25.83	24.65
	L.S.D0.05	0.97				0.48
	Average	22.02	24.04	25.90	25.67	
	L.S.D0.05	0.69				
Second cutting	T_1	22.7	25.4	29.27	27.1	26.12
	T_2	19.6	20.83	27.0	26.1	23.38
	T_3	20.8	25.3	25.87	28.27	25.06
	T_4	21.13	24.9	26.8	27.13	24.99
	L.S.D0.05	0.57				0.28
	Average	21.06	24.11	27.23	27.15	
	L.S.D0.05	0.22				
Third cutting	T_1	24.96	26.53	30.63	26.06	27.05
	T_2	20.3	20.86	27.46	25.03	23.41
	T_3	21.66	26.26	27.90	27.50	25.83
	T_4	22.23	26.0	27.70	26.03	25.49
	L.S.D0.05	1.13				0.56
	Average	22.29	24.91	**28.42**	**26.15**	
	L.S.D0.05	0.98				

Table 9 : The effect of foliar application of whey and periods of cutting and their interactions for the three cutting on the yield of crude fibers ($t.ha^{-1}$)

Cutting	Whey and fertilization treatment	Cutting periods				Average
		C_1	C_2	C_3	C_4	
First cutting	T_1	1.11	1.56	2.64	2.93	2.06
	T_2	1.28	1.79	3.59	4.07	2.68
	T_3	1.09	2.22	2.55	3.76	2.41
	T_4	1.36	2.27	3.20	4.03	2.72
	L.S.D0.05	0.38				0.19
	Average	1.21	1.96	3.00	3.70	
	L.S.D0.05	0.15				
Second cutting	T_1	1.02	1.15	1.50	2.02	1.42
	T_2	1.09	1.53	2.18	3.15	1.99
	T_3	1.07	1.42	1.93	2.62	1.76
	T_4	1.26	1.54	1.67	2.89	1.84
	L.S.D0.05	0.25				0.12
	Average	1.11	1.41	1.82	2.67	
	L.S.D0.05	0.17				
Third cutting	T_1	0.71	0.94	1.25	1.13	1.01
	T_2	0.80	1.05	1.64	1.98	1.37
	T_3	0.69	1.15	1.38	1.68	1.23
	T_4	0.80	1.04	1.35	1.77	1.24
	L.S.D0.05	0.14				0.07
	Average	0.75	1.05	1.40	1.64	
	L.S.D0.05	0.12				

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