Fodder yield, seed yield, and nutritional quality as influenced by row spacing and clipping stages of berseem clover under rainfed conditions of Sulaimani Region- Iraq

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Abstract:
This study evaluated the influence of different row spacing and clipping stages on the fodder yield and nutritional quality of Egyptian clover at Kanipanka location of Sulaimani region during the winter season of 2021-2022. The field experiment was laid out in a split-plot design arranged according to RCBD with three replications. Main plots consisted of three row spacings (20, 30, and 40 cm), and three clipping stages (no clip (control), clip at tillering stage, and clip at flowering stage) were executed in subplots. The results showed that the effect of row spacing on green, dry fodder yield, and dry matter% was significant and increased as row spacing was increased; also, biological, pod, and seed yield increased with increasing row spacing. Clipping at the whole flowering stage recorded maximum green, dry fodder yield, and dry matter percentage. No clip gave the most significant values of biological, seed yield, and straw yield, but the highest harvest index was recorded at the tillering stage. The effect of row spacing on nutritional values of berseem clover was significant for all traits except phosphorus%, which was not significant. Maximum percent of protein, fat, ash, and K were exhibited by the treatment of 20cm row spacing, while 40cm row spacing gave a maximum value of fiber%. On the other hand, the clipping stage's effect on nutritional value was significant for all characters except Ca% and P%. Protein, fat, ash, and K recorded the highest percent at the tillering stage, while the maximum fiber percent was obtained when clipped at the whole flowering stage.
Keywords: *Trifolium alexandrinum* L., Row spacing, Clipping stages, Fodder yield, Seed yield, Nutritional quality.

Introduction

Egyptian clover *Trifolium alexandrinum* L. is the most important winter legume fodder crop grown under irrigated conditions in Asia [1]. Due to its very high green fodder-producing capacity, it is also known as “the king of fodders.” It is best for

animal feeding due to its anti-nutritional and toxic effects [2]. Berseem or Egyptian clover is a winter annual legume of significant importance to Egyptian agriculture as a principal source of fodder and for conserving soil fertility under intensive cropping [3]. It provides highly nutritious and tasty fodder for livestock in the winter season in repeated cuttings [4]. It contains 17% crude protein, 25.9% crude fiber, and 60-65% TDN (Total Digestible Nutrients) content [5]. Berseem contains 2% proteins, 2.89% calcium, and 0.4 % phosphate at the green stage [6]. During the growing season of 4-5 months, Berseem has an advantage of multiple cuttings, and the farmers might take 8-10 cuttings if the soils are enriched in organic matter and nutritional status. Farmer produces hay during the off-season, and its quality mainly depends on the maturity stage of the crop and its chemical composition [7]. The proper sowing time leads to the benefit of favorable environmental conditions during growth, and sufficient time will be available after fodder cutting for optimum vegetative growth, attainment of bloom, pollination, and seed setting. Most of the farmers continued the fodder cutting till mid-April, and after that, the crop is retained for seed production. In such conditions, there is very little foliage, and during a hot and dry summer climate, the flowering and seed setting are impoverished, which leads to minimal seed production, and due to such negligence, the farmers get minimal benefit in seed production [8]. The last cut for fodder should be managed in such a way that blooming and seed development stages coincide with the favorable weather conditions, which may be decided by manipulation of the suitable date of sowing and last cut management [7]. Due to taking cuttings till late in the growing season, very little time is available for seed setting [9]. The objective of this investigation is to determine the productivity and quality of berseem clover as affected by row spacing and cutting stages under rainfed conditions of the Sulaimani region.

Materials and Methods

A field investigation was conducted during the winter season of 2021-2022 at the Kanipanka location of Sulaimani region according to the recommended seed rates of 40 Kg ha^{-1} of Egyptian clover (*Trifolium alexandrinum* L.). Split plot layout arrangement with randomized complete block design (RCBD) used in three replications. Main plots consisted of three different row spacing (20, 30, and 40 cm), and three clipping stages (no cut, cut at tillering stage, and cut at flowering stage) were executed in the subplots. Each sub-plot consists of 4 rows with 2m long. The recommended dose of phosphorus fertilizer was applied as a triple super phosphate (46 % P_2O_5) at the rate of 120kg ha^{-1} before planting. Sowing was done on the 5th of December by using a 40kg ha^{-1} seeding rate. All agricultural practice was done as required, such as weeding. Clipping was conducted at the tillering and flowering stage at a stubble height of 6-8 cm from the ground level to record the data of the following traits:

Fodder Yield Traits and Their Attributes:

Green Fodder Yield (ton ha^{-1}): Fresh fodder weight (g.m^{-2}) was determined and then converted to (ton ha^{-1}).

Dry Fodder Yield (ton ha^{-1}): Fodder dry matter yield was recorded and converted into dry matter production by using the following formula.

Dry yield (Kg/ha) = Dry yield in cut plot/ Plot area * 10000

Dry Matter%: The sub-samples of 100g were taken to put them in the oven at 65 C° for 72 hours to determine dry matter percent.

Fresh Leaf%: The Weight of fresh leaves from 100g of fodder was recorded

Fresh Stem%: The Weight of fresh stems from 100g of fodder was recorded.

Fresh Leaf/Stem Ratio: The ratio of fresh leaf percent divided by fresh stem percent for each plot.

Dry Leaf%: Weight of dry leaf from 100g of fodder was recorded after drying in the oven at 65 C° for 72 hours.

Dry Stem%: Weight of dry stems from 100g of fodder was recorded after drying in an oven at 65 C° for 72 hours.

Dry Leaf/Stem Ratio: The ratio of dry leaf percent divided by dry stem percent for each plot.

Seed Yield Traits:

Biological yield (ton ha^{-1}): The total vegetative biomass + total economic organ yields by (g m^{-2}), then converted to ton ha^{-1}.

Pod Yield (ton ha^{-1}): The Weight of pods in one square meter was estimated (g m^{-2}) and then converted to ton ha^{-1}.

Seed Yield (ton ha^{-1}): One square meter was harvested for each treatment and converted to ton ha^{-1}.

Straw Yield (ton ha^{-1}): Calculated after harvesting by weighing the biological yield without seed yield.

Straw Yield (ton ha^{-1}) = Biological yield (ton ha^{-1}) - Seed yield (ton ha^{-1})

Harvest Index: Calculate the harvest index according to the following equation:

H.I= Seed yield (ton ha^{-1})/ Biological yield (ton ha^{-1})* 100 [10].

Nutritional Quality Traits:

1. protein%
2. Fiber%
3. Fat%
4. As0h%
5. Calcium%
6. Potassium%
7. Phosphorus%

All plant samples of berseem clover were taken from tillering and full flowering stage to analyze nutritional quality (Protein, Fiber, Fat, Ash, Ca, K, and P) percent at the Laboratory of RAZGA COMPANY for Trading, General Contracting &Quality Control/LTD,

Calibration and accuracy were conducted by using EDXRF (BRUKER), Model: S2PUMA A35X1-4A2D1E6BA1, razga.co.lab@gmail.com, Iraq, Penjwen, International Border Compound of Bashmakh.

Statistical Analysis: The recorded data was statistically analyzed by using a statistical program (OPSTAT). The treatment means were compared at a 5% probability level by using the least significant difference (LSD) test [11].

Results and Discussions

Table 1 illustrate the influence of row spacing on fodder yield traits of berseem clover were significant for all the characters, maximum green fodder yield, dry fodder yield and dry matter percent were 24.396ton ha^{-1}, 5.652ton ha^{-1} and 23.262% respectively exhibited by the treatment of 40cm row spacing, while the treatment of 20cm row spacing gave minimum values of their traits were 8.735ton ha^{-1}, 1.600ton ha^{-1} and 18.415 % respectively. Fresh and dry fodder yield increased by increasing the space between rows because of the competition for nutrients, space, light, and water among plants. This result agrees with the previous result of [12], which reported that foliage yield generally increased with an increase in row spacing and also agrees with the results of previous research, which confirmed that fodder dry matter yields decrease by 12.0 t ha^{-1} and 9.3 t ha^{-1} as row spacing was narrowed from 80 to 40cm [13]. On the other hand, our result disagrees with previous results of [14], who reported that the decreasing row spacing progressively promotes the dry matter yield; maximum DMY was recorded at 12cm row spacing than 46cm row spacing at succeeding growth stages, also [15]. Revealed that increased row spacing significantly reduced DM yield, which averaged from 14.094 kg ha^{-1} at 25cm row spacing to 9.135 kg ha^{-1} at 75cm row spacing.

Table (1): Effect of Row Spacing on Fodder Yield and Dry Matter Percent

Row Spacing	Green Fodder Yield (Ton ha^{-1})	Dry Fodder Yield (Ton ha^{-1})	Dry Matter %
20cm	8.735	1.600	18.415
30cm	18.099	4.417	22.405
40cm	24.396	5.652	23.262
LSD (P≤0.05)	1.963	0.379	1.552

The data represented in Table 2 showed that the effect of clipping stages on fodder yield characters was significant for all characters. Green, dry fodder yield and dry matter percent gave maximum value at the full flowering stage were 20.585ton ha^{-1}, 4.864ton ha^{-1}, and 22.311% respectively, while at the tillering stage recorded minimum values of green fodder yield 13.568ton ha^{-1}, dry fodder yield 2.916ton $ha^{-1,}$ and dry matter 20.410%. This increase in fodder yield at the flowering stage compared to the tillering stage is due to elongation during the growth period. Similar results were obtained previously by [16], who confirmed that the highest dry matter percentage was recorded by cutting at the 50% heading stage as compared to the pre-booting stage.

Also, previous results showed that the dry matter yield significantly increased at advanced harvest stages [17].

Table (2): Effect of Clipping Stages on Fodder Yield and Dry Matter Percent

Clipping Stages	Green Fodder Yield (Ton ha^{-1})	Dry Fodder Yield (Ton ha^{-1})	Dry Matter %
Clip at Tillering Stage	13.568	2.916	20.410
Clip at Flowering Stage	20.585	4.864	22.311
LSD (P≤0.05)	3.483	0.608	1.151

Table 3 indicates that the effect of row spacing on all fodder yield attributes of berseem clover was significant, except dry leaf percent, which was not significant. A 20cm space between rows gave maximum values of fresh leaf percent, fresh leaf/stem ratio, and dry leaf/stem ratio were 43.769, 0.793and 1.125, respectively. However, fresh and dry stem percent gave the maximum values in 40cm row spacing were 67.875 and 14.735 commonly, while the minimum values for fresh leaf percent 32.125, fresh leaf/stem ratio 0.478 and dry leaf/stem ratio0.579 recorded in 40cm row spacing, but for dry stem percent the minimum value was 8.792 obtained by the treatment of 20cm row spacing. This decreasing in fresh leaf percent, fresh leaf/stem ratio and dry leaf/stem ratio was shown with increasing spacing from 20 to 40 cm in contrast with fresh stem percent and dry stem percent which increased by increasing spacing from 20 to 40 cm, this in agreement with the previous study, [18] reported a decreasing trend of fresh and dry leaf yield and fresh biomass yield with increasing spacing from 30 to 60 cm for Japanese mint. Also agree with the other research indicated that the forage yield component changed among spacings was plant density, which increased with spacing reduction [19].

Table (3): Effect of Row Spacing on Fodder Yield Attributes of Berseem Clover

Row Spacing	Fresh Leaf %	Fresh Stem %	Fresh Leaf/ Stem ratio	Dry Leaf %	Dry stem %	Dry Leaf/ Stem ratio
20cm	43.769	56.231	0.793	9.624	8.792	1.125
30cm	39.192	60.809	0.712	10.132	12.273	0.976
40cm	32.125	67.875	0.478	8.527	14.735	0.579
LSD (P≤0.05)	5.315	5.310	0.221	N.S	1.467	0.351

Table 4 illustrates that the influence of clipping stages on fodder yield components of berseem clover was not significant for all characters except dry stem percent, which was significant. The whole flowering stage, 13.089, obtained a considerable value of

dry stem percent. The minimum value of this trait was 10.778, exhibited by clipping at the tillering stage. The decrease in these yield components could be due to a reduction in the amount of energy captured in photosynthesis, especially for a shorter regrowth [20].

Table (4): Effect of Clipping Stages on Fodder Yield Attributes of Berseem Clover

Clipping Stages	Fresh Leaf %	Fresh Stem %	Fresh Leaf/ Stem ratio	Dry Leaf %	Dry stem %	Dry Leaf/ Stem ratio
Clip at Tillering Stage	40.886	59.114	0.735	9.632	10.778	0.993
Clip at Flowering Stage	35.837	64.163	0.587	9.222	13.089	0.794
LSD (P≤0.05)	N.S	N.S	N.S	N.S	1.335	N.S

Results of Table 5 explain the effect of row spacing on yield traits of berseem clover, which was significant for all traits except harvest index, which was not significant. The maximum biological, pod, seed, and straw yields were 11.809, 3.358, 1.780, and 10.028 ton ha^{-1} exhibited by the treatment of 20cm row spacing, while the treatment of 40cm space between rows gave minimum values of biological, pod, seed, and straw yield were 3.656, 1.101, 0.514, and 3.142ton ha^{-1}, frequently. Row spacing had no effect on harvest index this result similar with the result of [13], but when the space between rows increased from 20 to 40 cm the biological, pod, seed and strow yield decreased due to competition among plants, this agrees with the previous result of [21] who reported that row spacing of 30 and 60 cm had the highest and lowest biological yield respectively. Row spacing of 30cm had the maximum biological yield due to consistent distribution of plants; the reduced biological yield at row spacing of 60 cm can be attributed to competition among plants, limitation in available moisture, and nutrients to the soil.

Table (5): Effect of Row Spacing on Seed Yield Traits

Row Spacing	Biological yield (ton ha^{-1})	Pod Yield (ton ha^{-1})	Seed Yield (ton ha^{-1})	Straw Yield (ton ha^{-1})	Harvest Index %
20cm	11.809	3.358	1.780	10.028	16.3%
30cm	6.177	1.675	0.894	5.283	14.5%
40cm	3.656	1.101	0.514	3.142	14.0%
LSD (P≤0.05)	1.965	0.718	0.662	2.425	N.S

Table 6 showed that the effect of clipping stages on fodder yield was significant for all characters except pod yield, which was not significant. The biggest values of

biological, seed, straw yield, and harvest index obtained by no clipping were 8.041ton ha^{-1}, 1.346ton ha^{-1}, 7.161ton $ha^{-1,}$ and 16.7% respectively, while the lowest values for biological and straw yield were 6.042 and 5.080 ton ha^{-1} respectively, exhibited by clipping at the complete flowering stage. However, for seed yield and harvest index were 0.880ton ha^{-1} and 11.5% respectively, recorded by no clipping (control treatment). Regarding harvest index, the highest value, 17.0% was recorded when the plant was clipped at the tillering stage, and the control treatment gave the lowest harvest index, 11.5%. Previously, [9] reported that the Egyptian clover was frequently cut for fodder, leading to a decline in seed yield. Also, [22] indicated that the crop without harvesting gave the highest yield in comparison to when harvesting was done.

Table (6): Effect of Clipping Stages on Seed Yield Traits

Clipping Stages	Biological yield (ton ha^{-1})	Pod Yield (ton ha^{-1})	Seed Yield (ton ha^{-1})	Straw Yield (ton ha^{-1})	Harvest Index%
No Clipping	8.041	2.286	1.346	7.161	11.5
Clip at Tillering Stage	7.558	2.134	0.880	6.212	17.0
Clip at Flowering Stage	6.042	1.713	0.962	5.08	16.7
LSD (P≤0.05)	1.526	N.S	0.344	1.593	0.046

Table 7 illustrates that the effect of row spacing on nutritional values of berseem clover was significant for all characters except phosphorus, which was not significant. Maximum values for protein, fat, ash, and potassium percent were 27.810, 4.608, 14.428, and 1.969 and respectively, exhibited by the treatment of 20 cm row spacing. In comparison, the treatment of 30cm and 40 cm row spacing gave the maximum values for calcium were 1.493% and for fiber were 19.598% respectively. On the other hand, all characters gave minimum values at 40cm of row spacing, except fiber had the minimum values at 20cm row spacing was 14.528%, This result agrees with the results of previous research, which found that row spacing narrowed from 80 to 40 cm. Crud P yield increased from 13.0 to 20.6 kg/ha [13].

Table (7): Effect of Row Spacing on Nutritional Value of Berseem Clover

Row Spacing	Protein %	Fiber %	Fat %	Ash %	Ca %	K %	P %
20cm	27.810	14.528	4.608	14.428	1.311	1.969	0.055
30cm	22.078	17.573	3.700	11.735	1.493	1.568	0.044
40cm	18.035	19.598	2.915	8.505	1.192	1.280	0.041
LSD(P≤0.05)	2.098	1.187	0.101	0.608	0.176	0.101	N.S

Table 8 showed that the effect of clipping stages on nutritional value was significant for all characters except phosphorus and calcium percent, which were not significant. Protein, fat, ash, and potassium had the most significant percent when clipped at the tillering stage, 23.493%, 4.027%, 12.285%, and 1.747% respectively, while fiber gave the most significant percent at the whole flowering stage was 18.172%. However, the lowest values of protein, fat, ash, and potassium were recorded at the full flowering stage were 21.788%, 3.455%, 10.827%, and 1.464%, respectively. Fiber had the lowest percent at the tillering stage was 16.293%. This indicates that forage leaves contain considerably more protein and less fiber than the stems, so as forage matures and the stems become more prevalent and fibrous, the quality decreases**.** This result agrees with the result of [23].

Table (8): Effect of Clipping Stages on Nutritional Value of Berseem Clover

Clipping Stages	Pro-tein %	Fiber %	Fat %	Ash %	Ca%	K %	P%
Clip at Tillering Stage	23.493	16.293	4.027	12.285	1.364	1.747	0.046
Clip at Flowering Stage	21.788	18.172	3.455	10.827	1.300	1.464	0.046
LSD(P≤0.05)	1.094	0.907	0.132	1.233	N.S	0.121	N.S

From the results of this investigation, it was concluded that the effects of row spacing and clipping stages were significant on most traits of fodder yield, seed yield, and nutritional quality. By increasing the space between rows from 20cm to 40 cm, fodder yield and dry matter percent increased, but most fodder yield attributes, all seed yield traits, and nutritional values were decreased, except fiber percent increased by increasing row spacing. Concerning clipping stages, when the plant was clipped at the flowering stage, fodder yield, dry matter, and dry stem percent increased, while all nutritional values or quality were decreased except fiber percent, which was increased at the flowering stage in comparison to the tillering stage. Meanwhile, no clip or control treatment recorded maximum values of all seed yield traits.

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