Yield and quality responses of Egyptian clover (Trifolium alexandrinum L.) to changing sowing time and cutting intervals

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Research Article

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Abstract

Egyptian clover (*Trifolium alexandrinum* L.) is valued for its excellent forage quality and ratooning capacity, especially as a winter fodder crop. This study examined the effects of sowing dates and cutting intervals on the yield and quality of Egyptian clover. The experiment was conducted at the University of Agriculture, Faisalabad, using a randomized complete block design (RCBD) with a split-plot layout and three replicates. Two factors were studied: sowing dates (D1 = 16 October, D2 = 31 October, D3 = 15 November) and cutting intervals (C1 = 60 days after sowing (DAS), C2 = 75 DAS, C3 = 90 DAS). Sowing dates were kept in main plots while the cutting interval were in subplots. Statistical analysis was performed using Fisher's analysis of variance, and significant differences were evaluated with the LSD test at 5% probability using Statistix (v8.1) software. Results indicated that the highest plant population (164), plant height (84.3 cm), green forage yield (50.03 t ha^{-1}), and dry matter percentage (33.47%) were achieved in plots sown on 16th -31st October and harvested at 90 DAS (D1C3), whereas a decline in quality was observed when harvesting was done at 90 DAS. A balanced forage yield and quality was observed when harvesting was done 75 DAS. Based on these findings, sowing Egyptian clover in Mid-end October and harvesting at 75 DAS is recommended to optimize both forage yield and nutritional quality.

1. Introduction

Forages serve as an essential feed and valuable energy source for livestock preservation. The economic survey of Pakistan in 2023-24 highlighted that forage production contributed around 14% to the country's gross domestic product and 60% to the agricultural sector [1]. For livestock, forages are considered a cost-effective and highly nutritious source of nutrition [2]. However, the irregular and unpredictable availability of forage poses significant health challenges for livestock in our country, particularly issues related to malnutrition [3, 4]. In Pakistan, two main periods of fodder shortage are observed: the first from October to November during winter and the second from May to June in summer [5, 6]. The forage deficit can arise due to several factors, among which limited land, soil nutrients imbalances, insufficient water supply, unsuitable varieties of plants, and extreme climatic condition are included [7–10]. However, lack of knowledge amongst farmers regarding the techniques of producing, utilizing, and conserving forage production can escalate the problem even more.

Egyptian clover, introduced first to Egypt in the sixth century, eventually spread into India in the nineteenth century [11, 12] is one of the chief feed sources for livestock. This versatile crop is grown both as a pure crop and as a mixed crop in semi-arid regions of the world predominantly in Southeast Asia because of its superior quality [13, 14]. Due to its advantages such as being multi-cut, highly productive, highly nutritious [15] and adapted to a range a soils, Egyptian clover is the predominant legume fodder crop in Southeast Asia [13, 14]. Egyptian clover holds great importance as one of the significant leguminous forage crops [16] and plays a crucial role in improving the physical characteristics of the soil, enhancing soil fertility, and offering feed that contains higher levels of protein compared to grass species [17].

Out of total cultivated area of Pakistan, only 10% which is approximately 2.0 million hectares serve for fodder production [1]. In Pakistan's irrigated regions, Egyptian clover is recognized as the most nutritious winter fodder crop [18–20]. Given the substantial livestock population in Pakistan, there is a high demand for a consistent source of fresh feed [21, 22]. However, the low production of feed and its scarcity pose significant challenges to livestock rearing in Pakistan, leading to reduced animal productivity. Therefore, it is crucial to ensure the availability of sufficient quantities of high-quality feed to enhance animal output [23]. In Pakistan, Egyptian clover is known for its ability to provide lush and juicy fodder. Reports indicate that the dry matter (DM) content in Egyptian clover can exceed 20%, with young plants showing an increase to approximately 10.2% after the third cut [24]. Increased temperature due to climate change has significantly affected the crop sowing especial during winter season as sowing time for has been extended to 10th December which was previously 20th November [25]. Mohamed, Bakheit [26] has reported different seed yield of Egyptian clover due to temperature changes on sowing dates. Effects of changing sowing dates on Egyptian clover yield have also been reported [27]. Egyptian clover and wheat have same season of sowing, therefore, current research was planned with the hypothesis that increasing temperature will affect the sowing time and cutting interval in Egyptian clover. Our current research focused on evaluating the best combination of sowing time and harvesting date for the enhanced forage yield and quality of Egyptian clover and to analyse the nutritional quality of Egyptian clover under varying sowing dates and cutting intervals.

2. Materials and methods

2.1. Description of the experiment

Field experiment regarding the effect of different sowing time and cutting intervals on forage yield and quality of Egyptian clover was conducted at Student Research Farm, Department of Agronomy, University of Agriculture, Faisalabad (C3RF + 2W7, Sarfraz Colony Rd), during the winter season 2022-23. Location map of the farm is given in Fig. 1. Egyptian clover (cv Anmol) was cultivated with a seed rate of 20 kg ha^{-1} by following randomized complete block design with split plot arrangement having sowing dates in main plots (4m×7m) and their cutting time in subplots. Space between plots was 0.5m while the space between replications was 1m. Seeds were collected from Ayub Agricultural Research Institute, Faisalabad (longitude 73º74 East, latitude 30º31.5 North). The experiment was comprised of two factors; sowing dates in main plot (D1 = 16 October, 31 October, 15 November) and cutting time in sub-plot (C1 = 60 days after sowing (DAS), 75 DAS, 90 DAS). The treatment combinations used were D1C1, D1C2, D1C3, D2C1, D2C2, D2C3, D3C1, D3C2 and D3C3. Recommended dose of fertilizer @ 32 kg N ha^{-1} and 87 kg P ha^{-1} was applied uniformly at all the experimental plots [25].

2.2. Crop harvesting stage according to sowing and cutting interval

Crop sown on 16th October was harvested at 16th December (C1), 31st December (C2) and 15th January (C3). Crop sown on 31st October was harvested at 31st December (C1), 15th January (C2) and 30th January (C3). Similarly, crop sown on 15th November was harvested at 15th January (C1), 30th January (C2) and 15th February (C3). The growth stages of Egyptian clover at C1, C2 and C3 were pre-flowering (vegetative stage), flowering stage and seed development stage, respectively.

2.3. Procedures to record observations

Plots were harvested (single cut) according to the cutting plan (C1, C2, C3) manually with the help of sickle and data for plant height was measured using reassuring rod while the plant weights are recorded by using electronic balance. Whereas recommended procedures for crude proteins [28], total ash [29] and fiber [30] were followed. Dry matter percentage (DMP) of 1kg fresh sample was calculated after complete sun drying the sample followed by oven drying, whereas dry forage yield (DFY) was calculated using DMP and fresh forage yield (FFY) as per given formulae

$$\mathrm{DMP} = \frac{\text{Dry weight of the sample}}{\text{Fresh weight of the sample}} \times 100$$

$$\mathrm{DFY} = \mathrm{DMP} \times \mathrm{FFY}$$

2.4. Statistical analysis

The acquired data on growth, yields, and quality features will be statistically analysed using Fisher's analysis of variance technique. The statistical significance of the findings was assessed using a 5% level of significance by using linear model. The means of various treatments were compared and evaluated using the LSD (Least Significant Difference) test with the help of Statistix (v8.1) software. This test is useful for spotting substantial variations between the treatment means [31].

3. Results

3.1. Agronomic parameters

Sowing dates and cutting intervals significantly influenced the agronomic performance of Egyptian clover, including plant population, plant height, fresh and dry weight plant^{-1}, and forage yield. The highest plant population (164) and plant height (84.3 cm) were recorded in plots sown on October 16 with a 90 DAS cutting interval (D1C3), however treatment combination D1C2 was at par with D1C3. The lowest plant population (162) and height (82.3 cm) were recorded for the plots sown on November 15 with a cutting interval of 60 DAS (D3C1).

Fresh and dry weight per plant was in the same trend. Maximum values were recorded in D1C3, followed by D1C2. On the other hand, the lowest fresh and dry weight per plant was observed in D3C1. This indicates that early sowing and longer cutting intervals promote biomass accumulation in Egyptian clover. The highest yields of fresh (50.0 t ha^{-1}, 47.8 t ha^{-1}) and dry forage (15.1 t ha^{-1}, 14.4 t ha^{-1}) were achieved in D1C3 and D1C2 which were statistically similar to each other with minimum yields (39.9 t ha^{-1}, 9.83 t ha^{-1}) recorded from D3C1. The results showed that early sowing as well as timely cutting intervals was important for maximum productivity of forages.

3.2. Biochemical parameters

The crude protein, crude fiber, total ash, and dry matter percentage of Egyptian clover were significantly affected by the treatments. The maximum crude protein content (20.4%) was observed in D1C2 (16 October sowing × 75 DAS cutting interval), followed by D1C1 (16 October sowing × 60 DAS cutting interval). The minimum crude protein content (19.1%) was recorded in D2C1 (31 October sowing × 60 DAS cutting interval).

The crude fiber content (22.4%) was maximum in D1C2 followed by D1C1, while the minimum value (21.1%) was recorded in D2C1. The total ash content, indicating mineral density, also achieved its maximum (15.4%) in D1C2 followed by D1C1, and the lowest values (14.1%) were seen in D2C1. Dry matter percentage followed a similar trend where superior results were achieved due to early sowing and longer cutting intervals, as compared to later dates of sowing and shorter intervals. These results show that the optimal time for sowing is early, and more importantly, on October 16 with a 75 DAS cutting interval. Agronomic and biochemical parameters of Egyptian clover are therefore optimized to produce high-yielding, nutritionally rich forage.

3.3. Corelation and principal component analysis (PCA)

The correlation matrix (Fig. 6) illustrates the interrelation among key agronomic and quality traits of Egyptian clover. There is strong positive correlation between FFY and PH, FPW, and DFY, suggesting that the larger plants with greater biomass contribute to the most significant forage yield. Crude protein is in perfect correlation with crude fiber, thus illustrating their direct association. Dry matter percentage is moderately correlated with DFY and, therefore, an important determinant of forage quality. Other traits, including PH and the number of leaves, are significantly positively associated with yield components and highlight the role of these traits in optimizing production. The correlations calculated here underscore the interdependence of yield and quality traits and provide insights into breeding and management strategies to improve forage performance.

The PCA biplots (Fig. 7) show that sowing dates and cutting intervals greatly influence the agronomic and biochemical parameters of Egyptian clover, with PC1 and PC2 jointly explaining 88.7% of the variability. Early sowing on 16 October (D1) exhibited higher performance through all the traits, plant height, fresh and dry biomass, and crude protein content, whereas delayed sowing (D3) led to less than optimum growth and yield. Extended cutting intervals (C3, 90 DAS) were significantly related to increased crude protein, dry matter percentage, and forage yield, whereas frequent cutting (C1, 60 DAS) decreased these traits. These results point out that the interaction between early sowing and extended regrowth periods maximizes both yield and quality parameters in Egyptian clover.

4. Discussion

4.1. Agronomic parameters

Emergence count, one of the most important seed viability and germination success indicators, was significantly affected by sowing dates and cutting intervals. The highest emergence count was obtained for the mid-October sowing treatments, which might have provided optimal environmental conditions during seed germination and early seedling growth, including moderate temperature and adequate soil moisture. Amato, Giambalvo [32] and Giambalvo, Amato [33] have also reported similar responses in semi-arid environments.

Fresh and dry plant weights are, among the most important indicators of biomass accumulation, an indicator of such accumulation. The treatments sown in mid-October with longer intervals between cuts showed maximum weight. Early sowing ensured favourable conditions for initial growth and adequate periods between cuts to allow regrowth and biomass recovery and accumulation. These results are in agreement with the findings of [34] and [35] as they clearly pointed out that optimal sowing and cutting intervals were the keys to attaining maximum vegetative growth.

The same highest plant population and height was also observed in the sowing treatment of mid-October with more frequent cutting intervals that promoted lateral branching and regrowth. Optimal environment at sowing and growth stage of the plants provided with proper root establishment, nutrient uptake and increased plant height and density. The findings were also in accordance with Musa, Gondal [36] who reported to have attained higher plant density with enhanced plant height following better harvest management for Egyptian clover.

Both fresh and dry forage yields of Egyptian clover were significantly maximum with mid-October sowing and delaying the harvesting time. Long harvesting intervals resulted in increased growth periods because of which plants accumulated greater biomass before the first cut and adequate recovery time between cuts, which allowed for more accumulation of forage [37].

4.2. Quality parameters

Crude protein content is an important index for the assessment of forage nutritional quality. It was maximum with mid-October sowing treatments at intermediate intervals of cutting. Early sowing ensured a favourable growth climate, whereas timely cutting assured harvests at growth stages with active protein synthesis. Similar observations were presented by Singh, Singh [38] and Mala and Fadlala [39], who documented the influence of cutting stage on the protein contents in leguminous forages. Crude fiber content as an indicator of structural parts of plants increases with higher growth periods before harvesting, as maturation raises lignification and leads to greater accumulation of fiber. Similarly, Temel and Yolcu [40] stated that delayed harvest leads to higher fiber contents in forage crops. The ash content of the forage would have been maximized when those sown were at their maximum during the middle period of October. Better periods for longer growth phases and richness in soil will help build higher ash contents. In fact, the claim made here could be supported with evidence found [41]. Current results confirmed the crucial role of optimized sowing dates and cutting time for in enhancing both agronomic and biochemical traits of Egyptian clover.

5. Conclusion

This study highlights the significance of timely sowing and proper cutting schedules for maximum yield and nutritionally adequate Egyptian clover. Sowing on October 16 with a 75 DAS cutting interval (D1C2) produced the maximum plant population (164) and plant height (84.3 cm) which increased the fresh (50 t ha^{-1}) and dry forage yield (14.4 t ha^{-1}) consistently. Same treatment also enhanced the biochemical parameters, crude protein (20.4%), crude fiber (22.4%), total ash (15.4%), and dry matter percentage (33.4%), which reflects the better forage quality too. In contrast, delaying the sowing dates and shortening the cutting intervals lowered the forage productivity and quality. Sowing Egyptian clover in Mid-end October and harvesting it 75 DAS can be suggested for the forage scientists to evaluate it for further dynamics and farmers can also manage Egyptian clover for improving both yield and quality.

Declarations

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Contributions

FU: Conducted the research trial and recorded the data. AI: Provided the supervision and guidelines during research period. MAS: Helped in data analysis and writing the research paper, corresponding author

Authorship

The corresponding author needs to confirm they have read the journal policies and is submitting their manuscript in accordance with those policies

Corresponding author

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Ethics declarations

Conflict of interests

There is no conflict of interest among the authors

Plant guidelines

The authors confirm that the use of plants in the present study complies with international, national and/or institutional guidelines.

Permissions to collect the plants/plant parts

All plant specimens collected with permissions of Department of Agronomy, University of Agriculture, Faisalabad.

Source of the plant used in study

Seeds were collected from Ayub Agricultural Research Institute, Faisalabad, as described in materials and methods section.

Data availability statement

The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request

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Figures

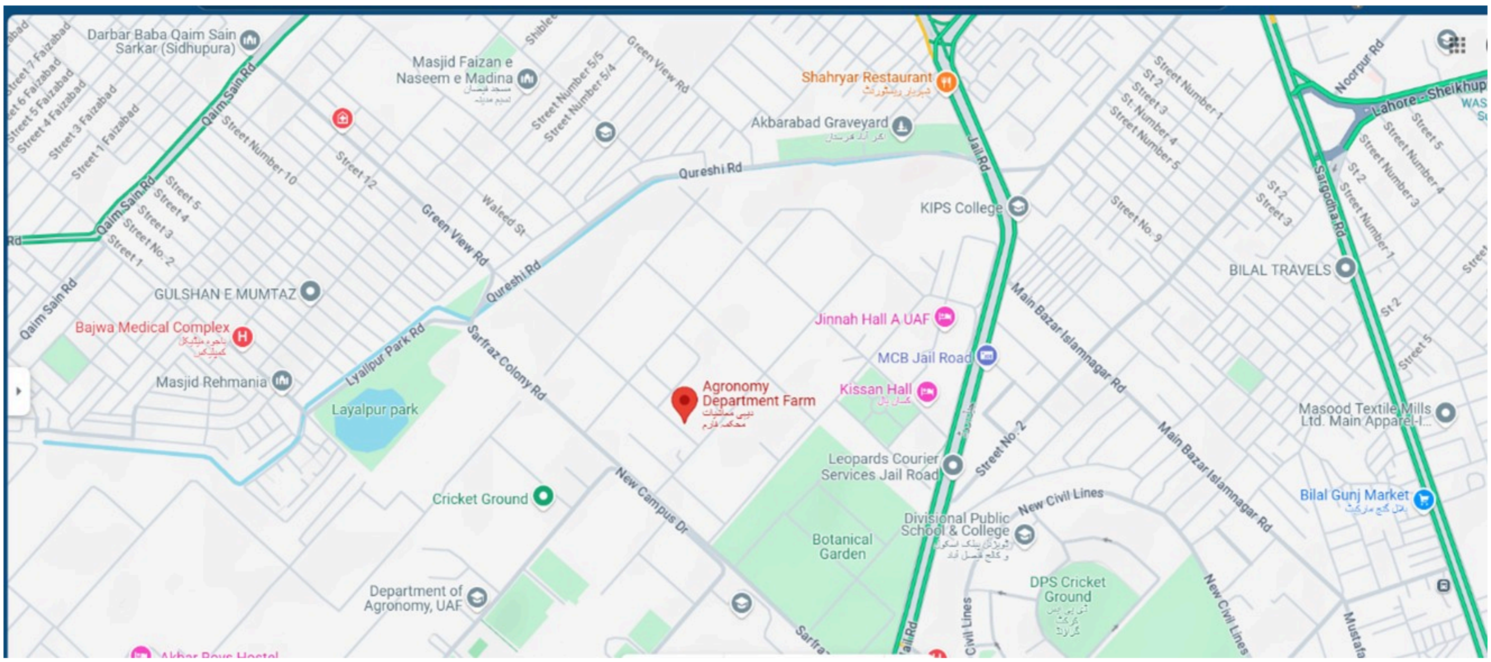

Figure 1

Location map of the experimental site

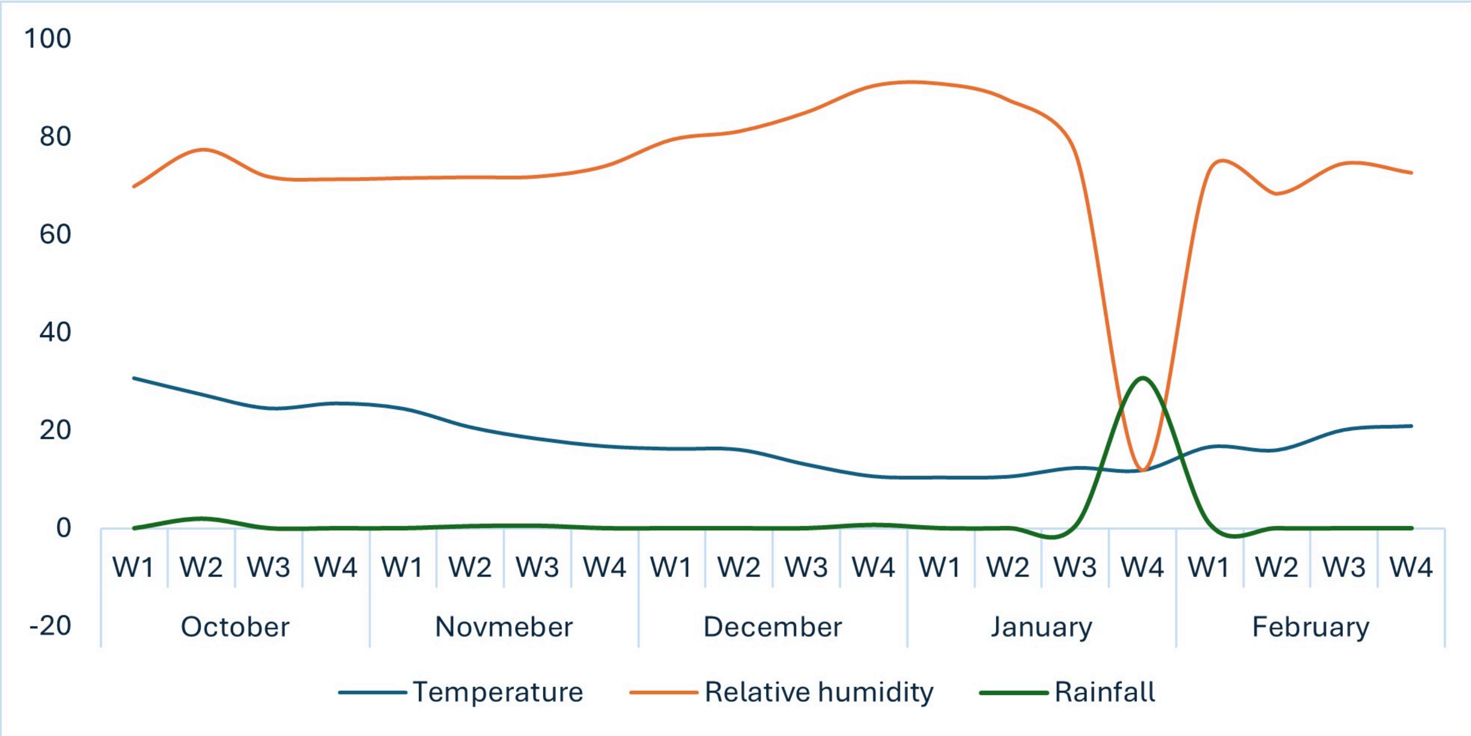

Figure 2

Graph showing weather data during the experiment period, where October, November and December belong to 2022 while January and February to 2023. W1= first week, W2= second week, W3= third week, W4= fourth week of each month

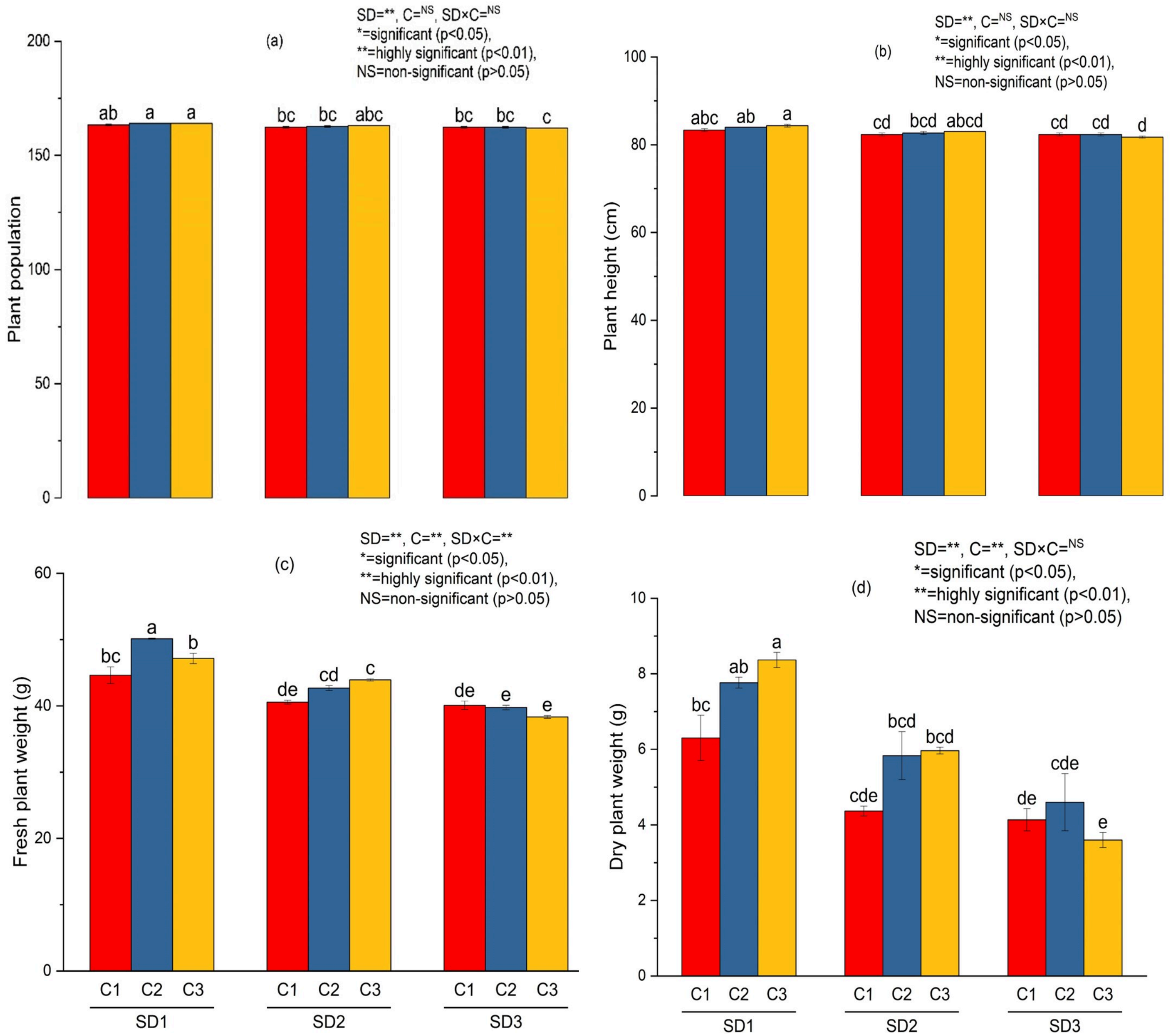

Figure 3

Plant population (a) and plant height (b) fresh weight per plant (c) and dry weight per plant (d) of Egyptian clover (Trifolium alexandrinum L.) in response to different sowing times (SD1=, Sowing on 16th October, SD2= Sowing on 31st October, SD3= Sowing on 15th November) and cutting intervals (C1=,60 DAS, C2=75 DAS, C3=90 DAS)

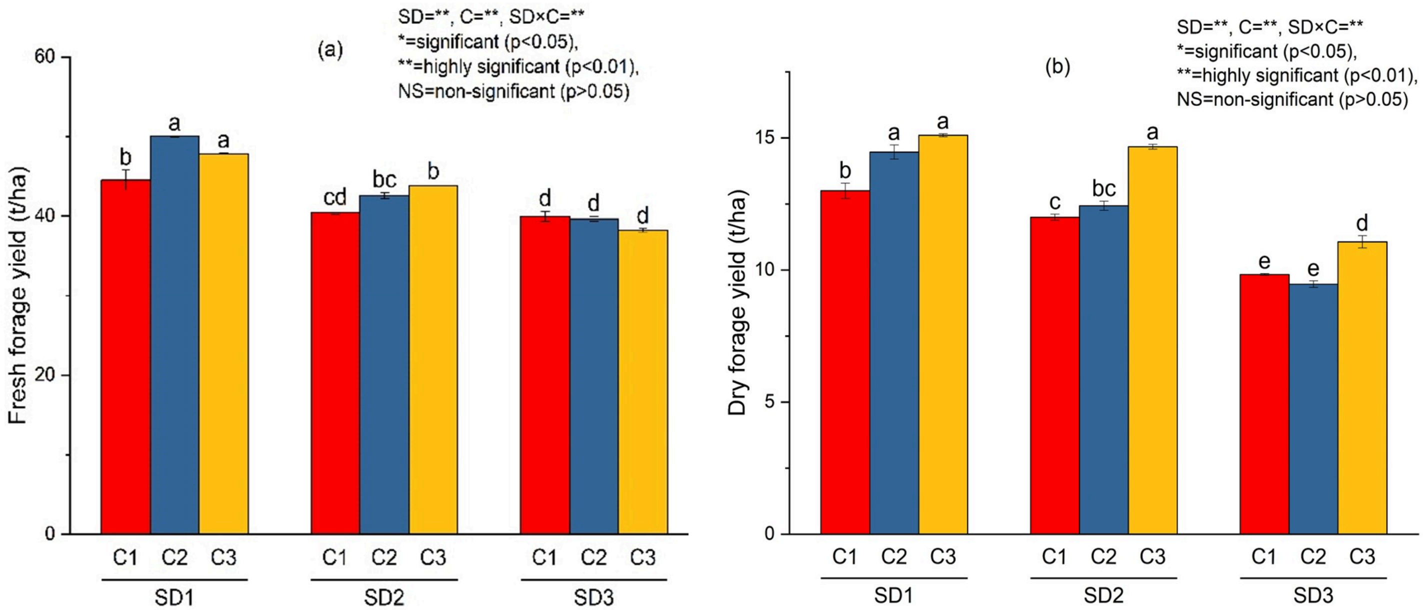

Figure 4

Fresh forage yield (a) and dry forage yield (b) of Egyptian clover (Trifolium alexandrinum L.) in response to different sowing times (SD1=, Sowing on 16th October, SD2= Sowing on 31st October, SD3= Sowing on 15th November) and cutting intervals (C1=,60 DAS, C2=75 DAS, C3=90 DAS)

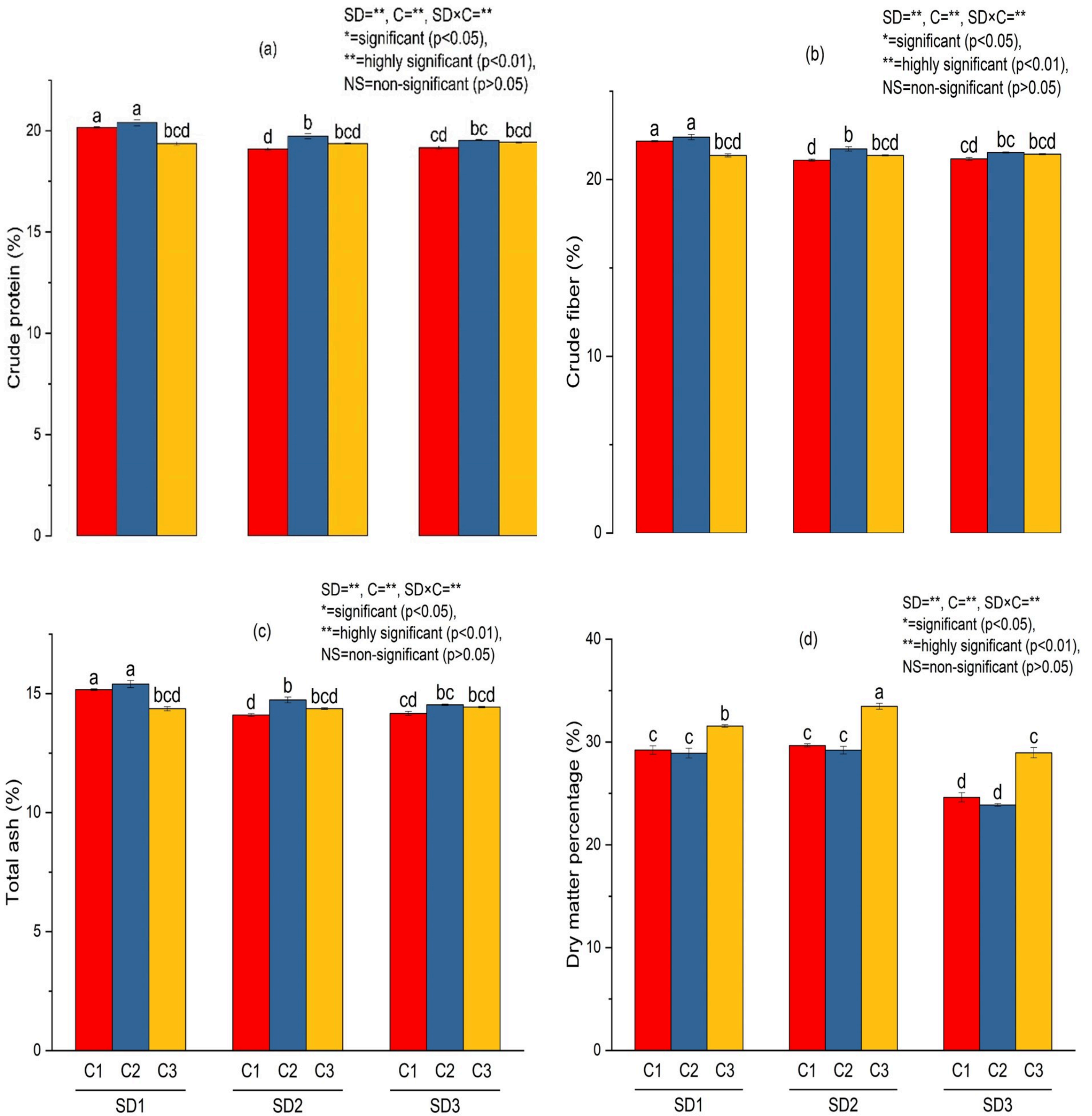

Figure 5

Crude proteins (a) crude fiber (b) total ash (c) and dry matter percentage (d) of Egyptian clover (Trifolium alexandrinum L.) in response to different sowing times (SD1=, Sowing on 16th October, SD2= Sowing on 31st October, SD3= Sowing on 15th November) and cutting intervals (C1=,60 DAS, C2=75 DAS, C3=90 DAS)

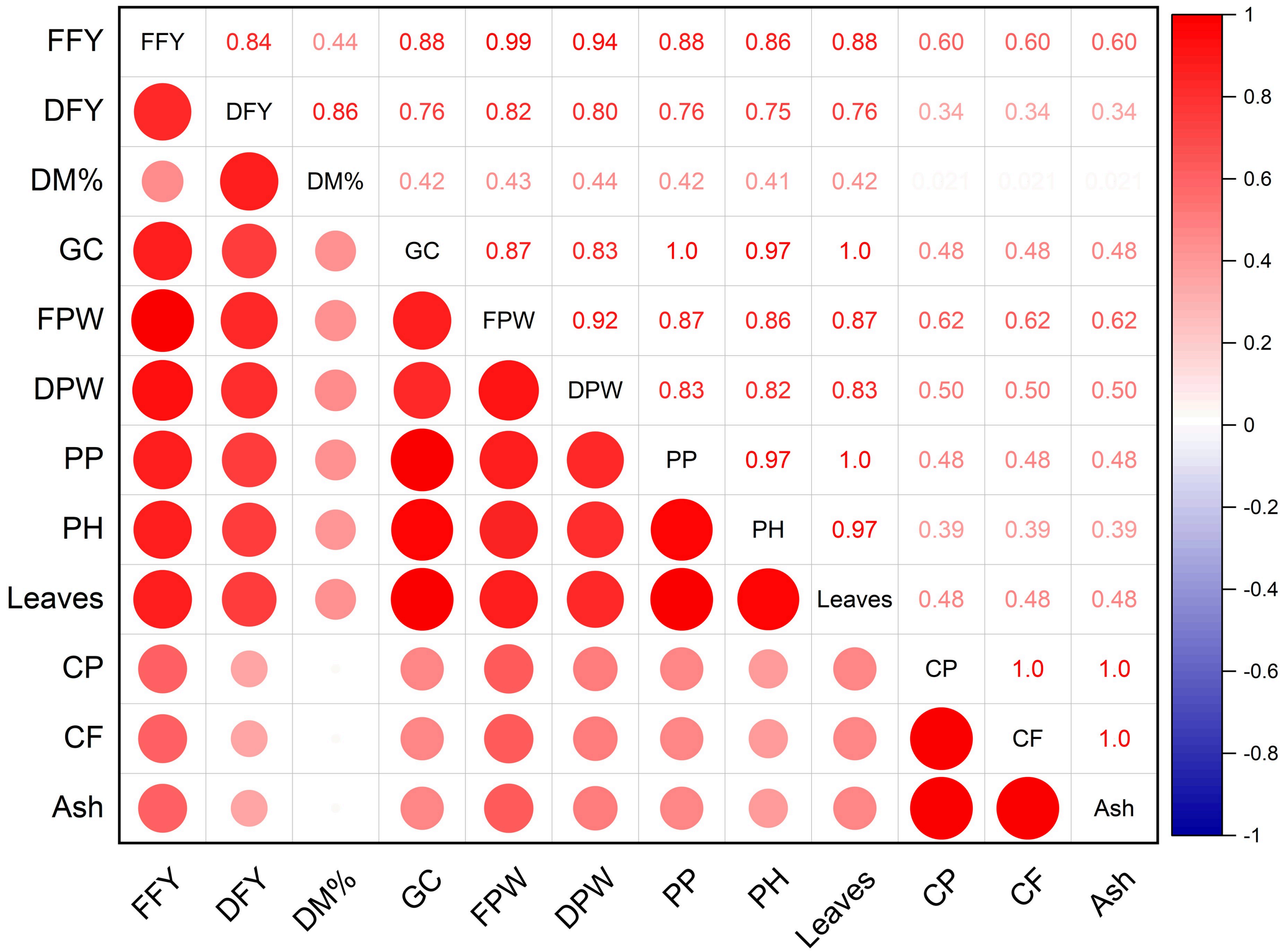

Figure 6

Corelation analysis of different attributes of Egyptian clover under varying sowing dates and cutting times

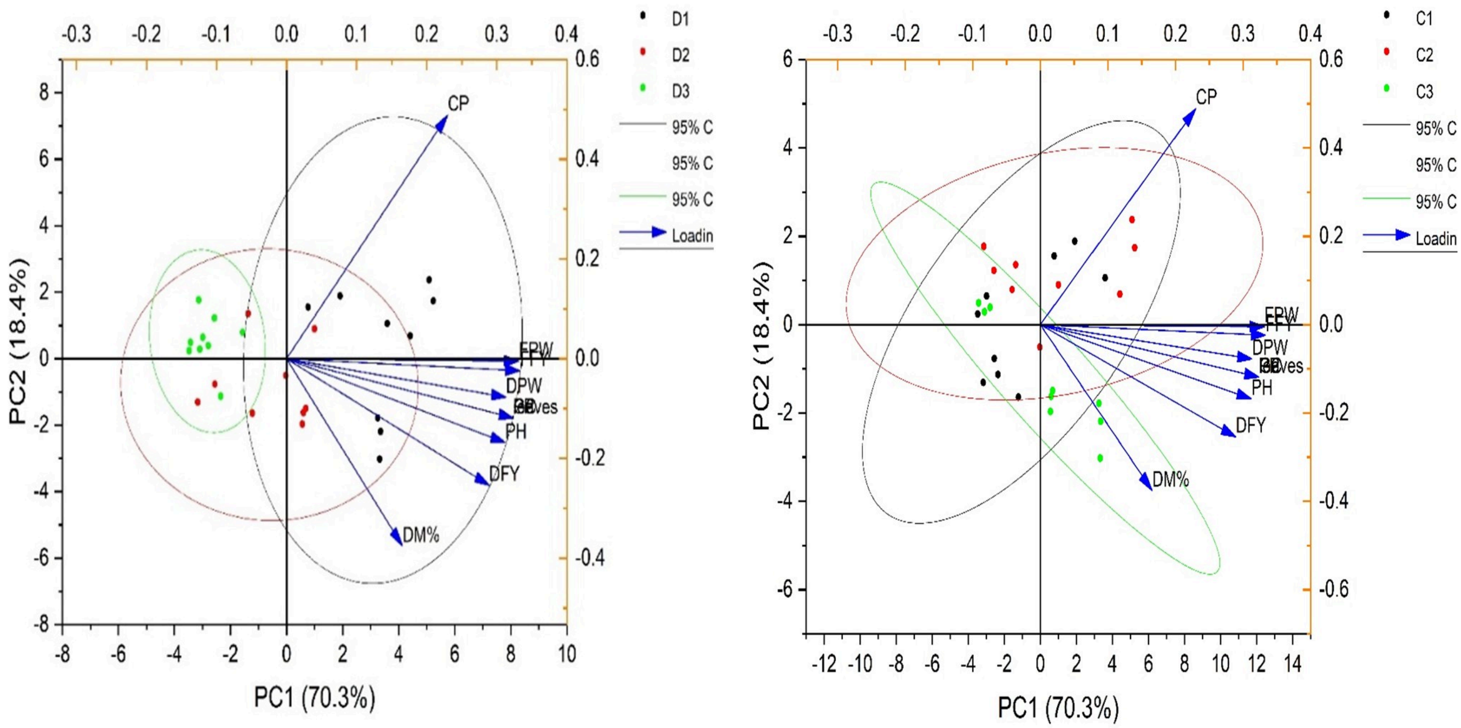

Figure 7

Pricipal comopnent analysis of different attributes of Egyptian clover under varying sowing dates (left pannel) and cutting times (right pannel)