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Forage and Hay Yield Performance of Different Berseem Clover (*Trifolium alexandinum* L.) Genotypes in Mazandaran Conditions

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Abstract: In order to compare forage and hay yield performance of 10 berseem clover genotypes a complete randomized block design with four replications has been undertaken in 2003 and 2004. Samples of 500 g per plot were selected for measuring of dry weight and dry matter percentages of each cultivar. Fresh forage yield of cultivars were significantly different and cultivar Sacromonte by producing 30.80 t ha^{-1} in average has been ranked as the first high yielding cultivar position, so that, control cultivar, Karmel, showed as a low yielding cultivar in fresh yield production. With regard to dry weight production, there also were significantly differences among different genotypes. Genotype Sacromonte with 5.07 t ha^{-1} produced the highest dry weight mainly because of higher fresh yield production; however, results obtained from ratios of dry matter brought position of cultivar Sacromonte from first in fresh and dry weight to fifth in percentage of dry matter. Laura with 20.7% has produced highest percentage of dry matter.

Key words: Berseem clover, forage, hay, harvest management

INTRODUCTION

Forages which either directly or indirectly consumes by cattle and poultries play tremendous important roles in animal production. Medics and clovers including berseem clover (*Trifolium alexandinum* L.) have constituted backbone of forage production crops. Berseem clover as an annual leguminous forage species well adapted to semi-arid conditions of the Mediterranean areas (Iannucci *et al.*, 1996). Berseem clover which is also known as a cool season clover (Rethwish *et al.*, 2002), is grown in both spring and fall growing seasons as direct cropping, intercropping or in crop rotation with rice in Mazandaran province conditions. From last decade, interest in berseem clover has increased in north part of Iran for several reasons including crop rotation with rice as well as potentially increasing economic returns via the forage crop and/or nitrogen fixation and reducing fertilizer applications for subsequent crops (Graves *et al.*, 1996). Differences exist among berseem clover varieties in the amounts of nitrogen fixation per unit area (Williams *et al.*, 1990).

Most of recent research on berseem clover have focused on intercropping system with annual forage grasses. Berseem clover's behavior in intercropping system is one of attractive scientific findings of a number of researches (Fukai and Trenbath, 1993; Ghaffarzadeh, 1997; Holland and Brummer, 1999; Juskiw *et al.*, 2000a-c; Ross *et al.*, 2003, 2004a and b). By definition of potential benefits of intercropping berseem clover with cereal crops include increased total dry matter yields, improved forage quality, reduced fertilizer needs and increased subsequent crop yield researchers found berseem clover as one of suitable forage plant (Reynolds *et al.*, 1994; Ghaffarzadeh, 1997; Stout *et al.*, 1997).

Berseem clover cultivars also differ in number of harvests, with cultivars being grouped into three types: single cut, intermediate and multiple cut (Putnam *et al.*, 1999; Ross *et al.*, 2003). Harvest management is the agronomic factor that most affects plant physiology and the expression of the yield potential of a genotype. In fact, dry matter production and its partitioning in the plant organs depend on the phonological stage of development in which plants are cut (Iannucci *et al.*, 1996; Juskiw *et al.*, 2000a). Therefore, harvest management of berseem can be manipulated to redistribute yield and achieve forage quality goals without sacrificing stand persistence. Furthermore, the knowledge of growth patterns and productivity under different cutting regimes of primary importance in the berseem breeding programs (Iannucci *et al.*, 1996; Juskiw *et al.*, 2000a). Variety trials conducted in California had resulted in complicated results in stand establishment and growth, with large differences between varieties noted for nodulation and other factors (Rethwish and Graves, 2000; Ross *et al.*, 2004b). Present study is going to examine berseem clover genotypes for finding a more suitable cultivar than commonly grown cultivar Karmel.

MATERIALS AND METHODS

Ten genotypes of berseem clover namely Karmel, Ecotypes A and B, Actanone, Tabor, Sacromonte, Saidi, Khadrawi, Miskawi and Laura from different origins have been tested to compare their yield performances in Mazandaran province experimental station of Iran. The applied experimental design was randomized complete block with four replications. Each experimental plot was considered to have an area equal to 6 m^2 (4×1.5) with 5 rows and 30 cm row intervals. Seed amount for sowing was calculated by 30 kg ha^{-1} which was formally recommended by Agricultural Department of Mazandaran, so that, 18 g $plot^{-1}$ seeds were necessary. Prior to planting and after preparation of seed bed 50 kg ha^{-1} urea fertilizer and 200 kg ha^{-1} ammonium phosphate fertilizer were added on the experimental area. Harvest was conducted using a hand sickle mower. Because berseem clover genotypes are differential in their post harvest re-growth, plants were cut from 5-8 cm above ground height when flowering time is initiated. Each harvest were conducted from area of 2.7 m^2 (To measure yield of each plot precisely, one row from both sides and one meter from top and down of each plot were considered as guard area). Immediately after harvest of each plot, for preventing of humidity loses, fresh forage yield has been determined using a portable balance in corner of the experimental field. To determine forage dry weight a 500 g sample was dried from each plot using room temperature without direct exposure of sunshine. After several days when samples showed equal weight during three subsequent days, the obtained weight was considered as approximate dry weight. Percentage of dry matter production (% DM) of each treatment was calculated according to Eq. 1:

$$\% \text{ DM} = (\text{DW}/500) \times 100 \quad (1)$$

Where:

DW = Abbreviated for dry weight.

% DM = Percentage of dry matter.

The experiment was undertaken on a silt-loam soil with pH = 7.5 in Mazandaran province, Iran in fall growing seasons during 2003 and 2004. Statistical analysis on fresh and dry forage yield and their ratios have been done using MSTAT C statistical software. To analyze the variance characters of each year with four harvests were firstly analyzed and then a combined analysis with two years and four harvests have also been provided.

RESULTS AND DISCUSSION

Table 1 showed highly significant differences among different factors and their interactions for total fresh and dry yield performance and the percentage of dry yield.

Fresh yield performance (TF): Genotypes showed different fresh forage outcomes in two years of studies using combined analysis method. At all, data from fresh yield of year two in comparison with year one has demonstrated higher results in all three treatments (Table 1 and 2). Also, there were significantly variations among four cuts in both years. At all, first and especially second cuts were better than the other two cuts for fresh forage production (Table 3).

Harvests had various productions regarding total fresh yield. The first harvest produced more fresh forage yield than three other harvests in year 2003, however,

Table 1: Analysis of variance of fresh and dry weight of total, stem and leaf along with their ratios in 10 berseem clover's genotypes

		Mean square		
Source	df	TF	TD	% DM
Year (Y)	1	469.3**	121.1**	8227.1**
Error (a)	6	40.2	0.8	33.8
Genotype (E)	9	15.5**	0.6**	5.7^ns
E×Y	9	7.2**	0.4**	22.0**
Error (b)	54	0.4	0.1	11.4
Harvest (H)	3	432.8**	32.9**	2235.2**
E×H	27	4.9**	0.2**	5.7**
H×Y	3	690.8**	3.9**	878.9**
E×H×Y	27	2.2**	0.1**	3.9^ns
Error (c)	180	0.1	0.02	3.3

df = Degree of freedom, TF = Total Fresh yield, TD = Total Dry weight, % DM = Percentage of dry matter, **: Highly significant difference, ns = Non significant

Table 2: Mean squares of total fresh yield, total dry weight and percentage of dry matter production between two years

Years	TF (t ha^{-1})	TD (t ha^{-1})	% DM
2003	5.40	1.04	17.00
2004	7.97	1.16	14.88
Average	6.69	1.10	15.49
LSD (5%)	0.26	0.06	1.05
CV	8.48	11.79	13.11

TF= Total Fresh yield, TD = Total Dry weight, % DM = Percentage of dry matter

Table 3: Means squares of total fresh yield, total dry weight and percentage of dry matter production among four harvests in two years

	TF (t ha^{-1})			TD (t ha^{-1})			% DM		
Harvest	2003	2004	Av.	2003	2004	Av.	2003	2004	Av.
H1	10.71	1.76	6.23	1.43	0.24	0.84	12.98	13.00	12.99
H2	9.39	13.54	11.47	2.46	1.49	1.98	26.20	10.99	18.60
H3	0.94	10.66	5.80	0.25	1.81	1.03	26.20	16.69	21.45
H4	0.57	5.93	3.25	0.01	1.11	0.56	2.62	18.86	10.74
Total	21.61	31.89	26.75	4.15	4.65	4.40	68.00	59.54	63.78
LSD (5%)	0.37	0.43	0.26	0.17	0.05	0.08	0.46	1.47	0.72
CV	4.95	9.48	8.48	16.08	6.55	11.79	14.58	10.83	13.11

TF = Total fresh yield, TD= Total dry weight, % DM = Percentage of dry matter, H1 to 4 = Harvest 1 to 4 function of the second harvest was better than the other harvests in 2004. The main reason of lower yield of the first cut in second year was laid behind its harvesting sooner for promoting plant establishment. In Average of two years studies the second harvest by producing 11.47 t ha^{-1} fresh yield was higher than the other harvests (Table 3). It means that, as it was predictable, the second cut is vital for forage production of multi cuts plants. Similar rule is governed on alfalfa second harvest, too. Most of scientists and farmers believed that the first cut should be done sooner because of plant establishment. Cut four produced lower amount of fresh forage yield (Table 3).

Cultivar Sacromonte'in both years had significantly produced higher fresh forage yield than the rest genotypes including the control cultivar (Karmel). Furthermore, all genotypes were superior to control in year 2003, however, only four from 9 genotypes were superior to control genotype regarding to fresh yield in year 2004. Cultivar Sacromonte with yielding about 24.4 and 37.2 t ha^{-1} fresh yield in years 2003 and 2004, respectively was superior comparing other genotypes (Table 3). Fresh yield of check cultivar showed an increase from 18.1 to 33.0 t ha^{-1} which imply that environmental conditions of year 2004 was more suitable for forage production than year 2003. This additive trend of fresh yield production from year 2003 to 2004 is true for all genotypes included in present experiment. In average, Sacromonte and Laura with 30.80 and 23.80 t ha^{-1} were superior and inferior cultivars in present experiment and Karmel as most commonly grown cultivar with only 25.55 t ha^{-1} was stayed at step 7th of fresh yield production. Even in growing season of 2004 Karmel could not be stayed at higher step than 4th (Table 3).

Total dry weight (TD): Similar to total fresh yield, differences between years were significant and all the data from dry yield in year 2004 are significantly higher than year 2003 (Table 1 and 2). Also, there are significantly variations among four cuts in both years. In contrast with fresh yield, the second and especially third cuts produced higher total dry weight than the other two cuts (Table 3).

Harvests had various productions regarding total dry weight yield. The second harvest produced more total dry weight performance than three other harvests in year 2003; however, the third harvest has better dry weight performance than the other harvests. In average of two years, the second harvest by producing 1.98 t ha^{-1} dry weight showed higher TD than the other harvests and the fourth and first harvest produced lower amount of dry weight performance (Table 3).

Cultivar Sacromonte in both years has significantly produced higher dry weight performance than the rest genotypes including the control cultivar (Karmel). Unlike the case of fresh yield, cultivar Karmel was not ranked lower than all genotypes in 2003. It seems that this cultivar plays better role in production of dry yields which will be considered in next section. Although control cultivar has produced 4.62 versus 4.03 t ha^{-1} dry weight for 2004 and 2003, respectively, its ranking position in 2004 is stayed lower than year 2003. Cultivar Sacromonte with yielding about 4.92 and 5.25 t ha^{-1} dry weight in years 2003 and 2004, respectively was superior comparing other genotypes (Table 3). All genotypes except cultivar Actanone have obviously demonstrated higher dry weight production in second year. In average, cultivars Sacromonte and Tabor with 5.09 and 3.91 t ha^{-1} were superior and inferior cultivars in present experiment and Karmel as most commonly grown cultivar with only 4.33 t ha^{-1} was stayed at step 6th of dry weight production. Even in growing season of 2004 cultivar Karmel could not be stayed at higher step than sixth (Table 3).

Percentage of dry matter production (% DM): Two years are significantly different for percentage of dry matter production (Table 1 and 2). In contrast with results of fresh yield and dry weight performance, year 2003 prepared higher percentage of dry matter than year 2004 (Table 2). Harvests two and three in 2003 and harvest four in 2004 by producing 26.20, 26.20 and 18.86% dry matter have demonstrated higher performances, respectively. In Average, third cut has provided superior percentage of dry matter (Table 3).

Although ranking of control cultivar Karmel in production of fresh yield and dry weight were not so good, the highest percent of dry matter has been produced by this genotype in 2003 (Table 4). It may be partly attributed to less removable humidity in Karmel in comparison with other genotypes using air drying methodology or inadequate reliability of the used drying system. Ecotype A with illustrating 23.8% dry matter production seems to have greater potential for reserving water in its organs (stem and leaves) than the other tested genotypes (Table 4). In other words, water ratios of above ground organs of genotypes are quite different or at the same temperature condition the potential water removal of various genotypes are different. Cultivar Khadrawi in 2004 had similar circumstances with what cultivar Karmel showed in 2003. By producing 15.9% DM cultivar Khadrawi higher % DM than all the other examined genotypes (Table 4). In Average, Laura has provided higher % DM than the other genotypes.

Table 4: Means of total fresh yield, total dry weight and percentage of dry matter production among 10 genotypes in two years

	TF			TD			%DM		
Genotype	2003	2004	Av.	2003	2004	Av.	2003	2004	Av.
Karmel	18.10e	33.00c	22.55e	4.03bc	4.62d	4.33bc	27.30a	13.30g	20.30ab
Ecotype B	21.70a	34.50b	28.10b	4.32b	4.73d	4.53bc	25.50b	14.10f	19.80ab
Actanone	22.90b	29.20f	26.05b	4.29b	3.79f	4.04ab	24.70bc	14.40e	19.60ab
Tabor	19.80d	31.10d	25.45d	3.52c	4.29e	3.91c	24.00c	14.70d	19.40b
Sacromonte	24.40a	37.20a	30.80a	4.92a	5.25a	5.09a	25.60b	14.70d	20.20ab
Saidi	21.00c	32.40c	26.70c	3.92bc	4.94c	4.43bc	24.60bc	15.50b	20.10ab
Khadrawi	21.40c	28.90e	25.15c	4.04b	4.27e	4.16bc	24.00c	15.90a	20.00ab
Miskawi	23.20b	33.30b	28.25b	4.32b	5.16ab	4.74ab	25.30b	15.40b	20.40ab
Ecotype A	22.50b	32.10c	27.30b	4.02bc	5.03bc	4.53bc	23.80c	15.10c	19.50b
Laura	21.40c	26.20e	23.80c	4.18b	4.43e	4.31bc	25.50b	15.80a	20.70a
LSD(5%)	0.82	0.70	0.82	0.47	0.19	0.64	1.12	0.21	1.14
CV	2.62	2.49	2.62	7.74	2.82	10.76	9.20	3.60	9.00

TF = Total Fresh yield, TD = Total Dry weight, % DM = Percentage of dry matter, Values with the same letter(s) are not significantly different at 5% level

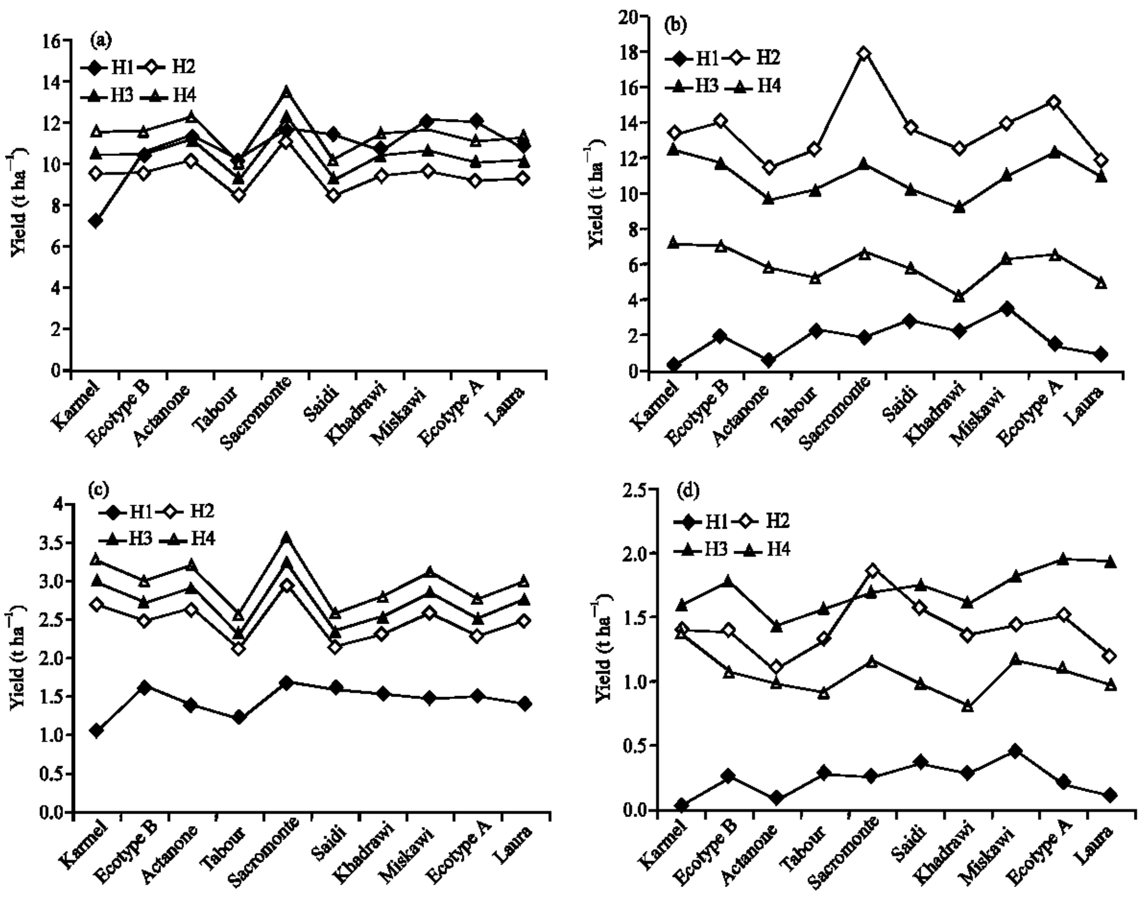

Fig. 1: Interactions of genotypes and total fresh and dry weight by different harvests in 2003 and 2004 (a) Total fresh forage yield (2003), (b) Total fresh forage yield (2004), (c) Total dry weight (2003) and (d) Total dry weight (2004)

Interactions between genotypes and harvest for total fresh yield in both years have been shown in Fig. 1a and 1b. While most genotypes except Saidi, Miskawi and Ecotype A showed higher results in third harvest in 2003, all genotypes were clearly higher in second harvest (Fig. 1b). Harvests one and four in year 2004 showed lower outcome from all tested genotypes than the other two harvests (Fig. 1b). The first harvest in both years showed obviously lower amount of total dry weight in comparison with the other three harvests for all examined genotypes (Fig. 1c and d). Cultivar Sacromonte in all cases in 2003 demonstrated higher dry weight than the other genotypes, but this trend was not so clear in 2004 experiment. The difference between experiments 2003 and 2004 is correlated with third harvest that in 2003 has acted as second highest dry weight producer, however, in 2004 it acted as the first highest dry weight producer (Fig. 1c and 1d).

CONCLUSIONS

Differences between cultivars in various harvests have obviously mentioned in numerous studies (Graves *et al*., 1996; Juskiw *et al*., 2000a-c; Ross *et al*., 2003; Ross *et al*., 2004a and b). According to present findings, fresh forage yield of cultivars Sacromonte, Miskawi, Ecotype B, Ecotype A and Actanone are much better than the control cultivar Karmel. It means that first selection procedure and introduction of cultivar Karmel to farmers in Northern provinces was not precisely considered. Because of high air relative humidity conditions in Mazandaran and difficulties existed for drying huge amounts of fresh forage, in most cases berseem clover has been directly consumed either by grazing or in fresh forage forms. Therefore, the produced forage can not be exported as hay to other parts of Iran and thus, in present investigation main focus is basically on fresh yield production.

According to results of current experiment, dry weight per a certain and equal amount of fresh forage samples are significantly different among cultivars. Data resulted from present research indicated that forage at cutting consisted of about 80% moisture and 20% dry matter. A yield of about 10 t ha^{-1} at 15% moisture when baled would contain about 29.7 t ha^{-1} of moisture at cutting, requiring air dry removal of almost 21.7 t ha^{-1} of water from the forage. The amount of time necessary to remove this amount of water will depend on the moisture holding capacity of the air, which is a function of primarily of temperature and relative humidity, as well as air movement in outdoor conditions (Rethwish *et al*., 2002). Therefore, water is constructing the main portion of consumable parts of plant shoots or leaves. Water removal from fresh green organs of forage plants is one of known problems in our province. Harvest management is one of the other key factors in production of forage crops. Because of three different types of berseem clover, attention should be directed to environmental conditions which the plant is grown (Putnam *et al*., 1999). For winter cropping system, it is recommended to utilize mono cut berseem clover (Rethwish and Graves, 2000). However, in practice, some multiple cut varieties have produced acceptable forage and hay in our conditions. Adjusting different cultivars included in present research to have multiple cut were done by cutting plants 7-10 cm over ground for preserving re-growth buds of mono cut cultivars (Rethwish *et al*., 2002).

Percentage of dry matter implies the ability of a certain cultivar to compensate and increase the ratio of dry weight and total fresh yield production. Despite weakness of cultivar Karmel in production of fresh forage yield, it is able to compensate this weakness by creating more ratio of dry matter. This achievement confirms the findings of Iannucci *et al*. (1996). Sacromonte as a high yielding cultivar showed that in comparison with control cultivar Karmel, larger portion of water in its fresh weight will lose when dried (Rethwish *et al*., 2002).

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