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EFFECTS OF CLIPPING INTENSITY ON DRY MATTER PRODUCTION AND GAS EXCHANGE CAPACITY OF *Atriplex halimus* L.

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ABSTRACT

This study was conducted on the Agriculture and Veterinary Experimental Station, King Faisal University, Al-Hassa, Saudi Arabia. *Atriplex halimus* was grown under greenhouse conditions and transplanted to the field. Clipping intensities were performed when 0 (control), 20, 40, 60 and 80% of the plant parts were removed. Dry matter of stems, leaves and total plants were recorded. Gas exchange capacity expressed as transpiration rate, stomatal conductance and transpiration was estimated. Water use efficiency was also calculated. Results showed that standing biomass under light clipping was significantly higher, while severe clipping caused substantial reduction in biomass production. Net photosynthesis was significantly higher under light clipping, while heavy clipping resulted in higher net photosynthesis only at six weeks after clipping. Stomatal conductance was not affected by clipping intensity, however, transpiration rate was greatly increased with higher clipping intensity. The water use efficiency under light to medium clipping was relatively high.

Key words : *Atriplex halimus , clipping intensity , dry matter, gas exchange.*

1. INTRODUCTION

Several studies demonstrated that grazing had detrimental effect on plant growth and biomass production of many range species (McNaughton 1983; Wallace 1990; Senock *et al.*, 1991; Morris and Jensen 1998, Venderklein and Reich 1999 and Garay *et al.*, 2000). Enhancing effects have been widely correlated with light grazing intensity (McNaughton 1983 and Vanderklein and Reich 1999), however severe grazing often causes deleterious effects (Mc Naughton 1983; Clark *et al.*, 1998 and Garay *et al.*, 2000). Stimulatory effects of light to medium grazing have been attributed to the increase in net photosynthesis through changes in source–sink relationships and rate of tissue senescence or through the effect of hormones supplied by roots (McNaughton 1984; Vanderheyden and Stock 1996 and Venderklein and Reich 1999). Alternation on conductance have been widely reported to play a significant role in controlling photosynthesis under grazing. Increasing photosynthesis following grazing was highly correlated with the increase in stomatal conductance (Detling and Painter 1983; Wallace *et al.*, 1984, Wallace 1990 and Kimberly and Edward,1995). On the other hand, increasing photosynthesis under grazing was also attributed to the increase in mesophyll conductance (Painter and Detling 1981; Wallace *et al.*, 1984 and Senock *et al.*, 1991).

Salt bush (*Atriplex halimus* L.) is an important range shrub in north and east Saudi Arabia (Chaudhary and Al-Jowaid 1999). *A. halimus* can be used in the revegetation of deteriorated rangeland, particularly in areas where water spreading is applicable or under irrigation using center pivot (El-Quinaibet, 1994).

The objective of this study was to determine the effect of clipping intensities on biomass production and gas exchange capacity (photosynthesis rate, stomatal conductance and transpiration) and water use efficiency of *A. halimus*.

2. MATERIALS AND METHODS

The present study was conducted during the period from Sept, 2000 to May, 2001 on the Agriculture and Veterinary Experimental Station, King Faisal University, Kingdom of Saudi Arabia. Soils are basically sandy to the depth of 45 cm. Climatic conditions during the experimental period were as in Table (1).

Table (1): Climatic conditions during the experiment period.

Period	Temperature (°C)		Humidity		Evaporation (mm)	RainFall (mm)
	Minimum	Maximum	Minimum	Maximum		
Sep., 2000	22.9	41.8	20.3	64.9	389	---
Oct., 2000	19.6	36.1	22.1	77.9	319	---
Nov., 2000	13.8	24.3	44.7	89.0	133	16
Dec., 2000	8.8	21.7	27.7	79.7	78	11.1
Jan., 2001	6.4	20.2	24.4	74.6	138	32.0
Feb., 2001	9.7	24.5	19.0	61.9	169	---
Mar.,2001	15.5	31.7	16.8	64.6	205	4
Apr., 2001	20.2	38.4	15.3	47.5	375	---
May,2001	22.0	41.7	15.2	36.2	481	---

Seeds of *Atriplex halimus* were sown in 10 cm plastic pots, filled with a mixture of 1 sand : 1 loam in the 1st Sept. 2000. On the of 15th Feb.2001, plants were transplanted into the field 1 m apart and irrigated every two weeks. Grazing (clipping), was done two weeks after transplanting. The clipping treatments were removing 0 (control, without clipping), 20, 40, 60 and 80 % of foliage. A randomized complete block design with six replicates was used. Each treatment per replicate was represented by 6 plants. Gas exchange capacity measurements were taken on young fully expanded leaves two weeks after clipping for all clipping intensities, except 80 % clipping where the measurements were done one month after clipping.

Net photosynthesis, stomatal conductance, transpiration rate were measured using Infra Red Gas Analyzer (IRGA) Ci-301 PS (CID, INC, USA) portable photosynthesis apparatus, open system). Measurement periods were morning from 0800– 1100 h where leaves of *A. halimus* were exposed to a saturation photon irradiance exceeding 1200 µmol/m^2/s (Al-Khateeb, 1997). Leaf temperature was 25 ± 5.0 °C. Air flow into the cuvette was 350 ml/min. The boundary layer conductance to water vapor was measured according to Parkinson (1984) and found to be 0.26 mmol /m^2/s over the measurement period. Photosynthesis gas exchange was measured in the six plants per treatment on two leaves per each plant. Dry matter weights of stems, leaves and total plant were estimated. Water use efficiency (WUE) was calculated using the following formula, WUE = Photosynthesis rate/transpiration.

Data were subjected to analysis of variance (ANOVA) of the randomized complete block design, as mentioned by Gomez and Gomez (1984) using the statistical analysis system (SAS, 1996).

3. RESULTS

There were great differences in the standing biomass of grazed and non-grazed plants. Total standing biomass on the light clipping plants (20 %) was significantly greater than non-clipped plants, while medium clipping (40%) was equal in standing biomass with non-clipped plants. The heavy clipping (80 %), however, was dramatically lower in standing biomass. Light clipping (20 %) had highly stimulative effect in producing leaves, which also appeared under medium clipping, compared to non-clipped plants. The heaviest clipping (80%) showed considerable production of stems and leaves (Fig.1).

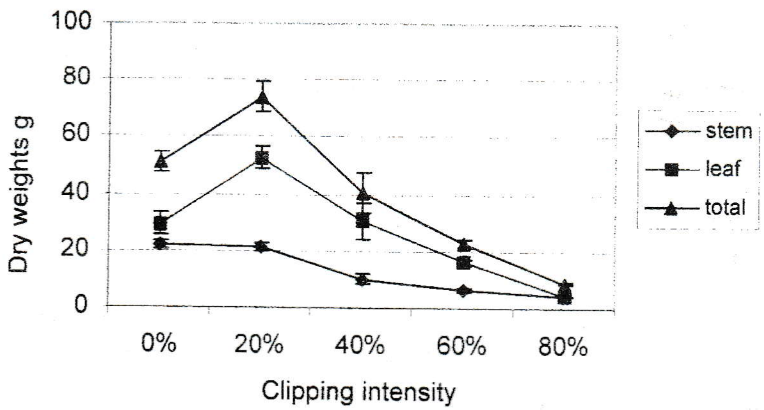


Fig.(1): Means (± SE,n=6) leaf, stem and total dry weights of *A. halimus* under different clipping intensities.

There was a tendency for significant increases of net photosynthesis under clipping. Light clipping (20 %) showed significantly higher net photosynthesis particularly in the first two weeks after clipping, while a relatively similar result was reflected with 80 % clipping intensity 6 weeks after clipping. The stimulation effects of clipping showed unclear trends after 8 weeks and thereafter (Fig. 2).

Stomatal conductance was not affected two weeks after clipping, but stomatal conductance was slightly increased with increasing clipping intensity. The significant increases in stomatal conductance with increasing clipping levels were much evident after four weeks of clipping. However, stomatal conductance in unclipped plants was higher than clipped ones, particularly 4 to 6 weeks after clipping (Fig.2).

Transpiration rate was significantly different between clipping and non-clipping plants (Fig. 3). There was a substantial increase in transpiration with increasing clipping levels. However, non-clipping plants showed the highest transpiration rate, particularly in the immediate period after clipping. Transpiration rate under the heaviest clipping (80 %) was almost equal to that recorded in non-clipped plants. There was also an increase in transpiration rate with time in clipping treatments, but not in control plants (Fig.3).

Water use efficiency was significantly higher under light and medium clipping. This trend was much evident two to four weeks after clipping. There were no significant differences detected in water use efficiency between non-clipped and heavy clipped plants. There was a decreasing trend of water use efficiency with time, particularly in clipping treatments (Fig. 3).

4. DISCUSSION

Although standing biomass was substantially reduced by heavy clipping, still light clipping induced stimulatory effects on biomass production illustrated by new leaf growth (Fig.1). Enhancement of net photosynthesis rate under clipping in the present study may be attributed to the change in source–sink ratio following clipping or defoliation. In addition, the reduced competition between the remaining leaves for water, nutrients or hormones supplied by roots may also play a role in this aspect (McNaughton 1984, Mooney and Chiariello 1984; Trumble *et al.* 1993; Senock *et al.* 1991 and Kimberly and Edward 1995). If the increase in photosynthesis was simply due to changes in source–sink relationships, then the greatest degree of enhancement should be immediately after clipping (Kimberly and Edward 1995). This trend was relatively clear in our study particularly two weeks after clipping (Fig.2).

The higher biomass production under light clipping may reasonably favor an elevation in net photosynthesis under these conditions. However, under medium clipping, biomass production was just sufficient to compensate for clipping losses. The reduction in net photosynthesis with increasing clipping intensity particularly two weeks after clipping may have resulted from suboptimal conditions of vegetation growth due to intense removal of apical meristems. The continuation of photosynthesis process despite the lack of vegetative growth, may results in the accumulation of assimilate from the excess photosynthesis (Vander Heyden and Stock 1996) which may contribute to the reduction of photosynthesis due to feed back inhibition effects. On the other hand, higher photosynthesis rate under severe clipping conditions could be attributed to the tendency of clipping to stimulate the growth of young active green leaves (Morris and Jensen 1998). However, higher net photosynthesis cannot compensate for the assimilate lost by removal of tissue as reported by Chapman *et al.*, (1990), Evans (1991) and Hoogesteger and Karlsson (1992). It was quite interesting to note and distinguish in this study between higher photosynthesis in younger regrowth and enhanced photosynthesis in remaining parts after clipping (Nowak and Caldwell 1984). Increasing rate of photosynthesis following clipping was not correlated with stomatal conductance since the increase in rate or net photosynthesis under light clipping was much higher than that reported in stomatal conductance (Fig.2). Thus, we can reasonably assume that the higher photosynthesis rate may probably not be due to change in stomatal conductance as reported by Wallace (1990); Senock *et al.* (1991) and Kimberly and Edward (1995), which is in contrast with the findings of Detling and Painter (1983) and Wallace *et al.* (1984).

Our results emphasize the role of non-stomatal component in enhancing net photosynthesis rate. Wallace *et al.* (1984), Wallace

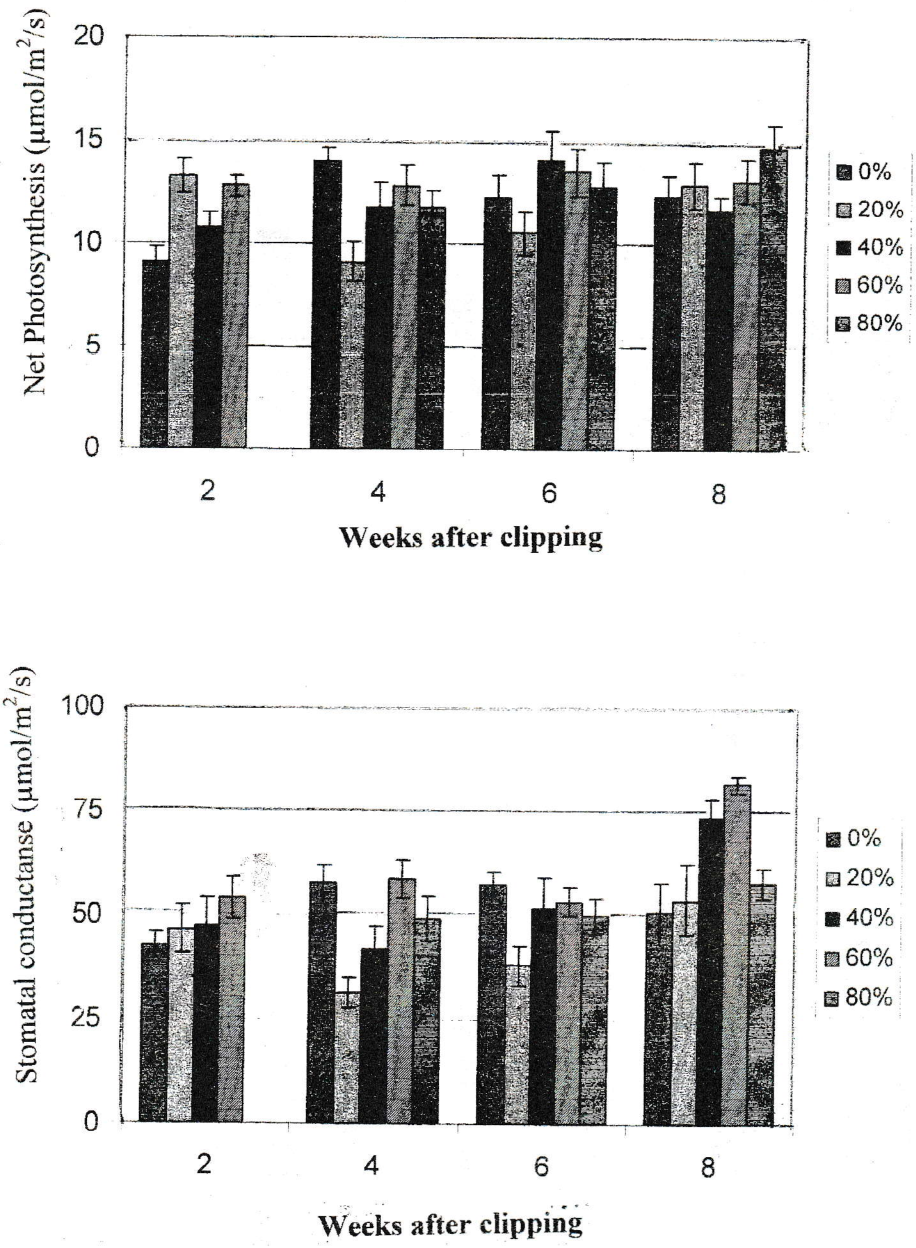
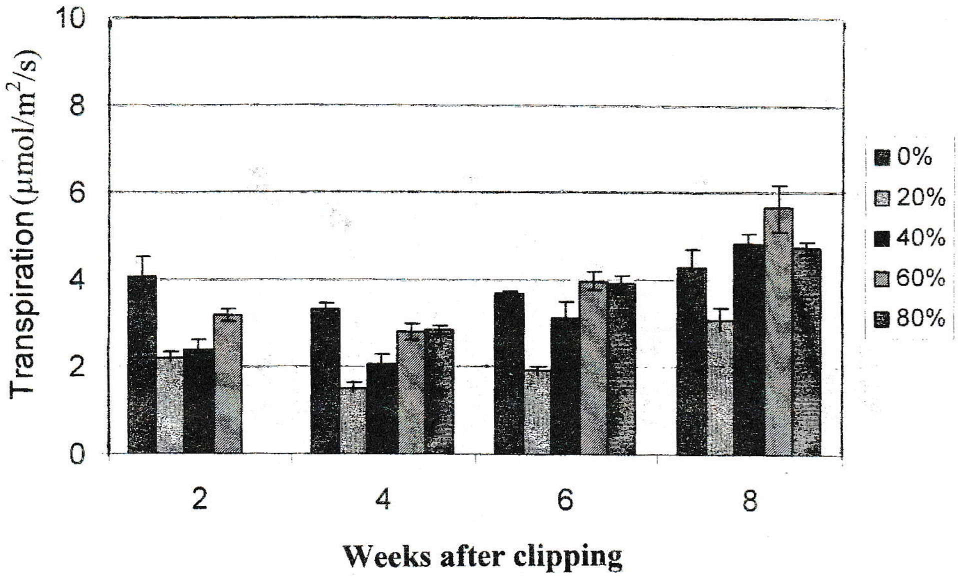


Fig. (2): Mean (± SE, n=6) photosynthesis rate and stomatal conductance of youngest fully expanded leaves of *A.halimus* as affected by clipping intensity.



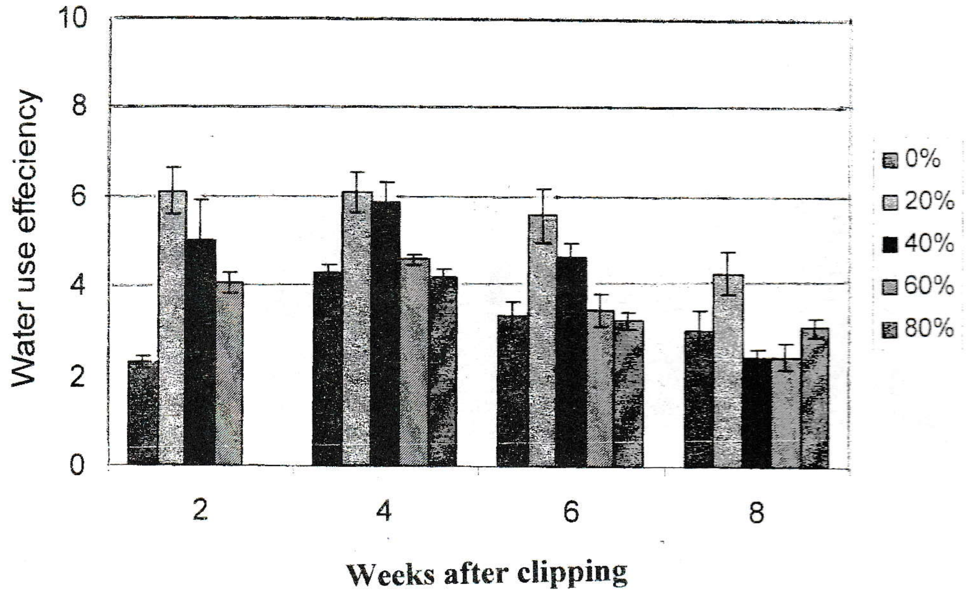


Fig. (3):Mean (± SE,n=6) transpiration rate and water use efficiency of youngest fully expanded leaves of *A.halimus* as affected by clipping intensity.

(1990) and Senock *et al.* (1991) attributed the increase in photosynthesis following defoliation to an increase in mesophyll conductance. However, the response of stomatal conductance to clipping was strongly correlated with transpiration (Fig.3). The lower transpiration rate was observed under light clipping level, as shown by Wallace (1990).

Water use efficiency was higher under light to medium clipping which indicates the role of both treatments to improve water status of clipped plants (Fig.3). Such pattern was also reported by Caldwell *et al.* (1983) and Nowak and Caldwell (1984), but differed from the observations of Wallace (1990).

Our results demonstrated that clipping intensity significantly varied in their effects upon photosynthesis and biomass production. In addition to the stimulatory effects of light clipping on net photosynthesis, enhancement in water status and water use efficiency did occur under light to medium clipping. It should be bear in mind that the positive effects of light to medium clipping on photosynthesis occurred in irrigated plants of *A. halimus*. Such effects are not likely to appear under severe arid conditions where level of precipitation is less than 100 mm as in Saudi Arabia. Under low level of precipitation excessive accumulations of vegetation usually do not occur. Al-Khateeb (2003) reported that proper vegetation production did appear in *A. halimus* under supplement irrigation of 100 mm.

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تأثير شدة الحش (القطع) على المادة الجافة والتبادل الغازي في القطف (*Atriplex halimus*)

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ملخص

أجريــت هــذه الدراسة بمحطة التدريب والأبحاث الزراعية والبيطرية، جامعـــة الملـــك فيصل بالأحساء ، المملكة العربية السعودية. زرعت بذور نبات القطف الملحي (*A. halimus*) تحت ظروف البيت المحمي وتم رعايتها إلى أن نقلــت الشـــتلات للحقل المستديم. تم تطبيق شدة الحش (القطع) وهي: صفر (أي تركت النباتات بدون حش)، حش ٢٠، ٤٠، ٦٠ و ٨٠ % من المجموع الخضري للنــبات. تم تقدير الوزن الجاف للساق والأوراق والنبات الكلي كما أخذت قياسات التــبادل الغازي (معدل التمثيل الضوئي، التوصيل الثغري، النتح) وحسبت كفاءة استخدام المياه. أشارت نتائج الدراسة إلى أن محصول النباتات من المادة الجافة قد زاد مع الحش الخفيف (٢٠%)، في حين أدى الرعي الجائر إلى نقص معنوي في محصول المادة الجافة. كان معدل التمثيل الضوئي أعلى تحت الحش الخفيف، في حين أدى الرعي الشديد إلى زيادة في معدل التمثيل الضوئي فقط بعد ٦ أسابيع مـــن الحش. لم يتأثر التبادل الثغري بشدة الحش إلا أن معدل النتح قد زاد معنويا بـــزيادة شـــدة الحـــش. أشارت النتائج أن كفاءة استخدام المياه تحت نظام الحش الخفيف والمتوسط كانت مرتفعة نسبيا مقارنة بالحش الجائر.

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