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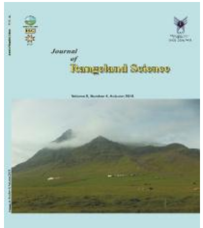

Research and Full Length Article:

Effects of Time and Frequency of Clipping on Production and Regrowth of *Agropyron trichophorum* (Link) Richt in Emam Gholi Summer Rangelands, Ghochan, Iran

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Abstract. Pubescent wheatgrass (*Agropyron trichophorum* (Link) Richt.) is growing in semiarid regions of Iran at altitude of 500 to 2000 m. Among different grasses growing in Iran, *A. trichophorum* is relatively resistant to grazing and defoliation as compared to other species of *Agropyron* genus which are dominant in the most summer rangelands. In Emam Gholi protected summer rangelands, Ghochan, Khorasan province, Iran, *A. trichophorum* as a dominant grass was selected for our study, and was subjected to a series of defoliation treatments. Forty eight quadrates of 0.5 m^2 were established in two macro-plots and subjected to one, two, three, and four weekly interval clipping started in May 6, 2016 in vegetative stage and other treatments of once clipping started in May 6, May 19, June 3, and a control treatment was clipped only once in July 15. Floral stalks of *A. trichophorum* were counted before clipping. Then, quadrates were clipped to the ground surface, air dried and weighed for different treatments. Using ANOVA, the responses to frequent clipping showed that there were no significant differences in daily, current, primary, and total production of *A. trichophorum* ($p>0.05$) which may be due to the reservation of carbohydrate in roots and base of this grass after 15 years of protection. Low slope of sigmoid curve for weight of clipped plants also confirmed the resistibility of this species to defoliation, but as the frequency of clippings were increased, the number of floral stalks was decreased showing an exponential model ($p<0.0$). To find the allowable use of *A. trichophorum*, further years of research will be required to evaluate the responses to defoliation in different locations.

Key words: Frequency of Clipping, Regrowth, Daily production, *Agropyron trichophorum*, Grassland

Introduction

Range plants grow together in almost similar environments and their responses to grazing and defoliation are different. Most range plants can tolerate cutting or defoliation of some top materials and still remain in protective conditions; i.e., they can maintain good vigor (Holechek *et al.*, 2011).

One of the main envisaged activities in almost all the management plans is the grazing system (Azimi and Mozafari, 2017). One of the most widely suggested options to sequeste more C in rangelands is the restoration of the degraded rangelands through grazing the exclusion (Niknahad Gharmakher *et al.*, 2015).

The continuous grazing increased the bare soil percent and decreased the vegetation cover. Also, it had negative impacts on botanical composition, biomass productivity and range carrying capacity. It was concluded that continuous grazing has a negative impact; it led to change the botanical composition of range plants of undesirable species with low nutritive value (Abdelsalam *et al.*, 2017). The best delay time for the rangeland utilization of this area considering the annual precipitation is the 15-day delay with the highest forage production for forbs and grasses and the highest cover percent for shrubs (Azimi and Mozafari, 2017).

The amount of foliage that can be removed from plants depends on the plant species and main environmental factors (precipitation and temperature). Considerable researches reviewed in literature (Child *et al.*, 1984; Vallentine, 2001; Briske and Richards, 1995) showed that 60% of annual leaf and stem production by grasses should be left as a metabolic source for regrowth while the remaining 40% can be safely removed by domestic and wild herbivores (Holechek *et al.*, 2011; Cook and Stubbendieck, 1986). The unremoved and reserved plant material plays a critical photosynthetic role in plant regrowth after defoliation, and protects the plant to maintain healthy growth system. The amount of plant tissue removals differs among different species and even between the individual plants of the same species. Among many plant species growing in rangelands, grasses have an important role in providing forage for livestock and in protecting soil from severe erosion (Vallentine, 2001).

Pubescent wheatgrass, *Agropyron trichophorum* (Link) Richt may be one of the common perennial grass species in the Irano-Turonian phytogeographical regions (Zohary, 1973) occurring in semiarid habitats of Iran (Mesdaghi, 2015). *A. trichophorum* as one of preferred species by livestock (Rashvand *et al.*, 2017; Erfanzadeh *et al.*, 2014) was chosen in this study.

The amount of efficient use of top materials depends on stage of development in different plant species. The dormant period is the least critical period for foliage removal; plants are photosynthetically inactive in this time. The initiation of vegetative growth is moderate to defoliation response although this stage can be critical in drought years. The most critical period for foliage removal for most grasses is from floral initiation through seed ripening. This period is critical because the opportunities to regrowth are often low due to the reaching of less-favorable temperature and soil moisture condition (Holechek *et al.*, 2011).

There are limited studies directly related to the defoliation response of *A. trichophorum*, but considerable research was conducted on responses of this species to grazing and forage production in Iran. In a study done by Bonvan *et al.* (1973) at Homand Experimental Range Station, phenology and the effects of clipping were investigated on some grasses of *Agropyron* spp. including *A. trichophorum*. The experiments on the effects of clipping were not published but these studies have shown that *A.*

trichophorum began the growth in late March and seed maturing in late July which was the latest date to compare other grasses such as *A. elongation* and *A. cristatum*. Caldwell *et al.* (1981) conducted some studies and showed that close-related species of *Agropyron desertorum* could reconstitute its canopy much faster than other grasses such as *Agropyron spicatum* in the protected semiarid regions in the USA.

Houshmand *et al.* (2008) had studied the changes of TNC (total nonstructural carbohydrate) in different phenological stages that were significantly different in storage organs of *A. trichophorum*. Reduction of TNC happened for crown of *A. trichophorum* during flowering and seed ripening which may be related to environmental factors. This species may not be able to recover the loss of photosynthetic tissue. Therefore, variations in carbohydrate reserve cycles of species indicate their different responses to frequency, intensity, and season of defoliation.

To investigate the productivity of *A. trichophorum* under the stress of defoliation, our objectives were summarized as follows:

1) To determine the effects of time and frequency of clipping on the regrowth and production of *A. trichophorum.*
2) To investigate the possibility of fitting sigmoid growth model to the weights of clipped plants in weekly time intervals.
3) To determine the effects of frequency of clipping on the floral stalks presentation.

Materials and Methods

Study area

Eman Gholi summer rangeland with an area of 27 ha is located 35 Km of Ghochan in Hazar Masjed mountains (Fig. 1). Research station of Emam Gholi was protected from 2002 for plant adaptation experiments of different species including perennial and annual grasses, forbs, and shrubs. The native grasses of *Agropyron* spp., *Bromus* spp. and *Festuca ovina* were renewed and replenished during protection. Now, a considerable amount of forage is available for utilization. One of the native bunch grasses with medium palatability is pubescent wheatgrass (*Agropyron trichophorum*) which is native in Iran and Russia (Dewey, 1978; Zohary, 1973). This station has an elevation of 1750 m and annual rainfall of 310 mm while being protected for almost 15 years. Long term preservation makes perennial grasses dominated. Northern and western regions have the area slopes completely covered by perennial grasses such as *Festuca ovina*, *Agropyron trichophorum* and *Dactylis glomerata*. Southern and eastern regions faced slopes dominated by a combination of shrub-grass species such as *Artemisia aucheri*, *Astragalus heratensis*, *Stipa caucasica* and *S. turkestanica*. Flat parts of the site are completely covered by *A. trichophorum*. The condition of this summer rangeland is excellent based on the 6-Factors method with a positive trend (Mesdaghi, 2015). It is noteworthy that the macro-plots of this research were established at a pure stand of *A. trichophorum* located at flat part of the site. This wheatgrass contains 100% of species composition of the macro-plots.

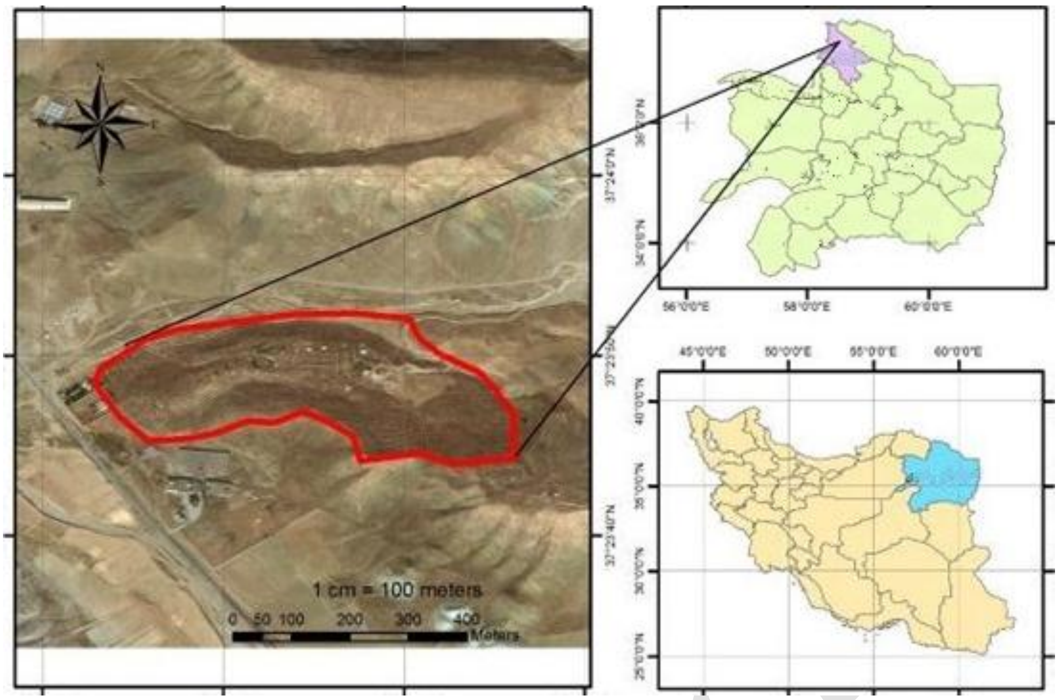

Fig. 1. Location of sampling plots (yellow mark) enclosed in an area of about 27 ha at Emam Gholi summer rangeland

Sampling method

A. trichophorum as one of preferred species by livestock (Rashvand *et al.*, 2017; Erfanzadeh, *et al.*, 2014) was chosen in this study. A representative stand of *A. trichophorum* was selected in Emam Gholi station, and 0.5×1 m quadrates within two 1×12 m macro-plots were randomly established.

Random sampling scheme of different treatments of two series of macro-plots was as follows:

T1 = weekly clipped,
T2 =2-weekly clipped,
T3=3-weekly clipped,
T4= 4-weekly clipped. Initial cuttings were started on May 6 2016 for above treatments.
T5= once clipped (May 6),
T6= once clipped (May 19),
T7= once clipped (June 3),
T8= control plot (once clipped at July 15).

Frist, before clipping in each quadrate, the number of floral stalks was counted. The schedule of clipping was started on May 6 2016, and quadrates within two macro-plots were clipped to the ground surface. After separation of stables and dead materials of previous year, the current plant materials were collected in paper bags, air dried and weighed.

Statistical analysis

Frist, the normality and homogeneity of collected data in different treatments were evaluated using boxplot and normality test. As there were no significant differences between two macro-plots, the total and daily production of eight treatments were analyzed using ANOVA or nonparametric tests. But as the time of the first 5 treatments (May 6) was different from the treatments of 6, 7 and 8, the primary and current productions were only analyzed for 5 first treatments.

To evaluate the growth form of *A. trichophorum* based on clipping treatment, cumulative weight of clipping treatments was summed and sigmoid model of logistic growth was fitted to them.

To evaluate the effects of frequency of clipping on the number of floral stalks, an appropriate model was searched.

Results

The primary, current and daily productions of eight treatments were summarized in Table 1. The variation trends of *A. trichophorum* production based on clipping frequency in different treatments are shown in Fig. 3.

Table 1. Primary, current and daily productions of *A. trichophorum* in eight clipping treatments

Treatment	frequent clippings	Primary	Current	Daily
T1	weekly	23.06± 6.49 b	10.66± 2.61	0.15± 0.04
T2	2-weekly	26.17± 6.04 b	8.21± 3.79	0.12± 0.05
T3	3-weekly	26.40± 4.40 b	10.54± 3.63	0.15± 0.05
T4	4-weekly	20.27± 3.37 b	9.50± 2.98	0.14± 0.04
T5	May 6	25.02± 6.67 b	11.55± 5.99	0.17± 0.08
T6	May 19	31.24± 14.5 b	3.77± 2.51	0.08± 0.05
T7	June 3	43.71± 8.43a	4.80± 3.62	0.14± 0.01
T8*	July 15	62.52 a		

Means of Primary productions column followed by same letters are not significantly different

* Control plot (only once clipped at July 15)

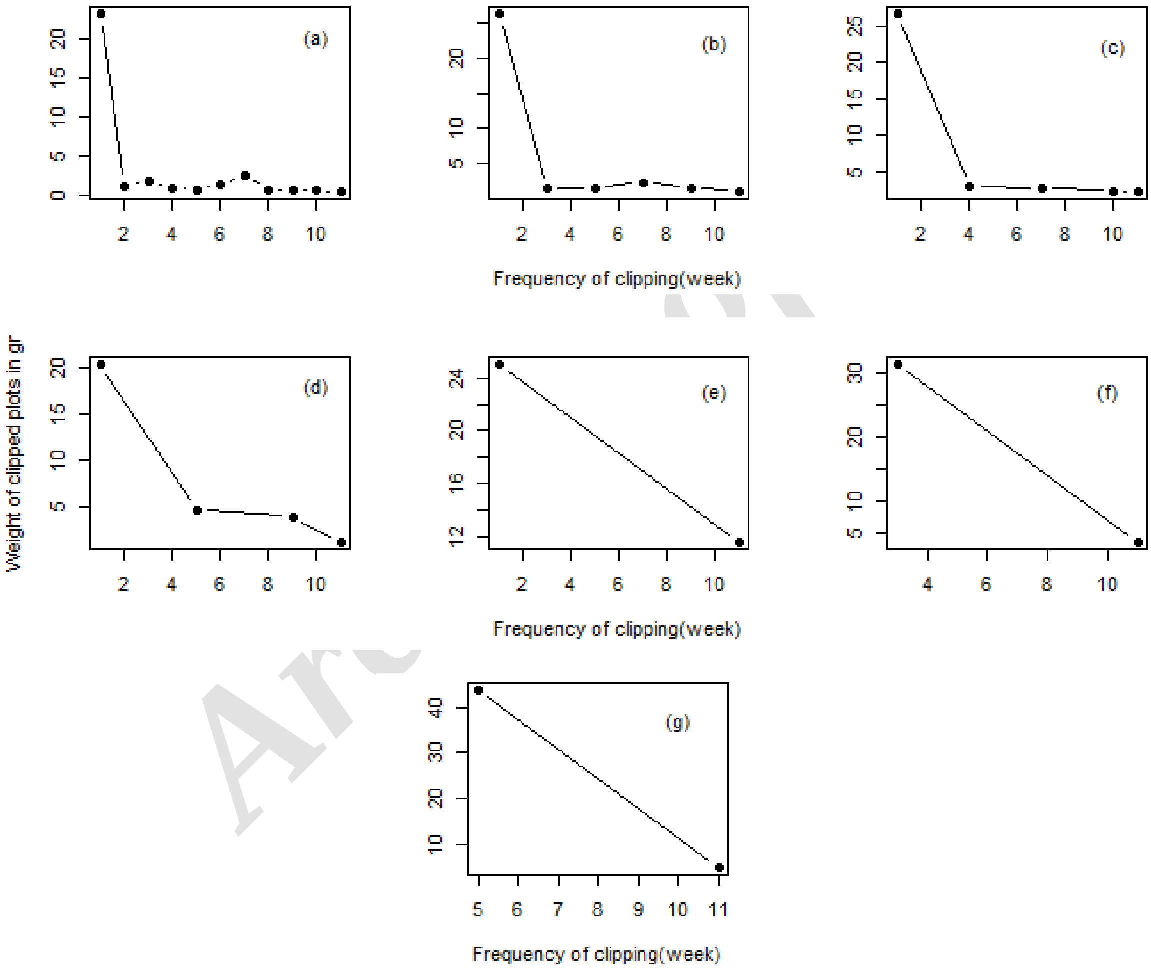

Fig. 3. The trends of mean weight in frequent clippings for (a) weekly, (b) 2-weekly, (c) 3-weekly, (d) 4-weekly, (e) Once clipped (May 6), (f) Once clipped (May 19), (g) Once clipped (June 3)

The result of ANOVA for total production confirmed the significant differences ($p<0.05$) including one clipping (T7) and control (T8) treatments (Fig. 4). The significant differences among treatments 7 and 8 and other treatments were due to delaying time of the first clippings (primary production). However, the frequent clipping of treatments of total, current, and daily productions were not significant (p>0.05) after omitting T7 and T8. The reason can be related to long protection of this species from grazing, so plants had enough opportunity to reserve carbohydrate for future regrowth.

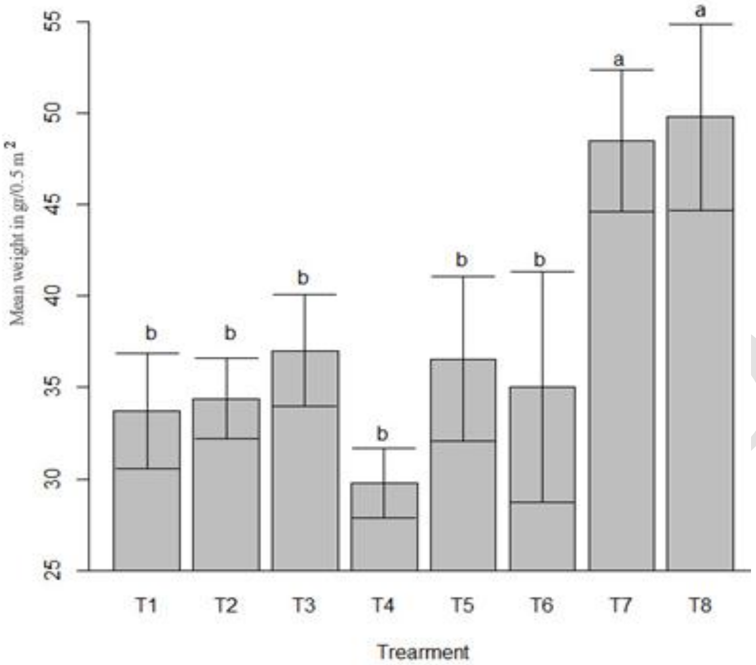

Fig. 4. Means of clipped weight for different treatments. Means with the same letters are not significantly different (p= 0.05). For definitions of T1 to T8 seed Table 1

Low steepness at inflection (inflection point in sigmoid regrowth of *A. trichophorum* (Fig. 5) also confirmed the resistibility of this species to cutting due to long time protection (15 years). But by intensifying the frequency of clipping, the number of floral stems was decreased demonstrating an exponential model of $Y=ae^{\beta x}$ (Bonham, 2013) (Fig. 6).

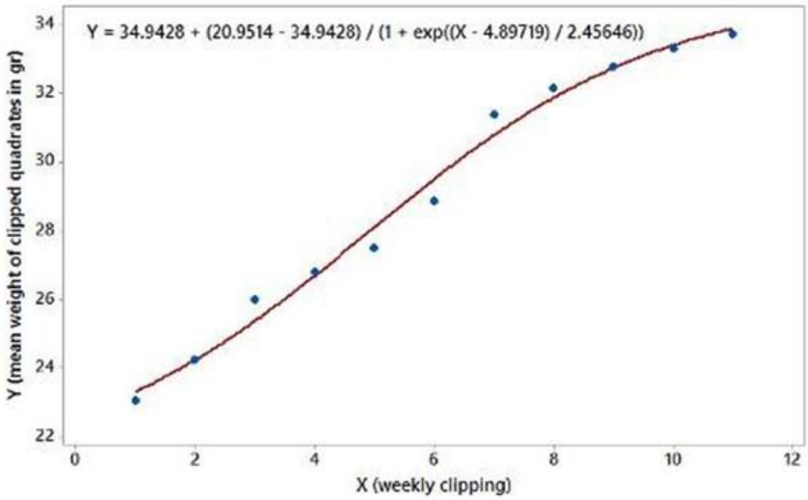

Fig. 5. Mean cumulative weight of *A. trichophorum* in relation to frequency of weekly clipping

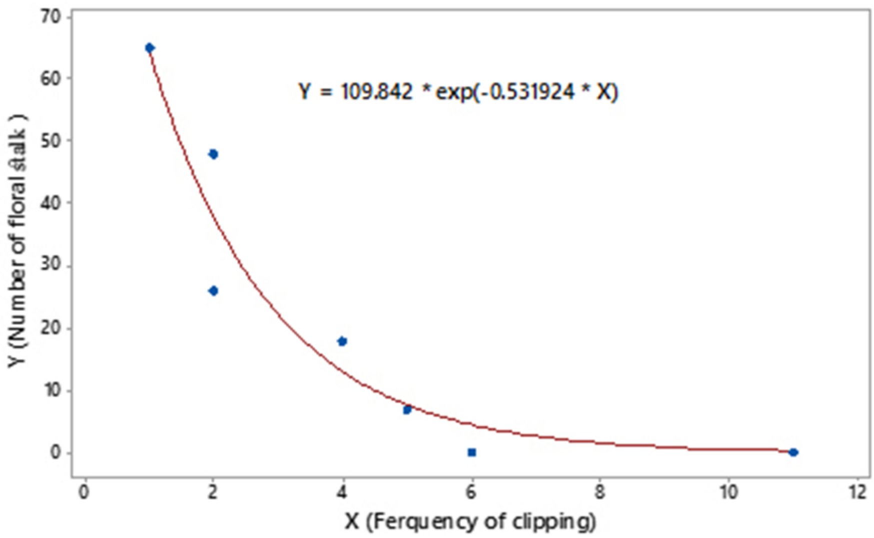

Fig. 6. The relation between numbers of floral stems to the frequency of clipping

Discussion and Conclusion

Long-term rangeland protection could cause the non-significant differences for frequent clipping of *A. trichophorum* and low slope of sigmoid curve (Fig. 6) also confirmed the resistibility of this species to defoliation. This result is probably due to accumulation of total nonstructural carbohydrate in base of *A. trichophorum* (Houshmand *et al.*, 2008). But the immediate response to clipping was revealed in productivity of this species (Fig. 7). The result reported by Caldwell *et al.* (1981) also proved that *Agropyron* species are more resistant to grazing and defoliation than other tribes of grasses. Further years of research are required to evaluate the responses of *A. trichophorum* to defoliation in different locations.

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اثرات زمان و دفعات قطع روی رشد مجدد و تولید علف گندمی کرکدار *Agropyron trichophorum* در مراتع تابستانی امام‌قلی قوچان

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چکیده. علف گندمی کرکدار، .*Agropyron trichophorum* (Link) Richt در مناطق نیمه خشک ایران در ارتفاع بین ۵۰۰ تا ۲۰۰۰ متر رشد می‌کند و در مقایسه با انواع علف‌گندمیان چیره مراتع ایران این گونه به چرای دام و دفعات قطع مقاومتر است. در مراتع ییلاقی حفاظت شده امام قلی، قوچان گونه *.A trichophorum* برای مطالعه انتخاب و تحت یک سری تیمارهای قطع قرار گرفت. ۴۸ پلات ۰/۵ متر مربعی انتخاب شده در دو سری ماکروپلات از تاریخ ۱۷ اردیبهشت ۱۳۹۵در معرض دفعات قطع یک هفتگی، دو هفتگی، سه هفتگی و چهار هفتگی قرار گرفت و سایر تیمارهای یکبار قطع از تاریخ ۱۷و ۳۱ اردیبهشت و ۱۴ خرداد و تیمار کنترل یکبار قطع در تاریخ ۲۴ تیر بود. قبل شروع تیمارهای قطع، تعداد ساقه‌های گلزای گیاهان درکلیه پلات‌ها شمارش شد و سپس کلیه پلاتها قطع و توزین شدند و در هر بار قطع نیز بعداز شمارش ساقه‌های گلزا، کلیه گیاهان تا سطح زمین کف‌بُر و در هوای آزاد خشک و توزین شدند. نتایج تحلیل واریانس نشان داد که بین تولید اولیه، جاری و روزانه، گیاه *A. trichophorum* تفاوت معنی‌دار وجود نداشت که احتمالاً به‌واسطه کربوهیدرات‌های ذخیره شده در ساقه‌ها و ریشه‌های گیاه بعد از ۱۵ سال قرق بود. شیب ملایم منحنی رشد مجدد سیگموئید نیز مؤید مقاوم بودن این گیاه به قطع بود. اما همین‌که دفعات قطع افزایش یافت، تعداد ساقه‌های گلزا روندی کاهشی داشت که با منحنی نمایی معکوس تطبیق می‌کرد. برای ارزیابی دقیق‌تر این گونه به دفعات قطع، لازم است که این تحقیق در مناطق مختلف طی چند سال ادامه یابد.

کلمات کلیدی: دفات قطع، رشد مجدد، تولید روزانه، *Agropyron trichophorum* ، علفزار، امام‌قلی، قوچان