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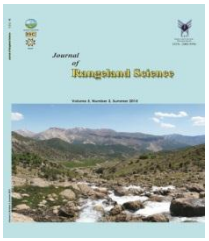

Research and Full Length Article:

Investigating the Effects of Number and Frequency of Incisions on Production and Survival of *Astragalus keyserlingii*

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Abstract. Tragacanth Gum is one of the most important medicinal and industrial products of rangelands and is obtained from the incision of gum tragacanth-producing *Astragalus* including *Astragalus keyserlingii*. The conservation of *Astragalus* species in rangelands has a special place in terms of economic profit and soil conservation. The increase in price of gum tragacanth in recent years and more attention of beneficiaries to the extraction of this material from the existing *Astragalus* in the rangelands could cause the destruction of *Astragalus* species producing gum tragacanth. This research was aimed to provide a scientific method for the exploitation of gum tragacanth as well as the conservation this species. The study was conducted in Tiran, Isfahan province, Iran using a split plot design in the layout of a completely randomized blocks design with three replications. Each replication included 30 shrubs that were exploited for the first time. Treatments included the number of incisions and harvests. The traits were gum tragacanths production, the plant mortality percent and canopy cover percent. According to the obtained results, the number of harvests had a negative effect on canopy cover. This result clearly shows that this plant is resistant against the incision since it has maximum canopy cover percent even under three-time incision in the sixth year. The highest mortality equivalent to 53% was recorded in six-time harvest and the highest production was obtained for six-time harvest a year with an average value of 156.9 g per 30 shrubs, having no significant difference with the four time one a year. Overall, two scars and four-time harvest could be recommended for the exploitation of *A. keyserlingii*.

Key words: Gum tragacanth, Incision, Number of harvests, *Astragalus*

Introduction

Tragacanth is one of the most important medicinal and industrial products of rangelands, obtained from *Astragalus* species producing gum tragacanth. Gum tragacanth is used in the pharmaceutical, textile, paper, cosmetics & health industries (Ahmadi Gavlighi, 2012). Gum tragacanth was first described by Theophrastus several centuries before Christ (Ahmadi Gavlighi, 2012). The name "tragacanth" comes from the appearance of the exuded gum which tends to form ribbons similar in appearance to a goat horn (from the Greek "tragos" meaning goat and "akantha" meaning horn). The gum is obtained from small shrubs of the *Astragalus* genus which is a small, low bushy perennial shrub having a large tap root along with branches, and grows wildly in the dry deserts and mountainous regions of South West Asia from Pakistan to Greece and in particular, in Iran and Turkey (Whistler, 1993). The world market for gum tragacanth is estimated up to 500 t/year (almost 300 t/year) (FAO, 1995).

In Isfahan province, Iran, there are several gum tragacanth-producing *Astragalus* including *A. gossypinus* with an area around 830000 ha, and *A. parrowianus*, *A. keyserlingii* and *A. soficus* with the area of 2.5 million ha of the rangelands (Bagherzadeh, 2000). *Astragalus* is the largest genus of flowering plants in Iran and has various complicated taxonomical difficulties in its classification (Ghorbani Nahooji *et al*., 2012). *Astragalus* with 804 species is one of the numerous genera from Papilionaceae family in Iran, of which 527 species equivalent to 65% are endemic to Iran (Maassoumi, 2005). *Astragalus* is known as a palatable plant which is a grazing tolerant, nutrient rich and prostrate species playing an undeniable role in soil conservation and animal feeding; hence, it deserves serious considerations (Yousefzadeh *et al*., 2010). To extract gum tragacanth, one side of the plant is dug up to a depth of 15-20cm by a special pick and then, the plant stem is scarified by a special sharp knife (Saffar and Razavi, 1993). Gum tragacanth is a hard, resistant and odorless substance which loses its moisture up to 15% in the heat of 100°C. An ash equivalent to 3-4% of initial weight remains from its burning.

Unlike gum arabic, gum tragacanth is not completely dissolved in water and if it is mixed with water, it will become swollen, producing a thick and viscous liquid in which the masses of swollen gums are seen. The dissolved part (Norman Truacnthing) which makes up 30% of gum tragacanth could be removed from the insoluble part (Bassorine, 70-60%). These two substances are insoluble in alcohol. Gum tragacanth is used in pharmaceutics to produce mucilage as an emulsifier (such as oils and resins) and glue in the manufacturing of various tablets (Ahmadi Gavlighi, 2012). Gum tragacanth is used in the textile, paper and shoes industries as well as in pharmaceutics to attach dentures. It is broadly applied in cosmetics industry in the manufacturing of lotions, hand cream and fat-free cream as well as shampoos as an emollient and emulsifier (Bagherzadeh, 2000).

In traditional medicine, the water of plant is used for the treatment of cough, shortness of breath and sore lungs as an antidote, laxative, kidney and bladder reliever and eye irritation (Zargari, 1989). Asadian and Barati (2006) studied the effects of the frequency (number) and method of incisions at different times on the amount of extracted gum tragacanth in *Astragalus gossypinus* and found that the frequencies (number) of incisions and vertical incisions were ineffective in the amount of extracted gum tragacanth. Asadian *et al*. (2008) investigated the effects of incision at different times on the amount of gum tragacanth in *A. parrowianus* and showed that there was

no significant difference between once or twice incisions in gum tragacanth production.

Astragalus species have a special role in rangelands due to the soil protection. Kolahchi *et al*. (2011) found that in rangelands, because of susceptibility to sheet erosion, mass erosion, landslides and solifluction, the cultivation of plants with high interception such as different genera of *Astragalus* enhanced the resistance of rangeland to the erosion. Therefore, according to the economic and conservation values of *Astragalus* species producing gum tragacanth, serious action is necessary to maintain their survival and regeneration. Non-normative exploitation is one of the main causes for the destruction of gum tragacanth-producing *Astragalus*. Therefore, in this study, the effects of exploitation on the survival and production of one major gum tragacanth-producing *Astragalus* were investigated in Isfahan province, Iran.

Materials and Methods

This research was conducted in Ghale Mousa Khan of Tiran, Isfahan province, Iran during 2000-2006 whose characteristics are shown in Table 1.

Table 1. Characteristics of research region

Site Characteristics	Ghale Mousa Khan
Location	15 km of Tiran
Geographic Coordinates	Longitude: 50° 58' E Latitude:32° 36'
Altitude (m) a.s.l	1815 m
Average Rainfall (mm)	152 mm
Average Daily Temperature (°C)	15°C
Soil Texture	Clay loam
Climate	Semi-arid

In this study, a completely randomized block design with three replications in a split plot design was used. Treatments included the number of scars (2 and 3 scars) and the number of harvests (two, four and six times) and control (no harvest).

During the exploitation, each plot contained 30 plants, exploited for the first time.

1. In 2000, appropriate shrubs were selected. These shrubs had canopy cover of minimum 300 and maximum 400cm^2.
2. In June 2001, some holes with a depth of 15-30 cm were dug near the plants, mostly in the North Slope to avoid direct sunlight. Then, the exploitation began from July and continued until September.
3. In 2005, the second stage of exploitation commenced by creating holes in late June and continued until September on the same shrubs. Exploitation from shrubs was not allowed during 2001-2005.

The product of each plant was separately collected in plastic containers and after weighing, the product of a plot (30 Shrub) was calculated. After the first exploitation in each year and after the end of the vegetative stage in each plot, the dried plants as a result of exploitation were counted and the plant mortality percent was recorded in each plot. The canopy cover of different plants was measured after full growth during 2001-2006 so that small and large diameters of each plant were measured and then, the canopy cover percent was estimated. The data were analyzed using SAS and MSTATC software. Figures were drawn using Excel.

Results

Gum tragacanth production

As seen in Table 2, results showed that the number of incisions and the interaction between the number of harvests and incisions had no significant effects on gum tragacanth production. However, significant differences were recorded for the number of harvests (P<0.01). The analysis of variance of the gum tragacanth production of *A. keyserlingii* in 2005 (Table 2), showed that there was no significant difference between the number of incisions for gum tragacanth production. However, significant differences were recorded among the number of harvests and the interaction between harvest and incision for gum tragacanth production (P<0.01).

Table 2. Analysis of variance of the gum tragacanth production of *A. keyserlingii* in 2002 and 2005

Sources of Variation	DF	MS	
		2002	2005
Block	2	2112.80	67.77
Number of Scar	1	27.306 ns	53.32 ns
Error a	2	1534.984	396.33
Harvesting number	2	5886.226 **	1062.97 **
Harvesting*Scar	2	1015.266 ns	1425.94 **
Error b	8	956.753	68.03

*, **, ns= Significance at 1%, 5% levels and non significant, respectively

The means of production in different harvests were compared with Duncan test (P<0.01). The highest production with an average of 156.9 g (from 30 shrubs) in 2002 was obtained for six-time harvests, showing no significant differences with four time harvest with an average of 129.5 g. The highest production in 2005 with an average of 121.58 g was obtained for six-time harvest, having no significant difference with four-time harvest with an average of 119.52 g (Fig. 1).

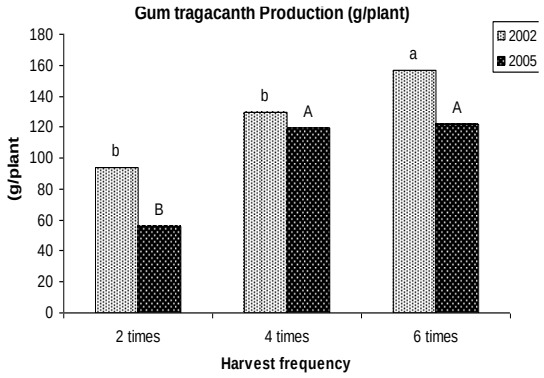

Fig. 1. Means comparison of gum tragacanth production (g/30plant)

Means comparisons of gum tragacanth production, interaction between the number of harvests and incisions were performed using Duncan's Test (P<0.01). As seen in Fig. 2, the highest gum tragacanth production with an average of 135.59 g was obtained in four-time harvest, showing no significant differences with six-time harvest and three-time incision with an average value of 131.75 g.

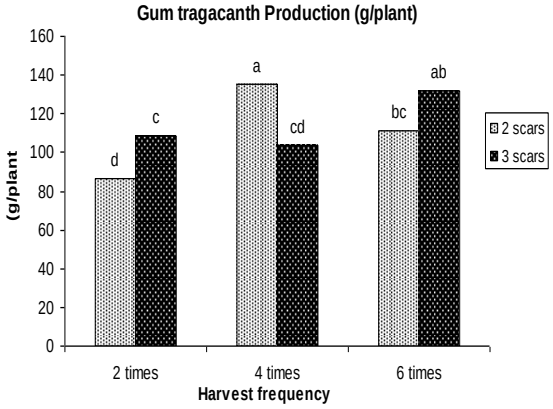

Fig. 2. Means comparison of gum tragacanth production (g/30plant)

Plant mortality

According to the results of ANOVA of mortality in different years, a significant difference was found among the number of harvests (P<0.01). The interaction effect between the number of harvests and incisions during 2004-2006 was also significant (P<0.01) (Table 3).

Table 3. Analysis of variance of *A. keyserlingii* mortality during 2002-2006

Sources of Variation	DF	MS				
		2002	2003	2004	2005	2006
Block	2	9.04	12.57	6.40	0.18	1.95
Number of scar	1	14.53ns	2.87ns	2.12ns	2.09ns	14.95ns
Error a	2	15.96	4.78	9.10	0.15	2.85
Harvesting time	3	1671.68**	1947.05**	1720.51**	1558.46**	934.52**
Harvesting x Scar	3	32.42ns	40.45ns	29.09**	79.82**	25.76**
Error b	12	19.40	14.44	5.96	2.28	4.02

*, **, ns= Significance at 1%, 5% levels and non significant, respectively

Means comparisons of plant mortality were performed using Duncan's test ($P<0.01$). According to Fig. 3, the highest mortality percent during 2002-2006 was recorded as 49, 52, 53, 52, and 53 with six-time harvest, respectively.

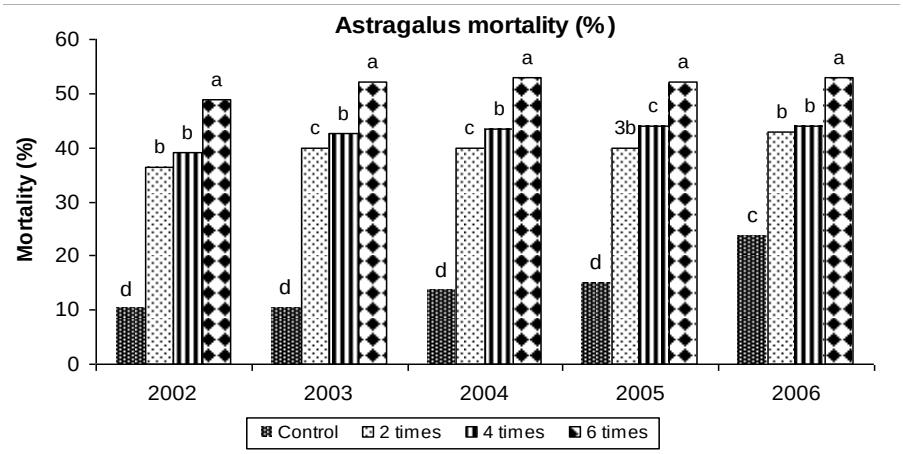

Fig. 3. Effects of number of harvests on the mortality percent of *A. keyserlingii*

Means comparisons of mortality percent between harvest and Scar interaction were made using Duncan's test ($P<0.01$) (Fig. 4). As seen in this graph, the highest mortality percent during 2004-2006 was recorded as 54, 55.4 and 54%, respectively. There were significant differences in all years and all incisions between 6-time harvest and 2 & 4 harvests.

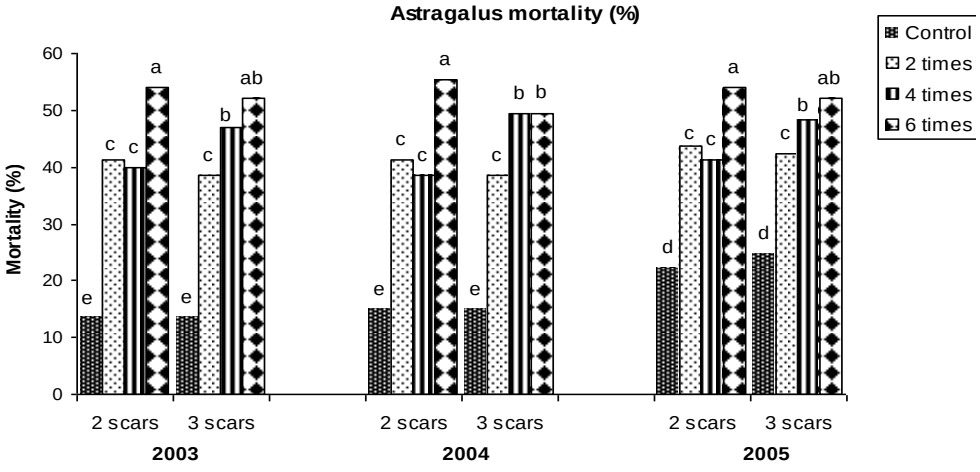

Fig. 4. Interaction effects between number of harvests and incisions on the mortality percent of *A. keyserlingii*

Canopy cover

As seen in Table 4, the differences between years, the interaction between year and incision, number of harvests and the interaction between harvest and incision on canopy cover percent were significant (P<0.01).

Table 4. Combined analysis of variance of the effects of year and the number of incisions and harvests on *A. keyserlingii* canopy cover

Sources of Variation	DF	MS	F
Number of scars (S)	1	171660.05	0.71^{ns}
Number of harvesting (H)	3	551433.72	9.20**
S x H	3	1153511.32	19.24**
Error a	2	243458.12	-
Year	5	16211552.06	881.25**
Year* Scars	5	60748.03	3.3**
Year * Harvesting	15	23405.44	0.39^{ns}
Year * Harvesting*Scars	15	12591.35	0.21^{ns}
Error b	20	18396.10	-

*, **, ns= Significance at 1%, 5% levels and non significant, respectively

Means comparisons of the effects of number of harvests on the canopy cover showed that the highest percent with an average of 839 cm^2 was recorded for the control treatment, showing no significant difference with the other treatments. Harvesting for two, four and six times had no significant effects on canopy cover (Fig. 5, left).

The means of canopy cover percent in different years showed the highest canopy cover with an average of 1057 cm^2 in the sixth year (Fig. 5, right).

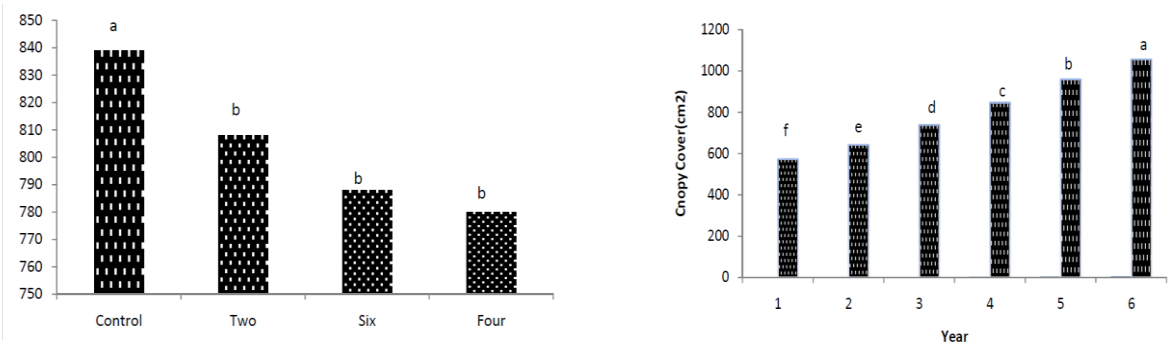

Fig. 5. Effects of harvesting number on canopy cover(Left), Effect of year on canopy covers (Right)

The means of interaction effects between incision and harvest on canopy cover were compared. The highest canopy cover with an average of 884 cm^2 was recorded for control treatment with two incisions, showing a significant difference with the other treatments and the lowest percent with an average of 741 cm2 was obtained for four-time harvest with two incisions (Fig. 6).

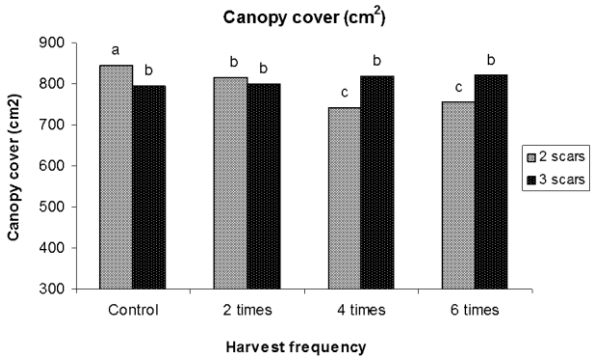

Fig. 6. Effect of harvesting frequency and scar on canopy covers (cm^2)

The means of the interaction between year and number of incisions on canopy cover were compared with Duncan test ($P<0.01$). The highest canopy cover percent (884 cm^2) was obtained for control treatment with two incisions, showing significant differences with other treatments (Fig. 7).

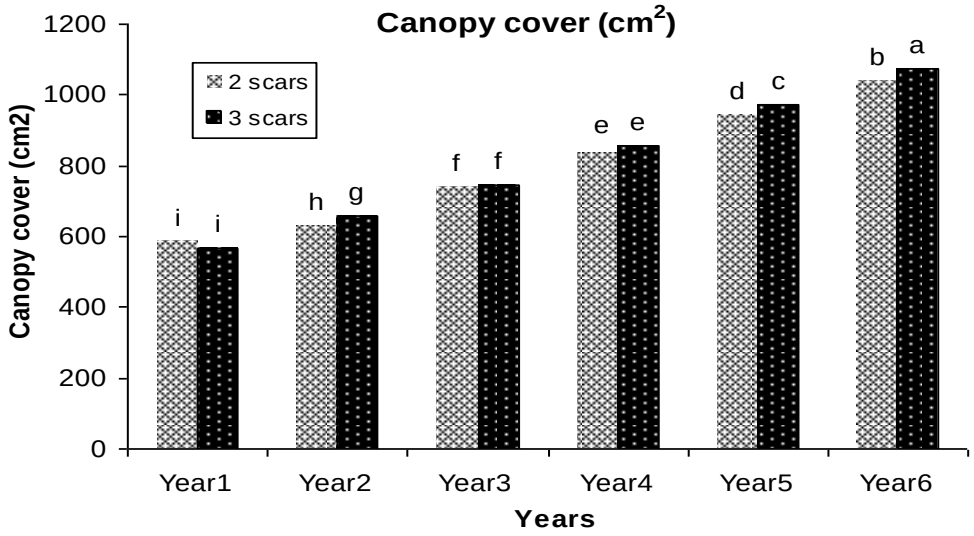

Fig. 7. Effects of scar number and year on canopy cover (cm^2)

Discussion

According to the analysis of variance of gum tragacanth production obtained from *A. keyserlingii* in 2002, no significant differences were found for the number of incisions. However, the number of harvests showed a highly significant difference and maximum gum tragacanth production was obtained for the treatment of six-time harvest with an average of 156.9 g having no significant difference with four-time harvest (125.9 g). In addition, (Table 2) shows that the number of harvests and the interaction of incision and harvest significantly affected the production of gum tragacanth so that maximum production with an average value of 121.58 g was obtained for six-time harvest having no significant difference with four-time harvest (119.52 g) (Fig. 1). Furthermore, maximum production was obtained for four-time harvest with two scars with an average value of 135.59 g showing no significant differences with six-time harvest and three scars with an average value of 131.75 g (Fig. 2). Therefore, four-time harvest and two incisions are logical for the exploitation of gum tragacanth obtained from *A. keyserlingii* to avoid the additional costs and damages to the plant.

In Fig. 3, it is seen that the highest plant mortality percent was recorded for six-time harvest occurred in five consecutive years and the interaction between harvest and incision clearly showed that the highest mortality percent occurred in three consecutive years was obtained for six-time harvest and three-time incision.

As seen in Fig. 5, *A. keyserlingii* had the highest canopy cover in the sixth year. Fig. 4 clearly shows that the number of harvests affected the canopy cover so that maximum canopy cover with an average of 839 cm^2 was obtained in control treatment and significant differences were not found for three harvest treatments. Thus, this species has been affected even by two harvests and its growth has declined. In addition, the interaction between the incision and harvest (Fig. 6) indicated that the plant was also affected by different harvest and

incision treatments. According to the interaction of year and incision (Fig. 7), maximum canopy cover was obtained in the sixth year and three-time incision with an average of 1075 cm^2. This result clearly shows that this plant is resistant against incision since it has maximum canopy cover percent even under three-time incision in the sixth year.

The findings reported by Asadian and Barati (2006) and Asadian *et al*. (2008) showed no significant differences between one or two incisions with the amount of gum tragacanth production. These results are contradicted with our results in which the number of harvests and incisions affected the production of gum tragacanth.

Conclusion

The conservation of *Astragalus* species in rangelands has a special place in terms of either economic profit (extraction of gum tragacanth and forage for livestock grazing) or soil conservation. The increase in price of gum tragacanth in recent years and more attention of beneficiaries to the extraction of this material from the existing *Astragalus* in the rangelands could cause the destruction of *Astragalus* species producing gum tragacanth. Consequently, according to the obtained results and in order to sustainable use of existing species, two scars and four-time harvest are recommended.

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تاثیر تعداد تیغ و دفعات تیغ زنی بر تولید و ادامه حیات *Astragalus keyserlingii*

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چکیده. یکی از فرآورده‌های مهم دارویی و صنعتی مراتع کشور کتیرا می‌باشد که از تیغ زنی گون‌های مولد کتیرا از جمله ***Astragalus keyserlingii*** به دست می‌آید. حفاظت از این گونه‌ها علاوه بر منافع اقتصادی، باعث جلوگیری از تخریب و فرسایش خاک می‌شود. افزایش قیمت کتیرا در سال‌های اخیر، توجه بیشتر سودجویان به استخراج این ماده از این گونه‌ها را باعث شده است. هدف از این مطالعه ارائه یک روش علمی است تا ضمن بهره‌برداری از کتیرا، حفظ و بقا این گونه را تضمین نماید. این تحقیق تحت آزمایش اسپلیت پلات در قالب طرح بلوک‌های کامل تصادفی در سه تکرار انجام شد. هر تکرار شامل ۳۰ بوته بود که برای اولین بار مورد بهره‌برداری قرار می‌گرفتند. تیمارها شامل تعداد تیغ زنی در هر برداشت، تعداد برداشت در سال بود. صفات اندازه‌گیری شده شامل میزان کتیرای بدست آمده از هر تکرار، درصد تلفات بوته، تاج پوشش و وزن هزار دانه بود. اثر سال تنها در میزان تاج پوشش بررسی گردید. نتایج نشان داد که اثر تعداد برداشت روی تاج پوشش منفی است. بیشترین تلفات معادل ۵۳ درصد در تیمار شش بار برداشت و بیشترین میزان محصول در تیمار شش نوبت در سال با میانگین ۱۵۶/۹ گرم در ۳۰ بوته بدست آمد که با چهار برداشت اختلاف معنی‌دار نداشت. در مجموع برای بهره‌برداری از گونه ***A. keyserlingii*** می‌توان حداکثر دو تیغ در هر نوبت و چهار نوبت بهره‌برداری در سال را توصیه نمود.

کلمات کلیدی: کتیرا، تیغ زنی، تعداد برداشت، گون