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The effects of artificial livestock trampling on germination and growth of *Stipa barbata*

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Abstract

To assess the effects of livestock grazing on soil compaction (density changes), the trampling action of livestock was simulated. The research field was located to the south west of Nazarabad in Savojbolagh district, south west of Tehran Province. Samples were annually collected based on a completely randomized design. From the triple regions (reference, key and critical) 36 cylindrical cores were taken they were 8 and 15 cm in diameter and depth respectively. Sampling was done at the end of each grazing season (early fall) in 2004-2005, pot experiments being composed of 9 treatments in 4 replicates. Collected data were analyzed in a completely randomized block design using ANOVA. The means were compared using Duncan Test. The results show that during conversion from critical to key and reference situations, germination rate and the height in critical condition, critical to key and critical to reference conditions have increased. The organic matter for these conversions were 0.033, 0.07 and 0.23 respectively, among which significant statistical differences are observed ($P \leq 0.05$). In conversion of key to critical and reference conditions, germination rates (in pot environments) for key, key to critical and key to reference conditions were reduced respectively. The organic matter contents were 0.052, 0.026 and 0.107 gr. While the heights being 51.19, 27.69 and70.62 cm respectively. *Stipa barbata* shows significant differences in germination rate as well as height. With decrease of bulk density and compaction in the first treatment, and with reverse conditions for the second one, in both treatments, germination rates were decreased. In converting reference to key and critical conditions, germination rates for pots of reference, reference to key and reference to critical conditions were 50, 56.25 and 29.69% respectively. The heights and organic matter were reduced and while in all treatments significant differences being observed ($P \leq 0.05$).

Keywords: Bulk density, Trampling, Germination, Organic matter, Height, *Stipa barbata*

1. Introduction

Livestock trampling results in extinction of plants susceptible to grazing. The main goal of range ecosystem management is to increase and improve soil vegetative cover. Mismanagement and degradation of grazed lands, especially in arid and semiarid regions, can lead to development of a vegetative cover which is not characterized as a desirable grazing cover. The restoration of vegetative cover would be possible via a consideration of such factors as potentials of the area, selection of native plants, plant competition as well as the readiness of the substrate. Biomass and density of vegetative cover is affected by physical and chemical characteristics of soil. These characteristics are changed through livestock trampling and they can lead to changes in plant cover characteristics (Kohandel, 2006). Considering the effects of soil compaction around the seed on germination rate of seeds and moisture content of soil, in this study we have investigated the effects of different soil

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compaction treatments (intense grazing, light grazing and no grazing), simulated artificially, on the germination rate of trampled seeds, organic matter as well as the height of the index plant.

In a study of interactions of soil and plant, the effects of sheep grazing on dry matter of *Lolium sp*. were assessed. Under grazing and soil compaction conditions, productivities of ranges were reduced by 21% in spring, but again during the coming summer restored to the original level. The growth of vegetative cover existing in a range improves by increase in seeding and budding rate and if these seeds come from suitable and high quality plants, it would lead to the improvement of the range, but if this is not the case, the ecosystem would be deteriorated (Drewry et. al, 2001). In a survey of range plants establishment, under different conditions of soil compaction, in Lar Dam basin, it was reported that the changes of soil bulk density in reference, key and critical regions don't have any significant effect on germination rate of index plant (Ataian, B., 2002). No need to mention that overgrazing resulted in decrease of vegetative cover in the same grazing season. It is impossible to predict the duration of the effects caused by overgrazing and/or how the reactions of plants of that area would be. Resistance of plants to trampling and grazing effects of livestock is highly different. Even a single species reacts differently under different environmental conditions.

2. Materials and Methods

The studied region, located in south west of Nazarabad in Savojbolagh district (south west of Tehran province) is located between 50° 27' 37" to 50° 30' 45" east longitude and 35° 51' 30" to 35° 53' 55" north latitudes. The slope of the area is 0-2% and its altitude 1150-1180 meters above sea level. The average annual rainfall is 229.3 mm. In order to simulate the effects of livestock trampling which leads to soil compaction, we had to artificially change the bulk density of soil. In other words, rangeland soil compaction due to grazing was simulated. Twelve samples of soil (totally 36 samples) were annually collected (using cylindrical cores of 8 and 15cm in diameter and height respectively), from the three regions referred to as: reference, key and critical. Sampling was conducted in early fall (end of grazing season) of 2004-2005. In the process of a pot experiment, samples were splitted in to 9 treatments of 4 replications. Recording data were compared in a completely randomized block experimental design. Following a preparation of the required data concerning soil and vegetative cover in the three regions, ANOVA was employed for analysis. The means were compared using Duncan test.

Density of soil in reference, key and critical regions were 1.01, 1.05 and 1.08 gr/cm^3 respectively. Based on these measurements soil bulk density changes were conducted as follows.

$$Bd = \frac{M}{V} \quad (1)$$

Where:
Bd: denotes soil bulk density,
M: dry soil organic matter and
V: the volume of sample.
Following symbols were used to show different experimental units
R: reference (no graze),
K: key or fairly grazed,
C: critical (intensively grazed).

$$R, R \rightarrow K, R \rightarrow C$$
$$K, K \rightarrow R, K \rightarrow C$$
$$C, C \rightarrow R, C \rightarrow K$$

Arrow symbol (→) refers to the interaction of bulk density among soil samples of the three regions. Change of soil bulk densities were found out using equation (I) in calculations.

The following procedure was used to determine changes of height (△h) for intact samples, as well as to convert bulk densities to each other.

1. Height and diameter measurements of soil samples to minimize errors in density changes.

2- Initial volume of samples were calculated using equation (2):

$$V_1 = \pi \times \frac{d^2}{4} \times h_1 \quad (2)$$

Where d is the diameter of sample (equal to diameter of cylinder) while h_1 denoting the height of the sample which is less than the height of the cylinder (15±1cm).

3- Based on the known bulk density of samples from each region and through a measurement the volume of each soil sample in cylinders, using equation (1), the mass of soils was calculated for each region (Bd_1). Here after, the bulk density equals to regional bulk density while the objective being to convert it to the bulk density for the soil of interested region (Bd_2).

4- Again using equation (1) and according to mass (M), bulk density of target region (Bd_2) and secondary volume (V_2) were calculated for the sample. To calculate the extent of height changes, which lead to changes of soil compaction and therefore bulk density, $\triangle h=h_2-h_1$ formula was employed. Following the above calculations, experimental height changes were introduced. Based on the values obtained for height differences ($\triangle h$), they could be classified in two groups: (1) ($\triangle h>0$) and (2) ($\triangle h<0$). For the first group there was an increase in height and for the second group a reduction in height. Increase in sample height or in its porosity implies a reduction in the sample's bulk density. Once the grazing periods fare over and during the freezing periods (in regions with severe winters), the volume of soil granules increases due to freezing that leads to compaction recovery. Based upon this phenomenon, samples with $\triangle h>0$, following watering around field capacity (an average of 2 liters of water) were placed in cold storage room (-20˚C) for 3 days (72 hours) which is supposed to happen during winters. After 72hr under cold storage, if there were not any increases observed in heights, storage duration would be extended until the target heights were reached. Then samples were again placed under ambient temperature (19˚C) and after defrost ration, the heights were measured to ensure of the intended height increases. If the increases of heights were more than expected, samples were fairly compressed to obtain the intended heights.

In the second case a mono axial press precisely was used to reduce the height and increase soil compaction. While soil height was reduced, to determine the effects of soil compaction (during grazing season) on germination and growth of range plants, pot experiments were conducted following a treatment of intact soil samples as noted above. In the first group of experiments, the effects of soil compaction on germination and growth of a range index plant, *Stipa barbata*, (of Savojbolagh origin) were studied. This plant species was selected from among plants inhabiting the reference region. A selection and determination procedure of index plant was as follows:

In early fall of 2003, after plants were mature, collection and identification of prevalence of the most suitable plant seeds was done in the reference region. The prevalent species was identified according to the identification guide books for range plant species. Samples were incubated at 19˚C in a Petri dish for 12 days and the germination capacity of seeds measured. The selected plant species had the highest germination rate. The seeds collected during early spring of 2003, were planted at a soil depth of 1.5 cm. In either year of experimentation period (150 days) factors such as growth, budding, stem height and biomass were recorded for future comparison and assessments. The stem height was measured at intervals of 15 days. To determine the phytomass, dry organic matter (110˚C for 24hr) of samples were evaluated.

3. Results

The artificial variation of bulk density of samples taken from reference, key and critical regions had significant effects on germination rate, organic matter and height of *Stipa barbata*. Table.1 presents the results of changes of different conditions according to and based on treatments.

Table 1. Comparison of germination rate, height and plant organic matter based on changes of different conditions in treatments

Source of change	Variable	Df	Conversion of key to reference and critical conditions	Conversion of reference to key and critical conditions	Conversion of critical to reference and key conditions
Treatment	Germination	2	*	*	**
	Height	2	**	**	**
	Organic matter	2	Ns	**	**
Year	Germination	1	Ns	Ns	Ns
	Height	1	Ns	Ns	Ns
	Organic matter	1	Ns	Ns	Ns
Treatment*(year)	Germination	2	Ns	Ns	Ns
	Height	2	Ns	Ns	Ns
	Organic matter	2	Ns	Ns	Ns

*Significant difference at 5% level
** Significant difference at 1% level
Ns: Non significant

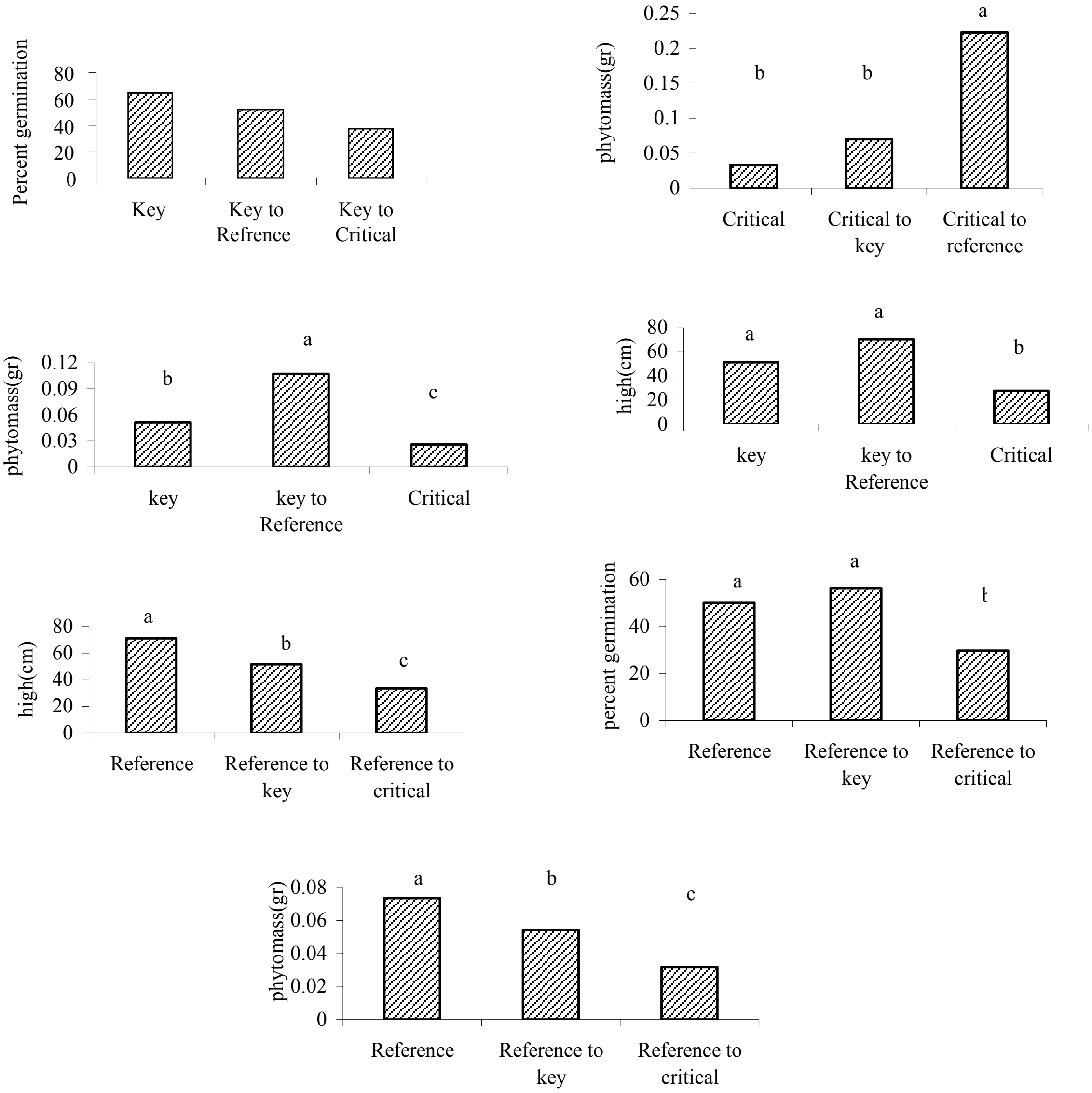

Fig.1. Changes in phytomass, height and germination of index plant under artificial conditions created in bulk density of soils from reference, key and critical regions

3.1. Conversion of different conditions according to treatments

Changes from critical to key and reference conditions, germination rates in pots under critical, critical to key (C→K) and critical to reference (C→R) were 29.7, 53.12 and 68.75% respectively. The heights were 26.12, 58 and 87.69 cm and the organic matters 0.033, 0.07 and 0.23 gr respectively. The differences in treatments were significant ($P \leq 0.05$). (C→K) and (C→R) treatments which resulted in a reduction in compaction and mechanical resistance as well as an increase in bulk density of soil, led to improved germination, height and plant organic matter for *Stipa barbata* in pot experiments. As shown in figure.1, the measurements during the period of 2003-2004 confirmed the increasing effect of reduction in compaction on germination and growth of index plant. Although there were enough organic matter and mineral compounds in reference region, physical properties of soil were of such on importance that the productivity and organic matter content of soil couldn't do much in terms of budding and growth rate in *Stipa barbata.* In converting and implementation of treatments in critical region and changing it to key conditions, the budding, height and plant organic matter were increased but in treatment (C→R), the differences were high and there was a relatively good increase in plant organic matter, indicating that physical characteristics of soil in addition enough organic matter and required nutrients can lead to increased biomass.

In converting the key to critical and reference conditions the germination rate in pots under key, key to critical (K→C) and key to reference (K→ R) were 62.5, 51.56 and 37.5 % respectively, 0.052, 0.026 and 0.107 gr were for organic matter as well as 51.19, 27.69 and 70.62 cm for height respectively. There was a significant difference observed between germination and height of *Stipa barbata*. In (K→C) and (K→R) treatments, as far the former which represents a reduction in bulk density, increase of mechanical resistance and a decrease of compaction, and in the latter case with reverse changes, germination rates were in either case significantly decreased ($P \leq 0.01$). Reduction in organic matter and height were significant at $P \leq 0.05$ in these treatments (Figure 1). In both treatments the controls demonstrated relatively good increase in terms of plant organic matter (about four times) and this indicates the effect of such physical conditions as reduction in mechanical resistance, and increased appropriatenees of soil density, finally resulting in an increase in production.

In converting the reference to critical and key conditions the germination rate in pots under reference, reference to key (R→K) and reference to critical (R→C) were 50, 56.25 and 29.69 % respectively and 71.13, 51.69 and 33.5 cm for height and 0.074, 0.04 and 0.032 gr. organic matter respectively, and there were statistically significant differences among all ($P \leq 0.05$). As it can be seen in figure.1, the treatment in which the reference condition was converted to key led to an increase in germination rate due to increase in density, because in the reference region, soil porosity is high and its mechanical resistance low, the drag between soil and seed would be less and it has a great effect in germination of seed which requires humidity together with nutrients. According to figure.1, this condition will limit rooting which inhibits establishment of index plant and causes some decrease in height and organic matter of *Stipa barbata.*

Results obtained by Profit *et al.* (1993), Warren (1995), Pit (1991), Krzic *et al.* (1999), Drewry *et al.* (2001) and Ataian *et al.* (2002) are in line with those in this study.

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