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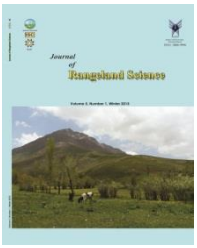

**Research and Full Length Article:**

# Determination of Suitable Lands for Sowing Alkaligrass *Puccinellia distans* (Case Study: Agh-Ghala Rangelands, Golestan Province, Iran)

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**Abstract.** Annually, 200 ha of Agh Ghala rangelands in Golestan, Iran are under Alkaligrass *Puccinella distans*'s cultivation but the failure in the identification of appropriate sites for seed sowing may result in high costs of cultivation. The current study aims to reduce such costs through the examination of apt sites to grow *P. distans* in northern rangelands of Agh Ghala Golestan, Iran. Because of the same topography and climate of the study area and Gomishan rangeland in closure where the plant grows and seeds are collected, a map of photomorphic units was first prepared using satellite images of Landsat 5 (28.05.2011) and Google Earth. Then, some soil physical and chemical properties including texture, EC, pH and organic matter were measured in three photomorphic units. In each photmorphic unit, three transects (length of 150 m and intervals of 50 m) were set up. Along each transect, three soil samples at the depth of 0–10 cm (9 samples in each photomorphic unit) were taken and transferred to the laboratory. In order to verify the suitability of the predicted photomorphic unit, the seeds had been sown in the above mentioned key area of each photomorphic unit and *P. distans* cover percent was estimated. Data were analyzed and means comparison was done between the units using Tukey method. Incorporating all the obtained data led to predict the location of appropriate photomorphic unit for the seed sowing of this plant. Despite the initial prediction of suitable seeding location (photomorphic unit 3), results indicated that the photomorphic unit 1 was the most successful area which had a lower depth of underground water table and higher EC and vegetation cover percent as compared to two other units. Based on the findings of current study, it is recommended that seeding operation should be concentrated on photomorphic unit 1.

**Key words:** *Puccinellia distans*, Soil properties, Photomorphic unit

## Introduction

About 15 percent of the world's arid and semi arid areas are affected by salinity and one third of the farmlands are exposed to Salinization (Ajmal Khan & Bilquees Gul, 2002). Iran is a country with vast areas of salty desert and almost 12.5 percent (about 204000 $km^2$) area of the country is located in the arid and semi-arid regions that have saline and alkaline soils (Bagherirad *et al.*, 2007). Regarding the increasing trend of saline lands' development and scarcity of agricultural lands in the world, the use of resistant varieties to salinity will be of great importance (Safarnejad *et al.*, 2005). Salinity resistance in such plants is 10 to 100 times greater than the other crops and therefore, the use of them for land rehabilitation purposes would be of low costs. Therefore, the mentioned plants can be introduced as an optimal economical option as compared to the crops. Moreover, these species can be used as biological land reformers in the irrigated lands in which the level of salt in groundwater is high (Ghaneimotlagh, 2007). Natural ecosystems include many biotic and abiotic factors which interact with each other so that they are very complex. Clearly, the establishment of a plant community is affected by climatic, edaphic and biological factors. Therefore, studying the above mentioned factors will identify the reasons of plant community's distribution and habitat potentials (Muller & Ellenberg, 1974). Investigating the relationships between vegetation and environmental factors revealed that there was a clear relationship between vegetation and edaphic factors (Naseri *et al.*, 2009). In an investigation on the halophyte plant communities and their relationships with soil physical and chemical characteristics in the rangelands of Sorkhdeh, Damghan using multivariate analysis, it was stated that the most important physical and chemical properties of soil in the segregation of the area's plant communities were electrical conductivity, potassium, lime and soil texture (Ghaderi *et al.*, 2010). During a similar study to examine the relationships between soil characteristics and vegetation in 14 rangeland habitats in Qom province, Iran using principal component analysis, it was concluded that major characteristics of soil effective in plant types' separation were texture, electrical conductivity and the amount of lime in the soil (Jafari *et al.*, 2005). To detect the varieties resistant to salinity and drought in saline mountainous rangelands of Qom, categorization techniques such as CCA and DCA were used. Results demonstrated that salinity and soil texture were the main factors limiting the growth of plant species in that area (Tatian *et al.*, 2010). In another study on the composition of vegetation and the structure of plant communities on the coast of Dawson Bay and Lake Manitoba, it was concluded that salinity is the most important factor in estimating vegetation pattern (Burchill & Kenkel, 1990).

It can take many years to reestablish the native plant communities in the degraded lands. There is growing interest in restoring the degraded lands by a sowing method. In the United States, native perennial grasses had been sown on highly degraded lands in the Great Plain states (Dunn *et al.*, 1993). In the other regions of Great Plains, the cultivated land had been restored or improved by seeding monocultures or mixtures of non native perennial grasses (Lawrence and Ratzlaff, 1989). The establishment of permanent cover can quickly stabilize some soil properties while increasing water retention and reducing the quantities of sediments, nutrients and agrochemicals transported to surface water within a few years (Dunn *et al.*, 1993).

Jabarzare *et al.* (2010) stated that the germination of species of *Artemisia* genus was significantly related to high rates of rainfall in winter. Tarasoff *et al.* (2007) studied the germination of *P. nuttalliana* and *P. distans* as compared to *Poa pratensis* with respect to negative water

potential and high temperature in western North America and concluded that *P. distans* had the highest resistance to drought and salinity. Saberi and Tavilli (2010) indicated that priming application has had considerable influences on seed germination of *P. distans* so that there were significant differences between the obtained results. Hosseini (1994) stated that *P. distans* can grow in saline or saline-alkaline soils with high underground water table or heavy soils with poor drainage. In a series of studies about salt tolerant rangeland species, Jafari *et al.* (2005) studied *Puccinellia* and the possibility of its cultivation in salt rangeland and asserted that *Puccinellia* can grow in wetland saline and alkaline (not acid) soils with an EC of saturation between 10 and 40 dS/m and it accumulates in the areas which are void of any vegetation cover due to salinity or flood proneness. In order to compare the resistance to salinity in three grassland species, namely *Agropyron elongatum*, *P. distans* and *Kochia prostrata* in greenhouse conditions, Akhzari *et al.* (2012) used factorial arrangement in a completely randomized design with five replicates. The results revealed that while *Kochia prostrat*a could only survive at salinity of 30 dS/m, *P. distans* and *Agropyron elongatum* could survive at salinities up to 40 dS/m. Thus, it can be stated that the physiochemical characteristics of soil are effective in the establishment of *P. distans* in a different way. Given the reduction of available forage of rangelands due to improper exploitation, overgrazing and wind erosion, conducting studies on halophytes seems necessary (Bakhshi Khaniki & Marof, 2006). As a result of little rainfall, high evaporation and soil salinity, the northern rangelands of Agh-Ghala are ecologically fragile and rehabilitation of vegetation cover in this area seems crucial. *P. distans* is one of the perennial and palatable plants in northern arid with mean annual precipitation of 250 mm (data of 20 years: 1990-2010), falling Golestan which is employed in the rehabilitation of saline lands and grazing (Bandani & Abdolzadeh, 2007). This is a halophytic species which grows in saline or alkaline soils with high ground water and medium to heavy textures. It is scattered in an area over 100,000 ha of the northern rangelands of Golestan province. However, it is becoming extinct due to the overgrazing or off-season grazing except for the protected areas such as Gomishan's inclosure (Bagherirad *et al.*, 2007). Results of an investigation on the adaptation of 19 plant species in Agh Ghala city for 5 years revealed that *P. distance* was established successfully and it was more vigor and productive than the others (Sanadgol, 2006). The seeds of this species were annually collected from Ghomiahan exclosure (Mirzaali *et al.*, 2006) and cultivated in 200 ha of rangelands in Agh Ghala city using a seeding method and locating the prone areas for its cultivation in order to reduce the costs resulting from the failure in seeding operations is necessary (Ghaderi *et al.*, 2010).

The main purpose of present study is to locate and propose appropriate areas for cultivating *P. distans* in the northern lands of Agh Ghala plain.

## Materials and Methods

### Study area

The study area is located in the northern part of Golestan province between northern Agh Ghala and western Inche Borun. The study area is limited by Turkmenistan in the north, Agh Ghala and Gomishan farmlands in the south, saline lands in west and Agh Ghala to Inche Borun road in east. The area lies at 54°14´58" to 54°39´16" longitude and 37°7´18" to 37°23´23" latitude; its area is 58,000 ha (Fig. 1).

Slope gradients are nearly flat (2%). The climate in this region is semi-arid to

mainly in the autumn and winter. The minimum and maximum height above sea

level is -25 and 14 m, respectively (Mohammadi Gonbadi, 2013).

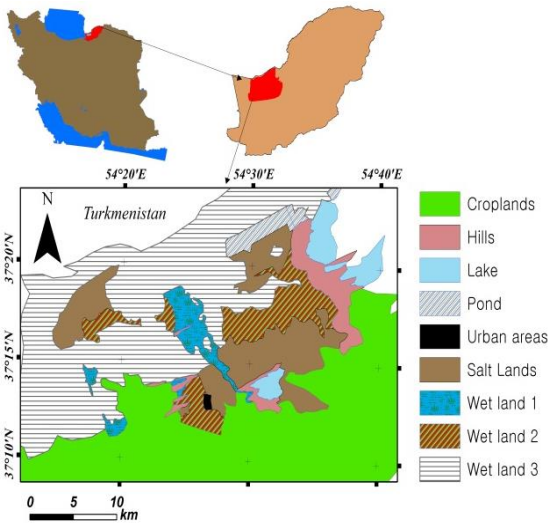


**Fig. 1.** Location of the study area in north of Iran

## Research Methodology

First, boundaries of the study area were accurately determined using satellite imagery, Google Earth software, field survey and GPS. Since *P. distans* grows in saline or saline-alkaline soils with high underground water table (Hosseini, 1994) and because of the same topography and climate of the study area and the ones for Gomishan's inclosure where the plant grows and seeds are collected, some soil properties were studied in different photomorphic units. Map of photomorphic units was prepared using satellite images of Landsat 5 (28.05.2011) and Google Earth (Alavipanah *et al.*, 2004). Finally, five photomorphic units (one from salt marshes, one from croplands, and three from wetland rangelands) were distinguished based on the satellite images' color tones; the darkest units of wetland rangelands were identified by code 1, the lightest ones were specified as the code 2, and the third unit which has tones of intermediate color was determined as the code 3. Photomorpic unit of salt marshes in addition to photomorpic unit of croplands was initially excluded. Then, three transects (length of 150 m and intervals of 50 m) were established in key areas of each photomorphic unit. Three soil samples at the depth of 0–10 cm were collected along each transect (total of 9 soil samples per photomorphic unit) and transported to the laboratory. Finally, by combining all the data, proper photomorphic unit for the cultivation of plant was located. In order to verify the suitability of the predicted photomorphic unit, the seeds were sown in the above mentioned key area of each photomorphic unit.

In the laboratory with plant materials and the removed trash, the soil samples were air-dried and sieved to pass a 2 mm screen. Particle size was determined using hydrometric method (Bouyoucos, 1962). Soil pH and Electrical Conductivity (EC) were determined (saturated paw method, AFNOR, 1987) by pH meter and conductivity meter, respectively. Soil Organic Matter (SOM) was determined by the Walkley–Black method (Nelson and Sommers, 1982).

## Data analysis

Before subjecting the data to a statistical analysis, the normalization of data was checked (Verdoodt *et al.*, 2009). One-way analysis of variance (ANOVA) was used to examine the differences in soil pH, EC, organic carbon percent and mean *Puccinellia distans* cover in three photomorphic units using SPSS16. Means comparisons were done using Tuckey test. Finally, Pearson correlation coefficient for soil properties and cover percent of *P. distans* was calculated.

## Results

There was no difference in soil texture of studied photomorphic units, and soil texture in the sites was silty-loamy.

Analysis of variance indicated no significant differences [$F(2, 20) = 0.682$; $P>0.01$] for soil pH between different photomorphic units (Table 1). According to (Fig. 2), soil acidity in the studied photomorphic units could not be effective in microbial activity and nutrients availability (Table 2).

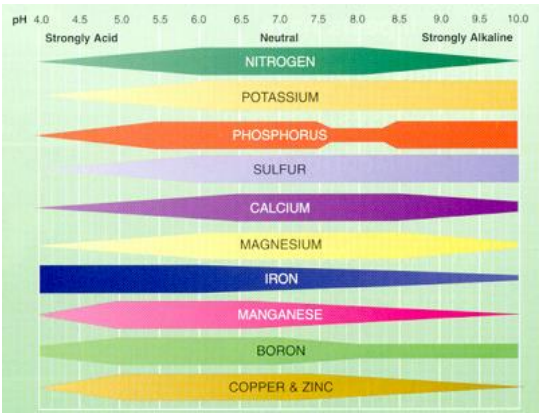


**Fig. 2.** Effects of pH on microbial activity and elements availability (Troug, 1943)

Statistical analysis demonstrated that there was a significant difference [F (2, 20) = 45.9, P<0.01] between the means of EC of soils in this study (Table 1). The obtained results indicated that EC values in photomorphic unit 1 were higher than those for the units of 2 and 3; but there was no difference between photomorphic units of 2 and 3 (Table 2).

Statistical analysis demonstrated that there was no significant difference between the means of organic matter in three photomorphic units of the study [F (2, 20) = 2.28; P>0.01]. The results indicated that the soil in photomorphic unit of 2 had the higher organic matter followed by unit 3. The lowest organic matter soil was obtained in photomorphic unit of 1 (Table 2). Calculation of the vegetative cover percent of *P. distans* in photomorphic units is shown in Table 2 and Fig. 3. Statistical analysis demonstrated that there was a significant difference between the means of *P. distans* cover percentage in different photomorphic units of the study (P<0.01). The result of Tuckey test demonstrated that photomorphic unit 1 with about 14% had the highest cover percent followed by unit 3 with the average value of 10.9%. The photomorphic unit 2 with the average value of 5% had the lowest cover percent of *P. distans* (Table 2 and Fig. 3).

For the prediction of the most suitable planting location, the photomorphic unit 3 was determined. Since it had the lower EC and higher humidity based on the satellite images' color tones, this photomorphic unit was predicted as the most suitable planting location.

**Table 1.** ANOVA results of soil properties and plant cover percentage of in three photomorphic units

| Variable | F test | Unit 1 vs. 2. | Unit 1 vs. 3. | Unit 2 vs. 3. |
|---|---|---|---|---|
| pH | 0.63 $^{ns}$ | 0.49$^{ns}$ | 0.81$^{ns}$ | 0.89 $^{ns}$ |
| EC (dS/m) | 45.97$^{**}$ | 0.00$^{**}$ | 0.00$^{**}$ | 0.56 $^{ns}$ |
| Organic matter (%) | 2.29 $^{ns}$ | 0.13 $^{ns}$ | 0.95 $^{ns}$ | 0.29 $^{ns}$ |
| Plant cover percentage | 25.6$^{**}$ | 0.00$^{**}$ | 0.05$^{*}$ | 0.00$^{**}$ |

$^{*}$, $^{**}$Significant at 0.05 and 0.01 probability level, respectively
ns= Not significant at 0.05 probability level

**Table 2.** Means comparisons of soil properties and plant cover percentage in three photomorphic units

| Photomorphic Unit | pH | EC(ds/m) | Organic Matter % | Plant Cover % |
|---|---|---|---|---|
| Unit 1(Wet test)= Wetland1 | 7.8 a | 44.6 a | 3.9 c | 14.0 a |
| Unit 2 (Dry test)= Wetland2 | 7.9 a | 20.7 b | 5.2 a | 5.0 c |
| Unit 3(Average) =Wetland3 | 7.9 a | 27.6 b | 4.1 b | 10.9 b |

Means of photomorphic unit for each column with the same letters has no significant differences based on Tukey 0.05 method

The result of correlation analysis showed that the mean cover percent of *P. distans* had the highest correlation [r=0.65, P<0.01] with the soil's EC. But there was no significant correlation between pH and soil organic matter (Table 3).

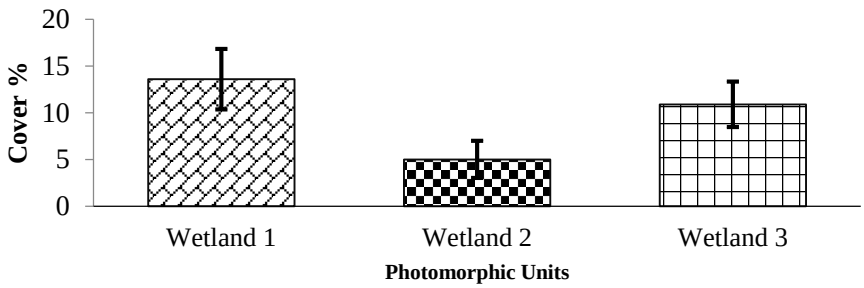


**Fig. 3.** The mean of vegetating cover percent of *Puccinellia distans* in 3 photomorphic units

**Table 3.** Pearson correlation between the soil parameters and plant cover percent in *Puccinellia distans*

| Variable | Correlation Coefficient (r) |
|---|---|
| pH | -0.32 |
| EC (dS/m) | 0.65** |
| OM % | -0.30 |

** Correlation coefficient is Significant at 0.01 probability level

## Discussion

If one hope to increase vegetation cover in the degraded lands in the arid and semi-arid areas, he must first understand which species where can be planted and then determine what management practices will be most effective in building the plant cover. Water logging and salinity are major environmental and economic problems in the northern lands of Agh Ghala plain. Use of native species *P. distans* to reclaim this plain would not only be economically beneficial but would also be ecologically relevant. The salt induced water deficit is one of the major constraints for plant growth in saline soils. According to the map of photomorphic units, color tone in unit 1 is darker and therefore, has a lower depth of underground water as compared to the other photomorphic units. It can be stated that due to high underground water level in this photomorphic unit on the one hand, and high temperature of the area – which results in intense evaporation from the surface – on the other hand, the area's underground water which contains numerous soluble salts comes to the surface while leaving the salts on the soil surface. As a result, due to excessive accumulating of salts, EC of soil in this photomorphic unit is higher than the other photomorphic units. In contrast, in the photomorphic unit map, it is shown that photomorphic unit 2 had a lighter color tone which means that this area has underground water with greater depth; so, its EC is lower in comparison with two other photomorphic units (Table 1). It can be concluded that the soil salinity has a relationship with the level of underground water in the study area that is the lower the level of underground water depth, the higher the soil's salinity. Table 2 shows the results of Tuckey test for cover percent of *P. distans* in soils of photomorphic units. Despite the initial prediction of the most suitable seeding location (photomorphic unit 3), mean percent in photomorphic unit 1 shows a significant difference with the other units. Table 3 represents Pearson correlation coefficient for the mean cover percent of *P. distans* and EC of the soil. This conclusion is confirmed by the results of other researches that have stated significant relationships between vegetation cover and soil EC (Ghaderi *et al.,* 2010; Jafari *et al.,* 2005; Tatian *et al.,* 2010 and Burchill & Kenkel, 1990). It should be pointed out that EC had a relationship with the level of underground water depth in this study. Dunn *et al.* (1993) showed that the stabilization of plant communities is affected by soil climate (soil temperature and moisture). Hosseini (1994) pointed out the significant effects of underground water depth on the establishment of this species. Plant species differ in their sensitivity or tolerance to salinity (Marschner, 1995). Some halophytes

not only tolerate high levels of salinity but also reach the optimal levels of growth under saline conditions (Ungar, 1991). Growth stimulation by salinity has been reported for the annual species of *Suaeda* (Ke-Fu *et al.*, 1995). Based on the findings of the current study, the possibility of success for cultivating *P. distans* by the seeding method is correlated with EC and underground water level. The most successful results were observed in photomorphic unit 1 which had a lower depth of underground water table and a higher electrical conductivity as compared to the other units.

Regarding the annual cultivation of 200 ha of rangelands in Agh Ghala city using the seeding method in order to reduce the costs resulting from the failure in seeding operation (Ghaderi *et al.*, 2010) and despite the initial prediction of the most suitable seeding location (photomorphic unit 3), the most successful result was observed in photomorphic unit 1 which had a lower depth of underground water table and a higher EC and higher vegetation cover percent as compared to the other units. Based on the findings of the current study, it is recommended that seeding operation should be concentrated on photomorphic unit 1.

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**مکان‌یابی کشت *Puccinellia distans* (مطالعه موردی: اراضی شمال دشت آقلا، استان گلستان، ایران)**

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**چکیده. بذر گونه گیاهی *Puccinellia distans* سالانه در ۲۰۰ هکتار از مراتع شهر ستان آقلا از طریق بذرپا شی، کشت می‌گردد که به‌دلیل نامشخص بودن مکان‌های منا سب جهت بذرپا شی، این عملیات با موفقیت اندکی همراه می‌باشـد. این تحقیق، به‌منظورکاهش هزینه‌های ناشـی از شکست عملیات بذر پا شی، جهت مکان‌یابی کشت گیاه *P. distans* در مراتع شمال شهر ستان آقلا انجام گرفت. از آنجا که توپوگرافی و اقلیم محدوده مورد مطالعه با قرق گمیشـان که محل رشد و جمع آوری بذور این گیاه است، یکسان می‌باشد، در ابتدا با استفاده از تصاویر ماهواره‌ای لندست ۵ (۱۳۹۰/۱/۸) و تصاویر گوگل زمین، نقشه واحدهای فتومورفیک تهیه شدند و سپس در هر واحد فتومورفیک برخی خ صو صیات خاک شامل بافت، هدایت الکتریکی، ا سیدیته، و ماده آلی اندازه گیری شد. بدین منظور در مناطق کلید واحدهای فتومورفیک، سه ترانسکت ۱۵۰ متری به فا صله ۵۰ متر از یکدیگر م ستقر گردید. در طول هر ترانسکت سه نمونه خاک از عمق ۱۰-۰ سانتیمتری (۹ نمونه خاک از هر واحد فتومورفیک) برداشت شده و جهت مطالعه به آزمایشـگاه انتقال داده شـدند. به منظور بررسـی صـحت مناسـب بودن واحد فتومورفیک پیش‌بینی شـده، در مناطق کلید ذکر شـده، اقدام به کاشـت این گیاه گردید. برای مقایسـه پارامترهای اندازه‌گیری شده در سه واحدهای فتومورفیک از آزمون تجزیه واریانس یک طرفه و مقایسه میانگین‌ها از روش توکی استفاده گردید. برخلاف پیش‌بینی اولیه که واحد فتومورفیک ۳ را به عنوان منا سب‌ترین واحد جهت کا شت *P. distans* پی شنهاد نموده بود، موفق آمیزترین نتیجه در واحد فتومورفیک ۱ که دارای کمترین عمق آب زیرزمینی و بالاترین هدایت الکتریکی و بیشـترین پوشـش گیاهی در قیاس با سـایر واحدهای فتومورفیک بود، مشـاهده گردید. بر اسـاس یافته‌های این تحقیق، توصـیه گردید که عملیات کاشـت *P. distans* از طریق بذر پاشی، در محدوده واحد فتوموریک ۱ متمرکز گردد.**

**کلمات کلیدی: *Puccinellia distans*، خصوصیات خاک، واحد فتومورفیک**