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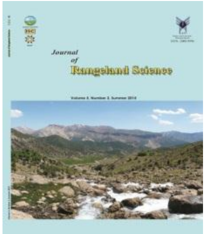

Research and Full Length Article:

Effects of Super-Absorbent Polymers (SAPs) Plus Manure Treatments on Vegetation Cover and Soil Nutrients of *Festuca ovina* under Drought Stress

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Abstract. Knowledge of physiological and environmental factors is important for forage grass production. *Festuca ovina* is a grass species adapted to Azerbaijan region climate, Iran. This species is a valuable source for forage production and soil conservation. Nitrogen (N), Phosphorus (P) and Potassium (K) are three most important plant nutrients. The aims of present study were to investigate the effects of super absorbance polymer and cattle manure on vegetation growth and soil NPK element of *Festuca ovina* under drought stress. A split-plot design was used with drought stress as the main plot (control, -0.3 and -0.9 Mp) and polymer +fertilizer as the sub factor (T_1: control, T_2: 50 g manure, T_3: 5 g polymer, T_4: 5 g polymer + 50g manure, T_5: 10 g polymer, and T_6: 10 g polymer + 50g manure) in five replications. N, P and K contents of soil samples were determined before and after the experiment using Kjeldal, P-Olsen and flame photometer methods. The data of NPK and two cuts of vegetation covers were collected and analyzed using SAS software. The results showed that the application of polymer and manure had positive effects on all the traits. Higher values of vegetation covers were observed in T_4 and T_6 treatments where both polymer and manure were applied. Higher values of NPK with the average values of 0.69%, 21 ppm, and 395 ppm, respectively were observed in T_6: (10 g polymer + 50g manure) and the higher vegetation cover with the average values of 82% and 46% were obtained in the first and second cuts, respectively at the same treatments. Since there were no significant differences between T_6 and T_4, it was recommended to apply 5g polymer coupled with 50g cattle manure in 4300 g of soil to improve grass production in drought environment.

Key words: Super-Absorbent polymers, Manure, Rangeland species, Vegetation cover, Soil nutrients, Drought stress

Introduction

Human life depends on food and consequently on agricultural practices, soil and water resources (Varavipoor, 2010).To identify the essential nutrients for rangeland species growth, the following items might be considered: a) the ones necessary during the plant life cycle, b) the ones directly affect plant species nutrient uptake and c) the ones improve soil conditions and quality (Alizadeh, 2011). The previous researches on soil nutrient had clearly showed that nitrogen (N), phosphorus (P), and potassium (K) are three main essential rangeland species nutrients. N is necessary for rapid growth, plant disease resistance, and protein and chlorophyll biosynthesis and its deficiency cause a delay in the plant growth and pale green foliage. K is also an essential nutrient for carbohydrate synthesis, cell wall thickening, and plant disease resistance. P plays a key role in cellular structure and can be an energy source in all biochemical reactions in living cells. Therefore, rangeland and natural resources programs should pay special attention to the soil in order to maintain and improve plant vitality and food production (Varavipoor, 2010).

Moreover, low soil quality in most farms, rangelands and orchards threatens the animals, food and other products' quality. Another limitation for the rangeland species and plants growth is drought conditions in these areas. Among all the environmental limitations, drought stress imposes the highest limitation on the plant growth and productivity (Agaba *et al.*, 2010). In Iran, a country with 240 mm mean annual precipitation classified as an arid and semi-arid region, drought is one of the most important obstacles to plant productivity. The recent drought events and water shortage as well as population growth highlight the necessity of proper framework for soil and range management (Jafari *et al.*, 2014). In fact, it is essential to improve water use efficiency in rangeland and natural resource systems in the country. Considering the fact of the increased population, deep knowledge of physiological and environmental parameters seems necessary to improve crop/forage performance and the systems' efficiency to prevent hunger (Sardans *et al.*, 2005). Many researchers developed new technologies and innovated some products for optimizing the soil, plant and water resource use. The absorbent materials such as hydrophilic polymers are one of the technologies for the efficient use of resources which not only absorb water but also modify soil and plant (Zohuriaan-Mehr *et al.*, 2010).

SAPs[1] are the dried-sugar like materials with the capacity to absorb and retain water higher than their weight. Despite the inflammation following water absorption, these particles have a fixed geometric shape before and after water absorption (Dorraji *et al.*, 2010). Considering the water saving potential, these particles could adjust soil osmotic potential and in turn, maintain the soil environment. Therefore, it seems to be a useful technique in drought stress studies in which soil potential adjustment is necessary (Allah Dadi *et al.*, 2005). They investigated the effects of using150 kg/ha superabsorbent polymer on yield, growth, and nodulation analysis of soybean (*Glycine max* L.) Merr. under drought conditions. They found a sharp increase in soybean traits including pods, seed oil, and root nodule dry weight. Zarfsaz (2013) investigated the effects of using different levels of superabsorbent polymer on growth characteristics of forest species. He found that using of super absorbent polymers improve the growth characteristics of forest species. Yousefi *et al.* (2010) showed that number of grains, 1000 grain weight, yield, and harvesting index of corn (*Zea mays*) were decreased due to drought stress, but they

[1] Super-Absorbent Polymers (SAPs)

increased following super absorbent and manure application. However, superabsorbent polymers could play crucial roles where drought stress is a major constrain such as natural systems. Research in these systems is limited here in Iran, especially on range species. Therefore, more investigation on the poly acryl amid polymers application in rangeland ecosystems is necessary both *in vitro* and *in situ*.

Bai *et al.* (2010) investigated the effects of super-absorbent polymers (SAPs) on soil physical and chemical properties under alternating dry and wet conditions. They found that soil properties such as C, N, K, pH, and EC were affected by SAPs. Similarly, Rajaei *et al.* (2010) concluded that using super absorbents polymers increases the soil microorganisms activities such as Nitrobacteria and Nitrosomonas, and it causes to accelerate the nitrification and other chemical activities which lead to alternate the soil nutrients.

Over time, the widespread use of chemical fertilizer has caused unacceptably high food health risk. Meanwhile, researchers had shown the benefits of animal manure application instead of chemical fertilizer. For example, Ahmadian (2008) demonstrated a significant increase in the numbers of umbels per plant, seeds per plant, productivity, and efficiency of cumin after manure application. The advantage of manure was also apparent in tomato plants and the bed soil as it decreased soil pH and increased tomato productivity and total soluble solid (TTS) was increased (Federico, 2007). AbdelHamid *et al.* (2004) also found positive impacts of manure application on soil fertility, soil aggregation and consequently, soil structure.

Considering all above, the present research aimed to study the effects of polyacrylamid polymers and manure application on soil nutrient and vegetation cover of *Festuca ovina* under drought conditions caused by Glycerin solution (PEG, 6000).

Materials and Methods

An experiment was conducted as split-plot design with 5 replications in Urmia University research greenhouse, Urmia, Iran in 2014. The first factor was drought stress in three levels of control, -0.3Mp and -0.9Mp (osmotic solutions of polyethylene glycol (PEG, 6000) and the second factor had 6 levels including 3 levels of poly acrylamid polymers[1] and 2 levels of decomposed cattle manures[2] as T_1: control, T_2: 50 g manure, T_3: 5g polymer, T_4: 5 g polymer + 50g manure, T_5: 10g polymer, and T_6: 10g polymer + 50g manure as sub factors. Treatments were applied to 90 pots (3 Stress levels x 6 fertilizer levels using complete randomized block with 5 replications) in the greenhouse. Seeds of *Festuca ovina* were sown as 1 g per pots in the depth of 1.5 cm. Each pot was irrigated twice a week with 250 ml water. The plants were grown and cut 2 times in vegetation stage. At the end of the experiment, pot soils were collected and analyzed for nitrogen (N), phosphorus (P), and potassium (K) using Kjeldal (Bremner & Mulvaney, 1982), Olsen (Olsen & Sommers, 1982), and flame photometer (Boltz & Howel, 1978) methods, respectively. Pre-analysis of soil samples is summarized in the following table (Table 1).

Table 1. A summary of *Festuca ovina* soil properties analysis prior treatment application

Soil Parameter Name	Unit	Values
Potassium	(ppm)	212.5
Phosphorous	(ppm)	11.69
Nitrogen	(%)	0.29
Soil texture		Sandy loam
Volume of pots	(cm^3)	2400
Weight of soil in pots	(g)	4300

[1] Three levels of poly acrylamide polymer with 0%, 0.1% and 0.2% of pot weight
[2] Two levels of cattle manures with 0% and 1% of pot weight

The collected data were tested for normality (Kolmogorov–Smirnov) and homogeneity of variance (Bartlett and Levene) using SPSS software package. As the data were normally distributed and homogeneity of variance assumption was met, no data transformation was performed for further analysis. Then, data were analyzed using split plot design. Means comparisons (Duncan analysis) were performed using SAS9 software packages.

Results

Results of analysis of variance showed significant effects of PEG (drought stress) on soil P and K availability and both cuts of vegetation cover ($p<0.01$). The effects of super absorbent polymer and cattle manure were also significant for all the traits ($p<0.01$). The drought x polymer interaction effects were also significant for soil NPK and vegetation cover in both cuts ($p<0.01$) (Table 2).

Table 2. Analysis of variance and mean square (MS) of N.P.K between drought stress levels caused by PEG at six super absorbent polymer and cattle manure treatments on *Festuca ovina*

SOV	df	MS				
		Soil N%	Soil P ppm	Soil K ppm	First Cut Vegetation Cover	Second Cut Vegetation Cover
Replication	4	1293.3**	858**	576.6**	1410**	941**
Drought stress (PEG)	4	271.1	1127.9**	241.6**	218**	198**
Error a	8	208.6	69.2	56.2	41.1	40.0
Treatments (SAPs + Manure)	5	1852.2**	456.9**	961.9**	1530**	1326**
Drought x Treatments	10	321.3	56.5**	1184.5	367**	244**
Error b	60	189	35.3	79.5	57	39

*, **=MS is significant at 0.05 and 0.01, probability levels

Soil NPK

Drought stress due to PEG application had no significant effect on soil available N content (Table 2). However, it had significant effects on soil P and K availability ($p<0.01$). Lower values of both P and K were obtained at -0.3 and -0.9 Mp (Fig. 1).

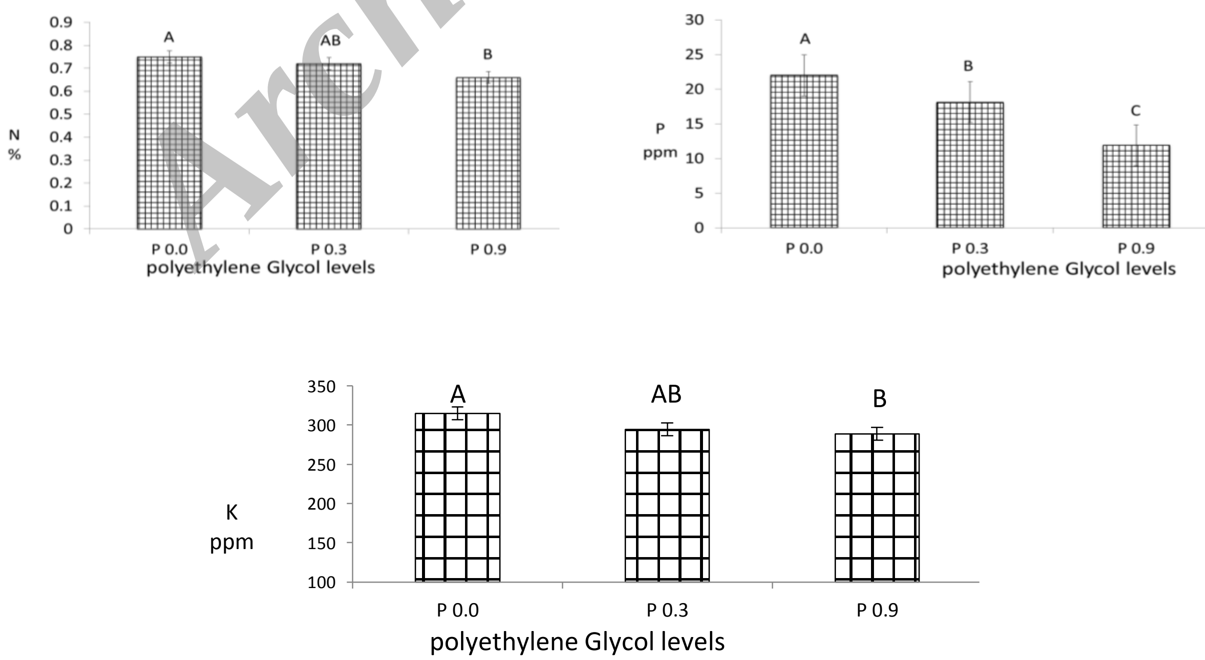

Fig. 1. The effects of drought stress on soils NPK concentration of *Festuca ovina* pots
Means with the same upper case and lower case letters are not significantly different ($\rho<0.01$)

The effects of treatments (levels of super absorbent polymer and cattle manure) were also significant for all of the traits ($p<0.01$). The maximum values of soil NPK availability were obtained at treatments of T_4: 5 g polymer + 50g manure, T_5: 10g polymer and T_6: 10g polymer + 50g manure (Fig. 2). The N values were increased by 73%, 59%, and 82% in T_4, T_5, and T_6 as compared to control (T_1), respectively. Phosphorus values were increased by 71%, 74%, and 86% in T_4, T_5, and T_6 as compared to control (T_1), respectively. Similarly, K values were increased by 35%, 76%, and 84% in T_4, T_5, and T_6 as compared to control, respectively (Fig. 2).

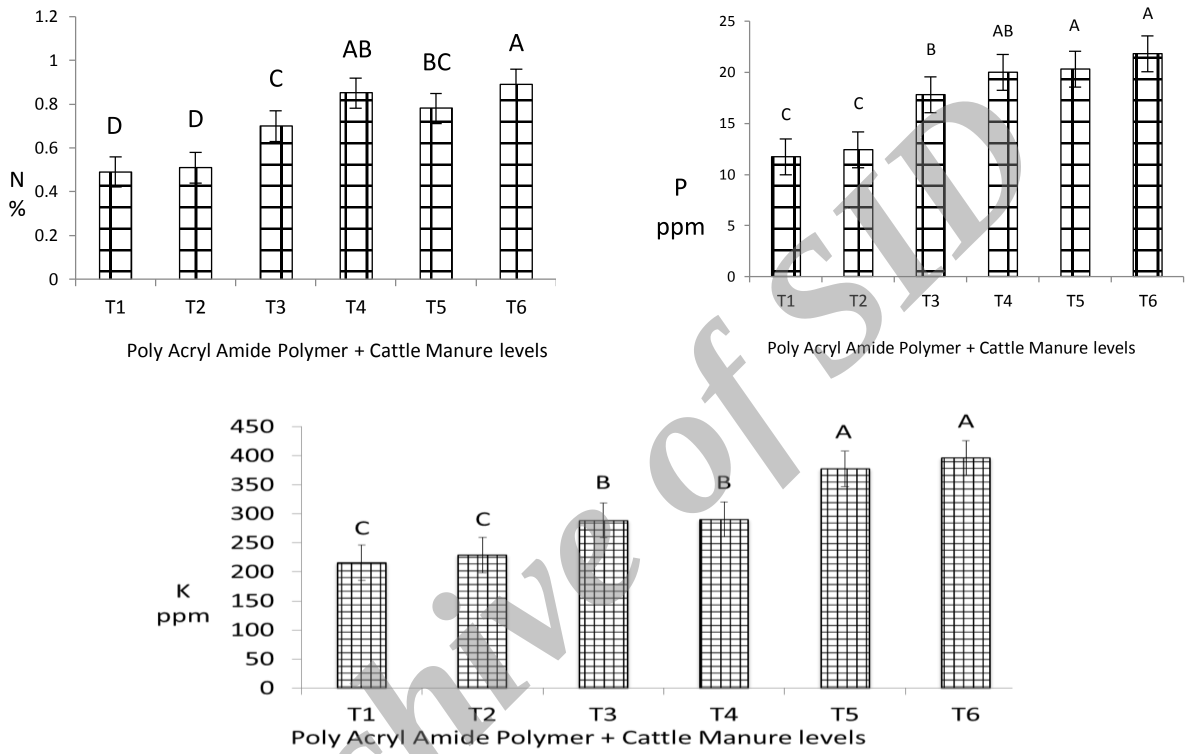

Fig. 2. The effects of super absorbent polymer and cattle manures treatments as T_1: control, T_2: 50 g manure, T_3: 5g polymer, T_4: 5 g polymer + 50g manure, T_5: 10g polymer and T_6: 10g polymer + 50g manure on NPK soil concentration of *Festuca ovina* pots. (Means with the same letters are not significantly different, $\rho<0.01$)

Vegetation cover

Drought stress due to PEG application had significant effects on vegetation cover of both cuts in *Festuca ovina* ($p<0.01$) (Table 2). Lower values of vegetation cover in both cuts were obtained at -0.9 Mp. However, there were no differences between -0.3 Mp and controls (Fig. 3). The effects of super absorbent polymer and cattle manure treatments were also significant for all of the traits ($p<0.01$). The maximum values of vegetation cover were obtained at the treatments of T_4: 5g polymer + 50g manure, T_5: 10g polymer and T_6: 10g polymer + 50g manure (Fig. 4). However, there were no significant differences between T_5 and T_6 treatments. The N values increased by 73%, 59%, and 82% in T_4, T_5, and T_6 as compared to control (T_1), respectively.

The first cut vegetation cover percent was increased by 83%, 62%, and 85%in T_4, T_5, and T_6 as compared to control, respectively. Similarly, the second vegetation cover percent was increased by 189%, 121%, and 200% in T_4, T_5, and T_6 as compared to control, respectively (Fig. 4).

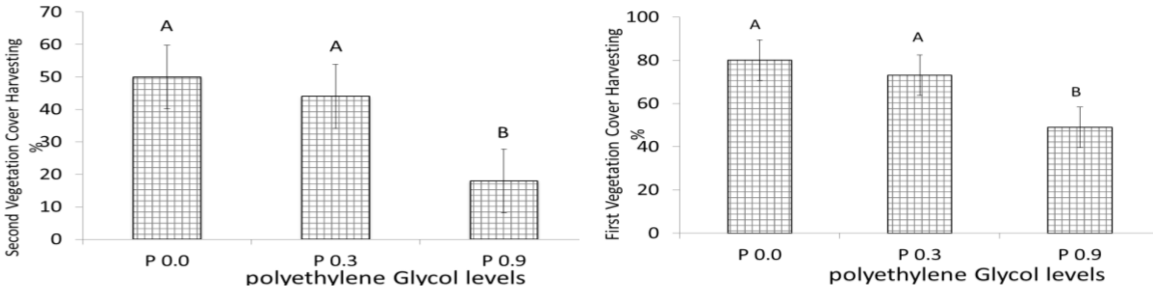

Fig. 3. The effect of drought stress on vegetation cover of *Festuca ovina* grown in pots

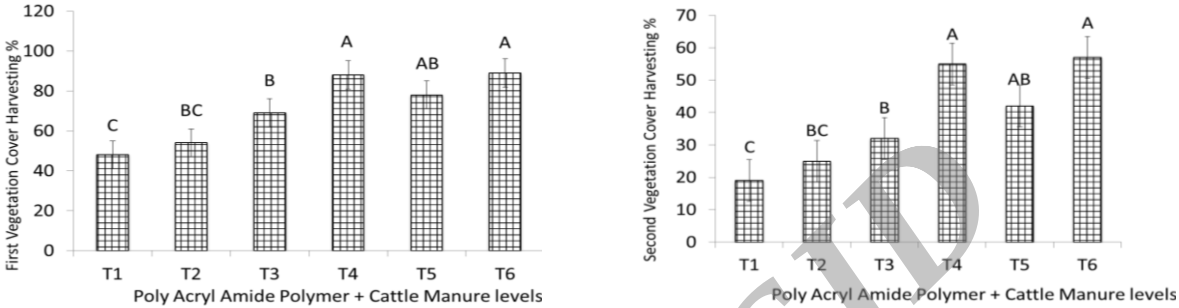

Fig. 4. The effects of super absorbent polymer and cattle manures treatments as T_1: control, T_2: 50 g manure, T_3: 5g polymer, T_4: 5 g polymer + 50g manure, T_5: 10g polymer and T_6: 10g polymer + 50g manure on *Festuca ovina* vegetation cover. (Means with the same letters are not significantly different, $\rho<0.01$)

Means comparisons of vegetation cover percent in two cuts are shown in Table 3. Results showed significant differences of treatments on vegetation covers ($\rho<0.01$). The vegetation covers of all treatments were reduced in the second cut; however, the reduction of vegetation cover for T_4 and T_6 was less than that for the other treatments indicating higher effects of these treatments on the second cuts of vegetation cover (Table 3).

Table 3. Means of vegetation covers in two cuts, in treatments

Treatments: SAPs Plus Cattle Manure	Vegetation Cover %	
	Cut1	Cut2
T_1: control	48 a	19 b
T_2: 50 g manure	54 a	25 b
T_3: 5g polymer	69 a	32 b
T_4: 5 g polymer + 50g manure	88 a	55 b
T_5: 10g polymer	78 a	42 b
T_6: 10g polymer + 50g manure	89 a	57 b

Means of rows between cuts with the same letters are not significantly different, $\rho<0.01$

Drought by treatments interaction effects

Results of ANOVA showed significant effects of drought x polymer for soil NPK and vegetation cover in both cuts ($p<0.01$) (Table 2). Means comparisons of drought by the interaction effects of treatments for soil NPK and Vegetation cover in *F. ovina* are presented in Table 4. Results showed that the highest values of all the traits were obtained at 0Mp drought stress in T_4, T_5, and T6 treatments. The values of soil NPK, the first and second cuts of vegetation cover were 0.88% 24.22ppm, 380ppm, 94%, and 52.4% in T_4 under 0Mp drought stress, respectively. These values were 0.86%, 22.5ppm, 315ppm, 78.9%, and 50.6% for T_5, and 0.91%, 31.1ppm, 401ppm, 96.6%, and 62.2% for T_6 regarding the same traits, respectively. In contrast, lower values of all the traits were obtained in -0.9Mp drought stress in T_1 and T_2 treatments. The lowest values for T_1 (control) in -0.9Mp drought stress were 0.47%, 7.65ppm, 213.4ppm, 33.3%, and 10% for soil NPK and the first and second cuts of vegetation cover, respectively.

Table 4. Means of drought x treatments interaction effects for soil NPK and Vegetation cover in *F. ovina*

Drought Stress	Treatments (SAPs + Manure)	Soil N (%)		Soil P (ppm)		Soil K (ppm)		Vegetation Cover cut1		Vegetation Cover cut2	
Control	T_1: control	0.51	ef	13.75	e	217.5	d	58.9	ge	37.2	de
	T_2: 50 g manure	0.52	ef	14.44	de	230.0	d	64.8	fg	41.7	cde
	T_3: 5g polymer	0.73	bc	18.82	d	310.0	b	75.2	cd	50.1	bc
	T_4: 5 g polymer + 50g manure	0.88	a	24.22	ab	380.0	a	94.0	a	52.4	ab
	T_5: 10g polymer	0.86	a	22.50	ab	315.0	b	78.9	cd	50.6	ab
	T_6: 10g polymer + 50g manure	0.91	a	31.10	a	401.0	a	96.6	a	62.2	a
-0.3 Mp	T_1: control	0.49	f	11.70	e	215.5	d	51.2	h	30.9	ef
	T_2: 50 g manure	0.50	f	12.42	e	231.0	d	54.5	fgh	35.9	e
	T_3: 5g polymer	0.71	cd	17.79	d	294.0	bc	62.6	fg	38.4	de
	T_4: 5 g polymer + 50g manure	0.86	a	20.96	abc	377.4	a	91.3	ab	48.3	bcd
	T_5: 10g polymer	0.85	a	19.40	bcd	300.5	bc	75.9	cd	43.4	cde
	T_6: 10g polymer + 50g manure	0.89	a	22.65	ab	397.0	a	94.3	a	52.8	ab
-0.9 Mp	T_1: control,	0.47	f	7.65	ef	213.4	d	33.3	i	10.0	g
	T_2: 50 g manure	0.48	f	8.36	ef	226.0	d	38.7	i	13.1	eg
	T_3: 5g polymer	0.59	def	12.10	e	237.0	cd	46.6	h	16.4	e
	T_4: 5 g polymer + 50g manure	0.83	ab	16.50	d	316.0	b	60.8	ge	27.1	ef
	T_5: 10g polymer	0.61	de	14.90	de	254.0	cd	53.2	fgh	21.2	e
	T_6: 10g polymer + 50g manure	0.87	a	16.64	d	318.5	b	63.1	fg	33.4	e

Means of column with the same letters are not significantly different, $\rho<0.01$

Discussion and Conclusion

Phosphorous is an essential soil element for plant growth considered as a macronutrient due to high quantity required by the plants. Potassium plays a crucial role as a soil amendment necessary for the plant growth and productivity. There was a significant reduction effect of drought stress on soil nutrient and vegetation cover of *Festuca ovina* as the stress increased from zero to -0.9 Mp. The exception was the responses of soil K and N under control to 0.3 Mp showing no significant differences. The fact that water stress may retard plant growth and lead to lower biomass and height, straw yield, panicle length, and spikelet per panicle (Saleem, 2003) supports our finding in this study. Drought conditions also caused a sharp decrease in the number of seeds and the weight of 1000 seeds in corn *Zea mays* (Khadem *et al.*, 2011). Therefore, plant growth would suffer from water stress even in fertile soils. It seems to be a good solution in soil composition and growth characteristics of rangeland species.

Positive effects of treatments (SAPs + manure) were observed in soil nutrient of *Festuca ovina* confirming the superabsorbent benefits (Figs. 2 and 4). The minimum value of soil N prior to the experiment was 0.29% in control (Table 1) and it increased to 80-90% at treatments of T_4, T_5 and T_6 (Fig. 2). Furthermore, an increasing trend in soil phosphorus was also evident at higher polyacrylamid application level; even though sometimes, the difference was not significant (Fig. 4). The same trend was occurred in soil K with the maximum value at T_5 and T_6 treatments (Fig. 4). In fact, higher SAPs and manure application rates caused higher soils NPK availability in *Festuca ovina*. Even though the difference was not significant, an increasing trend was still obvious. For example, the minimum and maximum soil N values were about 0.29% and 0.69% occurring at control (T_1) and T_6, respectively. The same trend was observed for soil available P with the maximum values of 21.8 ppm in T_6. Also, the highest value of soil available K occurred at T_6. Furthermore, the maximum amount of soil nutrient happened when drought stress was low (0 or -0.3 Mp) and vice versa.

This research investigated the effects of using Super-Absorbent Polymers (SAPs) on soil properties under alternating drought stress conditions. The results indicated that soil properties such as NPK are affected by SAPs. As Lakzian *et al.* (2010) have shown, soil moisture affects the chemical and biological characteristics of soil. So, drought stress changes the nutrient elements of soil and causes to make the soil less fertile. Gordon (2007) found that drying and wetting the soil had more effects on soil microbial community composition. He also showed that water increasing or decreasing has an important effect on nutrient leaching. Microbial activities are increased during a wetting cycle and cause to change the nutrient elements of soil (Sall and Chotte, 2002; Sardans and Peûuelas, 2005; Saetre and Stark, 2005; Gordon *et al.*, 2007; Xiang *et al.*, 2008; Bai *et al.*, 2010). Rajaei & Raeisi (2010) concluded that using super absorbents polymers increases the activity of soil microorganisms such as Nitrobacteria and Nitrosomonas and it causes to accelerate the nitrification and other chemical activities which lead to alternate the soil nutrients. Therefore, he showed that SAPs can affect the microbial activities and cause to change the nutrient elements and coverage level of soil.

Positive changes in vegetation cover of *Festuca ovina* due to SAPs + manure confirm the super absorbent benefits. The minimum values of first and second vegetation covers were around 43% and 26% respectively in the control (T_1). In contrast, the maximum values of vegetation cover were observed at treatments of T_4, T_5, and T6 (Fig. 4). Also, the highest value of first and second vegetation covers was obtained when drought stress was low (0.0 to -0.3 Mp). It appears that drought stress is the most important factor for the plant productivity, inhibiting the growth (Liu *et al.*, 2005). Water stress, among all other environmental stress, could present the most negative effects on plant characteristics in the agricultural and natural systems.

Considering the effects of treatments (SAPs + manure), the results are in agreement with previous studies. For example, super absorbent application enhanced plant height, dry matter and growth of *Zea mays*, particularly when the irrigation interval was longer (Allah Dadi *et al.*, 2005). The study of crops quality and productivity also showed an increasing trend in these parameters following copolymer polyacrylamid application due to higher water holding capacity (Roushan, 2002).

The addition of cattle manure could positively enhance the polymer advantage for species and soil systems, suppressing water stress and stimulating plant productivity and stability. SAPs + manure could partially compensate drought damages to the soil and plant systems (Eneji *et al.*, 2002; Laboski and Lamb, 2003; Talaie and Asadzadeh, 2005; Salar and Frahpoor, 2005; Poorsmaeil *et al.*, 2006; Habibi and Rahmani, 2009). Our results showed a synergetic effect of animal manure and polyacrylamid on some soil and vegetation properties of *Festuca ovina*. In addition, the positive effects of polyacrylamid application did not significantly differ when using more than 5gr in each pot, even though doubling the amount. According to the results, concurrent use of polyacrylamid polymer and manure is more effective than using extra amount of polyacrylamid alone. In overall, the results of the study were in agreement with previous findings, suggesting the strong positive effects of superabsorbent polymers and animal manure on soil nutrient and canopy cover of rangeland species even under drought stress conditions. Therefore, it is highly recommended to apply superabsorbent in rangeland ecosystems where drought is a dominant environmental constrain.

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تاثیر پلی اکریل آمید سوپر جاذب و کود دامی بر وضعیت پوشش گیاه و حاصلخیزی خاک در گونه مرتعی *Festuca ovina*

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چکیده. شناخت عوامل فیزیولوژیکی و محیطی موثر در حفظ یا افزایش عملکرد گیاهان علوفه‌ای، یکی از ضرورت‌های اصلاح، احیاء و توسعه مراتع است. گونه ***Festuca ovina*** بدلیل سازگاری با اقلیم آب و هوایی منطقه آذربایجان و امکان توسعه کشت آن نقش مهمی در تأمین علوفه و حفاظت خاک در این ناحیه دارد. هدف از این تحقیق امکان بهره‌گیری از ترکیبات مختلف پلی اکریل آمید و کود دامی بر روی این گونه در شرایط تنش خشکی می‌باشد. این تحقیق با استفاده از طرح کرت‌های یکبار خرد شده در قالب طرح پایه بلوک‌های کامل تصادفی در ۵ تکرار انجام گردید. فاکتور اصلی تنش خشکی در سه سطح شاهد ، ۰/۳ و ۰/۹ مگاپاسکال با استفاده از پلی اتیلن گلیکول PEG 6000 و فاکتور فرعی نسبت‌های مختلف پلیمر سوپر جاذب پلی اکریل آمید و کود دامی در شش سطح ۱) شاهد، ۲) ۵۰ گرم کود دامی، ۳) ۵ گرم پلیمر، ۴) ۵ گرم پلیمر+۵۰ گرم کود دامی، ۵) ۱۰ گرم پلیمر، ۶) ۱۰ گرم پلیمر +۵۰ گرم کود دامی بودند. عناصر NPK قبل و بعد از آزمایش اندازه‌گیری شد و سطح سبز پوشش گیاه گلدان‌ها در دو چین متوالی اندازه‌گیری شد. نتایج تحلیل‌ها نشان داد که کاربرد توأم پلیمر پلی اکریل آمید و کود دامی سبب بهبود و اصلاح فاکتورهای رویشی و NPK گردید. بطوری که با افزایش میزان ترکیبات پلیمر و کود دامی (تیمارهای ۴ و ۶) مقدار سطح پوشش گونه فستوکا اوینا نسبت به تیمار شاهد افزایش یافت. بیشترین مقدار عناصر N وP و K خاک به ترتیب با ۰/۶۹ درصد، ۲۱ و ۳۹۵ ppm و بیشترین سطح پوشش با ۴۶٪ و ۸۲٪ در تیمار شماره ۶ بدست آمد که مؤید تأثیر مثبت توأم پلیمر پلی اکریل آمید و کود دامی در مقایسه با کاربرد پلیمر به تنهایی بود. با توجه به عدم تفاوت معنی‌دار بین تیمارهای ۴ و ۶ کاربرد تیمار۴ (۵ گرم پلیمر و ۵۰ گرم کود دامی در مخلوط ۴/۳ کیلوگرم خاک) به منظور بهبود رشد اولیه گونه مرتعی ***Festuca ovina*** توصیه گردید.

کلمات کلیدی: پلیمر پلی اکریل آمید، کود دامی، گونه مرتعی، درصد پوشش، نیتروژن خاک، تنش خشکی