松嫩草地次生光碱斑种子流及其生态恢复意义

何念鹏[1,2], 吴 泠[1], 周道玮[2]*

(1. 中国科学院植物研究所 植被数量生态学重点实验室, 北京 100093; 2. 东北师范大学 植被生态重点实验室, 长春 130024)

摘要:通过陷井法,对松嫩草地次生光碱斑的表面种子流、土壤种子库动态进行了分析,调查发现次生光碱斑种子流数量巨大,种类相当丰富;次生光碱斑的表面种子流月份间差异极显著,6 月份最小,10 月份最大。次生光碱斑的土壤种子库很小,种类单一,原有的土壤种子库严重流失;与典型羊草群落相比,土壤种子库在种类和数量上均有很大差异。次生光碱斑的土壤种子库很小,尤其在 5、6 月,造成次生光碱斑种子极度缺乏,是次生光碱斑植物自然恢复进程极其缓慢的重要原因之一。根据种子流的生理-生态特征和数量特征,它对次生光碱斑的植被恢复具有重要意义,是潜在种源。

关键词:种子流; 土壤种子库; 种子动态; 退化; 次生光碱斑

Seed movement in the secondary bare alkali-saline patch and its implication for ecological restoration in the Songnen grassland, northeastern China

HE Nian-Peng[1,2], WU Ling[1], ZHOU Dao-Wei[2]* (1. *Laboratory of Quantitative Vegetation Ecology, Institute of Botany, Chinese Academy of Sciences, Beijing* 100093; 2. *Key Laboratory for Vegetation Ecology, Northeast Normal University, Changchun*, 130024, *China*). ***Acta Ecologica Sinica*, 2004, 24(4): 843~847.**

Abstract: Soil seed banks usually play an important role in the vegetation regeneration and succession, and there exists a very close relationship between vegetation dynamics and soil seed bank. Especially for some severely deteriorated ecosystems, soil seed banks are the main available seed source in natural conditions, serving as a template for subsequent successive processes such as germination, competition, growth, and ultimately shaping the stable native communities. Therefore, soil seed bank to some extent can impact the revegetation process and direction. The secondary bare alkali-saline patches (SAP), in this paper, are severely degraded ecosystems caused by irrational exploitation or overuse in the past decades.

Through setting seed pitfall traps in the secondary bare alkali-saline patches (SAP) in the Song-nen plain, seed dynamics of SAP, including seed movement over its surface and the seed bank in soil, were investigated during six successive months, which almost coincided with the non-frozen period there. The objective of the study was to evaluate seed movement of SAP and the implication for ecological restoration. The questions were addressed at: (1) how much were seed movement and seed bank in soils of SAP, and what kinds? (2) What was the eco-physiological property of the seed movement like, and whether can they be utilized to improve those secondary bare alkali-saline patches or not, serving as potential important seed sources?

The results showed that, the total number of seed movement of secondary bare alkali-saline patch (SAP) was enormous, and species composition was relatively abundant, Including 6 families and 13 genera. Moreover, there exists a significant change in the seed movement in SAP among different months, which being least in June, and most in October, 1111.1 grains/m^2 and 28210.1 grains/m^2, respectively. However, seed bank in soil of SAP was minor, and species composition was also quite simple. Of course, soil seed bank in SAP also changes significantly over time. No any soil seed can even be founded in May and June, while in October soil seed bank was relatively high. Compared with the typical *Leymus chinense* community, the seed

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作者简介:何念鹏 (1976~), 男, 四川人, 博士,主要从事植物生态学和草地生态学研究。E-mail: henp76@163.com

* **通讯作者** Author for correspondence, E-mail: zhoudw@ivy.nenu.edu.cn

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Biography: HE Nian-Peng, Ph. D. candidate, mainly engaged in plant ecology and grassland ecology.

band in soil of SAP was very low in August, because the intrinsic surface soil in SAP had been already destroyed seriously and soil seed bank here was lost drastically. Furthermore, seeds of salt-tolerant plants were predominant, not only in the seed movement but also soil seed bank in SAP, especially for *Chloris virgata*, which accounting for 91.83 % of the total seed movement, next were *Suaeda* spp. and *Puccinellia* spp..

Seed movement in SAP should be very important potentially for both scientists and grassland managers to improve or meliorate the secondary bare alkali-saline patches (SAP), serving as direct seed sources in natural conditions, due to their eco-physiological property and quantitative property. Many scientists and managers consider that the extremely high content of soluble saline ion in soil is the dominant cause, which makes the natural revegetation process of these secondary bare alkali-saline patches so slow. However, what is little known is that the deficiency of soil seeds also is another important factor in the SAP, especially in May and June, when it is prime period for native plants to germinate. Therefore, the seed movement should be potentially important seed sources and can be utilized in the revegetation process of the secondary bare alkali-saline patches (SAP).

Key words: seed movement; soil seed bank; seed dynamics; degradation; secondary bare alkali-saline patch
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由于土壤种子库在植被更新与演替过程中的重要作用,国外学者对种子库的研究十分重视;近年来,土壤种子库研究已成为植物种群生态学中比较活跃的领域.。不同植被类型(群落)土壤种子库的研究已较多[1~11],对土壤种子库在生态恢复过程中的重要作用也作了深入探讨[1, 2]。然而,我国对土壤种子库的研究相对较少[12~19],尤其是对松嫩草原[17, 19]。土壤种子库的种类及数量与植被动态具有密切的关系,一方面,土壤种子库来源与植物群落,另一方面,土壤种子库又影响着植被更新与演替[2, 3 5~9, 15]。通常,种子落地后可能沿地表发生水平移动和垂直移动,微地形(micro-site)差异对种子的地表移动具有重要影响,土壤种子库的空间分布格局受地表状况、风力、风向、水流和种子源的位置、动物搬运能力等影响很大[1, 3~4, 7, 14]。尤其在一些严重退化的生态系统中,土壤种子库是其植被重建与恢复的重要种源,是植被恢复的模板,很大程度上决定了植被恢复的进度和方向[1, 2, 8]。

长期过度放牧或不合理利用,松嫩草地盐渍化越来越严重,由此形成一系列面积不等的次生光碱斑,它们的表层土壤被严重破坏,土壤表层形成盐积层,光滑且少缝隙(在干旱情况下也少有裂缝);一方面,原有的土壤种子库严重流失,另一方面,次生光碱斑表面对植物种子的滞留能力大大降低,土壤种子库难以得到及时补充,使其处于种子源缺乏状况。在次生光碱斑自然恢复过程中,土壤种子库起着不可替代的作用,一定程度上决定了次生光碱斑植被恢复的方向和速度。文中的种子流(seed movement)是指单位时间内流经单位面积的种子数量[7]。本文的主要目的是要弄清次生光碱斑的表面种子流、土壤种子库现状,并从生态恢复的角度探讨其潜在意义。

1 研究区域自然状况

研究地点位于吉林省长岭县羊草自然保护区内,地理位置在 123°44′E,44°44′N 附近。属半干旱温带季风气候,关于该地区的自然状况,许多资料已详细描述[18~20]。

2 材料与方法

实验在 2001 年 4 月 15 日开始, 10 月 15 日结束。首先,选择一个面积约 200 m^2 的次生光碱斑。在选定的次生光碱斑中,随机地布置 30 个种子收集器,种子收集采用陷井法(Pitfall);保持收集器口与地面平齐。收集器口径 6 cm×6 cm,深度 15 cm,在瓶底扎上小孔以便排水[7]。每隔一个月进行一次种子收集,并将收集器放回原状;同时,在次生光碱斑上取 10 cm×10 cm×6 cm 土柱作土壤种子库调查,重复 6 次[17,19];次生光碱斑周围的植物群落组成和土壤种子库取样只在 8 月中旬进行,随机地取 6 个 1 m×1 m 的植物样方,测定植物种类组成、高度和地上生物量,并在每个样方内取 10 cm×10 cm×6 cm 土柱,进行土壤种子库测定。

所取样品倒入孔径为 0.2 mm 的土壤筛中,用水冲洗,排出土壤中可溶性杂质,阴干后手工挑选种子,在放大镜下对照种子标本鉴定物种,并记录数量。相关研究表明:发芽法和手工挑选方法所获得的结果显著相性($r=0.83$, $P<0.0001$, $n=250$ 土壤样品)[3,7]。

分析次生光碱斑种子流与周围植物群落间的相互关系时,采用 Jaccard 指数、Sorenson 指数和 Bray-Curtis 指数:

Jaccard 指数 $$C_j=j/(a+b-j)$$

Sorenson 指数 $$C_s=2j/(a+b)$$

式中,j 为植物群落和种子流的共有种数;a 和 b 分别为植物群落和种子流的物种数。

Bray-Curtis 指数　　$$C_N=\frac{2jN}{aN+bN}$$

式中,aN 植物群落的物种数目,bN 为种子流的物种数目;jN 为植物群落和种子流共有种中较小者之和,在计算时采用相对百分率来代替个体数。

3　结果与分析

3.1　次生光碱斑的表面种子流动态

次生光碱斑的表面种子流月份间差异很大,6 月份的种子流最少,10 月份最大,分别为 1111.1 grains/m^2 和 28210.1 grains/m^2(表 1)。ANOVA 分析表明次生光碱斑表面的种子流月份间差异极显著($df=5$, $F=94.25^{**}$);LSD 多重检验表明 5、6 月份种子流与 7、8、9 月份差异极显著,10 月份种子流与其它月份间差异极显著。种子流的种类组成比较丰富,月份间差异也很大;7 月份物种最丰富,共 8 种,5、10 月份物种较单一(表 1)。5～10 月份,次生光碱斑的表面种子流 59718.2 grains/m^2,虎尾草是其主要成份,占 91.83 %,其次是碱蓬属植物,其它植物所占的比例很小。

表 1　次生光碱斑表面种子流动态

Table 1　Dynamics of seed movement in the secondary bare alkali-saline patch (SAP) (grain/m^2)

种类 Species	5 月 May	6 月 Jun.	7 月 Jul.	8 月 Aug.	9 月 Sep.	10 月 Oct.
虎尾草 *Chloris virgata*	2048.8	846.6	8399.2	10746.4	10473.6	27203.6
羊草 *Leymus chinense*				145.4		
碱茅 *Puccinellia* spp.			150.1	341.6	130.5	
狗尾草 *Setaria viridis*					43.6	
寸草苔 *Carex duriuscula*			34.2			
野稗 *Echinochloa crusgalli*						96.9
马唐 *Digitaria ciliaris*						48.5
大花千里光 *Senecio ambracens*		58.1				
兴安胡枝子 *Lespedeza davurica*			18.9	55.7		
葱属 *Allium* spp.			33.6			
碱地肤 *Kochia prostrata*			3320.7			
碱蓬属 *Suaeda* spp.	150.6	86.8	235.9		1986.3	61.1
藜 *Chenopodium* spp.	316.5	119.6				
西伯利亚蓼 *Polygonum gracilius*			100.6			
合计 Total	2515.9	1111.1	12293.2	11289.1	12634	28210.1

3.2　次生光碱斑土壤种子库动态

次生光碱斑的土壤种子库月际变化很大,5、6 月份没有任何种子,10 月份相对较高,为 266.7 grain/m^2(图 1)。次生光碱斑土壤种子库相对较小,种类单一,主要是虎尾草,伴有少量碱蓬和碱茅。野外观察还发现,次生光碱斑的土壤种子主要分布在土壤表面,容易被大风带走;4～6 月份,当地的风很大,易把这些分布于地表的种子吹走,次生光碱斑却极度缺乏种子。在当地植物的最佳萌发期,土壤种子库缺乏,是次生光碱斑自然恢复进程极其缓慢的重要原因之一。

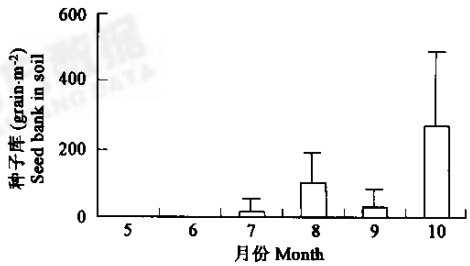

图 1　次生光碱斑土壤种子库动态

Fig. 1　Dynamics of soil seed bank in SAP

4　结论与讨论

4.1　次生光碱斑表面种子流于周围植物群落的关系

次生光碱斑的种子流主要来源与周围植被,与周围的植物群落密切相关。次生光碱斑表面的种子流与周围植物的相似性较高,Jaccard 指数、Sorenson 指数和 Bray-Curtis 指数分别为 0.714 和 0.833,0.589。J 指数、S 指数与 B 指数间差异较大,主要是由于 J 指数和 S 指数是对物种组成的定性分析,不受数量差异的影响;而 B 指数是定量分析,受各物种的相对数量的影响较大。虎尾草种子可从较远的植物群落传播过来的,使虎尾草种子在种子流中所占比重很大,而羊草群落中的虎尾草相对含量又较小,造成 Bray-Curtis 指数较低。总的来说,周围的植物群落对次生光碱斑的表面种子流具有较大的影响,很大程度上决定了次生光碱斑表面种子流的种类和数量特征。

4.2　土壤种子库比较

与羊草群落相比,次生光碱斑的土壤种子库很小、且种类单一。8 月份羊草群落土壤种子库由 5 个物种组成,分别为羊草

(*Leymus chinense*, 166.66±136.63 grain/m^2)、碱茅属(*Puccinellia* spp., 33.33±51.64 grain/m^2)、虎尾草(*Chloris virgata*, 1616.67±376.38 grain/m^2)、碱蓬属(*Suaeda* spp., 100.00±154.92 grain/m^2)和西伯利亚蓼(*Polygonum gracilius*, 33.33±51.64 grain/m^2),总量为 2083.37 粒/m^2,而次生光碱斑土壤种子库主要为虎尾草,总量仅为 100.00±167.33 粒/m^2。长期过度放牧或不合理利用,在风、雨等的作用下,次生光碱斑表层土壤被严重破坏,原有的土壤种子库大量流失;又由于次生光碱斑表面光滑且少缝隙(在干旱情况下也少有裂缝),降低了次生光碱斑对其表面种子流的截留能力,土壤种子库得不到及时补充,土壤种子库的自然恢复很慢,使次生光碱斑土壤种子库很低。

4.3 次生光碱斑表面种子流的生态-生理特性分析

松嫩草地次生光碱斑表面种子流的种类组成相当丰富,共 6 科,13 属,禾本科植物种子占多数。根据植物对盐碱胁迫的耐受能力,植物可分为耐盐植物(Salt-tolerant plant)和非耐盐植物(Non-salt-tolerant plants)[20],次生光碱斑表面种子流中耐盐植物种类占多数(共 8 种),耐盐植物种子的比例达到 99.05%,主要是虎尾草、角碱蓬和碱茅等耐盐植物的种子;非耐盐植物种子所占的比例很少。种子流的生理-生态特性,为其在次生光碱斑植被恢复中的应用提供了生理-生态基础,在一定条件下,这些种子流可成为其植被恢复的重要种源。

4.4 次生光碱斑表面种子流的恢复生态学意义

退化生态系统的恢复进程受许多因素的影响,其中土壤状况和土壤种子库相对比较重要。松嫩平原次生光碱斑的土壤含盐量大、pH 值过高,是制约植被自然恢复的重要因素之一[18,20];一直以来,土壤种子库在次生光碱斑植被恢复过程中的重要作用未受到重视。实验表明:次生光碱斑表面的种子流很大,种类组成丰富,土壤种子库却很低;种子流中,盐生植物的种子占绝大多数。因此,在次生光碱斑的植被恢复过程中,其表面种子流是巨大种源,具有潜在的可利用性。通过一些简单的工程方法,如铺埋玉米秸秆、或扦插玉米秸秆等,提高次生光碱斑的土壤种子库(通过截留其表面的种子流),可加快次生光碱斑的植被恢复进程[18]。相关实验还表明,碱蓬等耐盐碱植物的种子可直接在次生光碱斑上萌发,并完成整个生活史,如果土壤中具有大量这类耐盐碱植物的种子,次生光碱斑的植被恢复进程可加快①。根据次生光碱斑表面种子流、土壤种子库动态,可从种源角度解释为什么次生光碱斑恢复进程极其缓慢:次生光碱斑土壤种子库极度缺乏,尤其是在 5、6 月份(当地植物的最佳萌发期),可萌发的植物种子很少,再加上极强的盐份胁迫,植物的存活率很低,最终导致次生光碱斑上很少有植物生长,植被恢复进程极其缓慢。因此,种源缺乏也应是次生光碱斑植被恢复进程缓慢的重要原因之一。次生光碱斑表面种子流的这些生理-生态特征和数量特征,使其在植被恢复与重建中具有潜在的重要意义,是直接的、重要的种源。

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