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Ecologo-coenotic factors in restoration of steppe vegetation in "M. M. Gryshko" national botanical garden

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Abstract: The "Steppe of Ukraine" plot at "M.M. Gryshko" National Botanical Garden in Kyiv was founded in 1949. Steppe vegetation is formed under the influence of ungulates and fires. Such conditions cannot be created in a botanical garden. Therefore xerophytes appeared less competitive than mesophytes and disappeared or reduced drastically their abundance on the plot. The analyses of ecologo-coenotic conditions showed that restoration of steppe vegetation required two key factor be taken into account: 1) humidity; 2) excessive spread of aggressive rhizomatous grasses (*Elytrigia repens, E. intermedia, Arrhenatherum elatius*) and invasive weed of *Solidago canadensis*. Gradient analysis along the scales of these two factors showed that they are interrelated: propagation of rhizomatous mesophytes caused increase in soil humidity, which in turn promoted growth of mesophytes and further increase in soil humidity. The results of field experiment established that mowing in dry period of summer (July) promoted xerotization, giving the advantage to xerophytic grasses over mesopytic ones, and also effectively controlled spread of *S. canadensis*.

Keywords: steppe vegetation, soil humidity, cenotic interactions, invasive species.

Introduction

The "Steppe of Ukraine" plot at "M.M. Gryshko" National Botanical Garden in Kyiv was founded in 1949 as a part of a collection. It is situated on a hillside, in climatic conditions suitable for steppe vegetation (BORODINA 1972). The latter is known to form under the influence of ungulates and fires (OSYCHNYUK 1973). Such conditions cannot be created in a botanical garden. Therefore xerophytes appeared less competitive than mesophytes and disappeared or reduced dramatically their abundance on the plot. It should be noted, that till 2001 the mowing was conducted only late in autumn on the plot. Because of this the moisture in soil under tall grasses was stored and the vegetation in some places looked like forest-meadow (MARYUSHKINA et al. 2002). On the other hand, the active spread of monodominant communities of *Solidago canadensis* L. due to excessive humidity, absence of natural enemies, correspondence of environment conditions to the requirements of this species and biological aggressiveness of the latter also impeded restoration of steppe vegetation.

Therefore it became necessary to work out measures to restore typical steppe communities on that plot and control spread of aggressive indigenous weeds and invasive *S. canadensis*.

The aim of our study was to investigate contribution of soil moisture and cenotic factor in the observed degradation of steppe vegetation on the plot as well as to work out maintenance techniques stimulating spread of typical steppe species and controlling aggressive weeds.

Material and methods

To investigate plant species interactions on the "Steppe of Ukraine" plot 268 vegetation descriptions were made on sample plots (0,25 x 0,25 m^2) located along a transect crossing all the plot area from the southwest to the north-east. Simultaneously soil samples were collected for the assessment of humidity. The effects of steppe species abundances and soil humidity on the abundances of other plants were determined by the method of cenogradient analysis (GRODZINSKY & AL. 1985).

Two-year field experiment modeling different techniques of *S. canadensis* control was conducted. It included following treatments: 1 (control) – grass stand was not mowed; 2 – mowing of the whole grass-stand; 3 – cutting down of *S. canadensis* only. Mowing of the whole grass-stand and cutting down of *S. canadensis* only were conducted in the first half of July – budding and beginning of flowering phase of this species. In the summer, prior to experimentation and in autumn partial phytomass of all species in stand in the two treatments and in control was measured. Statistical analysis was conducted by the method of one-way ANOVA (ZAYTSEV 1984).

Results and discussion

The analysis of ecological groups of plant species (Fig. 1) showed that their spectrum was more characteristic for the open habitats of Forest-Steppe zone with sufficient humidity, though the percentage of typical steppe species was considerable. The analysis of the dependence of the abundances of dominants of the studied communities on soil humidity showed that the species react even to little changes of humidity: steppe species by increasing their cover at the lowest humidity, and the most but not all of meadow and meadow-steppe species reduced their cover. For example, marked indifference to humidity conditions displayed rhizomatous grasses with wide ecological amplitude such as *Elytrigia intermedia* (HOST) NEVSKI and *E. repens* (L). NEVSKI.

As it was important to know not only the effect of soil humidity, but also that of cenotic surrounding on dominating species (forest and meadow species on steppe species and vice versa at different humidity conditions), we conducted ceno-eco-gradients analysis of species cover distribution along the gradients of the mentioned above factors.

It was revealed that xerophytes sharply reduced their abundances in stand at high values of humidity and cover of *Arrhenatherum elatius* (L) J. ET C. PRESL and when these two factors interacted (Fig. 2). Steppe-forest-meadow species of *Galium verum* L. was more tolerant to these two factors. *Elytrigia intermedia* was indifferent to humidity factor, but avoided sites with high cover of *A. elatius*. While *A. elatius* was sensetive to the both cenotic effect of *E. intermedia* and soil humidity (Fig. 3). *Poa angustifolia* L. was tolerant to the both factors, except for maximum values. *Galium verum* "gravitated" to the average values of the both factors. *Galatella dracunculoides* (LAM). NEES was indifferent to cenotic factor, but avoided humidified places, which fully agreed with ecological requirements of this species.

Thus, the analyses of abiotic and coenotic conditions showed that restoration of steppe vegetation required two key factors be taken into account: 1) humidity; 2) excessive spread of rhizomatous grasses (*Elytrigia repens, E. intermedia, Arrhenatherum elatius*) and invasive weed (*Solidago canadensis*).

Gradient analysis along the scales of these two factors confirmed their interrelatedness: spread of rhizomatous species caused increase in soil humidity, which in turn gave the advantage to mesophytes over xerophytes and further increased soil humidity.

Therefore to preserve steppe vegetation in the given conditions practices of maintenance of xerophytic regime (mowing in dry season or periodic burnings of dry stand) could be utilized. As burnings could not be conducted in a botanical garden, we conducted two-years field experiment modeling two types of summer mowing: mowing of the whole grass-stand and cutting down of *S. canadensis* only.

The results of this experiment showed that the both techniques noticeably influenced steppe species and weeds abundances. Cutting down of *S. canadensis* only was the most effective against this weed. When such a

measure was applied also in autumn of the same year (beginning of November) on the next spring dry weight of *S. canadensis* reduced by 84,6 % comparing to control and species richness increased almost 3 times at the account of typical steppe xerophytes and xeromesophytes (*Festuca pratensis* L., *Achillea nobilis* L. etc.), which were completely replaced by *S. canadensis* before the experiment. Some other typical steppe species such as *Dactylis glomerata* L., *Coronilla varia L., Festuca heterophylla Lam., Medicago romanica* PROD., *Veronica steppacea* KOTOV etc. increased their position in the grass-stand (Fig. 4).

Mowing of the whole grass-stand lead to noticeable reduction of *S. canadensis* abundance. When such a measure was applied also in the autumn of the same year (beginning of November) on the next season participation of *S. canadensis* reduced by 16,8 % and species richness increased 2,5 times in comparison with control. The abundances of steppe and meadow-steppe species of *Arrhenatherum elatius, Medicago romanica* PROD., *Galium verum* etc. increased. While *Elytrigia repens* was positively associated with *S. canadensis*: when the latter reduced the former reduced too (Fig. 4).

Though the most effective technique to control *S. canadensis* in given conditions was cutting down of this weed only during budding – flowering phases, mowing of the whole grass-stand together with *S. canadensis* was more effective for xerotization of ecotope and stimulated typical xerophytic and xeromesophytic steppe vegetation. The latter technique is more suitable for maintenance of steppe vegetation, especially, on large territories. While the former is more appropriate on sites where rare steppe species vulnerable to mowing need to be conserved.

It also should be noted that after application of the both techniques on plots dominated mainly meadow-steppe species: *Achillea nobilis*, *Festuca heterophylla* LAM., *Medicago romanica*, *Veronica steppacea*. While in control dominated forest-steppe species: *Lolium perenne* L., *Rubus caesius* L. and ubiquist – *Elytrigia repens*.

To conclude, we recommend usage of mowing in July and November to restore steppe vegetation and control invasive weed of *S. canadensis* as well as other aggressive mesophytes on the studied plot. Taking into account scanty percentage of natural steppe vegetation in Ukraine and its great importance as a buffer system, the continuation of investigations of ecological aspects of restoration of steppe vegetation is rather urgent.

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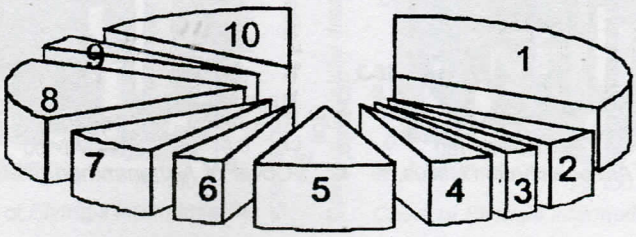

Fig. 1. Representation of plant species belonging to different ecological groups (1 – steppe, 2 – forest-steppe, 3 – forest-meadow, 4 – steppe-forest-meadow, 5 – forest, 6 – meadow, 7 – forest-meadow, 8 –ubiquists, 9 – adventive weeds, 10 – indigenous weeds) on the "Steppe of Ukraine" plot.

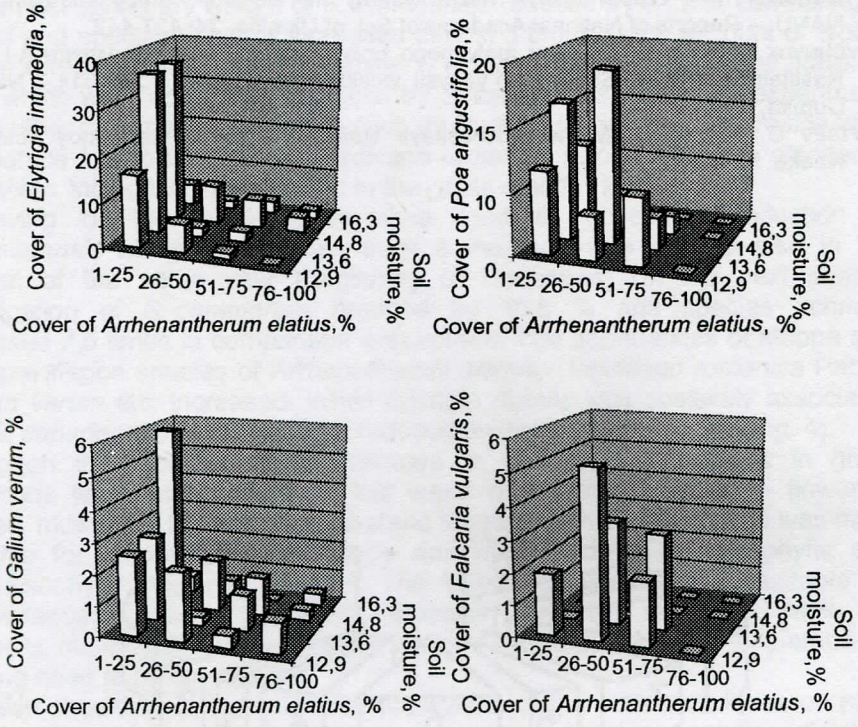

Fig. 2. Ceno-eco-gradient of influence of *Arrhenatherum elatius* and soil moisture on some steppe dominants

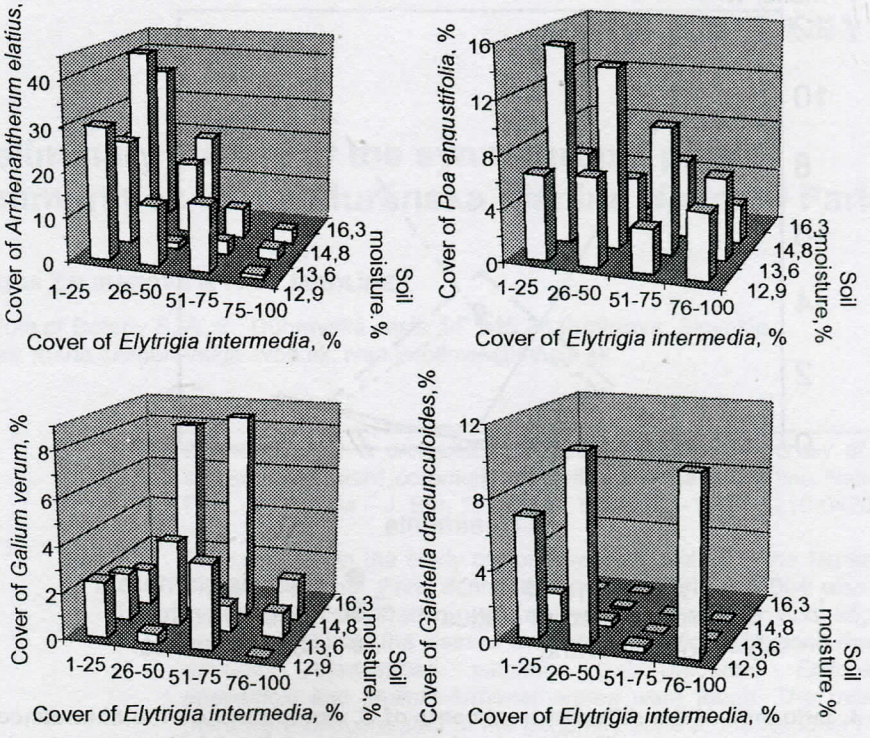

Fig. 3. Ceno-eco-gradient of influence of *Elytrigia intermedia* and soil moisture on some steppe dominants

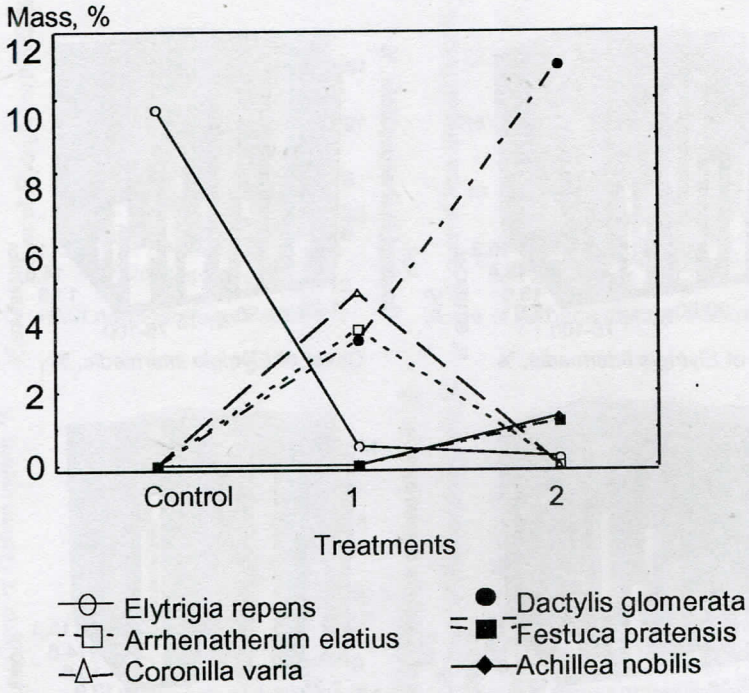

Fig. 4. Influence of the different treatments of *S. canadensis* on the abundances of steppe-meadow species. Treatments: 1– moowing of the whole grass-stand, 2 – cutting down of *S. Canadensis* only.