UDC 581.5:632.5
Original scientific paper

A COMPETITIVE RESPONSE OF THE SPECIES *PLANTAGO MAJOR* L. IN AN INVASIVE EXPERIMENT

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Mijović Aleksandar, Branko Karadžić and Zorica Jovanović (2004): *A comparative response of the species Plantago Major L. in an invasion experiment.* - Acta herbologica, Vol. 13, No. 1, 129-134, Beograd.

Population dynamics of the species Plantago major inside an artificial meadow site *Arrhenatheretum* during two vegetation seasons was analysed. The aim of this experiment was to observe the fate of typical r-strategists in conditions of strong interspecific competition after simulation of total site destruction. The population dynamics of *P. major* was observed through numerous demograophic and morphometric parameters. A significant increase in aboveground biomass and great production of seeds are important characteristics of the competitive response of *P. major* in conditions of strong interspecific interference. Because of an impossibility of new cochort emergence, the presence of this species in the environment is limited by the lenght of the lifetime of these individuals. The seeds of *P. major* are stored in the soil, so in case of repeated disturbance, the new conditions make possible ephemeral exsistence of this pionir species in communities with strong competitors.

Key words: competition; invasive experiment; *Plantago major*; r-strategists; stage structure

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INTRODUCTION

In response to the environment, plant species react with specific redistribution of asimilates during their growth period. This activity reflects the differences in their morphology, physiology and behavior. The plasticity of plant characters has vital significance in the optimization of recourse acquisition and utilization (GRIME *et al.*, 1986). The concept of organic matter redistribution is in the base of a so-called reproductive effort - BAZZAZ and CARLSON (1979). Namely, the amount of recourses invested in reproductive structures can be considered as a degree of decrease in vegetative growth, which is an important adaptive characteristic determinating the fate of an individual, as well as the fate of the population on site. When a plant's individual needs for recourses exceed the recourse amount, direct confrontation occurs between plants, which results in density stress. Density stress acts through reduction of surviving individuals in a population - *mortality*, or through reduction of the growth rate and seed number - *plastic response* (PALMBLAD, 1968; ANTONOVICS and LEVIN, 1980). The intensity of response depends on population density and recourse amount in the habitat.

METHODS

Experimental plots were placed inside the yard of IBIS "Siniša Stanković", close to 29. novembra Street, within an arteficial meadow site *Arrenatheretum*, in natural conditions not inhabited by species *P. major*. The results presented in this article are part of a greater experiment performed during 1995 and 1997. An area (sized 12x8m) was treated with a total fast-degradible herbicide (glyphosat), and then the entire area dug up 20 cm in depth. The area was divided into a net of 50x50 cm squares. Every sown square was surrounded by 8 usown ones. The number of *P. major* and *P. annua* seeds sown per square was 600, and seed proportion for both species was: 600 : 0; 480 : 120; 300 : 300; 120 : 480. Vegetation was allowed to develop on the experimental plot (*invasive experiment*). Complete plant material was sampled twice during two vegetation seasons from plots sized 20x20cm. Population dynamics of the analysed species was monitored by using the main population parameters (number of individuals, mortality, stage structure index). The life cycle of *P. major* is defined by stage categories with teh following numerical values: seedling-juvenile **0.5**, immature-vegetative *1.0*, reproductive **2.0**. This evaluation of stage categories represents a modification of the age structure evaluation of perennial plants (URANOV, 1975; VORONTZOVA *et al.*, 1985). A similar priciple was applied in analysing the stage structure of annual plants (MIJOVIĆ, 1993). An onthogenetic state of a species is defined by the stage structure index (URANOV, 1975): $IUS = \Sigma k_i m_i \Sigma k_i$ (k_i is the number of individuals in i-stage category, m_i is the value of i-stage category). Values measured in the morphometric analysis of aboveground plant organs and in the measuring of dry plant mass are shown as total or mean values. Relative growth rate was measured as an increase in plant weight (*dW*) over time interval (*dt*): $RGR=(1/W)\ (dW/dt)$ (POORTER, 1989).

RESULTS AND DISSCUSION

I year of experiement

- Summer census

The species *Plantago major* expressed a very small number of individuals, compared to the amount of seeds sown (Table 1). A low degree of ontogenetic development in the summer census and uniform stage structure indicated a strong competitive pressure of species in the environment.

Table 1. - Number of P. major - a mean number of individuals of P. major on the experimental plots in the summer census and percentage of seed realization (in parentheses); I.U.S. - stage structure index; number of other species (x) on plot and number of individuals* of other species on plot*

plot	number of *P.major*	I.U.S.	number of species *	numb. of individ.*
P 600:0	12.5 (2.1%)	1.0	3	25.0
P 480:120	18.8 (3.9%)	1.0	4	31.3
P 300:300	6.3 (2.1%)	1.0	3	18.8
P 120:480	0.0	-	-	-

The mean aboveground mass of individuals was greater than the mean aboveground mass of individuals of other species (Table 2), which indicates a great growth rate of *P. major* in this period.

Table 2. - Total (in parentheses is the % of participation compared with total aboveground plant mass) and mean aboveground mass of P.major and other species on the plots in the summer census

plot	total aboveground mass Plantago(g)	mean aboveground mass Plantago(g)	tot. abov. mass of others(g)	mean abov.mass of others(g)
P 600:0	25.5 (45%)	2.0	31.7	1.5
P 480:120	35.8 (42%)	1.9	50.1	1.6
P 300:300	14.4 (29%)	2.3	34.6	1.8

Increase in leaf area (Table 3) represents a clear competitive response of the species *P. major* in the presence of strong competitors (MIJOVIĆ, 2003).

Table 3. - Mean number of leaves and mean maximal leave lengths of P. major, and the means of other species individuals

plot	leaves/ind (mean number)	max length of leaf (cm)	other species (cm)
P 600:0	11.0	7.4	27.4
P 480:120	9.3	7.2	44.7
P 300:300	11.0	7.9	32.5

- Autumn census

All *P. major* individuals in the invasive experiment in the autumn census were in reproductive stage (Table 4). In contrast to the summer census (Table 2),

participation of the aboveground biomass of *P. major* in total aboveground mass in the autumn census decreased (Table 5). Based on a growth rate (Table 6), the number of leaves and mean length of leaves of *P. major* (Table 7), it is clear that a slower growth occurred in vegetative structures, because of a redistribution of photosynthates in reproductive structures.

Table 4. - as in Table 1

plot	number of *P.major*	I.U.S.	number of species *	numb. of individ.*
P 600:0	12.5	2.0	3	37.5
P 480:120	12.5	2.0	3	37.5
P 300:300	6.3	2.0	3	31.3

Table 5. - as in Table 2

plot	total aboveground mass Plantago(g)	mean aboveground mass Plantago(g)	tot. abov. mass of others(g)	mean abov.mass of others(g)
P 600:0	43.5 (31%)	3.5	98.2	2.6
P 480:120	20.9 (21%)	1.7	78.0	2.1
P 300:300	18.2 (21%)	2.9	69.8	2.2

Table 6. - Increase in the aboveground mass and relative growth rate P. major (RGR) and mean relative growth rate of other species (RGRAL) in the August-October period (51 day).

plot	% increase of abovegr.mass	% incr. of mean abovegr. mass.	RGR (mg/g/day)	RGRAL (mg/g/day)
P600:0	70%	70%	13.7	15.3
P480:120	-42%*	-12%*	-2.4*	5.8
P300:300	26%	26%	5.1	4.1

Table 7. - as in Table 3

plot	leaves/ind (mean number)	max length of leaf (cm)	other species (cm)
P 600:0	11.0	7.8	24.2
P 480:120	7.5	8.0	19.6
P 300:300	10.0	8.1	24.5

II year of experiment

- Late-summer census

In the second year of experiment a new cohort of *P. major* failed to appear, which indicates that restoration of the species from seeds was not possible in conditions of closed vegetation complex. Total aboveground mass of *P. major* was many times smaller than that of other species present on the plots (Table 9). The greatest mean weight of *P. major* was observed in the plot with the greatest total and mean aboveground mass of other individuals. Great dimensions of leaves of *P. major* indicate a specific competitive response of the leaves of this species in strong competitive environment (Table 10).

Table 8. as in Table 1

plot	number of *P.major*	I.U.S.	number of species *	numb. of individ.*
P 600:0	6.3	1.0	4	37.5
P 480:120	12.5	1.5	3	31.3
P 300:300	12.5	2.0	5	31.3

Table 9. - as in Table 2

plot	total aboveground mass Plantago(g)	mean aboveground mass Plantago(g)	tot. abov. mass of others(g)	mean abov.mass of others(g)
P 600:0	12.6 (11%)	2.0	101.6	2.7
P 480:120	86.8 (15%)	6.9	480.5	15.4
P 300:300	45.7 (30%)	3.7	106.3	3.4

Table 10. - as in Table 3

plot	leaves/ind (mean number)	max length of leaf (cm)	other species (cm)
P 600:0	23.8	4.0	21.5
P 480:120	28.0	7.0	22.5
P 300:300	24.0	6.0	17.3

CONCLUSION

Based on our results, we may conclude that the presence of typical plants of open sites is primarily limited to periodically or permanently disturbed areas. On periodically disturbed sites, where restoration of vegetation occurs, the pioneer species can be present in smaller numbers, but their second generation doesn't appear. Seeds of the pioneer species stay stored in soil, and in case of a new disturbance in the habitat and the opening of an empty space, germination of these species occurs. The main characteristics of the competitive response of *P. major* in conditions of strong inter-specific interference are significant increase in dimensions and mean aboveground mass, and intensive seed production.

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Recieved March 25, 2004
Accepted April 10, 2004

KOMPETITIVNI ODGOVOR VRSTE *PLANTAGO MAJOR* L. U INVAZIVNOM EKSPERIMENTU

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I z v o d

U radu je analizirana populaciona dinamika vrste *Plantago major* L. tokom dve vegetacijske sezone u okviru veštačkog livadskog staništa tipa *Arrhenatheretum*. Seme *P. major* i *Poa annua* L. je zasejano po tipu eksperimenta zamenskih serija. Cilj eksperimenta bio je da se pri simulaciji totalne destrukcije staništa (što je čest slučaj u ruderalnoj vegetaciji) prati sudbina tipičnih r-strategista u uslovima jake interspecificne kompeticije. Usled nedostatka posebnih mehanizama za disperziju semena ove visoko-reproduktivne vrste, invazija semena *P. major* u "prazne" prostore nikada nije masovna, a samim tim ni gustina njegovih inicijalnih populacija. Za razliku od brojnih eksperimenata u kojima se manipuliše velikim gustinama semena, ova istraživanja proučavala su interakcije u uslovima malih inicijalnih gustina. Populaciona dinamika vrste praćena je kroz veći broj demografskih i morfometrijskih parametara. Značajan rast nadzemne mase i velika produkcija semena predstavljaju važne odlike kompetitivnog odgovora vrste *P. major* u uslovima jake interspecifične interference. Zbog nemogućnosti javljanja novog kohorta, prisustvo ove vrste u takvom okruženju ograničeno je dužinom životnog veka ovih jedinki. Seme *P.major* ostaje deponovano u podlozi, pa se u slučaju novog narušavanja staništa, što je tipično za ruderalna staništa, ponovo stvaraju uslovi za efemeran boravak ove pionirske vrste u zajednicama sa jakim kompetitorima.

Primljeno 25. marta 2004.
Odobreno 10. aprila 2004.