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Adapted Environmental Factors for a Neophyte Pokeweed (*Phytolacca americana*)

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귀화식물 미국자리공(*Phytolacca americana*)의 적응환경요인

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Abstract

귀화식물인 미국자리공의 군락 구조와 무기환경요인을 추적하였다. 서식지 식생은 *Pinus densiflora, Persicaria perfoliata, Miscanthus sinensis, Smilax china, Rubus crataegifolius, Paederia scandens, Rosa multiflora, Commelina communis, Carex lanceolata*가 우점 하였으며 파괴된 *Pinus densiflora* 아극상 삼림군락에 침입하여 적응한 형태였다. 서식지 토양의 속성은 pH 4.6의 높은 산도, 높은 중금속과 유기물 함량이 특징적이었으며 이는 전형적인 황지식물군락의 환경요인이었다. 생장조절실 내에서 수행한 제한요인 처리에 의해 나타나는 유식물의 피해반응은 인공산성비에 의한 pH 2.0과 500 Lux의 광도에서 나타났으며 일시위조점은 pF 2.6－2.7에서, 그리고 영구위조점은 pF 2.8－2.9에서 각각 나타났다.

Introduction

The diversity of ecological niche makes an ecosystem stable, but the simplification of niche caused by anthropocentric behavior offers free space for the neophytes to invade. Natural vegetation is an indicator of qualitative and quantitative environmental factors and changes caused by the plant-environment interactions[1]. In this aspect, it has been tried to analyze natural vegetation and understand vegetation patterns since early this century, but a clear answer could not be found because of the complexity in data and the lack of objectiveness. But statistical theories based on the probability and computer system have been developed, and therefore possibility and reliability have been increased[2,3,4].

Record, classification and distribution of neophyte in Korea were studied by Chung[5], Lee and Kim[6], Yim and Jeon[7], Park[8] and Sun *et al.*[9]. The pokeweed was listed as a neophyte by Yim and Jeon[7] and Kim[10] also reported that it is a tolerant plant to air pollution.

The test plant, pokeweed (*Phytolacca americana* L., Pokeberry, Red-ink-plant), is a geophyte belonging to Phytolaccaceae. It originated from North-America and distributed in whole South-Korea, and spreaded to Southern Europe[11].

Morphological characteristics of the pokeweed are a

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red colored 1－2m high stem, white flowers on a raceme, a small and round calyx, black berries with 10 obvious carpels, and the berry dispersal by birds[12]. The berry containing betacyanine was used as a natural dye and boiled young leaves as an edible vegetable. It is called Sangryook in Chinese medicine, and the pokeweed and other herbs in the same family were used as a medicine for diuretics, rabies, tuberculosis and tumours. Physiological research on the accumulation of betacyanine in the seeds[13,14] and on the lectins agglutinating the dog erythrocyte[15] were carried out. Recently, the pokeweed was introduced as a pollution related neophyte by the news media and this was debated hotly.

In this research, we analyzed species composition in the two well known pokeweed communities, and detected the environmental factors of pokeweed seedlings in the controlled environment chamber.

Materials and Methods

Study area

Figure 1 shows the location and climate diagrams drawn by reports of the nearest stations from study areas. The summaries of Taegu and Ulsan from the data of the last 22 years are as follows : Taegu showed 57.8 m of height above the sea level, 13.4℃ of average temperature, 1046mm of precipitation, 39.5℃ of highest temperature measured, －15.1℃ of lowest temperature measured ; and Ulsan showed 31.5m of height above the sea level, 13.3℃ of average temperature, 1288mm of precipitation, 38.6℃ of highest temperature measured, －12.5℃ of lowest temperature measured. Climatic environments of the two areas were similar, but Taegu was comparatively more continental than Ulsan.

Species composition

Ten plots of 100 m^2, over the minimal area, were selected from the homogeneous stand of every site ; 2 sites at Sinsunsan Yaumdong Ulsan Kyongnam and 2 sites at Daedong Kyongsan Kyongpook. To adjust seasonal vegetation aspects by the life cycle, we surveyed 8 times each of the same area and quantified the plant communities by the dominance value of Braun-Blanquet[16] and arranged these data by the constancy in the table.

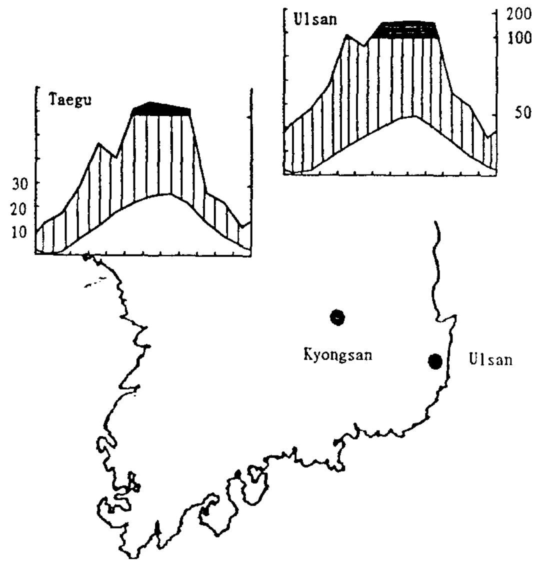

Figure 1. Location and climate diagram of study areas.

Analysis of habitat soil properties

In October at 3 random points in every plot, soil samples of A-horizon were collected with a 100 cm^3 soil corer and transported in a vinyl sack. Air dried samples were sieved by 2 mm meshes and homogenized. As results we recorded the averages of 5 analyzed values from the mixed samples. For the pH measurement, we prepared a 1 : 2.5 H_2O supernatant by the centrifuge and measured it with the pH-Meter (SUNTEX,TS－1). Organic matter in the soil was analyzed by the oxidation of carbon by $K_2Cr_2O_7$ and H_2SO_4, and the rest titration value of $K_2Cr_2O_7$ and ferrosalt was calculated. To analyze P_2O_5 we prepared a supernatant of perchloric acid, amidol and ammonium molybdate mixture after shaking it with lactate and filtering it with filter paper (No.5B). It was analyzed with Spectrophotometer (Hitachi 320) at 650 nm. Quantitative analysis of Ca, Mg, K, Na, B, SO_4 were performed by Spectrophotometer (Palintest 7000). Cd, Cu, Zn, Fe, Mn, As, Pb were analyzed by ICP Spectrophotometer (JOBIN YVON JY50P) after shaking it in HCl and filtering it as above, and Se after digestion by perchloric acid. The spectrum bands to analyze these heavy metals were 228.8 nm for Cd, 324.8 nm for Cu, 213.9 nm for Zn, 238.2 nm for Fe, 257.6 nm for Mn, 193.7 nm for As, 220.4 nm for Pb and 196.1 nm for Se.

Productivity according to the soil properties

5 different soils of habitat soil in Kyongsan, vermiculite, vermiculite-calcium carbonate mixture, sand and experimental field soil in Yeungnam University were prepared to examine the seedling productivities. The seeds were soaked 5 days long in 30℃ distilled water to avoid the autotoxicity and 100 seeds were sown in every flower boxes. The conditions of controlled environment chamber were 25℃ air temperature, 5000 Lux light intensity of greenhouse fluorescent tube and 10 hours illumination in a day, and every 3 days soil irrigation with distilled water up to pF 1.2. The productivity was calculated by average value from 10 dried seedlings in a drying oven of 80℃ and 48 hours.

Effects of acid rain

The concentration of simulated acid rain was adjusted to pH 1.5, 2.0, 2.5, 3.0, 3.5 by diluted H_2SO_4 and sprayed every 3 days up to pF 1.2. We used vermiculite as the medium soil and the conditions of controlled environment chamber were the same as above.

Effects of light intensity

To examine the response of seedlings on the light intensity, we adjusted to 5, 50, 500 and 5000 Lux by shielding with dark vinyl and one plot in situ. We used the Hoagland-Arnon solution[17] as soil irrigation water, and other conditions of controlled environment chamber were the same as above.

Table 1. Synoptic vegetation table of study area. Condensed and simplified into the constancy degree and the range of dominance value. Species with constancy degree under II are excluded

Study area		Ulsan	Kyongsan
Coverage (%)	Tree	80	75
	Shrub	80	85
	Herb	65	60
Phytolacca americana		V (4−5)	V (4−5)
Pinus densiflora		V (1−3)	V (1−5)
Persicaria perfoliata		V (+−3)	V (0−4)
Miscanthus sinensis		V (+−4)	V (0−5)
Smilax china		V (+−3)	IV (0−1)
Rubus crataegifolius		V (0−4)	V (0−3)
Paederia scandens		V (+−2)	IV (0−1)
Rosa multiflora		III (0−3)	IV (0−2)
Commelina communis		IV (0−2)	III (0−1)
Carex lanceolata		III (0−1)	IV (0−1)
Pinus thunbergii		V (+−3)	
Cocculus trilobus		III(0−+)	III(0−+)
Carex fernaldiana		III (0−3)	II (0−+)
Erigeron canadensis		III (0−1)	II (0−+)
Artemisia princeps		II (0−+)	II (0−1)
Prunus sargentii		III (0−1)	II (0−1)
Pteridium aquilinum		II (0−1)	II (0−1)
Calamagrotis arundinacea		II (0−2)	III (0−2)
Castanea crenata		II (0−3)	II (0−3)
Oplismenus undulatifolius		II (0−1)	II (0−1)
Robinia pseudo-acacia		III (0−3)	I (0−3)
Persicaria viscofera		II (0−+)	II (0−+)
Quercus acutissima		II (0−+)	II (0−1)
Juniperus rigida		II (0−1)	I (0−+)
Eupatorium chinense		II (0−2)	I (0−2)
Euonymus japonica		I (0−+)	I (0−1)
Lactuca raddeana		I (0−+)	II (0−1)
Achyranthes japonica		II (0−2)	I (0−+)
Pueraria thunbergiana		I (0−+)	I (0−3)
Rhododendron mucronulatum		II (0−2)	
Quercus mongolica		II (0−1)	
Ligustrum obtusifolium		II (0−1)	
Aralia elata		I (0−1)	I (0−+)
Quercus serrata		II (0−+)	

Responses on the drought

Drought gradients with 5 soil environments as above in the controlled environment chamber were set up to determine the tolerances. The soils were saturated by distilled water, and the changes of water content in the soil and growth of seedlings were detected. Water in the soil was measured by Tension Meter (Takemura). Other conditions of controlled environment chamber were the same as above.

Results and Discussion

Species composition

Table 1 shows the list of species, constancy degree and the range of dominance value of 40 plots. The dominant species throughout the whole study area were *Phytolacca americana, Pinus densiflora, Persicaria perfoliata, Miscanthus sinensis, Smilax china, Rubus crataegifolius, Paederia scandens, Rosa multiflora, Commelina communis, Carex lanceolata,* and the pokeweed invaded and adapted itself to the destroyed *Pinus densiflora* forest. The morphological characteristics of perennial and well developed storage root system and autotoxicity of seeds [18] made it more competitive and easier to find a new habitat.

Properties of habitat soil

Two study areas were divided into 4 sites ; site A and B in Ulsan area and site C and D in Kyongsan. Table 2 shows the results of soil analysis. Soil properties of the whole area were similar by high acidity of pH 4.6 in average and high in heavy metal contents. Especially a high level of Mn, As and Fe was found.

Productivity according to the soil properties

Five experimental soils were prepared ; Table 3 shows the detailed properties of these soils, and the results of productivity measurements of the seedlings on these soil conditions are shown in Figure 2A. In spite of high acidity and heavy metal contents, the pokeweed showed high productivity in the soil I and V with high content of organic matter.

Table 2. Soil properties of study area. Site A and B in Ulsan, and site C and D in Kyongsan area

A. General properties

Site	pH	OM	P_2O_5	Exchangeable Cation(me/100g)				SO_4
	(1 : 2.5 H_2O)	(%)	(ppm)	Ca	Mg	K	Na	(ppm)
A	4.6	3.81	23.5	1.69	0.32	0.32	0.55	304
B	4.5	4.16	23.0	2.81	0.63	0.39	0.37	239
C	4.6	4.50	22.0	2.38	0.57	0.39	0.45	248
D	4.6	3.84	24.2	2.39	0.91	0.40	0.45	438
Average	4.6	4.08	23.2	2.31	0.61	0.38	0.46	307

B. Heavy metals in soil

Site	Cd	Cu	Zn	Fe	Mn	As	Pb	Se	B
					(ppm)				
A	0.08	1.15	7.55	38.0	694	17.9	3.35	0.0	0.19
B	0.10	1.35	9.25	31.4	437	20.2	2.75	0.0	0.23
C	0.10	1.55	8.40	35.8	348	19.6	2.45	0.0	0.30
D	0.15	1.55	9.35	41.3	415	18.9	1.95	0.0	0.32
Average	0.11	1.40	8.64	36.6	474	19.2	2.63	0.0	0.26

Table 3. Properties of experimental soils. Number I for habitat soil in Kyongsan, number II for vermiculite, number III for vermiculite with calcium carbonate soil, number IV for sand and number V for experimental field soil in Yeungnam University

A. General properties

Soil	pH	OM	P_2O_5	Exchangeable Cation(me/100g)				SO_4
	(1 : 2.5 H_2O)	(%)	(ppm)	Ca	Mg	K	Na	(ppm)
I	4.6	3.84	24.2	2.39	0.91	0.40	0.45	438
II	7.4	0.14	33.0	4.69	2.31	1.07	1.02	409
III	7.3	0.07	25.0	8.29	2.63	0.71	1.07	296
IV	7.3	0.11	5.2	2.33	0.35	0.10	0.51	115
V	4.6	2.94	541.4	3.26	0.74	1.04	0.41	241

B. Heavy metals in soil

Area	Cd	Cu	Zn	Fe	Mn	As	Pb	Se	B
				(ppm)					
I	0.15	1.55	9.35	41	415	18.9	1.95	0.0	0.32
II	0.00	5.70	3.30	339	747	1.2	1.35	0.0	0.17
III	0.00	4.05	3.05	256	736	7.3	1.30	0.0	0.00
IV	0.05	1.10	1.15	47	123	9.6	0.10	0.0	0.08
V	0.15	55.55	9.05	209	578	12.2	19.25	0.0	0.24

Effects of acid rain

Figure 2B shows productivities in different conditions of simulated acid rain. The pokeweed showed extremely high tolerance up to pH 2.0. The acidity of the outside pokeweed community was the same as inside. It means that the pokeweed has a high tolerance to acidity and did not change the environment in acidity. This tolerance is one of the reason why it appears often in a polluted area.

Effects of light intensity

Figure 2C shows the productivities in different light intensities. There was no change in productivity over 5000 Lux of intensity, but, below 500 Lux it show clear decrease.

Responses on the drought

Figure 2D shows responses of endurance and productivity of seedlings on different soil properties and conditions. The first sign of drought injuries appeared at pF 2.6−2.7 as temporary wilting point and permanent wilting point at pF 2.8−2.9, but on sand pF 1.7 and pF 1.9 each. It means that the seedlings are intolerant to drought.

The pokeweed invaded and adapted itself to the destroyed *Pinus densiflora* forest[19]. Adapted environmental factors for the pokeweed were the soil with high organic matter and high heavy metal contents, acid soil, normal light intensity and rather humid soil. Injuries of the seedling by the limiting factors occurred at pH 2.0 by the simulated acid rain, at 500 Lux of light intensity, temporary wilting point at pF 2.6−2.7 and permanent wilting point at pF 2.8−2.9 in the controlled environment chamber. Morphological traits of the perennial and well developed storage root system showed tolerance to the pollution, and transportation by bird (*Paradoxomis webbiana*) and through the digestive tract of disseminator to avoid autotoxicity[18] on seed germination made it more competitive to find a new habitat. Therefore the

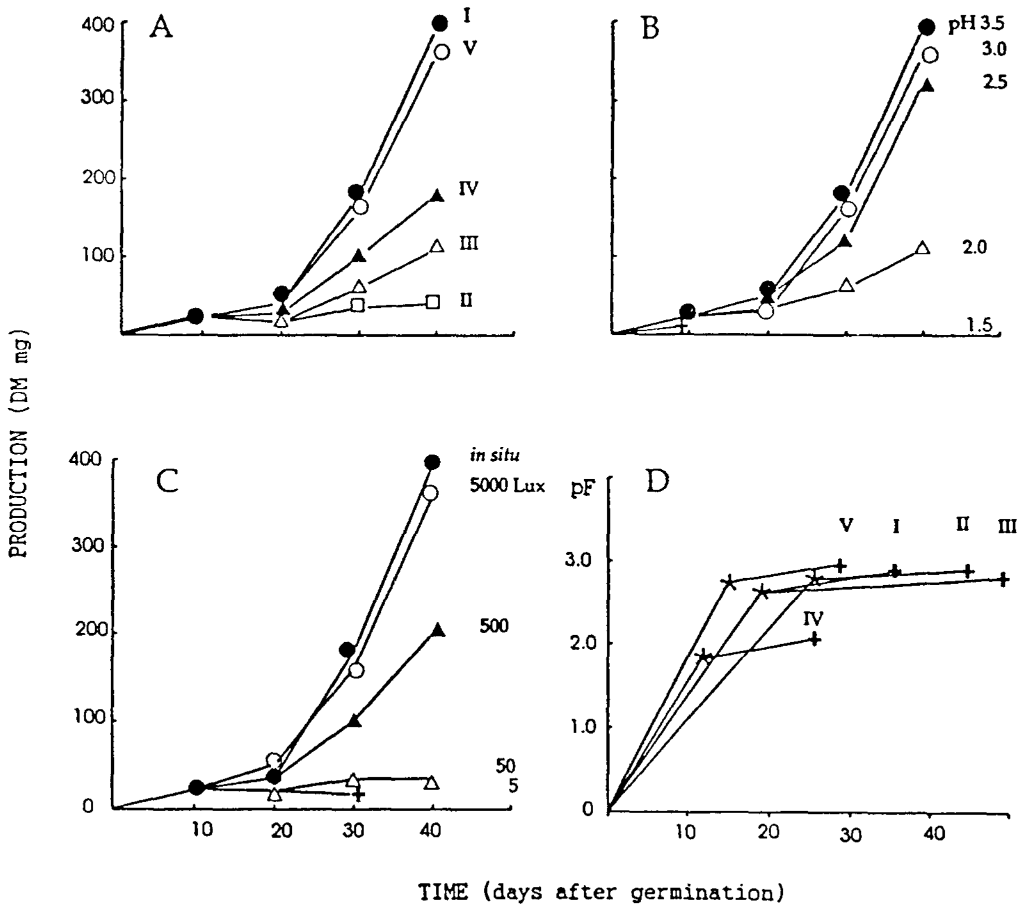

Figure 2. Production and tolerance of Pokeweed seedlings in controlled environment chamber. A. Production and soil type. B. Production and acid rain. C. Production and light intensity. D. Drought tolerance and soil type. * =Temporary wilting point. + =Permanent wilting point or died, DM=Dry Matter.

pokeweed made no particular community of species group but showed ruderal characteristics[1]. And the community dominated by pokeweed may be an indicator for high acidity of the soil.

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References

1. Walter, H. and Straka, H. : *Arealkunde*. Floristisch-historische Geobotanik, pp. 478, Eugen Ulmer, Stuttgart(1970).
2. Hill, M. O. : Reciprocal averaging : An eigenvector method of ordination. *J. Ecol.,* **61**, 237(1973).
3. Hill, M. O. and Gauch, H. G. : Detrended correspondence analysis, an improved ordination technique. *Vegetatio.,* **42**, 47(1980).
4. Ter Braak, C. J. F. : Canonical correspondence anal-

ysis ; a new eigenvector technique for multivariate direct gradient analysis. *Ecology,* 67, 1167(1986).
5. Chung, T. H. : On the plant dyes in Korea. *Kor. J. Bot.,* 2, 56(1957).
6. Lee, D. B. and Kim, Y. C. : A historical review of some plant of American origin in Korea. *Kor. J. Bot.,* 4, 25(1961).
7. Yim, Y. J. and Jeon, E. S. : Distribution of naturalized plants in the Korean peninsula. *Kor. J. Bot.,* 23, 69(1980).
8. Park, S. H. : Unrecorded naturalized plant in Korea. *Kor. J. Pl. Tax.,* 22, 59(1992).
9. Sun, B. Y., Kim, C. H. and Kim, T. J. : Naturalized weed and new locatiom of plant to Korean flora. *Kor. J. Pl. Tax.,* 22, 235(1992).
10. Kim, J. G. : Study on herbs vegetation of Onsan industrial complex. Korean *J. Ecol.,* 15, 247(1992).
11. Zeven, A. C. and Zhukovsky, P. M. : *Dictionary of cultivated plants and their centres of diversity*, pp.219, Centre for Agricultural Publishing and Documentation, Wageningen(1975).
12. McDonnell, M. J. : *Dispersal of bird-disseminated plants. The effect of vegetation a landscape structure* (*New Jersey*), pp.164, Ph.D. Thesis, Rutgers the State Univ. of New Jersey(1983).
13. Sakuta, M., Hirano, H. and Komanine, A. : Stimulation by 2,4-Dichlorophenoxyacetic acid of betacyanine accumulation in suspension-culture of *Phytolacca americana. Physiologia Plantarum,* 83, 154(1991).
14. Hirano, H., Sakuta, M. and Komanine, A. : Inhibition by cytokinin of the accumulation of betacyanin in suspension-culture of *Phytolacca americana. Amer. J. Biosci.,* 47, 705(1992).
15. Andrews, G. A. : *Studies of canine erythrocyte antigens* (*erythrocyte antigens*), pp.114, Ph.D. Thesis, Kansas State University(1992).
16. Braun-Blanquet, J. : *Pflanzensoziologie* : Grundzuge der Vegetationskunde. 3. Aufl., pp.865, Springer, Wien, New York(1964).
17. Ali, A. : *Growth and yield of barley* (*Hordeum vulgare* L.) *as affected by salinity and mixed ammonium and nitrate nutrition*, pp.130, Ph.D. Thesis, University of Arizona(1993).
18. Edwards, M. E., Harris, E. M. and Wagner, F. H. : Seed germination of American pokeweed (Phytolacca americana). I. Laboratory techniques and autotoxicity. *Amer. J. Botany,* 75, 1794(1988).
19. Ri, C. U. : Two types of forest vegetation in Kyungpook area. *Korean J. Ecol.,* 3, 17(1980).