

## Variation in Demography of *Taraxacum officinale* Seeds Harvested from Different Seasons

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**ABSTRACT** : We investigated the variation in adaptation to growth for four ecotypically-differentiated population of *Taraxacum officinale* found naturally in temporal environmental heterogeneity. Seeds collected from the four seasons were germinated in incubators and were grown for four months in greenhouse to test genetic variation among biotypes. Biotypes, segregated by seeds collected seasonally, were the part of natural population in Mokpo, South Korea. Each biotype was different in total dry weight of seeds, biomass, and leaf area, confirming previous finding. Differences between biotypes grown under a common environment indicated a genetic basis to their distinct demographic rates. Therefore, biotypes with similar annual rates of growth and contrasting seasonal rates should persist in the population. This differential response suggests that temporal variation in environment may be responsible, in part, for the maintenance of genetic variation within populations.

**Key words** : *Taraxacum officinale*, Fitness, Temporal variation, Genetic variation, Biotype.

### INTRODUCTION

A plant's environment is extremely dynamic within a year. Many of these environmental changes can be grouped by each season. Among many abiotic factors, temperature, precipitation, and photoperiod fluctuate seasonally in temperate zone (Vavrek *et al.* 1996, 1997, Yang 2001). Population growth and decline have been found to vary as a function of this heterogeneity (Selman 1970, Sharitz and McCormik 1973, Sarukhan and Gadgil 1974). To understand the consequences of environmental heterogeneity on population growth, vital demographic rates have been observed across time and space. For example, differences in annual demographic rates have been shown for *Arisaema triphyllum* (Bierzuchudek 1982), *Bromus tectorum* (Mack and Pyke 1984), *Alnus incana* (Huenneke and Marks 1987), *Ascophyllum nodosum* (Aberg 1992), *Collinsia verna* (Kalisz and McPeck 1992), and *T. officinale* (Kang and Choi 1998). This environmental control of plant demography has implications for population stability and distribution. For example, population size and dispersion may fluctuate as a result of differential sensitivity of population growth to environmental change across space and time. Differential demographic rates within populations may also serve as indicators of underlying genetic composition, life histories, and evolutionary change.

Temporal environmental heterogeneity occurs both among years and within years (seasonally). Several studies have incor-

porated seasonal variation in their studies (Sarukhan and Gadgil 1974, Law 1981, Park and Park 1997, Kang and Choi 1998), but have not specifically examined differential demographic responses of plant populations across seasons (with the exception of Bullock *et al.* 1994). Variation in demography among seasons, however, may be greater than variation among years because seasonal variation in weather is generally large relative to annual differences. In the temperate climates, temperature and precipitation are clearly season-dependent (Fig. 1).

Seasonal variation in temperature, precipitation, irradiance, and photoperiod directly affect plant populations (Vavrek *et al.*

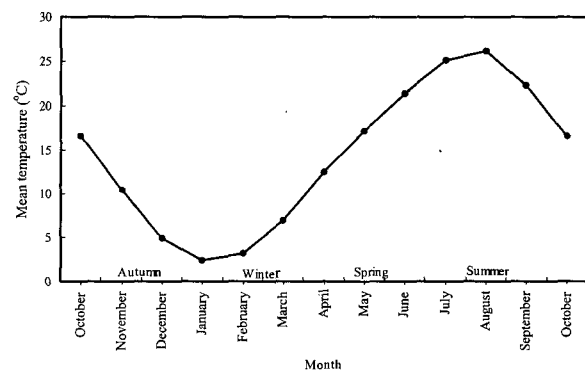


Fig. 1. Mean temperature for Mokpo, Chonnam, Korea from 1991 to 2000.

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1996, Yang 2001). Indirect effects also occur because seasonal weather patterns influence rates of mineralization (Williams 1969, Davy and Taylor 1974, Morecroft *et al.* 1992), evapotranspiration (Caprio 1974), and decomposition (Katz and Lieth 1974, Rochow 1974). Changes in these rates, in turn, influence resource abundance and availability to plants.

Population-level demographic rates may also be influenced by genotype-specific responses to seasonal environmental change. Differential genotypic responses may underlay overall demographic patterns and may serve to maintain genetic variability within the population, just as genotype-environment interactions can maintain genetic variation (Antonovics 1976).

In this experiment, four clonally replicated biotypes of *Taraxacum officinale* were grown under a common environment to test if the biotypes are responding differentially in terms of growth. Differential biotypic responses may serve to augment or ameliorate responses to seasonal abiotic fluctuation. In addition, we experimentally test whether group by season interactions for fitness of *T. officinale* can explain genetic variability within the population.

**MATERIALS AND METHODS**

*Taraxacum officinale* is a ubiquitous, herbaceous perennial commonly found in lawns, meadow, and disturbed areas. *T. officinale* generally maintains foliage throughout the entire year in Korea. Seeds of a natural population of *T. officinale* within the Mokpo University lawn, were collected from the same plant

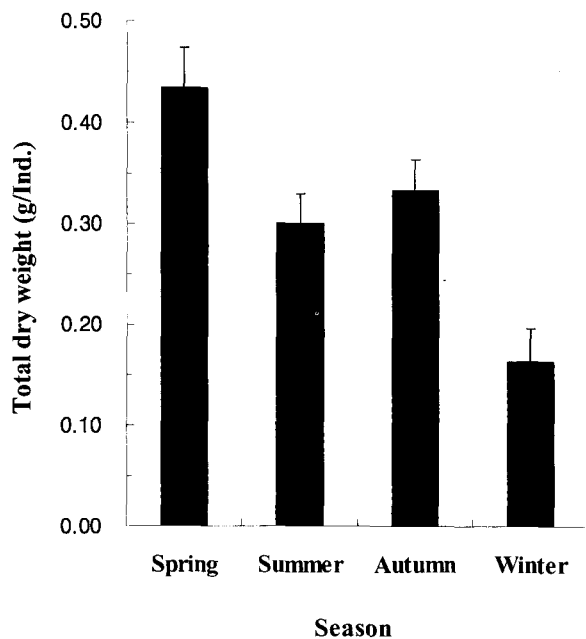


Fig. 2. Total dry weight (mean ± se) of *Taraxacum officinale* groups cultured in greenhouse for four month (n=90).

throughout the entire year of 1999~2000 for this study. All seeds collected were stored in paper bags at 4 °C. These seeds were classified into four biotypes. These biotypes, spring (April to July; A), summer (July to October; B), autumn (October to January; C), winter (January to April; D), were selected based upon monthly climatic patterns and demographic patterns of natural population of *T. officinale* (Vavrek 1994, Yang 2001).

Seven days after seeds were planted for germination, available seedlings were transplanted to 15 cm diameter pots filled with Promix BX soil in the same treatment. The four pots were placed together as a unit on the greenhouse bench (mean temperature = 25~30 °C, 170 μmol m<sup>-2</sup> s<sup>-1</sup>; 12h photoperiod, Promix BX soil). Three such adjacent units were considered as a block. Each unit within a block was randomly assigned to one of four biotypes. In total, 120 pots were placed in 10 blocks. All pots were watered once daily during four months. Aboveground and underground dry weight, and seed weight were measured after 48 h at about 100 °C in a drying oven. The number of leaves, leaf area (Li-Cor LI-3000; USA), and seed weight of 90 plants were measured at the end of the experiment on February 10, 2002.

To determine whether seeds collected during the four seasons respond differentially to growth, one-way ANOVA was performed. All analyses were performed using SAS JMP (v 4.0)(2001).

**RESULTS**

The pattern of temperature change during the seed collection was typical for a temperate climate (Fig. 1). Analysis of temperature variance for the survey site in southwestern of Korea peninsular (KMA 1991-2000, Mokpo, Korea) yielded little effect of year ( $F=0.04, P=1.000$ ), but a large effect of season ( $F=784.87, P<0.001$ ).

The total dry weights of the all biotypes (Fig. 2) were significantly different (Table 1,  $F=11.26, P<0.001$ ). Total dry weight was low in biotype winter (mean±sd=0.163 ± 0.034 g) relative to the mean response for biotype spring (0.434 ± 0.040 g), summer (0.300 ± 0.031 g), and autumn (0.332 ± 0.029 g). Biotype spring produced the highest biomass among all biotypes. These differences display that the seeds of natural plant population under-

Table 1. F values for ANOVA of total dry weights, number of leaves, total leaves areas, and total dry weight of seeds for four *Taraxacum officinale* biotypes grown under a common environment

Source of variation	df	Total biomass	No. of leaf	Total leaf area	Total dry weight of seed
Biotypes	3	11.126***	1.286	32.034***	9.632**
Error	86				

\*\*\*  $p<0.001$ , \*\*  $p<0.01$ .

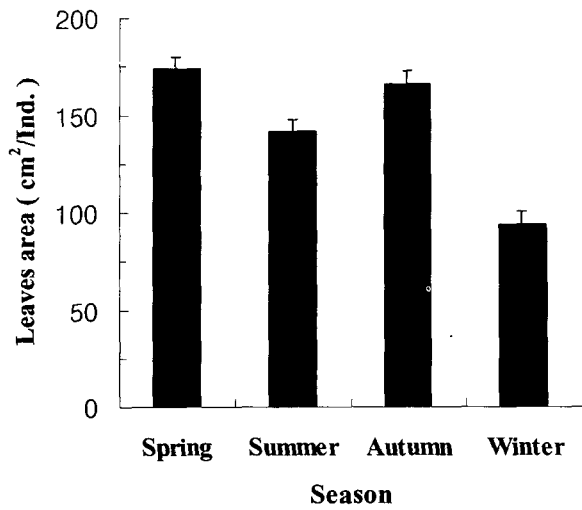


Fig. 3. Leaf area (mean ± se) of *Taraxacum officinale* biotypes cultured in greenhouse for four months (n=90).

gone long time seasonal heterogeneity may have genetic variation. The leaf area showed statistically significant differences (Table 1). The leaf area was lower in biotype winter ( $94.000 \pm 5.815 \text{ cm}^2$ ) than mean leaf area of all biotypes ( $143.798 \pm 6.321 \text{ cm}^2$ ). Biotype spring was the highest leaf area ( $\pm 173.810 \pm 6.324 \text{ cm}^2$ ) relative to biotype summer ( $141.524 \pm 5.876 \text{ cm}^2$ ), autumn ( $165.857 \pm 7.269 \text{ cm}^2$ ), and winter ( $94.000 \pm 5.815 \text{ cm}^2$ ) (Fig. 3). These differences in leaf area depend on biotypes, and appear the variation of fitness between biotypes. The number of leaves of biotypes were not statistically significant

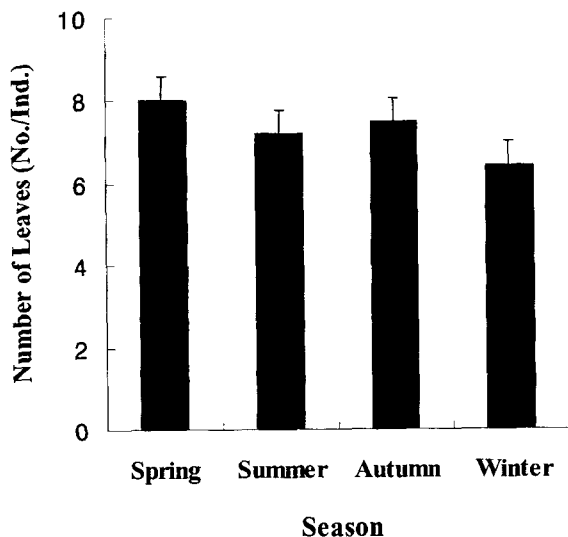


Fig. 4. The number of leaves (mean ± se) of *Taraxacum officinale* biotypes cultured in greenhouse for four months (n=90).

(Table 1). However, the number of leaves of biotype spring was higher than other biotypes (Fig. 4).

Total dry weight of seeds are statistically significant (Table 1). Total dry weight of seeds of biotype autumn ( $2.363 \pm 0.32 \text{ g}$ ) was the highest relative to all other biotype, spring ( $1.873 \pm 0.32 \text{ g}$ ), summer ( $1.321 \pm 0.32 \text{ g}$ ) and winter ( $1.132 \pm 0.32 \text{ g}$ ). These differences in total dry weight of seeds mean the variation of fitness between biotypes. Response in terms of growth rates and fitness allowed a definition of genetic variation in demography of four biotypes of *T. officinale*.

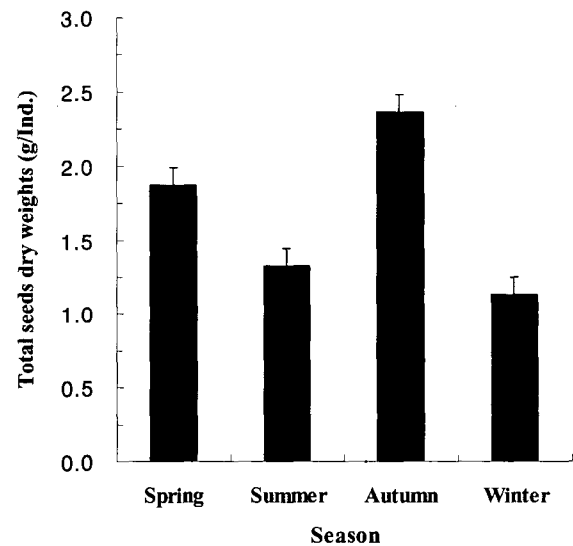


Fig. 5. Total dry weight of seeds (mean ± se) of *Taraxacum officinale* biotypes cultured in greenhouse for four months (n=90).

## DISCUSSION

Four biotypes of *Taraxacum officinale* were classified based upon monthly climatic patterns (seasons) and germination rates (Yang 2001). This result collaborates the finding by Lyman and Ellstrand (1984) that on average five genotypes existed per population in an isozyme and morphological survey, and Vavrek *et al.* (1996, 1997) found that two biotypes existed per population by cluster analysis of leaf morphology of *T. officinale* populations in North America. Thus, genetic diversity is relatively low in *T. officinale* population. Lyman and Ellstrand (1984), and Vavrek *et al.* (1996) found a range of only one and two to thirteen genotypes per population, respectively. The maintenance of this variability may be important, however, to persistence of these populations in the face of environmental change. We proposed that this within-population genetic variation may be maintained by the differential response of biotypes to season-dependent environ-

mental heterogeneity. The results show that differences in biotype demography are season-specific that the four biotypes are genetically distinct as indicated by differences in plant germination, total dry weight, leaves area, and leaves number under a common environment.

Temporal environmental variation has been suggested as a casual factor in the maintenance of species diversity within communities (Fowler and Antonovics 1981, Chapin and Shaver 1985), which is an extension of the principle demonstrated here. Many species are adapted differentially to a combination of environmental factors in time and space resulting phenologies as well as resource use. The timing and control of recruitment by different species may be particularly important for species richness. Genetic differences among species in physiological control for the release from dormancy, for example, contribute to the separation of specific niches within a year (Grubb 1977). The greater number of niches allows for the coexistence of a greater number of species within a community. Thus, species-specific demography influences community composition in the same manner that genotypic differentiation influences within-population diversity. Additionally, the diversity within populations determines limits for species ecology within communities (Antonovics 1976). Therefore, the processes occurring within populations are not only similar to community processes, but are interrelated.

Our results suggest that biotypes within a population may also specialize in resource use temporally as exhibited by distinct demographic patterns. Temporal heterogeneity, thus, affects population structure as well as community composition. The differential response of biotypes to cyclic seasonal fluctuations within populations may be particularly important for the maintenance of genetic diversity in apomictic species in which little or no new genetic variation arises. Rapid production of identical offspring by a clone with an adaptive advantage would allow that clone to eventually dominate the population (Sebens and Thorne 1985). However, if selective forces change with seasons, relative fitness of individual clones will also change. For example, two morphological clones of *Bosmina longirostris* (a cladoceran) are maintained by their differential relative fitness in response to seasonal change in the dominant predator species (Black 1980). If only one predator was present throughout the year, clone with the lower fitness would be lost from the population.

Spatial environmental heterogeneity has been found to be important across gradients from kilometers to centimeters in length (Clausen *et al.* 1940, McNeilly and Antonovics 1968). Others have demonstrated interannual fluctuation in demography (Klemow and Raynal 1983, Mack and Pyke 1984). Similarly, we have shown temporal variation to be important across seasons (three months) within a year. Plant biotypes may respond differentially to temporal fluctuations on an even smaller scale, across months or weeks. Ultimately, we may discover that different genotypes may be responding differentially to hour by hour

changes in the environment.

This study reiterates and expands the finding of Vavrek *et al.* (1996, 1997) demonstrating that seasonal environments have large effects on demography. Biotypes within populations respond differentially to seasonal environments influencing population growth which may in turn influence community composition. Demographic change as a function of season may also affect population viability if the population is more vulnerable during particular seasons or if biotypes within the population have fluctuating vulnerabilities. Within-population genetic variation may be a mechanism which maintains plant population.

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