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Occurrence of Weed Species in Pear Orchards in Chungnam Province of Korea

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A survey of weed occurrence was conducted to identify noxious weed species in pear orchards to obtain basic information for effective weed control. The survey was conducted in pear orchards situated in Chungnam province of Korea from April to June 2015, for spring, and from September to October 2015, for autumn. A total of 19 survey sites were randomly selected. The weed species were summarized as a total of 63 taxa belonging to 24 families. Specifically, 18 exotic weeds, belonging to 9 families, were identified. The majority of weeds were Compositae (10), followed by Poaceae (7) and Polygonaceae (6). Rumex crispus and *Poa annua* were dominant weeds. In terms of life cycle, there were 17 species of annual weeds, 13 species of biennial weeds, and 17 species of perennial weeds for the spring survey, and 15 species of annual weeds, 6 species of biennial weeds, and 11 species of perennial weeds for the autumn survey. The continuous application of single control method was unbeneficial for weed management in pear orchards. These results could be useful for the establishment of weed multi–control methods in pear orchards in Chungnam province of Korea.

Key words: Dominant weed, exotic weed, orchard field, weed flora, weed occurrence

INTRODUCTION

In Korea, the cultivated area of fruit trees increased from 20,000ha in 1955 to 155,000 ha in 2005, of which pear trees occupied a significant portion (Ha and Chung, 2012). Moreover, the pear tree area in Chungnam province is ranked third in the country, encompassing 1,280 ha and concentrated in Cheonan city (Yoon, 2014). With this increasing cultivated area, a large amount of labor is required. However, the rapid ageing of the population and labor shortages are serious problems in Korea, which leads to the decline of productivity (Kim, 2009). The use of herbicides is one of the most effective ways to improve productivity.

In pear orchards, there is a competitive relationship for water and nutrients between weeds and pear trees. Weeds have a significant influence on pear tree vitality (i.e., shoot extension, leaf size, and fruit size) (Larsen and Ries, 1960; Raese, 1991). Additionally, weeds also serve as an inoculum source for diseases and alternate host for insects (Johnson *et al*., 1993; Fitzgerald and Solomon, 2004). The application of herbicide to establish weed–free pear orchards can help avoid these threats. However, the excessive and indiscriminate application of herbicides brings about a series of adverse effects (e.g., water or soil pollution and increase of herbicide resistant weeds) (Zhang *et al*., 2005; Park *et al*., 2014). Consequently, it is necessary to investigate the weed species present and to select effective herbicide or management methods accordingly.

Studies of the occurrence of weeds show their abundance and diversity in orchards. Hwang and Park (2016) reported that 64 weed species belonging to 27 families, including 39 annuals and 25 perennials, were identified in apple orchards of Chungnam province. Furthermore, according to another classification, 7 species of grasses, 60 species of broad leaves, and 2 species of sedges were observed in pear orchards (Jung *et al*., 1997). In addition, a number of exotic weeds were also identified in orchards; for example, *Chenopodium album* var. *album* (Chenopodiaceae) and *Conyza Canadensis* (Compositae) had a relatively high occurrence frequency (Oh *et al*., 2004). Due to the diversity of weeds, it is more effective to use integrated weed management methods than any single weed management method (Rifai *et al*., 2002).

The objective of the current study is to determine pear orchard weed flora and corresponding weed management methods, as well as to provide a useful database to identify troublesome weed species and control technologies. On that ground, understanding the occurrence of weeds is crucial for effective weed control in pear orchards. The ultimate purpose of performing this weed survey is to obtain maximum pear yields while reducing labor force input through reasonable and effective weed management methods in the province of Chungnam.

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MATERIALS AND METHODS

Survey period and sites

The study was carried out in the Chungnam region, (i.e., Daejeon, and Sejong) from April to June 2015, for spring, and from September to October 2015, for autumn. The 19 survey sites were randomly selected in pear orchards. All of the survey sites were taking little to no preventive measures against weeds.

Survey methods

The frequency, species, and number of weeds were investigated at each survey site. GPS (ICE CPS 100c) information and address of survey sites were recorded to ensure precise test field location. As a result, exotic weed species locations could be known in each pear orchard. The area of each test field was estimated by pacing; counting the number of steps of a researcher from one end of the field to the other. Weed population and surrounding areas were recorded by photography with a camera (Canon 100D) in the test fields (Hwang *et al*., 2014).

Weed species were identified by visual observation in the survey field. The covering ratio was computed according to Braun–Blanquet (7–level system, 5, 4, 3, 2, 1, + and r) (1964). Braun–Blanquet's coverage scale for weed estimation was as follows: 5, covering more than 75% of the whole test field; 4, any number of individuals covering 50–75% of the area; 3, any number of individuals covering 25–50% of the area; 2, very numerous or covering at least 5% of the area; 1, plentiful but of small cover value; +, sparsely present, cover small; r, very sparsely present, cover very small (Poore, 1955).

Data analysis

The results of weed survey were compiled into lists according to the Synonymic List of Vascular Plants of Korea (Korea National Arboretum, 2007). Exotic weeds (EW) were identified by "Colored Illustrations of Naturalized Plants of Korea" (Park, 2009) and with the paper describing upland field flora by Lee *et al*., in 2015. For classification into life cycles, weeds were divided into annuals, biennials, and perennials (Raunkiaer, 1934). Distribution proportion of each family of weeds was then calculated.

The importance values were analyzed based on spring and autumn survey results (Curtis and McIntosh, 1950). Frequency was defined as a percentage of weed samples where some species are present in all the orchard fields under observation. The frequency formula is the number of samples of any species multiplied by the total number of samples of all species divided by 100. Relative frequency (RF) was calculated by dividing frequency by the sum of frequencies of all the species multiplied by 100. The relative coverage (RC) is the coverage of any species divided by the percentage of total coverage of all the species. The importance value (Ⅳ) is the importance index for assessing biodiversity, which is calculated by adding the relative frequency and the relative coverage and dividing the result in half.

RESULTS AND DISCUSSION

According to the results of two survey seasons, there were a total of 63 taxa including 24 families, 47 genera, 57 species, and 6 varieties. The majority of weed species belonged to the Compositae (10), followed by the Poaceae (7) and Polygonaceae (6). For the spring survey, weeds were summarized as 47 taxa belonging to 20 families, 35 genera, 41 species, and 6 varieties. The families were mainly classified as Poaceae, Compositae, and Polygonaceae in order of importance. *Rumex crispus* (7.45%) was the most dominant species, followed by *Poa annua* (7.98%) and *Stellaria aquatic* (7.98%) (Table 1). In the autumn survey, the weeds were summarized as 32 species belonging to 18 families and 31 genera. Compositae and Polygonaceae were identified as the main families. The most dominant weed species was *Rumex crispus* (9.47%) followed by *Poa annua* (7.27%) and *Stellaria aquatic* (6.17%) (Table 2). Based on two seasons' data, *Rumex crispus* and *Poa annu*a were the dominant weed species in pear orchards. The two seasons' results were similar to apple orchard weed species surveys of the Chungnam region in 2015 (Hwang and Park, 2016). This is because the two studies were carried–out in similar survey periods and regions, which leads to similarities in weed types.

In addition, 12 exotic weeds were identified in the spring survey, including *Rumex crispus* (7.45%), *Trifolium repens* (3.61%) and *Veronica didyma* var. *lilacina* (3.31%) etc. (Table 1). Meanwhile, in the autumn survey, 10 exotic weeds were discovered in pear orchards, including *Rumex crispus* (9.47%), *Taraxacum officinale* (5.02%), and *Eclipta alba* (4.49%) etc. (Table 2). In terms of results combining two seasons' surveys, the *Rumex crispus* was confirmed as the most dominant exotic weed. A similar previous study (2003) conducted for the occurrence of exotic weeds in orchards of Chungnam region showed that *Amaranthus lividus* was the most dominant exotic weed (Choi *et al*., 2009). This difference in the exotic weed dominance between 2003 and 2015 indicates that it is necessary to survey weed occurrence regularly.

The analysis of weed life–cycles showed that there were 17 annual weeds, 13 biennial weeds, and 17 perennial weeds in the spring survey. For all weed species, the annuals occupied 36.17%, biennials 27.66%, and perennials 36.17% in the spring survey (Fig. 1.A). According to importance values ranking, the top 10 weed species were classified as 50% of perennials, 30% of biennials, and 20% of annuals. Top 10 weed species data showed that the most dominant weeds were perennial in the spring. In the autumn survey, there were annual weeds (15), biennial weeds (6), and perennial weeds (11). Moreover, the annual weeds occupied 46.88% of all weed species and 50% of the top 10 weed species (Fig. 1. B). The autumn results were similar to those from the 2003 survey of apple orchards (Park *et al*., 2005) in that a large number of annual weeds were observed in orchards.

According to the dominance value analysis accord-

Table 1. Occurrence of weed species in spring pear orchards in Chungnam in 2015

Rank	Scientific name	Family	Life cycle	I.V.	EW
1	*Rumex crispus*	Polygonaceae	Perennial	7.45	○
2	*Poa annua*	Poaceae	Annual	7.27	
3	*Stellaria aquatica*	Caryophyllaceae	Biennial	6.17	
4	*Plantago asiatica*	Plantaginaceae	Perennial	5.46	
5	*Artemisia princeps*	Compositae	Perennial	4.66	
6	*Stellaria media*	Caryophyllaceae	Biennial	4.18	
7	*Rorippa indica*	Cruciferae	Perennial	3.91	
8	*Trifolium repens*	Leguminosae	Perennial	3.61	○
9	*Capsella bursa–pastoris*	Cruciferae	Biennial	3.57	
10	*Veronica didyma* var. *lilacina*	Scrophulariaceae	Annual	3.31	○
11	*Agropyron tsukushiense*	Poaceae	Annual	3.09	
12	*Galium spurium* var. *echinospermon*	Rubiaceae	Biennial	2.74	
13	*Taraxacum officinale*	Compositae	Perennial	2.74	○
14	*Humulus japonicus*	Cannabaceae	Annual	2.63	
15	*Chenopodium ficifolium*	Chenopodiaceae	Annual	2.22	○
16	*Acalypha australis*	Euphorbiaceae	Annual	2.10	
17	*Poa sphondylodes*	Poaceae	Perennial	2.03	
18	*Persicaria vulgaris*	Polygonaceae	Annual	2.03	
19	*Polygonum aviculare*	Polygonaceae	Annual	2.03	
20	*Oenanthe javanica*	Umbelliferae	Perennial	2.03	
21	*Chenopodium album* var. *centrorubrum*	Chenopodiaceae	Annual	1.92	○
22	*Commelina communis*	Commelinaceae	Annual	1.81	
23	*Duchesnea indica*	Rosaceae	Perennial	1.81	
24	*Echinochloa utilis*	Poaceae	Annual	1.69	
25	*Persicaria hydropiper*	Polygonaceae	Annual	1.69	
26	*Calystegia sepium* var. *japonicum*	Convolvulaceae	Perennial	1.58	
27	*Veronica persica*	Scrophulariaceae	Biennial	1.46	○
28	*Digitaria ciliaris*	Poaceae	Annual	1.17	
29	*Cerastium glomeratum*	Caryophyllaceae	Biennial	1.05	○
30	*Chenopodium album*	Chenopodiaceae	Annual	1.05	○
31	*Rorippa palustris*	Cruciferae	Perennial	1.05	
32	*Agropyron tsukushiense* var. *transiens*	Poaceae	Perennial	1.05	
33	*Alopecurus aequalis*	Poaceae	Annual	1.05	
34	*Taraxacum platycarpum*	Compositae	Perennial	0.82	
35	*Rubia akane*	Rubiaceae	Perennial	0.75	
36	*Sonchus oleraceus*	Compositae	Biennial	0.64	○
37	*Leonurus japonicus*	Labiatae	Biennial	0.64	
38	*Persicaria senticosa*	Polygonaceae	Annual	0.64	
39	*Potentilla freyniana*	Rosaceae	Perennial	0.64	
40	*Solanum carolinense*	Solanaceae	Perennial	0.64	
41	*Solanum nigrum*	Solanaceae	Annual	0.64	
42	*Achyranthes fauriei*	Amaranthaceae	Perennial	0.53	
43	*Senecio vulgaris*	Compositae	Biennial	0.53	○
44	*Cardamine flexuosa*	Cruciferae	Biennial	0.53	
45	*Cardamine fallax*	Cruciferae	Biennial	0.53	
46	*Conyza canadensis*	Compositae	Biennial	0.41	○
47	*Malva sylvestris* var. *mauritiana*	Malvaceae	Biennial	0.41	

I.V.: importance value.
EW: exotic weed.

Table 2. Occurrence of weed species in autumn pear orchards in Chungnam in 2015

Rank	Scientific name	Family	Life cycle	I.V.	EW
1	*Rumex crispus*	Polygonaceae	Perennial	9.47	○
2	*Poa annua*	Poaceae	Annual	7.98	
3	*Stellaria media*	Caryophyllaceae	Biennial	7.98	
4	*Digitaria ciliaris*	Poaceae	Annual	7.51	
5	*Commelina communis*	Commelinaceae	Annual	7.35	
6	*Rorippa indica*	Cruciferae	Perennial	5.86	
7	*Taraxacum officinale*	Compositae	Perennial	5.02	○
8	*Eclipta alba*	Compositae	Annual	4.49	○
9	*Metaplexis japonica*	Asclepiadaceae	Perennial	4.18	
10	*Galium spurium*	Rubiaceae	Annual	4.18	
11	*Oenanthe javanica*	Umbelliferae	Perennial	3.81	
12	*Calystegia sepium*	Convolvulaceae	Perennial	2.85	
13	*Sonchus oleraceus*	Compositae	Biennial	2.85	○
14	*Acalypha australis*	Euphorbiaceae	Annual	2.85	
15	*Phytolacca americana*	Phytolaccaceae	Perennial	2.38	○
16	*Potentilla freyniana*	Rosaceae	Perennial	2.33	
17	*Cyperus amuricus*	Cyperaceae	Annual	2.01	
18	*Solanum carolinense*	Solanaceae	Perennial	1.85	○
19	*Senecio vulgaris*	Compositae	Biennial	1.69	○
20	*Persicaria thunbergii*	Polygonaceae	Annual	1.16	
21	*Bidens bipinnata*	Compositae	Annual	1.16	
22	*Persicaria senticosa*	Polygonaceae	Annual	1.16	
23	*Lindernia procumbens*	Scrophulariaceae	Annual	1.16	
24	*Pilea mongolica*	Urticaceae	Annual	1.16	
25	*Duchesnea indica*	Rosaceae	Perennial	1.00	
26	*Erigeron annuus*	Compositae	Biennial	1.00	○
27	*Cuscuta pentagona*	Convolvulaceae	Annual	1.00	○
28	*Polygonum aviculare*	Polygonaceae	Annual	1.00	
29	*Veronica didyma*	Scrophulariaceae	Biennial	1.00	
30	*Crepidiastrum sonchifolium*	Compositae	Biennial	0.84	
31	*Oxalis corniculata*	Oxalidaceae	Perennial	0.84	
32	*Pharbitis nil*	Convolvulaceae	Annual	0.84	○

I.V.: importance value.
EW: exotic weed

ing to Braun–Blanquet's scale, the covering ratio initially increased, and then decreased in the two seasons surveyed (Fig. 2). In the spring survey, the dominance value was level + and 1 (both of 33.93%) in pear orchards. In the autumn survey, 44.94% of pear orchards had dominance values of 1. These results indicated that weed occurrence frequency was low in pear orchards.

The study defined the most dominant weed species was *Rumex crispus*, which is an exotic weed that belongs to the Polygonaceae family, in pear orchards of the Chungnam region. Meanwhile, the main noxious weeds were perennial in the spring and annual in autumn. At present, mowing can be used to control the rhizome of *Rumex crispus* in both spring and autumn. In addition, mulching can also reduce weed occurrence to a certain extent. However, mulching is inconvenient for fertilization treatments and increases production costs. Likewise, sod–culture can partly control *Poa annua* and *Stellaria aquatica* through the rapid growth of white clover (*Trifolium repens*) coverage of pear orchards in spring, and *Poa annua* and *Stellaria media* through the cold resistance of hairy vetch (*Vicia villosa* Roth) and its coverage of pear orchards in autumn. However, the effect of a single control method is unsatisfactory in orchards (Rifai *et al*., 2002). Thus, periodical surveys to identify weed types can be beneficial to the application of targeted, more effective, multi–control methods for preventing weed occurrence.

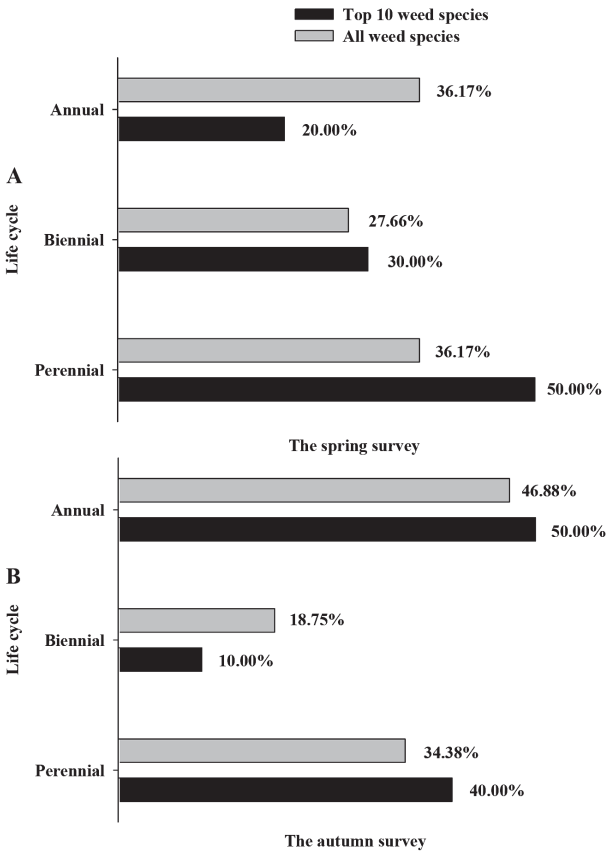

Fig. 1. Classification of all weed species and top 10 weed species occurring in pear orchards fields based on life cycle according to A) spring and B) autumn survey.

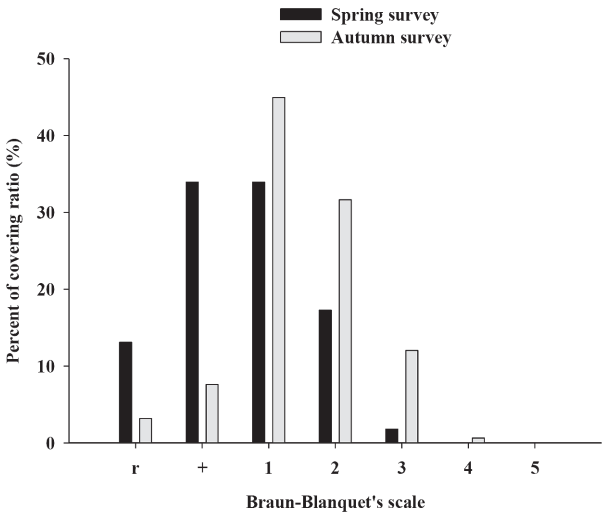

Fig. 2. Percent of covering ratio by Braun–Blanquet's cover–abundance scale (from r to 5) at total survey sites in spring and autumn of 2015. (Braun–Blanquet's scale: "r", cover very small; "+", cover small; "1", plentiful but of small cover value; "2", cover at least 5%; "3", cover 25–50%; "4", cover 50–75%; "5", cover more than 75% of the area.).

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