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Review

Status of Paddy Weed Flora and Community Dynamics in Korea

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韓國의 논雜草分布 및 群落現況

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ABSTRACT

Nationwide weed survey of paddy rice field conducted in 1981 and 1971 was compared and determined major dominant weed community types distributed by province.

Based on the similarity coefficients between 1971 and 1981 the floristic composition based on the degree of dominance was greatly dissimilar while kind of weed flora were not much differed. Degree of dominance were concentrated to perennial weeds in 1981 while these were at annual weeds in 1971.

The most important 10 weed species and their dominance in 1981 were *Monochoria vaginalis* Presl.(22.2%), *Sagittaria pygmaea* Miquel(17.5%), *S. trifolia* L.(9.0%), *Potamogeton distinctus* Benn.(9.0%), *Cyperus serotinus Rottb.*(8.5%), *Rotala indica* Koehne(6.0%), *Aneilema japonica* Kunth(4.4%), *Lindernia procumbens* Philcox (3.9%), *Eleocharis kuroguwai* Ohwi(3.4%) and *Ludwigia prostrata* Roxb(3.0%), respectively while these for 1971 were *R. indica*(34.5%), *Eleocharis acicularis* Roem. et Schult (11.9%), *M. vaginalis*(11.1%), *Cyperus difformis* L.(8.7%), *Echinochloa crus-galli* Beauv.(6.9%), *L. procumbens*(3.3%), *P. distinctus*(3.1%), *A. Japonica* (2.4%), *E. kuroguwai*(1.8%) and *P. hydropiper*(1.8%), respectively.

Weed occurrence was also closely related with soil type, cropping pattern and cultural practices. Particularly, the occurrence of *P. distinctus* was negatively correlated with the degree of land utilization.

Weed community types defined by two-dimensional ordination analysis were 11 for Jeonnam province, 9 for Gyeonggi, Gangweon, Chungbuk and Gyeongnam provinces, 8 for Jeonbuk and Gyeongbuk provinces, 7 for Chungnam province and 4 for Jeju province, respectively.

Key words: paddy weeds, flora, community dynamics.

INTRODUCTION

The weed vegetation of a particular area is determined by various factors which are themselves interrelated. These factors are largely classified as climatic, physiographic and biotic factors. Climatic factors include light (intensity, quality, day length), temperature (extremes, range, average, frost-free period), water (amount, percolation, runoff, evaporation), wind (velocity, duration) and atmosphere (CO_2, O_2, humidity, toxic substances) and physiographic factor include edaphic (soil factors including PH, fertility, texture structure, organic matter content, CO_2, O_2, water drainage) and topographic (altitude, slope, exposure to the sun)while biotic factors include plants (competition, disease, toxins, stimulants, parasitism, soil flora) and animals(insects,

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grazing animals, soil fauna, man). However, the weed vegetation is most strongly affected by the biotic factor, particularly, by human activity through the cultural practices.

Several workers confirmed the effect of cultural practice on weed growth. For example, the cultivar grown (deDatta, 1981; Kim et al., 1981; Kim et al., 1982a; Chang, 1970), the weeding regime (Kim, 1979 1980b; Kim et al., 1981), land preparation techniques (Kim et al., 1975), and moisture regime (Smith et al., 1977; Swain, 1973; deDatta, 1980) all caused shifts in weed populations in rice fields.

Some species, however, are able to flourish under a wide range of conditions, and it is this adaptability which is an important factor in their success as dominant weeds.

About 350 species in more than 150 genera and 60 plant families have been reported as weeds of rice (Akobundu and Fagade, 1978; Barrett and Seaman, 1980; deDatta, 1977; Holm et al. 1977; Horng and Leu, 1977; Matsunaka, 1970; Noda, 1977; Pancho et al., 1969; Ronoprawiro et al., 1971; Singh et al., 1974; Smith et al., 1977; Suvatabandhu, 1950; Swain, 1973; WARDA, 1979). Species of Gramineae are the most common, with more than 80 reported as weeds of rice (Smith, 1983). Species of Cyperaceae rank next in abundance with more than 50 reported as weeds of rice (Smith, 1983). Other families with 10 or more species reported as weeds of rice include Alismataceae, Asteraceae, Fabaceae, Lythraceae, and Scrophulariaceae (Smith, 1983).

E. crus-galli is the most troublesome weed of rice and followed by *E. colona* in the world(Holm et al. 1977). *E. colona* tends to grow along the equator, but *E. crus-galli* has a greater range from north to south. Other rice field weeds of world importance are *Cyperus difformis, C. rotundus, C. iria, Eleusine indica, Fimbristylis littoralis, Ischaemum rugosum, M. vaginalis,* and *Sphenochlea zeylanica* (Smith, 1983).

Nationwide weed survey in paddy rice field was conducted in 1971 and 1981 by Office of Rural Development(ORD). The survey in 1971 was independently conducted by three crop experiment stations; Crop experiment station for middle region, Honam crop experiment station for Honam region and Yeongnam Crop experiment station for Yeongnam region, respectively. In 1981, the survey was carried out as the joint project between research bureau and extension bureau under ORD.

The paper reviewed the weed flora mainly based on these two nationwide weed survey and the factors affecting the weed growth in paddy rice field.

WEED FLORA

About 453 weed species belonging to 92 families were reported in clutivated arable land in Korea. Of these, 92 species of 27 families are mainly found in paddy field (Kim, 1974; Lee, 1979; Weed Flora in Korea, 1972). Table 1 gives the weed distribution by weed group in different cultures. During the last 10 years kind of weed species occurring in paddy rice field was not much differed. However, floristic composition in terms of the degree of dominance was drastically changed during this time. As shown in Table 2 the similarity coefficients between 1971 and 1981 in terms of floristic composition based on the degree of dominance were ranged from 15.4% to 35.0% in three regions (Fig. 1) and hence, implied drastic change of dominant weed species

Table 1. Weed distribution by weed group in Korea. Kim 1974

Classification	Annual				Perennial				Total
	Broad leaf	Grasses	Sedges	Sub-Total	Broad leaf	Grasses	Sedges	Sub-Total	
Paddy	16	8	9	33	33	4	22	59	92
Upland	122	29	1	152	119	26	3	148	300
Mixture	26	5	10	41	9	5	6	20	61
Total	162	42	20	226	161	35	31	227	453

Table 2. Similarity coefficient in terms of floristic composition between 1971 and 1981. CES, HCES, YCES 1970-'72: ORD, 1981.

Region	Similarity coefficient (%)
Middle	35.0
Honam	29.7
Yeongnam	15.4
Mean	26.7

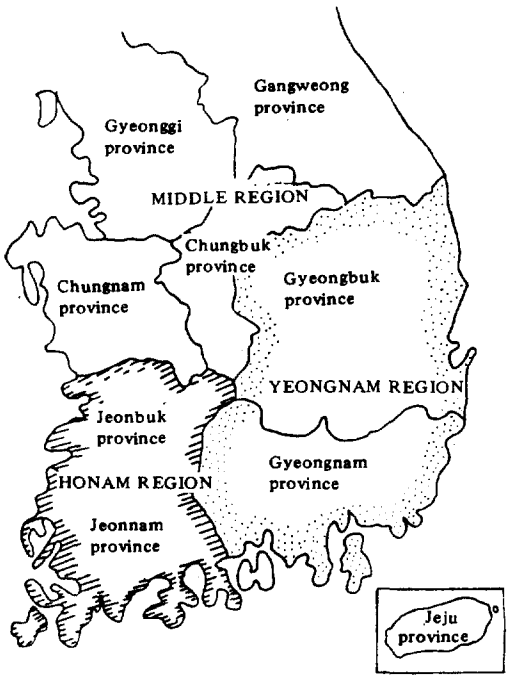


Fig. 1. Map of administrative provinces and regions.

during past 10 years.

In 1971, in average, approximately 67% of weed population growing in paddy rice field was belonged to broadleaf weeds while populations of other weed groups were 25.1% for sedges and 7.8% for grasses, respectively (Table 3). And also, broadleaf weeds were more flourished at the warmer region which practiced relatively high double cropping (Honam and Yeongnam region) compared to relatively cooler region which had mostly single crop area (Middle region). However, this trend was reversed for sedge weeds. This situation was also same in 1981 although the ratio of composition among

Table 3. Changes in weed flora based on the degree of dominance. CES, HCES, YCES, 1970-'72; ORD, 1981.

Region	Year	Broadleaf weeds	Grasses	Sedges
Middle	1971	52.0	18.5	29.5
	1981	74.1	4.8	21.1
Honam	1971	69.4	2.3	28.2
	1981	83.1	3.1	13.8
Yeongnam	1971	79.6	2.7	17.7
	1981	84.7	3.8	11.5
Mean	1971	67.0	7.8	25.1
	1981	80.6	3.9	15.5

weed group was changed. In general, the population of composition among weed group was changed. In general, the population of broadleaf weeds have been significantly increased by ranging from 5% to 22% during the last 10 years while, interestingly, weed flora belonging to grasses and sedges were reversed during these periods. The degree of dominance shared by weed group and life form based on density (or population) was shown in Table 4. The degree of dominance of weeds in 1971 was mainly concentrated by annual weed species having their dominance by about 81% of the top 10 most important weed species and 7 weed species of the 10 important weed species were belonged to annual (Fig. 2).

In nationwide, the most important top 10 weed species in 1971 in terms of the degree of dominance and their dominance were *R. indica* (34.5%), *E. acicularis* (11.9%), *M. vaginalis* (11.1%), *C. difformis* (8.7%), *E. crus-galli* (6.9%), *L. procumbens* (3.3%), *P. distinctus* (3.1%), *A. japonica* (2.4%), *E. kuroguwai* (1.8%) and *P. hydropiper* (1.8%), respectively and the dominance represented by these 10 weed species was approximately 86%(Fig. 2). There were some regional variation in degree of dominance ahared by the above troublesome 10 weeds; *E. crus-galli* and *C. difformis* were more dominated for middle region while this was *R. indica* for honam and yeongnam regions (Figs. 3,4 and 5).

For 1981 survey, 28 weed species belong to 17 families, Cyperaceae was the biggest family in terms of the number of weed flora while the highest

Table 4. Degree of dominance in association with weed group by province. CES, HCES, YCES, 1970-'72; ORD, 1981.

Region	Province	Annual				Perennial			
		Broad-leaf weeds	Grasses	Sedges	Sub-total	Broad-leaf weeds	Grasses	Sedges	Sub-total
Middle	Gyeonggi	31.3	1.8	1.2	34.3	42.2	3.8	19.7	65.7
	Gangweon	20.6	1.0	1.0	22.6	50.4	1.4	25.6	77.4
	Chungbuk	44.0	2.9	1.9	48.8	30.2	4.2	16.8	51.2
	Chungnam	48.7	2.0	2.2	52.9	28.9	2.2	16.0	47.1
	Mean	36.2	1.9	1.6	39.7	37.9	2.9	19.5	60.3
	(1971)	(41.7)	(15.4)	(15.3)	(72.4)	(10.3)	(3.1)	(14.2)	(27.6)
Honam	Jeonbuk	44.3	1.4	0.7	46.4	37.1	0.8	15.7	53.6
	Jeonnam	47.6	2.0	0.7	50.3	37.1	2.1	10.5	49.7
	Mean	46.0	1.7	0.7	48.4	37.1	1.4	13.1	51.6
Yeongnam	Gyeongbuk	47.0	4.2	4.3	55.5	30.5	1.5	12.5	44.5
	Gyeongnam	47.8	1.3	1.0	50.1	44.0	0.8	5.1	49.9
	Mean	47.4	2.8	2.7	52.9	37.3	1.1	8.8	47.2
	(1971)	(48.2)	(2.2)	(8.5)	(58.9)	(31.4)	(0.5)	(9.2)	(41.1)
Jeju	Jeju	34.0	8.0	0	42.0	6.0	1.0	51.0	58.0
Nationwide		41.6	3.6	1.2	46.4	28.7	1.5	23.4	53.6

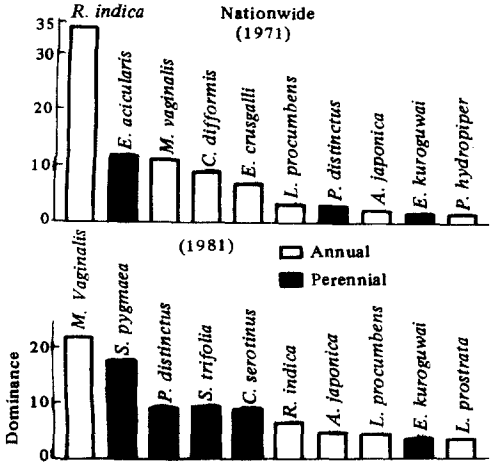


Fig. 2. Degree of dominance of the top 10 important weed species in Korea. CES, HCES, YCES, 1970-'72: ORD, 1981.

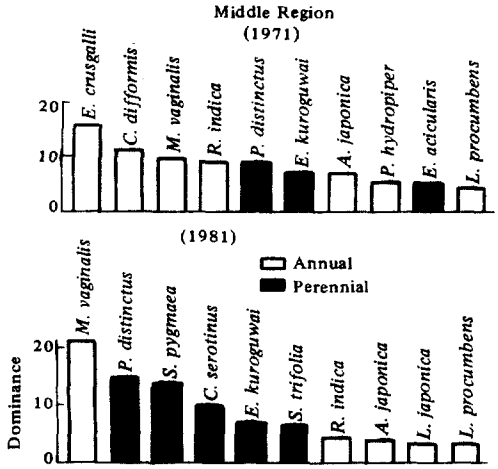


Fig. 3. Degree of dominance of the top 10 important weed species in Middle region. CES, 1971; ORD, 1981.

dominance (based on density or population) was represented by Alismataceae(Table 6). However, for the single species, *M. vagilis* which is belonged to Pontederiaceae showed the highest dominance having its dominance of 22.2% in nationwide. In nationwide the most important 10 weed species and their degree of dominance in 1981 were *M. vaginalis* (22.2%), *S. pygmaea*(17.5%), *S. trifolia*(9.0%), *P. distinctus*(9.0%), *C. serotinus*(8.5%), *R. indica* (6.0%), *A. japonica*(4.4%), *L. procumbens*(3.9%), *E. kuroguwai*(3.4%), and *L. prostrata*(3.0%), respectively(Table 7 and Fig. 2). Approximately 87% of total dominance was shared by above 10 weed species and among these 54% was occupied by peren-

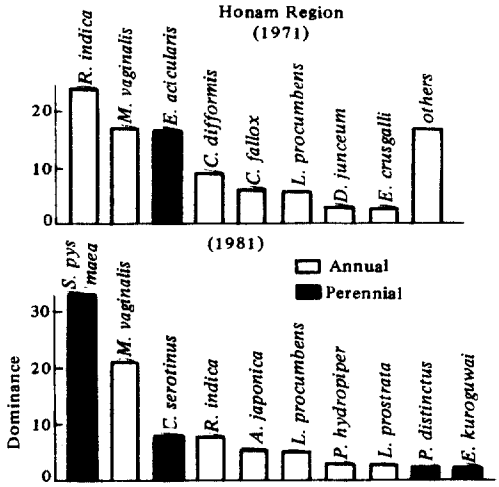


Fig. 4. Degree of dominance of the top 10 important weed species in Honam region. HCES, 1972; ORD, 1981.

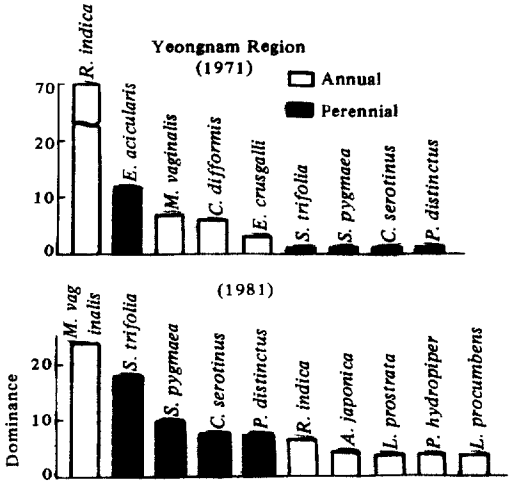


Fig. 5. Degree of dominance of the top 10 important weed species in Yeongnam region. YCES, 1970; ORD, 1981.

Table 5. Main weeds in paddy field in Korea. ORD, 1981.

Family	Scientific name	Life cycle	Dominance (%)
Alismataceae	*Sagittaria pygmaea* Miquel.	P	17.5
	S. trifolia L.	P	9.0
Commelinaceae	*Aneilema japonica* Kunth.	A	4.4
Cyperaceae	*Cyperus serotinus* Rottb.	P	8.5
	Eleocharis kuroguwai Ohwi	P	3.4
	E. acicularis Roem. et Schult	P	1.6
	Scirpus hotarui Ohwi	A	1.3
	S. maritimus L.	P	0.3
	E. congesta Don.	A	0.2
	Fimbristylis miliacea Vahl.	A	0
Eriocaulaceae	*Eriocaulon sieboldianum* Sieb et Zucc.	A	0.2
Gramineae	*Echinochloa crusgalli* Beauv.	A	2.3
	Leersia japonica Makino	P	2.1
Leguminosae	*Aeschynomene indica* L.	A	0.1
Lemnaceae	*Spirodela polyrhiza* Schleider	P	0.3
	Lemna minor L.	P	
Lobeliaceae	*Lobelia chinensis* Lour.	P	0.3
Lythraceae	*Rotala indica* Koehne	A	6.0
Marsileaceae	*Marsilea quadrifolia* L.	P	0.1
Onagraceae	*Ludwigia prostrata* Roxb.	A	3.0
Polygonaceae	*Polygonum hydropiper* L.	A	2.7
Pontederiaceae	*Monochoria vaginalis* Presl.	A	22.2
	M. korsakowii Regel et Maack	A	0.7
Potamogetonaceae	*Potamogeton distinctus* Benn.	P	9.0
Salviniaceae	*Salvinia natans* All.	A	0
Scrophulariaceae	*Lindernia procumbens* Philcox	A	3.9
	Gratiola juncea Roxb.	A	0.2
Umbelliferae	*Oenanthe javanica* Dc.	P	0.4

Table 6. Degree of dominance and number of species by family. ORD, 1981.

Family	Number of species	Dominance
Alismataceae	2	26.5
Pontederiaceae	2	23.0
Cyperaceae	7	15.3
Potamogetonaceae	1	9.0
Lythraceae	1	6.0
Gramineae	2	4.5
Comelinaceae	1	4.4
Scrophulariaceae	2	4.1
Onagraceae	1	3.0
Polygonaceae	11	2.7
Umbelliferae	1	0.4
Eriocaulaceae	1	0.3
Lobeliaceae	1	0.3
Lemnaceae	2	0.3
Leguminosae	1	0.1
Marsileaceae	1	0.1
Salviniaceae	1	0
17	28	100

nial weeds. As shown in Fig. 2, among the above most important weed species 5 weed species belonged to annual while another 5 weed species belonged to perennial. These results imply that the degree of dominance have been shifted from annual weeds to perennial weeds since 1971. This situation was also same in region basis even though the degree of increase in perennial weeds was varied by region; from 21.3% to 52.3% for middle region, from 16.6% to 46.3% for Honam region and from 19.0% to 42.5% for Yeongnam region, respectively (Fig. 3,4 and 5). Table 7 also

Table 7. Degree of dominance of important weed species by province, ORD, 1981.

Weed species	Gyeong-gi	Gang-weon	Chung-buk	Chung-nam	Jeon-buk	Jeon-nam	Gyeong-buk	Gyeong-nam	Jeju	Mean	Nationwide (Areabasis)
M. vaginalis	18.9	7.8	28.1	26.3	19.2	22.2	126.1	20.6	7.0	19.6	22.2
S. pygmaea	17.8	17.2	2.2	16.0	33.6	33.3	0.5	23.1	1.0	16.1	17.5
P. distinctus	18.8	17.6	15.6	9.2	2.2	2.7	9.7	3.7	–	8.8	9.0
S. trifolia	4.7	14.2	11.2	2.3	0.5	–	19.6	15.2	–	7.5	9.0
C. serotinus	9.3	10.8	9.9	10.1	9.4	6.7	10.8	2.8	13.0	9.2	8.5
R. indica	1.4	5.6	7.3	5.4	8.3	7.6	4.3	9.4	2.0	5.7	6.0
A. japonica	3.9	0.9	3.4	5.5	4.4	6.0	3.7	4.7	–	3.6	4.4
L. procumbens	2.6	2.8	1.5	5.7	4.6	5.5	4.1	3.0	6.0	4.0	3.9
E. kuroguwai	9.3	8.4	6.4	3.4	1.8	2.7	0.3	0.6	–	3.7	3.4
L. prostrata	2.0	1.0	0.4	4.5	0.4	4.4	4.3	3.1	1.0	2.3	3.0
P. hydropiper	1.7	1.8	2.3	0.5	4.7	1.6	4.4	2.8	17.0	4.1	2.7
E. crusgalli	1.8	1.0	2.9	2.0	1.4	2.0	4.2	1.3	8.0	2.7	2.3
L. japonica	3.8	1.4	4.2	2.2	0.8	2.1	1.5	0.8	1.0	2.0	2.1
E. acicularis	1.1	6.4	0.5	1.3	4.5	0.7	1.3	1.4	38.0	6.1	1.6
S. hotarui	–	–	1.9	1.6	–	0.7	4.0	0.3	–	0.9	1.3
M. korsakowii	–	–	–	–	1.4	0.2	–	3.8	–	0.6	0.7
S. maritimus	–	–	–	1.2	–	0.4	0.1	0.3	–	0.2	0.3
G. juncea	0.6	0	–	–	0.6	0	–	0.1	–	0.1	0.2
S. natans	–	–	0	–	–	–	–	–	1.0	0.1	0
E. sieboldianum	–	0.7	1.0	0.7	0.1	0.1	0	0.2	–	0.3	0.2
A. indica	0.2	–	0	0.1	0.6	–	0.1	0.1	–	0.1	0.1
S. polyrhiza	0.4	0.7	0.5	0	0	0.3	0.4	0.5	–	0.3	0.3
M. quadrifolia	–	–	0.4	–	–	–	0	0.2	4.0	0.5	0.1
L. chinensis	0	0	–	1.2	0	0.2	0.1	0.8	0	0.3	0.3
O. javanica	0.5	0.7	0.3	0.2	0.8	0.6	0.2	0.5	1.0	0.5	0.4
E. congesta	0.9	0	–	0.1	–	0	0.2	0.3	–	0.2	0.2
F. miliacea	0.3	1.0	–	0.5	0.7	–	0.1	0.4	–	0.3	0.3

given the degree of dominance of species by province. In general, perennial weed species was more dominanted at the Gyeonggi and Gangweon provinces that had mostly single cropping area. These perennial weeds were mostly *P. distinctus*, *S. pygmaea*, *S. trifolia* and *C. serotinus*.

Species order in terms of dominance, community dominance (which indicates the dominance of the top two species in the community (McNaughton, 1968) and simpson index (which expresses the concentration of the dominance of the most common species of the community(in Whittaker, 1965)) were varied depending upon provinces(Table 8).

Table 8. Simpson index and community dominance by province. ORD, 1981.

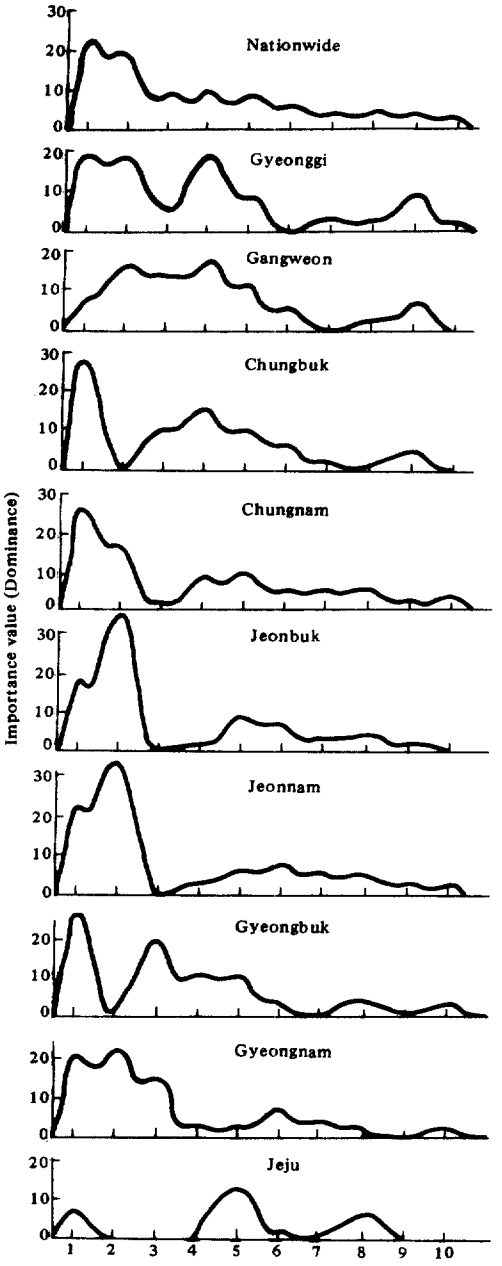
Province	Simpson Index	Community Dominance
Gyeonggi	0.128	37.7
Gangweon	0.115	34.8
Chungbuk	0.141	43.7
Chungnam	0.127	42.3
Jeonbuk	0.175	52.8
Jeonnam	0.182	55.5
Gyeongbuk	0.140	45.7
Gyeongnam	0.137	43.7
Jeju	0.207	55.0
Mean	0.150	45.7

Table 9. Similarity coefficient in terms of floristic composition between provinces. ORD, 1981.

Province	Gyeong-gi	Gang-weon	Chung-buk	Chung-nam	Jeon-buk	Jeon-nam	Gyeong-buk	Gyeong-nam	Jeju
Gyeonggi	–	77.3	72.3	75.2	65.4	65.7	60.2	65.0	28.4
Gangweon		–	67.7	64.5	58.2	53.1	58.5	63.2	35.5
Chungbuk			–	71.7	53.3	56.7	77.0	60.1	29.2
Chungnam				–	68.8	78.0	72.5	68.5	31.8
Jeonbuk					–	86.2	52.9	73.4	36.6
Jeonnam						–	56.0	74.5	29.1
Gyeongbuk							–	64.9	36.5
Gyeongnam								–	23.8
Jeju									–

As shown in this Table 8 the highest Simpson index were obtained from Jeju and Jeonnam provinces while the least value was shown in Gangweon province. These results imply that Jeonnam and Jeju provinces were dominanted more by a particular weed species while the degree of dominance was not concentrated to a particular weed species in Gangweon province. On the other hand, the similarity coefficients between provinces in terms of floristic composition based on the degree of dominance were represented in Table 9. Floristic composition was much differed between Jeju province and other provinces, in general, and relatively high similarity coefficients were obtained between Gengweon and Gyeonggi provinces, Gyeonggi and Chungnam provinces, Chungbuk and Gyeongbuk provinces, Chungnam and Jeonnam provinces, Jeonbuk and Jeonnam provinces and Jeonnnam and Gyeongnam provinces.

The most important 10 weed species in nationwide were given by province in Fig. 6. The fluctuation patterns in terms of degree of dominance of these important weeds varied depending upon province. *M. vaginalis* was flourished under a wide range of areas; this was represented as the most important weed species for Gyeonggi, Chungbuk, Chungnam and Gyeongbuk provinces. *S. pygmaea* which was the second most important weed species in nationwide was peculiarly dominanted for Jeonbuk, Jeonnam, Gyeongnam, Gyeonggi and Gangweon, Gyeongbuk and Gyeongnam provinces. Interestingly, *P. distinctus* was one of the most important weed species in middle region(Gyeonggi, Gangweon, Chungbuk and Chungnam provinces) which single crop cultivation was mostly practiced. Another interesting relationship was given in Fig. 7; there was a high negative correlation between the occurrence of *P. distinctus* and the degree of land



1 = *M. vaginalis* 2 = *S. pygmaea* 3 = *S. trifolia*
4 = *P. distinctus* 5 = *C. serotinus* 6 = *R. indica*
7 = *A. japonica* 8 = *L. procumbens* 9 = *E. kuroguwai*
10 = *L. prostrata*

Fig. 6. Importance values of major 10 weed species in association with province. ORD, 1981.

utilization.

Perennial sedge weeds, *C. serotinus* and *E. kuro-*

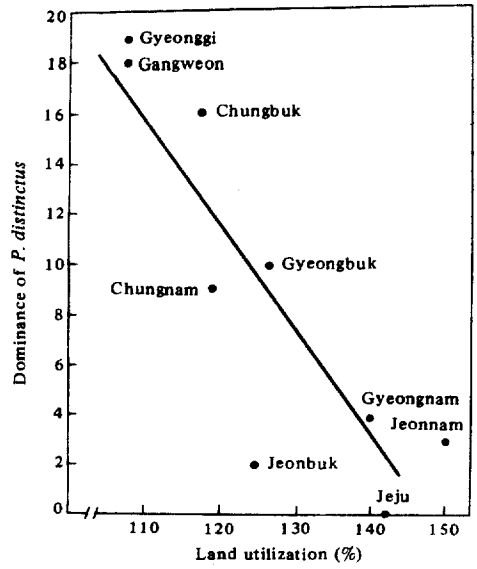


Fig. 7. The relationship between land utilization and the degree of dominance of *P. distinctus*. ORD, 1981.

guwai, were also important in middle region. Compared to other province, dominant weed species were quite unique for Jeju province. *E. acicularis* was the most important weed species and followed by *P. hydropiper* and *C. serotinus*(Table 7).

Among the most important weed species, *M. vaginalis* flourished under wide range of conditions and this fact could be possibly understand by the following postulation.

When the strong competitors such as *E. crus-galli* were eliminated from the weed flora by repeated applications of herbicides, *M. vaginalis* which was not controlled or poorly controlled by the herbicides had an opportunity to proliferate and took over the ecological niche from the *E. crus-galli*. *M. vaginalis* can also produce 6000 to 7000 seeds per plant (Pancho, 1964; Kim and Moody, 1980a). Also, *M. vaginalis* might have gradually acquired resistance to the herbicides through continued absorption of the herbicide at subherbicidal concentrations or through the build up of a resistant ecotype. However, further research is needed to confirm this.

Weed occurrence was also closely related with cropping pattern and plowing time. More weeds were grown at single cropping area than double

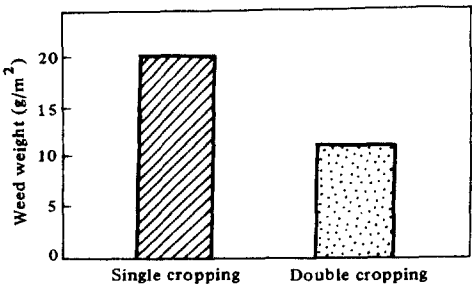


Fig. 8. Effect of cropping pattern on weed occurrence. ORD, 1981.

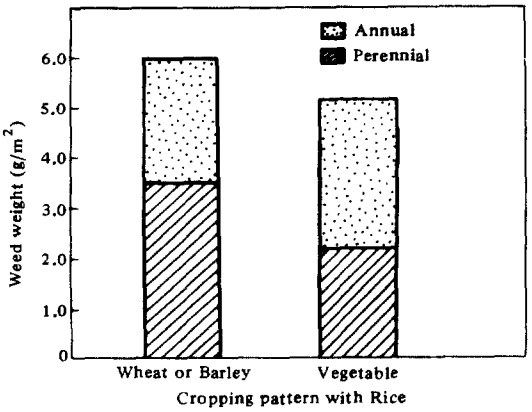


Fig. 9. Effect of double cropping pattern on weed occurrence. ORD, 1981.

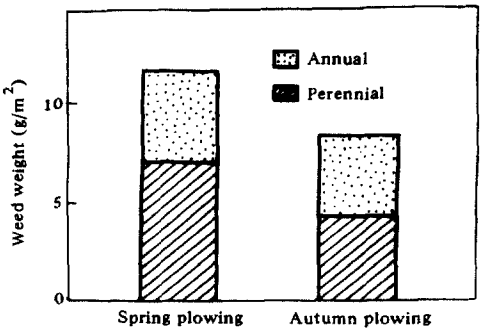


Fig. 10. Effect of plowing time on weed occurrence. ORD, 1981.

Table 10. Simpson index and community dominance in association with soil type. ORD, 1981.

Soil Type	Simpson Index	Community Dominance
Nomal	0.126	43.6
Unpaddified	0.110	38.0
Sandy	0.107	36.4
Poorly drained	0.128	42.1
Saline	0.152	49.4

cropping area (Fig. 8). Within double cropping area, the area of rice-wheat & barley cropping pattern resulted in more weed growth by increase of

Table 11. Similarity coefficient in terms of floristic composition between soil types. ORD, 1981.

Soil type	Normal	Unpaddified	Sandy	Poorly drained	Saline
Normal	–	89.2	89.4	87.8	58.1
Unpaddified		–	85.0	81.1	53.0
Sandy			–	88.5	59.8
Poorly drained				–	61.2
Saline					–

weeds compared to ice-vegetable cropping pattern possibly due to frequent soil disturbance through weeding operation (Fig. 9). Spring plowing harvested more weeds particularly pernennial weeds than autumn plowing primarily due to desiccation and freezing effect during winter (Fig. 10).

Weed flora was also surveyed by the soil types which were distributed in paddy rice field throughout the nation. Weed flora based on the degree of dominance was not much different among soil types of normal soil, unpaddyfied soil, sandy soil and poorly drained soil based on Simpson index (Table 10) that had ranging from 0.110 to 0.128 and similarity coefficient (Table 11) in terms of floristic composition that represented more than 80% among each other. However, the weed flora of saline soil was less diversed (Table 10) among soil types and the floristic composition was also much differed from other soil types (Table 11). The similarity coefficient in terms of floristic

Table 12. Distribution of weeds by life from in various soil types. ORD, 1981.

Soil type	Annual	Perennial
Normal	47.3	52.7
Unpaddified	45.8	54.2
Sandy	49.9	50.1
Poorly drained	47.3	52.7
Saline	34.9	65.1

Table 13. Distribution of weeds of weed group in various soil types. ORD, 1981.

Soil type	Broadleaf weeds	Grasses	Sedges
Normal	82.9	3.0	14.1
Unpaddified	82.3	3.0	14.7
Sandy	79.3	6.1	14.6
Poorly drained	75.6	6.8	17.6
Saline	45.8	5.9	48.3

Table 14. Distribution of weeds by soil type. ORD, 1981.

Classification	Annual				Perennial			
	Broadleaf weeds	Grasses	Sedges	Sub-total	Broadleaf weeds	Grasses	Sedges	Sub-total
Normal	43.9	1.7	1.7	47.3	39.0	1.3	12.4	52.7
Unpaddified	41.5	1.9	2.4	45.8	40.8	1.1	12.3	54.2
Sandy	45.1	3.2	1.6	49.9	34.2	2.9	13.0	50.1
Poorly drained	42.9	2.2	2.2	47.3	32.7	4.6	15.4	52.7
Saline	30.3	3.4	1.2	34.9	15.5	2.5	47.1	65.1

Table 15. Degree of dominance of important weed species by soil type ORD, 1981.

Weed species	Soil type				
	Normal	Sandy	Unpaddified	Poorly drained	Saline
M. vaginalis	23.4	21.9	18.3	26.7	22.9
S. pygmaea	20.2	14.4	19.7	15.4	9.3
P. distinctus	8.7	10.7	7.4	9.4	2.8
S. trifolia	8.6	8.0	12.9	7.6	–
C. serotinus	7.2	9.1	7.3	9.0	26.5
R. indica	5.7	6.4	7.3	3.7	1.4
A. japonica	4.5	4.5	4.2	4.9	0.4
L. procumbens	4.1	4.7	3.4	2.4	0.4
E. kuroguwai	3.8	2.6	2.3	4.2	10.9
L. prostrata	2.4	3.5	3.8	2.7	0.6
P. hydropiper	2.5	3.0	2.9	1.8	2.4
E. crusgalli	1.7	3.2	1.9	2.2	3.4
L. japonica	1.3	2.9	1.1	4.6 q	2.5
E. acicularis	1.2	1.3	2.5	2.2	3.4
S. hotarui	1.4	1.1	1.5	1.9	0.6
M. korsakowii	0.8	0.3	1.4	0.6	1.0
S. maritimus	0.2	–	0.2	–	6.0
G. juncea	0.1	0.2	0.1	–	1.2
S. natans	–	–	0	–	–
E. sieboldianum	0.3	0.3	0.1	0.1	0
A. indica	0.1	0.3	0	0	1
S. polyrhiza	0.7	0.2	0.1	0	–
M. quadrifolia	0.1	0.1	–	–	–
L. chinensis	0.3	0.3	0.5	0.1	0
O. javanica	0.4	0.5	0.2	0.2	3.4
E. congesta	0.1	0.3	0.2	0.1	0.6
F. millacea	0.2	0.2	0.7	0.2	–

composition was always less than 60% between saline soil and other soil types. And also, the weed flora in saline soil type was dominated more by perennial weeds (Table 12), particularly by perennial sedges (Tables 13 and 14). Species order based on the degree of dominance among soil types but saline soil type also showed similar trend with the nationwide troublesome weeds discussed early. Some of the most important weed species and their dominance in saline soil were *C. serotinus* (26.5/), and *E. kuroguwai* (10.9%) (Table 15).

WEED COMMUNITY TYPE

The various weed ecological indices were calculated by methods based on those of Simpson (in Whittaker, 1965), McNaughton (1968), and Newsome and Dix (1968) to determine community diversity and community type. Weed community type was defined by a two-dimensional ordination diagram. An aggregation of sample plots in a two-dimensional ordination diagram is a conceptual grouping of a number of stands of similar morphology and biotic composition. A community type was defined by a single species or a combination of species that have a restricted range of distribution over the entire sample spectrum. The methods of ordination analysis were as follow;

The similarity coefficient of each stand was determined by using the degree of dominance (importance value) which was based on number. The similiarity coefficient (C) which reflects the degree of similarity between the stands in terms of floristic composition was calculated using the equation.

$$C = \frac{2w}{a+b} \times 100$$

where w = sum of the lower importance values (I.V) of species shared by two stands

a = sum of the I.V.S. of all species in the first stand

b = sum of the I.V.S. of all species in the second stand

The similarity coefficient of stands was converted to a dissimilarity coefficient (D) by the equation.

$$D = 100 - C$$

where C = the similarity coefficient

A two-dimensional ordination system was used in locating the position of each plot in the ordination diagram. The two most dissimilar stands were determined and the other stands were located with reference to them. The similarity values of each stand were totalled and the stand having the least similarity total (or the greatest dissimilarity total) was designated as stand A and assigned a value of 0 along the X-axis. Stand B which had the greatest dissimilarity to stand A was selected and assigned a value of 100 along the X-axis. The distance (X) of each of the remaining stands from A anb B was calculated using the equation,

$$X = \frac{(L)^2 + (DA)^2 - (DB)^2}{2L}$$

where L = dissimilarity value between stand A and stand B

DA= dissimilarity value between stand A and the stand in question

DB= dissimilarity value between stand B and the stand in question

In selecting stand B, there were at least three similarity values of 50% or above shared by the stand under consideration with the other communities. This was to avoid using two reference stands (communities) which were totally dissimilar. The poorness of fit(e) which is the distance from the crossing arcs to the axis associated with each stand was calculated using the equation,

$$e = \sqrt{DA^2 - X^2}$$

where DA= dissimilarity value between stand A and the stand in question

X = computed distance of the stand in question with reference to stand A and stand B.

The stand having a maximum value for e or having the poorest fit was designated as A′ and assigned a value of 0 on the Y-axis. B′ was determined by the same method used in obtaining B and was assigned a value of 100 along Y-axis. The distance(Y) of each of the remaining stands from A′ and B′ was then

calculated using the equation,

$$Y = \frac{(L')^2 + (DA')^2 - (DB')^2}{2L'}$$

where L' = dissimilarity value between stand A' and stand B'

DA' = dissimilarity value between stand A' and the stand in question

DB' = dissimilarity value between stand B' and the stand in question

To test the relationship between the direct distance(s) of the stand under consideration and its dissimilarity value (D), a correlation coefficient, r, was computed. For these purposes, 30 random pairs of stands were used. The direct distance(S) between stands in each random pair was obtained using the equation,

$$S = \sqrt{DX^2 + DY^2}$$

where DX= difference of stands in a random pair on the X - axis

DY= difference of stands in a random pair on the Y - axis

The correlation coefficient, r, was then calculated using the equation,

$$r = \frac{\Sigma\, x \cdot y}{\sqrt{\Sigma\, x^2 \cdot \Sigma y^2}}$$

Weed Community Types Distributed by province

Gyeonggi province

The most important 5 weed species in Gyeonggi province were *M. vaginalis, P. distinctus, S. pygmaea, C. serotinus* and *E. kuroguwai* and importance values of these were approximately 19%, 19%, 18%, 9% and 9%, respectively (Table 7). From the two-dimensional ordination analysis, 9 weed community types were identified from 25 locations (Fig. 11). These were *L. japonica-A. japonica-C. serotinus* community, *C. serotinus-M.vaginalis-P. distinctus* community, *C. serotinus-E.kuroguwai-M. vaginalis* community, *M. vaginalis-P.distinctus* community, *P. distinctus-M. vaginalis-C. serotinus* community, *M. vaginalis-S.pygmaea* community, *M. vaginalis-P. distinctus-S. pygmaea* community, *S. pygmaes-M. vaginalis* community and *S. pygmaea* community (the order of weed indicate the order of degree of dominance). As community type implied most of weed communities was hardly dominated by a particular single weed species but shared the dominance by several weed species. Analysis was based on the administrative unit "City" or "Gun" (in this paper expressed as location). Approximately 28% of all administrative locations were belonged to *P. distinctus-M. vaginalis-C. serotinus* community type which was the most widely distributed in Gyeonggi province.

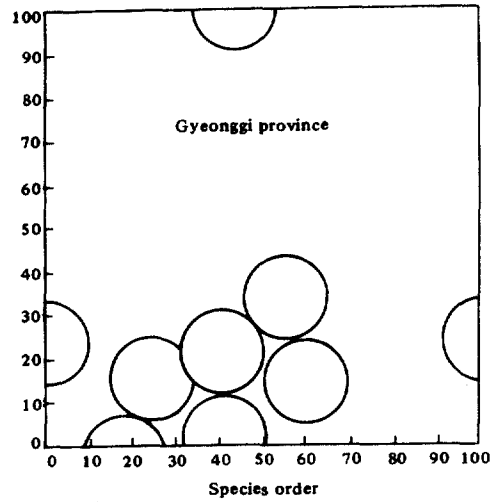


Fig. 11. Weed community types distributed in Gyeonggi province. ORD, 1981.

Plot No.	Location	Community Type
3	Euijeongbu	*L. japonica-A. japonica-C. serotinus*
18	Ongjin	*C. serotinus-M. vaginalis-P. distinctus*
12,17,20	Siheung, Yeoncheon Paju	*C. serotinus-E. kuroguwai-M. vaginalis*
7,8,22, 23	Ganghwa, Goyang, Seongnam, Pyeongtaeg	*M. vaginalis-P. distinctus*
1,10,11, 15,21,24, 25	Suweon, Gimpo, Namyangju Yangpyeong, Yongin, Hwaseong, Pocheon	*P. distinctus-M. vaginalis-C. serotinus*
2,5,9	Incheon, Bucheon, Gwangju	*M. vaginalis-S. pygmaea*
4,6,16	Anyang, Gapyeong, Yeoju	*M. vaginalis-P. distinctus-S. pygmaea*
14,19	Yangju, Icheon	*S. pygmaea-M. vaginalis*
13	Anseong	*S. pygmaea*

Gangweon province

The most predominant 5 weed species in Gangweon province were *P. distinctus, S. pygmaea, S. trifolia, C. serotinus* and *E. kuroguwai* having their importance values of 18%, 18%, 14% 11% and

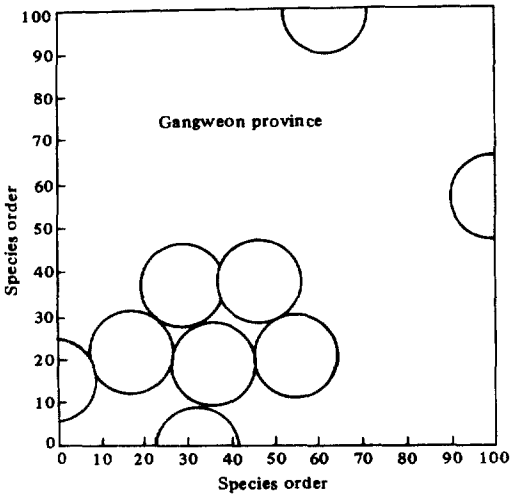


Fig. 12. Weed community types distributed in Gangweon Province. ORD, 1981.

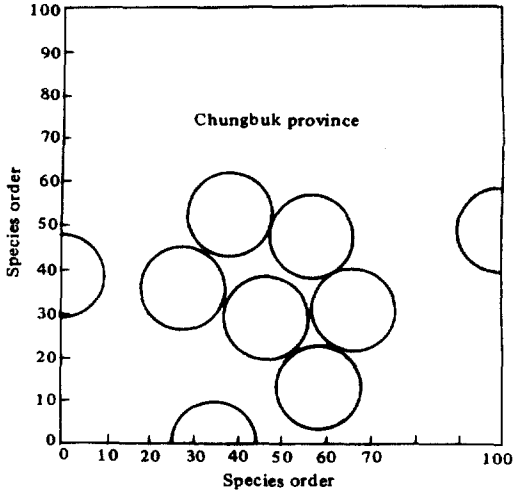


Fig. 13. Weed community types distributed in Chungbuk province. ORD, 1981.

Plot No.	Location	Community Type
7	Samcheong	*P. distinctus-R. indica*
15	Chunseong	*P. distinctus-M. vaginalis*
1,3,11,	Chuncheon, Weonju	*P. distinctus-S. trifolia-*
13,14,18	Weonseong, Jeongseon	*S. pygmaea*
19	Cheolweon, Hwacheon Hoengseong	
4,5,17	Sogcho, Goseong, Hongcheon	*C. serotinus-P. distinctus*
8	Yanggu	*S. trifolia-E. kuroguwai-P. distinctus*
6,9	Myeongju, Yangyang	*S. trifolia-S. pygmaea*
2	Gangleung	*S. trifolia*
20	Donghae	*E. acicularis*
10,12,16	Yeongweol, Inje Pyeongchang	*R. indica-M. vaginalis-S. trifolis-S. pygmaea*

Plot No.	Location	Community Type
8	Ogcheon	*C. serotinus-M. vaginalis-R. indica*
1,6	Cheongju, Boeun	*P. distinctus-M. vaginalis-S. pygmaes-C. serotinus*
2,5	Chungju, Danyang	*C. serotinus-M. vaginalis-S. trifolia*
7	Yeongdong	*M. vaginalis-A. japonica*
9	Eumseong	*M. vaginalis-E. kuroguwai*
4,13	Goesan, Cheongweon	*M. vaginalis-C. serotinus*
10, 12	Jeweon, Jincheon	*P. distinctus-M. vaginalis-S. trifolia*
11	Jungweon	*M. vaginalis*
3	Jecheon	*P. distinctus*

8%, respectively (Table 7). These were all belonged to perennial. Like Gyeonggi province, 9 weed community types were classified from 20 locations in Gangweon province (Fig. 12). These were *P. distinctus-R. indica* community, *P. distinctus-M. vaginalis* community, *P. distinctus-S. trifolia-S. pygmaea* community, *C. serotinus-P. distinctus* community, *S. trifolia-E. kuroguwai-P. distinctus* community, *S. trifolia-S. pygmaea* community, *S. trifolia* community, *E. acicularis* community and *R. indica-M. vaginalis-S. trifolia-S. pygmapa* community. Most of the communities, as shown in Fig. 12, dominance was shared by more than 2 weed species.

The most predominant weed community type was *P. distinctus-S. trifolia-S. pygmaea* community including 7 locations (35%).

Chungbuk province

The most predominant weed species was *M. vaginalis* having its importance value of 28% and followed by *P. distinctus, S. trifolia C. serotinus, R. indica,* etc. (Table 7). According to the two-dimensional ordination analysis 9 weed communities were determined from 13 locations (Fig. 13). These were *C. serotinus-M. vaginalis-R. indica* community, *P. distinctus-M. vaginalis-S. pygmaea-C. serotinus* community, *C. serotinus-M. vaginalis-S. trifolia* community, *M. vaginalis-A. japonica* community, *M. vaginalis-E. kuroguwai* community, *M. vaginalis-C. serotinus* community, *P. distinctus-M. vaginalis-S. trifolia* community, *M. vaginalis* community and *P. distinctus* community.

Chungnam province

Similar to Chungbuk province, the most important weed species in Chungnam province was *M.*

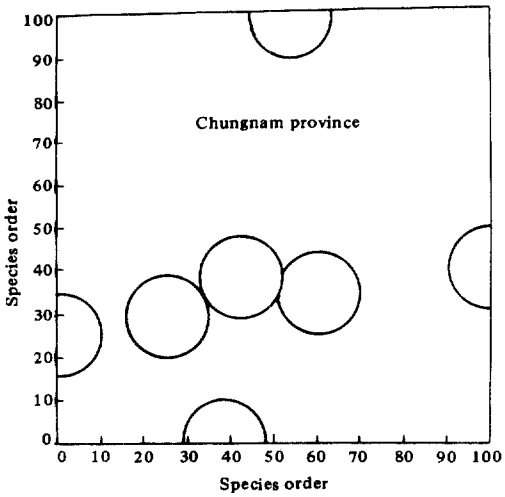


Fig. 14. Weed community types distributed in Chungnam Province. ORD, 1981.

Plot No.	Location	Community Type
13	Yeongi	*M. vaginalis*
5	Geumsan	*M. vaginalis-R. indica-E. kuroguwai-L. prostrata*
1,7,16	Daejeon, Daedeug Cheongyang	*M. vaginalis-R. indica-L. procumbens-A. japonica*
3,4,6,9, 10,11,14, 15,17	Gongju, Nonsan, Dangin, Buyeo, Seosan Cheonweon, Seocheon Yesan, Hongseong	*M. vaginalis-S. pygmaea*
12	Asan	*P. distinctus-M. vaginalis*
8	Boryeong	*S. pygmaea-p. distinctus*
2	Cheonan	*A. japonica-L. japonica-C. serotinus*

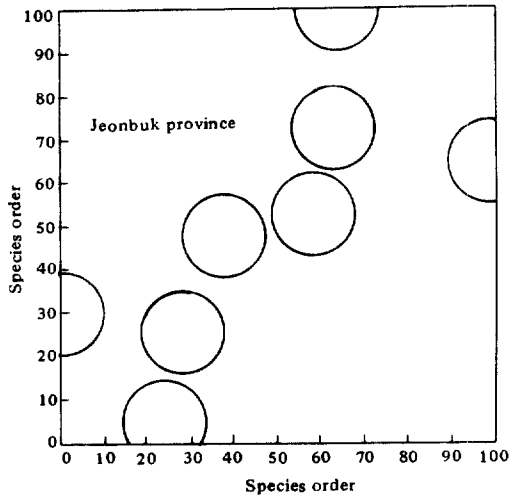


Fig. 15. Weed community types distributed in Jeonbuk province. ORD, 1981.

Plot No.	Location	Community Type
5	Gimje	*S. pygmaea-E. acicularis*
3	Iri	*S. pygmaea*
11	Wanju	*S. pygmaea-A. indica*
2,4,10, 14	Gynsan, Gochang Oggu, Jangsu	*S. pygmaea-M. vaginalis*
6,8	Namweon, Sunchang	*S. pygmaea-A. japonica-E. acicularis*
9, 12, 15	Buan, Igsan, Jeongeub	*M. vaginalis-S. pygmaea*
1	Jeonju	*C. serotinus-M. vaginalis*
7,13,16	Muju, Imsil, Jinan	*R. indica-M. vaginalis-S. pygmaea*

vaginalis having its importance value of 26%. The second most predominant weed species were *S. pygmaea, C. serotinus* and *P. distinctus* (Table 7). Seventeen locations were grouped into 7 weed community types from the two-dimensional ordination analysis (Fig. 14). These were *M. vaginalis* community, *M. vaginalis-R. indica-E. kuroguwai-L. prostrata* community, *M. vaginalis-R. indica-L. procumbens-A. japonica* community, *M. vaginalis-S. pygmaea* community, *P. distinctus-M. vaginalis* community, *S. pygmaea-P. distinctus* community and *A. japonica-L. japonica-C. serotinus* community. Among 17 locations, 9 locations (approximately 53%) were belonged to *M. vaginalis-S. pygmaea* community type that implied wide range of distribution by this weed community.

Jeonbuk province

Unlike to other provinces, *S. pygmaea* was the most predominant weed species in Jeonbuk province having its importance value of 34% (Table 7). Some other important weed species were *M. vaginalis, C. serotinus* and *R. indica*. Eight weed community types were obtained from 16 locations (Fig. 15). These were *S. pygmaea-E.acicularis* community, *S. pygmaea* community, *S. pygmaea-A. indica* community, *S. pygmaea-M. vaginalis* community, *S. pygmaea-A. japonica-E. acicularis* community, *M. vaginalis-S. pygmaea* community, *C. serotinus-M. vaginalis* community and *R. indica-M. vaginalis-S. pygmaea* community.

Jeonnam province

The most important top 2 weed species were the same as Jeonbuk province; *S. pygmaea* and *M. vaginalis* having their importance values of 33% and 22%, respectively (Table 7). The most diversed weed community types 11 weed communities, were determined from 26 locations (Fig. 16). These were *S. pygmaea-P. distinctus* community, *S. pygmaea-*

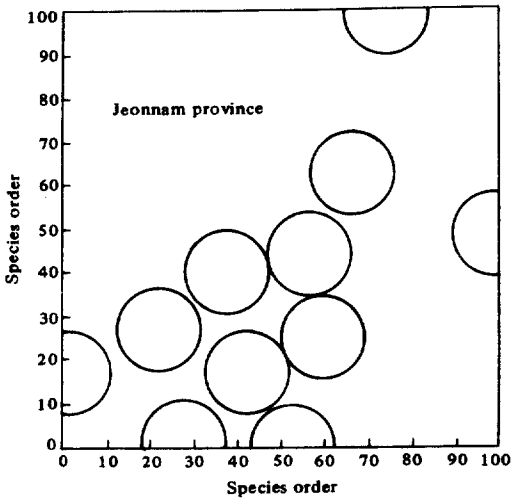


Fig. 16. Weed community types distributed in Jeonnam Province. ORD, 1981.

Plot No.	Location	Community Type
19	Yeongnam	*S. pygmaea-P. distinctus*
1	Gwangju	*S. pygmaea-P. distinctus-A. japonica*
2,24,26	Mogpo, Hampyeong Hwasun	*M. vaginalis*
5,8,12, 14,17,18, 20,21	Wando, Jangseong Gangjin, Gwangsan Damyang, Boseang Yeocheon, Yeonggwang	*S. pygmaea-M. vaginalis*
15	Seungju	*M. vaginalis-S. pygmaea-C. serotinus*
4,6,25	Suncheon, Goheung	*M. vaginalis-S. pygmaea-A. japonica*
3,7,10 11,23	Yeosu, Gogseong Gurye, Naju, Jindo	*M. vaginalis-S. pygmaea*
13	Muan	*M. vaginalis-C. serotinus-S. pygmaea*
9	Gwangyang	*M. vaginalis-L. prostrata*
22	Jangheung	*M. vaginalis-P. distinctus-A. japonica*
16	Sinan	*M. vaginalis-C. serotinus*

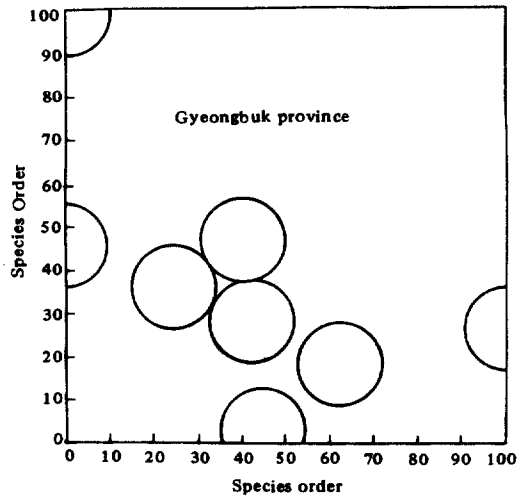


Fig. 17. Weed community types distributed in Gyeongbuk Province. ORD, 1981.

Plot No.	Location	Community Type
12	Gunwi	*S. trifolia-P. distinctus*
7	Andong(city)	*S. trifolia*
9,13,13,	Gumi, Euiseong	*S. trifolia-C. serotinus-M. vaginalis*
17,25	Andong, Yeongdeog Seongju	
20,21,22	Yeongcheon, Gyeongsan Cheongdo	*S. trifolia-M. vaginalis-C. serotinus-P. distinctus*
2,10,11, 15,16,18, 19,26,27, 28,30	Uljin, Yeongju, Cheongsong, Yeongyang, Yeongil, Weolseong, Chilgog, Geumleung, Seonson, Mungyeong, Dalseung	*M. vaginalis-S. trifolia-P. distinctus*
1,3,4,6, 8,24	Bonghwa, Pohang, Daegu Gimbheon, Yeongpoong, Goryeong	*M. vaginalis-S. trifolia-P. hydropiper-R. indica*
5	Gyeongju	*M. vaginalis-S. trifolia*
23,29	Yecheon, Sangju	*M. vaginalis-P. distinctus-C. serotinus*

P. distinctus-A. japonica community, *M. vaginalis* community, *S. pygmaea-M. vaginalis* community, *M. vaginalis-S. pygmaea-C. serotinus* community, *M. vaginalis-S. pygamaea-A. japonica* community, M. vaginalis s. pygmaea community, *M. vaginalis-C. serotinus-S. pygmaea* community, *M. vaginalis-L. prostrata* community, *M. vaginalis-P. distinctus-A. japonica* community and *M. vaginalis-C. serotinus* community. The most widely distributed weed communities were *S. pygmaea-M. vaginalis* community and *M. vaginalis-S. pygmaea* community having their locations of 8 and 5, respectively. This result imply that 50% of the locations were determined by these two weed species; *M. vaginalis* and *S. pygmaea*.

Gyeongbuk province

Eight weed community types were classified from 30 locations (Fig. 17). These were *S. trifolia-P. distinctus* community, *S. trifolia* community, *S. trifolia-C. serotinus-M. vaginalis* community, *S. trifolia-M. vaginalis-C. serotinus-P. distinctus* community, *M. vaginalis-S. trifolia-P. distinctus* community, *M. vaginalis-S. trifolia-P. hydropiper-R. indica* community, *M. vaginalis-S. trifolia* community and *M. vaginalis-P. distinctus-C. serotinus* community. Most of the weed communities were characteristically dominated by. *S. trifolia* and *M. vaginalis* which were the top two most important

weeds (Table 7). Among 8 weed communities, however, *M. vaginalis-S. trifolia-P. distinctus* community was widely distributed in this province. Eleven locations (36% of all locations) were belonged to this community.

Gyeongnam province

S. pygmaea was the most important weed species and followed by *M. vaginalis* and *S. trifolia* in this province (Table 7). Approximately 60% of the dominance were shared by these three weeds. Nine weed community types were encountered from 26 locations by two dimensional ordination analysis (Fig. 18). These were *S. trifolia-P. distinctus-M. vaginalis* community, *S. trifolia* community, *S. trifolia-M. vaginalis* community, *M. vaginalis-S. pygmaea-S. trifolia-R. indica* community, *M. vaginalis-S. pygmaea-S. trifolia* community, *S. pygmaea-S. trifolia-M. vaginalis* community, *M. vaginalis-S. pygmaea* community, *S. pygmaea-R. indica-M. vaginalis* community and *S. pygmaea* community. As shown in this figure, most of the communities were aggregated by *S. trifolia* and *M. vaginalis* and also the most commonly distributed community type was *S. pygmaea-S. trifolia-M. vaginalis* community which included 7 locations.

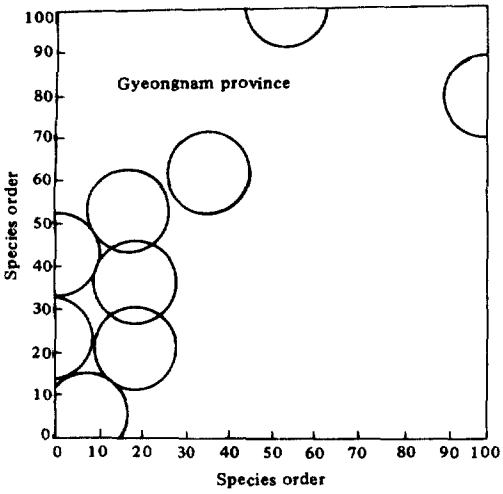


Fig. 18. Weed community types distributed in Gyeongnam Province. ORD, 1981.

Plot No.	Location	Community Type
24	Jinju	*S. trifolia-P. distinctus-M. vaginalis*
20	Samcheonpo	*S. trifolia*
12,25	Gimhae, Ulsan	*S. trifolia-M. vaginlis*
1,2,9,16	Habcheon, Geochang Tongyeong, Changyeong	*M. vaginalis-S. pygmaea-S. trifolia-R. indica*
3,11,14, 19	Hamyang, Euichang Yangsan, Jinyang	*M. vaginalis-S. pygmaea-S. trifolia*
4,8,15, 13,17,21, 23	Sancheong, Geoje, Ulju, Yangsan, Haman Chungmu, Changweon	*S. pygmaes-S. trifolia-M. vaginalis*
26	Masan	*M. vaginalis-S. pygmaea*
5,10,18	Namhae, Goseung Euiryeong	*S. pygmaea-R. indica-M. vaginalis*
6,7,22	Hadong, Sacheon, Jinhae	*S. pygmaea*

Jeju province

Unlike other provinces, only 4 weed communities were determined in this province (Fig. 19) and mostly dominated by *E. acicularis* as shown in Table 7. The floristic composition and degree of dominance of weeds were greatly dissimilar to other provinces. Four weed communities were *R. indica* community, *E. acicularis-C. serotinus* community, *E. acicularis* community and *E. acicularis-P. hydropiper-E. crus-galli* community.

FACTORS AFFECTING THE WEED GROWTH

Many ecological and crop production principles

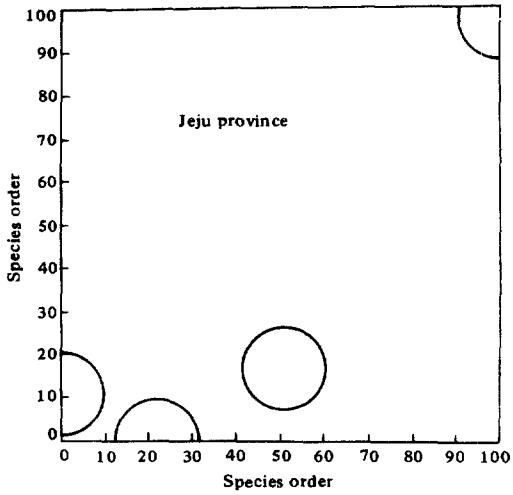


Fig. 19. Weed community types distributed in Jeju Province. ORD, 1981.

Plot No.	Location	Community Type
6	Bugjeju	*R. indica*
1	Jeju (city)	*E. acicuaris-C. serotinus*
2,3,4	Jeju(city) Namjeju	*E. acicularis*
5	Namjeju	*E. acicularis-P. hydropiper-E. crusgalli*

influence the presence and abundance of species or groups of weeds in rice fields. Important factors include seeding method, soil moisture regime, cropping pattern, land preparation, transplanting method, fertilization, rice cultivar, herbicide, plant spacing, seedling age, weed control technology, and the interactions of those factors.

Seeding Method, Soil Moisture Regimes and Transplanting Method

Rice is usually transplanted into wet paddy fields and however, also may be direct-seeded by drilling or broadcasting seeds into moist soil or by broadcasting dry or pregerminated seed on the flood water. Therefore, transplanted and direct-seed rice are grown under different moisture regimes. As shown in Table 16 yield loss was greater at dry seeding compared to wet seeding and at machine transplanting than hand transplanting. And also, less weeds were harvested from the hand transplanted rice field than machine transplanted rice field in several weeding regimes (Table 17). These results were primarily due to headstart advantage and suppression effect of flooding on weed growth. Shift in cultural practice from hand to machine transplanting resulted in changes in weed problems. Some of the important factors that affect the weed problem are the the younger stage of the rice seedling at transplanting, much higher crop densities, a more shallow planting depth, and a more shallow water depth after transplanting (Kim, 1983). All these factors interact to give a weaker seedling and hence a less competitive crop, which results in more weed infestation.

Table 16. Yield loss due to competition with weed in association with cultivation method. Kim, 1982.

Classification	Cultivation method			
	Transplanting		Direct seeding	
	Hand	Machine	Wet	Dry
Yield loss (%)	21	45	40	65

Table 17. Weed growth and rice grain yield as affected by transplanting method. YCES, 1982.

Weeding Regime	Hand Transplanting				Machine Transplanting			
	Weed (/m^2)			Grain yield (t/ha)	Weed (/m^2)			Grain yield (t/ha)
	Number	Weight (g)	Suppression rate (%)		Number	Dry weight (g)	Suppression rate (%)	
ACN/MCPB/nitrogen	699	174	66	5.6	1174	225	40	5.7
Bifenox	587	61	88	5.8	267	90	76	5.1
Perfluidone	74	79	85	6.1	86	47	87	6.8
Hand weeding	21	2	100	7.1	19	2	99	7.1
No weeding	1007	513	0	3.1	1141	374	0	2.8

Rice Cultivar

Short-statured, early-maturing, erect rice cultivars were less competitive with weeds than tall, late-maturing, drooping cultivars (Tables 18, 19 and 20). The faster rate of growth of the early maturing

Table 18. Effect of rice cultivar having different culm length on weed growth and rice grain yield, Kim et al., 1981.

Cultivar	Plant spacing (cm)	Weed Weight (g/m^2)			Grain Yield (g/ha)		
		Hand weeding	No weeding	Difference	Hand weeding	No weeding	Difference
Cheongcheong-byeo (long-statured)	30x15	8.7a	60.7a	52.0*	4.89b	4.44b	0.45*
	40x(10x10)	12.0a	66.7a	54.7*	4.63b	4.47b	0.16ns
	10x10	14.7a	26.3b	11.6ns	5.30a	5.30a	0ns
Manseogbyeo (short-statured)	30x15	7.7a	74.7a	67.0*	4.62b	4.04b	0.54*
	40x(10x10)	7.7a	83.3a	75.6*	4.37b	4.10b	0.27*
	10x10	10.7a	37.3b	26.6*	5.35a	5.11a	0.24*

Table 19. Yield reduction of rice as affected by competition with weed for different rice varieties. Kim et al, 1982a.

Variety	Yield Reduction (%) Weed Weight (g/m^2)				Weed Weight Required for 50% Yield Reduction (g/m^2)
	100	200	300	400	
Yeongnamjosaeng (early maturing)	16.6	53.2	79.8	93.7	188.2
Tongil (late maturing)	12.4	44.7	67.1	89.4	223.6

Table 20. Yield reduction of rice as affected by competition with weed for different rice varieties Kim et al. 1982b.

Variety	Yield Reduction (%) Weed Weight (g/m^2)				Weed Weight Required for 50% Yield Reduction (g/m^2)
	100	200	300	400	
Seogwangbyeo (erect leaf)	23.5	47.1	70.6	94.1	212.5
Nakdongbyeo (droopy leaf)	20.8	41.5	62.3	83.1	241.0

cultivar resulted in earlier and faster canopy formation that could compete better for light. Unfortunately, the evolution of rice cultivars has been accompanied by improved crop production technology and the subsequent loss of competitiveness of the crop against the weeds.

Fertility Level

Weed growth and subsequent competition with rice were usually stimulated by fertilizer application. However, weed species varied in their competitiveness depending upon fertilizer level due to differential responsive nature of weeds. Degree of dominance of *M. Vaginalis* increased with the increase of nitrogen level while the degree of dominance of *E. crus-galli* and *S.hotarui* dcereased (Table 21). Not only floristic composition but also competition pattern affected by fertilizer level. In general, *M. vaginalis* usually compete for nutrient with rice due to short-statured nature. However, as shown in Fig. 20, *M. vaginalis* could compete for light when nitrogen level is high. The weed community type was also related to the soil chemical properties (Fig. 21). Critical factors for weed growth were phosphorus concentration for *M. vaginalis*, organic

Table 21. Changes in the importance value of weeds as affected by nitrogen amount. Kim and Moody, 1980a.

Species	Importance value (%) Nitrogen level (kg/ha)		
	0	80	160
F. crusgalli	11	7	6
M. vaginalis	51	88	90
S. hotarui	38	5	4
Simpson Index	0.42	0.79	0.83

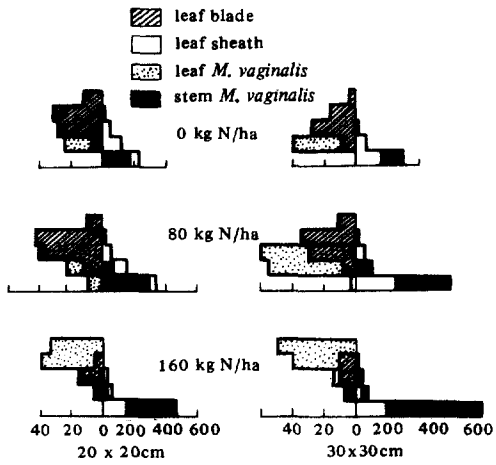


Fig. 20. Changes in the productive structures as affected by crop spacing and nitrogen level from competition with *M. vaginalis*, Kim and Moody, 1980a.

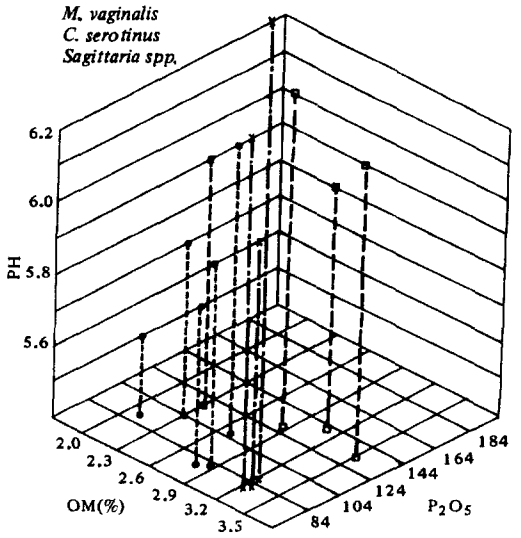


Fig. 21. Relationship between soil chemical properties and weed community type Kim, 1982.

matter content and phosphorus concentration for *C. serotinus* and soil pH and phosphorus concentration for *Sagittaria spp.* community types.

Plant Spacing

Weed growth gradually suppressed when plant

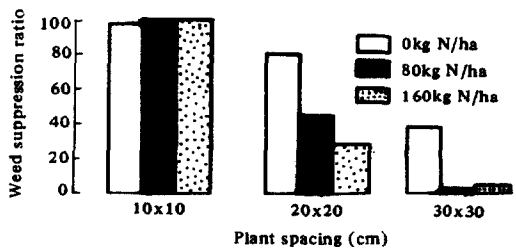


Fig. 22. Effect of plant spacing on weed suppression in association with nitrogen level. Kim and Moody, 1980a.

spacing became narrower because of light penetration into the crop canopy increased as row spacing increased, stimulating weed growth. Narrow spacing by 10x10cm sufficiently suppressed the growth of weeds for all nitrogen levels while crop spacings of 20x20cm and 30x30cm allowed more weed growth with increase of nitrogen levels (Fig. 22). Crop spacing also influenced the floristic composition and subsequent weed growth in the following crop season. *E. crus-galli* rapidly increase its dominance when rice was cultivated by 20x20cm plant spacing while this trend reversed at 10x10cm plant spacing

Table 22. Changes in the importance value of major weeds growing in the unweeded plots as affected by plant spacing and cropping sequence. Kim and Moody, 1980 b:

Weed species	Plant spacing (cm)							
	10x10	10x10	10x10	20x20	20x20	20x20	20x20	20x20
	First crop	Second crop	Third crop	Fourth crop	First crop	Second crop	Third crop	Fourth crop
Echinochloa glabrescens	55	50	25	54	5	62	79	69
Monochoria vaginalis	42	35	39	31	86	21	12	10
Cyperus difformis	1	2	21	5	1	1	7	14
Paspalum distichum	1	12	15	10	0	2	2	6
Weed weight (g/m^2)	29	34	42	67	66	149	520	182

Table 23. Effect of plant spacing on the residual effect of weed suppression at the following year. Kim et al. 1980.

Plant Spacing (cm)	Weed Density ($no./m^2$)	Weed Weight (g/m^2)	Suppression Rate (%)	Importance Values of Weed Species (%)		
				Scirpus hotarui	*Sagittaria pygmaea*	*Eleocharis kuroguwal*
30x15 (Hand weeding)	94	38.8	81.3	44.8	49.8	5.4
30x15 (No weeding)	577	207.4	0	87.6	12.1	0.3
40x(10x10)	315	112.7	45.7	92.8	4.6	1.4
10x10	72	32.8	84.2	52.3	24.4	23.3

(Table 22). On the other hand, *M. vaginalis*, *C. difformis* and *P. distinctus* were relatively grow well at the close plant spacing. Close crop spacing by 10x10cm gave good weed suppression not only on crop season but also subsequent following crop season as effective as hand weeding treatment (Table 23).

Land Preparation

Basic objects of cultivation are the inversion of the top soil so as to bury trash and provide a clean surface the loosening of the soil surface to create a seedbed for the new crop and the control of weeds. The ways in which cultivation achieves weed control are burial for the covering of weeds by soil so that they die, cutting for the severance of the aerial parts from the roots or rhizomes (usually below ground level), stimulation for the provision of a soil environment that encourages dormant seeds or buds to change into an active and therefore vulnerable state, desiccation or freezing for rhizomes or roots are brought to the soil surface where they may be exposed to a dry and cool atmosphere, or to dry soil, and exhaustion for continuous stimulation of dormant buds on perennial weeds coupled with a denial of photosynthetic

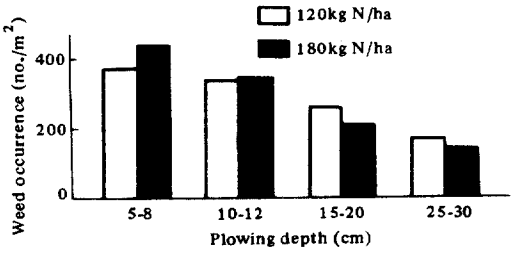


Fig. 23. Effect of plowing depth on weed occurrence. Kim, 1982.

Table 24. Effect of harrowing on weed occurrence. Kim, 1979.

Harrowing date (days before transplanting)	Weed weight (g/m^2)
20-10-1	205ab
20-10	277a
20	151b
20	288a

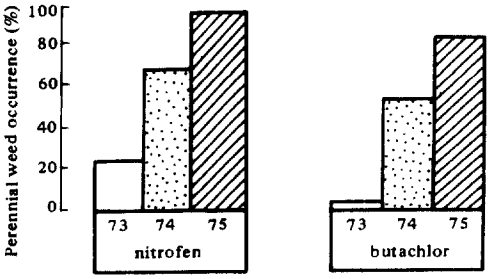


Fig. 24. Effect of repeated application of herbicide on perennial weed occurrence. Kim, 1982.

activity leading to the exhaustion of carbohydrate reserves and the death of meristems. The frequency and time of cultivation, as well as whether it is shallow or deep, influence the establishment of weeds. Weed occurrence was gradually decreased as the plowing depth increased (Fig. 23). In general, weed growth also suppressed as the number of harrowing operation increase and the time of last harrowing is more critical (Table 24).

Herbicide

Chemical weed control has been extensively evaluated since butachlor and nitrofen were introduced since early of 1970. These herbicides effectively controls many annual grasses, broadleaf weeds, and sedges and can be applied preemergence or post emergence. Due to the insufficient control ability against perennial weeds, perennial weeds rapidly increased by repeated using of these herbicide (Fig. 24). In the present situation, approximately 40 herbicides were available in market in Korea and one half of these were used as herbicide for paddy rice field. Most of herbicides can selectively control weeds and hence, eventually resulted in different weed flora by repeated application of some herbicide.

Interactions of All Factors

Based on the above results it can be concluded that all the cultural practices influence the weed growth. In practical situation, weed growth seldom affected by single factor rather affected by interactions of all factors. These relationships could possibly be summarized as Fig. 25.

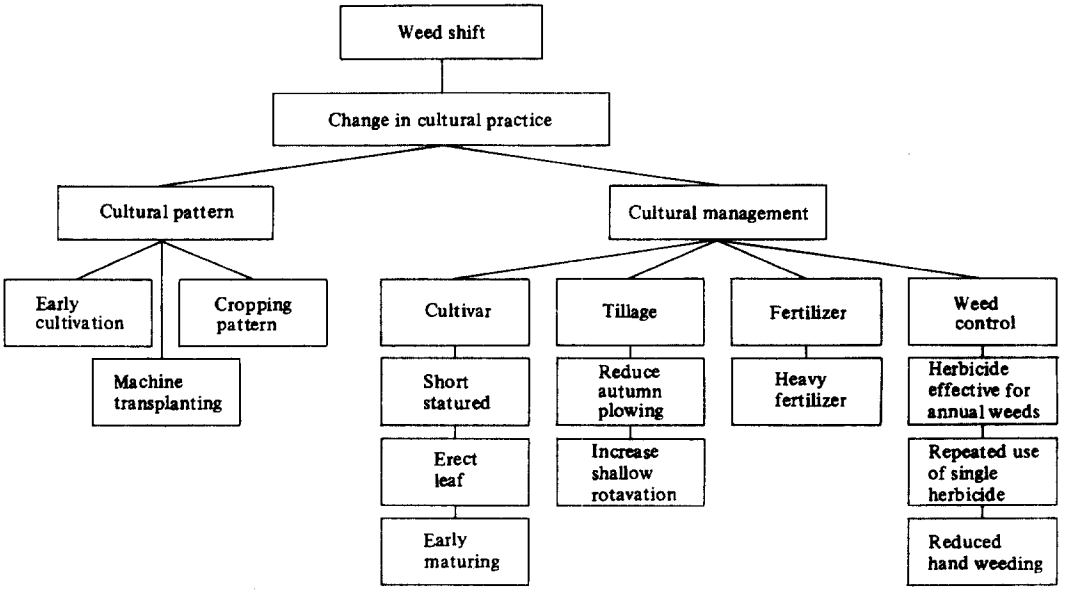


Fig. 25. Integrated factors affecting weed shift in paddy rice field.

摘　　要

1971年과 1981年 2回에 걸쳐 農村振興廳 試驗研究機關에서 실시하였던 우리나라 논 잡초 분포조사 結果를 比較 分析하고, 雜草 發生에 影響을 미치는 여러 가지 要因들을 지금까지 試驗된 結果를 中心으로 檢討하였다.

1. 우리나라 논에 分布되어 있는 雜草는 지난 10年 동안(1971～1981) 雜草種類는 그다지 크게 變化되어 있지 않았으나, 優占草種은 많이 변화되었는데, 1971年에는 主로 一年生 雜草가, 1981年에는 主로 多年生 雜草가 優占草種이였다.

1971年度와 1981年度의 10大 優占草種과 優占度는 다음과 같다.

〈1971年〉	〈1981年〉
① 마디꽃(34.5%)	① 물달개비(22.2%)
② 쇠털꽃(11.9%)	② 올　　미(17.5%)
③ 물달개비(11.1%)	③ 벗　　풀(9.0%)
④ 알방동산이(8.7%)	④ 가　　래(9.0%)
⑤ 피 (6.9%)	⑤ 너도방동산이(8.5%)
⑥ 밭뚝외풀(3.3%)	⑥ 마 디 꽃(6.0%)
⑦ 가　래(3.1%)	⑦ 사마귀풀(4.4%)
⑧ 사마귀풀(2.4%)	⑧ 밭뚝외풀(3.9%)
⑨ 올방개(1.8%)	⑨ 올 방 개(3.4%)
⑩ 여　뀌(1.8%)	⑩ 여뀌바늘(3.0%)

2. 多年生 雜草의 發生比率은 中部地方에서 높았는데, 主要草種은 가래, 올미, 벗풀, 너도방동산이였다. 특히 가래 發生은 耕地利用率과 負의 相關關係를 보였다.

3. 우리나라 논에 分布되어 있는 土壤 類型別 雜草發生 狀態는 鹽害畓을 除外하고는 土壤 類型別 間에 별 差異가 없었으나 鹽害畓은 特히 多年生 방동산이 科 雜草인 너도방동산이와 올방개가 優占되었다.

4. 2毛作 栽培地가 單作 栽培地보다 雜草發生量이 적었고, 2毛作 栽培에서도 米-麥 作付 樣式이 米-菜蔬 作付樣式보다 雜草發生量이 많았는데, 特히 多年生 雜草發生이 많았다.

5. 봄의 耕耘보다 가을에 耕耘하므로서 雜草發生이 적어졌는데 主로 多年生 雜草發生이 減少된데 原因이 있었다.

6. 道別 發生되는 雜草를 Two-dimensional ordination 分析法에 依해 雜草 群落型을 分析한 結果, 全南이 11個, 京畿, 江原, 忠北, 慶南이 9個, 全北과 慶北이 8個, 忠南이 7個, 濟州가 4個의 雜草群落型으로 分布되었다.

7. 벼 栽培에 있어 雜草發生에 影響을 미치는 要因을 分析한 結果, 벼 品種, 栽植距離, 施肥方法, 除草劑, 耕耘方法 等 모든 栽培 方法들이 雜草發生에 影響을 미치는 것으로 밝혀졌는데, 벼品種 特性으로

는, 熟期가 길수록, 稈長이 길수록, 잎이 수그러지는 品種일수록, 그리고 栽植距離가 가까울수록, 耕耘깊이가 깊을수록 雜草發生이 적었고, 發生되는 雜草의 種類도 施肥量, 土壤理化學的 特性 및 除草劑에 따라 크게 달라졌다.

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