Weed Control in Upland Farming of Japan

By KANENORI NAKAYAMA

Upland Farming Division, Central Agricultural Experiment Station

It has been said that "farming is a struggle against weeds" in Japan, which has heavy rainfall and high temperature in the summer season, being located in the monsoon region. Holdings of each farmers are generally small. This is a result of high productivity of crops per unit land area due to favorable natural condition, but also difficulties of controlling vigorous weeds must have restricted the size of holdings. In spite of this situation, research on weed control has only a short history. Particularly with the upland farming which was regarded as subordinate to rice farming almost no study had been made. However, in the late 1940s 2·4-D was first introduced, and the shortage of farm labor caused by industrial development since about 1960 has stimulated the study on weed control in upland farming.

In the present paper, a brief description of recent studies will be presented.

Kinds and distribution of weeds in upland farms

Different weeds require different temperature for their emergence. Daily mean temperature at the time of beginning and peak of emergence of major 8 summer weeds, observed yearly in fields, is given in Table 1. *Chenopodium album* L. (common lamb's quarters) emerges at the lowest temperature, and is followed by *Polygonum lapathifolium* L., and *Commelina communis* L. (Asiatic dayflower). They begin to emerge at the temperature below 10°C, and reach a peak emergence at the time of 10–15°C. On the contrary 5 other weeds begin to emerge at 13–15°C and reach the peak emergence at about 20°C.

It is a traditional practice to sow or plant summer upland crops in May. In Hokkaido, where snow remains until late-April and the frost-free period is only 130–150 days, the sowing or planting is made as soon as possible

Table 1. Air-temperature at the time of emergence of major weeds in upland farms

Weed species	Temperature (℃)	
	Beginning of emergence	Peak emergence
Chenopodium album L.	6— 7	10—13
Polygonum lapathifolium L.	7—10	10—15
Commelina communis L.	10	13—15
Amaranthus lividus L.	10—13	~20~
Portulaca oleracea L.	12—13	20~
Echinochloa crus-galli Beauv. *Praticola* Ohwi	13	20
Digitaria adscendens Henr.	13—15	20~
Cyperus microiria Steud.	15	20~

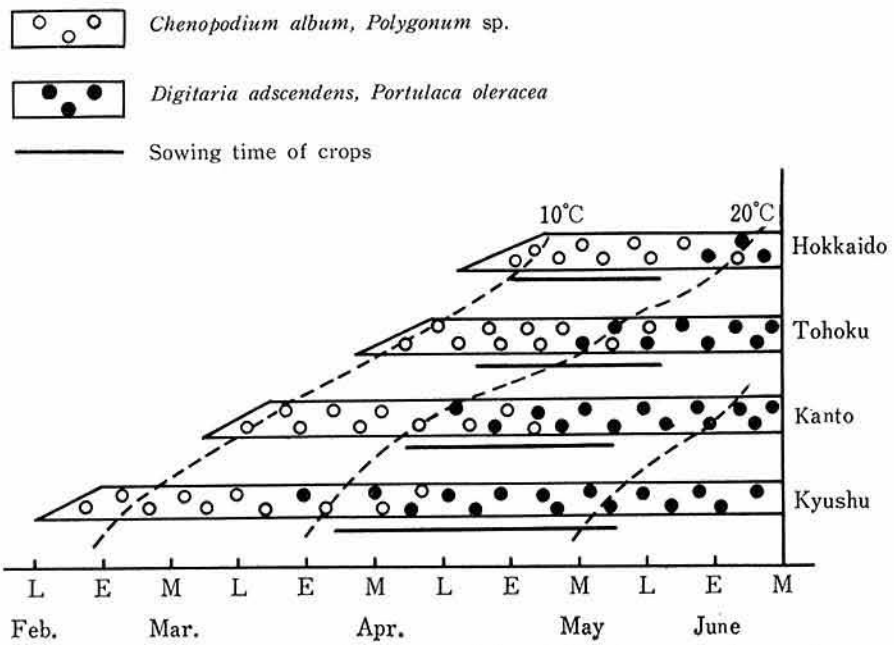

Fig. 1. Time of emergence of major weeds in relation to average temperature of regions

after the snow disappears. This time is just in the month of May. On the other hand, in southern Japan a system of 2 crops a year with wheat or barley as winter crops is commonly practiced. As wheat is harvested at the time when average temperature becomes about 20°C, most summer crops are usually interplanted between rows of winter crops. To avoid a prolonged duration of interplanting, which should be at least within 1 month, their planting time falls in May. Therefore, although the planting time is similarly in May, the average temperature and accordingly kinds of weeds are different between northern and southern Japan as shown in Fig. 1.

In Hokkaido, weeds with low temperature germinability such as Common lamb's-quarters, *P. lapathifolium* and Asiatic dayflower are dominant. In addition, *Polygonum nepalense* Meins., and *Elsholtzia ciliata* Hylander are also abundant. All of them are broadleaf weeds. Although gramineous weeds such as *Digitaria violascens* Link, *Echinochloa crus-galli* Beauv. var. *praticola* Ohwi (Barnyardgrass), and *Setaria faberi* Herrmann (Giant foxtail) emerge to some extent, particularly when sowing is delayed to late-May, the broadleaf weeds predominate in general.

On the other hand, in warm Kyushu with average temperature of 18–19°C in May, *Digitaria adscendens* Henr. (Large crabgrass), *Portulaca oleracea* L. (Common purslane), and *Cyperus microiria* Steud. (Chufa) emerge abundantly. In addition, *Eleusine indica* Gaertn. (Goose grass), *Setaria viridis* Beauv. (Green foxtail), *Amaranthus lividus* L. (Liuid amaranth) and *Amaranthus viridis* L. (Green amaranth) are also abundant. Since *P. oleracea* and *C. microiria* have a characteristic that their growth is retarded under a shaded condition, their growth is usually suppressed in the fields with growing crops. Thus, the gramineous weeds, *D. adscendens* and *E. indica* come to be dominant, contrary to the case in Hokkaido. Weed emergence in the Kanto region is similar to Kyushu, except that *E. indica* is not found, and that of the Tohoku region is similar to Hokkaido in case of early sowing while it is similar to Kanto in case of late sowing. Even in southern Japan, *C. album*

and *P. lapathifolium* are dominant when sowing or planting is made early in March to April, although their quantity is relatively small.

As to winter weeds, *Stellaria neglecta* Weihe, *Capsella bursa-pastoris* Medik. (Shepherd's purse) and *Stellaria alsine* Grimm var. *undulata* Ohwi are abundant throughout the country. In Hokkaido, *Rorippa islandica* Borbas is also abundant, and *S. neglecta* gives a noxious effect as a summer weed. In Tohoku and southward regions, most upland farms are of volcanic acid soil, on which formation and melting of frost pillars and wind erosion occur seriously with a result of poor emergence of weeds. However, in areas with high moisture content of soil due to high ground water level the emergence of weeds, particularly of *Alopecurus aequalis* Sobor. var. *amurensis* Ohwi (water foxtail) and *Galium aparine* L. (Cleavers) is abundant, causing great effects to crops.

Methods of weed control

1) Chemical weed control

Since 2·4-D was introduced in 1940s, rapid progress has been made in the development and utilization of new herbicides. At present it is estimated that herbicides are used on about 80% of the total upland farm area. It is a common practice to apply herbicides to soil (soil treatment) after sowing. In most cases, non-selective herbicides such as simazine, DCMU, linuron and chlorpropham, etc. are used. However, lenacil pyrazone is used for sugarbeet which is sown under a shallow soil covering, and trifluralin is used in soybean, groundnut and vegetable farms in southern Japan, where gramineous weeds are dominant. The non-selective herbicides listed above have an advantage of low prices, but there is a risk of crop injury in achieving sufficient effectiveness of weed control. Herbicides with higher effectiveness and less phytotoxicity are required. An attempt to develop herbicide mixtures produced a promising formula of benthiocarp-prometryne.

As a new method of soil treatment, the volatile selective herbicide like trifuralin is incorporated into soil. However, this method is not popularized for the following reasons: in Hokkaido this method is apt to cause crop injury because the application has to be made to wet soil immediately after snow melting and both crops and weeds are broadleaf plants, and in southern Japan the operation is difficult because the multiple cropping is being practiced.

As to the foliar treatment, phenmedipham is widely used for sugarbeet, and propanyl etc. for upland rice. At present, new herbicides to be used in controlling gramineous weeds such as *D. adscendens* in soybean, groundnut and sweet potato fields are urgently required, and some ones were developed for the practical use.

2) Mechanical weeding

Mechanical weeding consists of uprooting, cutting off, and burying of weeds, according to the type of weeding knife. For example, the sweep shows a strong cutting performance, spring tooth (pencil point weeder) shows strong uprooting, shovel of cultivator works for uprooting and burying, and the rotary for burying mainly.

When soil is dry, all of uprooting, cutting and burying are effective, but when soil is wet under rainy conditions only the burying is effective, because rooting and regeneration occurs with other methods. Particularly for *D. adscendens* and *P. oleracea* which are abundant in southern Japan, cutting and uprooting are less effective.

As given in Fig. 2, the weather in June, when the mechanical weeding is needed, is dry in northern Japan (Hokkaido and Tohoku) with more evaporation than precipitation. On the contrary, it is wet in southern Japan. The same is almost true in May and July. Therefore, weeders adapted to the climatic conditions must be used: cultivator and steerage hoe in northern Japan and rotary cultivator in southern Japan. Actually they are going to be used so. Cultivator and steerage hoe are of high

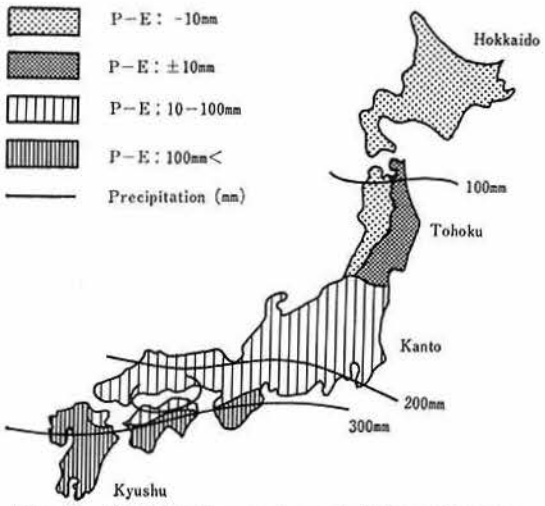

Fig. 2. Precipitation and precipitation-evaporation (P-E) in June

operational efficiency and suitable to large area cultivation.

3) Utilization of tillage

In general weed seeds survive for many years, not rarely for more than several decades. But seeds of *D. adscendens* can survive for only about 2 years. Based on this fact, it was made possible to kill the seeds by burying them after they fell on soil surface.

Tillage removes growing weeds, but at the same time it promotes the emergence of weeds, particularly of *C. album*, *D. adscendens*, and *C. microiria*, which require light in awakening from seed dormancy. Taking advantage of this characteristic, it is possible to reduce weed population by inducing weed emergence after crop harvest by shallow tillage with disk harrow, etc. and then exposing them to low temperature of winter.

4) Weed control system

Weed control systems have made a rapid progress by adopting chemical methods, mechanical methods and the use of tillage as stated above, but are still not enough. The systems currently practiced by farmers are as follows:

Northern Japan: Soil treatment after sowing+intertillage (by cultivator)+weeding by hoe (by hand). Frequency of intertillage and hoe-weeding varies with different crops: for corn and soybean, 1–2 times and 2–3 times of intertillage and 0 and 1–2 times of hoe-weeding respectively. It is also practiced to remove remaining weeds by hand sickle before their seeds fall down.

Southern Japan: Soil treatment after sowing+intertillage (by rotary cultivator) or foliar application of herbicides+sickle weeding (by hand), Foliar application is widely practiced for upland rice. Sometimes it is supplemented by one time of intertillage. For other crops, intertillage is done two times. Sickle weeding is done 1–2 times to remove remaining weeds.

Future research needs

1) More than 600 *l* of water is needed to dilute herbicides at present. Because water is not easily available in upland areas, spraying techniques to save water use is required to be developed.

2) With mechanical weeding, machines for effective control of weeds within rows are required.

3) Ecological method of weed control to minimize weed seeds population in soil—to clean the fields—is needed to be established. For that purpose, seasonal trends of seed dormancy and survival of seeds in soil, etc. have to be studied in relation to cropping and tillage, etc.

4) Exotic weeds such as *Solanum carolinense* L., and *Agropyron repens* (L.) Beauv., etc. have been introduced due to an increased international trade. In orchards, perennial weeds such as *Oxalis Martiana* Zucc. and *Cyperus rotundus* L. (Purple nutsedge) etc. have increased due to less tillage resulted from frequent herbicide application. The control measures for these weeds are urgently needed.

References

1) Naka, S. & Sato, K.: The effects of weed control by several weed control machines.

Weed Research, Japan, **10**, 43–49 (1970) [In Japanese with English summary].

2) Nakayama, K.: Present status and problems on weed control in upland fields. *Weed Research, Japan*, **19**, 1–6 (1975) [In Japanese].
3) Nakazawa, A.: Changes in the weed flora on upland fields by farming. *Weed Research, Japan*, 8, 1–9 (1969) [In Japanese].
4) Takabayashi, M. & Nakayama, K.: Herbicides for weed control in upland fields. *J. Agri. Sci., Japan*, **29**, 210–214 (1974) [In Japanese].
5) Watanabe, Y. & Hirokawa, F.: Longevity of buried weed seeds. *Weed Research, Japan*, 11, 40–43 (1971) [In Japanese with English summary].
6) Watanabe, Y. & Hirokawa, F.: Ecological studies on the germination and emergence of annual weeds. 1. Effect of temperatures on the dormancy-breaking in seeds of *Chenopodium album*, *Echinochloa crusgalli* var. *praticola* and *Polygonum Lapathifolium*. *Weed Research, Japan*, **17**, 24–28 (1974) [In Japanese with English summary].
7) Watanabe, Y. & Hirokawa, F.: Ecological studies on the germination and emergence of annual weeds. 2. The period of dormancy-breaking and the death of seeds in the process of dormancy-breaking in the field in *Chenopodium album*, *Echinochloa crusgalli* var. *Praticola* and *Polygonum Lapathifolium*. *Weed Research, Japan*, **17**, 29–33 (1974) [In Japanese with English summary].