SEASONALITY OF GROWTH AND DEVELOPMENT IN YARROW

G. W. BOURDÔT, J. G. H. WHITE and R. J. FIELD

*Department of Plant Science,
Lincoln College,
Canterbury*

Summary

Observations and experimental evidence have been used to establish the general pattern of the seasonality of growth and development in yarrow (*Achillea millefolium*). The main months of flowering were January and February with fruit set occurring from late January. An estimated 900,000 seeds/m² were produced with a mean weight of 0.166 mg and a germination of 98% after 4 months dry storage. Germination was observed to occur on bare ground during April and May. Rhizome growth continued vigorously throughout the winter until terminal shoots emerged from the soil. Buds on single-node rhizome fragments showed no pronounced dormancy and demonstrated a sprouting ability of at least 90% from October 1977 until October 1978.

INTRODUCTION

Yarrow is a perennial rhizomatous herb, first recorded in New Zealand by Hooker (1864). It was sown in much of the hill country as a component of pasture mixtures and was considered highly palatable for sheep (Cockayne 1920) but was early reported as an important South Island weed both of pasture and arable land (Cockayne 1916, 1917). Yarrow seed was listed among the 50 most common seed impurities (Cockayne 1912), and Hughes (1915) commented on its ability to establish from seed. Yarrow is now a major weed on many mixed cropping farms in Canterbury. Build-up of local populations would seem to be associated with the decline of fallowing (Hilgendorf and Calder 1952) in intensive farming systems and the lack of suitable chemical control (Matthews 1975). Yarrow can be a serious problem in white clover seed crops, peas, beans, beets and other root crops and may reduce yields considerably while only a small number of plants will reduce the oil quality of peppermint crops.

Recognising that a knowledge of seasonality and reproductive processes of a weed may lead to intelligent and effective control measures, this paper draws on experimental data obtained at Lincoln and Rolleston to build up a picture of the life history of yarrow. A simplified life history diagram is presented below (Fig. 1) and aspects of this are discussed in the text, making reference to the implications for formulating control measures.

EXPERIMENTAL METHOD

Seasonality of flowering and rhizome production

A field experiment with yarrow planted 5 cm deep at two densities (25 and 50, 10 cm lengths of rhizome/m²) was established on the Lincoln College Research Farm in November 1977 and growth was measured until

Rhizomatous Weeds

FIG 1: Life History of Yarrow

September 1978. Regular samples of 0.12m^2 were taken and dry weights of rhizomes, leaves, stems and flowers recorded. Roots were not recovered. The results presented here are the means of both densities.

Components of seed (cypsela) yield

Measurements were made on an established stand of yarrow on the property of Mr D. G. Watson at Rolleston. From 0.1m^2 samples taken on 31 January 1977 flower stem and capitula numbers were counted. The number of seeds/capitulum was estimated by counting number of seeds in 90 capitula on 1 March using only those from which no obvious seed loss had occurred. Seed weight was estimated from samples taken on 15 March. Some of this seed was stored in paper bags at room temperature for 4 months when a germination test following I.S.T.A. recommendations (8 hours light at 30°C and 16 hours darkness at 20°C) was conducted.

Seasonality of rhizome bud activity

The seasonality of rhizome bud activity was studied in an area of dense yarrow from 13 October 1977 until 27 April 1978. The experiment was a randomised complete block design with seven sampling dates and four replicates, with plots 1.0m^2 . The study was continued in the same layout in another similar area from 20 July until 20 November 1978 when samples were taken on four occasions.

Rhizomes were forked up at intervals and after washing away adhering soil, 100 2cm single node lengths were selected from each of the four replicates. Only unsprouted and undamaged buds were used. The lengths were placed on dampened blotting paper in four shallow plastic trays, covered with glass and incubated in darkness for 10 days at 25°C . The percentage of buds that had sprouted (exceeded 3mm in length) was determined and the dry weights of shoots recorded.

Rhizomatous Weeds

The data from the two areas were subjected separately to analysis of variance to determine the significance of changes in bud activity with time. The percentage data was arcsine transformed before analysis but the presented means and their 95% confidence limites are the back-transformed values.

RESULTS

Seasonality of flowering and rhizome production

During the summer and early autumn yarrow produced mainly aerial growth (Fig. 2). After 4-5 weeks in the rosette form, rapid stem elongation occurred and by late March the total dry weight (excluding roots) was 8.5 tonnes/ha, 87% of this above ground. Flowering occurred during February and seed was set and shed from mid February until June (Fig. 2). From late March onwards, senescence of the capitula, stems and cauline leaves and shedding of seed caused a rapid decline in above ground dry weight and was associated with a marked increase in the dry weight of rhizomes. There was a drop in total plant dry weight during April, when the rate of decline in the weight of aerial structures appeared to exceed the increase in rhizome weight, but by early May the total weight was again increasing. By July senescence had finished, there was no further decline in aerial weight (Fig. 2) and the plants overwintered as rosettes formed by shoots that had not flowered.

FIG 2: Dry matter accumulation in yarrow regenerating from buried rhizome fragments.

Rhizomatous Weeds

By early August the rhizome dry weight had increased to 5.8 tonnes/ha or 57% of the total dry weight. This winter rhizome growth involved rapid extension and the formation of many dormant lateral buds, the majority of which did not grow unless the rhizome was damaged, releasing the buds from apical dominance. Rhizome dry weight increase stopped abruptly in August when the terminal buds began to emerge from the soil (Fig. 2), rhizome extension consequently being curtailed.

The curves showing capitula and rhizome weights (Fig. 2) show that a far greater proportion of the total dry weight was incorporated into rhizome than into seed during the studied growth period. Seed shed from these plants germinated in exceedingly large numbers (up to 2500 seedlings/m²), in April and May (Fig. 2) on open ground but little germination occurred under the cover of the existing yarrow. Seedlings were found up to 6 m from the parents.

Components of seed yield

In the Rolleston stand the first ligulate ray florets appeared in late December, flowering continued through to mid February and mature seeds were present from mid January. This seed had a germination rate of 98%.

The components of seed yield are presented in Table 1. The average number of capitula/stem was 109 and the mean number of seeds/capitulum was 25.5 giving approximately 2800 seeds/stem. Single plants growing without interference from neighbours have been shown to form up to 20 flowering stems in their first season from seed and thus may be expected to form approximately 60,000 seeds. In the Rolleston stand an estimated 900,000 seeds/m² were formed.

The weight/seed was 0.166 mg at 7.4% moisture.

TABLE 1: Components of seed yield in yarrow at Rolleston 1977.

Flower stems /m ² (31.1.77)	Capitula /m ² (31.1.77)	Capitula /stem (31.1.77)	Seeds/capitulum (1.3.77)	Seed weight mg (15.3.77)	Estimated seeds/m ²
320	34,900	109	25.5	0.166	900,000

Seasonality of rhizome bud activity

The percentage of buds sprouting on single node rhizome fragments after 10 days in the dark at 25 °C (per cent bud activity) was in excess of 96% from late February until October 1978 (Fig. 3). A reduction in per cent activity occurred during December - early February 1977/78 when activity fell to 90% ($P < 0.01$) and in November 1978 when it fell to 60% ($P < 0.01$). A concomitant reduction in shoot dry weight occurred with the reductions in bud activity. The fall in activity and vigour was associated with the observed period of flower stem elongation and flowering (Fig. 3).

DISCUSSION

In the expanding population of yarrow at Lincoln College, the vegetative reproductive effort was very high (Fig. 2) compared with other studied perennials (Harper *et al* 1970). This strategy allows the plant to consolidate its hold in an existing habitat and explains the rapid spread of individuals on newly cultivated soil, in widely spaced and/or low stature crops and in crop stubbles left uncultivated over the autumn and winter. The strategy allows survival under grazing by virtue of the large numbers of dormant regenerative buds formed below the soil surface where they are protected and also greatly increases the chance of surviving the disturbance of soil cultivation.

Rhizomatous Weeds

FIG 3: Percent bud activity and shoot dry weights of single-node rhizome fragments.

The vigorous winter rhizome extension growth is likely to confer a considerable advantage on the plant when growing in association with species showing little cool season activity e.g., grasses, clovers and field peas. O'Connor *et al* (1968) showed that less than 8% of the mean annual production from a ryegrass - white clover pasture at Lincoln occurred during the months of June, July and August - just the months when yarrow is actively producing rhizome.

It would seem that in a regenerating population (e.g., after cultivation or spraying) yarrow diverts a much smaller proportion of its dry matter into seed than into rhizome over the first growth period (Fig. 2). However the numerous very small seeds which are produced (Table 1), although without a pappus, are dispersed by wind and as observations have shown that successful establishment of yarrow seedlings occurs on open ground but not in shade, the sexual strategy is clearly one favouring dispersal and colonisation of new habitats at the expense of early seedling vigour and competitiveness. Yarrow then, has a double reproductive strategy which allows it to escape from highly competitive habitats by seed dispersal and to build up quickly when conditions are favourable in existing habitats by rhizome formation.

Seasonality of growth from rhizome fragments commonly occurs in many creeping perennials (Leakey *et al* 1977) and in couch, nitrogen mobilisation from old rhizomes into new rhizomes is a possible explanation for the so called late - spring - dormancy of lateral buds (Johnson and Buchholtz 1961; Leakey *et al* 1977). When dormant rhizome buds of yarrow were released from apical dominance by cutting rhizomes into single-node pieces they displayed high activity throughout the 13 months of experimentation (Fig. 3) indicating that there was no period of pronounced dormancy in the buds other than the almost total apical dominance. This allows yarrow to regenerate from rhizome buds at all times of the year. The association of the period of reduced activity and shoot vigour with stem elongation and flowering does suggest, however, that these processes bear a causal relationship with bud growth. It would

Rhizomatous Weeds

seem likely that whatever is causing the reduced activity is also reducing the vigour of those buds which do grow out.

The information provided by this study on the seasonality of yarrow growth is summarised in Fig. 1 and below is a list of implications which should be considered when attempting to control the plant.

1. Rhizome food and bud reserves could be depleted at any time of the year by an initial cultivation to fragment the rhizomes, followed by cultivations to break off the growing shoots.
2. Autumn cultivations as in 1. above would have the additional effect of preventing the marked autumn/winter rhizome growth.
3. Autumn cultivations are likely to kill large numbers of seedlings before they become well established.
4. The efficacy of translocated herbicides may be greatest if applied in the autumn as movement of assimilate, into the rhizomes is likely to be most active during this period of vigorous extension growth.

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