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# SOME EFFECTS OF DENSITY AND FERTILIZER ON THE GROWTH AND COMPETITION OF *EPILOBIUM HIRSUTUM* AND *LYTHRUM SALICARIA*.

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**Abstract**

Seedlings of *Epilobium hirsutum* and *Lythrum salicaria* were grown 1, 3, 5, 7, 10 and 15 in. apart in 30 square plots in the open sun and shade, separately and in mixture, on dry and wet sites.

On the dry site, *E. hirsutum* did not survive at any density level both in the shade and in open sun. Survival anp growth of *L. salicaria* was comparatively better in the open sun than in shade in all the

On the wet site, application of fertilizer did improve the growth and survival of *E. hirsutum* though it failed to compete with *L. salicaria*. Fertilizer treatment greatly improved the performanc of *L. salicaria* and 3 in. spacing between the plants gave best results with regard to survival and growth.

*L. salicaria* also successfully competed with *Juncus effusus* both on dry and wet sites.

## Introduction

The two species investigated, *Epilobium hirsutum* and *Lythrum salicaria* are typical plants of fen communities (Clapham *et al*., 1952; Turrill, 1948; Ellis, 1965; shamsi, 1970). An account of their comparative eco-physiology is given in Shamsi and Whitehead (1974 a, b).

*E. hirsutum* has a tendency to form large mono-specific stands in the base rich fens of Britain and most of northern Europe. It rarely occurs as scattered individuals or as clones in other community types. It seems quite sensitive to extreme conditions of habitats, particularly with regard to soil moisture and nutrients.

Occasionally *L. salicaria* also forms considerably large stands on the bared soil in early summer in England, but these tend to be penetrated and intermixed quickly by other species (Ellis, 1963). Unlike *E. hirsutum*, it shows greater abundance in warm central and southern Europe and Ireland (Perring and Walters, 1962; Hulten, 1950) Also, it shows a much wider ecological amplitude with regard to soil moisture and nutrients. It seems to withstand competition from other species and frequently occurs as single individuals in other community types (Whitehead, 1969; Pers. Comm.)

This paper reports the results of some field experiments on the growth and survival of these plants on soils deficient in nutrients during summer periods. The object was to test their ability to compete among themselves and with other plants and to develop hypothesis concerning their distribution and survival in various community types.

## Materials and Methods

The source of the material has been described in Shamsi and Whitehead (1974a). The seedlings of both the species were raised in sand culture at 25°C using Long Ashton nutrient solution (Hewitt, 1952) to 4-leaf stage before transplantation.

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The area selected was located around the margin of a swamp in an open valley, near the Imperial College Field Station, Silwood Park, Berks. The valley as a whole is an extension of Bagshot sands mixed with pebbles and gravel drift, receiving drainage from springs coming off nutrient poor Baghot sands (Druce, 1897). The sites selected for different experiments were cleared of the existing vegetation and the thick clayey substratum was dug to a depth of about 50 cm. to reduce it to a more or less uniform consistency. Each site was properly fenced. Temperature recorded during the course of the experiments is shown in Table 1.

The general setting up of the various experiments was such that in each site, eighteen plots, each 30 in. square, were marked out at 1ft. intervals in three rows, so that there were six sets of plots each consisting of three units. Each set was labelled for the distance at which the seedlings were transplanted i.e., 1,3,5,7,10 and 15in. apart and the corresponding number of seedlings i.e., 900,100,36,16,9 and 4 were transplanted. The central unit of each set contained the two species mixed together with a pare unit of each species on either side. In the mixed plot the two species were transplanted alternately.

## Observations and Results

Experiment I. The object of this experiment was to study the effect of density on the inter-specific and intra-specific competition and survival of the two species on a dry site Two relatively dry, 25 ft. square sites about 10ft. away from the margin of the swamp, one in the open sun and other in the shade were selected. In each site seedlings of both the species were transplanted at different spacings as outlined above in June, 1967. All the plots were watered for some time during the early stages of seedling establishment.

In the sunny site a few days after transplantation, mature leaves and the mature parts of stems of *E. hirsutum* seedlings started developing red colour. They persisted for some time without making any growth and gradually dried up both in the pure and mixed plots. *L. salicaria* seedlings started responding after about 10 days of transplantation and continued to grow at a slow pace. In the beginning of July *Juncus effusus* seedlings started to appear in almost all the plots and by the end of the month it had grown over all the experimental area except pure *L. salicaria* plots with seedlings spaced 1 in. apart.

In the shade also, *E. hirsutum* seedlings failed to establish at all density levels and gradually died away. The growth of *L. salicaria* was rather poor and most of the seedlings especially those widely spaced were eliminated. The most well developed plants in 1 in. density plots attained a height of only 19 cm. whereas in the open sun at this density their height varied from 15-74 cm. Here, 10 large plants flowered as well while only three flowered in the mixed plot. The surviving *L. salicaria* plants in the various densities on both the sites were counted on 23rd September and recorded as in Table 2.

Experiment II. The results of experiment I suggested that the dryness of the substratum and nutrient deficiency were responsible for the failure of *E. hirsutum* seedlings. In order to overcome these factors the above experiment was repeated on a wet site and a fertilizer was applied to improve its growth. Four 25ft. × 12 ft. areas, two in the open sun and two in the shade were selected on the wet muddy bank of the marsh. In each area, two sites, each one with eighteen plots were marked out as in experiment 1. In either site, one set of 18 plots each, was treated with Fison's "TOP GROW 8" fertilizer (rich in N, P and K in the ratio of 2:3:2) at the rate of 4 oz. per plot. The transplantation of seedlings of both the species was completed on 18th May, 1968. The meanpH of the mud in the sun and shade was 5.2 and 4.8 respectively.

In shade the growth of both the species was rather slow. Later due to heavy rains in July, most of the seedlings in all the plots were washed away. The remaining ones in the high density plots were burried under the mud and eventually decayed due to extremely low light intensity, high humidity and high temperature.

In the open sunny site, both the species in the fertilizer treated plots were much healthier than in the untreated plots. In the treated plots most of *L. salicaria* plants spaced 1 in. apart varied between 40 to 70 cm. in height and the tall plants measured upto 112 cm. *E. hirsutum* plants did not exceed a height of 12 cm. even in the treated plots. The surviving plants of both the species in all the treatments were harvested on 5th October, 1968 and their performance is summed up in Table 3 (a,b,c).

Table 3a shows that application of fertilizer greatly improved the biomass per unit area and dry weight per plant in the case of *L. salicaria* where the plants were spaced 1 in apart. First decline in density resulted in 5-fold rise in the individual plant dry weight. Further decline did not cause any noticeable increase in plant dry weight. Table 3a also shows a corresponding increase in the growth of *J. effusus* with each decline in the density of *L. salicaria*. It is interesting to note that biomass of *J. effusus* per plot is higher in the untreated than in the treated plots.

Compared with *L. salicaria*, the performance of *E. hirsutum* is not so good both in the treated and untreated plots (Table 3b). However, fertilizer treatment improved the growth of *E. hirsutum*. Also growth of *J. effusus* in these plots was greater than in the *L. salicaria* plots. In the mixed plots, not only the growth of *E. hirsutum* was greatly suppressed but it was completely eliminated by the fast growing *L. salicaria* and *J. effusus* plants (Table 3c).

None of the *E. hirsutum* plants flowered in any treatment. *L. salicaria* not only successfully competed with *J. effusus* but most of its plants also flowered in all the treatments in the pure as well as mixed stands.

## Discussion

The data presented show that while *E. hirsutum* failed to establish and grow in the shade, *L. salicaria* made some viable growth. However, the growth and survival of *L. salicaria* was not as high in the shade as in the open sun even in the high density plots (Table 2). Pearsall (1918) and Ellis (1965) reported the occurrence of *L. salicaria* in both open and closed "carrs" with a greater frequency in the former than the latter. On the other hand, *E. hirsutum* is known to be a typical species of open habitat. *L. salicaria* is more capable of sustaining growth on the dry substratum than *E. hirsutum*. Its survival at different density levels varied from 20 to 40%. *E. hirsutum* failed to continue growth beyond a few weeks after transplantation. Batten (1918) in a series of experiments has also shown that *E. hirsutum* seedlings can not establish on dry substration. However, on the wet site there was a considerable improvement in the growth and survival of *E. hirsutum* but still the plants showed nutrient deficiency symptoms (red colour of stems and leaves). Haslam (1966) in his experiments also noted these symptoms and reported the absence of

**Table 1. Mean monthly temperatures (C°) during the course of the experiments I and II.**

| Month | 1967 Maximum | 1967 Minimum | 1968 Maximum | 1968 Minimum |
|---|---|---|---|---|
| May | 14.9 | 6.2 | 14.9 | 5.4 |
| June | 19.5 | 8.5 | 19.9 | 10.0 |
| July | 22.7 | 11.7 | 20.3 | 10.7 |
| August | 20.3 | 10.9 | 19.7 | 11.2 |
| September | 17.3 | 9.7 | 18.0 | 10.0 |
| October | 14.2 | 7.6 | 15.8 | 9.7 |

**Table 2. Number of survivors of *Lythrum salicaria* at different density levels in open and shaded positions and in pure and mixed species plots on a dry site in experiment I.**

**Pure Species Plots**

| Distance in inches. | 1 | 3 | 5 | 7 | 10 | 15 |
|---|---|---|---|---|---|---|
| N. of seedlings transplanted | 900 | 100 | 36 | 16 | 9 | 4 |
| Survivors in open plots | 295 | 28 | 15 | 3 | 2 | — |
| % Survival | 32.8 | 28 | 41.7 | 18.8 | 22.2 | — |
| Survivors in shaded plots | 73 | 5 | — | 1 | — | — |
| % Survival | 8.1 | 5 | — | 6.2 | — | — |

**Mixed Species Plots**

| Distance in inches | 1 **LY | 1 EP | 3 LY | 3 EP | 5 LY | 5 EP | 7 LY | 7 EP | 10 LY | 10 EP | 15 LY | 15 EP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Seedlings transplanted | 450 + | 450 | 50 + | 50 + | 18 + | 18 + | 8 + | 8 | 5 + | 4 | 2 + | 2 |
| Survivors in open plots | 83 | — | 13 | — | 8 | — | 2 | — | 2 | — | 1 | — |
| % Survival | 18.4 | — | 26 | — | 44.4 | | 25 | | 40 | | 50 | |
| Survivors in shaded plots | 13 | — | — | — | — | — | | — | | — | | — |
| % Survival | 2.9 | — | — | — | — | — | | — | | — | | |

**Ly Lythrum salicaria

EP Epilobium hirsutum

**Table 3. Performance of *Epilobium hirsutum* and *Lythrum salicaria* per unit area at different density levels in pure and mixed species plots and with and without fertilizer treatment.**

(a) **LYTHRUM SALICARIA**

| | Pure plots | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Fertilizer treated** | | | | | | **Non-treated** | | | | | |
| Distance in inches | 1 | 3 | 5 | 7 | 10 | 15 | 1 | 3 | 5 | 7 | 10 | 15 |
| Seedlings transplanted | 900 | 100 | 36 | 16 | 9 | 4 | 900 | 100 | 36 | 16 | 9 | 4 |
| Total survivors | 795 | 90 | 34 | 16 | 9 | 4 | 750 | 86 | 30 | 12 | 7 | 3 |
| % Survival | 88.3 | 90 | 94.4 | 100 | 100 | 100 | 83.3 | 86 | 83.3 | 75 | 77.7 | 75 |
| Biomass per plot g | 2464.5 | 1395 | 578 | 273.6 | 146.7 | 72.4 | 1215 | 439 | 141 | 54.7 | 30.7 | 12.4 |
| Mean dry wt. per plant g | 3.1 | 15.5 | 17 | 17.1 | 16.2 | 18.1 | 1.6 | 5.1 | 4.7 | 4.6 | 4.4 | 4.1 |
| **Juncus** biomass per plot g | — | 49 | 129.8 | 118.7 | 113.0 | 158.7 | — | 298 | 463 | 578 | 715 | 798 |

(b) **EPILOBIUM HIRSUTUM**

| | Pure plots | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Fertilizer treated** | | | | | | **Non-treated** | | | | | |
| Distance in inches | 1 | 3 | 5 | 7 | 10 | 15 | 1 | 3 | 5 | 7 | 10 | 15 |
| Seedlings transplanted | 900 | 100 | 36 | 16 | 9 | 4 | 900 | 100 | 36 | 16 | 9 | 4 |
| Total survivors | 407 | 39 | 12 | 4 | — | — | 275 | 19 | 7 | — | — | — |
| % survival | 45.2 | 39 | 33.3 | 25 | — | — | 30.5 | 19 | 19.4 | — | — | — |
| Biomass per plot g | 732.6 | 64.4 | 20.5 | 6.7 | — | — | 137.5 | 7.8 | 2.7 | — | — | — |
| Mean dry wt. per plant g | 1.8 | 1.65 | 1.7 | 1.7 | — | — | 0.5 | 0.41 | 0.39 | — | — | — |
| **Juncus** biomass per plot g | 533.7 | 735.15 | 713.3 | 972 | 873 | 1011 | 780 | 903.6 | 1109 | 1178 | 1183 | 1203 |

(c) **E. HIRSUTUM L. SALICARIA** Mixed plots

| | Fertilizer treated | | | | | | | | | | | | Non-treated | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Distance in inches | 1 | | 3 | | 5 | | 7 | | 10 | | 15 | | 1 | | 3 | | 5 | | 7 | | 10 | | 15 | |
| | *L | E : | L | E : | L | E : | L | E : | L | E : | L | E | L | E : | L | E : | L | E : | L | E : | L | E : | L | E |
| Seedlings transplanted | 450 | 450 | 50 | 50 | 18 | 18 | 8 | 8 | 5 | 4 | 2 | 2 | 450 | 450 | 50 | 50 | 18 | 18 | 8 | 8 | 5 | 4 | 2 | 2 |
| Total survivors | 363 | — | 43 | — | 15 | — | 5 | — | 4 | — | 2 | — | 305 | — | 38 | — | 14 | — | 4 | — | 3 | — | 1 | — |
| % survival | 81.8 | — | 86 | — | 88.3 | — | 62.5 | — | 80 | — | 100 | — | 67.8 | — | 76 | — | 77.7 | — | 50 | — | 60 | — | 50 | — |
| Biomass per plot g | 766.5 | — | 550.4 | — | 244.5 | — | 87 | — | 58.4 | — | 22.4 | — | 396.5 | — | 148.2 | — | 68.6 | — | 13.2 | — | 12.3 | — | 1.6 | — |
| Mean dry wt. per plant g | 2.1 | — | 12.8 | — | 16.3 | — | 17.4 | — | 14.6 | — | 11.2 | — | 1.3 | — | 3.9 | — | 4.9 | — | 3.3 | — | 4.1 | — | 1.6 | — |
| Juncus biomass per plot g | 38.0 | — | 109.8 | — | 149.3 | — | 205.1 | — | 212.0 | — | 228.7 | — | 178.0 | — | 378.4 | — | 501.8 | — | 715.0 | — | 812.0 | — | 877.0 | — |

*L — *L. salicaria* E — *E. hirsutum*

*E. hirsutum* from nutrient poor acidic head valley fens. Though the application of fertilizer considerably improved the performance of *L. salicaria* (Table 3), *E. hirsutum* failed to resume full growth and flowering despite heavy manuring. It would appear that the low pH of the mud is an important factor in curtailing its growth and development.

The results also indicate that *L. salicaria* is highly successful in the inter-specific as well as intra-specific competition. It did not only eliminate *E. hirsutum* but was fairly successful in competing with *J. effusus* both on the dry and wet sites even in the low density plots. In these plots the growth of *J. effusus* was so luxuriant (as indicated by its biomass per unit area. Table 3) that some *L. salicaria* plants were hardly 10 cm. in height. It may be asserted that once established, *L. salicaria* plants would be able to stand high competitive pressure from its surrounding vegetation and thus be able to survive as scattered individuals in other vegetation types.

Density of plantation greatly affects the growth and dry weights of the plants. Rennie (1974) has shown that dry weight gained by the plant was directly related to the quantity of the environmental factors available to the plant. This was demonstrated by varying the density of plantation. The more the space available for the plant to expand into and draw on from environmental factors within the limits of its physiological process, the greater its weight. Donald (1951), Kira *et al.*, (1953), and Aspinal and Milthorpe (1959) compared yield for different densities of planting and growing periods. They found that average plant weight increases with a decrease in plant density per unit area. In this study, 3 in. distance between the *L. salicaria* plants was the minimum adequate spacing where both the growth and survival per unit area are at their best.

It is concluded that the comparative success of *L. salicaria* under high temperature conditions is due to its tolerance of shade, low pH and nutrient poor dry habitat. Some laboratory stuides (Shamsi and Whitehead 1974 b, 1977) have already shown that this tolerance in *L. salicaria* is due to the presence of morphological adaptations of its phenotype to unfavourable conditions of light and nutrients. This appears to be a highly significant factor in its growth, competition and survival in other plant communities. There would, therefore, be under comparable conditions a greater elimination of spring or early summer germinating *E. hirstum* plants when competing with *L. salicaria*. This may explain the greater abundance of *L. salicaria* among the fen vegetation in the warm estuarine fens of Dalmation coast and in the central and southern Europe as mentioned earlier.

Finally, it may be added that the plant growth is a mutifactoral phenomenon. The interaction of various controlling factors is very complex in determining the competition between the species. Harper (1961) has already emphasized that to most ecologists the term "competition" carries this long term implication and covers all those forces by which one organism succeeds at the expense of another.

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