THE EFFECT OF SEEDING RATE, PHOSPHATE, DEFOLIATION AND MATURITY ON THE HARVEST INDEX OF SUBCLOVER

J. W. BOWDEN and D.J. GILLESPIE

Dept of Agriculture, Baron-Hay Court, South Perth, W.A. 6151

SUMMARY

The interaction of the management factors seeding rate, phosphorus status, defoliation and cultivar of sub clover, on dry matter, seed yield, harvest index and hard seededness was studied in a mediterranean environment. Large increases in dry matter and seed yield resulted from increased phosphorus status and seeding rate. Defoliation had no effect on total dry matter production but usually reduced seed production. Harvest index and hard seededness was invariably higher with earlier maturing cultivars. Within cultivars there were strong interactions between the management factors on both harvest index and hard seededness. Although not directly measured, water use during flowering and seed set can explain much of the variation in harvest index. The implications of this work for further research and modelling are discussed.

Keywords: defoliation, phosphate, seeding rate, subclover variety.

INTRODUCTION

Season to season variation in seed set in *Trifolium subterraneum* (subclover) is governed by many factors, one of the main ones being water relations at or around seed set (Collins 1981). By altering the time of flowering through an appropriate choice of cultivars, and by changing the rate of dry matter accumulation using different management strategies, it is possible to change the levels of seed set and the efficiency of the conversion of tops dry matter to seed (harvest index). All factors studied in the experiment reported here have been studied before either singly or in partial combination (Rossiter 1959, 1961; Yates 1961; Quinlivan *et al.* 1973; Collins *et al.* 1976; Collins 1978, 1981; Dear and Loveland 1984; Bolland 1990). The information in this paper was gathered in an attempt to integrate and understand all the above effects.

METHODS

Three cultivars of subclover (Northam, Seaton Park and Mount Barker with measured times to flowering of 82, 102 and 122 days respectively) were sown at 2 seeding rates (5 and 100 kg/ha) into a clean seed bed on a gravelly sandy loam soil (Ks Uc 4.2, Northcote (1974)) at Wundowie 70 km east of Perth on 23 May 1982. Two levels of fertiliser phosphorus (10 and 160 kg P/ha) were applied to adjust soil phosphorus status to marginal and luxury levels respectively. A defoliation treatment (using a roller mower set at 3 cm, mown at 3 weekly intervals, the last mowing being about 3 weeks after the start of flowering of each cultivar) was compared with an undefoliated treatment. The treatments were applied in factorial combinations in a completely randomised block design with 3 replications. Tops dry matter accumulation through time, tops on offer, flowering dates, seed yield, seed weight, burr number, burr weight, hard seed and limited soil moisture measurements were made.

RESULTS AND DISCUSSION

Total tops dry matter accumulation (TDM) and tops on offer (TOO), both at peak growth (which occurred earlier for Northam), are shown for all treatments in Table 1. Seed yield, harvest index and percentage of hard seed 4 months after maturity, are also shown.

Defoliation.

It is apparent that, despite its severity, the defoliation regime reduced tops on offer significantly (vis-à-vis the non-defoliated controls), only at levels of production above about 3.5 t/ha. On all treatments, the total accumulated tops growth for the defoliated plots was similar to the non-defoliated plots; i.e. defoliation did not reduce growth of the pasture. Defoliation reduced seed yield for treatments where tops on offer was reduced which suggests that flowers were being removed. A similar result was observed (cf Rossiter 1961; Collins and Aitken 1970; Collins 1978, 1981) for treatments which were strongly defoliated during flowering, though total tops growth was also reduced by defoliation in those experiments. For burr burying species such as subclover (as opposed to *Medicago* spp.), seed yield and harvest index better relate to total growth than forage on offer except when the defoliation technique removes significant numbers of flowers (Rossiter 1961).

When defoliation markedly reduced tops on offer, lower hard seed percentages were observed for the
defoliated treatments. This was possibly due to increased softening due to the lack of a protective surface cover (Quinlivan 1965).

**Maturity**

Cultivars of *Trifolium* species placed in increasing order of days to first flower, define the maturity grading for the species (Rossiter 1959). In this case, all the seed, burr and hard seed measurements decreased with increasing maturity. Harvest index also decreased markedly with maturity, indicating either a genetic difference in seed setting efficiency (unlikely, given the trend towards increasing seed set with maturity for spaced plants (Rossiter 1959)) or the effect of increasing water stress during critical seed setting stages of growth (Collins 1981). These sensitive stages of development for late flowering varieties, occur later in the season when water stress is liable to be more severe.

In this trial, burr number was the yield component most sensitive to maturity grading (data not presented) and was the yield component most sensitive to drought according to Collins (1981).

Peak dry matter and tops on offer increased in the order Northam < Mt Barker < Seaton Park for all but a couple of treatments (Table 1). The season terminated early so that water stress would have prevented the later flowering Mt Barker reaching its stress free, dry matter potential at a level higher than Seaton Park (eg. Dear and Loveland 1984). Slight decreases in total tops growth with increasing maturity grading have been recorded for sward experiments (Rossiter 1959; Yates 1961; Bolland 1990).

<table>
<thead>
<tr>
<th>Variety</th>
<th>P Seeding rate (fl day)</th>
<th>Peak growth (t/ha)</th>
<th>Seed yield (kg/ha)</th>
<th>Harvest Index (%)</th>
<th>Hard seed (kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Northam</td>
<td>10 5</td>
<td>0.8 0.8 0.9</td>
<td>80 50</td>
<td>10 10 5</td>
<td>54 31</td>
</tr>
<tr>
<td>(82)</td>
<td>160 100</td>
<td>2.7 2.8 2.8</td>
<td>530 360</td>
<td>20 20 20 20 19 19</td>
<td>32 45</td>
</tr>
<tr>
<td>Seaton Park</td>
<td>10 5</td>
<td>1.8 1.8 1.5</td>
<td>300 290</td>
<td>22 19 19 19 19 19</td>
<td>56 56</td>
</tr>
<tr>
<td>(102)</td>
<td>160 100</td>
<td>3.0 4.2 4.2</td>
<td>720 1170</td>
<td>24 17 28 37 37</td>
<td>54 54</td>
</tr>
<tr>
<td>Mt Barker</td>
<td>10 5</td>
<td>1.0 1.0 1.1</td>
<td>60 60</td>
<td>6 6 5</td>
<td>42 38</td>
</tr>
<tr>
<td>(122)</td>
<td>160 100</td>
<td>2.4 2.7 2.7</td>
<td>410 620</td>
<td>12 17 17 17 17 17</td>
<td>77 79</td>
</tr>
<tr>
<td></td>
<td>10 100</td>
<td>1.6 1.6 1.8</td>
<td>770 780</td>
<td>17 16 15 15 15 15</td>
<td>49 44</td>
</tr>
<tr>
<td></td>
<td>160 100</td>
<td>3.8 6.1 6.2</td>
<td>360 750</td>
<td>9 12 21 21 21 21</td>
<td>21 21</td>
</tr>
<tr>
<td>LSL (P &lt; 0.05)</td>
<td>0.35 114</td>
<td>2.6 6.2</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Phosphorus supply**

All dry matter and seed yields increased with increasing phosphorus supply except for Mt Barker seed yield at the high seeding rate. Mature burr number responses (data not presented) also increased with high phosphorus status except for Seaton Park and Mt Barker at high seeding rates.

Harvest index increased with increasing phosphorus at low seeding rates (probably because low ground cover on the low phosphorus treatments caused dry soil surface conditions resulting in poor burr
burial (Collins et al. 1976)). Harvest index decreased with phosphorus level at high seeding rates for the later flowering cultivars probably because the higher tops dry matter at high phosphorus levels induced water stress. The tendency for harvest index to increase with increasing phosphorus status for the early maturing cultivar, Northam, supports the proposition that water was not the limiting factor for the conversion of tops to seed at high levels of dry matter accumulation when flowering was early enough for subsequent rain to alleviate stress during seed set. Bolland (1990) showed only a slight effect of phosphorus on harvest index, with phosphorus increasing harvest index for late flowering cultivars and reducing harvest index for early maturing cultivars. Data from 3 other experiments (Bowden, unpublished) show a reduction in harvest index as phosphorus supply increases.

Hard seed percentage decreased as phosphorus supply increased in this experiment despite the higher dry matter cover on some of the treatments and is an unexpected result (Quinlivan 1971). However the yield of hard seed increased with phosphorus supply for most comparisons because of the large increases in seed yield.

Seeding rate

At low phosphorus status, increasing seeding rate increased all the measures shown in Table 1 for all cultivars. At high phosphorus status, tops growth increased with seeding rate but seed yield increases were less apparent, particularly for the late maturing cultivars. Harvest index therefore decreased with increasing density for all high phosphorus status treatments. The literature has varying findings on responses to increased seeding rate which depend on the site, season and management conditions of the experiments. Invariably dry matter production per hectare increases with density. Seed yield and harvest index were shown to increase initially but then decrease as density increased for both high and low phosphorus status (Bolland 1990). For early maturing cultivars, seed yield and harvest index increased while for late maturing cultivars seed yield and harvest index decreased as density increased (Rossiter 1959; Yates 1961). Seed yield increased with density for all levels of phosphorus, nitrogen and times of sowing for 2 years at Esperance (Quinlivan et al. 1973).

CONCLUSIONS

The results of the trial reported here, when set in the context of the existing literature, suggests that the relationship between seed production of subclover and various management practices is complex. A parameter which reflects water relations during seed set is harvest index.

There is a need for an integrating framework which covers all the major factors affecting seed production in subclover if better use is to be made of the wealth of information currently available. Rossiter (1966) has provided the conceptual framework but there is a need for a more quantitative approach. A model which can provide this framework and also allow predictions of the impact of seasonal conditions will have to have water supply as a key variable.

REFERENCES


