Nitrogen Fertilization of Meadowfoam

J. W. Johnson, M. B. Devine, R. Kleiman, and G. A. White

ABSTRACT

Limnanthes alba Benth. is a potential oil seed crop with unique long chain fatty acids. Information available on the fertility needs for meadowfoam is scarce. Therefore the effects of rate and time of application of N fertilization on seed yield, seed weight, protein, oil, winter survival, flowering date, plant height, and erectness of meadowfoam were studied in the field for 2 years in Maryland. Nitrogen as ammonium nitrate was applied on plots of two plant introductions at the rates of 0, 45, and 90 kg N/ha in fall (planting) or early spring. In 1976, N was also applied in both fall and spring. The seed yield of meadowfoam was decreased as much as 24% with the addition of 90 kg N/ha. Seed yield was linearly related to N application. For each 10 kg N/ha applied, the seed yield decreased approximately 3%. The time of N application had no significant effect on seed yield. Seed weight was not affected by rate or time of N application. The protein content of the seed was directly related to the rate of N applied with an increase of 1 and 3% for each 10 kg N/ha in PI 374790 and 374800, respectively. The combined fall and spring application of N resulted in a 5 and 10% increase in the protein content over the individual fall and spring application, respectively. The addition of 90 kg N/ha resulted in a 12% average reduction in the oil content of the seeds. The time of N application did not affect the oil content for either year. The correlation between seed weight and oil content was positive, r = 0.92 (at the 0.01 level). Increasing N fertilization resulted in insignificant decrease in seed yield and oil content but an increase in protein content.

Additional index words: Limnanthes alba, Seed yield, Protein content, Oil content.

MEADOWFOAM (Limnanthes R. Br.) is an oil seed crop adapted to the California and Oregon coasts (Gentry and Miller, 1965) and Maryland and Alaska (Higgins et al., 1971). It is of economic interest because the seeds contain unique long-chain fatty acids, fatty alcohols, and wax esters. The oil content of meadowfoam ranges from 20 to 35% and the protein content ranges from 15 to 25% depending on the species. High levels of lysine and methionine in seed meal also make meadowfoam advantageous as a high value supplement in animal feed. Agronomic evaluation of meadowfoam revealed that the species L. alba Benth. has potential as a new crop (Higgins et al., 1971). Devine and Johnson (1978) reported that L. alba was highly self-compatible and seed from cross-pollination could be easily obtained.

The information available on the cultural practices for meadowfoam is limited. However, studies have been conducted to determine the optimum planting dates, seeding rates, and the proper stage of maturity for harvest. Johnson et al. (1978) obtained seed yields as high as 1,460 kg/ha by harvesting 1 week before maturity. The highest oil content (26%) and seed weight were obtained by harvesting at maturity. Johnson et al. (1980) reported that good yields of meadowfoam could be obtained from early to middle October planting using at least 25 kg seed/ha. Oil content and seed weight were not affected by planting rates; however, these characters expressed a considerable amount of variation because of the planting dates. Higgins et al. (1971) also reported that an early October planting resulted in the highest average yield. This study was initiated to determine the effects of rate and time of N application on seed yield and other plant characters of meadowfoam.

MATERIALS AND METHODS

The field experiments were conducted in 1975 and 1976 at the plant research farm, Beltsville, Md., on a Beltsville silt loam (fine-loamy, mixed Mesic Typic Fragiudults). Seed was obtained from the Germplasm Resources Laboratory, SEA-FR, USDA, Beltsville, Maryland. Two Plant Introductions, PI’s 374790 and 374800 were selected on the basis of their yielding ability as demonstrated in a evaluation nursery. Meadowfoam was planted each year during the third week of October in six rows spaced 10 cm within a 3.0 m by 1.2 m area at a rate of 22 as ammonium nitrate was applied at the rates 45, 90, and 150 kg/ha in the fall (planting) or early spring. In 1976, was also fall and early spring. The seed yield of meadowfoam was decreased as much as 24% with the addition of 90 kg N/ha. Seed yield was linearly related to N application. For each 10 kg N/ha applied, the seed yield decreased approximately 3%. The time of N application had no significant effect on seed yield. Seed weight was not affected by rate or time of N application. The protein content of the seed was directly related to the rate of N applied with an increase of 1 and 3% for each 10 kg N/ha in PI 374790 and 374800, respectively. The combined fall and spring application of N resulted in a 5 and 10% increase in the protein content over the individual fall and spring application, respectively. The addition of 90 kg N/ha resulted in a 12% average reduction in the oil content of the seeds. The time of N application did not affect the oil content for either year. The correlation between seed weight and oil content was positive, r = 0.92 (at the 0.01 level). Increasing N fertilization resulted in insignificant decrease in seed yield and oil content but an increase in protein content.

RESULTS AND DISCUSSION

Highly significant differences between years were detected for seed yield, seed weight, protein content, and oil content. The interactions of year × entry, year × rate, and time × rate × year were only significant for seed yield and protein content. Therefore, the 2 years will be discussed separately unless a significant interaction was noted.
Table 1. Effect of rate and time of N application on agronomic characteristics of meadowfoam entries in 1975 and 1976.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Yield (kg/ha)</th>
<th>Seed weight (g/200)</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>PI 374790</td>
<td>794</td>
<td>1.08</td>
<td>22</td>
<td>28</td>
<td>81</td>
</tr>
<tr>
<td>PI 374800</td>
<td>561</td>
<td>0.92</td>
<td>24</td>
<td>25</td>
<td>70</td>
</tr>
<tr>
<td>L.S.D. 5%</td>
<td>153</td>
<td>0.10</td>
<td>1</td>
<td>1</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Time</th>
<th>Yield (kg/ha)</th>
<th>Seed weight (g/200)</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fall</td>
<td>657</td>
<td>0.99</td>
<td>23</td>
<td>26</td>
<td>74</td>
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<tr>
<td>Spring</td>
<td>698</td>
<td>1.01</td>
<td>24</td>
<td>26</td>
<td>78</td>
</tr>
<tr>
<td>Fall &amp; Spring</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Rate (kg/ha)</th>
<th>Yield (kg/ha)</th>
<th>Seed weight (g/200)</th>
<th>Protein (%)</th>
<th>Oil (%)</th>
<th>Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>799</td>
<td>1.02</td>
<td>23</td>
<td>28</td>
<td>86</td>
</tr>
<tr>
<td>45</td>
<td>624</td>
<td>1.00</td>
<td>24</td>
<td>26</td>
<td>78</td>
</tr>
<tr>
<td>90</td>
<td>612</td>
<td>0.98</td>
<td>25</td>
<td>25</td>
<td>64</td>
</tr>
<tr>
<td>L.S.D. 5%</td>
<td>96</td>
<td>NS</td>
<td>1</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

Seed and Seed Weight

Meadowfoam yields were significantly lowered by the application of N fertilizer (Table 1). In both years, a 90 kg N/ha application reduced seed yield by 24% and 45 kg N/ha reduced seed yield by 22% in 1975. Calhoun and Crane (1978) compared the application of ammonium nitrate and ammonium sulfate at rates of 56 and 112 kg/ha to the zero rate on Limnanthes. Total seed yield was not increased; however, N application of ammonium nitrate did increase seed yield over the application of ammonium sulfate. Similar results have been reported for other crops (Koli and Morrill, 1976).

As the rate of N increased, there was a significant decrease in seed yield ($r = -0.36^*$). The regression equations of seed yield ($Y$) on rate of N applied ($X$) were as follows:

PI 374790: $Y = 596.9 - 1.74X$, $r^2 = 0.68^*$
PI 374800: $Y = 562.1 - 1.35X$, $r^2 = 0.57^*$

Therefore, an application of 50 kg N/ha would result in a yield reduction of 15 and 12%, respectively, for PI 374790 and PI 374800, respectively. The time of application had no effect on seed yield. The rate and time of N application had no effect on seed weight. The seed weight of PI 374790 was approximately 14% higher than PI 374800 in both years.

Protein Content

The protein content of the seed was significantly correlated to the rate of N application ($r = 0.43^{*!*}$). The regression equations relating protein content ($P$) to N rate ($X$) were:

PI 374790: $P = 21.4 + 0.02X$, $r^2 = 0.56^{*!*}$
PI 374800: $P = 22.1 + 0.07X$, $r^2 = 0.52^{*!*}$

The percentage of protein in PI 374790 increased 1% for each 10.5 kg N/ha increase and 3.2 kg N/ha in PI 374800. The protein content of seed samples from the plots receiving N at the 90 kg/ha rate was approximately 9% higher than samples from plots receiving no N. No entry $\times$ rate interaction occurred indicating entries responded similar to N rates.

The protein content of meadowfoam decreased with an increase in N application. The correlations between protein content and seed yield and weight were negative and highly significant ($r = -0.51^{*!*}$ and $r = -0.49^{*!*}$, respectively). The regression equation of seed yield ($Y$) on protein content ($P$) was $Y = 596.9 - 153.5P$, $r^2 = 0.69^{*!*}$ for PI 374790. In 1976, the combined fall and spring application of N resulted in an increase in the protein content. The combined application exceeded the individual fall and spring application by 5% and 10%, respectively. As the protein content of the seed increased, there was significant decrease in the oil content ($r = -0.44^*$). Thus, the application of N results in an increase of protein while causing a decrease in oil content.

Oil Content

Oil content of the seed decreased significantly with the addition of 90 kg N/ha in 1975 and 45 and 90 kg N/ha in 1976. At the 90 kg/ha rate, the oil content was reduced 9% and 16% over the control in 1975 and 1976, respectively. The linear regression of oil content ($O$) on rate of N applied ($X$) accounted for 90% of the variation in PI 374790 and 87% in PI 374800. The linear equations were as follows:

PI 374790: $O = 23.2 - 0.07X$, $r^2 = 0.90^{*!*}$
PI 374800: $O = 20.7 - 0.05X$, $r^2 = 0.87^{*!*}$

The time of N application did not affect the oil content in either year. The entries differed significantly for seed oil content; PI 374790 averaged 26% oil which was 10% higher oil content than PI 374800. Although seed weight was not affected by the increase in N rates, the correlation between seed weight and oil content was $r = 0.92^{*!*}$.

Plant Characteristic

Winter survival of plants was affected by the rates of N application. The 90 kg/ha application caused a significant decrease in plant survival in both years.
However, survival did not differ for time of application or entry. The reason for the decrease in plant survival with high rate of N is not apparent. Since no time X rate interaction occurred for winter survival, the winter survival must have responded similarly at the different times of application. The higher N rates may have resulted in fertilizer injury to seedlings.

Calhoun and Crane (1978) observed a more upright growth habit and dense vegetation mass with an increase in N fertilization. We did not observe an increase in plant height (12 cm) or plant erectness with an increase in N fertilization at any time of application. However, plants from the N-applied plots did flower 2 or 3 days later than plants from the control plots. Plant height of PI 374790 was significantly higher than for PI 374800, 13 vs 10 cm, respectively.

In summary, N application of 90 kg/ha reduced seed yield and oil content of meadowfoam significantly whereas the protein content of the seed was increased. The time of N applications had no significant effect on any of the characters measured, except protein content. Information is needed on the effects and sources of N fertilization on yield and plant characteristics of meadowfoam.

LITERATURE CITED


Cotton Production Affected by Row Profile and N Rates

C. H. Harris and C. Wayne Smith

ABSTRACT

Cotton (Gossypium hirsutum L.) production in the Delta of Arkansas requires 150+ days from planting to final harvest. The evolved system for growing cotton includes planting on raised beds with N applied preplant into or under the bed. Maturity delays and associated yield reductions in recent years may have been related to this system. A study was initiated in 1975 to compare four genotypes grown in flat or bedded seedbeds with twice the recommended rate of N and half the recommended rate in order to evaluate the role of salts on seed-cotton yield and earliness. The four genotypes represented a range of genetic maturity. A split-block, split-plot arrangement of a randomized complete block was utilized and the test site was Calloway silt loam, a fine-silty mixed, thermic alfisol, located on the Cotton Branch Experiment Station, Marianna, Ark.

Observations confirmed the surface drainage advantage of raised seedbeds. Otherwise, row profile contrasts had no effect on yield during any year, and we found no evidence that nitrate salts became concentrated in raised seedbeds, discounting the suggestion that increase in these salts resulted from the raised beds and thus directly delayed maturity.

The 134 kg/ha rate of N resulted in higher seedcotton yields than did 34 kg/ha but also delayed maturity as indicated by percent first pick, regardless of row profile. Aborted terminals were shown not to be the cause of delayed maturity with the high rate of N. Genotypes responded to the effects of contour and N equally as indicated by the lack of significant interactions.

Additional index words: Genotypes, Aborted terminals, Earliness, Gossypium hirsutum L.

COTTON (Gossypium hirsutum L.) yields well in the Mississippi River Delta during years of long, warm summers with adequate sunshine and moisture. Summer droughts have a significant effect upon crop growth and development, but unless the drought is extremely severe and long, the indeterminate growth habit of cotton will allow for normal yields, assuming that the moisture stress is removed early enough that sufficient growing season remains.

Delta producers must content also with late spring rains, which delay plantings, and early autumn rain, which may result in boll rot, delayed maturity, and decreased yields. Early and late rain and cloudy weather are not uncommon and therefore producers desire earlier maturing genotypes and/or cultural practices which will decrease the number of days required from planting to harvest.

Cotton has traditionally been planted on “beds” in the rainbelt section of the cotton-producing area. These beds are raised mounds of soil formed into rows by tillage implements and the beds aid stand establishment in two ways. First, during dry springs they allow the producer to remove or “knock-off” the top portion of the bed and place the seed into moist soil, and secondly, excess water from spring rains will drain away from the germinating seed and seedlings.

As early as 1954, researchers were aware that too much N fertilizer could result in excess vegetation and delayed maturity (1). Maples and Keogh (3, 4, 5) have measured or monitored the movement of N salts in Arkansas Delta soils since the mid 1950’s and have found that nitrates accumulate in the soil profile and move within that profile with the wetting front. Ma-

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