

the florets during pollination and early seed development. If such an effect were significant, this would be an apparent trade-off with the beneficial effect of higher plant density which increases overall seed yield. More detailed investigation is needed to determine whether the timing of anthesis can be modified to significantly alter seed set.

The results of this study show that close spacings of onion bulbs planted for seed production by the bulb to seed method are necessary to maximize seed production per unit of area. Since the number of scapes produced per bulb is unaffected by spacing, there is no advantage from wider plant spacing. This confirms much of the standard practices used in industry today. However, even higher populations may be more advantageous for facilitating mechanical harvest by reducing lodging and centralizing the positioning of umbels within the canopy.

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Investigations on the Interaction Between Level of Nitrogen Application in the Autumn and Time of Nitrogen Application in the Spring to Various Grasses Grown for Seed

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ABSTRACT

In 1979-84 studies were conducted on several grass species to study the effect of time of spring nitrogen, 50 and 100 kg N ha⁻¹, combined with 0 and 50 kg ha⁻¹ in the autumn on seed production.

In all species studied, except Italian ryegrass (*Lolium multiflorum*), a delayed spring nitrogen application reduced the number of fertile tillers per unit area, regardless of the level of autumn nitrogen application. With Kentucky bluegrass (*Poa pratensis*), red fescue (*Festuca rubra*), and cocksfoot (*Dactylis glomerata*) the delay also resulted in reduced seed yield. The reduction was especially great where no nitrogen was applied in the autumn. With meadow fescue (*Festuca pratensis*) the late nitrogen application caused a significant decrease in seed yield if no nitrogen had been given in the autumn, but no decrease if the

opposite was the case. The seed yield of Italian ryegrass was not influenced by the time of spring nitrogen application. With timothy (*Phleum pratense*) a delay caused an increased seed yield in all cases. A delay in nitrogen application resulted in an increased seed weight and an increased number of seeds per fertile tiller, except in Italian ryegrass.

The later spring nitrogen application is delayed, the greater the positive effect of a nitrogen application in the autumn. On the contrary, the influence of increasing the nitrogen rate in the spring from 50 to 100 kg ha⁻¹ declined the later the nitrogen was applied. When producing seed of Kentucky bluegrass, red fescue and cocksfoot under Danish conditions it is recommended to apply nitrogen at the beginning of March as soon as it is possible to drive on the ground without risk of damaging the grass. An early application is especially important if the grass was under-supplied with nitrogen in the autumn. For meadow fescue, perennial ryegrass, and Italian ryegrass it is recommended that nitrogen be applied at the first of April and at the end of April for timothy.

Additional index words: seed production, Kentucky bluegrass, red fescue, cocksfoot, meadow fescue, timothy, Italian ryegrass

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INTRODUCTION

A series of trials were conducted in Denmark during 1970-80 on several grass species grown for seed to investigate the effect of the time of spring nitrogen application (Nordestgaard 1979, 1980, 1981a, 1981b, 1983). These trials were carried on grasses optimally fertilized in the autumn before the year of experimentation. Further trials were carried out during 1979-84 to investigate the effect of the time of spring applied nitrogen changed if the grass was under-supplied with nitrogen from the previous autumn.

MATERIALS AND METHODS

The trials were conducted at the Government Research Stations using a factorial plan with 12 combinations, each in two replications.

Factor 1

- a. 0 N in autumn
- b. 50 kg N ha⁻¹ in autumn

Factor 2

- a. 50 kg N ha⁻¹ in spring
- b. 100 kg N ha⁻¹ in spring

Factor 3

- a. Application when ground is free of snow and thawed to 5 cm depth, not earlier than 15 February.
- b. Application when grass becomes green and with tillers about 5 cm long, not earlier than 22 March or two weeks later than a.
- c. Application when new tillers are 15-20 cm long, not earlier than 15 April or two weeks later than b.

All grasses were undersown in a cover crop to which moderate seed rates and nitrogen rates were applied. Cover crops for Kentucky bluegrass (*Poa pratensis*) were spring barley, winter wheat or winter barley; for the other grasses only spring barley was used. The grass was sown immediately after the cover crop on 12 cm row spacing. The cultivar and seed rate of grasses as well as the number of trials with each cultivar is shown in Table 2.

In Italian ryegrass (*Lolium multiflorum*), trials were carried out in the first seeding year. In other species, studies were conducted in first, second, and third seed crop years. The effect of the experimental treatment and the interaction did not depend on the age of the seed crop, therefore only the averages of all trials are included in the results. Consequently the 22 Kentucky bluegrass trials included ten from the first, nine from the second, and three from the third seed crop years.

Autumn application was of calcium ammonium nitrate broadcast in late September. The timing of spring application was the same for all grasses but depended on the earliness of the spring (Table 1). The species and cultivars studied, seeding rate, and other experimental conditions are shown in Table 2.

The grass was laid in swaths when the seeds began to fall. After drying in the swaths the crop was threshed with a combine. The number of fertile tillers was counted on a 0.25 m² plot taken at full ear emergence.

Table 1. Date of nitrogen application, average.

Year	Treatment		
	a	b	c
1979	15/3 ¹	9/4	7/5
1980	13/3	8/4	6/5
1981	18/3	10/4	2/5
1982	8/3	30/3	26/4
1983	4/3	6/4	1/5
1984	1/3	8/4	28/4

¹Day/month

Table 2. Cultivars, seed rates and number of trials.

Species	Cultivar	Seed Rate	Year of Seed Prod.	No. of Trials
Kentucky bluegrass (<i>Poa pratensis</i>)	Erte	7	1st-3rd	22
Kentucky bluegrass (<i>Poa pratensis</i>)	Trampas	7	1st-3rd	10
Red fescue (<i>Festuca rubra</i>)	Rubina	7-8	1st-3rd	20
Red fescue (<i>F. rubra</i> spp. <i>commutata</i>)	Veni	7-8	1st-3rd	16
Cocksfoot (<i>Dactylis glomerata</i>)	Hera	4	1st-3rd	12
Meadow fescue (<i>Festuca pratensis</i>)	Senu	6	1st-3rd	5
Timothy (<i>Phleum pratense</i>)	Topas	3	1st-3rd	16
Italian ryegrass (<i>Lolium multiflorum</i>)	Prego (2n)	8-11	1st	8
Italian ryegrass (<i>Lolium multiflorum</i>)	Bofur (4n)	14-21	1st	6

RESULTS

Seed Yield

The average seed yield for the individual grass species and cultivars are shown (Table 3). The Kentucky bluegrass, red fescue, cocksfoot (*Dactylis glomerata*) and meadow fescue (*Festuca pratensis*) combinations with 50 kg N ha⁻¹ in the autumn yielded considerably better than corresponding combinations with no nitrogen.

The positive autumn nitrogen effect was greatest where only 50 kg N ha⁻¹ was applied in the spring. The response increased the later nitrogen was applied in the spring. Combinations with total nitrogen of 100 kg N ha⁻¹ per year can be compared with the columns 0 + 100 kg N ha⁻¹ and 50 + 50 kg N ha⁻¹, in the autumn and spring, respectively (Table 3). In Kentucky bluegrass, red fescue and meadow fescue the combination 50 + 50 kg N ha⁻¹ produced a larger seed yield than 0 + 100 kg N ha⁻¹. The difference increased when the spring application was delayed.

In cocksfoot, the combination 0 + 100 kg N ha⁻¹ resulted in the largest seed yield after the early spring application and smallest after the later application.

In Italian ryegrass, 0 + 100 kg N ha⁻¹ gave a better seed yield than 50 + 50 kg N ha⁻¹.

An autumn nitrogen dressing did not increase the seed yield of timothy (*Phleum pratense*).

The effect of a higher nitrogen rate in the spring as well as the effect of the application time were influenced by the level of nitrogen applied in the autumn. The additional yield from an increase in the spring nitrogen was larger for 0 than for 50 kg N ha⁻¹ in the autumn. In the Kentucky bluegrass cv. Trampas and red fescue cv. Veni the increase in the spring applied nitrogen did not bring about any additional yield if 50 kg N ha⁻¹ had been applied in the autumn. The mentioned additional yield decreased in most grasses in case of a delayed application.

Delaying the spring nitrogen application caused a considerable decrease in the seed yield in Kentucky bluegrass, red fescue and cocksfoot. The decrease was the greatest where no nitrogen was applied in the autumn and, in addition, it was greater after 100 kg N ha⁻¹ in the spring than after 50. The late application also gave a significant decrease in meadow fescue seed yield in the plots which had not been fertilized in the autumn. On the contrary the delay, regardless of the nitrogen level in the autumn, brought about an increased seed yield of timothy cv. topas. In Italian ryegrass the early application tended to give the smallest seed yield.

Population of fertile tillers

The autumn nitrogen dressing in most grasses had a marked positive effect on the number of fertile tillers per unit area (Table 4). All treatment combinations with 50 kg N ha⁻¹ in the autumn produced, in all grasses except Italian ryegrass, a considerably larger number of fertile tillers per unit area than the corresponding combinations which included no nitrogen in the autumn. Contrary to the seed yield response, this positive effect depended very little on the amount of nitrogen applied in the spring or on the time of application.

A comparison of the 0 + 100 kg N ha⁻¹ with 50 + 50 kg N ha⁻¹, in the autumn and spring, respectively, could be made with the number of fertile tillers (Table 4) as with seed yield (Table 3). Splitting the yearly nitrogen amount of 100 kg N ha⁻¹ into 50 kg in the autumn and 50 kg in the early spring gave, except in Italian ryegrass, a far greater number of fertile tillers per unit area than if all the nitrogen had been applied in the spring.

Except for Italian ryegrass, delaying the spring nitrogen application reduced the number of fertile tillers per unit area and depended very little on the nitrogen level in autumn as well as in spring.

Seed weight

Seed weight was generally not affected by the nitrogen rates. The autumn dressings caused a minor reduction in most grasses and the extra spring rate increased the seed weight in red fescue cv. Rubina, meadow fescue cv. Senu and Italian ryegrass. Delaying the nitrogen application in the spring, in most cases, increased the seed weight (Table 5).

Number of seeds per fertile tiller

The number of seeds per fertile tiller has been calculated, based on seed yield, the number of fertile tillers m⁻² and seed weight. The main effect is shown in Table 5. The autumn

nitrogen dressing reduced the number of seeds per fertile tiller except in Kentucky bluegrass cv. Trampas and Italian ryegrass. An increase of the nitrogen rate in the spring from 50 to 100 kg ha⁻¹ increased the number in Kentucky bluegrass cv. Trampas, cocksfoot, timothy and Italian ryegrass. In the other species and cultivars an increase in the spring nitrogen had no significant effect.

Delaying the date of the nitrogen application increased the number significantly in Kentucky bluegrass cv. Erte, red fescue cv. Veni, cocksfoot and timothy. This was not the case in the other species and cultivars.

Lodging

Increased nitrogen in both autumn and spring increased lodging (Table 5). Delaying application in the spring increased the lodging in all cultivars of Kentucky bluegrass, red fescue, meadow fescue and Italian ryegrass. The opposite effect was observed in cocksfoot. Lodging was most severe in timothy for the medium application time.

Secondary vegetative tillering

In some trials with heavy lodging secondary tillering was observed before swathing. A nitrogen dressing both in autumn and spring increased the secondary tillering, being greatest with the spring application (Table 5). A delayed nitrogen application in the spring also increased the secondary tillering; the late application caused a severe increase.

DISCUSSION

The yield decrease from a delayed spring nitrogen application was greater in Kentucky bluegrass, red fescue, and cocksfoot where no nitrogen had been applied in the autumn than with a 50 kg N ha⁻¹ application (Table 3). In meadow fescue, where in previous trials delayed nitrogen application did not result in any yield decrease (Nordestgaard 1981a), a significant reduction of seed yield was observed after the late application if no nitrogen had been applied in the autumn. In timothy the additional yield caused by delaying the nitrogen application until late April did not depend on the nitrogen level in the autumn.

In order to illustrate the effect of application on the seed yield and its components — a number of fertile tillers per unit area, seed weight and number of seeds per fertile tiller — graphs have been made for representative cultivars (Figs. 1, 2 and 3) showing the effect of altering the time of spring nitrogen application. Curves are shown for all nitrogen combinations (0 + 50, 0 + 100, 50 + 50, 50 + 100 kg N ha⁻¹ applied in autumn and spring, respectively). Curves for Kentucky bluegrass cv. Trampas, red fescue cv. Veni, and Italian ryegrass cv. Bofur are not shown because the effect of time of application is similar to the cultivars of the respective species shown.

In Kentucky bluegrass, red fescue, cocksfoot, and meadow fescue seed yield and number of fertile tillers m⁻² was markedly higher for combinations with 50 kg N in the autumn than for combinations without nitrogen; for the number of seeds per fertile tiller the opposite was true, while seed weight was mostly unaffected by the autumn fertilization.

In timothy cv Topas, the number of fertile tillers m⁻² was the highest for autumn application of 50 kg nitrogen; this was

Table 3. Seed yield, kg ha⁻¹ (12% moisture) and mean.

Date of N-appli- cation (Mean)	N, autumn (kg ha ⁻¹)	0			50			Mean		
		N, spring (kg ha ⁻¹)	50	100	Mean	50	100	Mean	50	100
Kentucky bluegrass (<i>Poa pratensis</i>), Erte, 22 trials										
(mo/da)										
3/6		810	960	880a	1000	1040	1020a	900	1000	950a
4/5		770	880	830b	980	1000	990b	870	940	910a
4/29		690	780	740c	890	940	920c	790	860	830c
Mean		760b	880a		960b	990a		860b	940a	
Kentucky bluegrass (<i>Poa pratensis</i>), Trampas, 10 trials										
3/6		550	630	590a	710	690	700a	630	660	640a
4/4		510	590	550b	690	670	680a	600	630	620a
4/29		470	530	500c	650	600	620b	560	560	560b
Mean		510b	580a		680a	650a		600a	620a	
Red fescue (<i>Festuca rubra</i>), Rubina, 20 trials										
3/9		1000	1220	1060a	1130	1230	1180a	1060	1170	1120a
4/6		950	1050	1000b	1100	1150	1120b	1020	1100	1060b
5/1		880	950	910c	1040	1050	1050c	960	1000	980c
Mean		940b	1040a		1090b	1140a		1020b	1090a	
Red fescue (<i>Festuca rubra</i>, spp. <i>commutata</i>), Veni, 16 trials										
3/8		1050	1140	1090a	1180	1150	1170a	1110	1150	1130a
4/6		980	1090	1030b	1130	1100	1120b	1060	1100	1080b
4/30		920	990	950c	1100	1070	1080c	1010	1030	1020c
Mean		980b	1080a		1140a	1110a		1060b	1090a	
Cocksfoot (<i>Dactylis glomerata</i>), Hera, 12 trials										
3/11		950	1220	1080a	1160	1310	1230a	1050	1270	1160a
4/4		900	1140	1020b	1120	1270	1200b	1010	1210	1110b
4/30		820	980	900c	1090	1200	1150c	960	1090	1020c
Mean		890b	1110a		1120b	1260a		1010b	1190a	
Meadow fescue (<i>Festuca pratensis</i>), Senu, 5 trials										
3/9		1030	1110	1070ab	1170	1220	1200a	1100	1170	1130a
4/5		1000	1160	1080a	1160	1220	1190a	1080	1190	1130a
4/30		1020	1090	1050b	1160	1240	1200a	1090	1160	1130a
Mean		1010b	1120a		1160a	1230a		1090b	1170a	
Timothy (<i>Phleum pratense</i>), Topas, 16 trials										
3/9		690	760	720c	690	710	700c	690	730	710c
4/6		720	790	750b	710	750	730b	720	770	740b
4/30		740	820	780a	750	780	770a	750	800	770a
Mean		720b	790a		720b	750a		720b	770a	
Italian ryegrass (<i>Lolium multiflorum</i>), Prego, 2n, 8 trials										
2/6		1660	1850	1750b	1750	1890	1820a	1700	1870	1780a
4/6		1700	1850	1770ab	1740	1890	1820a	1720	1870	1800a
4/29		1690	1890	1790a	1790	1860	1820a	1740	1870	1800a
Mean		1680b	1860a		1760b	1880a		1720b	1870a	
Italian ryegrass (<i>Lolium multiflorum</i>), Bofur, 4 n, 6 trials										
3/6		1830	2120	1970a	2070	2080	2070a	1950	2100	2020a
4/6		1860	2180	2020a	2080	2180	2130a	1970	2180	2080a
4/29		1880	2120	2000a	2080	2210	2150a	1980	2170	2070a
Mean		1860b	2140a		2080b	2160a		1970b	2150a	

Mean figures with different letters indicate significance at the 5% level.

Table 4. Mean number of fertile tillers m⁻².

Date of N-appli- cation (Mean)	N, autumn (kg ha ⁻¹)	0			50			Mean		
		N, spring (kg ha ⁻¹)	50	100	Mean	50	100	Mean	50	100
(mo/da)		Kentucky bluegrass (<i>Poa pratensis</i>), Erte, 22 trials								
3/6		1341	1432	1386a	1777	1983	1880a	1559	1708	1633a
4/5		1037	1150	1093b	1589	1792	1691b	1313	1471	1392b
4/29		957	942	949c	1418	1494	1456c	1188	1218	1203c
Mean		1111b	1175a		1595b	1756a		1353b	1466a	
		Kentucky bluegrass (<i>Poa pratensis</i>), Trampas, 10 trials								
3/6		1631	1787	1709a	2239	1965	2102a	1935	1876	1905a
4/4		1455	1491	1473b	2020	1895	1957a	1738	1693	1715b
4/29		1435	1388	1412b	1924	1646	1785b	1680	1517	1598c
Mean		1507a	1555a		2061a	1835b		1784a	1695a	
		Red fescue (<i>Festuca rubra</i>), Rubina, 20 trials								
3/9		2178	2290	2234a	3048	3018	3033a	2613	2654	2633a
4/6		1945	1980	1963b	2797	2770	2783b	2371	2375	2373b
5/1		1800	1760	1780c	2550	2500	2525c	2175	2130	2152c
Mean		1974a	2010a		2798a	2762a		2386a	2386a	
		Red fescue (<i>Festuca rubra</i>, spp. <i>commutata</i>), Veni, 16 trials								
3/8		3241	3612	3427a	3855	4028	3941a	3548	3820	3684a
4/6		2981	3224	3103b	3580	3609	3594b	3281	3416	3349b
4/30		2568	2747	2657c	3301	3219	3260c	2934	2983	2958c
Mean		2930b	3194a		3579a	3618a		3254b	3406a	
		Cocksfoot (<i>Dactylis glomerata</i>), Hera, 12 trials								
3/11		661	744	702a	917	870	893a	789	807	798a
4/4		599	644	622b	774	799	786b	686	722	704b
4/30		483	486	484c	730	716	723c	607	601	604c
Mean		581b	625a		807a	795a		694a	710a	
		Meadow fescue (<i>Festuca pratensis</i>), Senu, 5 trials								
3/9		1425	1601	1513a	1866	1839	1852a	1645	1720	1683a
4/5		1344	1453	1398ab	1732	1772	1752ab	1538	1613	1575ab
4/30		1351	1248	1299b	1726	1642	1684b	1538	1445	1492b
Mean		1373a	1434a		1775a	1751a		1574a	1593a	
		Timothy (<i>Phleum pratense</i>), Topas, 16 trials								
3/9		843	901	872a	999	954	977a	921	927	924a
4/6		879	858	869a	1025	925	975a	952	892	922a
4/30		814	748	891b	911	915	913b	863	832	847b
Mean		845a	836a		978a	931b		912a	884a	
		Italian ryegrass (<i>Lolium multiflorum</i>), Prego, 2n, 8 trials								
3/6		1545	1504	1524a	1582	1449	1515a	1563	1476	1520a
4/6		1492	1512	1502a	1536	1464	1500a	1514	1488	1501a
4/29		1539	1630	1585b	1550	1582	1566b	1545	1606	1575a
Mean		1525a	1549a		1556a	1498a		1540a	1523a	
		Italian ryegrass (<i>Lolium multiflorum</i>), Bofur, 4n, 6 trials								
3/6		1057	1095	1076b	1175	1047	1111a	1116	1071	1094b
4/6		1022	1110	1066b	1149	1153	1151a	1086	1131	1108b
4/29		1205	1179	1192a	1122	1207	1164a	1163	1193	1178a
Mean		1094a	1128a		1149a	1136a		1122a	1132a	

Mean figures with different letters indicate significance at the 5% level.

Table 5. Seed weight, number of seeds per fertile tiller, score for lodging and for secondary vegetative tillering before harvest. Main effect.

Species	Cultivar	No. of trials	kg N ha ⁻¹						Time of N-application ¹		
			Autumn		Spring					a	b
			0	50	50	100					
Seed weight, mg											
Kentucky bluegrass	Erte	22	0.35a	0.34b	0.35a	0.35a	0.34c	0.35b	0.36a		
Kentucky bluegrass	Trampas	10	0.43a	0.42b	0.42a	0.42a	0.41c	0.42b	0.44a		
Red fescue	Rubina	20	1.33a	1.31b	1.30b	1.34a	1.28c	1.32b	1.36a		
Red fescue	Veni	16	1.01a	1.00a	1.00a	1.01a	0.99c	1.00b	1.03a		
Cocksfoot	Hera	12	1.09a	1.06b	1.08a	1.07a	1.05b	1.06b	1.10a		
Meadow fescue	Senu	5	1.81a	1.81a	1.77b	1.85a	1.74c	1.79b	1.90a		
Timothy	Topas	16	0.43a	0.40b	0.41a	0.41a	0.41b	0.41b	0.42a		
Italian ryegrass	Prego, 2n	8	2.29a	2.28a	2.25b	2.32a	2.27b	2.31a	2.28b		
Italian ryegrass	Bofur, 4n	6	3.55a	3.54a	3.52a	3.57a	3.53a	3.55a	3.55a		
Number of seeds per fertile tiller											
Kentucky bluegrass	Erte	22	227a	191b	208a	210a	191b	211a	225a		
Kentucky bluegrass	Trampas	10	94a	94a	90b	98a	97a	96a	90a		
Red fescue	Rubina	20	40a	33b	36a	37a	36a	37a	37a		
Red fescue	Veni	16	35a	33a	34a	33a	32b	34ab	35a		
Cocksfoot	Hera	12	159a	147b	143b	164a	142b	156a	161a		
Meadow fescue	Senu	5	43a	38b	41a	41a	40a	41a	42a		
Timothy	Topas	16	222a	203b	200b	224a	201b	208b	227a		
Italian ryegrass	Prego, 2n	8	52b	55a	51b	56a	54a	54a	52a		
Italian ryegrass	Bofur, 4n	6	52b	54a	51b	55a	54a	55a	51b		
Score for lodging before harvest ²											
Kentucky bluegrass	Erte	20	2.9b	4.4a	2.3b	5.0a	2.9c	3.6b	4.4a		
Kentucky bluegrass	Trampas	2	0.2b	1.9a	0.2b	1.9a	0.9a	0.8a	1.4a		
Red fescue	Rubina	20	6.1b	7.2a	5.4b	7.9a	6.1c	6.6b	7.2a		
Red fescue	Veni	16	5.9b	7.1a	5.6b	7.4a	6.2c	6.5b	6.9a		
Cocksfoot	Hera	12	2.1b	4.4a	2.0b	4.5a	3.5a	3.3ab	3.0b		
Meadow fescue	Senu	5	4.6b	6.6a	4.5b	6.7a	5.4a	5.5a	5.9a		
Timothy	Topas	15	3.9b	5.4a	3.7b	5.6a	4.5b	4.9a	4.5b		
Italian ryegrass	Prego, 2n	8	7.8b	8.1a	7.9b	8.0a	7.7c	8.0b	8.2a		
Italian ryegrass	Bofur, 4n	6	7.5b	8.0a	7.3b	8.1a	7.3b	7.8a	8.2a		
Score for vegetative tillering before harvest ³											
Kentucky bluegrass	Erte	3	1.0a	1.3a	0.3b	2.0a	0.6b	0.8b	2.0a		
Red fescue	Rubina	10	1.4b	1.7a	0.6b	2.5a	1.1c	1.4b	2.1a		
Red fescue	Veni	6	1.2b	1.8a	0.7b	2.3a	1.0c	1.4b	2.1a		
Meadow fescue	Senu	2	0.6b	1.3a	0.4b	1.5a	0.6b	0.7b	1.5a		
Italian ryegrass	Prego, 2n	2	2.1a	2.8a	1.3b	3.5a	2.0a	2.5a	2.8a		
Italian ryegrass	Bofur, 4n	1	1.0b	2.1a	0.5b	2.6a	1.4a	1.5a	1.8a		

¹ Time of application - See factor 3 in Methods

² 0-10; 0 = no lodging, 10 = total lodging

³ 0-10; 0 = no secondary vegetative tillering, 10 = heavy s. v. t.

not the case for seed yield. For the combination 0 + 100 kg nitrogen the seed yield was considerably higher than those brought about by 50 + 50 and 50 + 100 kg nitrogen. As in the other grasses, the number of seeds per fertile tiller was the smallest where nitrogen had been applied in the autumn and in timothy this also gave the lowest seed weight. In Italian ryegrass the only factor that affected seed yield and its components was to alter the spring nitrogen rate from 50 to 100 kg ha⁻¹.

The declining seed yield from delaying the nitrogen application in Kentucky bluegrass, red fescue and cocksfoot is more severe with 0 than with 50 kg applied in the autumn, therefore, it is demonstrated that the best effect of autumn nitrogen is when it is combined with the late spring applica-

tion. On the other hand, the yield components show that there is little difference if 0 or 50 kg N ha⁻¹ is applied in the autumn.

As in the tables, combinations with a total nitrogen amount of 100 kg ha⁻¹ can be compared using the two middle sets of curves (0 + 100 and 50 + 50 kg N ha⁻¹, respectively). In all grasses, except Italian ryegrass, the combination 50 + 50 kg N ha⁻¹ brings about markedly more fertile tillers than 0 + 100 kg N ha⁻¹ and that delaying the application for both combinations results in a decrease. These results emphasize the great importance of an autumn dressing for the formation of fertile tillers in these grasses.

In Kentucky bluegrass, red fescue and to some extent in meadow fescue, the yield was greater for 50 + 50 kg nitrogen than for 0 + 100 kg. The difference becomes greater when the

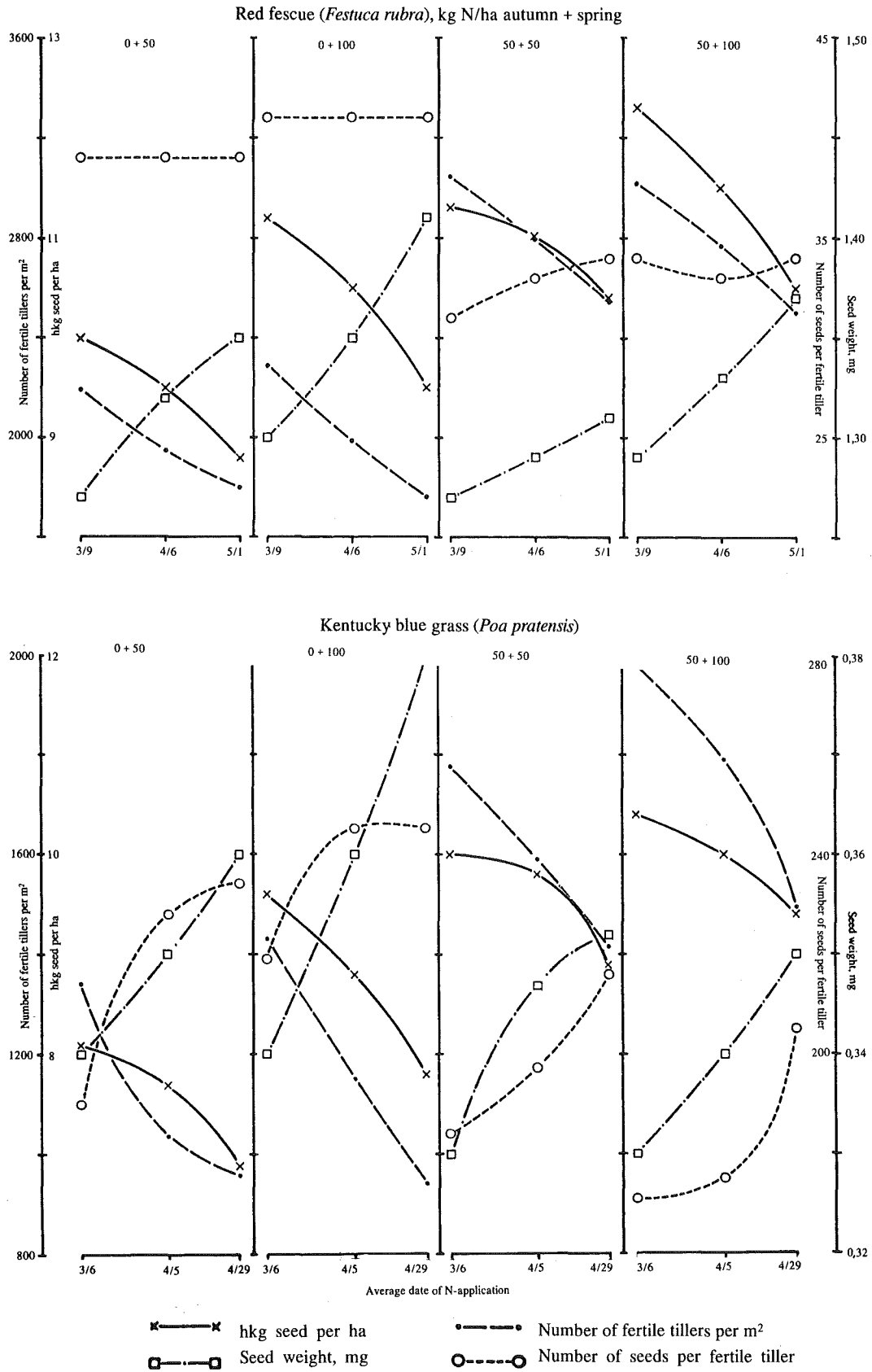


Figure 1. Influence of time of nitrogen application on the seed yield and the yield components: number of fertile tillers per m², seed per fertile tiller in red fescue Rubina and Kentucky blue grass Erte.

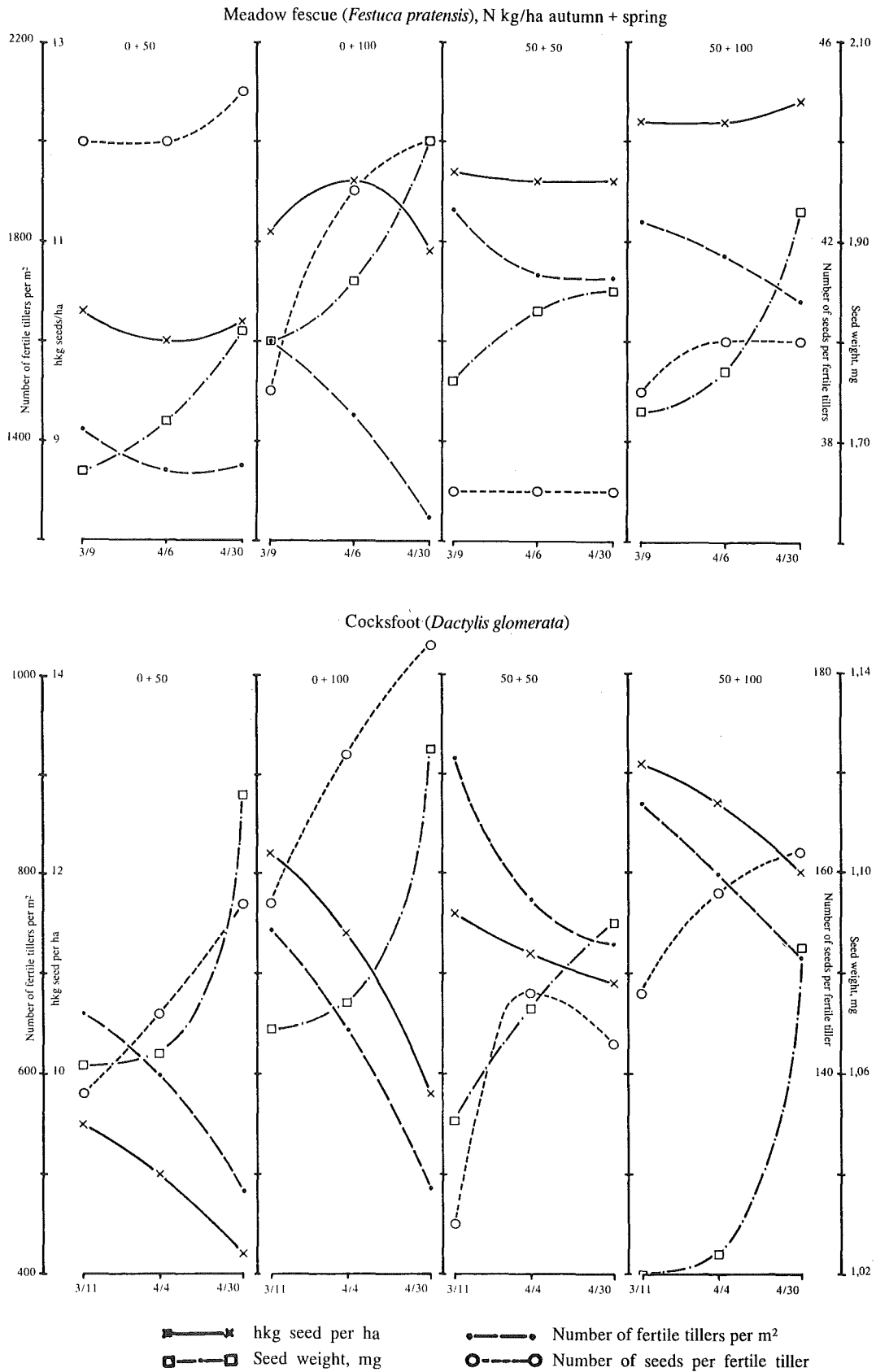


Figure 2. Influence of time of nitrogen application on the seed yield and the yield components: number of fertile tillers per m², seed per fertile tiller in meadow fescue and cocksfoot.

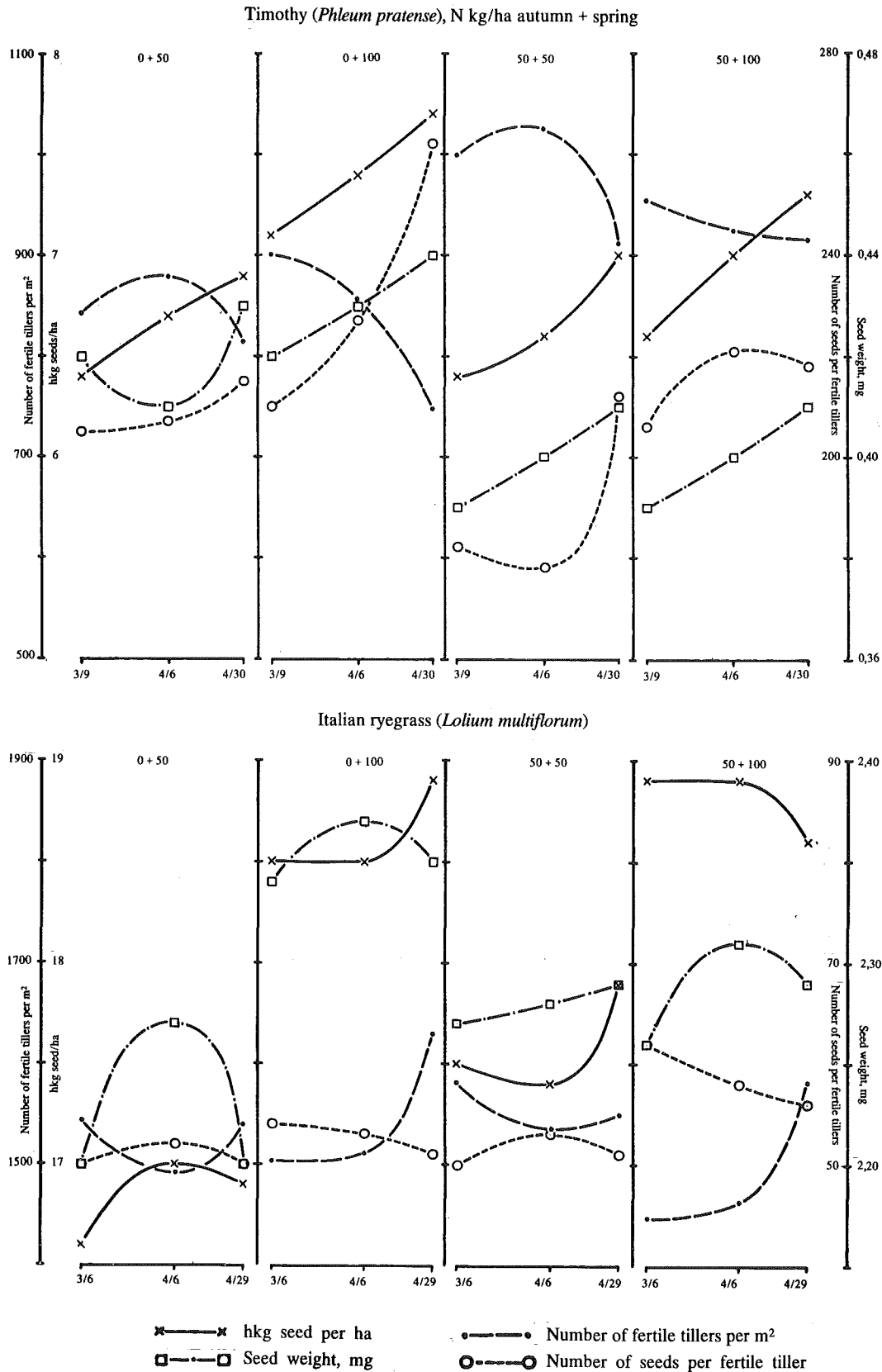


Figure 3. Influence of time of nitrogen application on the seed yield and the yield components: number of fertile tillers per m², seed per fertile tiller in Timothy Topa and Italian rye grass Prego.

spring application is delayed. Cocksfoot given 50 + 50 kg nitrogen yielded least after the first application but most after the final one. In timothy and Italian ryegrass 0 + 100 kg gave a considerably higher yield than 50 + 50 kg, regardless of the time of application.

Even if in meadow fescue a lower seed yield after a delayed nitrogen application was only observed when the grass was under-supplied with nitrogen from the autumn, and even if Italian ryegrass yielded the same, regardless of the nitrogen level in the autumn as well as of the time of application in the spring, it is recommended to apply nitrogen to these grass species about the first of April. A later application will increase the secondary vegetative tillering (Table 5) which will cause difficulties when harvesting particularly in the case of direct combining.

Similar results showing a heavier secondary tillering after a late nitrogen application has been reported in German, English, and American trials (Schoberlein, 1972; Hebblethwaite and Ivins, 1978; and Young, et al., 1984).

It is recommended to delay the nitrogen application in timothy until late April whether nitrogen has been applied in the autumn or not.

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