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Résumé de l'article

En 1986 et 1987, un inventaire des mauvaises herbes a été effectué dans 187 champs de céréales de printemps au Nouveau-Brunswick. Au total, 76 espèces ont été identifiées, 40 d'entre elles étant considérées comme importantes sur le plan agronomique. Environ 50% des espèces étaient vivaces. L'ortie royale (*Galeopsis tetrahit*), le chiendent (*Agropyron repens*), la petite oseille (*Rumex acetosella*), la marguerite blanche (*Chrysanthemum leucanthemum*), la spargoute des champs (*Spergula arvensis*) et la stellaire moyenne (*Stellaria média*) avaient les plus hautes valeurs d'abondance relative. Le chiendent et l'ortie royale avaient les plus fortes densités à 8,0 et 7,1 plantes m^{-2}, respectivement. La densité de mauvaises herbes la plus élevée (103 plantes m^{-2}) a été observée chez l'avoine (*Avena sativa*) cultivée à la suite de plantes fourragères. La plus faible densité a été détectée chez le blé (*Triticum aestivum*) suite à une culture de pomme de terre (*Solanum tuberosum*). La plupart des espèces abondantes étaient tolérantes au MCPA, l'herbicide le plus fréquemment utilisé. Les agriculteurs pourraient lutter plus efficacement contre les mauvaises herbes dans les céréales en choisissant un herbitolérantes au MCPA ou au 2,4-D, et a en pré-plantation ou en post-récolte ses herbes vivaces.

Weed survey of spring cereals in New Brunswick

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During 1986 and 1987, a weed survey of 187 New Brunswick cereal fields was conducted. A total of 76 species were identified of which 40 were considered agronomically important. About 50% of the species were perennial. Hemp-nettle (*Galeopsis tetrahit*), quack grass (*Agropyron repens*), sheep sorrel (*Rumex acetosella*), ox-eye daisy (*Chrysanthemum leucanthemum*), corn spurry (*Spergula arvensis*), and chickweed (*Stellaria media*) had the highest relative abundance values. Quack grass and hemp-nettle had the highest densities at 8.0 and 7.1 plants m^{-2}, respectively. The highest weed density (103 plants m^{-2}) was found in oats (*Avena sativa*) grown after a forage crop. The lowest density (24 plants m^{-2}) was found in wheat (*Triticum aestivum*) grown after potatoes (*Solanum tuberosum*). Most of the abundant species were tolerant to MCPA, the most commonly used herbicide. Farmers could make major improvements in cereal weed control by choosing a herbicide that would control species tolerant to MCPA or 2,4-D, and using preplant or postharvest weed control to minimize the impact of perennial weeds.

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En 1986 et 1987, un inventaire des mauvaises herbes a été effectué dans 187 champs de céréales de printemps au Nouveau-Brunswick. Au total, 76 espèces ont été identifiées, 40 d'entre elles étant considérées comme importantes sur le plan agronomique. Environ 50% des espèces étaient vivaces. L'ortie royale (*Galeopsis tetrahit*), le chiendent (*Agropyron repens*), la petite oseille *(Rumex acetosella*), la marguerite blanche (*Chrysanthemum leucanthemum*), la spargoute des champs (*Spergula arvensis*) et la stellaire moyenne (*Stellaria media*) avaient les plus hautes valeurs d'abondance relative. Le chiendent et l'ortie royale avaient les plus fortes densités à 8,0 et 7,1 plantes m^{-2}, respectivement. La densité de mauvaises herbes la plus élevée (103 plantes m^{-2}) a été observée chez l'avoine (*Avena sativa*) cultivée à la suite de plantes fourragères. La plus faible densité a été détectée chez le blé (*Triticum aestivum*) suite à une culture de pomme de terre (*Solanum tuberosum*). La plupart des espèces abondantes étaient tolérantes au MCPA, l'herbicide le plus fréquemment utilisé. Les agriculteurs pourraient lutter plus efficacement contre les mauvaises herbes dans

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les céréales en choisissant un herbicide qui pourrait réprimer les espèces tolérantes au MCPA ou au 2,4-D, et aussi en utilisant des méthodes de lutte en pré-plantation ou en post-récolte qui minimiseraient l'effet des mauvaises herbes vivaces.

INTRODUCTION

The survey of New Brunswick spring cereals is part of a program of the Research Branch of Agriculture and Agri-Food Canada to document relative abundance and geographic distribution of weedy species across Canada. In addition, it will provide baseline information for monitoring changes in weed populations through time. Surveys provide weed biologists and ecologists with quantitative information on weed communities that is used in the development of integrated weed management strategies, and weed scientists and extension specialists with information for weed control (herbicide) recommendations. To date, accounts of the weed flora in the provinces of Saskatchewan (Dale and Thomas 1987; Thomas 1985), Manitoba (Goodwin *et al.* 1986; Thomas 1991; Thomas and Dale 1991; Thomas and Donaghy 1991), Quebec (Doyon and Bouchard 1981; Doyon *et al.* 1982; Lemieux *et al.* 1988), Prince Edward Island (Thomas and Ivany 1990), and Nova Scotia (McCully *et al.* 1991) have been published.

Botanical lists of weedy taxa occurring in New Brunswick have been prepared by Fletcher (1897), by Groh and Frankton (1949), and by Bassett (1953); however, a quantitative assessment of the weed flora of New Brunswick spring cereal crops was lacking. This gap in knowledge led to the initiation of a 3-yr survey project beginning in 1985. Specific concerns were raised about the annual grassy weed, wild oats (*Avena fatua* L.), which was perceived to be increasing in northwestern New Brunswick. Wild oats is one of the most abundant and troublesome weeds of annual crops of western Canada (Sharma and Vanden Born 1978) and its presence in New Brunswick cereal fields posed a potentially serious threat. Information on the relative importance of this species in relation to other weeds in cereal crops was needed to help direct research and extension efforts. A preliminary survey was conducted during 1985 to evaluate methods and to gain support for a provincial survey conducted during 1986 and 1987. Only data from the last 2 yr will be presented in this paper.

MATERIALS AND METHODS

Description of the area

The province of New Brunswick comprises an area of 73 400 km^2 located between 44°35' and 48°05' west longitude in eastern Canada. The surface topography is generally low and level along the east coast on the Gulf of St. Lawrence, rising to a highland region in the northwest with the highest point being 820 m. The highlands are too rugged for farming except along the valleys of the St. John River, the largest river in the province, and the Kennebacasis River. Farming also occurs along the rivers flowing across the lowlands on the east coast. Along the St. John River Valley, the mean temperatures for January and July are approximately -11°C and 18°C, respectively, which is similar to the mean temperatures of -10°C and 19°C along the east coast. These areas receive approximately 750 mm of precipitation annually (Van Groenewoud 1984).

Soils that are used for grain production in New Brunswick (Podzolic and Brunisolic orders) range from sandy to clay loam surface textures with very compacted subsurface horizons. Soils are derived primarily from glacial, marine or alluvial deposits. Surface horizons vary in pH from 5.5 to 6.5 and subsoils from 4.5 to 5.5. Hydraulic conductivity varies widely.

Agriculture is livestock based; however, the province is also a major producer of seed, tablestock, and processing potatoes (*Solanum tuberosum* L.).

Approximately 20 000 ha of potatoes are grown annually, mostly in the upper St. John River Valley in northwestern New Brunswick. Typically a 2- to 4-yr rotation of either potatoes and cereals or potatoes, cereals, and forages (various legume and grass mixtures) is followed. Cereals and forages are grown more for their rotational value to potatoes than as cash crops. On livestock farms, cereals are often underseeded with forages, greatly limiting options for herbicide treatment. Cereals are usually consumed on-farm.

Sampling procedure

The province is divided into 15 counties. The number of fields selected for the survey was proportional to the area in cereals for each county. A stratified random sampling procedure (Cochran 1977) was used to select fields. Each of the 15 counties formed a stratum but only 13 of the counties had a cereal area large enough to be included in the survey. A total of 74 fields were surveyed during 1986 and 113 during 1987. The number of fields varied among the counties reflecting the proportional sampling: Carleton (82), Victoria (21), Restigouche (18), Kings (16), York (14), Madawaska (13), Westmoreland (8), Kent (7), Northumberland (2), Gloucester (2), Albert (2), Sunbury (1), Queens (1). Barley (*Hordeum vulgare* L.), oats (*Avena sativa* L.), and wheat (*Triticum aestivum* L.) were represented in the survey by 82, 70, and 35 fields, respectively. A proportion of the fields, were underseeded with a forage. For wheat, 33% of the fields were underseeded, for barley 43%, and for oats 54%.

A field was sampled for weeds according to an inverted W-pattern as described previously by Thomas (1985) with five quadrats, each 0.25 m^2, located equidistant along each of the four arms of the pattern. The number of weeds was recorded by species in each quadrat. Shoot numbers were recorded for perennial species. A tillered annual grass was considered a single plant. In some instances, specific identification of species was not possible and similar species were grouped together by genera. Sampling was carried out between 6 July and harvest, after the application of any postemergence chemical control.

The crop rotation, crop seed source, and herbicide treatments used on both the surveyed crop and the preceding crop were obtained by interviewing the farm operator of each field. Preceding crops were classified as forage, cereal, potato, or other. The forage crop category included alfalfa (*Medicago sativa* L.), hay, and pasture. The other crop category (36 fields), which included numerous types of vegetables and also fields where the previous crop could not be determined, was not used in the analysis.

Treatment of data

Data for the two survey years were combined and summarized using three quantitative measures. Frequency, mean field uniformity, and mean field density were computed for each species using the method of Thomas (1985). Frequency indicates the percentage of fields infested by a species and is an estimate of geographic extent of the infestation in the province. Frequency only considers the presence or absence of the weed in a field. Mean field uniformity indicates the percentage of quadrats infested by a species and is an estimate of the area infested by a weed. Mean field density indicates the number of plants m^{-2} and is used to indicate the magnitude of the infestation in all the surveyed fields.

Frequency, mean field uniformity, and mean field density values for each species were combined into a single synthetic value called relative abundance as described by Thomas (1985). This value is used to rank the contribution of individual species in the weed community and to compare the contribution of groups of species. It does not indicate the competitiveness of the weed. A relative value has an advantage because it allows comparisons to be made among data collected for weed communities in various years, locations, crops, or management systems. Total value for relative abundance of all species in a community is 300.

The structure of weed communities for barley, oats, and wheat were explored by constructing dominance curves using relative abundance. The relative abundance values of individual species were plotted against their rank, with the species ranked in decreasing order of relative abundance. A curve with a steep declining slope indicates a weed community dominated by one or a few species whereas a curve with less slope indicates that species are more equally abundant in the community (Thomas and Ivany 1990).

To illustrate the impact on the weed community of a forage, cereal, or potato crop grown the year preceding the surveyed cereal crop, a scatter plot of relative abundance for pairs of crop rotations were prepared using only the 20 most abundant species. If the relative abundances in both rotations were similar, then the value would fall along a diagonal line indicating equal relative abundances in both rotations. Deviations greater than 10 relative abundance units from the diagonal line were considered important for purposes of discussion.

RESULTS AND DISCUSSION

Weed flora

A total of 76 species were found in quadrats during the two survey years, but 36 occurred in less than seven of the surveyed fields and were therefore considered to be of minor importance. The 40 most frequently occurring species are listed in order of their relative abundance values in Table 1. These 40 species represented 16 families and had a summed relative abundance of 289.0 out of 300. The Asteraceae contributed 10 species and ranked first with a summed relative abundance of 60.4. The Caryophyllaceae contributed five species with a summed relative abundance of 45.8; Polygonaceae contributed three species with an abundance of 41.2; Poaceae contributed six species with an abundance of 39.1; Fabaceae contributed two species with an abundance of 17.3; and Brassicaceae contributed four species with an abundance of 6.4 Each of the remaining 10 species represented a different family: Chenopodiaceae, Equisetaceae, Lamiaceae, Oxalidaceae, Plantaginaceae, Rosaceae, Rubiaceae, Scrophulariaceae, Violaceae, Apiaceae. The importance of particular families in the weed community could not be judged solely on the basis of number of species. The Lamiaceae contributed only one of the 40 species but hemp-nettle (*Galeopsis tetrahit* L.) was the most abundant species in the survey.

Species with a perennial life cycle accounted for 20 of the 40 species in Table 1. Perennials were divided into two groups based on method of reproduction. Ten of the perennials spread vegetatively by means of rhizomes or roots and had a summed relative abundance of 86.7. Ten perennials were wholly dependent on seed for dispersal and their summed relative abundance was 58.2. Similar agricultural production systems in Quebec (Lemieux *et al.* 1988) and Prince Edward Island (Thomas and Ivany 1990) had weed floras in which perennials also accounted for approximately 50% of the species.

The 20 annual or biennial species in Table 1 had a summed relative abundance of 144.1. Only three grasses were found among the 20 annuals. The summed relative abundance of barnyard grass [*Echinochloa crusgalli* (L.) Beauv.], oats, and wild oats was only 4.4 and they were ranked 22nd, 39th, and 40th respectively (Table 1). In the neighbouring provinces of Prince Edward Island (Thomas and Ivany 1990) and Quebec (Lemieux *et al.* 1988), where similar crop rotations exist, it was also found that annual grasses were relatively unimportant as compared to perennial grasses such as quack grass [*Agropyron repens* (L.) Beauv.]. Barnyard grass, witch grass (*Panicum capillare* L.), crabgrass (*Digitaria*) species, and foxtail (*Setaria*) species were the most frequently encountered annual grasses in these other provinces. Wild oats was not recorded from either Prince Edward Island or Quebec. The low abundance of grassy weeds in spring cereals of New Brunswick, Prince Edward Island, and Quebec is in sharp contrast to the major contribution made

Table 1. Species, life cycle, and quantitative measures for weed species recorded in seven or more of the fields during the 1986 and 1987 surveys of cereal crops in New Brunswick

Rank	Scientific name	Common name	Life cycle[a]	Frequency (%)	Mean field uniformity (%)	Mean field density (plants m^{-2})	Relative abundance (0-300)
1	*Galeopsis tetrahit* L.	Hemp-nettle	A	74.3	30.9	7.1	32.8
2	*Agropyron repens* (L.) Beauv. [= *Elytrigia repens* (L.) Nevski]	Quack grass	PV	34.8	14.8	8.0	23.6
3	*Rumex acetosella* L.	Sheep sorrel	PV	61.5	19.8	3.7	21.2
4	*Chrysanthemum leucanthemum* L.	Ox-eye daisy	PS	54.0	20.9	3.7	20.8
5	*Spergula arvensis* L.	Corn spurry	A	52.9	17.4	4.4	20.3
6	*Stellaria media* (L.) Vill.	Chickweed	A	49.7	15.5	4.2	19.0
7	*Vicia cracca* L.	Tufted vetch	PV	49.2	16.7	2.3	16.0
8	*Gnaphalium uliginosum* L.	Low cudweed	A	36.4	8.4	4.3	14.8
9	*Chenopodium album* L.	Lamb's-quarters	A	34.8	11.0	3.6	14.5
10	*Polygonum lapathifolium* L. and *Polygonum persicaria* L.	Pale smartweed and lady's-thumb	A	46.5	10.4	1.2	11.4
11	*Poa compressa* L.	Canada blue grass	PV	13.4	4.4	3.4	9.2
12	*Polygonum convolvulus* L.	Wild buckwheat	A	34.2	8.3	0.8	8.6
13	*Taraxacum officinale* Weber	Dandelion	PS	36.9	7.2	0.5	7.8
14	*Oxalis stricta* L.	European wood-sorrel	PS	24.1	6.1	1.3	7.4
15	*Plantago major* L.	Broad-leaved plantain	PS	27.8	6.3	0.9	7.1
16	*Potentilla* spp.	Cinquefoil	PS	24.6	5.7	1.0	6.7
17	*Matricaria matricarioides* (Less.) Porter	Pineappleweed	A	17.6	2.9	0.4	3.8
18	*Achillea millefolium* L.	Yarrow	PV	11.2	3.1	0.4	3.1
19	*Cerastium fontanum* Baumg.	Mouse-eared chickweed	PS	14.4	2.4	0.3	3.1
20	*Cirsium arvense* (L.) Scop.	Canada thistle	PV	18.7	1.9	0.1	3.0
21	*Linaria vulgaris* Mill.	Yellow toadflax	PV	10.7	2.3	0.4	2.9
22	*Echinochloa crusgalli* (L.) Beauv.	Barnyard grass	A	8.0	1.8	0.6	2.7
23	*Hieracium floribundum* Wimm. & Grab.	Yellow devil hawkweed	PV	11.8	1.8	0.2	2.4
24	*Equisetum arvense* L.	Field horsetail	PV	8.0	1.5	0.5	2.3
25	*Silene vulgaris* (Moench) Garcke	Bladder campion	PS	8.0	2.3	0.3	2.3
26	*Solidago* spp.	Goldenrod	PV	12.3	1.7	0.1	2.3
27	*Raphanus raphanistrum* L.	Wild radish	A	11.2	1.5	0.1	2.1
28	*Capsella bursa-pastoris* (L.) Medic.	Shepherd's-purse	A	10.2	1.6	0.1	1.9
29	*Viola arvensis* Murr.	Field violet	A	4.8	1.1	0.6	1.9
30	*Panicum lanuginosum* Ell.	Woolly panicum	PS	8.6	1.1	0.3	1.9
31	*Galium mollugo* L.	Smooth bedstraw	PV	8.6	1.1	0.3	1.8
32	*Daucus carota* L.	Wild carrot	B	8.0	1.0	< 0.1	1.4
33	*Sinapis arvensis* L.	Wild mustard	A	5.9	1.3	0.1	1.3
34	*Medicago lupulina* L.	Black medick	A	6.4	1.0	0.1	1.3
35	*Sonchus arvensis* L.	Perennial sow-thistle	PV	5.9	1.0	0.1	1.3
36	*Erigeron strigosus* Muhl.	Rough fleabane	A	5.9	0.7	0.1	1.1
37	*Erysimum cheiranthoides* L.	Wormseed mustard	A	4.8	1.0	0.1	1.1
38	*Stellaria graminea* L.	Grass-leaved stitchwort	PS	3.7	0.9	0.2	1.1
39	*Avena sativa* L.	Oats	A	4.8	0.7	< 0.1	0.9
40	*Avena fatua* L.	Wild oats	A	3.7	0.8	< 0.1	0.8

[a] A: annual; B: biennial; PV: perennial species that reproduce vegetatively; PS: perennial species that only reproduce by seed.

by grassy weeds to the weed flora in other parts of Canada. Green foxtail [*Setaria viridis* (L.) Beauv.] ranked first and wild oats ranked second or third in the Prairie provinces of Manitoba (Thomas 1991) and Saskatchewan (Thomas 1985) where cereal rotations are common.

Wild oats appeared in 3.7% of the New Brunswick cereal fields. This level of occurrence suggests a slight increase from the 1940s when the weed was recorded in 0.8% of sites surveyed in the Maritime region (Groh and Frankton 1949) and in 1953 when the weed was found along a roadside at one site only (Bassett 1953). Wild oats occurred primarily in fields with long cereal rotations and where nonpedigreed seed was used.

Mean field uniformity is used as an estimate of the area infested with a weed. Hemp-nettle was estimated to infest 30.9% of the area seeded to spring cereals in New Brunswick (Table 1). Sheep sorrel (*Rumex acetosella* L.) and ox-eye daisy (*Chrysanthemum leucanthemum* L.) infested approximately 20% of the area. Each of the other species infested less than 20% of the area. Wild oats only infested 0.8% of the survey area.

Several species were found infrequently in fields, but at densities greater than 5.0 plants m^{-2} when averaged over only the fields in which they occurred (occurrence density). Canada blue grass (*Poa compressa* L.), field violet (*Viola arvensis* Murr.), barnyard grass, field horsetail (*Equisetum arvense* L.), and European wood-sorrel (*Oxalis stricta* L.) had mean field densities of less than 3.4 plants m^{-2} but had occurrence densities of 25.6, 11.7, 7.8, 6.1, and 5.5 plants m^{-2}, respectively. These weeds therefore have the potential to be a problem if they spread into previously uninfested fields.

Most of the species listed in Table 1 were recognized as weeds of fields and waste areas nearly 100 yr ago (Fletcher 1897). Little change in the species composition of the weed flora had occurred when Bassett (1953) prepared his list 50 yr later. Four species found among the 40 most abundant weeds in the current surveys of New Brunswick were absent from these previous lists. Canada blue grass, European wood-sorrel, field violet, and woolly panicum (*Panicum lanuginosum* Ell.) are species that may have increased in abundance and populations of these species should be monitored in the future.

Of the 76 species found in the survey, 36 occurred in less than 3.5% of the fields and contributed a summed relative abundance of only 11.0 (Table 2). Although rarely encountered in the surveyed fields, some of these species may become more important members of future weed communities if changes occur in crop management practices. Field mint (*Mentha arvensis* L.), yellow nut sedge (*Cyperus esculentus* L.), common milkweed (*Asclepias syriaca* L.), common mallow (*Malva neglecta* Wallr.), and colt's-foot (*Tussilago farfara* L.) were absent or rare in previous surveys (Bassett 1953) and are generally considered by extension staff to be on the increase in the province and their abundance should be closely monitored.

Herbicide use and species abundance

MCPA [(4-chloro-2-methylphenoxy)acetic acid] was the most commonly used herbicide on surveyed spring cereals. It was applied either alone or as part of a mix to 68% of the fields. 2,4-D [(2,4-dichlorophenoxy)acetic acid] or 2,4-DB [4-(2,4-dichlorophenoxy)butanoic acid] were applied either alone or as part of a mix to 18% of the fields. Only 5% of the fields received a herbicide other than these three. More than one herbicide was applied to 10% of the fields and 19% of all the fields did not receive a herbicide. The percentage of treated fields was lowest for oats at 67%, intermediate for barley at 89%, and highest for wheat where all the fields were treated. Survey results indicate that oats and barley planted following forages were treated less than when planted following cereals or potatoes. The number of wheat fields following a forage (two fields) or cereal crop (five fields) was too few to give an adequate indication of herbicide use and species abundance.

Table 2. Frequency of species occurring in less than 3.5% of the cereal fields surveyed in New Brunswick

Scientific name	Common name	Frequency (%)
Ranunculus acris L.	Tall buttercup	3.2
Solanum tuberosum L.	Potato	3.2
Setaria glauca (L.) Beauv.	Yellow foxtail	2.7
Mentha arvensis L.	Field mint	2.7
Medicago sativa L.	Alfalfa	2.1
Hordeum vulgare L.	Barley	2.1
Amaranthus retroflexus L.	Redroot pigweed	2.1
Carex spp.	Sedges	2.1
Fragaria virginiana Duchesne	Strawberry	2.1
Fagopyrum esculentum Moench	Buckwheat	1.6
Polygonum hydropiper L.	Marshpepper smartweed	1.6
Setaria viridis (L.) Beauv.	Green foxtail	1.6
Polygonum ramosissimum Michx.	Yellow-flowered knotweed	1.6
Polygonum aviculare L.	Prostrate knotweed	1.6
Poa pratensis L.	Kentucky blue grass	1.1
Cyperus esculentus L.	Yellow nut sedge	1.1
Leontodon autumnalis L.	Fall hawkbit	1.1
Asclepias syriaca L.	Common milkweed	1.1
Polygonum cuspidatum Sieb. & Zucc.	Japanese knotweed	1.1
Sedum telephium L.	Live-forever stonecrop	1.1
Spiraea latifolia (Ait.) Borkh.	Broad-leaved meadowsweet	1.1
Malva neglecta Wallr.	Common mallow	1.1
Senecio vulgaris L.	Common groundsel	0.5
Sonchus oleraceus L.	Annual sow-thistle	0.5
Ambrosia artemisiifolia L.	Common ragweed	0.5
Rubus spp.	Raspberry	0.5
Brassica campestris L.	Bird rape	0.5
Apocynum androsaemifolium L.	Spreading dogbane	0.5
Lysimachia terrestris (L.) BSP.	Swamp loosestrife	0.5
Agrostis capillaris L.	Colonial bent grass	0.5
Eupatorium maculatum L.	Spotted Joe-Pye weed	0.5
Tussilago farfara L.	Colt's-foot	0.5
Epilobium angustifolium L.	Fireweed	0.5
Aster simplex Willd.	Tall white aster	0.5
Veronica officinalis L.	Common speedwell	0.5

Herbicide treatment applied to the field in the year preceding the survey was strongly correlated with the type of crop grown. No herbicides were used on any of the forage crops. The proportion of cereals grown the preceding year that received a herbicide treatment of MCPA, 2,4-D, dicamba (3,6-dichloro-2-methoxybenzoic acid), or bromoxynil (3,5-dibromo-4-hydroxybenzonitrile) was 67%, and 84% of potatoes grown the preceding year received metribuzin [4-amino-6-(1,1-dimethylethyl)-3-(methylthio)-1,2,4-triazin-5(4*H*)-one], dinoseb [2-(1-methylpropyl)-4,6-dinitrophenol], or one of several other herbicide treatments.

Hemp-nettle was the most widespread species in New Brunswick cereal crops infesting 74.3% of surveyed fields with a mean field uniformity of 30.9% and a mean density of 7.1 plants m^{-2} (Table 1). Improper herbicide selection and time of application are important reasons for the first place ranking of hemp-nettle. Generally hemp-nettle control from MCPA is poor, but some control is possible if applications are made before the 4-leaf stage and high rates are applied. Hemp-nettle is not susceptible to 2,4-D or 2,4-DB. A lack of control throughout most of the crop rotation would ensure adequate seed supplies for maintaining high population levels. Hemp-nettle is capable of producing enough seeds to reinfest a field, even when growing in a highly competitive crop such as oats (Légère and Deschênes 1989).

The data clearly indicate that herbicides used by New Brunswick farmers were not effective against the seven most abundant weeds and many of the other species in Table 1. The perennial weeds, quack grass, sheep sorrel, ox-eye daisy, and tufted vetch (*Vicia cracca* L.) were ranked 2nd, 3rd, 4th, and 7th, respectively. These species would not be adequately controlled by the herbicides used on spring cereals (Ontario Ministry of Agriculture and Food 1988). Two of the Caryophyllaceae, corn spurry (*Spergula arvensis* L.) and chickweed [*Stellaria media* (L.) Vill.], which are not controlled by MCPA and 2,4-D, were ranked 5th and 6th. Farmers can make major improvements in cereal weed control by choosing a herbicide that will control species tolerant to MCPA or 2,4-D.

Species that are known to be susceptible to MCPA and 2,4-D were also found in a number of fields. Lamb's-quarters (*Chenopodium album* L.) was found in 35% of the fields at densities of 3.6 plants m^{-2} and low cudweed (*Gnaphalium uliginosum* L.) was found in 36% of the fields and at densities of 4.3 plants m^{-2} even though MCPA and 2,4-D should have adequately controlled these weeds. Individuals of these species may have emerged subsequent to herbicide application because of intermittent germination. Hume (1988) lists nine other mechanisms that would allow plants to avoid or escape the effects of herbicides. Detailed field monitoring would be required to fully understand the incidence of lamb's-quarters.

Crop rotation and species abundance

Seven types of rotations were found in the surveyed fields (Table 3). For example, 53% of the barley fields followed potatoes and 23% followed a forage crop. In contrast, 30% of the oat fields followed potatoes and 48% followed forage crops. Herbicide use patterns, total weed density, and relative abundance were related to these rotations. Extensive use of herbicides in some rotations would have selectively removed some sensitive species creating space for other species to expand their populations. This type of response was least important in oats following forages because only 45% of the fields received a herbicide treatment in the survey year (Table 3) and no herbicides the previous year. Tufted vetch, ox-eye daisy, and sheep sorrel are perennials and were the highest ranked species in this rotation. The weed community in wheat following potatoes was associated with a more intensive use of herbicides (100% of the fields treated). This may explain the prevalence of two Caryophyllaceae, chickweed and corn spurry, not controlled by the herbicides used on wheat. These two species are most abundant following potatoes, less abundant following cereals, and do not occur among the first three species following forages. A similar change in the quantitative aspects of community structure was documented for the long-term effects of 2,4-D on the weed community in wheat (Hume 1987).

Quack grass was prevalent in oats or barley when forage or cereal crops were grown the previous year but did not rank in the first three species in fields after potatoes (Table 3). High herbicide use, extensive cultivation, and vine desiccation and soil disturbance associated with fall harvest in potatoes would make it difficult for perennials to survive. Quack grass would be expected to be prevalent when cereal crops were grown the preceding year because farmers allow quack grass to grow in oat and barley fields for a month or more after harvest. Perennial weed infestations resulting from preceding forage crops and cereals could be minimized by better preplant weed control and postharvest weed control, respectively.

A further indication of the relationship between the crop grown the year preceding the survey and the relative

Table 3. Characteristics of weed communities found in oats, barley, and wheat when perennial, cereal, or potato crops were grown previously

Previous crop type	Crop	Number of fields	Fields treated with herbicides (%)	Total weed density (plants m^{-2})	Three most abundant species in surveyed crop	Cumulative relative abundance of first three species[a]
Forage	oats	29	45	103	tufted vetch	26.5
					ox-eye daisy	52.0
					sheep sorrel	75.3
	barley	16	69	73	hemp-nettle	38.4
					quack grass	75.3
					lamb's-quarters	99.7
Cereal	oats	14	86	65	hemp-nettle	44.4
					quack grass	87.8
					corn spurry	114.6
	barley	17	88	75	hemp-nettle	49.9
					chickweed	93.0
					quack grass	128.4
Potato	oats	18	89	31	hemp-nettle	36.6
					corn spurry	68.8
					Canada blue grass	98.4
	barley	37	97	26	chickweed	46.7
					hemp-nettle	82.5
					corn spurry	111.2
	wheat	20	100	24	chickweed	47.3
					corn spurry	92.8
					low cudweed	128.9

[a] Based on a total maximum of 300.

abundance of specific weeds is shown in Figure 1. Rotations involving forage crops allow for establishment, growth, and reproduction of perennial species that persist in subsequent cereal crops. The relative abundance of quack grass and hemp-nettle in the surveyed crops were higher in fields with cereals grown previously than in fields with forage or potato crops grown previously. Low cudweed and Canada blue grass had a higher relative abundance in the surveyed crops when potatoes were grown previously than in cereals grown previously.

Community structure

The response of the weed community to different herbicide use patterns and crop rotations is summarized by the dominance curves for barley, oats, and wheat (Fig. 2). Dominance curves indicate that the most diverse weed communities are found in oats following forages and the least diverse in wheat following potatoes and barley following cereals. Differences in the shape of the dominance curves is indicated by the cumulative relative abundance of the first three species (Table 3). The weed community in oats following forage crops had the smallest cumulative abundance (75.3) for the first three species. The dominance curve for oats after forage crops is most similar in shape to the curve for cereals on Prince Edward Island (Thomas and Ivany 1990). In both provinces, weed communities are influenced by a lack of or limited use of herbicides, partly because many fields are underseeded to a legume. The weed community in surveyed crops following potatoes or cereals is more strongly dominated by the first three species than is the weed community following forages. The curve for wheat after potatoes resembles the dominance curve for Saskatchewan cereal and oilseed crops (Thomas 1985). In Saskatchewan herbicides are used extensively and the first three ranked species had a relative abundance of 132.3.

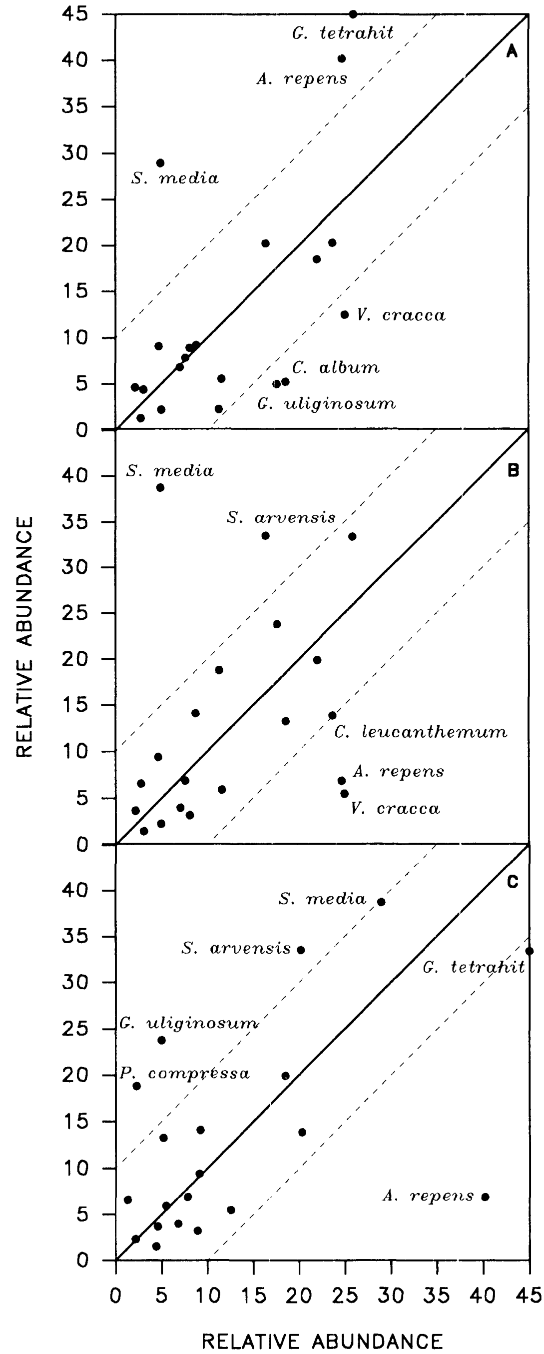

Figure 1. Comparison of the relative abundance (RA) of the 20 most abundant species in the surveyed cereal fields. A) RA when forages (*x*-axis) or cereals (*y*-axis) were grown previously; **B)** RA when forages (*x*) or potatoes (*y*) were grown previously; **C)** RA when cereals (*x*) or potatoes (*y*) were grown previously. Species falling between the dashed lines were considered equally abundant (± 10) in both rotations.

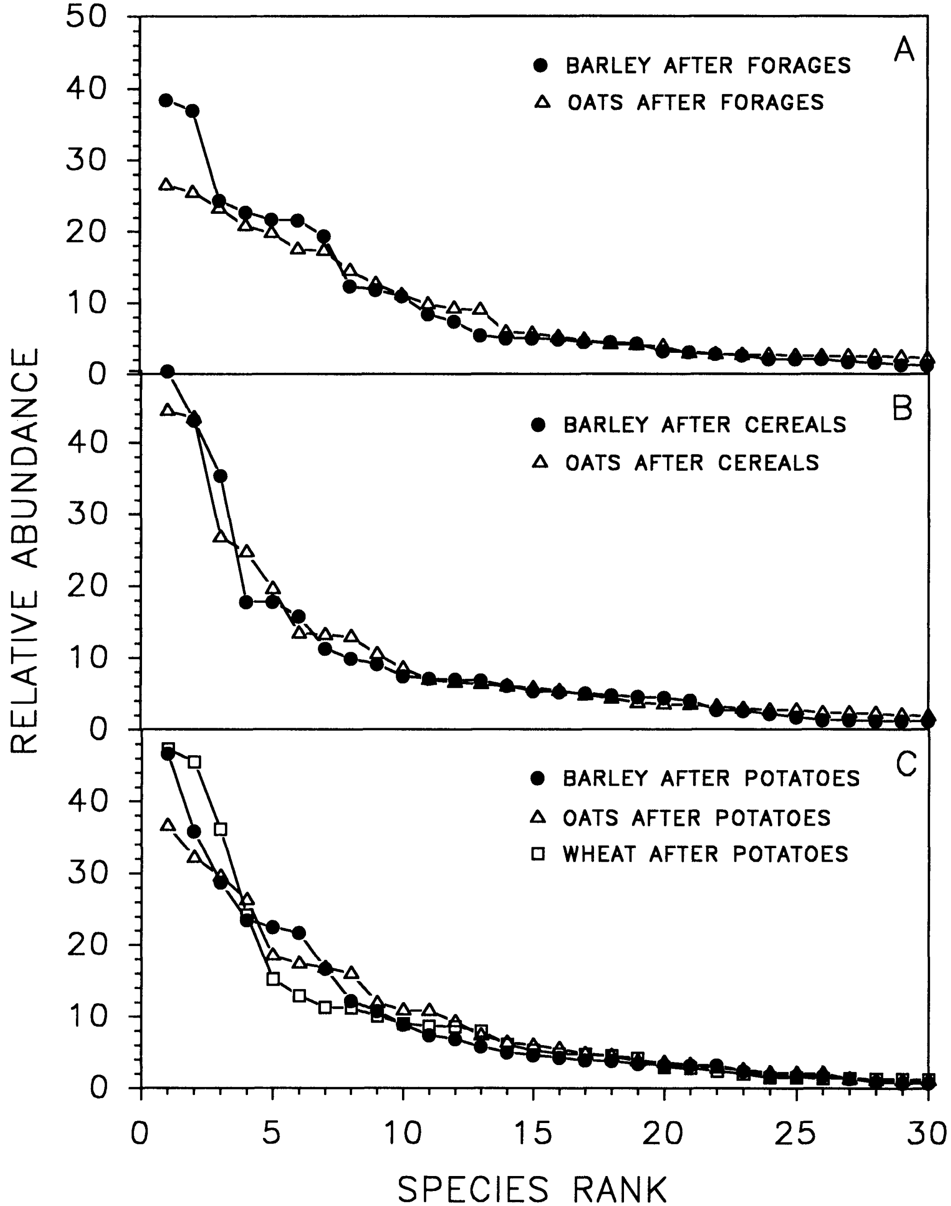

Figure 2. Dominance curves of the 30 most abundant species in barley, oats, and wheat in New Brunswick following A) forages, B) cereals, and C) potatoes. Species are plotted in descending order based on relative abundance.

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