

THE EFFECTS OF INCREASING DENSITIES OF VOLUNTEER CEREALS
ON THE GROWTH AND YIELD OF FLAX (LINUM USITATISSIMUM)
AND CANOLA (BRASSICA NAPUS)

BY

WESLEY ROTHER

A thesis
presented to the University of Manitoba
in partial fulfillment of the
requirements for the degree of
MASTER OF SCIENCE

in the
Department of Plant Science

Winnipeg, Manitoba
(c) Wesley Rother

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ABSTRACT

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The Effects of Increasing Densities of Volunteer Cereals on the
Growth and Yield of Flax (Linum usitatissimum) and Canola
(Brassica napus)

Major Professors: George Marshall and Ian N. Morrison

Field trials were conducted at Portage la Prairie (1982 and 1983) to determine the effects of increasing densities (0, 7.5, 15, 30, 45 and 60/m²) of volunteer wheat (Triticum aestivum) or volunteer barley (Hordeum vulgare) on the growth and yield of flax (Linum usitatissimum) or canola (Brassica napus). Constant densities of wild oats (Avena fatua) at 30-35/m² and green foxtail (Setaria viridis) at 150-180/m² were also seeded to simulate a weed flora which might occur under normal farming practices. The graminaceous weeds were selectively removed with herbicides in order that crop growth and final yield could be assessed in the presence and absence of weeds. Both the shoot vegetative dry weight and the seed yield of flax and canola were increasingly reduced as volunteer density increased. The greatest incremental reduction in oilseed yield occurred between the weed-free situation and the first density increment. Volunteer barley was more competitive than wheat in both crops. At densities of only 15 volunteer barley plants/m² the yield of flax was reduced by 35% and 44% (1982 and 1983, respectively), significantly higher than comparable reductions of 12% and 14% (1982 and 1983, respectively) recorded in canola. The accuracy of predictive assessments of the potential yield reductions caused by volunteer barley or wheat was influenced by the presence of mixed

weed populations (including green foxtail and wild oats) and the weather throughout the season. The results obtained could be used to determine the cost/benefit relationship where known volunteer infestations are to be selectively controlled in crops by graminicides.

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DEDICATION

To my parents and Patrice

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1. INTRODUCTION

Flax (Linum usitatissimum) and canola (Brassica napus) are two important oilseed crops grown in Canada (Tables 1.1 and 1.2). More than 75% of Canadian flaxseed production is exported as seed. Canadian flaxseed is well received on the world market because it has a higher oil content and iodine value than seed produced elsewhere (Anon. 1976). Canola is a major oilseed crop grown in Western Canada. For Canada, canola has become the third most valuable field crop, following wheat (Triticum aestivum) and barley (Hordeum vulgare) and ahead of flax (Adolphe 1974). Canola has changed Canada's position from a net importer to an exporter of edible oilseeds (Table 1.3).

Table 1.1 Value of production of principal crops for Manitoba and the prairie provinces¹.

Crop	Manitoba			Prairie provinces		
	1984	1983	1982	1984	1983	1982
	(\$ '000,000)					
Wheat	611	593	569	3992	4059	3110
Barley	216	191	227	1169	1108	1100
Canola	109	152	190	594	970	1106
Flaxseed	104	96	131	181	144	213

¹ Anon. (1984a, b, e)

Table 1.2 Area planted to principal crops in Manitoba and the prairie provinces¹.

Crop	Manitoba			Prairie provinces		
	1984	1983	1982	1984	1983	1982
	('000 ha)					
Wheat	1801	1862	1619	11332	12161	11069
Barley	728	708	809	4107	3905	4714
Canola	486	384	344	2894	2246	1720
Flaxseed	405	304	364	704	431	627

¹Anon. (1984a, b, e)

Table 1.3 Value of principal crops exported from Canada¹.

Crop	1984	1983	1982
	(\$ '000,000)		
Wheat	4709	4648	4287
Barley	636	815	886
Canola	648	432	419
Flaxseed	168	186	137

¹Anon. (1984f)

Both flax and canola are adapted to warm, moist regions of Western Canada and are capable of producing high yields of seed (Table 1.4). Methods of crop production and equipment for sowing, harvesting and threshing are the same for flax and canola as for

Table 1.4 Average yields for principal crops for the prairie provinces¹.

Crop	1984	1983	1982	Av. 10 year
	(kg/ha)			
Wheat	1567	1937	2125	1849
Barley	2198	2376	2700	2441
Canola	1080	1159	1271	1182
Flaxseed	960	1035	1167	998

¹ Anon. (1984c, d)

other small grains such as wheat and barley. Oilseeds are especially well suited to rotation with wheat and barley crops (Legge 1982). However, the shedding of small grains due to excessive combine-operating speeds and the straw trail may produce an overwintering seed reservoir. Such a reservoir may result in volunteer cereals as a crop weed the following spring. Cussans (1978) reported that a 0.75-5.0% loss in cereal seed during harvest could result in 70-470 potential volunteer plants/m². Volunteer cereals have been shown to compete with the crop being produced, interfere with field operations and reduce the marketability of the crop (Soper 1978).

Historically, volunteer cereals have not been considered to be a problem in oilseed production: emphasis was on the control of weed such as green foxtail (Setaria viridis), wild oat (Avena fatua) and broadleaf weeds. However, in the last decade, the advent of new generation selective graminicides (e.g. diclofop-methyl, flamprop-

methyl, sethoxydim, fluazifop-butyl) has resulted in a trend away from summerfallow and delayed seeding as a means of weed control to a more continuous cropping scheme. The acreage of flax and canola seeded into stubble is much greater than those seeded on summerfallow (Table 1.5).

Table 1.5 Percentage of flaxseed and canola seeded on summerfallow from 1976 to 1985¹.

Year	Manitoba		Prairie provinces	
	Canola	Flaxseed	Canola	Flaxseed
	(%)			
1976	48	19	72	46
1977	40	17	63	53
1978	32	16	59	48
1979	32	13	56	44
1980	37	12	64	44
1981	32	9	58	40
1982	16	7	44	34
1983	19	7	42	31
1984	19	7	41	35
1985 ²	12	4	35	25

¹ Anon. (1984c)

² Estimated

This change in farming practices has resulted in an increased prominence of volunteer cereals in crop production and weed control strategies. In cereal-oilseed rotations in Manitoba, volunteer wheat or volunteer barley frequently occurred in flax and canola fields (Table 1.6). In the 1981 Weed Survey of Cultivated Land in

Table 1.6 Ranking of the top 30 weed species from the Manitoba survey of cultivated land, 1982¹.

Rank	Species	Rank	Species
1	Green foxtail	16	Bluebur
2	Wild oats	17	Hemp-nettle
3	Wild buckwheat	18	Field horsetail
4	Smartweed	19	Thyme-leaved spurge
5	Canada thistle	20	Shepherd's-purse
6	Lamb's-quarters	21	Volunteer wheat
7	Wild mustard	22	Cow cockle
8	Sow thistle	23	Volunteer barley
9	Redroot pigweed	24	Prostrate knotweed
10	Catchfly	25	Dandelion
11	Stinkweed	26	Round-leaved mallow
12	Quackgrass	27	Dog mustard
13	Barnyard grass	28	Chickweed
14	Volunteer flax	29	Black medic
15	Russian thistle	30	Rose spp.

¹Thomas (1982)

Manitoba (Thomas 1982), volunteer wheat and volunteer barley ranked as the 11th and 14th most abundant weeds in flax and 8th and 17th most abundant weeds in canola, respectively. Wild oats and green foxtail ranked first and second, respectively.

Volunteer cereals are well adapted to present agronomic practices, having been bred specifically for crop production. Volunteer cereals compete well for available nutrients, water and light thereby reducing yields and interfering with crop production (Anderson 1976). Graminicides (e.g. dichofop-methyl) until recently

did not selectively control volunteer cereals in oilseeds. However, new herbicides such as sethoxydim and fluazifop-butyl, have enabled farmers to control common grassy weeds (wild oat and green foxtail) as well as volunteer cereals in flax and canola.

Researchers ultimately wish to be able to predict yield reductions due to weed competition before they occur and in this way to cost the economic returns to be gained from weed control practices and in particular the use of herbicides. Friesen (1967), speaking in Vienna, posed a series of weed-crop ecology questions with regard to the understanding of any weed species (Appendix 8.1). For many major weeds which reduce crop yields, information is insufficient to precisely calculate expected reductions as demanded by Friesen (Sagar 1968).

This research was undertaken because no information regarding growth and yield losses caused by volunteer cereals in flax and canola was available. The primary purpose was to determine the effects of increasing volunteer wheat and volunteer barley densities on the final yield of flax and canola. The results obtained might provide oilseed growers with a measure of the cost-benefit relationship where volunteer infestations are to be controlled by herbicides.

2. LITERATURE REVIEW

Weeds in crops reduce yields by competing for nutrients, moisture, light and space (Clements et al. 1907). The growth of such plants in a multispecific community is influenced at some or all stages of development by biological and physical processes which are frequently referred to as competition.

2.1 Definition of Competition

The literature on the subject of competition is vast and is equalled only by the number of definitions given to the word (e.g. de Wit 1960a; Milthorpe 1961; Donald 1963; Harper 1964). The definition of competition put forward by Clements et al. (1929) remains a classic in the study of the plant world. It was stated that competition is purely a physical process. Competition arises from the reaction of one plant upon the physical factors about it in relationship to another plant. Clements further clarified this idea by suggesting that competition between two plants does not take place as long as the water content, the nutrient material and the light are in excess of the needs of both. Thus, when the immediate supply of a single necessary factor falls below the combined demands of the plants, competition begins.

The term competition, however, remains open to further interpretations. Harper (1961) noted the term's strong association with human activities such as sports and with certain principles of economics and its lack of scientific meaning. Hall (1974) stated that competition is often used to describe ecological and agronomic

phenomena in a rather loose manner with little scientific foundation. Hall further acknowledged that this might lead to a misunderstanding of the actual processes involved.

2.2 Competition Vs. Interference

Harper (1961, 1964, 1977) in a series of papers proposed the use of 'interference' as a substitute for competition. Harper intended this new term to comprise all changes in the environment brought about by the proximity of individuals. Interference would also include the effect of neighbours due to the consumption of resources in limited supply, the production of toxins or changes in conditions such as protection from wind and influences on the susceptibility to pests and diseases. Thus, plant interference relates to the response of an individual plant or plant species to its total environment as this is modified by the presence and/or growth of other individuals or species.

Competition itself is only one facet of interference between plants. However, at times it may be the most dominant. Competition is the most commonly used term in agricultural literature (Glauning and Holzner 1982).

2.3 Non-competitive Vs. Competitive Competition

Competition, or interference, can be partitioned into two processes: non-competitive and competitive competition (Hall 1974). Non-competitive processes occur when one species modifies the light and temperature microenvironment of another by virtue of its differential growth characteristics. The growth of the associated

species could be either reduced because the level of illuminance became too low for optimum growth, or, in some cases, encouraged because the plant was intolerant of high illuminance levels. Competitive competition is competition in the strictest sense of what is available: nutrients, light and space. Perhaps the use of indirect and direct competition would be more appropriate. However, research is often focused on the effects of competitive (direct) competition.

2.4 Approaches to Studying Competition

Weed control measures are focused directly or indirectly on improving the competitive ability of the crop with respect to the weeds. Spitters and van den Bergh (1982) advocated a system-analytical approach for studying competition. Their idea was to analyze the system as a whole. Such an approach would be particularly useful in obtaining an outline of the relations within the system, their structure and relative importance. They realized that a simulation model, when developed, would enable the prediction of results of situations not yet tested.

Researchers have three major approaches for studying competition: additive experiments, replacement experiments and experiments designed to simulate competition in time. Other models are usually hybrids of these.

2.4.1 The Additive Model

Additive experiments are most commonly used by researchers. A known population of a weed is added to a known crop population. It

is common to express crop yield in weed infested plots as a percentage of weed-free yield. This model is useful in helping answer the most common agricultural question, "What will a given weed density do to my crop yield?" However, the main disadvantage of this approach is the lack of adequate mathematical models to quantify and qualify the results of competition and to make predictions of various competitive situations (de Wit and Baeumer 1967).

2.4.2 The Replacement Model

The second approach is the use of a replacement or substitution model. Here, a monoculture of species A is progressively replaced with those of species B until a monoculture of the latter is obtained. Many mathematical models have been developed by de Wit and his colleagues Ennick and van den Bergh in a series of papers (de Wit 1960a,b; de Wit and van den Bergh 1965; de Wit et al. 1966; van den Bergh 1968) in attempts to quantify the competition effects in replacement experiments. Trenbath (1978) and Spitters (1980) have both shown that de Wit's model published in 1960a is the most adequate. The major drawback of this experimental approach is that it does not directly coincide with practical weed problems in the field.

2.4.3 The Dynamic Model

Baeumer and de Wit (1968) developed a model for dynamic simulation of competition, the third approach available to researchers. This model was used to predict the competitive relations in a mixture of species at any given time on the basis of

parameters derived from a spacing experiment with the species grown in monocultures and harvested at set intervals. The model is based on the hyperbolic relationship between biomass and plant density. As the degree of curvature increases, the species occupies a greater part of the available space. The authors used 'space' to embrace all growth requisites including light, water and nutrients for which the species compete. The species which is able to occupy the available space at an earlier time will be the stronger competitor. The model has been tested by Baeumer and de Wit (1968) with mixtures of oats and barley, oats and peas, long and short peas, by de Wit (1970) with a mixture of two barley cultivars, and by Rerkasem (1978) with mixtures of wheat and ryegrass. In these experiments, the model gave satisfactory predictions of the competition effects observed.

2.5 Competition Experiments

Clements et al. (1929) studied interplant competition. They cited four points concerned with a plant's competitive ability: (1) duration or perennation--owing its effects to occupation and height; (2) rate of growth--most effectively expressed by expansion and density of the shoot and root systems; (3) rate and amount of germination--initial advantage; and (4) vigour and hardiness--ability to survive under stress. Most competition studies tend to focus on one or more of these points.

Thomas Pavlychenko provided the foundation for many of the principles of modern weed science through classic studies (Bubar and Morrison 1982). In one study, he quantified the relative distribu-

tion and lengths of roots of many plant species. Pavlychenko and Harrington (1934) defined plant competition as a powerful natural force tending towards the limitation or extinction of the weaker competitor. The species or variety which is able to utilize the environment most efficiently attains competitive supremacy. Pavlychenko (1935, 1937) extensively studied annual weed and cereal crop competition. Cereal crops were found to vary in their competitive efficiencies. Barley was the most competitive small grain followed by rye, wheat and oats in descending order. Flax was the poorest competitor. This ranking has been confirmed by other researchers (Bowden and Friesen 1967; Bell and Nalewaja 1968a, b). Canola was not included in any of these studies.

To further qualify the relative competitive abilities of the cereals, Pavlychenko and Harrington (1935) studied their respective root systems. The authors provided evidence of a close correlation between competitive efficiency and development of the root system: barley had the most competitive root system while the other cereals followed in the order as mentioned before. It was also observed that plant competition did not take place where the plants were spaced far enough apart that their root systems did not meet underground. Competition was, however, observed as soon as the spacing between neighbouring plants was reduced to the extent that their root systems began to overlap. It can be surmized that levels of water and nutrients, important environmental factors (Clements et al. 1907) would be less than those required by the competing root systems. Vengris et al. (1953) reported that large quantities of major nutrient elements absorbed by weeds are the limiting factor in

crop production.

Water and nutrients are available only at certain times and in certain quantities in the soil zone. A farmer is able to manipulate and optimize these only to a limited extent. However, the amount of available light is a constant value to the aerial portion of the plant. Weeds can compete with crops for light by growing faster and higher, developing larger leaves and utilizing climbing devices (Fogelfors 1972). Goodwin (1984) studied the effects of companion crops, flax and rapeseed, on the light penetration to alfalfa seedlings over the growing season. Goodwin noted a sharp decrease in light penetration to alfalfa seedlings in plots sown to either companion crop. The greatest amount of light reduction occurred 5 weeks after crop emergence. Flax reduced light penetration to 25% of full sunlight and rapeseed to only 9%. Rapeseed reduced light penetration to a greater extent than flax throughout the growing season.

The use of different models and approaches for studying competition fall under the umbrella of experimental ecology. It has been proposed by Donald (1958) that growth factors such as light, water and various essential nutrients may be interrelated. Thus, results obtained from competition research are difficult to interpret and their applications may be limited. Donald reported results from which he concluded that an interaction between light and nutrient competition was evident. However, other researchers (King 1971; Snaydon 1971) using similar techniques were not able to arrive at the same conclusions. It still remains debatable whether different factors do actually 'interact' or are merely additive (Hall 1974).

2.6 Volunteers As Weeds

A volunteer cereal can be defined as a cereal plant growing as a weed in a subsequent crop. Several conditions can lead to a volunteer crop problem: (1) shattering of the crop prior to harvest, often accentuated by late swathing; (2) grain passing through the combine; (3) poor germination of the preceding crop; and (4) poor germination of shattered grain in the fall or before planting in the spring.

Klinner (1979) has described how losses occur before harvest. A standing crop is subject to progressive shedding and deterioration. Actual harvested losses also increase with time regardless of the harvesting method used. Therefore it is economically sound to plan for minimal delay after the crop has reached maturity--factors which slow down the speed of working of a normal combine would contribute to the losses as much as would the use of slow working machines (Bell 1977).

Some grain crops lack dormancy mechanisms. Moist, warm conditions will cause most crop seeds to germinate before the next crop is planted. Volunteers usually suffer from winter kill or uprooting by various tillage operations. However, Cussans (1978) in the United Kingdom found some volunteer cereal seeds were able to germinate up to 14 months after seeding.

2.7 Flax

Pavlychenko and Harrington (1935) demonstrated flax to be a poor competitor with weeds. Tests conducted in Manitoba (Friesen and Shebeski 1960) showed average yield reductions of flax due to

mixed weed populations were 27, 31 and 22% for the years 1956 to 1958, respectively. Yield losses due to weeds were consistently greater in flax than in barley, wheat or oats.

Gruenhagen and Nalewaja (1969) studied competition between wild buckwheat (Polygonum convolvulus) and flax at various locations in North Dakota. Maximum yield losses of flax sown at 47.2 kg/ha were 11.1 and 12.4 bu/ha during 1964 and 1965, respectively. Wild buckwheat densities between 5.4 and 10.8 plants/m² reduced flaxseed production as much as did higher wild buckwheat densities of 216 plants/m². However, the percent yield reduction caused by P. convolvulus appeared dependent upon flax stands and their ability to withstand the stresses of competition.

Wild oat competition in flax was studied by Bell and Nalewaja (1968a). Averaged over two locations and two fertilizer levels, 67 wild oat/m² reduced yield 60.1% in 1964 and 134 plants/m² by 82.1 and 86.1% in 1965 and 1966, respectively. Flaxseed yield components, including bolls/m², plants/m² and weight/1000 seed were reduced by wild oat competition. A reduction in the number of branches and bolls/m² accounted for 90.7% of the yield loss.

Similar yield reductions of flax due to wild oat competition was reported by Bowden and Friesen (1967). Eight wild oats/m² were sufficient to reduce yields significantly on both summerfallow and stubble land. Severe competition was found to have already occurred prior to the 2-3 leaf stage of the weed in 1964. Competitive effects increased drastically with time and with wild oat density. In 1966, a high rainfall year, yield losses did not become significant until wild oat density reached 33 plants/m². The

results suggested that wild oat control at an early stage was essential to the successful production of a flax crop.

Other researchers have conducted varying weed-crop competition studies and have obtained similar results, all indicating the relatively poor competitive ability of flax: Alex (1968) with cow cockle (Saponaria vaccaria), Burrows and Olson (1955) with wild mustard (Brassica kaber), Dew (1975b, 1978a) with tartary buckwheat (Fagopyrum tataricum), and Alessi and Power (1970) with green foxtail. It can be concluded from the foregoing review that flax is less competitive than any of the cereal crops. Although canola was seldom included in experiments, the relative competitive ability would be expected to fall between that of flax and rye. The distinction between the competitive abilities of the crops, however, is not as well defined and results have varied with different climatic and cultural conditions.

2.8 Canola

The literature available on canola-weed competition is limited. The majority of studies are reported annually in the Western Section of the Expert Committee on Weeds.

Competition work done by Dew with wild oats, tartary buckwheat (1975a, b) and wild buckwheat (1977) proved to be inconsistent, often due to adverse weather conditions resulting in erratic seed germination and poor competition. Similar results were reported by Keys (1975) working with wild oats. However, the data collected by both researchers indicated the relative ability of canola to withstand weed competition as compared to other crops.

Separate experiments involving tartary buckwheat competition in canola (Dew 1975b) and flax (Dew 1978a) showed that a minimum of 150 tartary buckwheat plants/m² was required to cause a highly significant yield reduction in canola. However, only 25 tartary buckwheat plants were required to produce the same effect in flax.

The influence of various densities of volunteer barley on canola yields was studied by de St. Remy and O'Sullivan (1984). Westar (Brassica napus) and Tobin (B. campestris) yields were reduced proportionally as the density of volunteer barley was increased. Losses were greater in Westar than in Tobin when volunteer barley was present at a similar density.

Hühn and Schuster (1975) quantitatively estimated the competitive effects of neighbouring plants in winter rape (B. napus) populations. They found that the yield components plant height and number of kernels per siliqua were insensitive to competition. However, grain weight per plant, number of siliquae per plant and 1000-kernel weight were very sensitive to competition.

3. MATERIALS AND METHODS

Trials were conducted to determine the effects of increasing densities of volunteer cereals in flax and canola at the Plant Science Research Station at Portage la Prairie in 1982 and 1983. As volunteer wheat and volunteer barley were not naturally present, the cereals were hand-spread in the experiments at seeding time to simulate volunteer cereal infestations which would occur under standard farming practices. Henceforth and throughout this manuscript, wheat and barley will be referred to as volunteer cereals.

3.1 The Effects of Wild Oat, Green Foxtail and/or Increasing Densities of Volunteer Cereals on the Growth and Yield of Flax

3.1.1 General outline

In one set of trials wheat was sown as the volunteer (Table 3.1), whereas, barley was sown as the volunteer in the other set of trials (Table 3.2). Green foxtail and wild oats were seeded at constant densities across the trials to simulate field-type infestations.

A split plot design with four replicates was used. Only the first replicate was not randomized. Each replicate was divided into main plots, measuring 8.4 m in width and 5 m in length. These plots corresponded to the volunteer densities. In 1982, the volunteer densities seeded were 15, 30, 45 and $60/m^2$. In 1983, the density increments were repeated with the addition of a $7.5/m^2$ density. Each main plot was divided into three subplots measuring 2.8 m in width by 5 m in length. One subplot was a weedy control. This

Table 3.1 Summary of planting, treatments and assessments carried out during the 1982 and 1983 volunteer wheat-flax field trials¹.

Seeding date	Volunteer density seeded (plants/m ²)	Spray date	Plant stage at spraying	Assessments ²		
				Emergence (plants/m ²)	Mid season (plants/m ² ; g/m ²)	Seed yield (g/m ²)
28/5/82	15	21/6/82	GF 1-3 lf	23/6/82 Den: GF, WO, VW	12/8/82 Den: All plants Culms: WO, VW DM: All plants	25/9/82 Yield: FL, VW
	30		WO 2-3 lf			
	45		VW 2-3 lf			
	60		FL 5-7 cm			
17/5/83	7.5	12/6/83	GF 4 lf + 1 tiller	15/6/83 Den: GF, WO, VW	2/8/83 Den: All plants Culms: WO, VW DM: All plants	1/9/83 Yield: FL, VW
	15		WO 4 lf + 1 tiller			
	30		VW 4 lf + 1 tiller			
	45		FL 6-9 cm			

Den: Density; DM: Dry matter; FL: Flax; GF: Green foxtail; VW: Volunteer wheat; WO: Wild oats

¹Overspray with bromoxynil: MCPA on 25/6/82 and 20/6/83

²Assessments: Emergence - two 1/2 m² squares randomly placed in each weedy control plot
Mid season - one 1 m² square randomly placed in rear of each plot
Seed yield - Hege plot combine used to harvest 1.2 m x 3.5 m area down the middle of each plot

Table 3.2 Summary of planting, treatments and assessments carried out during the 1982 and 1983 volunteer barley-flax field trials¹.

Seeding date	Volunteer density seeded	Spray date	Plant stage at spraying	Assessments ²		
				Emergence	Mid season	Seed yield
	(plants/m ²)			(plants/m ²)	(plants/m ² ; g/m ²)	(g/m ²)
28/5/82	15	21/6/82	GF 1-3 lf	25/6/82	15/8/82	25/9/82
	30		WO 2-3 lf			
	45		VB 2-3 lf			
	60		FL 5-7 cm			
17/5/83	7.5	12/6/83	GF 4 lf + 1 tiller	16/6/82	4/8/83	1/9/83
	15		WO 4 lf + 1 tiller			
	30		VB 4 lf + 1 tiller			
	45		FL 6-9 cm			

Den: Density; DM: Dry matter; FL: Flax; GF: Green foxtail; VB: Volunteer barley; WO: Wild oats

¹Overspray with bromoxynil: MCPA on 25/6/82 and 20/6/83

²Assessments: Emergence - two 1/2 m² squares randomly placed in each weedy control plot
Mid season - one 1 m² square randomly placed in rear of each plot
Seed yield - Hege plot combine used to harvest 1.2 m x 3.5 m area down the middle of each plot

subplot comprised flax competing with the volunteer cereal, wild oat and green foxtail. The second subplot was a volunteer only treatment. The wild oat and green foxtail were chemically removed leaving the oilseed crop to compete directly with the volunteer cereal. The third subplot was weed free. All graminaceous weeds were chemically removed so that the flax had no competition. This subplot also served as a zero volunteer cereal density.

Trials were conducted on a well drained Edenburg series clay loam (25% sand, 44% silt, 31% clay). The 1982 trials were established on a field previously sown to barley. The 1983 trials were situated on land which had been fallowed the previous season. Both sites were fertilized with ammonium phosphate fertilizer. In 1982 and 1983, 205 kg/ha of 23-16-0 was applied. The fertilizer was broadcast in the spring with a Barber applicator.

Germination tests for wild oats and green foxtail were performed both years. Germination for wild oats was 84% and 80%, and 90% and 84% for green foxtail in 1982 and 1983, respectively. The amount of seed required to give predetermined densities of 60 wild oat plants/m² and 200 green foxtail plants/m² was weighed out and an additional 20% added to compensate for potential losses during establishment. Certified seed was used for the volunteer wheat (cv. Neepawa) and the volunteer barley (cv. Bonanza). Wheat and barley seeds were treated with Vitaflo [40% carboxin(5,6-dihydro-2-methyl-1,4-oxathin-3-carbonanilide) and 40% thiram (tetramethylthiuram disulfide)], a systemic fungicidal seed treatment, to avert the possibility of fungal pathogens adversely affecting seedling development.

3.1.2 Seeding

Wild oat seeds were spread uniformly by hand over the experimental area. Wheat or barley was then spread on the main plots at the predetermined densities. The plots were disced to a depth of 5-10 cm to incorporate the seeds and fertilizer. Green foxtail was then spread over the experimental area and harrowed in. Finally, flax (cv. Dufferin) was sown at a rate of 38.5 kg/ha with a double disc drill. The seed was planted 3 cm deep and in rows 15 cm apart.

3.1.3 Treatments

Each main plot was subdivided as follows:

- (1) Weedy control--contained volunteer cereal, wild oats and green foxtail with no chemical treatment.
- (2) Volunteer cereal only--wild oats and green foxtail removed using diclofop-methyl {(190 g/l emulsifiable concentrate) (2-(4-(2,4-dichlorophenoxy) phenoxy) propionic acid)} applied at 0.8 kg/ha. Application dates as indicated in Tables 3.1 and 3.2.
- (3) Weed free (zero volunteer cereal density)--volunteer cereal, wild oats and green foxtail removed using HOE 00736, an experimental herbicide from Hoechst Ag, a mixture of two active ingredients of 2 parts fenthiaprop-ethyl {(120 g/l emulsifiable concentrate)[ethyl 2-(4-(2,6-benzoxazolyloxy)-phenoxy)-propanoate]]}, to 1 part fenoxaprop-ethyl {(60 g/l emulsifiable concentrate) [ethyl 2-(4-(6-chloro-2-benzoxazolyloxy)-phenoxy)-propanoate]} applied at 0.25 kg/ha.

Application dates as indicated in Tables 3.1 and 3.2.

An overspray of Buctril M, a mixture of equal parts bromoxynil {(225 g/l emulsifiable concentrate)[3,5-dibromo-4-hydroxybenzo-nitrate (4-cyano-2,6-dibromophenol)]} and MCPA {(225 g/l emulsifiable concentrate)[((4-chloro- σ -tolyl)oxy) acetic acid (2-methyl-4-chlorophenoxyacetic acid)]} was applied at 0.56 kg/ha to control broadleaf weeds. Application dates indicated in Tables 3.1 and 3.2.

All herbicides were applied with a bicycle sprayer. The spray volume was 112 l/ha and the chemicals were applied with 8001 Teejet stainless steel nozzles at 200 kPa.

3.1.4 Assessments

Assessments were made during the growing season (Tables 3.1 and 3.2).

Emergence counts were taken in weedy check plots approximately four weeks after seeding. Two $1/2 \text{ m}^2$ squares, were randomly placed in each plot and the number of volunteer cereals, wild oats and green foxtail plants recorded. Vegetative production (on a dry weight basis) was measured in early August in all plots. A 1 m^2 square was placed in the rear 1.5 m of the plot. Specific assessments varied as follows:

- volunteer cereal - counts, culm counts and dry weight
- wild oats - counts, culm counts and dry weight
- green foxtail - counts and dry weight
- flax - counts and dry weight

Samples were oven-dried at 80 C for 48 hours prior to weighing.

A Hege plot combine was used to harvest a 1.2 m by 3.5 m area

down the center of each subplot. Harvested samples were separated and screened into oilseed and volunteer cereal fractions using a small clipper and an air column cleaner. The fractions were air dried and weighed.

3.1.5 Statistical interpretation

The results of the experiments were analyzed using the analysis of variance technique for a split-plot design and adjacent means compared using least significance difference (L.S.D.) values. Coefficients of determinations were calculated for flax dry matter and seed yield. The data was transformed to percent crop loss and regressed against the square root transformation of the volunteer density seeded.

3.2 The Effects of Wild Oats, Green Foxtail and/or Increasing Densities of Volunteer Cereals on the Growth and Yield of Canola

This set of trials was conducted in a similar manner as the trials involving flax-volunteers (3.1) with some changes (Tables 3.3 and 3.4). The canola cultivar used was 'Reagent' and was sown at 7.8 kg/ha. Carbofuran (2,3-dihydro-2,3-dimethyl-7-benzofuranyl carbamate) insecticide was applied with the seed at 5.6 kg/ha for early season flea beetle control. No overspray of Bucril M was applied on the rape. Periodic applications of liquid carbofuran were used to control any flea beetle outbreaks. Assessments were conducted as in the flax trials. At physiological maturity, a 1 m by 2 m area of rape was hand-harvested from each subplot. The samples were air-dried and threshed using a Vogel stationary thresher. Samples were cleaned and separated as before (3.1.4).

Table 3.3 Summary of planting, treatments and assessments carried out during the 1982 and 1983 volunteer wheat-canola field trials¹.

Seeding date	Volunteer density seeded	Spray date	Plant stage at spraying	Assessments ²		
				Emergence	Mid season	Seed yield
	(plants/m ²)			(plants/m ²)	(plants/m ² ; g/m ²)	(g/m ²)
28/5/82	15	21/6/82	GF 1-3 lf	27/6/82	18/8/82	18/9/82
	30		WO 2-3 lf	Den: GF, WO, VW	Den: All plants	Yield: CA, VW
	45		VW 2-3 lf		Culms: WO, VW	
	60		CA 5-7 cm		DM: All plants	
17/5/83	7.5	12/6/83	GF 4 lf + 1 tiller	16/6/82	8/8/83	29/8/83
	15		WO 4 lf + 1 tiller	Den: GF, WO, VW	Den: All plants	Yield: CA, VW
	30		VW 4 lf + 1 tiller		Culms: WO, VW	
	45		CA 6-9 cm		DM: All plants	

CA: Canola; Den: Density; DM: Dry matter; GF: Green foxtail; VW: Volunteer wheat; WO: Wild oats

¹Overspray with liquid Furadan to control flea beetles when it was required

²Assessments: Emergence - two 1/2 m² squares randomly placed in each weedy control plot
Mid season - one 1 m² square randomly placed in rear of each plot
Seed yield - Hege plot combine used to harvest 1.2 m x 3.5 m area down the middle of each plot

Table 3.4 Summary of planting, treatments and assessments carried out during the 1982 and 1983 volunteer barley-canola field trials¹.

Seeding date	Volunteer density seeded	Spray date	Plant stage at spraying	Assessments ²		
				Emergence	Mid season	Seed yield
	(plants/m ²)			(plants/m ²)	(plants/m ² ; g/m ²)	(g/m ²)
28/5/82	15	21/6/82	GF 1-3 lf	28/6/82	23/8/82	19/9/82
	30		WO 2-3 lf	Den: GF, WO, VB	Den: All plants	Yield: CA, VB
	45		VB 2-3 lf		Culms: WO, VB	
	60		CA 5-7 cm		DM: All plants	
17/5/83	7.5	12/6/83	GF 4 lf + 1 tiller	17/6/83	10/8/83	30/9/83
	15		WO 4 lf + 1 tiller	Den: GF, WO, VB	Den: All plants	Yield: CA, VB
	30		VB 4 lf + 1 tiller		Culms: WO, VB	
	45		CA 6-9 cm		DM: All plants	

CA: Canola; Den: Density; DM: Dry matter; GF: Green foxtail; VB: Volunteer barley; WO: Wild oats

¹ Overspray with liquid Furadan to control flea beetles when it was required

² Assessments: Emergence - two 1/2 m² squares randomly placed in each weedy control plot
 Mid season - one 1 m² square randomly placed in rear of each plot
 Seed yield - Hege plot combine used to harvest 1.2 m x 3.5 m area down the middle of each plot

4. RESULTS

4.1 The Effects of Wild Oats, Green Foxtail and/or Increasing Densities of Volunteer Cereals on the Growth and Yield of Flax

Approximately four weeks after seeding, wild oat, green foxtail and volunteer wheat or volunteer barley seedlings were counted in weedy control plots to determine the degree of establishment. Actual dates on which these assessments were made are shown in Tables 3.1 and 3.2.

The average densities for wild oats and green foxtail were consistent for 1982 and 1983; wild oat averaged 30-35 plants/m² and green foxtail 149-174 plants/m² (Appendix 8.2). However, densities were less than intended.

The number of volunteer wheat or volunteer barley seedlings counted approximated the intended seeding densities (Appendices 8.3 and 8.4). All observed densities were within $\pm 10\%$ of the intended densities except for the 30/m² and 60/m² volunteer barley densities in the 1983 trial.

In the weed-free subplots, zero volunteer cereal densities, stand counts and dry weight data collected in August of both years indicated that HOE 00736 reduced the growth of all graminaceous species by 94% or more, as compared to unsprayed controls.

4.1.1 Dry matter production

Comparisons of weedy control plots showed that as densities of volunteer wheat or volunteer barley were increased the total shoot dry matter productions of flax, wild oats and green foxtail

decreased (Tables 4.1 - 4.4). However, total dry matter production (TDMP) remained constant over the range of volunteer densities.

To allow visual comparison of the relative partitioning of TDMP, the percentage composition of the individual plant species was calculated and presented graphically (Figures 4.1 and 4.2). As the density of volunteer cereal increased, the percentage of the TDMP corresponding to either wheat or barley also increased. Similar densities of volunteer barley comprised a greater percentage of TDMP than did volunteer wheat. The relative composition of remaining flax, wild oats and green foxtail varied between volunteer trials and years, however, there was no clear trend. In the volunteer wheat trials in 1982 and 1983, no single species comprised greater than 50% of the TDMP over the range of densities seeded. This was not the fact in the volunteer barley trials. Barley densities greater than $30/\text{m}^2$ comprised 50% or more of the TDMP.

To compare the effects of volunteer wheat or volunteer barley alone on the production of flax diclofop-methyl was used to selectively remove wild oats and green foxtail. The herbicide application reduced stand counts and dry weights of wild oat and green foxtail by 95% or more compared to unsprayed controls.

The greatest incremental reduction in dry matter production of flax occurred between the weed-free situation and the lowest volunteer cereal densities in both years. In 1982, 13 volunteer wheat plants/ m^2 reduced flax dry matter from $542 \text{ g}/\text{m}^2$ (weed free) to $409 \text{ g}/\text{m}^2$, a decrease in 25% (Table 4.1). In 1983, 9 volunteer wheat plants/ m^2 reduced flax by 20% (Table 4.2). In 1982, a reduction of 23% was effected by 14 plants/ m^2 (Table 4.3) and in 1983, 8

Table 4.1 The effect of green foxtail, wild oats and/or increasing densities of volunteer wheat on dry matter production for the 1982 flax trial.

Treatment	Volunteer wheat density seeded (plants/m ²)	Dry matter production				
		Green foxtail	Wild oats	Volunteer wheat	Flax	Total
				(g/m ²)		
Weedy control	15	184	234	146	260	824
	30	120	212	227	210	769
	45	129	198	319	209	855
	60	101	163	378	202	844
L.S.D. (0.05)		NS	NS	113	NS	NS
Volunteer only	15			121	409	530
	30			322	369	681
	45			324	333	657
	60			453	264	717
L.S.D. (0.05)				110	NS	132
Weed-free					542	542

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer wheat density seeded).

Wheat vs. flax in weedy control $r = -0.8900$

Wheat vs. flax in volunteer only $r = -0.9932$

Table 4.2 The effect of green foxtail, wild oats and/or increasing densities of volunteer wheat on dry matter production for the 1983 flax trial.

Treatment	Volunteer wheat density seeded	Dry matter production				
		Green foxtail	Wild oats	Volunteer wheat	Flax	Total
	(plants/m ²)			(g/m ²)		
Weedy control	7.5	166	316	75	167	724
	15	148	317	105	165	735
	30	184	261	208	137	790
	45	141	244	269	116	770
	60	114	227	303	117	761
L.S.D. (0.05)		NS	NS	88	NS	NS
Volunteer only	7.5			122	387	509
	15			248	316	564
	30			304	285	589
	45			414	252	666
	60			437	221	658
L.S.D. (0.05)				152	113	NS
Weed-free					484	484

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer wheat density seeded).

Wheat vs. flax in weedy control $r = -0.9659$

Wheat vs. flax in volunteer only $r = -0.9395$

Table 4.3 The effect of green foxtail, wild oats and/or increasing densities of volunteer barley on dry matter production for the 1982 flax trial.

Treatment	Volunteer barley density seeded	Dry matter production				
		Green foxtail	Wild oats	Volunteer barley	Flax	Total
	(plants/m ²)			(g/m ²)		
Weedy control	15	198	262	232	110	802
	30	180	224	290	104	798
	45	135	181	440	99	855
	60	102	164	530	79	875
L.S.D. (0.05)		69	70	60	NS	NS
Volunteer only	15			227	323	550
	30			386	243	629
	45			496	152	648
	60			599	140	739
L.S.D. (0.05)				127	127	164
Weed-free					421	421

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer barley density seeded).

Barley vs. flax in weedy control $r = -0.9093$

Barley vs. flax in volunteer only $r = -0.9778$

Table 4.4 The effect of green foxtail, wild oats and/or increasing densities of volunteer barley on dry matter production for the 1983 flax trial.

Treatment	Volunteer barley density seeded (plants/m ²)	Dry matter production				
		Green foxtail	Wild oats	Volunteer barley	Flax	Total
				(g/m ²)		
Weedy control	7.5	140	352	135	199	826
	15	119	257	243	132	751
	30	123	261	299	115	798
	45	82	220	305	104	711
	60	42	196	672	75	895
L.S.D. (0.05)		90	157	204	106	238
Volunteer only	7.5			236	464	700
	15			448	306	754
	30			548	214	762
	45			714	150	864
	60			800	105	905
L.S.D. (0.05)				272	80	NS
Weed-free					562	562

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer barley density seeded).

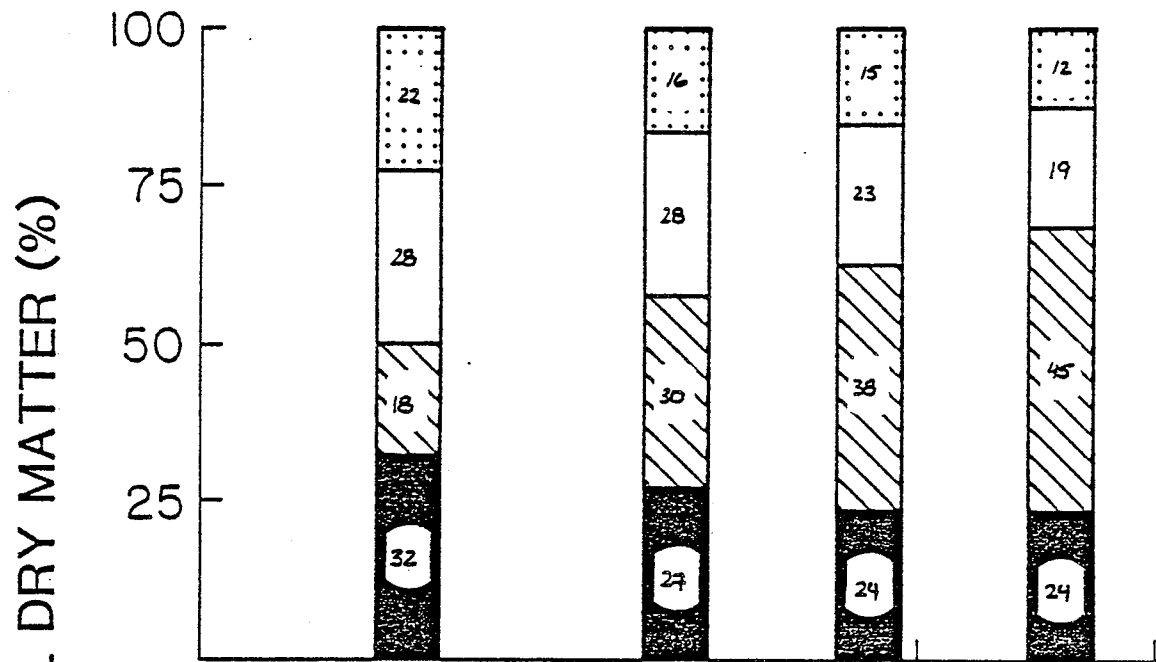
Barley vs. flax in weedy control $r = -0.9368$

Barley vs. flax in volunteer only $r = -0.9844$

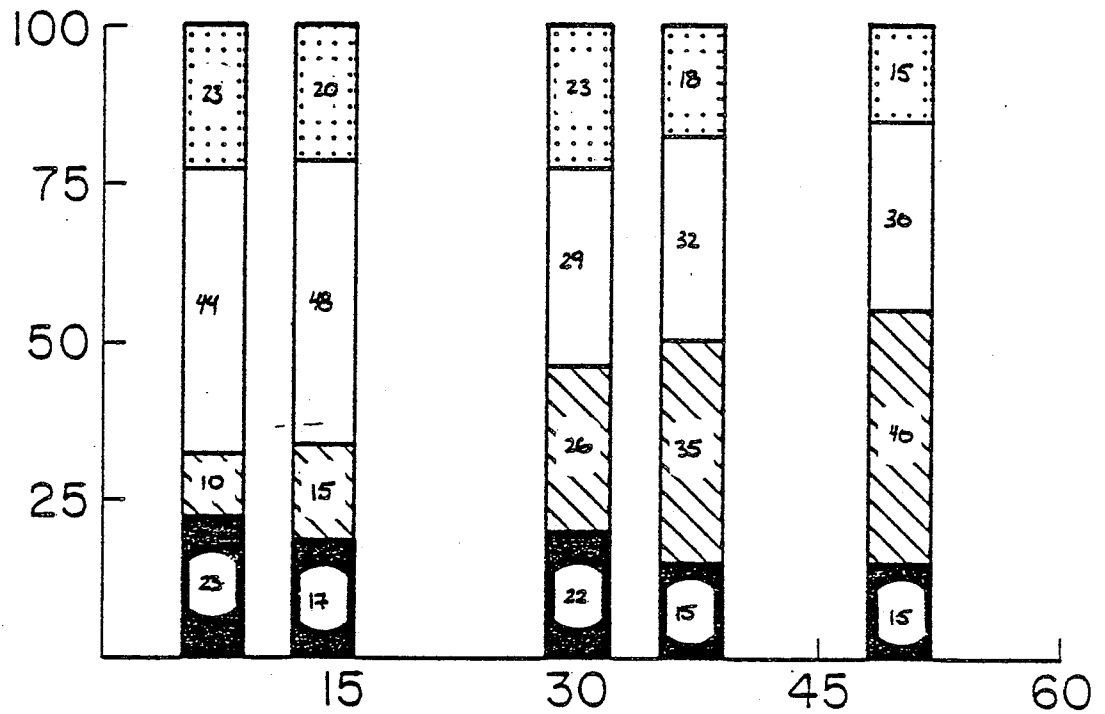
Figure 4.1 Relative partitioning of total dry matter production (TDMP) into percent composition of individual plant species for the weedy control treatment in the 1982 and 1983 volunteer wheat-flax trials.

1982

34



1983



VOLUNTEER WHEAT DENSITY (no.·m⁻²)



Flax



Volunteer
Wheat



Wild
Oat

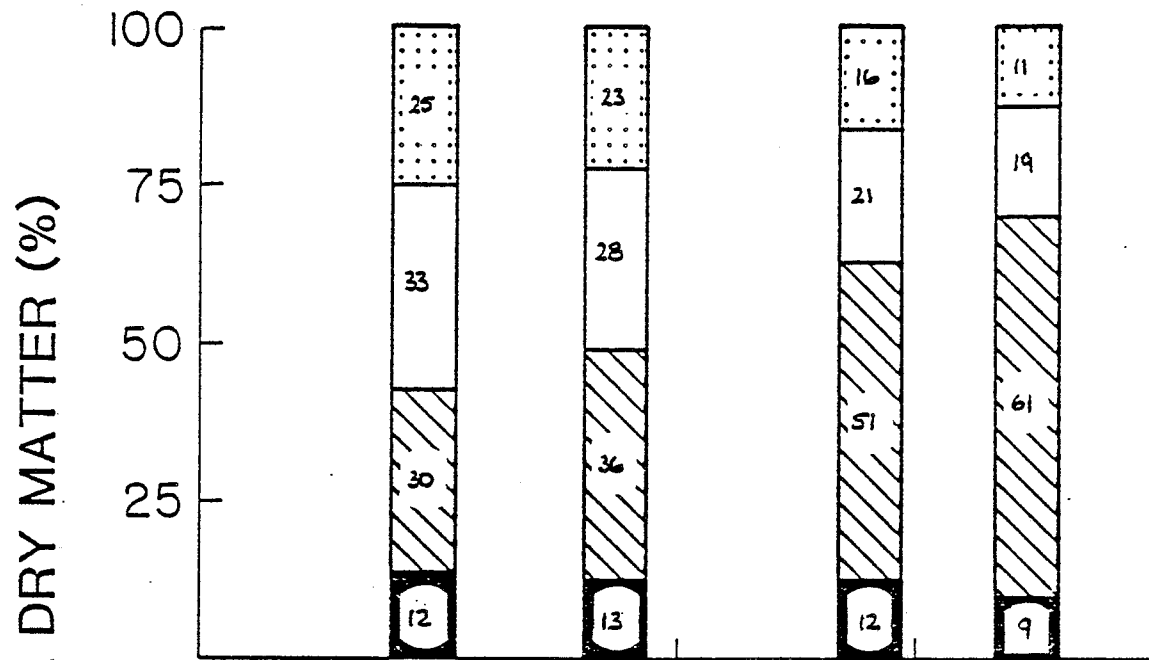


Green
Foxtail

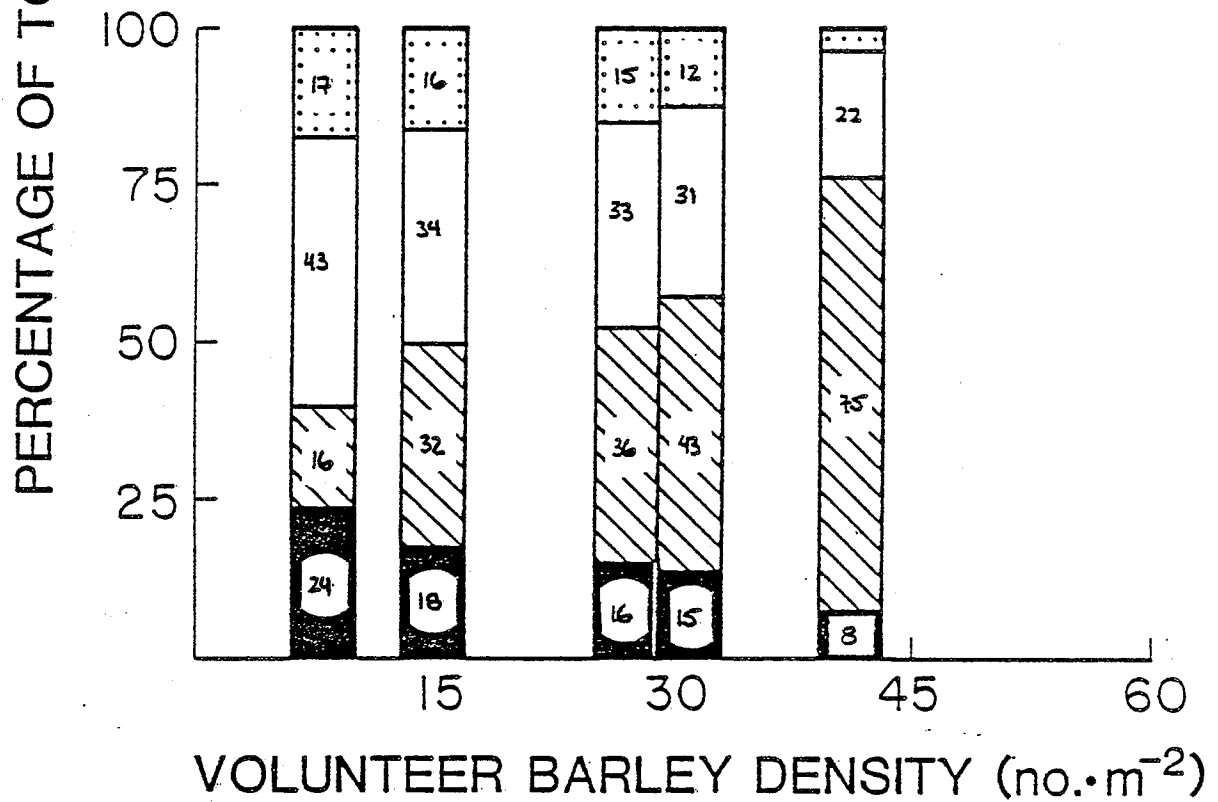
Figure 4.2 Relative partitioning of total dry matter production (TDMP) into percent composition of individual plant species for the weedy control treatment in the 1982 and 1983 volunteer barley-flax trials.

1982

36



1983



Flax Volunteer Barley Wild Oat Green Foxtail

plants/m² caused a 34% reduction (Table 4.4).

Total dry weight increased slightly in the volunteer wheat experiment, whereas there was a more pronounced increase in the volunteer barley experiments over a similar density range.

4.1.2 Culm counts and final seed yield

The number of wild oat and volunteer cereal culms were counted during dry matter sampling in August of both years (Tables 4.5 and 4.6). The number of volunteer culms/m² increased as the density of volunteers increased. However, the average number of culms/volunteer plant generally decreased as the density of volunteers increased. Generally, volunteer cereal plants in the weedy controls had fewer culms/plant than in plots where wild oat and green foxtail had been removed. There was no consistent trend in the number of culms/m² or culms/plant for wild oats.

Flax seed yields were greatly reduced by the presence of graminaceous weeds (Tables 4.7 and 4.8). Reduction in weedy controls were greater than those in plots with volunteer cereals only. In 1982, weedy controls seeded with 15 volunteer wheat plants/m² reduced flax seed yield from 205 g/m² (weed-free) to 65 g/m² (Table 4.7). Seed yield with 60 volunteers/m² was further reduced to 44 g/m². In the absence of wild oat and green foxtail competition, seed yield with 15 volunteers/m² and 60 volunteers/m² was 136 g/m² and 81 g/m², respectively. Similar results occurred in the volunteer barley experiment (Table 4.8). The presence of volunteer barley consistently resulted in greater yield reductions as compared to wheat.

Table 4.5 Wild oats and volunteer wheat densities and culm counts for the 1982 and 1983 flax trials.

Treatment	Volunteers	Wild oats			Volunteer wheat		
	seeded	Density	Culms	Culms	Density	Culms	Culms
	(plants/m ²)	(plants/m ²)	(no/m ²)	(no/plant)	(plants/m ²)	(no/m ²)	(no/plant)
1982							
Weedy control	15	26	131	5.1	13	89	6.8
	30	36	181	5.0	30	142	4.7
	45	31	128	4.2	42	182	4.4
	60	32	129	4.1	54	265	4.9
L.S.D. (0.05)		NS	NS	NS	6	49	1.2
Volunteer only	15				13	65	5.3
	30				35	175	5.1
	45				36	176	4.9
	60				49	238	4.9
L.S.D. (0.05)					17	87	NS
1983							
Weedy control	7.5	42	140	3.2	7	48	6.7
	15	36	144	4.1	12	71	6.0
	30	30	118	4.1	30	147	5.0
	45	43	160	3.8	37	176	4.7
	60	40	131	3.2	50	231	4.6
L.S.D. (0.05)		NS	NS	NS	15	72	0.9
Volunteer only	7.5				9	89	8.9
	15				20	156	9.0
	30				22	167	7.6
	45				49	273	5.7
	60				57	312	5.4
L.S.D. (0.05)					18	108	2.0

Table 4.6 Wild oats and volunteer barley densities and culm counts for the 1982 and 1983 flax trials.

Treatment	Volunteers seeded	Wild oats			Volunteer barley		
		Density	Culms	Culms	Density	Culms	Culms
	(plants/m ²)	(plants/m ²)	(no/m ²)	(no/plant)	(plants/m ²)	(no/m ²)	(no/plant)
				<u>1982</u>			
Weedy control	15	33	167	5.1	14	84	5.9
	30	31	116	3.8	25	111	4.4
	45	26	109	4.2	42	160	3.8
	60	31	136	5.4	52	200	3.9
L.S.D. (0.05)		NS	NS	1.2	7	45	0.8
Volunteer only	15				14	83	6.3
	30				27	138	5.2
	45				43	186	4.4
	60				54	223	4.2
L.S.D. (0.05)					4	42	1.7
				<u>1983</u>			
Weedy control	7.5	34	187	5.5	8	51	5.8
	15	35	156	4.4	15	91	6.3
	30	39	155	4.4	27	112	4.5
	45	40	155	4.5	25	124	5.4
	60	37	132	3.5	41	214	5.6
L.S.D. (0.05)		NS	NS	1.2	14	73	NS
Volunteer only	7.5				8	82	10.2
	15				16	144	8.8
	30				24	196	8.9
	45				49	290	6.5
	60				54	316	5.8
L.S.D. (0.05)					21	84	2.9

Table 4.8 The effects of wild oats, green foxtail and/or increasing densities of volunteer barley on seed yields for the 1982 and 1983 flax trials.

Treatment	Volunteer density	Seed yield	
	seeded	Volunteer barley	Flax
	(plants/m ²)	(g/m ²)	
		<u>1982</u>	
Weedy control	15	77	36
	30	132	28
	45	178	29
	60	192	28
L.S.D. (0.05)		34	5
			$r = -0.8225$
Volunteery only	15	97	118
	30	164	89
	45	196	63
	60	210	49
L.S.D. (0.05)		40	30
			$r = -0.9991$
Weed-free			182
		<u>1983</u>	
Weedy control	7.5	48	33
	15	77	18
	30	98	7
	45	136	9
	60	137	8
L.S.D. (0.05)		65	17
			$r = -0.8652$
Volunteer only	7.5	80	91
	15	122	73
	30	142	61
	45	176	44
	60	202	33
L.S.D. (0.05)		45	17
			$r = -0.9692$
Weed-free			163

4.2 The Effects of Wild Oats, Green Foxtail and/or Increasing Densities of Volunteer Cereals on the Growth and Yield of Canola

Approximately four weeks after seeding, wild oats, green foxtail and volunteer wheat or volunteer barley were counted in weedy control plots to determine the degree of establishment. Actual dates on which these assessments were made are shown in Tables 3.3 and 3.4.

The average densities for wild oats and green foxtail were consistent for 1982 and 1983; wild oats averaged 28-30 plants/m² and green foxtail 145-169 plants/m² (Appendix 8.5). However, densities were less than intended.

The number of volunteer wheat or volunteer barley seedlings counted approximated the intended seeding densities (Appendices 8.6 and 8.7). All observed densities were within $\pm 10\%$ of the intended densities except for the 60/m² density in the 1983 volunteer wheat trial, and the 30/m² density in the 1982 volunteer barley trial.

In the weed-free subplots, used as a zero volunteer cereal density treatment, stand counts and dry weight data collected in August of both years indicated that the HOE 00736 reduced the growth of all graminaceous species by 94% or more, as compared to unsprayed controls.

4.2.1 Dry matter production

Comparisons of weedy control plots showed that as densities of volunteer wheat or volunteer barley were increased, the total shoot dry matter productions of canola, wild oats and green foxtail decreased (Tables 4.9 - 4.12). However, total dry matter production

Table 4.9 The effect of green foxtail, wild oats and/or increasing densities of volunteer wheat on dry matter production for the 1982 canola trial.

Treatment	Volunteer wheat density seeded (plants/m ²)	Dry matter production				
		Green foxtail	Wild oats	Volunteer wheat	Canola	Total
				(g/m ²)		
Weedy control	15	22	62	31	640	755
	30	23	69	44	584	720
	45	23	58	90	564	735
	60	27	67	128	547	769
L.S.D. (0.05)		NS	NS	55	NS	NS
Volunteer only	15			30	562	592
	30			71	515	586
	45			81	500	581
	60			108	451	559
L.S.D. (0.05)				77	115	NS
Weed-free					636	636

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer wheat density seeded).

Wheat vs. canola in weedy control $r = -0.9787$

Wheat vs. canola in volunteer only $r = -0.9889$

Table 4.10 The effect of green foxtail, wild oats and/or increasing densities of volunteer wheat on dry matter production for the 1983 canola trial.

Treatment	Volunteer wheat density seeded	Dry matter production				
		Green foxtail	Wild oats	Volunteer wheat	Canola	Total
	(plants/m ²)			(g/m ²)		
Weedy control	7.5	1	45	9	394	449
	15	3	37	9	367	416
	30	1	27	30	352	410
	45	3	18	35	325	381
	60	2	14	97	310	423
L.S.D. (0.05)		NS	NS	51	128	NS
Volunteer only	7.5			6	500	506
	15			13	475	488
	30			15	454	469
	45			30	434	464
	60			93	402	495
L.S.D. (0.05)				60	86	NS
Weed-free					593	593

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer wheat density seeded).

Wheat vs. canola in weedy control $r = -0.9819$

Wheat vs. canola in volunteer only $r = -0.9826$

Table 4.11 The effect of green foxtail, wild oats and/or increasing densities of volunteer barley on dry matter production for the 1982 canola trial.

Treatment	Volunteer barley density seeded	Dry matter production				
		Green foxtail	Wild oats	Volunteer barley	Canola	Total
	(plants/m ²)			(g/m ²)		
Weedy control	15	74	114	68	558	814
	30	81	137	200	518	936
	45	81	114	225	455	875
	60	43	112	335	440	930
L.S.D. (0.05)		NS	NS	94	NS	NS
Volunteer only	15			54	619	673
	30			152	556	708
	45			188	494	682
	60			294	427	721
L.S.D. (0.05)				123	130	NS
Weed-free					642	642

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer barley density seeded).

Barley vs. canola in weedy control $r = -0.9830$

Barley vs. canola in volunteer only $r = -0.9837$

Table 4.12 The effect of green foxtail, wild oats and/or increasing densities of volunteer barley on dry matter production for the 1983 canola trial.

Treatment	Volunteer barley density seeded	Dry matter production				
		Green foxtail	Wild oats	Volunteer barley	Canola	Total
	(plants/m ²)			(g/m ²)		
Weedy control	7.5	0	15	16	582	613
	15	0	7	28	501	536
	30	0	19	30	476	525
	45	0	22	80	408	510
	60	0	23	191	343	557
L.S.D. (0.05)		NS	NS	83	103	90
Volunteer only	7.5			25	564	589
	15			43	528	571
	30			114	450	564
	45			188	417	605
	60			206	401	607
L.S.D. (0.05)				81	123	NS
Weed-free					567	567

Coefficient of determination (based on percent crop loss regressed on the square root transformation of volunteer barley density seeded).

Barley vs. canola in weedy control $r = -0.9811$

Barley vs. canola in volunteer only $r = -0.9809$

(TDMP) remained constant over the range of volunteer densities.

TDMP tended to be lower in 1983 as compared to 1982.

To allow visual comparison of the relative partitioning of TDMP, the percentage composition of the individual plant species was calculated and presented graphically (Figures 4.3 and 4.4). As the density of volunteer cereal increased, the percentage of the TDMP corresponding to either wheat or barley also increased. Similar densities of volunteer barley comprised a greater percentage of TDMP than did volunteer wheat. Canola dry matter comprised 50% or more of TDMP over the range of volunteer cereals seeded. The contribution of the remaining species, wild oats and green foxtail, consistently comprised less than 25% of TDMP in the volunteer wheat trials and less than 12% in the volunteer barley trials. In the 1983 volunteer barley trial, no green foxtail plants could be found.

Comparison of the effects of volunteer wheat or barley alone on canola production was assessed on the basis that the diclofop-methyl treatment reduced stand counts and dry weights of wild oats and green foxtail by 95% or more compared to unsprayed controls.

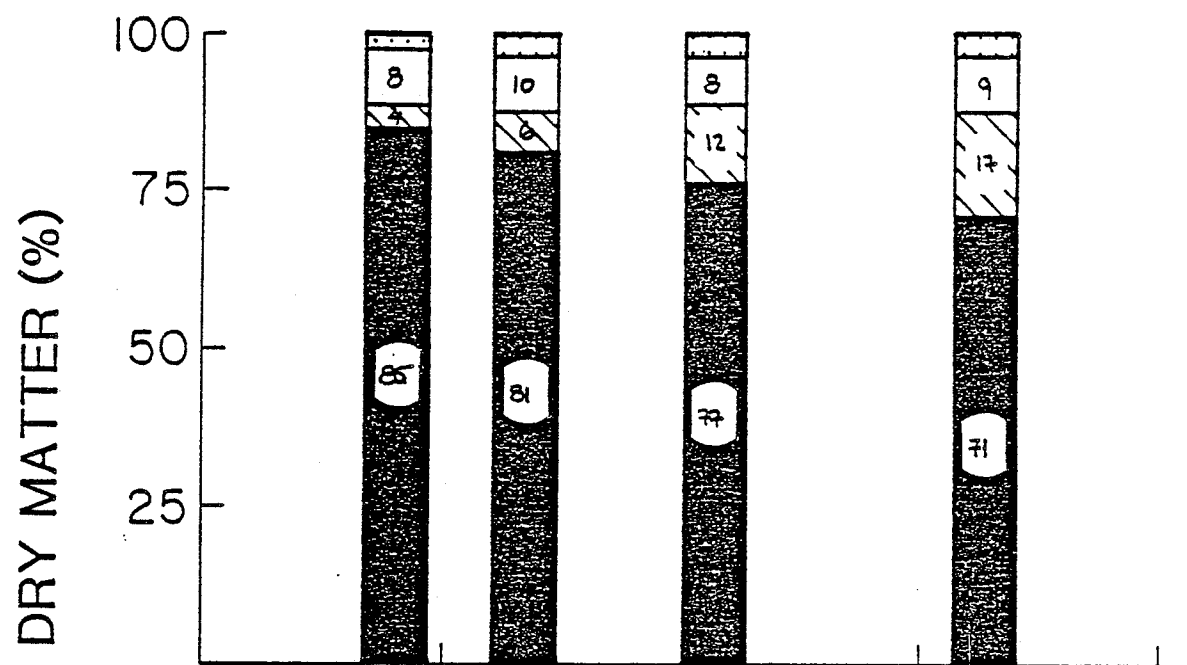
Generally, the greatest increment reduction in dry matter production of canola occurred between the weed-free situation and the first cereal density in both years. Volunteer barley competition consistently caused greater reductions as compared to volunteer wheat.

Canola growth reductions were less in volunteer-only plots as compared to weedy controls with similar volunteer cereal densities. Also, there was no consistent trend for TDMP in either volunteer wheat or volunteer barley trials.

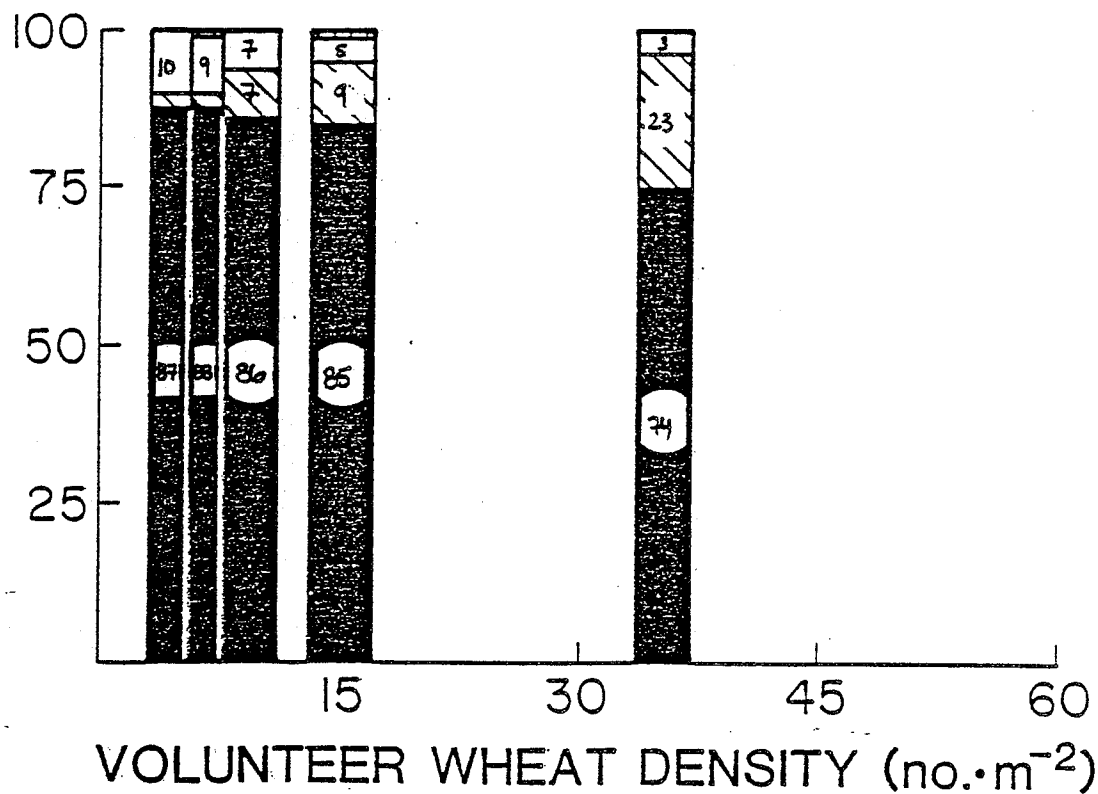
Figure 4.3 Relative partitioning of total dry matter production (TDMP) into percent composition of individual plant species for the weedy control treatment in the 1982 and 1983 volunteer wheat-canola trials.

1982

49

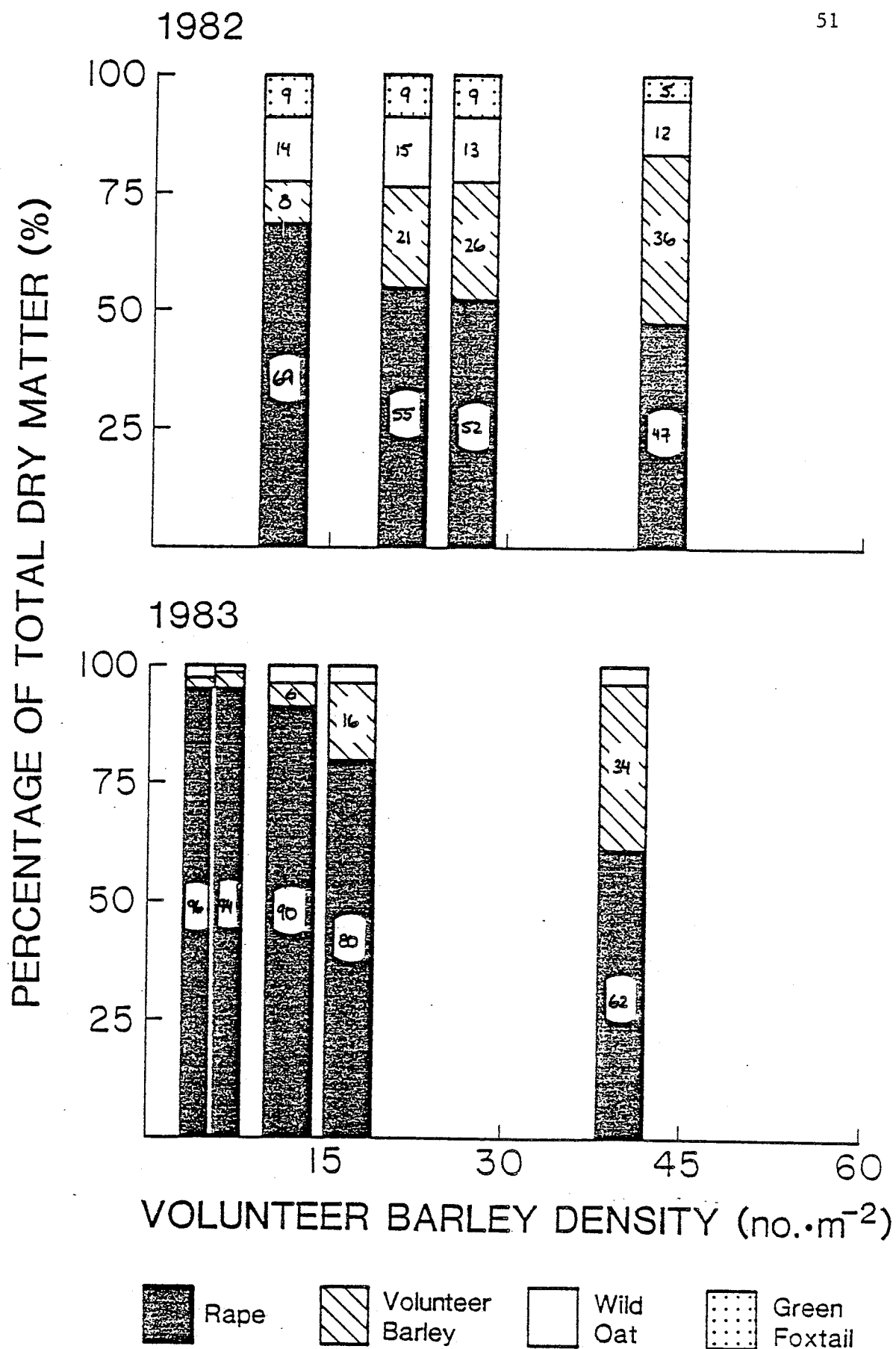


1983



Rape
 Volunteer Wheat
 Wild Oat
 Green Foxtail

Figure 4.4 Relative partitioning of total dry matter production (TDMP) into percent composition of individual plant species for the weedy control treatment in the 1982 and 1983 volunteer barley-canola trials.



4.2.2 Culm counts and final seed yield

The number of wild oat and volunteer culms were counted during dry matter sampling in August of both years (Tables 4.13 and 4.14). The number of volunteer culms/m² increased as the density of volunteers increased. However, there was no consistent trend in the average number of culms/volunteer plant.

Generally, volunteer cereals in weedy controls had slightly fewer culms/plant than in plots where wild oats and green foxtail had been removed. However, the values were inconsistent over the range of volunteers seeded.

Wild oat were seeded at a constant density both years. However, there was no consistent trend in the number of culms/m² or culms/plant.

Canola seed yields were reduced by the presence of graminaceous weeds (Tables 4.15 and 4.16). Reduction in weedy control plots were greater than those in plots with wild oats and green foxtails removed. In 1982, weedy controls seeded with 15 volunteer wheat plants/m² reduced canola seed yield from 179 g/m² (weed-free) to 152 g/m² (Table 4.15). Seed yield with 60 volunteers/m² was 140 g/m², a further reduction of only 12 g/m². In the absence of wild oats and green foxtail competition, seed yield with 15 volunteers/m² and 60 volunteers/m² was 165 g/m² and 149 g/m², respectively. Similar results occurred in the volunteer barley trials (Table 4.16). The presence of volunteer barley resulted in greater yield reductions as compared to volunteer wheat.

Table 4.13 Wild oats and volunteer wheat densities and culm counts for the 1982 and 1983 canola trials.

Treatment	Volunteers	Wild oats			Volunteer wheat		
	seeded	Density	Culms	Culms	Density	Culms	Culms
	(plants/m ²)	(plants/m ²)	(no/m ²)	(no/plant)	(plants/m ²)	(no/m ²)	(no/plant)
<u>1982</u>							
Weedy control	15	19	41	2.2	12	25	2.1
	30	23	45	2.1	20	40	2.1
	45	17	33	1.9	32	56	1.8
	60	24	42	1.6	48	99	2.1
L.S.D. (0.05)		NS	NS	NS	20	33	NS
Volunteer only	15				10	24	2.4
	30				24	56	2.3
	45				23	47	2.3
	60				29	60	1.9
L.S.D. (0.05)					19	NS	NS
<u>1983</u>							
Weedy control	7.5	18	27	1.4	4	7	1.4
	15	26	55	1.4	7	9	1.3
	30	12	15	0.8	12	23	1.8
	45	9	13	1.2	16	28	1.4
	60	27	54	1.9	39	66	1.6
L.S.D. (0.05)		NS	NS	NS	11	34	NS
Volunteer only	7.5				5	5	1.0
	15				6	11	1.2
	30				9	9	0.9
	45				15	14	0.9
	60				35	60	1.5
L.S.D. (0.05)					15	35	NS

Table 4.14 Wild oats and volunteer barley densities and culm counts for the 1982 and 1983 canola trials.

Treatment	Volunteers	Wild oats			Volunteer barley		
	seeded	Density	Culms	Culms	Density	Culms	Culms
	(plants/m ²)	(plants/m ²)	(no/m ²)	(no/plant)	(plants/m ²)	(no/m ²)	(no/plant)
<u>1982</u>							
Weedy control	15	23	56	2.4	11	25	2.4
	30	24	68	2.9	21	73	3.5
	45	22	46	2.4	27	74	2.9
	60	20	38	1.8	45	121	2.8
L.S.D. (0.05)		NS	NS	1.0	10	28	0.8
Volunteer only	15				10	20	1.9
	30				15	41	2.7
	45				27	68	2.5
	60				39	116	2.9
L.S.D. (0.05)					11	47	0.7
<u>1983</u>							
Weedy control	7.5	9	11	1.1	5	6	1.2
	15	15	15	1.0	6	7	0.6
	30	16	16	1.0	13	12	0.8
	45	12	15	1.5	17	23	1.3
	60	12	18	1.3	40	55	1.4
L.S.D. (0.05)		NS	13	NS	16	26	NS
Volunteer only	7.5				5	8	1.8
	15				10	9	0.9
	30				25	49	1.9
	45				37	62	1.9
	60				38	64	1.7
L.S.D. (0.05)					9	23	NS

5. DISCUSSION

The main focus of this study was to evaluate the effects of increasing densities of volunteer wheat or volunteer barley on the growth and yield of flax and canola. The results obtained will be discussed in relation to (a) the weed-crop interactions, (b) the influence of environmental factors, and (c) overall interpretations of the competition studies.

5.1 Weed-Crop Interactions

A great deal of research has substantiated the inverse relationship between weed density and crop yield. As the density of an individual weed species increases, the increased competition results in reduced crop yields (Zimdahl 1980). Clements et al. (1929) described competition in terms of the ability of one species to out-compete another species for growth factors such as water, light and nutrients. A crop which shares the available soil moisture with weeds would be expected to suffer at least to the extent that the weeds thrived (Barnes and Hopkins 1930). Although no research has been published on the competitive ability of volunteer cereals in flax and canola, other competition studies provide insight into weed-crop interactions.

Pavlychenko and Harrington (1934, 1935) studied the ability of crops to withstand annual weed (primarily wild oats) competition under dryland farming conditions in Saskatchewan. Barley was found to be the most competitive small grain, followed by rye (Secale cereale), wheat, tame oats (Avena sativa) and flax in descending

order. This ranking has been confirmed in other studies (Bell and Nalewaja 1968a, b). In a more recent study on wild oats competition in barley, wheat and flax, canola was included (Dew 1983). The results of the study reported herein are in agreement with the generally accepted order of competitiveness vis barley > wheat > canola > flax (Table 5.1).

Table 5.1 The effects of wild oat density on barley, wheat, canola and flax yields¹.

Wild oat density (plants/m ²)	Reduction in yield			
	Barley	Wheat	Canola	Flax
	%			
10	4	8	10	23
40	7	16	20	53
70	14	24	27	64
160	22	38	41	76

¹ Dew (1983)

Greater oilseed losses observed in volunteer barley experiments in this study demonstrated the superior competitive ability of barley in comparison to volunteer wheat. Increasing densities of both volunteers, wheat and barley, resulted in severe yield reduction measured both as dry matter production and final seed yields for flax (Tables 4.1 - 4.4, 4.7 and 4.8) and for canola (Tables 4.9 - 4.12, 4.15 and 4.16). Greater reductions occurred in flax stands as compared to canola with similar volunteer densities. The

greatest incremental yield reductions occurred between the weed-free situation (zero volunteer density) and the first volunteer density: 15 volunteers/m² in 1982 and 7.5 volunteers/m² in 1983.

Root development has been shown to be a primary factor contributing to the competitive efficiency of one species relative to another. Pavlychenko and Harrington (1934) suggested that the most successful competitor would exhibit a large mass of fibrous roots close to the soil surface, but deeply penetrating main roots. Arnon (1972) reported that flax produced a relatively small taproot which may only reach 60 to 90 cm in depth. In contrast, wheat and barley may penetrate up to 200 cm (Weaver 1926; Kemper et al. 1961). The root system of barley has been found to be more extensive than that of wheat (Pavlychenko and Harrington 1934, 1935). Farley (1973) studied the root distribution of Neepawa wheat and Bonanza barley. Wheat had 10% less root weight in the 0 to 50 cm depth and 10 to 15% more root weight in the 50 to 90 cm depth than barley. Barley produced three times as much dry weight of root tissue as wheat. Two rapeseed varieties, Zephyr and Span, were also included in the study. Rapeseed was found to have a larger percentage of root weight at the 50 to 90 cm depth in comparison to the cereals. This difference would suggest a strong capability to take up nutrients and moisture at depth. Flax was not included in the study. Differential root development may explain a major component of the yield losses observed in flax and canola with increasing densities of volunteer wheat or barley.

Light interception is another component of weed-crop interaction. Flax plants are relatively short, with little foliage which

do not form an extensive canopy (van Rijn 1964). Volunteer cereals grew up to 60 cm taller than the flax stems. Wheat and barley developed a more prostrate canopy with time, shading the leaves and developing seed bolls of the flax. The shading would have intensified with increased volunteer cereal density, further stressing the flax plants and reducing yields.

Canola plants quickly established a rosette of broad leaves. The total amount of dry matter that a plant can produce is related to the amount of solar radiation the foliage can intercept. Older leaves at the base of the plant continued to increase in size. Full sunlight interception by canola may have encouraged taproot growth, reduced soil evaporation and smothered weeds. The smothering growth of canola together with volunteer cereals and wild oats severely reduced the infestations and growth of green foxtail plants. None could be found in the 1983 volunteer barley-canola trial during dry matter sampling in early August (Table 4.12).

Volunteer cereal plants grew to approximately the same height as canola. There would have been some degree of crop shading by the volunteer cereals, especially at the higher densities. This shading may have contributed to the reduction in dry matter and seed production of canola observed, however, to a lesser extent than in flax.

Visual observations of the flax and canola plants in this study provided additional information with regard to the nature of the weed-crop interaction. Flax plants from weedy controls and volunteer-only plots showed a decrease in the number of basal shoots and inflorescence branching as compared to the weed-free plots.

Total production of seed and straw has been shown to be a function of branching. Bell and Nalewaja (1968a) studied the competitive effects of wild oats on flax yield components. Although all components were reduced by wild oat competition, a reduction in the number of branches/m² and flax bolls/m² accounted for 90.7% of the yield loss. A reduction in 1000 seed weight accounted for a further 7.0% of the yield loss.

Visual examination of canola plants from weedy controls and volunteer-only plots showed a decrease in the number and thickness of primary, secondary and tertiary branches and pods as compared to weed-free plots. Other researchers have shown that with high plant populations, especially under drought conditions, competition between canola plants often resulted in fewer and smaller pods, concentrated on the upper part of the plant. The higher pod canopy combined with thinner stems frequently resulted in lodging problems. In the 1983 canola trials, lodging was especially severe. This lodging resulted in the death of many volunteer cereal and wild oat plants. This contributed to the reduction in the number of volunteer and wild oat plants/m² to levels well below the densities intended. Differences in lodging between plots may have accounted for some of the variation in data collected. Lodging in 1982 may have been in part due to an incidence of Sclerotinia sclerotium stem infection.

At the flowering stage of the volunteer cereals, culm number/plant was generally reduced in weedy controls as compared to volunteer-only plots (Tables 4.5, 4.6, 4.13 and 4.14). The reduced number of culms produced per cereal plant is probably a direct

consequence of interspecific competition created by the green foxtail and wild oat infestations in the weedy controls. Coupled with an aggressive crop, canola, the combination of crop competition and interspecific weed competition produced cereal plants with infertile tillers. This accounted for values of culms/plant being less than 1 (Tables 4.13 and 4.14).

In weedy controls, the combination of the three graminaceous weeds, volunteer cereal, wild oats and green foxtail resulted in interspecific as well as intraspecific competition. The individual effects of volunteer wheat and barley were determined in plots in which wild oats and green foxtail had been chemically removed. This study was, however, not designed to show the competition due to wild oats and/or green foxtail (weed species present in most farmer's fields in Manitoba (Thomas 1982)). Alex (1970) studied the competition of both wild mustard and cow cockle in wheat. Wild mustard competed strongly with cow cockle. The competitive effects of both species together were found not to be fully additive because the effects of one species tended to obscure the effects of the other. As the density of each weed species increased, productivity per plant decreased. However, the total productivity of all individuals more than compensated for the smaller productivity of each individual. In this study, TDMP remained constant. However, total seed yield initially decreased in weedy controls, with increasing volunteer densities. The distribution of plant species was also markedly affected (Figures 4.1 - 4.4).

Thus in this present study the interaction of different species growing in competition at various densities has been assessed at

both vegetative and reproductive (seed) stages of growth. These observations should now be considered in relation to the possible influence which the environment can exert upon the crop-weed interaction.

5.2 Environmental Factors

Weather conditions varied greatly between 1982 and 1983 (Appendices 8.8 and 8.9). During both years there were no apparent differences in the relative date of emergence of the crops and graminaceous weeds. The 1982 season was characterized by a cool and wet spring resulting in retarded crop growth and a sparse crop stand. Subsequently, much more favourable growing conditions prevailed and high final yields of flax and canola were recorded. By contrast, the spring of 1983 provided favourable conditions for crop establishment and early season growth. Later, however, drought conditions reduced the final crop yields compared to the 1982 results. Flax was clearly less sensitive to the drought since respective final yields for 1982 and 1983 were 194 g/m^2 and 159 g/m^2 (Tables 4.7 and 4.8) where all graminaceous weeds were controlled. Canola yields were reduced by some 50% in the 1983 drought: 187 g/m^2 in 1982 vs. 97 g/m^2 in 1983 (Tables 4.15 and 4.16).

Previous studies with flax (Tiver and Williams 1943) confirmed the relative drought-tolerant nature of flax. Alessi and Powers (1970) have shown that flax, during drier years, was capable of developing deeper root systems. However, Newman (1966) reported severe reductions in primary, secondary and lateral root growth of flax after only 2 days without water. In contrast, canola, a high

user of water (Downey et al. 1974), produced extensive lateral roots in order to exploit any available moisture. Richard and Thurling (1978), observed droughted canola plants with reduced taproot weights but a significantly increased ratio of lateral root to total root weight. Intense competition would have developed in the root zones of this study, irrespective of the season. The greater root distribution of cereals as compared to the two oilseeds, especially flax, was probably reflected in the consistency of yield losses associated with increasing densities of volunteer cereals in both the moist season of 1982 and under the drought of 1983.

5.3 Interpretations of Competition Studies

Several studies have shown that crop yield losses increase with increasing wild oat density (Bell and Nalewaja 1968a, b; Bowden and Friesen 1967; Chancellor and Peters 1974; Friesen and Shebeski 1960). In these studies, weeds were seeded to obtain the desired weed populations. Using analysis of variance techniques, the number of weeds required to cause a significant loss in yield was determined. This was termed the critical density.

Dew (1972) used the data generated in some of these studies (Bell and Nalewaja 1968a, b; Bowden and Friesen 1967) to develop an index of competition that could be used to predict crop losses due to different wild oat densities. The accuracy of the index was later confirmed for western Canada (Hamman 1979) where the information is currently being used to determine the economics of controlling different populations of wild oats (Dew 1972, 1976, 1978b; Dew and Keys 1976; O'Donovan and Sharma 1983) and Canada

thistle (O'Sullivan et al. 1982) with herbicides in cereal and oilseed crops.

Dew's competition equations can be written as:

$$Y' = 100 - b' \sqrt{WO}$$

where Y' is the yield of the crop expressed as a percentage of the expected weed-free yield, WO is the wild oat plant density (plants/m²), and b' is a regression coefficient which Dew termed an index of competition. Dew reported that the index of competition (b') for barley, wheat and flax grown with wild oat was 2.30, 3.39 and 6.01, respectively. Hence, barley was the best competitor and flax the poorest. The indices were relatively independent of the weed-free yield potential of the crop. Dew realized that the competition indices gave a numerical value to a competitive ability that would be unique for each weed and crop combination.

In 1976, Dew and Keys published a regression coefficient of 3.22 for wild oats in Polish rape (Brassica campestris). Although, there are relatively few detailed studies of the growth pattern of rape (Clarke 1977), B. napus and B. campestris appear to be similar (Thurling 1974a, b; Krogman and Hobbs 1975). Therefore, the b' value for B. campestris can be used for B. napus with a degree of confidence.

It would be of interest to determine the relative competitive abilities of wild oats, volunteer wheat and volunteer barley in flax and canola. This can be accomplished by comparing theoretical yield losses due to wild oat (derived using Dew's formula $Y' = 100 - 6.01 \sqrt{\text{comparable volunteer density}}$) with yield losses observed in volunteer wheat and volunteer barley trials for 1982 and 1983

(Tables 5.2 and 5.3).

If the ability of wild oats to cause yield reductions in flax was taken as 1, the data showed that volunteer wheat was 1.38 and 1.67 and volunteer barley 1.57 and 2.12 times more competitive than wild oat in 1982 and 1983, respectively (Table 5.2). The apparent differences in competitive abilities between 1982 and 1983 may be partially attributed to environmental conditions and the inclusion of the 7.5 volunteer plants/m² density increment. The relative

Table 5.2 Comparison of flax seed yield losses due to a theoretical wild oat and observed volunteer wheat or volunteer barley densities for 1982 and 1983.

Plant density (plants/m ²)	Theoretical losses due to wild oats ¹ —— % ——	Observed yield losses	
		Volunteer wheat	Volunteer barley
		1982	
15	23	34	35
30	33	49	51
45	40	50	65
60	46	60	73
		1983	
7.5	16	28	44
15	23	48	55
30	33	59	63
45	40	57	73
60	46	60	80

¹ Wild oat indexed losses calculated using Dew's formula
(Y' = 100 - 6.01 √density).

Table 5.3 Comparison of canola seed yield losses due to a theoretical wild oat and observed volunteer wheat or volunteer barley densities for 1982 and 1983.

Plant density (plants/m ²)	Theoretical losses due to wild oats ¹ —— % ——	Observed yield losses	
		Volunteer wheat	Volunteer barley
		1982	
15	12	8	12
30	18	14	29
45	22	16	30
60	25	17	39
		1983	
7.5	9	15	9
15	12	24	14
30	18	25	29
45	22	24	43
60	25	26	48

¹Wild oat indexed losses calculated using Dew's formula ($Y' = 100 - 3.22 \sqrt{\text{density}}$).

competitive abilities were higher for 1983 compared to 1982. This may have been a result of the delayed application timing of herbicide in 1983 due to weather conditions. Graminaceous weeds were at a more advanced stage than in 1982. Studies have indicated the date of removal of wild oat has an effect on yield (Chancellor and Peters 1974). Barley was more competitive than wheat when compared to wild oat in 1982 and 1983.

Similar comparison of the competitive abilities of wild oats, volunteer wheat and volunteer barley in canola were made (Table

5.3). Volunteer wheat was 0.71 and 1.44 and volunteer barley 1.38 and 1.53 times as competitive as wild oats in 1982 and 1983, respectively. Volunteer barley was more competitive than volunteer wheat.

The exercise of comparing the relative competitive ability of the graminaceous weeds in flax and canola indicated that the presence of volunteer cereals would consistently result in greater potential yield losses as compared to an equal density of wild oats alone. However, the degree to which the yield of flax or canola would suffer due to volunteer cereal competition varied. Averaged for 1982 and 1983, volunteer wheat was 1.53 times more competitive than wild oat in flax and only 1.1 times in canola. This would indicate that canola was better able to withstand volunteer wheat competition than flax. Similarly, volunteer barley was 1.85 times more competitive than wild oats in flax and only 1.46 times in canola. This would also indicate that canola was better able to withstand volunteer barley.

Coefficients of determination (r) were calculated for flax and canola dry matter and seed yield data in weedy controls and subplots containing only volunteer cereals as the graminaceous weed. A number of transformations were made on each data set to improve the fit of the equations. The highest coefficients of determination were obtained for percent crop yield loss regressed on the square root transformation of the volunteer densities seeded. In other studies, transformation of yield weed density has also increased r values (Dew 1972; O'Sullivan et al. 1982; de St. Remy et al. 1985).

Regression coefficients for volunteer only plots were generally

higher than for weedy controls. It appeared that the inclusion of more than one weed species increased the variability of the data obtained. Similar results have been observed by Alex (1970). The increased variability may in part influence the type of weed competition studies performed by researchers. Although grower's fields seldom contain only one weed species, most studies do not focus on this situation. Zimdahl (1980) reported that competition with more than one weed species was not additive. This makes the interpretation of data obtained in multispecific studies more difficult. Hence, the majority of published competition studies involve only one weed species.

Variable r values for 1982 and 1983 indicate that factors other than direct competition may also have influenced the competitive relationship between graminaceous weeds and the crops. It is likely that variable environmental factors (edaphic and/or climatic) contributed to the variation in crop yield losses among years. It was not possible, however, to draw reliable relationships between crop yield loss due to weed competition and environmental conditions during weed and crop growth, since detailed measurements of these factors were not conducted during the course of the experiment. A recent review by Patterson (1985) gives a comprehensive treatise of the influence of the environment on the growth and development of weed species.

The development of an index of competition for volunteer cereals in flax and canola similar to Dew's formulae would be useful. However, the number of data points available is very limited. The trials in this study were conducted at only one

location over two environmentally different years. Many more trials at varying locations, over a number of years, with a range of cultivars under different cultural conditions would be needed to develop a set of formulae that would approach the accuracy and durability of those developed by Dew. Although this was not possible, the data is of value to oilseed growers to provide practical information regarding the level of volunteer cereal infestations which would warrant herbicide application.

BASF Canada Inc. used some of the data generated in this study for a promotional booklet entitled Poast: Guide to Superior Grass Control in Canola, Flax and Other Broadleaf Crops (Anon. 1985). In the volunteer cereal section, realistic oilseed prices were applied to actual yield reductions observed to determine the weed density at which it would be economical to spray; the break even point. Growers were provided with easy to understand break even points in volunteer cereal plants/ft² (Appendices 8.10 and 8.11).

The prevention of weed competition which reduces crop yield is of interest to herbicide developers and growers alike. There can be no doubt that weeds in sufficient number and of sufficient aggressiveness reduce the yield of crops to a value that justifies current herbicide costs. Weed competition is not simple nor are the effects easy to predict. Also, competition is very variable. Further studies are necessary to determine the relative importance of factors such as available soil moisture, soil nutrient status, temperature and time of emergence between volunteer cereals and oilseed crops.

6. CONCLUSIONS

A study was carried out with the primary purpose to determine the effects of increasing densities of volunteer wheat and volunteer barley on the final yield of flax and canola. Wild oats and green foxtail were also included in the weedy controls to simulate an average crop infestation that would occur in a farmer's field. The following is a list of conclusions:

- (a) Volunteer barley caused a greater reduction in the vegetative growth and seed yield of flax and canola as compared to volunteer wheat.
- (b) Reductions in vegetative growth and seed yield were greatest in flax.
- (c) Reductions in flax and canola seed yield increased as the volunteer density increased ($7.5\text{-}60/\text{m}^2$).
- (d) The greatest incremental reduction in the seed yield of flax and canola occurred between the weed-free situation and the first density increment; $15\text{ plants}/\text{m}^2$ in 1982 and $7.5\text{ plants}/\text{m}^2$ in 1983.
- (e) The accuracy of prediction of crop yield loss at a given density of volunteer was reduced in the mixed weed stands and overall was subject to seasonal variation.
- (f) Using competition formulae developed by Dew, the relative order of the ability to cause reductions in flax and canola was volunteer barley > volunteer wheat > wild oats.
- (g) The results obtained can be used by oilseed growers to determine the cost-benefit relationships where defined volunteer infestations are to be controlled by herbicides.

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8. APPENDIX

Appendix 8.1

Friesen (1967) speaking in Vienna posed a series of questions of any weed:

- What densities are necessary to reduce yields?
- Do similar densities have similar effects in all crops?
- At what stages of development does competition occur?
- What is the influence of fertility and moisture?
- How far is a delay in sowing (or emergence) of the crop important in determining the outcome of competition?
- How reproducible are the effects of weeds from field to field, area to area and country to country?
- How do different species (or populations) of weeds compare?

Table 8.2 Emergence counts for wild oats and green foxtail plants for the 1982 and 1983 flax trials.

Flax trial	Year	Wild oat	Green foxtail
		(plants/m ²)	
Volunteer wheat	1982	31 $\pm$ 2 ¹	158 $\pm$ 10
	1983	34 $\pm$ 2	149 $\pm$ 9
Volunteer barley	1982	30 $\pm$ 2	174 $\pm$ 7
	1983	35 $\pm$ 2	160 $\pm$ 12

¹ Values represent mean densities ($\bar{x}$) $\pm$ S.E. for all weedy control plots in all replicates (16 plots for 1982, 20 plots for 1983).

Table 8.3 Volunteer wheat plants present in the intended density treatments during the sampling periods for 1982 and 1983 flax trials.

Volunteer wheat density				
Intended	1982		1983	
	Emergence ¹	Mid season ²	Emergence ³	Mid season ⁴
	(plants/m ²)			
7.5	-	-	7	7
15	15	13	14	12
30	30	30	27	30
45	44	42	45	37
60	58	54	55	50
L.S.D. (0.05)	7	16	5	14

Dates density counts made:

¹ June 24-26, 1982

² August 12-13, 1982

³ June 16, 1983

⁴ August 2-5, 1983



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Table 8.4 Volunteer barley plants present in the intended density treatments during the sampling periods for 1982 and 1983 canola trials.

Volunteer barley density				
Intended	1982		1983	
	Emergence ¹	Mid season ²	Emergence ³	Mid season ⁴
	(plants/m ²)			
7.5	-	-	7	8
15	14	14	16	15
30	31	26	26	27
45	46	42	44	36
60	57	52	54	41
L.S.D. (0.05)	6	7	7	14

Dates density counts made:

¹ June 24-26, 1982

² August 15-18, 1982

³ June 17, 1983

⁴ August 2-5, 1983

Table 8.5 Emergence counts for wild oats and green foxtail plants for the 1982 and 1983 canola trials.

Canola trial	Year	Wild oat	Green foxtail
		(plants/m ²)	
Volunteer wheat	1982	28 ₂ ¹	166 ₁₃
	1983	29 ₂	145 ₈
Volunteer barley	1982	29 ₂	169 ₁₀
	1983	30 ₂	148 ₈

¹ Values represent mean densities ($\bar{x}$) $\pm$ S.E. for all weedy control plots in all replicates (16 plots for 1982, 20 plots for 1983).

Table 8.6 Volunteer wheat plants present in the intended density treatments during the sampling periods for 1982 and 1983 canola trials.

Volunteer wheat density				
Intended	1982		1983	
	Emergence ¹	Mid season ²	Emergence ³	Mid season ⁴
	(plants/m ²)			
7.5	-	-	7	4
15	15	12	13	7
30	29	20	28	12
45	41	22	44	16
60	55	48	54	39
L.S.D. (0.05)	6	20	4	11

Dates density counts made:

¹ June 24-26, 1982

² August 12-13, 1982

³ June 18, 1983

⁴ August 8-12, 1983

Table 8.7 Volunteer barley plants present in the intended density treatments during the sampling periods for 1982 and 1983 canola trials.

Volunteer barley density				
Intended	1982		1983	
	Emergence ¹	Mid season ²	Emergence ³	Mid season ⁴
	(plants/m ²)			
7.5	-	-	7	5
15	14	11	12	6
30	26	21	31	12
45	41	27	43	17
60	55	43	57	40
L.S.D. (0.05)	4	10	6	16

Dates density counts made:

¹ June 24-26, 1982

² August 12-13, 1982

³ June 18, 1983

⁴ August 8-12, 1983

Figure 8.8 Summary of mean weekly temperature ($^{\circ}\text{C}$) and total weekly rainfall (mm) data from May to September, 1982.

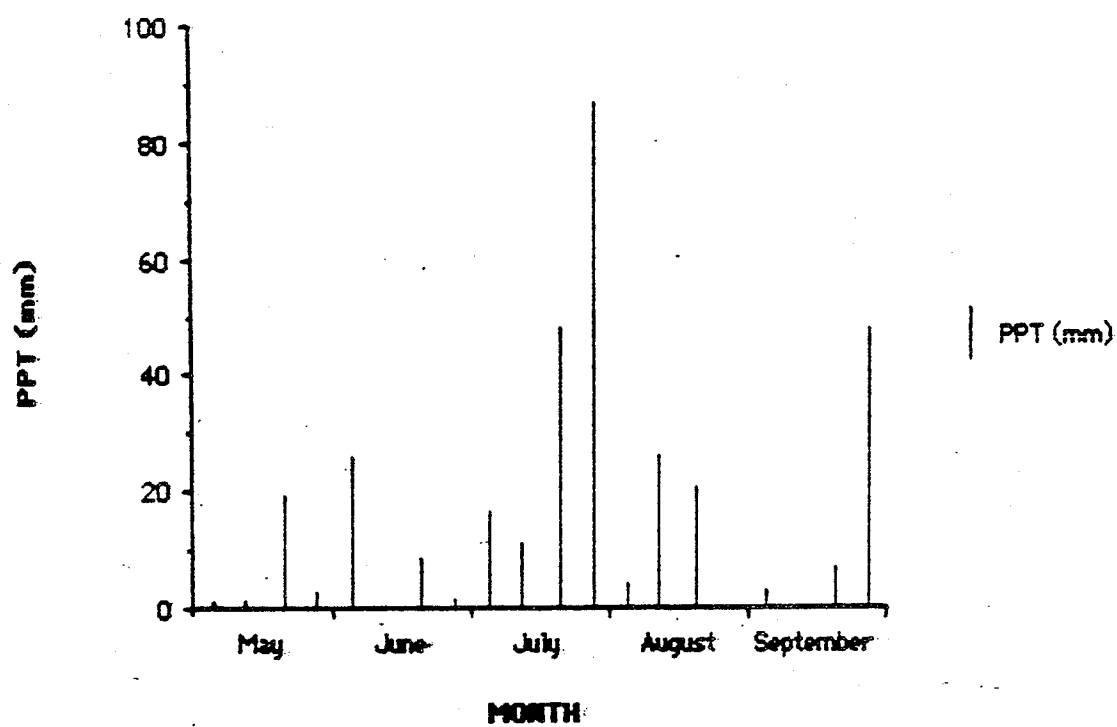
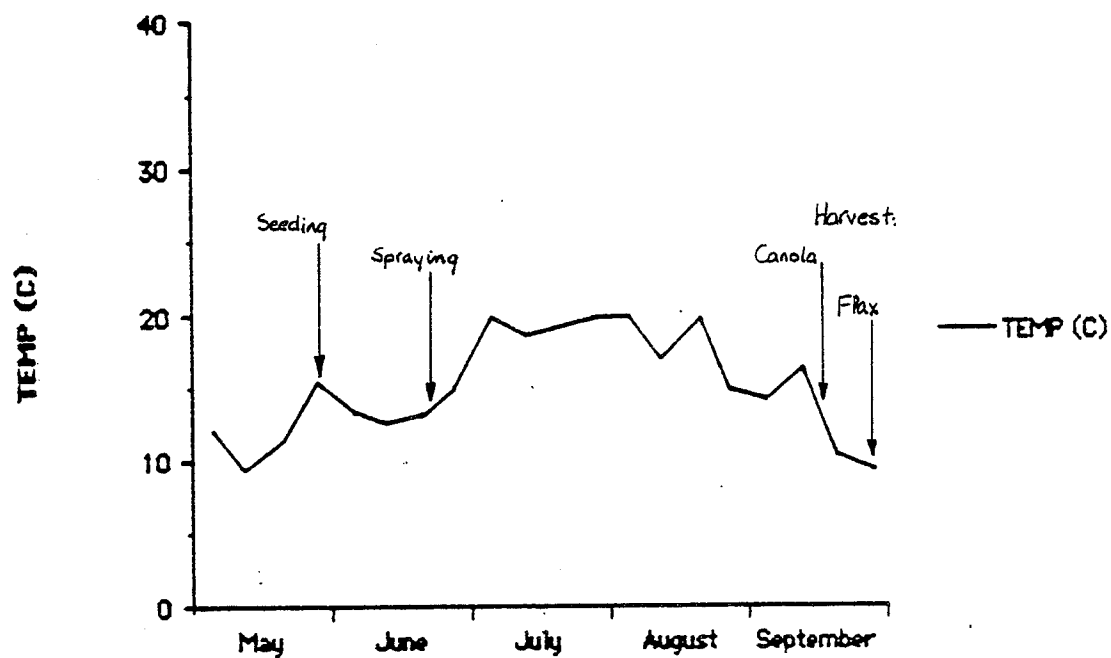


Figure 8.9 Summary of mean weekly temperature ($^{\circ}\text{C}$) and total weekly rainfall (mm) data from May to September, 1983.

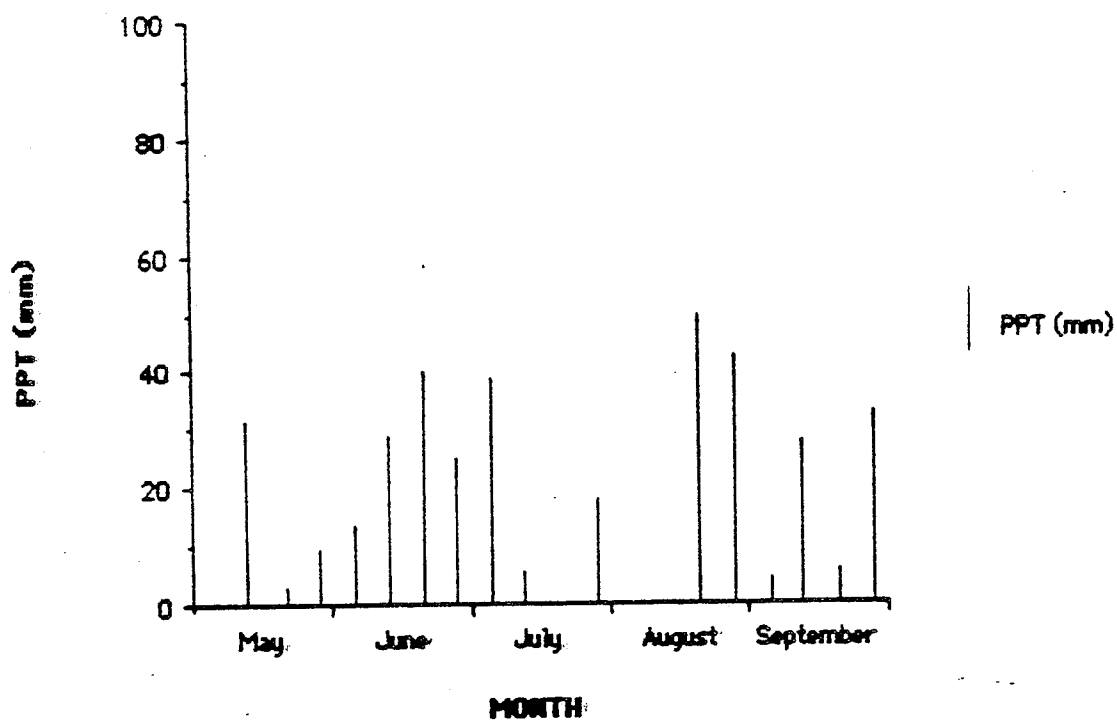
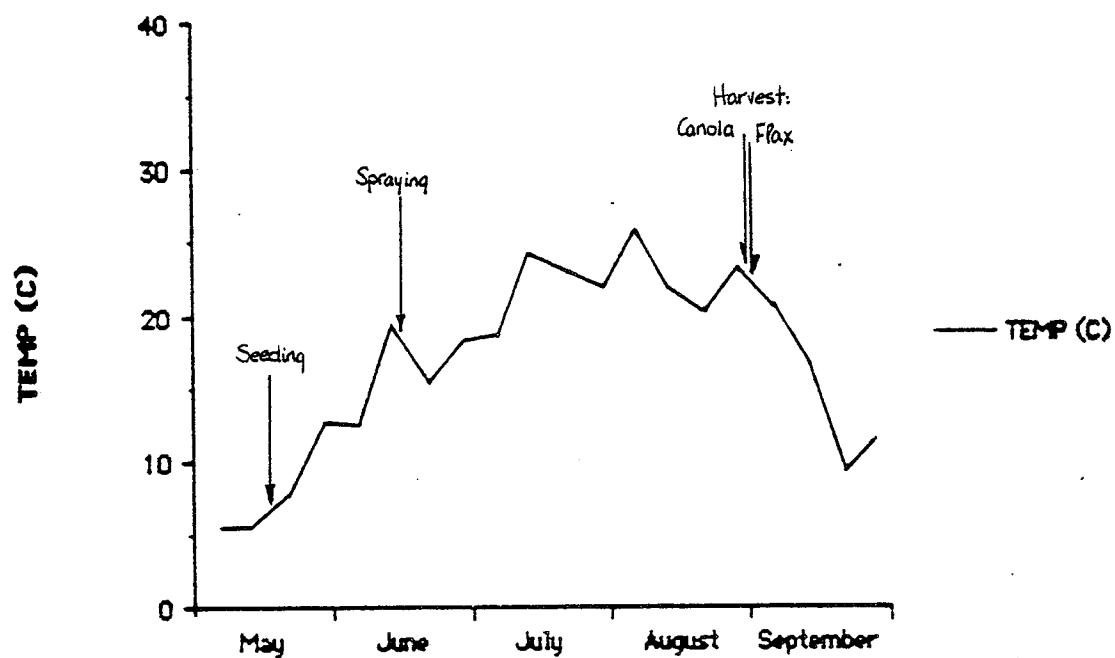
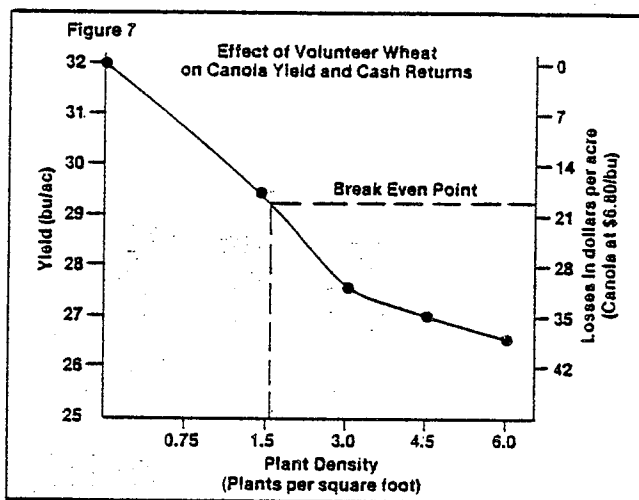
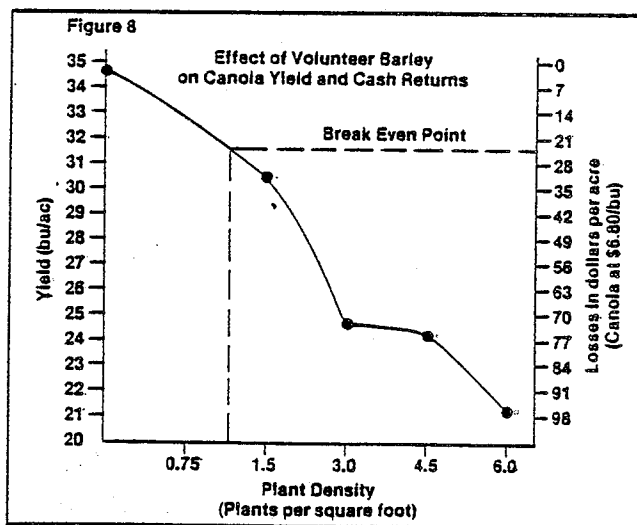


Figure 8.10 Excerpt for the BASF Poast publication (Anon. 1985),
Volunteer Cereal Section: volunteer wheat and
volunteer barley effects on canola yield.

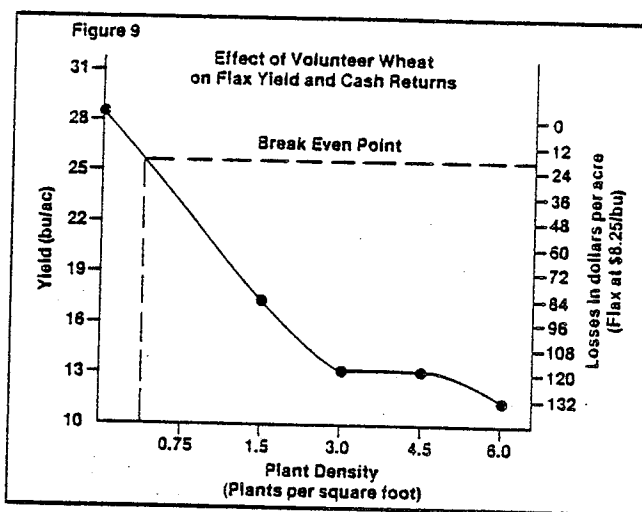


Rother, W. and Morrison, I.N. 1982. Based on the Volunteer Wheat rate/cost of Poast. At the Volunteer Wheat rate it is economical to spray Poast on infestations of 1.5 plants per square foot or more.

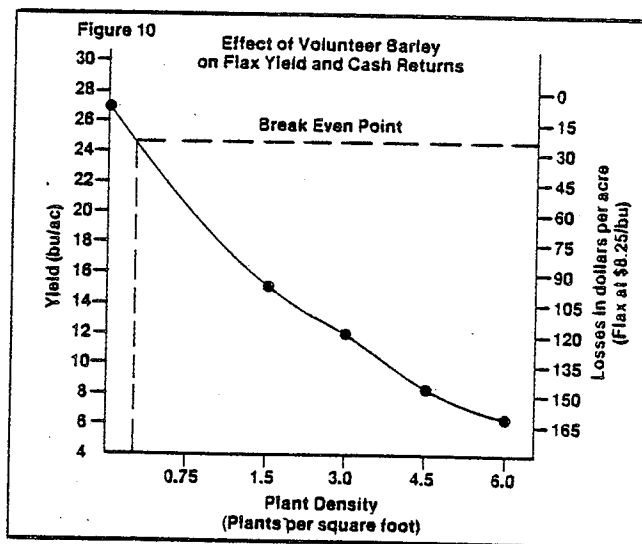


Rother, W. and Morrison I.N. 1982. Based on the Volunteer Barley rate/cost of Poast. At the Volunteer Barley rate it is economical to spray Poast on infestations of 1 plant per square foot or more.

Figure 8.11 Excerpt for the BASF Poast publication (Anon. 1985),
Volunteer Cereal Section: volunteer wheat and
volunteer barley effects on flax yield.



Rother, W. and Morrison I.N. (Ave 1982 & 1983). Based on the Volunteer Wheat rate/cost of Poast. At the Volunteer Wheat rate it is economical to spray Poast on infestations of 1 plant per square foot or more.



Rother, W. and Morrison I.N. (Ave 1982 & 1983). Based on the Volunteer Barley rate/cost of Poast. At the Volunteer Barley rate it is economical to spray Poast on infestations of 1 plant per square foot or more.