ON-FARM EVALUATION OF WHEAT PRODUCTION AS AFFECTED BY THREE WEEDING SYSTEMS AND TOP-DRESSED NITROGEN IN CHAOUIA (SEMI-ARID ZONE OF MOROCCO)

by

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INTRODUCTION

Bread wheat (*Triticum aestivum* L.) and durum wheat (*Triticum durum* Desf.) rank second after barley (*Hordeum vulgare* L.) in crop acreage in Morocco, but production is low and has not kept pace with increased demand resulting from population growth. More than 50% of the production is in arid and semi-arid zones (Jouve & Daoudi, 1984), where the average annual rainfall ranges from 250 to 450 mm. Spring varieties of durum and bread wheats are typically planted from October through December, and harvested in May and June. Most wheat is broadcast-seeded at rates exceeding 100 kg/ha, in a two-year rotation following weedy fallow, rainfed corn (*Zea mays* L.) or food legumes, especially lentils (*Lens culinaris* Medik.).

On farms with mechanical traction, the seedbed for wheat is prepared in moist soil by one or two passes of an offset disk. Seed is then broadcast and incorporated with another offset disking. In fields where animal traction is used, the seed is broadcast directly on the untilled soil, then incorporated with a single pass of a small moldboard plow.

Whatever the traction source, farmers in the Chaouia region generally do not plant cereals until after fall rains have begun, and many weeds have emerged. This results in delayed crop establishment, but the tillage associated with planting thus removes most or all germinated weeds. Wheat germination is generally uneven due to variations in soil moisture and depth of seed burial.

Nitrogen fertilizer is often added at planting time, and the crop may be top-dressed with additional nitrogen if winter rainfall is favorable.

In dryland farming areas of Morocco, little critical attention has been given to weeds associated with wheat; whereas insect pests and plant diseases have drawn much greater attention from the farmers and researchers. This may be because injuries by insects and pathogens are easily noticeable; whereas weeds wage a hidden war on crop plants. Competition by weeds for light, nutrients, and moisture in growing wheat may be one of the most serious losses sustained by farmers. Yet many farmers and agronomists have little appreciation for the losses in crop production due to weeds.

There are three approaches to weed control in wheat in the Chaouia:

1) no control whatsoever, hereafter called nonweeded,
2) manual removal of the largest, most conspicuous weeds, which are usually, but not always, collected for use as forage, hereafter called hand-weeded, and
3) chemical control using phenoxy-type herbicides applied at the full-tiller growth stage of the cereals, hereafter called 2,4-D treated.

The purpose of this research was to study the above three weeding systems on farms in a part of the Chaouia (semi-arid) region, to determine possible effects of top-dressed nitrogen on the weeding systems, and to characterize the weed flora of these wheat fields.

LITERATURE REVIEW

Weed and yield loss surveys.

In Morocco. Several workers have surveyed the weed flora of various crops and in various regions of Morocco (Table 1). The goals of these surveys were to document the numeric abundance and geographic distribution of individual species in the weed flora associated with crops. The surveys were not designed to assess economic losses due to weeds.

Chettou and Taleb (1981) surveyed 120 fields and reported that 250 weed species were associated with rainfed barley and wheat in southern Chaouia. Of these, 87% were dicots. Species with a frequency equal to or greater than 70% were lesser bindweed (*Convolvulus althaeoides* L.), field bindweed (*Convolvulus arvensis* L.), bedstraw (*Galium verrucosum* Hudson), and bladder campion [*Silene vulgaris* (Moench) Garcke].

In other countries. During his four-year weed survey in Saskatchewan for cereal and oilseed crops, Thomas (1985) recorded 164 weed species in 4423 fields. Green foxtail [*Setaria viridis* (L.) Beauv.], wild buckwheat (*Polygonum convolvulus* L.), and wild oat (*Avena fatua* L.) were the three most frequent species.

Dexter et al. (1981) reported in their survery in North Dakota that wild oat, green foxtail and Canada thistle [*Cirsium arvense* (L.) Scop.] were the three most important weeds in reducing North Dakota wheat and barley production. They estimated wheat loss from weeds to be 14.3% and 17.0%, and barley loss to be 11.7% and 15.1%, in 1978 and 1979, respectively.

Table 1. Areas and crops surveyed for weeds in Morocco.

Crop	Area	Species number	Source
Barley and wheat	Haute Chaouia	250	Chettou & Taleb (1981)
Barley and wheat	Sais	150	Loudyi (1982)
Citrus	Souss	248	Bah Thierno (1982)
Various crops	Rabat-Zaers	270	El Houjjaji (1982)
Vegetables	Souss	182	Belaid (1982)
Various crops	Loukkos	255	Chougrani (1984)
Sugarbeet	Gharb	256	Tanji et al. (1984)
Various crops	Abda	270	Wahbi (1985)
Corn	Chaouia	200	Tanji (1986)
Various crops	Tadla	330	Tanji & Boulet (1986)

Mukula et al. (1969, in Zimdahl, 1980) surveyed 2710 wheat fields in Finland and found that soil type, temperature, water conditions and preceding crops were the primary influences on distribution of 304 weed species.

A partial survey of South Dakota wheat fields showed a total of 48 weed species with a mean density of 35 plants per square foot (Dosland and Arnold, 1964).

Dubuis (1973) listed 80 weed species infesting various crops in Algeria. Sixty of them were dicotyledonous species.

In Canada, McRostie (1949) estimated the total loss from weeds at $200 million, an amount equivalent to $15 a year for each man, woman and child. He reported that over 24 million bushels of weed seeds were handled annually in the Canadian grain crops.

The average annual losses due to weeds in wheat have been estimated for the years 1975-1979 to vary from 9 to 20% for the United States, and 5 to 15% for Canada (Chandler et al., 1984).

Cramer (in Longchamp, 1973) estimated losses due to weeds in various crops to be 9% in Europe.

In France, a study of weed interference in wheat and barley conducted in 17 on-farm sites showed an estimated loss of 13% (Barralis and Marnotte, 1980).

Interference of various weed species with wheat.

In Morocco. Little information is available on wheat yield losses due to weeds. Pedzolt and Bennani (1978) found that densities of 10 to 20 plants/m^2 of sterile oat (*Avena sterilis* L.) did not significantly reduce wheat yields; whereas Derbal and Zidane (1980) reported that densities of 20 to 30 panicles/m^2 decreased wheat yield by 30%, and more than 100 panicles/m^2 reduced it by 80%.

Losses were estimated at 74% when wild oat densities were 170 panicles/m^2. A simple regression model ($Y = 2.95 + 0.46X$) was found between the wheat yield loss and panicles of wild oat (Sidibe, 1982). The same author reported that significant wheat yield losses were noted from 10 plants/m^2 of sterile oat and wild mustard (*Sinapis arvensis* L.), from 20 plants/m^2 of Italian rye grass (*Lolium multiflorum* Lam.), and from 40 plants/m^2 of rough bedstraw (*Galium tricornutum* Dandy).

In other countries. It is not surprising that a sizeable amount of literature has accumulated on weed-crop "competition". A review of such literature to June 1978 by Zimdahl (1980) included 586 citations, 57 of which dealt with the effect of weeds on wheat. Some crop losses attributed to weed competition may actually be due to allelopathic properties of weeds rather than competition. Unless experiments are done to elucidate possible allelopathic effects, the word "interference", encompassing both allelopathy and competition, more accurately describes the relationship between weeds and crops (Radosevich and Holt, 1984; Rice, 1984).

Whereas allelopathic interference results from the addition of chemical compounds to the environment, competitive interference involves the removal or reduction of some growing factor(s) from the environment. Since crop and weed plants grow together on the same field, they both have demands for moisture, light, heat and nutrients (Pavlychenko, 1949). Frequently, one or more of these growing factors are present in quantities insufficient to assure the optimum development of even the crop alone. Under these circumstances, weed plants found in the crop use part of the limited supplies and may ultimately reduce crop development and yield (Pavlychenko, 1949).

Zimdahl (1980) reported that competition was recognized by Petrus de Crescentiis in 1305 in a forest community. Zimdahl mentioned that the first studies of plant competition dated back as early as 1860. Clements et al. (1929, in Zimdahl, 1980) stated (page 12): "Competition is a purely physical process... that arises from the reaction of one plant upon the physical factors around it and the effect of the modified factors upon its competitors. In the exact sense, two plants, no matter how close, do not compete with each other so long as the water content, the nutrient material, the light, and the heat are in excess of the needs of both. When the immediate supply of a simple necessary factor falls below the combined demands of the plants, competition begins".

Pavlychenko and Harrington (1934) discussed weeds' competitive efficiency in cereal crops and proposed that root system development may be more important than early germination or the development of a large assimilation surface. Root systems nearest the surface were most effective in competition. They ranked wheat as the least efficient competitor of weeds after barley and rye (Secale cereale L.). Other studies have confirmed that barley competes more vigorously than wheat (Bell and Nalewaja, 1968).

A critical time period exists for wheat during which weed interference will most severely reduce the yield. The length of the weed-free period which is desirable varies with the duration of intensive competition for limiting environmental factors. Under nonirrigated conditions in the semi-arid prairies of North Dakota and Manitoba, wheat tolerated competition for only two weeks after wheat emergence (Dawson, 1970).

Swan and Furtick (1962) reported that one coast fiddleneck (Amsinckia intermedia Fish. and May.) per square foot reduced wheat yields, but wheat that emerged prior to germination of the weeds was not adversely affected by coast fiddleneck interference.

Carter et al. (1946) found that heavy stands of field peppergrass [Lepidium campestre (L.) R. Br.] reduced wheat yield 50% in a favorable (normal rainfall) year and 100% in an unfavorable (irregular rainfall) year.

Wild mustard is an aggressive weed (Koch, 1967). Density of 190 plants/m^2 reduced wheat grain yield 38% and 314 plants/m^2 of cow cockle (Saponaria vaccaria L.) reduced yields by 36%. The competitive effects of both species together were not fully additive (Alex, 1970).

Rola and Rola (1984) demonstrated that the wheat yield losses in Poland brought about by densities of 10, 25, 50 and 100 Tripleurospermum inodorum (L.) Schultz B.P. plants per square meter, were 7, 23, 27 and 34%, respectively.

Appleby et al. (1976) noted that as Italian rye grass increased from one to 93 plants per square meter, wheat grain yields decreased from 0 to 4,100 kilograms per hectare.

Bowden and Friesen (1967) found that from ten to forty wild oat plants per square yard were sufficient to cause significant yield reductions in wheat. It has been reported that the effects of wild oats did not start until the wheat had four leaves (Chancellor and Peters, 1974).

Downy brome (Bromus tectorum L.) is a constant threat to winter wheat. Under certain climatic and field conditions, it can seriously curtail production of winter wheat. Fenster and Wicks (1974) showed that a moderate infestation of downy brome reduced wheat yields 30% and a heavy infestation by 80%.

Cheat (Bromus secalinus L.) was found to grow slowly after germination in wheat fields. This weed proved to be weakly competitive when grown in association with wheat in a thick stand (Carter et al., 1957).

Weed competition for nitrogen.

It is obvious that weeds are nourished by the same food that would nourish crops. Several studies on mineral nutrients (mainly N, P, and K) removed by weeds growing in association with crops have been reported. Weeds have great ability to remove nutrients from the soil profile. Alkamper (1976, in Zimdahl, 1980) stated that weeds usually take up fertilizers more rapidly than crops. Competition for P, K, and other nutrients is much less likely than competition for nitrogen and water (Aldrich, 1984). Blackman and Templeman (1938) found that competition in a year of normal rainfall is primarily for nitrogen and light.

Fertilizer applications are not to be used as measures to increase yields when heavy infestations of weeds are present (McBeath et al., 1970). It was found that applied nitrogen increased wheat yields, but did not prevent crop losses from weed competition (Welbank, 1963; Wells, 1979).

It has been shown that the addition of nitrogen to winter wheat infested with Italian rye grass increased the percentage reductions in wheat yields (Appleby et al., 1976). Removal of weeds resulted in significant increases in grain protein content, suggesting that weeds compete very effectively with grain crops for available nitrogen (Friesen and Shebeski, 1960; Friesen et al., 1960). Jordan et al. (1982 a & b) showed that wild oat alone or associated with Italian rye grass reduced the total wheat plant nitrogen.

ICARDA (1984) researchers in Syria used on-farm diagnostic trials to determine the effects of weed control and fertilizer treatments. They showed strong interactions between weed control and nitrogen fertilization in the wetter sites (seasonal rainfall between 341 and 417 mm) having severe weed infestations. No nitrogen response was obtained in the drier sites (seasonal rainfall between 232 and 323 mm).

History and use of 2,4-D

In April 1942, Zimmerman and Hitchcok, scientists at the Boyce Thompson Institute, reported the discovery of a hormone-like substance identified as 2,4-dichlorophenoxy-acetic acid. The popular abbreviation, "2,4-D", was not used until 1945 (Peterson, 1967). Simultaneously, studies by Slade et al. on 2,4-D were also underway in England (Zimdahl, 1969). The discovery of 2,4-D provided the stimulus which started weed research on its way as a full-fledged new science (Timmons, 1970). For the first time farmers had at their disposal an effective means of controlling many of the weed species occurring in grain fields (Burrows & Olson, 1955).

2,4-D is a systemic herbicide and is widely used for control of broadleaf weeds in cereal crops, sugarcane, turf, pastures, and noncrop land. Spray application is usually post-emergence. The mechanism of action of 2,4-D has been studied more than for any other herbicide. Investigation has shown that it causes abnormal growth response and affects respiration, food reserves, and cell division (Herbicide Handbook, 1983).

The soil persistence of 2,4-D is between one and four weeks. It is moderately toxic (oral LD50 = 300-1000 mg/kg for rats, guinea pigs, and rabbits on a weight basis). It has little or no biological activity on insects, nematodes, or plant pathogens (Herbicide Handbook, 1983).

2,4-D exists in three different formulations: 1) ester, 2) amine salt, and 3) alkaline salt. Ester formulations are quickly absorbed by leaves and are insoluble in water. However, amine and alkaline salts are soluble in water (Detroux, 1965).

2,4-D is the leading herbicide used on wheat in the U.S.A., accounting for 71% of the wheat herbicides sold in 1976 (Anonymous, 1981). It is the most widely used herbicide in Kansas (Temme, 1986).

There is evidence for critical timing of application of 2,4-D. Yield per acre was lowest when wheat plants were treated at the pre-tillering stage (Aitken et al., 1952). Application of 2,4-D to wheat is recommended when the crop is fully tillered, but before it is in the boot stage of growth (Vidal et al., 1979; Whitesides, 1984). Some varieties are susceptible to the rates of 2 and 4 kg acid equivalent (a.e.)/ha when wheat starts to tiller, but these rates are tolerated at full-tiller stage (Cochet et al., 1971).

The reaction of cereals to growth regulator herbicides is largely dependent on the growth stage of the young heads at the time of application (Friesen & Olson, 1953). For example, 2,4-D can cause head deformities if sprayed before the spikelets have been determined (Fryer and Elliott, 1953). If sprayed at the later stage, when cells are dividing to form the pollen and ovules, it sometimes causes sterility. The upper spikelets fail to produce grain and give the head a characteristic "rat-tailed" appearance (Longchamp et al., 1952).

The avoidance of 2,4-D damage to crops, therefore, requires accurate identification of the most tolerant stages of the shoot apex; this may be possible from the external appearance of the plant (Mersie and Parker, 1983). In spring cereals, the number of leaves on the main shoots has so far proved an adequate guide to spray timing (Myers, 1953). In winter wheat, the crop is found to be tolerant when the length of the leaf sheath on the main shoot is 5-10 cm (Tottman, 1977).

Pallas (1960) found that in bean (Phaseolus vulgaris L.), a 2,4-D susceptible species, 2,4-D was absorbed and translocated more at low humidities (34-48%) than at high humidities (70-74%). Movement of 2,4-D in the leaf was generally confined to the vascular bundles and followed the route of the assimilate stream out of the leaf and into the stem, bud and roots.

Hand-Weeding

In Morocco. Hand-weeding is widely practiced by farmers (especially small farmers) throughout Morocco. Taller weeds are pulled out or cut from different crops and used to feed the livestock (Chettou and Taleb, 1981; Benatya et al., 1983; Wahbi, 1985; Herzenni et al., 1986).

In other countries. Mukhopadhyay et al. (1962) reported that in India, hand-weeding is an effective method of weed control. However, it is laborious, costly and time consuming and, therefore, unsuitable for large areas. Pande (1953) found that hand-hoeing and hand-pulling significantly increased grain yield of drilled wheat over nonweeded treatments. Similar results were obtained by Pavlychenko and Harrington (1934) and Godel (1935). Hand-weeding is almost exclusively done by females in semi-arid tropical areas of India (Binswanger and Shetty, 1977).

MATERIALS AND METHODS

Growing Season 1984-85. In February, 1985, 20 identical experiments were established in wheat at the early-tiller stage. Sixteen experiments were on farmers' fields within 60 km of Settat (Fig.1). Two were at the Sidi El Aydi Experimental Station (14 km north of Settat) and two at the Ben Ahmed Agricultural School property (20 km east of Settat). All 20 sites had been planted to either "Nesma 149" bread wheat, or "Cocorit" or "2777" durum wheat. The sixteen sites on farmers' fields had been broadcast-seeded, and the four remaining sites had been seeded with a drill (Appendix Table 1).

All sites were situated on soils which were at least 60 cm deep. These soils are classified* as vertic calcixerolls in the Ben Ahmed area (60 km east of Settat) and calcixerollic chromoxererts in the Oulad Said area (20 km west of Settat). The previous crops in most experiments were lentils, corn, or weedy fallow.

A randomized complete block design with two replications was used. Each replication consisted of six treatments, including three weeding systems and two top-dressed nitrogen levels. The treatments were:

1) application of 480 g a.e./ha 2,4-D low-volatile ester in 200 L/ha spray volume, at the full-tiller stage of wheat;

2) same as treatment 1, plus application of 25 kg/ha nitrogen in the form of ammonium sulphate, at the early-tiller stage of wheat;

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*P. N. Soltanpour, Soil scientist, Aridoculture Center, BP 290, Settat, Morocco. (pers. comm.).

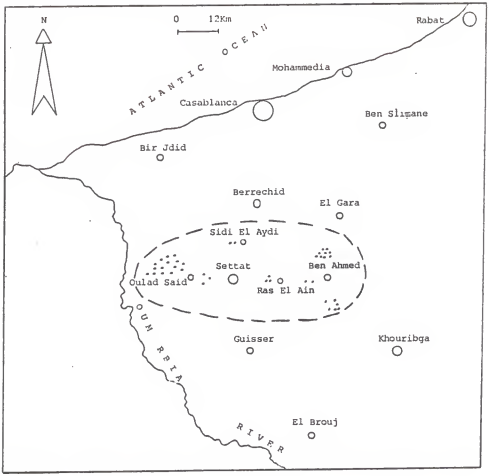

Figure 1. location of the experiments in the Chaouia region;
. experimental site; —— —— limit of the area studied.

3) hand-removal of the larger weeds at wheat heading to simulate farmer practice;

4) same as treatment 3, plus 25 kg/ha nitrogen top-dressed;

5) no weeding;

6) same as treatment 5, plus 25 kg/ha nitrogen top-dressed.

The phenoxy herbicide, 2,4-D, was selected because weeds infesting wheat fields in the Chaouia are predominately dicotyledonous (Chettou and Taleb, 1981), and because 2,4-D is the least expensive and most widely used herbicide for broadleaf weed control in wheat in the region. The individual plot size was 2.5 m x 10 m.

Weeds were sampled (1 m^2 from the nonweeded plots and 3 m^2 from the hand-weeded plots) for density and dry weight determinations by hand-pulling at the time of wheat heading. Weed species were identified following Flora Europaea (Tutin et al., 1984), then ranked according to frequency, uniformity and density using a weed index (Dexter et al., 1981; Buhler et al., 1982). The weed index (WI) was expressed as:

$$WI = \frac{WF + 2WU + 6WD}{3}$$

where:

1) WF (weed frequency) is the percentage of total sites surveyed (40 in both years) where the weed species was present;

2) WU (weed uniformity) is the percentage of total plots (480 in both years) in which the weed species was present;

3) WD (weed density) is the average weed population per m^2 based on all fields sampled.

All sampled weeds were oven-dried (60^{o}C for 48 hr) and weighed by species. For each experiment, those species from the nonweeded and hand-weeded treatments that together made up more than 70% of the weed biomass, were used to create an index of weed biomass.

Wheat grain yields were determined by hand-harvesting two m^2 samples from each plot. Grain yield losses were calculated by comparing the yields of the 2,4-D treatment with those of the nonweeded and the hand-weeded treatments, then expressing the result as percentages.

Growing Season 1985-86. In January, 1986, 20 identical experiments were established in growing wheat at the pre-tiller stage. Nineteen experiments were on farms within 60 km of Settat, and one was at Ben Ahmed Agricultural School property (Appendix Table 2). The general area and soil types were the same as the previous year, but the group of cooperating farmers was different. The same treatments were used as in the previous season, except the design was changed to a split-plot design, with nitrogen as the main plot and weed control system as the subplot. Plot size was 2 m x 12 m.

Weeds were identified and sampled (1 m^2 from both the 2,4-D sprayed plots and nonweeded plots, and 24 m^2 from the hand-weeded plots) for density and dry weight determinations by hand-pulling at the time of wheat heading. Wheat grain yield was determined by harvesting a single 0.62 m x 10 m swath from each plot, with a "Suzue" binder.

RESULTS AND DISCUSSION

Wheat was under moisture stress for about two months from the boot to heading stages in March and April 1985, but sufficient rainfall was received to support plant growth later in the growing season. Good distribution of rainfall was received throughout the 1985-1986 growing season (Appendix Table 3).

Effect of top-dressed nitrogen on weed density in three weeding systems.

Weed density in nonweeded treatments was affected by top-dressed nitrogen in only one of 20 experiments (#20, Appendix Table 2) in 1985-1986, and none in 1984-1985. Overall, top-dressed nitrogen had no significant effect on weed density in any of the three weeding systems in either 1984-1985 or 1985-1986 (results not shown).

Effect of top-dressed nitrogen on weed dry weight in three weeding systems.

In only one experiment (#16, Appendix Table 2) did top-dressed nitrogen show any effect on weed dry weight in 1985-1986. Overall, top-dressed nitrogen had no significant effect on weed dry weight in 1984-1985 and 1985-1986 (results not shown).

Effect of top-dressed nitrogen on wheat grain yield in three weeding systems.

In 1984-1985, no effect of top-dressed nitrogen on grain yield was shown in any of the experiments when analyzed individually. But a significant increase in grain yield due to top-dressed nitrogen occurred in one site (Appendix Table 2) in 1985-1986. Top-dressed nitrogen at the rate of 25 kg/ha, applied at the early-tiller stage, did not significantly affect overall wheat grain yield within any weeding system (Tables 2 and 3). These observations may be explained by three possible reasons:

1) adequate nitrogen was applied in most of farmers' fields at seeding time;
2) some nitrogen remained in soils from preceding crops, and
3) the nitrogen application in 1984-1985 was followed by several weeks of drought.

Effect of three-weeding systems on weed density.

A total of 92 and 149 weed species were identified on the experimental sites in 1984-1985 and 1985-1986, respectively. Dicotyledonous species made up 95 and 89% of the total, respectively. Weed species were classified by decreasing weed index (Appendix Tables 4 and 5). Corn poppy (*Papaver rhoeas* L.) had the highest weed index in both growing seasons. This species appeared to be the most abundant and frequent weed in wheat fields in Chaouia.

A total of 157 weed species were identified on all 40 experimental sites in both years (Appendix Table 6). Of these, 86% were fall-germinating winter annuals, 4% were spring-germinating annuals, and 10% were perennials.

In the study area, farmers typically waited for fall rains before planting wheat. Thus, early flushes of weeds were destroyed by tillage, and weed pressure was considered low in many experimental sites in both seasons.

Table 2. Wheat grain yield as affected by top-dressed nitrogen and three weeding systems: nonweeded, hand-weeded, and 2,4-D treated in 19 experiments in 1984-1985 growing season.

Experiments	Nonweeded		Hand-weeded		2,4-D	
	0*	N	0	N	0	N
	----------------	------	----kg/ha----	------	------	----------------
1	1780	1610	1940	1835	1920	2165
2	570	540	620	565	955	1035
3	2390	2390	1995	2650	2470	2305
4	1760	2595	1605	2250	1710	1925
5	1670	1445	955	1570	1535	1830
6	1950	2355	1880	2095	2250	2135
7	1155	1490	1840	1520	1980	1455
8	2835	2755	3540	3265	3020	3145
9	3125	2990	2715	2460	3325	3345
10	3195	3340	3275	3160	3520	3025
11	2415	2295	2130	2075	2050	2785
12**	--	--	--	--	--	--
13	725	740	710	640	2420	1495
14	2135	2360	2075	1845	2580	2400
15	2705	2675	2065	2755	2775	2490
16	2805	2935	2450	2555	2365	2620
17	675	930	820	930	965	850
18	600	825	785	620	845	955
19	1295	1330	1200	1175	1240	1275
20	1030	1315	1240	1155	1185	1395
Average***	1832	1943	1781	1848	2058	2033
LSD (0.05)****	---- 122 ----		---- 163 ----		---- 176 ----	

* 0 = without top-dressed nitrogen; N = with 25 kg/ha top-dressed nitrogen.

** Experiment 12 was not harvested.

*** Average of 19 experiments.

**** Least significant difference to compare average values for each pair of columns.

Table 3. Wheat grain yield as affected by top-dressed nitrogen and three weeding systems: nonweeded, hand-weeded, and 2,4-D treated in 20 experiments in 1985-1986 growing season.

Experiments	Nonweeded		Hand-weeded		2,4-D	
	0*	N	0	N	0	N
	kg/ha					
1	2980	2814	2626	2706	2986	2714
2	1391	1461	1643	1784	1366	1862
3	2251	2011	2041	1889	2851	2367
4	2105	1162	2122	1441	2348	2057
5	2300	2099	2167	1776	2225	2003
6	1258	1323	1449	1303	1656	1193
7	1774	1942	2085	1912	2229	2049
8	1966	1599	1782	1593	1975	1607
9	3541	4001	3384	3755	3898	3970
10	3640	3215	3107	3152	3579	3227
11	1738	1699	1669	1837	1837	1640
12	2623	2563	2750	2375	2660	2662
13	2286	2398	2354	2438	2379	2513
14	1077	1258	842	1050	1293	1371
15	958	1075	788	1119	1268	1311
16	761	531	622	481	679	545
17	1481	1624	1631	1609	1576	1551
18	3330	3326	3163	3426	3187	2987
19	1589	1929	1830	2293	1339	1945
20	1984	2165	2069	2144	2288	2104
Average	2051	2010	2006	2004	2181	2084
LSD (0.05)**	145		133		133	

* 0 = Without top-dressed nitrogen; N = with 25 kg/ha top-dressed nitrogen.

** Least significant difference to compare average values for each pair of columns.

Average weed populations in the nonweeded treatments were 80 and 89 plants/m^2 in 1984-1985 and 1985-1986, respectively (Tables 4 and 5). Hand-weeding for forage removed 41% of the weeds in 1984-1985 and 18% in 1985-1986. The thoroughness of hand-weeding varies from year to year, depending on the need for forage, the size and distribution of the weeds, motivation of the workers, etc., since only large weeds are generally removed.

Application of 2,4-D at the full-tiller stage significantly reduced overall weed density from 89 plants/m^2 to 30 plants/m^2 in the 1985-1986 growing season (Table 6). When experiments were analyzed individually, significant reduction in weed density occurred in 15 of 20 experiments in 1985-1986. Weed species collected from 2,4-D sprayed plots at wheat heading were grasses, partially controlled dicots, and/or late germinating weeds.

Effect of three weeding systems on weed dry weight.

Average dry weights of weeds in the nonweeded treatments were 650 and 730 kg/ha in 1984-1985 and 1985-1986, respectively (Tables 7 and 8). Hand-weeding removed 88 and 40% of the weed dry weight in 1984-1985 and 1985-1986, respectively. Hand-weeding provided 570 kg/ha of forage in 1984-1985 and 284 kg/ha in 1985-1986. Dry weight of weeds pulled from hand-weeded plots increased linearly with their density in 40 experiments (Fig. 2).

Table 4. Weed densities in nonweeded plots, and numbers of weeds pulled in hand-weeded plots, in 20 experiments in 1984-1985 growing season.

Experiments	Nonweeded	Hand-weeded
	---------plants/m^2--------	
1	34	22
2	152	65
3	8	6
4	321	58
5	78	56
6	36	36
7	61	16
8	131	22
9	42	11
10	22	10
11	45	18
12	84	64
13	132	97
14	63	9
15	37	15
16	36	24
17	181	70
18	22	20
19	28	20
20	82	26
Average	80	33

Table 5. Weed densities in nonweeded plots, and numbers of weeds pulled in hand-weeded plots, in 20 experiments in 1985-1986 growing season.

Experiments	Nonweeded	Hand-weeded
	---------plants/m^2---------	
1	50	8
2	121	11
3	38	1
4	102	4
5	185	16
6	89	18
7	76	7
8	29	2
9	71	6
10	104	15
11	105	13
12	75	12
13	174	20
14	108	31
15	109	33
16	60	11
17	107	11
18	32	9
19	11	1
20	134	100
Average	89	16

Table 6. Weed densities in nonweeded plots, and weeds remaining in 2,4-D sprayed plots in 20 experiments in 1985-1986 growing season.

Experiments	Nonweeded	Hand-weeded
	---------plants/m^2---------	
1	50	11
2	121	35
3	40	9
4	102	15
5	185	24
6	89	32
7	76	17
8	29	16
9	71	21
10	104	25
11	105	42
12	75	35
13	174	101
14	108	37
15	109	52
16	60	35
17	107	39
18	32	3
19	11	2
20	134	39
Average	89	30
LSD (0.05)*	-----------16-----------	

* Least significant difference to compare average values for the two columns.

Table 7. Weed dry weights in nonweeded plots, and dry weight of weeds pulled from hand-weeded plots in 20 experiments in 1984-1985 growing season.

Experiments	Nonweeded	Hand-weeded
	------------kg/ha-----------	
1	553	792
2	1596	1903
3	724	634
4	704	326
5	993	855
6	152	145
7	61	295
8	296	204
9	170	46
10	131	130
11	491	257
12	1080	1499
13	2168	1830
14	1342	424
15	1459	750
16	51	166
17	453	386
18	59	92
19	276	243
20	241	423
Average	650	570

Table 8. Weed dry weights in nonweeded plots, and dry weight of weeds pulled from hand-weeded plots in 20 experiments in 1985-1986 growing season.

Experiments	Nonweeded	Hand-weeded
	----------kg/ha-----------	
1	358	140
2	688	323
3	201	55
4	369	55
5	559	239
6	301	165
7	772	238
8	155	44
9	520	214
10	1035	292
11	1154	339
12	720	339
13	1781	584
14	844	260
15	2199	836
16	782	362
17	735	161
18	186	105
19	50	17
20	1187	913
Average	730	284

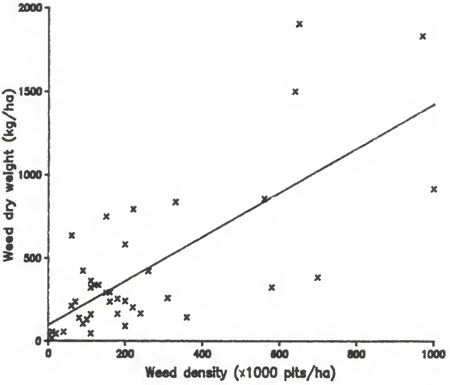

Figure 2. Dry weight of weeds from hand-weeding treatment, in relation to weed density.

$Y = 99 + 1.32\ X$

$R^2 = 0.53$

Application of 2,4-D resulted in a highly significant reduction of weed biomass (from 730 kg/ha to 135 kg/ha) in 1985-1986 (Table 9), the year that weed biomass in the 2,4-D treatment was measured. This biomass reduction of more than 80% supports the adequacy of 2,4-D as an appropriate herbicide for wheat in the Chaouia. When analyzed separately, 15 of 20 experiments showed a statistically significant weed biomass reduction due to 2,4-D treatments. Those not showing significant reductions were populated largely by partially controlled weed species.

Most dicotyledonous weed species, including corn poppy, were susceptible to 2,4-D low-volatile ester used at the rate of 480 g a.e./ha. The five weed species that contributed most to weed biomass were field marigold (Calendula arvensis L.), corn poppy, wild mustard, crown daisy (Chrysanthemum coronarium L.), and chicory (Cichorium endivia L.) (Table 10). Certain species with high weed indexes were not important in terms of weed interference.

Some annual species such as milkvetch (Astragalus boeticus L.), spiny emex (Emex spinosa (L.) Campd.), and crown daisy were partially controlled but generally survived 2,4-D applications. Rates exceeding 480 g a.e./ha would be required to control them.

Effect of three weeding systems on wheat grain yield.

Chemical control with 2,4-D increased wheat grain yield by 6.7% and 9.5% over nonweeded and hand-weeded treatments, respectively, in the 40 experiments (Tables 11 and 12). These increases were statistically significant at the 0.05 level, when treatment means of each site

Table 9. Weed dry weights in nonweeded plots, and dry weight of weeds remaining in 2,4-D sprayed plots in 20 experiments in 1985-1986 growing season.

Experiments	Nonweeded	Hand-weeded
	----------kg/ha-----------	
1	358	47
2	688	315
3	201	36
4	369	18
5	559	312
6	301	95
7	772	25
8	155	44
9	520	47
10	1035	181
11	1154	198
12	720	200
13	1781	394
14	844	100
15	2199	220
16	782	233
17	735	75
18	186	8
19	50	6
20	1187	141
Average	730	135
LSD (0.05)*	-----------225------------	

* Least significant difference to compare average values for the two columns.

Table 10. Mean biomass, weed indexes and susceptibility to 2,4-D of 35 weed species in descending order of contribution to biomass, from 40 sites in the Chaouia region in 1984-1985 and 1985-1986.

Weed species	Mean biomass 1984-1986 g/m^2	Weed index 1985-1986*		Susceptibility to 2,4-D**
1. *Calendula arvensis*	6.10	66	39	C
2. *Papaver rhoeas*	5.43	100	57	C
3. *Sinapis arvensis*	3.40	35	0	C
4. *Chrysanthemum coronarium*	2.66	31	18	P
5. *Cichorium endivia*	2.61	60	8	C
6. *Diplotaxis assurgens*	2.43	29	0	C
7. *Diplotaxis catholica*	2.01	12	0	C
8. *Silene vulgaris*	1.89	30	18	P
9. *Diplotaxis tenuisiliqua*	1.57	18	4	C
10. *Vaccaria pyramidata*	1.23	34	25	C
11. *Emex spinosa*	0.85	34	13	P
12. *Convolvulus althaeoides*	0.84	34	8	P
13. *Centaurea diluta*	0.82	2	0	C
14. *Medicago polymorpha*	0.60	67	27	C
15. *Carthamus caeruleus*	0.49	8	4	C
16. *Scolymus maculatus*	0.48	30	2	C
17. *Ridolfia segetum*	0.40	17	2	C
18. *Bupleurum subovatum*	0.37	48	4	C
19. *Centaurea eriophora*	0.30	23	9	C
20. *Scorpiurus muricatus*	0.25	58	49	C
21. *Avena sterilis*	0.22	11	0	N
22. *Astragalus boeticus*	0.18	43	15	P
23. *Mantisalca salmantica*	0.17	15	5	C
24. *Beta macrocarpa*	0.13	21	7	C
25. *Convolvulus arvensis*	0.12	17	9	P
26. *Vicia monantha*	0.12	23	0	C
27. *Malva parviflora*	0.11	31	17	C
28. *Chenopodium murale*	0.10	29	5	C
29. *Rhagadiolus stellatus*	0.10	32	15	C
30. *Lathyrus articulatus*	0.10	9	2	C
31. *Arisarum vulgare*	0.09	42	38	P
32. *Glaucium corniculatum*	0.08	31	13	C
33. *Torilis nodosa*	0.08	38	13	C
34. *Anagallis foemina*	0.07	53	55	C
35. *Anchusa azurea*	0.07	19	6	C

* First column of weed index is average of nonweeded and hand-weeded treatments. Second column is from 2,4-D treatment.
** C = Controlled, P = Partial control, N = Not controlled.

Table 11. Wheat grain yield in nonweeded, hand-weeded, and 2,4-D sprayed plots in 19 experiments in 1984-1985 growing season.

Experiments	Nonweeded	Hand-weeded	2,4-D
	-------------------kg/ha	-------------------	
1	1695	1888	2043
2	555	593	995
3	2390	2322	2388
4	2178	1928	1818
5	1558	1263	1683
6	2153	1988	2193
7	1323	1680	1718
8	2795	3403	3083
9	3058	2588	3335
10	3268	3218	3273
11	2355	2103	2418
12*	--	--	--
13	733	675	1958
14	2248	1960	2490
15	2690	2410	2633
16	2870	2503	2493
17	803	875	908
18	713	703	900
19	1313	1188	1258
20	1173	1198	1290
Average**	1888	1815	2046
LSD (0.05)***	------------------ 148 ------------------		

* Experiment 12 was not harvested.

** Average of 19 experiments.

*** Least significant difference to compare average values for the three columns.

Table 12. Wheat grain yield in nonweeded plots, hand-weeded plots, and 2,4-D sprayed plots in 20 experiments in 1985-1986 growing season.

Experiments	Nonweeded	Hand-weeded	2,4-D
	--------------------	kg/ha	--------------------
1	2897	2666	2850
2	1426	1713	1614
3	2131	1965	2609
4	1633	1781	2202
5	2200	1971	2114
6	1290	1376	1424
7	1858	1999	2139
8	1783	1687	1791
9	3771	3569	3934
10	3427	3129	3403
11	1719	1753	1738
12	2593	2562	2661
13	2342	2396	2446
14	1168	946	1332
15	1016	954	1289
16	646	551	612
17	1553	1620	1564
18	3323	3295	3087
19	1759	2061	1642
20	2075	2106	2196
Average	2031	2005	2132
LSD (0.05)*	--------------------	92	--------------------

* Least significant difference to compare average values for the three columns.

were analyzed as replicates in the analysis of variance. Grain yields were numerically higher in 28 of 40 experiments when 2,4-D treatment was compared to the nonweeded treatment (Tables 13 and 14). When compared to hand-weeded treatment, yields in 2,4-D treated wheat were higher in 31 of 40 experiments (Tables 15 and 16).

When experiments were analyzed individually, coefficients of variation tended to be high, and treatment differences for grain yield were generally not significant. In addition to the heterogeneity usually associated with natural weed populations, there was crop heterogeneity resulting from hand-broadcasting of wheat seed and from uneven wheat emergence due to the use of offset disks for seed incorporation. This was previously encountered by other researchers conducting on-farm trials (Barralis and Marnotte, 1980; Troeh, 1986).

Grain yields in the hand-weeded treatments were 231 and 127 kg/ha less, in 1984-1985 and 1985-1986, respectively, than in the 2,4-D treatment (Tables 15 and 16). Furthermore, hand-weeding did not increase grain yields over the nonweeded treatment. The reasons for the reduced yield are:

1) the late timing of the removal of weeds;
2) damage to some wheat plants by nearby weeds being pulled, and
3) trampling of the crops by workers.

Gains in forage may compensate for losses to grain yield in the hand-weeded treatment. For the two years, each kg dry weight of forage collected reduced grain yield 0.41 and 0.45 kg.

Table 13. Percent grain yield reduction, when comparing yields in 2,4-D sprayed plots and nonweeded plots in 19 experiments in 1984-1985 growing season.

Experiments	2,4-D	Nonweeded	Difference	Yield loss
	--------------kg/ha--------------			%
1	2043	1695	348	17
2	995	555	440	44
3	2388	2390	-2	-1
4	1818	2178	-360	-20
5	1683	1558	125	7
6	2193	2153	40	2
7	1718	1323	395	23
8	3083	2795	288	9
9	3335	3058	277	8
10	3273	3268	5	1
11	2418	2355	63	3
12*	--	--	--	--
13	1958	733	1225	63
14	2490	2248	242	10
15	2633	2690	-57	-2
16	2493	2870	-377	-15
17	908	803	105	12
18	900	713	187	21
19	1258	1313	-55	-4
20	1290	1173	117	9
Average**	2046	1888	158	
LSD (0.05)***	--------164--------			

* Experiment 12 was not harvested.
** Average of 19 experiments.
*** Least significant difference to compare average values for the two columns.

Table 14. Percent grain yield reduction, when comparing yields in 2,4-D sprayed plots and nonweeded plots in 20 experiments in 1985-1986 growing season.

Experiments	2,4-D	Nonweeded	Difference	Yield loss
	--------------kg/ha	--------------		%
1	2850	2897	-47	-2
2	1614	1426	188	12
3	2609	2131	478	18
4	2202	1633	569	26
5	2114	2200	-86	-4
6	1424	1290	134	9
7	2139	1858	281	13
8	1791	1783	8	1
9	3934	3771	163	4
10	3403	3427	-24	-1
11	1738	1719	19	1
12	2661	2593	68	3
13	2446	2342	104	4
14	1332	1168	164	12
15	1289	1016	273	21
16	612	646	-34	-6
17	1564	1553	11	1
18	3087	3323	-236	-8
19	1642	1759	-117	-7
20	2196	2075	121	6
Average	2132	2031	101	
LSD (0.05)*	--------91---------			

* Least significant difference to compare average values for the two columns.

Table 15. Percent grain yield reduction, when comparing yields in 2,4-D sprayed plots and hand-weeded plots in 19 experiments in 1984-1985 growing season.

Experiments	2,4-D	Hand-weeded	Difference	Yield loss
	--------------kg/ha--------------			%
1	2043	1888	155	8
2	995	593	402	40
3	2388	2322	66	3
4	1818	1928	-110	-6
5	1683	1263	420	25
6	2193	1988	205	9
7	1718	168	38	2
8	3083	3403	-320	-10
9	3335	2588	747	22
10	3273	3218	55	2
11	2418	2103	315	13
12*	--	--	--	--
13	1958	675	1283	66
14	2490	1960	530	21
15	2633	2410	223	9
16	2493	2503	-10	-1
17	908	875	33	4
18	900	703	197	22
19	1258	1188	70	6
20	1290	1198	92	7
Average**	2046	1815	231	
LSD (0.05)***	--------169--------			

* Experiment 12 was not harvested

** Average of 19 experiments

*** Least significant difference to compare average values for the two columns.

Table 16. Percent grain yield reduction, when comparing yields in 2,4-D sprayed plots and hand-weeded plots in 20 experiments in 1985-1986 growing season.

Experiments	2,4-D	Hand-weeded	Difference	Yield loss
	--------------kg/ha	--------------		%
1	2850	2666	184	7
2	1614	1713	-99	-6
3	2609	1965	644	25
4	2202	1781	421	19
5	2114	1971	143	7
6	1424	1376	48	3
7	2139	1999	140	7
8	1791	1687	104	6
9	3934	3569	365	9
10	3403	3129	274	8
11	1738	1753	-15	-1
12	2661	2562	99	4
13	2446	2396	50	2
14	1332	946	386	29
15	1289	954	335	26
16	612	551	61	10
17	1564	1620	-56	-4
18	3087	3295	-208	-7
19	1642	2061	-419	-26
20	2196	2106	90	4
Average	2132	2005	127	
LSD (0.05)*	--------112	--------		

* Least significant difference to compare average values for the two columns.

Apparent losses due to weeds in nonweeded treatments compared to 2,4-D treatment were 7.7% in 1984-1985 and 4.8% in 1985-1986 (Tables 13 and 14). These losses increased linearly with weed biomass in 28 of 40 experiments with weed biomass (Fig. 3). However, these losses are lower than might be expected, and lower than reported in most literature citations. This suggests that farmers in the Chaouia have developed a wheat production system with much "built-in" weed control. Practices such as late seeding, high seeding rates, and crop rotation can provide effective weed control. While recent research in Morocco suggests that wheat yields can be significantly increased by earlier planting (Bouchoutrouch, 1986), preliminary studies (El Brahli, 1986) suggest that earlier wheat planting will greatly increase losses due to weeds if adequate control measures are not taken.

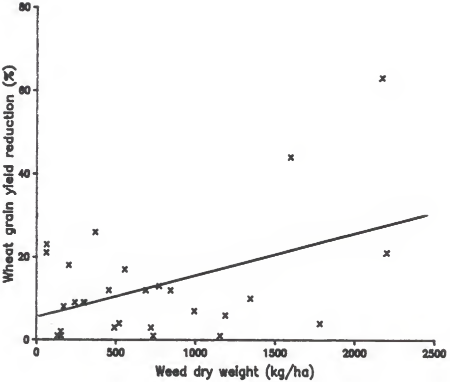

Figure 3. Percent grain yield reduction as a function of weed dry weight, when comparing 2,4-D sprayed and non-weeded plots at 28 experimental sites.

$Y = 5.70 + 0.01\ X$

$R^2 = 0.20$

SUMMARY AND CONCLUSIONS

The effect of top-dressed nitrogen and three weeding systems on wheat were studied under dryland conditions in the Chaouia region, Morocco, in 1984-1985 and 1985-1986.

Top-dressed nitrogen (25 kg/ha) applied at full tillering stage had no significant effect on wheat grain yield. Fertilization at seeding or from previous crops provided enough nitrogen so that there was no advantage from additional top-dressed nitrogen.

For the two years, an average of 30% of the weeds were removed by hand-weeding. Treatment with 2,4-D removed 66% of the weeds in 1985-1986. Hand-weeding removed an average of 64% of the weed dry weight in the two years. Treatment with 2,4-D reduced weed dry weight by 80% in 1985-1986.

Hand-weeding for forage produced an average of 570 kg/ha weed dry matter in 1984-1985, and 280 kg/ha in 1985-1986. However, it lowered wheat grain yield by 231 kg/ha in 1984-1985 and 127 kg/ha in 1985-1986. Over both years, the cost of each kg weed forage was 0.43 kg grain yield loss. Nonweeding reduced grain yields by 158 kg/ha in 1984-1985 and 101 kg/ha in 1985-1986, compared to 2,4-D treatment.

Weed control with 2,4-D increased wheat grain yields over both nonweeded and hand-weeded treatments by an average of 154 kg/ha, over both seasons. Under present price and wage conditions, this approximates a 4:1 average return on investment. Clearly, farmers must assess the need for weed control on a field-by-field basis.

Subsequent studies could investigate the timing and density threshold of weeds in wheat, as well as the economic and social advantages and disadvantages, of each weeding system.

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APPENDIX

Appendix Table 1. Agronomic practices in fields containing the 20 experiments in 1984-1985 growing season.

Experiment	Variety planted	Seeding date	Seeding rate	Seeding mode	Nitrogen applied	Preceding crop
			kg/ha		kg/ha	
1	Nesma	24 Nov.	60	D*	10	wheat
2	Nesma	27 Nov.	60	D	10	wheat
3	2777	17 Nov.	120	B**	10	corn
4	Nesma	15 Nov.	110	B	19	corn
5	2777	20 Nov.	100	B	0	corn
6	2777	3 Jan.	130	B	0	lentils
7	Nesma	15 Feb.	170	B	23	lentils
8	Nesma	19 Nov.	170	B	14	corn
9	2777	15 Nov.	170	B	14	corn
10	2777	15 Nov.	125	B	19	corn
11	2777	15 Nov.	120	B	14	corn
12	Nesma	15 Nov.	120	B	28	corn
13	Nesma	25 Dec.	160	B	14	fenugreek
14	Nesma	15 Dec.	60	D	10	fallow
15	Nesma	15 Dec.	60	D	10	lentils
16	Nesma	5 Dec.	130	B	0	peas
17	Nesma	15 Nov.	160	B	0	fallow
18	2777	8 Nov.	130	B	14	lentils
19	2777	15 Nov.	160	B	21	lentils
20	Nesma	2 Dec.	140	B	10	garlic

* D = on-station sites planted with drill.
**B = broadcast seeded, incorporated with offset disk.

Appendix Table 2. Agronomic practices in fields containing the 20 experiments in 1985-1986 growing season.

Experiment	Variety planted	Seeding date	Seeding rate	Seeding mode	Nitrogen applied	Preceding crop
			kg/ha		kg/ha	
1	Nesma	25 Nov.	120	B*	14	coriander
2	2777	5 Dec.	150	B	7	corn
3	Nesma	15 Dec.	150	B	14	corn
4	Nesma	15 Dec.	150	B	14	faba bean
5	Cocorit	15 Dec.	150	B	14	faba bean
6	Nesma	25 Nov.	120	B	14	wheat
7	2777	30 Nov.	120	B	14	faba bean
8	Nesma	8 Dec.	190	B	29	corn
9	Cocorit	8 Dec.	150	B	19	fallow
10	Cocorit	8 Dec.	140	B	19	corn
11	Nesma	28 Nov.	140	B	19	onion
12	Nesma	28 Nov.	200	B	42	peas
13	2777	15 Nov.	180	B	18	peas
14	2777	15 Dec.	120	B	0	fallow
15	2777	3 Dec.	120	B	0	fallow
16	Nesma	5 Dec.	100	B	0	barley
17	2777	15 Dec.	140	B	44	fallow
18	2777	5 Dec.	110	B	0	lentils
19	2777	8 Dec.	140	B	29	corn
20	Nesma	20 Dec.	100	D**	10	wheat

* B = broadcast seeded, incorporated with offset disk.
**D = on-station site planted with drill.

Appendix Table 3. Monthly rainfall at three locations in the Chaouia region in 1984-1985 and 1985-1986 growing seasons.

Month	Oulad Said		Sidi El Aydi		Ben Ahmed	
	84-85	85-86	84-85	85-86	84-85	85-86
	-------------	-------------	-------------	mm	-------------	-------------
Sept.	0	1	0	0	0	0
Oct.	6	0	9	0	7	0
Nov.	110	67	121	53	83	63
Dec.	32	39	24	31	35	22
Jan.	174	59	125	47	120	61
Feb.	81	111	55	79	52	95
Mar.	6	49	4	22	3	37
Apr.	24	63	20	48	24	44
May	4	0	27	0	18	0
June	0	4	0	0	0	11
July	0	0	0	0	0	0
Aug.	0	0	0	0	0	0
Total	437	393	385	280	342	333

Appendix Table 4. Weed species from 20 experiments, listed in order of decreasing weed index in 1984-1985 growing season.

Weed species	Weed freq-ency (%)	Weed unifor-mity (%)	Weed density (plants/m^2)	Weed index
1. *Papaver rhoeas*	85	54	10.14	85
2. *Vaccaria pyramidata*	85	45	1.27	61
3. *Sinapis arvensis*	65	44	1.54	55
4. *Anagallis foemina*	80	36	2.28	55
5. *Melilotus sulcata*	55	39	2.94	50
6. *Convolvulus arvensis*	55	32	3.66	47
7. *Misopates orontium*	75	29	1.17	47
8. *Scorpiurus muricatus*	60	33	1.12	44
9. *Cichorium endivia*	65	31	0.91	44
10. *Calendula arvensis*	55	28	3.15	43
11. *Medicago polymorpha*	60	29	0.49	40
12. *Convolvulus althaeoides*	55	19	2.55	36
13. *Torilis nodosa*	45	22	0.69	31
14. *Silene vulgaris*	45	16	2.50	31
15. *Arisarum vulgare*	35	15	2.64	27
16. *Glaucium corniculatum*	45	16	0.36	26
17. *Diplotaxis tenuisiliqua*	35	16	1.99	26
18. *Vicia monantha*	50	13	0.12	26
19. *Chenopodium murale*	35	13	1.60	24
20. *Galium tricornutum*	40	14	0.22	23
21. *Galium verrucosum*	35	15	0.55	23
22. *Vicia sativa*	30	18	0.37	23
23. *Rhagadiolus stellatus*	40	11	1.03	23
24. *Bupleurum subovatum*	45	18	0.47	22
25. *Ridolfia segetum*	30	14	0.50	20
26. *Tragopogon hybridus*	40	10	0.14	20
27. *Plantago psyllium*	30	13	0.26	19
28. *Scandix pecten-veneris*	40	8	0.07	19
29. *Polygonum aviculare*	30	12	0.18	18
30. *Diplotaxis assurgens*	15	11	2.34	17
31. *Anacyclus radiatus*	20	13	0.62	17
32. *Astragalus boeticus*	30	9	0.10	16
33. *Herniaria hirsuta*	30	8	0.12	16
34. *Muscari comosum*	30	8	0.07	15
35. *Diplotaxis catholica*	20	9	1.35	15
36. *Emex spinosa*	25	9	0.16	15
37. *Chrysanthemum coronarium*	20	8	1.04	14
38. *Anchusa azurea*	30	6	0.01	14
39. *Silene nocturna*	10	2	0.01	14
40. *Fumaria parviflora*	25	6	0.40	13
41. *Polycarpon tetraphyllum*	10	13	0.40	13

Appendix Table 4 (cont.)

42. Silene gallica	20	7	0.62	13
43. Eruca vesicaria	20	8	0.17	12
44. Silene muscipula	25	4	0.04	11
45. Lathyrus cicera	25	4	0.03	11
46. Scolymus maculatus	20	6	0.17	11
47. Lathyrus articulatus	20	6	0.80	11
48. Filago pyramidata	20	5	0.31	11
49. Chenopodium vulvaria	20	5	0.10	10
50. Euphorbia exigua	20	5	0.04	10
51. Beta macrocarpa	20	4	0.22	10
52. Sinapis alba	25	2	0.03	10
53. Centaurea diluta	15	7	0.12	10
54. Malva parviflora	20	4	0.02	9
55. Euphorbia medicaginea	15	6	0.05	9
56. Matthiola parviflora	15	5	0.09	9
57. Lolium rigidum	15	4	0.19	8
58. Calendula stellata	15	4	0.10	8
59. Rumex bucephalophorus	5	5	0.31	8
60. Lamium amplexicaule	10	6	0.05	7
61. Spergularia purpurea	5	5	1.09	7
62. Capsella bursa-pastoris	10	3	0.74	7
63. Trigonella foenum-graecum	5	1	0.01	7
64. Ornithogalum narbonense	15	3	0.01	7
65. Malva nicaeensis	15	2	0.01	6
66. Chenopodium album	10	3	0.47	6
67. Teucrium resupinatum	10	4	0.12	6
68. Biscutella auriculata	10	4	0.04	6
69. Lens culinaris	15	0.6	0.05	6
70. Desmazeria rigida	10	3	0.02	5
71. Ecballium elaterium	10	2	0.02	5
72. Conringia orientalis	10	2	0.01	5
73. Asperula arvensis	10	1	0.03	4
74. Valerianella discoidea	10	1	0.01	4
75. Vicia lutea	10	1	0.01	4
76. Avena sativa	5	3	0.05	4
77. Torilis arvensis	5	3	0.03	4
78. Euphorbia helioscopia	5	0.6	0.60	3
79. Coronilla scorpioides	5	2	0.02	3
80. Eryngium ilicifolium	5	1	0.09	3
81. Buglossoides arvensis	5	1	0.01	2
82. Medicago truncatula	5	0.6	0.03	2
83. Allium nigrum	5	0.6	0.01	2
84. Centaurea melitensis	5	0.6	0.01	2
85. Nigella hispanica	5	0.6	0.01	2
86. Phalaris brachystachys	5	0.6	0.01	2
87. Silene apetala	5	0.6	0.01	2
88. Sisymbrium irio	5	0.6	0.01	2
89. Vicia benghalensis	5	0.6	0.01	2

Appendix Table 4 (cont.)

90. *Hedypnois cretica*	5	0.6	0.01	2
91. *Linaria reflexa*	5	0.6	0.01	2
92. *Raphanus raphanistrum*	5	0.6	0.01	2

Appendix Table 5. Weed species from 20 experiments listed in order of decreasing weed index in 1985-1986 growing season.

Weed species	Weed frequency	Weed uniformity	Weed density (plants/m^2)	Weed index
1. *Papaver rhoeas*	95	72	10.20	100
2. *Misopates orontium*	90	58	2.30	73
3. *Medicago polymorpha*	80	56	1.20	67
4. *Calendula arvensis*	90	46	2.50	66
5. *Cichorium endivia*	70	40	5.10	60
6. *Scorpiurus muricatus*	65	46	2.80	58
7. *Anagallis foemina*	95	68	4.20	53
8. *Bupleurum subovatum*	60	34	2.30	48
9. *Silene muscipula*	80	27	0.30	45
10. *Astragalus boeticus*	65	31	0.40	43
11. *Arisarum vulgare*	60	28	1.80	42
12. *Silene nocturna*	55	31	0.30	40
13. *Herniaria hirsuta*	75	19	0.90	39
14. *Torilis nodosa*	55	28	0.70	38
15. *Melilotus sulcata*	55	28	0.30	37
16. *Sinapis arvensis*	65	20	0.10	35
17. *Emex spinosa*	60	21	0.10	34
18. *Convolvulus althaeoides*	60	20	0.20	34
19. *Vaccaria pyramidata*	15	41	0.60	34
20. *Rhagadiolus stellatus*	50	23	0.20	32
21. *Chrysanthemum coronarium*	45	22	0.90	31
22. *Malva parviflora*	40	26	0.30	31
23. *Glaucium corniculatum*	40	25	0.30	31
24. *Plantago afra*	50	20	0.20	30
25. *Desmazeria rigida*	55	16	0.50	30
26. *Scolymus maculatus*	50	19	0.20	30
27. *Silene vulgaris*	50	18	0.60	30
28. *Chenopodium murale*	55	15	0.40	29
29. *Diplotaxis assurgens*	10	28	3.60	29
30. *Fumaria parviflora*	45	19	0.20	23
31. *Polygonum aviculare*	40	16	0.20	24
32. *Anacyclus radiatus*	45	13	0.10	24
33. *Filago pyramidata*	40	15	0.30	24
34. *Galium verrucosum*	40	15	0.20	24
35. *Centaurea eriophora*	45	11	0.20	23
36. *Vicia monantha*	30	18	0.40	23
37. *Galium tricornutum*	45	11	0.10	22
38. *Muscari comosum*	50	8	0.01	22
39. *Ornithogalum narbonense*	50	8	0.03	22
40. *Matthiola parviflora*	35	14	0.10	22
41. *Teucrium resupinatum*	40	12	0.20	22

Appendix Table 5 (cont.)

42. *Beta macrocarpa*	40	11	0.20	21
43. *Scandix pecten-veneris*	40	10	0.10	20
44. *Euphorbia medicaginea*	30	14	0.30	20
45. *Vicia benghalensis*	30	14	0.20	20
46. *Anchusa azurea*	30	13	0.20	19
47. *Silene behen*	40	7	0.10	18
48. *Lolium rigidum*	40	7	0.04	18
49. *Papaver hybridum*	35	9	0.02	18
50. *Diplotaxis tenuisiliqua*	20	13	1.40	18
51. *Vicia sativa*	35	9	0.10	18
52. *Ridolfia segetum*	30	11	0.10	17
53. *Convolvulus arvensis*	30	8	0.80	17
54. *Eryngium ilicifolium*	25	12	0.30	17
55. *Hedypnois cretica*	30	9	0.10	17
56. *Polycarpon tetraphyllum*	25	9	0.40	15
57. *Mantisalca salmantica*	20	10	0.70	15
58. *Lolium multiflorum*	30	6	0.03	14
59. *Chenopodium vulvaria*	25	8	0.10	14
60. *Tragopogon hybridus*	25	7	0.10	13
61. *Pisum sativum*	20	9	0.10	13
62. *Lathyrus cicera*	25	6	0.01	13
63. *Diplotaxis catholica*	25	5	0.10	12
64. *Campanula erinus*	25	4	0.10	12
65. *Avena sterilis*	25	4	0.01	11
66. *Ammi majus*	20	6	0.10	11
67. *Silybum marianum*	20	6	0.01	10
68. *Cynodon dactylon*	15	7	0.40	10
69. *Trigonella monspeliaca*	20	5	0.02	10
70. *Coriandrum sativum*	15	7	0.04	10
71. *Biarum bovei*	20	4	0.10	9
72. *Lathyrus articulatus*	15	6	0.10	9
73. *Hirschfeldia incana*	20	4	0.01	9
74. *Asperula arvensis*	20	3	0.01	9
75. *Medicago truncatula*	15	6	0.03	9
76. *Vicia lutea*	15	6	0.03	9
77. *Adonis annua*	15	5	0.07	9
78. *Calendula stellata*	15	5	0.03	8
79. *Euphorbia exigua*	20	3	0.03	8
80. *Buglossoides arvensis*	20	3	0.01	8
81. *Sonchus oleraceus*	15	4	0.03	8
82. *Ecballium elaterium*	15	4	0.10	8
83. *Carthamus caeruleus*	10	4	0.70	8
84. *Fumaria agraria*	15	4	0.01	8
85. *Hippocrepis multisiliquosa*	15	4	0.03	8
86. *Medicago orbicularis*	15	3	0.01	7
87. *Linaria gharbensis*	15	2	0.10	7
88. *Notobasis syriacum*	5	5	0.40	6
89. *Phalaris brachystachys*	10	4	0.02	6

Appendix Table 5 (cont.)

90.	Spergulari purpurea	5	5	0.50	6
91.	Vicia faba	10	4	0.02	6
92.	Sonchus asper	10	3	0.03	6
93.	Rumex bucephalophorus	5	5	0.10	5
94.	Astragalus hamosus	10	3	0.02	5
95.	Nigella hispanica	10	3	0.01	5
96.	Picris echioides	10	3	0.04	5
97.	Coronilla scorpioides	10	2	0.01	5
98.	Delphinium peregrinum	10	2	0.01	5
99.	Euphorbia helioscopia	10	2	0.01	5
100.	Lathyrus ochrus	10	2	0.01	5
101.	Silene gallica	10	2	0.01	5
102.	Astragalus sesameus	5	4	0.02	4
103.	Capsella bursa-pastoris	10	1	0.01	4
104.	Gladiolus segetum	5	4	0.02	4
105.	Mandragora autumnalis	10	1	0.01	4
106.	Medicago turbinata	10	1	0.01	4
107.	Ononis biflora	10	1	0.01	4
108.	Onopordon macracanthum	10	1	0.01	4
109.	Picris cupiligera	10	1	0.01	4
110.	Reseda lutea	10	1	0.01	4
111.	Rumex pulcher	10	1	0.01	4
112.	Scolymus hispanicus	10	1	0.01	4
113.	Sinapis alba	10	1	0.01	4
114.	Torilis arvensis	10	1	0.01	4
115.	Plantago coronopus	5	3	0.04	4
116.	Centaurea melitensis	5	3	0.03	4
117.	Allium nigrum	5	2	0.01	3
118.	Centaurea calcitrapa	5	2	0.01	3
119.	Convolvulus gharbensis	5	2	0.01	3
120.	Lamium amplexicaule	5	2	0.01	3
121.	Kickxia commutata	5	2	0.01	3
122.	Capnophyllum peregrinum	5	1	0.01	3
123.	Carduus myriacanthus	5	1	0.01	3
124.	Chenopodium album	5	1	0.01	3
125.	Lotus arenarius	5	1	0.01	3
126.	Leontodon saxatilis	5	0.6	0.10	2
127.	Allium cepa	5	0.6	0.01	2
128.	Astragalus epiglottis	5	0.6	0.01	2
129.	Atractylis gummifera	5	0.6	0.01	2
130.	Bromus rigidus	5	0.6	0.01	2
131.	Bromus rubens	5	0.6	0.01	2
132.	Caucalis bifrons	5	0.6	0.01	2
133.	Caucalis leptophylla	5	0.6	0.01	2
134.	Centaurea diluta	5	0.6	0.01	2
135.	Cicer arietinum	5	0.6	0.01	2
136.	Crucianella angustifolia	5	0.6	0.01	2
137.	Eryngium tricuspidatum	5	0.6	0.01	2
138.	Lamarckia aurea	5	0.6	0.01	2

Appendix Table 5 (cont.)

139. Lens culinaris	5	0.6	0.01	2
140. Leontodon hispidulus	5	0.6	0.01	2
141. Malva nicaeensis	5	0.6	0.01	2
142. Medicago scutellata	5	0.6	0.01	2
143. Orobanche mutelii	5	0.6	0.01	2
144. Phalaris paradoxa	5	0.6	0.01	2
145. Raphanus raphanistrum	5	0.6	0.01	2
146. Reseda alba	5	0.6	0.01	2
147. Rhaponticum acaule	5	0.6	0.01	2
148. Stellaria media	5	0.6	0.01	2
149. Trifolium tomentosum	5	0.6	0.01	2

Appendix Table 6. List of weeds infesting wheat in 40 experiments in 1984-1985 and 1985-1986 growing seasons and their

Family and scientific name	Common name	Life cycle
1. Araceae		
1. *Arisarum vulgare* Targ.-Tozz.	Arum	P*
2. *Biarum bovei* Blume	Arum	P
2. Boraginaceae		
3. *Anchusa azurea* Mill.	Italian bugloss	A**
4. *Buglossoides arvensis* (L.) J.M.J.	Corn gromwell	A
3. Campanulaceae		
5. *Campanula erinus* L.	Bellflower	A
4. Caryophyllaceae		
6. *Herniaria hirsuta* L.	Rupture-wort	A
7. *Polycarpon tetraphyllum* L.	Polycarpon	A
8. *Silene apetala* Willd.	Catchfly	A
9. *Silene behen* L.	Catchfly	A
10. *Silene gallica* L.	English catchfly	A
11. *Silene muscipula* L.	Catchfly	A
12. *Silene nocturna* L.	Night flowering catchfly	A
13. *Silene vulgaris* (Moench) Garcke	Bladder campion	P
14. *Spergularia purpurea* Pers.	Red sandspurry	A
15. *Stellaria media* (L.) Vill.	Common chickweed	A
16. *Vaccaria pyramidata* Medicus	Cowherb	A
5. Chenopodiaceae		
17. *Beta macrocarpa* Guss.	Beet	A
18. *Chenopodium album* L.	Common lambsquarters	A
19. *Chenopodium murale* L.	Nettleleaf	A
20. *Chenopodium vulvaria* L.	Stinking goosefoot	A

* P = perennial
**A = annual

Appendix Table 6 (cont.)

6. Compositae

21. *Anacyclus radiatus* Lois.	Langwort	A
22. *Atractylis gummifera* L.		P
23. *Calendula arvensis* L.	Field marigold	A
24. *Calendula stellata* Cav.	Algerian marigold	A
25. *Carduus myriacanthus* Dur. non Salzm.	Thistle	A
26. *Carthamus caeruleus* L.	Carthamus	P
27. *Centaurea calcitrapa* L.	Purple starthistle	A
28. *Centaurea diluta* Ait.	Knapweed	A
29. *Centaurea eriophora* L.	Starthistle	A
30. *Centaurea melitensis* L.	Malta starthistle	A
31. *Chrysanthemum coronarium* L.	Crown daisy	A
32. *Cichorium endivia* L.	Chicory	A
33. *Filago pyramidata* L.	Filago	A
34. *Hedypnois cretoca* (L). Dum-Courset	Hedypnois	A
35. *Leontodon hispidulus* Poiret.	Hawkbit	A
36. *Leontodon saxatilis* Lam.	Hawkbit	A
37. *Mantisalca salmantica* (L.) Briq. & Cav.		A
38. *Notobasis syriacum* (L.) Gaertn.	Syrian blumed thistle	A
39. *Onopordon macracanthum* Schousb.	Thistle	A
40. *Picris cupiligera* (Dur.) Walp.	Oxtongue	A
41. *Picris echioides* L.	Bristly oxtongue	A
42. *Rhagadiolus stellatus* (L.) Gaertn.		A
43. *Rhaponticum acaule* (L.) DC.		P
44. *Scolymus hispanicus* L.	Spanish oyster plant	A
45. *Scolymus maculatus* L.	Oyster plant	A
46. *Silybum marianum* (L.) Gaertn.	Blessed milk thistle	A
47. *Sonchus asper* (L.) Vill.	Spiny sowthistle	A
48. *Sonchus oleraceus* L.	Annual sowthistle	A
49. *Tragopogon hybridus* L.	Salsify	A

7. Convolvulaceae

50. *Convolvulus althaeoides* L.	Lesser bindweed	P
51. *Convolvulus arvensis* L.	Field bindweed	P
52. *Convolvulus gharbensis* Batt. & Pit.	Gharbian bindweed	A

8. Cruciferae

53. *Biscutella auriculata* L.	Buckler mustard	A
54. *Capsella bursa-pastoris* (L.) Medik.	Shepherd's purse	A
55. *Conringia orientalis* (L.) Dum.	Hares-ear	A
56. *Diplotaxis assurgens* (Del.) Grenier	Wall rocket	A
57. *Diplotaxis catholica* (L.) DC.	Wall rocket	A

Appendix Table 6 (cont.)

58. *Diplotaxis tenuisiliqua* Del.	Wall rocket	A
59. *Eruca vesicaria* (L.) Cav.	Garden rocket	A
60. *Hirschfeldia incana* (L.) Lag.-Fors.	Shortpod mustard	A
61. *Matthiola parviflora* (Schousb.) R.Br.	Little stock	A
62. *Raphanus raphanistum* L.	Wild radish	A
63. *Sinapis alba* L.	White mustard	A
64. *Sinapis arvenis* L.	Wild mustard	A
65. *Sisymbrium irio* L.	London rocket	A
9. Cucurbitaceae		
66. *Ecballium elaterium* Rich.	Squirting cucumber	P
10. Euphorbiaceae		
67. *Euphorbia exigua* L.	Little spurge	A
68. *Euphorbia helioscopia* L.	Sun spurge	A
69. *Euphorbia medicaginea* Boiss.	Spurge	A
11. Fumariaceae		
70. *Fumaria agraria* Lag.	Fumitory	A
71. *Fumaria parviflora* Lamk.	Fumitory	A
12. Gramineae		
72. *Avena sterilis* L.	Sterile oat	A
73. *Bromus rigidus* Roth.	Brome	A
74. *Bromus rubens* L.	Foxtail brome	A
75. *Cynodon dactylon* (L.) Pers.	Bermudagrass	P
76. *Desmazeria rigida* (L.) Tutin	Hard grass	A
77. *Lamarckia aurea* (L.) Moench	Goldentop	A
78. *Lolium multiflorum* Lamk.	Italian ryegrass	A
79. *Lolium rigidum* Gaud.	Swiss ryegrass	A
80. *Phalaris brachystachys* Link.	Canary grass	A
81. *Phalaris paradoxa* L.	Hood canarygrass	A
13. Iridaceae		
82. *Gladiolus segetum* Ker.-Gawl.		P
14. Labiatae		
83. *Lamium amplexicaule* L.	Henbit	A
84. *Teucrium resupinatum* Desf.	Germander	A

Appendix Table 6 (cont.)

15. Leguminosae

85. *Astragalus boeticus* L.	Milkvetch	A
86. *Astragalus hamosus* L.	Milkvetch	A
87. *Astragalus epiglottis* L.	Milkvetch	A
88. *Astragalus sesameus* L.	Milkvetch	A
89. *Cicer arietinum* L.	Chick pea	A
90. *Coronilla scorpioides* (L.) Koch.	Crownvetch	A
91. *Hippocrepis multisiliquosa* L.		A
92. *Lathyrus articulatus* L.	Vetching peavine	A
93. *Lathyrus cicera* L.	Flatpod peavine	A
94. *Lathyrus ochrus* (L.) DC.	Yellow pea	A
95. *Lens culinaris* Medik.	Lentil	A
96. *Lotus arenarius* Brot.	Trefoil	A
97. *Medicago orbicularis* (L.) Bart.	Burclover	A
98. *Medicago polymorpha* L.	Burclover	A
99. *Medicago scutellata* (L.) Miller	Burclover	A
100. *Medicago truncatula* Gaertn.	Burclover	A
101. *Medicago turbinata* (L.) Willd.	Burclover	A
102. *Melilotus sulcata* Desf.	Sweetclover	A
103. *Ononis biflora* Desf.		A
104. *Pisum sativum* L.	Pea	A
105. *Scorpiurus muricatus* L.	Furrowed caterpillar	A
106. *Trifolium tomentosum* L.	Clover	A
107. *Trigonella foenum-graecum* L.	Fenugreek	A
108. *Trigonella monspeliaca* L.		A
109. *Vicia benghalensis* L.	Purple vetch	A
110. *Vicia faba* L.	Broad bean	A
111. *Vicia lutea* L.	Yellow vetch	A
112. *Vicia monantha* Retz.	Bard vetch	A
113. *Vicia sativa* L.	Common vetch	A

16. Liliaceae

114. *Allium cepa* L.	Onion	A
115. *Allium nigrum* L.	Wild onion	P
116. *Muscari comosum* L.	Tessel hyacinth	P
117. *Ornithogalum narbonense* L.	Star of Bethlehem	P

17. Malvaceae

118. *Malva nicaeensis* All.	Bull mallow	A
119. *Malva parviflora* L.	Little mallow	A

18. Orobanchaceae

120. *Orobanche mutelii* Schultz.	Broomrape	A

Appendix Table 6 (cont.)

19. Papaveraceae		
121. Glaucium corniculatum (L.) J.H. Rud.	Horned poppy	A
122. Papaver hybridum L.	Hybrid poppy	A
123. Papaver rhoeas L.	Corn poppy	A
20. Plantaginaceae		
124. Plantago coronopus L.	Plantain	A
125. Plantago afra L.	Plantain	A
21. Polygonaceae		
126. Emex spinosa (L.) Campd.	Prickly dock	A
127. Polygonum aviculare L.	Prostrate Knotweed	A
128. Rumex bucephalophorus L.	Canaigre	A
129. Rumex pulcher L.	Fiddleleaf dock	P
22. Primulaceae		
130. Anagallis foemina Miller	Blue pimpernel	A
23. Ranunculaceae		
131. Adonis annua L.	Pheasant eye	A
132. Delphinium peregrinum L.	Delphinium	A
133. Nigella hispanica L.	Love-in-a-mist	A
24. Resedaceae		
134. Reseda alba L.	White mignonette	A
135. Reseda lutea L.	Yellow mignonette	A
25. Rubiaceae		
136. Asperula arvensis L.	Woodruff	A
137. Crucianella angustifolia L.		A
138. Galium tricornutum Dandy	Rough bedstraw	A
139. Galium verrucosum Hudson	Bedstraw	A
26. Scrophulariaceae		
140. Kickxia commutata (B. ex. R.) F.	Toadflax	A
141. Linaria gharbensis Batt. & Pit.	Toadflax	A
142. Linaria reflexa Desf.	Toadflax	A
143. Misopates orontium (L.) Rafin	Snapdragon	A

Appendix Table 6 (cont.)

27. Solanaceae		
144. Mandragora autumnalis Spreng.	Mandrake	P
28. Umbelliferae		
145. Ammi majus L.	Greater ammi	A
146. Bupleurum subovatum Link ex Spr.	Bupleurum	A
147. Capnophyllum peregrinum (L.) Lange		A
148. Caucalis bifrons (Pomel) M.		A
149. Caucalis leptophylla L.		A
150. Coriandrum sativum L.	Coriander	A
151. Eryngium ilicifolium Lam.	Snakeroot	A
152. Eryngium tricuspidatum L.	Snakeroot	A
153. Ridolfia segetum Moris.	Ridolfia	A
154. Scandix pecten-veneris L.	Venus comb	A
155. Torilis arvensis (Huds.) Link	Hedgeparsley	A
156. Torilis nodosa Gaertn.	Knotted hedgeparsley	A
29. Valerianaceae		
157. Valerianella discoidea (L.) Lois.	Cornsalad	A

ON-FARM EVALUATION OF WHEAT PRODUCTION AS AFFECTED BY THREE WEEDING SYSTEMS AND TOP-DRESSED NITROGEN IN CHAOUIA (SEMI-ARID ZONE OF MOROCCO)

by

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AN ABSTRACT OF A MASTER'S THESIS

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In dryland farming areas of Morocco, little critical attention has been given to weeds associated with wheat; whereas, insect pests and plant diseases have drawn much greater attention of the farmers and researchers. There are three approaches to weed control in wheat in the Chaouia:

1) no control whatsoever,
2) manual removal of the largest, most conspicuous weeds, which are usually, but not always collected for use as forage, and
3) chemical control using phenoxy-type herbicides applied at the ful-tiller growth stage of wheat.

Nitrogen fertilizer is often added at planting time, and the crop may be top-dressed with additional nitrogen if winter rainfall is favorable. The purpose of this research was to study the above three weeding systems on farms in a part of the Chaouia (semi-arid) region, to determine possible effects of top-dresssed nitrogen on the weeding systems, and to characterize the weed flora of these wheat fields.

Forty (40) identical experiments were established in bread wheat (Triticum aestivum L.) and durum wheat (Triticum durum Desf.) at the early-tiller stage during 1984-1985 and 1985-1986 growing seasons. Most of the experimental sites had been broadcast seeded.

Top-dressed nitrogen (25kg/ha) applied at early-tiller stage had no significant effect on wheat grain yield. Fertilization at seeding or from previous crops provided enough nitrogen so that there was no advantage from additional top-dressed nitrogen.

For the two years, weed numbers were reduced an average of 30% by hand-weeding. Treatment with 2,4-D removed 66% of the weeds in 1985-1986. Hand-weeding removed an average of 63% of the weed dry weight in the two years. Treatment with 2,4-D reduced weed dry weight by 82% in 1985-1986.

Hand-weeding for forage produced an average of 570 kg/ha weed dry matter in 1984-1985, and 284 kg/ha in 1985-1986. However, it lowered wheat grain yield by 231 kg/ha in 1984-1985, and 127 kg/ha in 1985-1986. Over both years, the cost of each kg weed forage was 0.43 kg grain yield loss. Nonweeding reduced grain yields by 158 kg/ha in 1984-1985 and 101 kg/ha in 1985-1986, compared to 2,4-D treatment.

Weed control with 2,4-D increased wheat grain yields over both nonweeded and hand-weeded treatments by an average of 154 kg/ha, over both seasons.

A total of 157 weed species belonging to 29 botanical families were identified on all 40 experimental sites in both years; 89% were dicots. Corn poppy (*Papaver rhoeas* L.), a 2,4-D susceptible plant, was the most abundant annual weed in wheat fields in Chaouia.

Subsequent studies could investigate the timing and density threshold of weeds in wheat, as well as the economic and social advantages and disadvantages of each weeding system.