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Response of Barley Cultivars to Simulated Grazing (Cutting) in Three Different Regions of Morocco

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Abstract

The strategic role of barley in animal feeding systems under contrasting environmental conditions of Morocco is briefly outlined. Results of multi-site experiments on the response of barley cultivars to simulated grazing are used to evaluate the suitability of the tested varieties for dual-purpose use. The compromise between forage production and grain plus straw yield is discussed in relation to simulated grazing and to rainfall pattern.

1. Introduction

In Morocco, rainfed farming systems rely heavily on cereal cropping, with barley (*Hordeum vulgare.* L.) as the dominant crop both in terms of land use and total production. Several field surveys have described barley systems and explained their strategic role, particularly in the regulation of cereal-livestock integration (Papy, 1979; Lelièvre, 1981; Benkhira, 1984; Papy *et al.*, 1984; Ameziane and Berkat, 1985). In a recent study of the ecological characterization of forage resources and animal feeding systems, information gathered clearly demonstrates the economic importance of barley and other cereals for livestock production, both regionally and nationwide (Fort, Rzozi and Ameziane, 1986; Ameziane and Berkat, 1989). It was found that on a national scale cereals contribute 46% of total animal requirements, in the form of green fodder, grain, stubble and straw. Further, of the total barley grain production, 37 and 47% was used as animal feed in a dry year and a normal year, respectively.

Farmers' strategies for the management of barley systems strongly depend on the prevailing weather conditions, especially rainfall. In the drier areas, barley is usually grazed because of insufficient alternative feed availability in winter. However, expected poor grain yields in these areas also justify this form of barley utilization. As rainfall increases from 300 to 450 mm, defoliation of barley through cutting or grazing becomes a common practice, providing valuable herbage during early winter but allowing some grain production to be harvested eventually. In the higher rainfall areas, cutting is often seen as improving grain yields. It is also practised on wheat, particularly in northern Morocco, where old tall hard wheat varieties are still used.

This paper examines the suitability of several existing and recently released barley varieties for dual-purpose use, i.e. for green fodder and grain production. Previous studies in cereals (e.g. Lelièvre, 1981; Ismaili, 1982; ICARDA, 1982; Amri, 1983; Hadjichristodoulou, 1983; Droushiotis, 1984) have indicated that the compromise between forage production and grain yield depends on a large array of interacting factors. These include species and variety, sowing date, timing and intensity of defoliation in relation to stage of development, and recovery after defoliation as affected by the amount of rain and its distribution over the growing season. The present research was carried out to provide further information on the response of different barley varieties to defoliation under contrasting rainfed conditions.

2. Materials and Methods

The experiments were conducted between 1984 and 1988 at three different sites in central-western and north-western Morocco which, in a normal year, represent a transition from semi-arid to sub-humid conditions. Table 1 gives soil type, weather and crop management information for these sites, and Table 2 indicates some characteristics of the ten barley varieties studied.

2.1 Experiment 1

At Sidi El Aydi and Merchouch, all ten barley varieties were tested by two cuttings for forage yield at two stages during the growing season 1984-85. The effects of this operation on yield and other growth attributes were assessed by comparison with a control treatment, using a split-plot design with three replicates. Cutting stages and the uncut control treatments occupied the main plots, and varieties the sub-plots, which measured 5.4 m^2. Cutting consisted of an "early" and a "late" operation, as indicated in Table 3. At Sidi El Aydi, the early cutting took place when tillering began and the late cutting at the end of tillering. At Merchouch, the first cutting was made at mid-tillering and the late cutting at jointing. At both cutting times, thirty plants were randomly collected from each sub-plot to determine the precise stage of development of each variety, based on apex height and number of leaves and tillers per plant. Cutting of the total plot was done by hand, leaving a stubble height around 2 cm^2. The fresh weight cut from each plot was recorded on 1 m^2 basis, and samples were taken for dry matter and other forage quality determinations. Subsequently, plant height, heading time, lodging, diseases and other crop parameters were recorded; and at maturity, grain yield, yield components and straw yield were measured.

2.1 Experiment 2

Three of the above barley varieties were studied again during the seasons 1986-87 and 1987-88 at Mograne (sub-humide) to compare the reaction of old and new varieties to

Table 1. Soil types, weather and management practices at the experimental sites

Site	Soil and climate	Management practices	
Sidi El Aydi	Clay loamy soil with calcareous layer below 60 cm depth. Mean annual rainfall : 381 mm. Annual mean minimum temperature 9.9°C and mean maximum 23.8°C. Coldest month : January (5.4°C) Hottest month : August (36.1°C)	21.11.84	: Preplanting N:P:K application of compound fertilizer (22-44-22) at 100 kg/ha.
		23.11.84	: Hand sowing at 300 seeds/m^2. Application of 30 kg N/ha after each defoliation.
		20.02.85	: Manual weed control.
		15.05.85	: Grain and straw harvest.
Merchouch	Deep clay soil (Tirs) with good structure. Mean annual rainfall : 474 mm; Coldest month : 5°C. Hottest month : 32.2°C.	22.11.84	: Preplanting N:P:K application of compound fertilizer (26-13-26) at 200 kg/ha.
		10.12.84	: Mechanical seeding at 350 seeds/m^2. Application of 30 kg/ha after each defoliation.
		17.3.85	: Manual weeding.
		10.6.85	: Final harvest.
Mograne	Deep clay and loamy soil with low permeability. Mean annual rainfall : 600 mm. Annual mean minimum and maximum temperatures : 10.8°C and 24.7°C. Coldest month : 5°C. Hottest month : 31.6°C.	23.9.86	: Preplanting application of 150 kg P_20_5 and 100 kg/ha K_20.
		28.11.86	: Mechanical seeding at 350 seeds/m^2. Application of 30 kg N/ha after defoliation.
		20.5.87	: Final harvest.

Table 2. Origin and some characteristics of plant material used in the experiments

Cultivar	Origin	Characteristics
Two-row barley		
1703 (Tamlalet)	INRA*	Short straw. Adapted to favorable conditions.
1579 (Asni)	INRA	Medium height. Adapted to favorable conditions and high altitude.
1580 (Tissa)	INRA	Short straw. Adapted to favorable conditions and high altitude.
Roho	ICARDA	Adapted to semi-arid zones.
ER/Apm	ICARDA	Early, productive. Adapted to semi-arid zones.
ACSAD 60	ACSAD	Adapted to semi-arid zones.
Six-row barley		
905 (Arig 8)	ITALY	Large adaptation.
628	INRA	High forage yielding.
UC 77095	CALIFORNIA	Short straw. Adapted to semi-arid conditions.
ACSAD	ACSAD	Adapted to semi-arid conditions.

* INRA-Morocco.

simulated grazing in this different environment. The varieties were the newly released ACSAD 60 and the old material, barley 905 and barley 895. Cutting and the control were arranged in a split-plot design replicated four times, with varieties as the main plots and cutting as the sub-plots. Sub-plot size was 50 m^2. The times of cutting are shown in Table 3. Stages of development were observed using 40 randomly selected plants per

Table 3. Harvesting dates, plant characteristics at the time of cutting at different sites and dry matter yield of harvested herbage. Values are means of ten varieties at Sidi El Aydi and Merchouch and of three varieties at Mograne

Timing of cutting and plant characters	Experiment 1 (1984/85)		Experiment 2	
	Sidi El Aydi	Merchouch	Mograne 86/87	Mograne 87/88
Early cutting				
Date of harvest	27 Dec.	30 Jan.	2 Feb.	7 Jan.
Development stage	Early tillering	Mid-tillering	Late tillering	Early tillering
Plant height (cm)	24.0	29.4	48.3	33.0
Apex removal (%)	0	0	32	0
DM yield (t/ha)	0.50	0.78	1.53	0.54
Late cutting				
Date of harvest	21 Jan.	13 Feb.	16 Feb.	28 Jan
Development stage	Late tillering	Early jointing	Mid-jointing	Late tillering
Plant height (cm)	34.0	56.4	60.0	47.0
Apex removal (%)	20	100	100	25
DM yield (t/ha)	1.44	1.98	2.95	1.9

cultivar. Measurements were made of "grazed" dry matter (DM) yield (on a central area of 6 m^2), grain and straw yields (on 4 m^2), yield components (on 6 linear meters per plot) and other crop parameters.

3. Results

3.1 Climatic Characterization

Annual precipitation recorded during 1984-85 was 375 mm at Sidi El Aydi, close to the average value, and 340 mm at Merchouch, well below average. At both sites, most of the rain fell during November, January and February. As a result of this irregular distribution pattern, the crop experienced two periods of drought, in December and March-April. At Mograne, the growing season 1986-87 was abnormally dry with only 289 mm total rainfall between November and April, as compared to 600 mm in an average year. During 1987-88, annual rainfall reached 509 mm but was concentrated between October and January with no rain at all in March. Variations in rainfall and temperature regimes are shown in Figure 1.

3.2 Dry Matter Yield of Cut Herbage

The dry matter yield of the cut herbage, averaged over varieties within experimental sites, increased from 0.5 to almost 3.0 t DM/ha as the cutting stage was delayed from early tillering to jointing (Table 3). At all sites, DM yield was below 0.8 t/ha when cutting took place before mid-tillering while it was above 1.4 t/ha from late cutting. There were significant differences among varieties at Sidi El Aydi and Merchouch under both cutting regimes but only with late cutting at Mograne. In most situations, the varieties ACSAD 60, ACSAD 176, Barley 628 and ER/Apm produced high DM yields.

3.3 Effect of Defoliation on Grain Yield

The effects of cutting treatments on grain and straw yields are shown in Table 4. Except in the case of Mograne'88, where early cutting slightly increased grain yield, average yields were decreased by cutting. When this operation took place at the tillering stage, the grain yield was reduced by an average of 15.5% at Merchouch, 32.8% at Sidi El Aydi and 42.4 % at Mograne'87. Late cutting decreased yields by 28% at Sidi El Aydi, 47% at Merchouch and by 73% at Mograne'87. However, this general effect of cutting at each site hides large differences between varieties (data not shown). For example, at Sidi El Aydi, both cutting regimes reduced mean grain yields but had no significant effect on those of ACSAD 60 and UC 77095. At Merchouch, responses of a given cultivar were different from those observed at Sidi El Aydi, in the sense that late cutting decreased grain yields of all varieties by almost 50%, whereas the effect of early defoliation was rather moderate for most cultivars.

3.4 Effect on Dry Matter Yield of Straw

Cutting treatments reduced the straw yields of all varieties at all sites. In the case of Mograne'88, the straw yield was reduced slightly by early cutting and by 24% by late

Table 4. Effect of defoliation on grain and straw yields at Sidi El Aydi and Merchouch (mean of ten varieties) and Mograne (mean of three varieties)

Site	Grain yield (kg/ha)			Straw yield (kg/ha)		
	Control	Early cutting	Late cutting	Control	Early cutting	Late cutting
Sidi El Aydi	3321	2232	2389	7318	5648	4921
Merchouch	2837	2396	1511	6723	5059	3150
Mograne 87	2710	1560	740	5100	2600	1110
Mograne 88	2630	2710	1820	6300	6100	4800

LSD's (5%) for comparing treatment means are 702, 256, 404 and 152 for grain yield and 935, 789, 727 and 370 for straw yield at Sidi El Aydi, Merchouch, Mograne'87 and Mograne'88 respectively.

cutting. In the other situations, average reduction in straw yields varied from 23 to 49% and from 33 to 78%, with early and late cutting respectively (Table 4). Responses to defoliation in terms of straw production were relatively similar between varieties of different origin, although at Sidi El Aydi the varieties Roho, ER/Apm, and Tamlalet outyielded the others. During the dry season of 1986-87 at Mograne, the straw yield was greatly reduced by delayed cutting as was the grain yield, regardless of the variety tested.

3.5 Harvest Index and Other Plant Attributes

At Sidi El Aydi, early cutting decreased harvest index, while late cutting increased it for most varieties. Both cutting treatments improved the harvest index at Merchouch, particularly with Barley 1703, Barley 1579, UC 77095, ACSAD 60 and ACSAD 176. At Mograne, the harvest index was not significantly affected by defoliation in either of the growing seasons. At all sites, heading was delayed for all varieties. The delay was much more variable at Sidi El Aydi, with 2 to 20 days (early cutting) or 2 to 24 days (late cutting), than at the other sites. Cutting also significantly reduced plant height at final harvest and thus prevented lodging in most varieties.

4. Discussion

Responses to defoliation varied greatly with barley genotype, cutting stage, site and weather conditions, as found in most studies conducted in the Mediterranean region. Droushiotis (1984) tested five harvesting treatments, including a cutting at the green stage in January to simulate the effect of grazing on forage hay and grain yields of barley in Cyprus. He reported an average dry matter yield of harvested herbage of around 0.8 t/ha, with no significant differences between varieties and no significant interaction between varieties and sites. A similar yield, when averaged over sites, was obtained in the present study, with early cutting applied during tillering between 27 December and 2 February (Table 3). However, there were significant differences between varieties and sites, as found in other reports (Ismaili, 1982; Amri, 1983; Hadjichristodoulou, 1983). As the cutting stage was delayed from early tillering to mid-jointing, dry matter yield more than doubled, again with large differences between cultivars. Such differences would be expected because of varietal differences in tillering pattern and in growth rates. The growth rates measured during tillering at Sidi El Aydi or jointing at Merchouch varied from 25 to 57 kg DM/ha/day and from 65 to 114 kg DM/ha/day, respectively.

Cutting at the green stage was generally followed by a reduction in grain and straw yields, a typical pattern in the Mediterranean environment (Lelievre, 1981; Hadjichristodoulou, 1983; Droushiotis, 1984), as conditions to alleviate the depressive effect of defoliation are rarely met. These were described by Skorda (1977) as being early germination for good stand establishment, moderate grazing and good growing conditions for rapid recovery after defoliation. These requirements may have been partially met in the case of late defoliation at Sidi El Aydi, where rainfall distribution in relation to stand establishment and to recovery from defoliation (Figure 1) was adequate

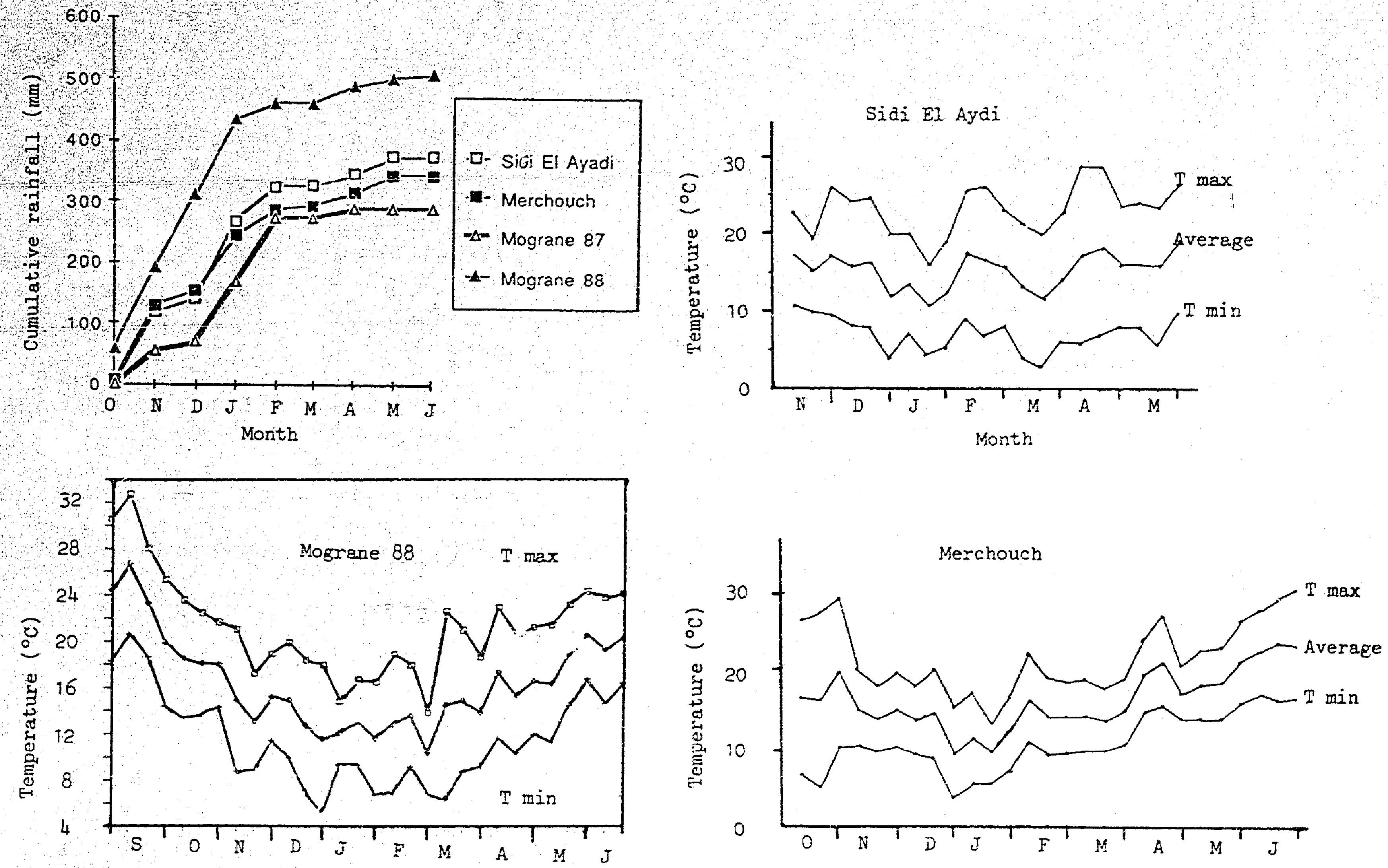

Fig. 1 Growing season rainfall patterns and temperature regimes at the experimental sites

and defoliation intensity, as judged by low apex removal, was least severe (Table 3). This may explain why at this site most varieties responded more favorably to late than to early cutting, in disagreement with general findings (Holliday, 1956; Dunphy *et al.*, 1982; ICARDA, 1982; Ismaili, 1982). In line with those findings, however, the data for Merchouch and Mograne clearly indicated the detrimental effect of delayed cutting on grain and straw yields (Table 4).

Barley cultivars for dual-purpose use may be selected on the basis of amount of dry matter removed by defoliation, grain and straw yields after defoliation and yield loss per unit of dry matter gained. Using these last two criteria, the best compromise at both Sidi El Aydi and Merchouch was achieved with UC 77095, ACSAD 176 and ACSAD 60 (Figure 2, Group 1). Of the three varieties tested at Mograne, ACSAD 60 and cultivar 905 showed some flexibility. Depending on the timing of cutting, the INRA varieties 1580 and 905 were suitable with early cutting at Sidi El Aydi and late cutting at Merchouch, respectively, while the ICARDA variety Roho performed well with early cutting at Merchouch. However, the site- and season-specific nature of these results should be pointed out. The data from all sites also demonstrated how critical timing of cutting is in the dual-purpose use of barley, in agreement with Croy (1983) who reported that cutting during jointing should be avoided. The best time for grazing is thus during the period ranging from the beginning to the end of tillering.

One final point. Within the data set collected in the present trials, no significant correlation was found between the grain yields of cut treatments and uncut controls. One explanation of this is that most, perhaps all, of the varieties were selected originally for high grain-yield potential rather than dual-purpose utilization. To make better use of barley under dryland conditions and, particularly, to accomodate farmers' different modes of utilization, more attention should be given in breeding and variety selection to the need for high-performance dual-purpose barley.

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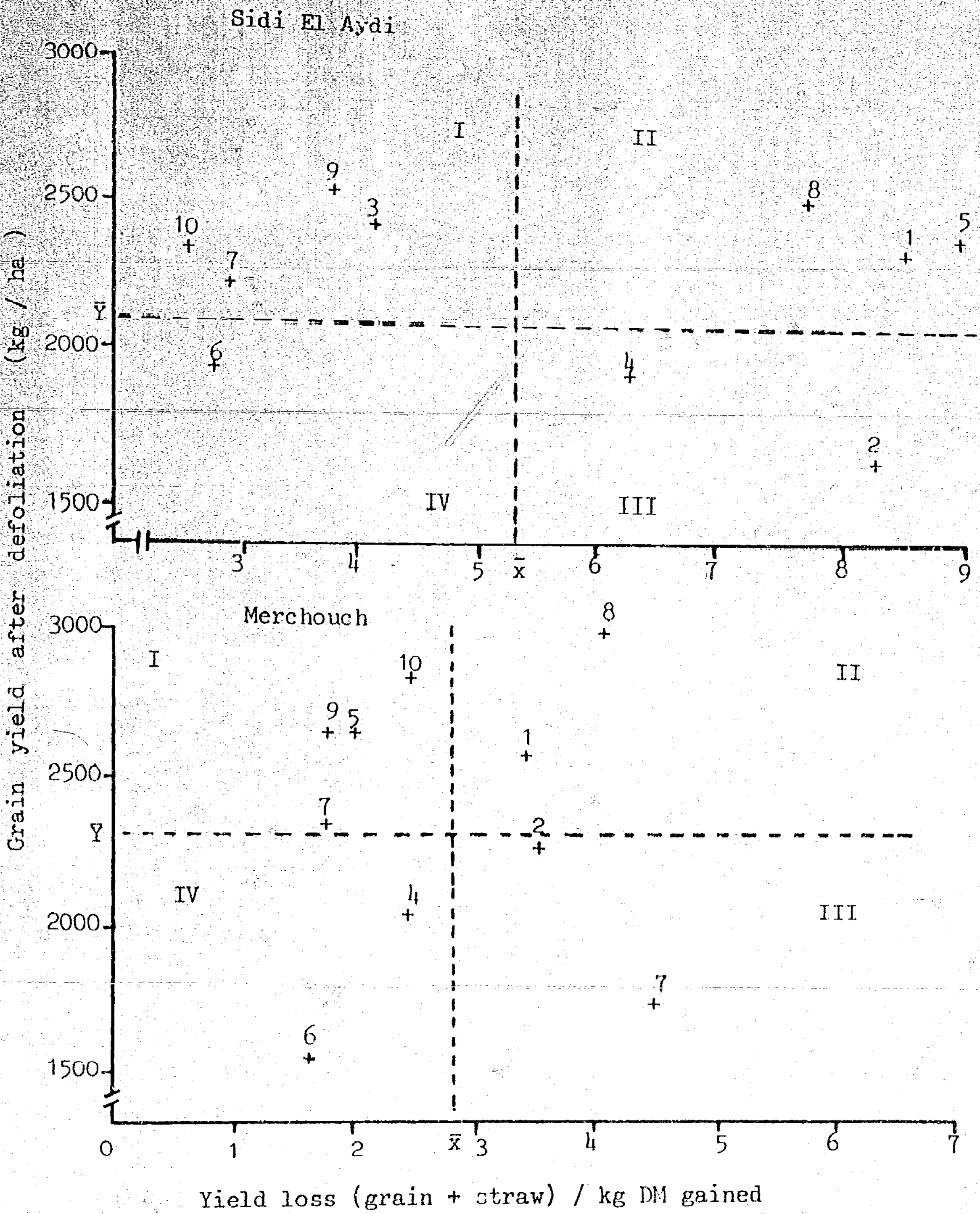

Fig. 2 Classification of varietal responses to defoliation based on grain yield and grain yield loss per kg of herbage harvested previously. (Group I represents the best dual-purpose cultivars, with grain yields above the average (y) and yield loss below the average (x). See Table 2 for cultivar identification.)

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