DISCUSSION PAPER
No.1

PRELIMINARY
AGRONOMIC STUDIES ON
WHEAT AND BARLEY
IN THE 1977-78 SEASON

THE INTERNATIONAL CENTER FOR AGRICULTURAL RESEARCH IN THE DRY AREAS

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The work reported here was supervised and guided by Andreas Hadjichristodoulou who was supported by other scientists and technicians in the Cereals Improvement Program.

CONTENTS

SUMMARY

The effect of seed rate, row spacing and sowing date on six cereal varieties (two durum wheat, two bread wheat and two barley) was studied at Tel Hadya, both under rainfed conditions and with one supplementary irrigation. The effect of nitrogen fertilization was studied under rainfed conditions for two barley varieties.

The seed rate had a significant effect under rainfed conditions (highest yields being obtained at highest seed rates, 130 kg/ha, plantings being done by seed drill), but not under supplementary irrigation. The variety and seed rate interaction was significant. Tiller number of all varieties increased, but vitreousness of durum wheat decreased, with increase in seed rate.

Row spacing had no significant effect on the performance of the varieties. The trial is being repeated in the 1978-79 season using drill sowing at all spacings.

Early sowing gave higher yields than medium or late sowing under both rainfed and irrigated conditions, mainly due to greater number of grains per spike. There was a significant variety x sowing date interaction, with barley being more suitable for late sowing than wheat.

Moderate applications of nitrogen fertilizer (40 and 60 kg N/ha) gave significant increases in barley grain yields.

The average yield of four wheat varieties over three trials was 1095 kg/ha under rainfed conditions compared to 2079 kg/ha with one supplementary irrigation. Irrigation increased all yield components, especially number of grains per tiller. The main yield of barley under rainfed conditions (three trials) was 2114 kg/ha compared to 1095 kg/ha for the four wheat varieties.

INTRODUCTION

Improvements in both crop varieties and agronomic practices are needed in order to obtain maximum increases in cereal grain yields. It is also considered essential that the best varieties and the optimum agronomic practices for a particular region are selected by carrying out trials in that particular agroclimatic area.

The work described in this paper was carried out at ICARDA's Tel Hadya site near Aleppo in Northern Syria in the 1977-78 growing season. A map of the site is given in Appendix 1. It was intended to find out the relative importance of a number of selected agronomic practices and to determine how they might be optimised. In that this was the first season that such trials had been carried out on the ICARDA site this work constituted a preliminary investigation. The initial selection of the cultural practices was based on experience gained from areas with agroclimatic conditions similar to those of the Aleppo province.

These trials were conducted under both rainfed and irrigated conditions so that the results obtained could be considered relevant to a wide range of conditions under which cereal crops are grown. Thus it was expected that the information obtained from these studies would prove expedient to agricultural researchers elsewhere in Syria and in other areas with agroclimatic conditions similar to those of the Tel Hadya area.

Seed rate, row spacing, sowing date and the use of nitrogen fertilizer were considered to be the most important factors to be included in preliminary agronomic trials of this kind. These factors were therefore investigated by determining how they affected the growth of cereal crops under both rainfed and irrigated conditions.

Proper seed rates are essential for the establishment of a good stand and are therefore critical to optimal cereal production. That is particularly so in the dry areas where sowing is often done in dry soil where moisture may be insufficient for a good seed bed preparation and for germination. Low seed rates in dry areas can therefore result in too thin stands which cannot compete with weeds and which cannot make optimum use of all the available soil moisture and nutrients. High seed rates, on the other hand, can result in too dense populations, which in dry areas may produce relatively low grain yields compared to total straw production (low harvest index), especially if dry conditions prevail in spring during the anthesis to maturity stage.

For a given seed rate, the production of optimum yields is also dependent on the spacing between rows. In general, an increase in row spacing gives higher within-row and lower between-row competition, and can result in an inadequate exploitation of the available space, thereby reducing the overall yield. It was therefore decided to investigate the effect of row spacing per se and to study the effect of variations in row spacing on different varieties; variety x row spacing interactions are commonly found in trials of this type.

It is worth nothing that while most commercial drills are set at around 18 cm, most variety trials are conducted at 28 cm row spacing. This is another reason why it was considered important to incorporate row spacing into these agronomy trials.

Sowing cereal crops too early in the dry areas is likely to be disadvantageous because soil moisture may be insufficient to ensure adequate germination, and because it is not practical to prepare seed beds prior to an early sowing date except in fields under fallow. Conversely, sowing too late is likely to reduce the length of the growing period and thus to restrict the development of the plants. It was considered important, therefore, to include sowing date in the initial agronomy trial at Tel Hadya. It has been observed in trials in Cyprus that under rainfed conditions barley competes better with both broadleaved and grass weeds when sown early. As a result grain yields were found to be significantly higher with early sowing. Late sown barley and wheat had the disadvantage that they reached the critical heading to maturity stage during the hot dry spells frequently encountered in Cyprus, and elsewhere in the Middle East.

It is well established that the level of soil fertility varies significantly with field, previous management and rotation patterns. Thus the need for fertilizer application varies with location, and crops grown in trials in different regions will be expected to show different responses to the use of fertilizers.

It was decided to carry out an observation trial in order to obtain preliminary information on the response of barley to nitrogen fertilization under rainfed conditions. It is stressed that similar trials should be carried out in each area of interest, as the results obtained at Tel Hadya are relevant only to the soil and other agroclimatic conditions found in that region.

MATERIALS AND METHODS

The trials were carried out at ICARDA's Tel Hadya site, which is situated 25 km South West of Aleppo in Northern Syria. A map of the site is given in Appendix 1. The agronomic conditions under which the trials were carried out are summarised in Table 1.

Table 1. Summary of the Agronomic Practices used in the Trials[1]

	SEED RATE TRIAL	ROW SPACING TRIAL	SOW. DATE TRIAL	N FERTILIZER TRIAL
Seed Rate	70, 100, 130	100	100	100
Rows per Plot (each 5m long)	6	8, 6, 5	6	6
Row spacing (cm)	28	16, 24, 32	28	28
Rows harvested	4	6, 4, 3	4	4
Sowing Date	13 / 11	13 / 11	13/11, 27/12 22/1	13/11
Fertilization (kg/ha)	60N $60P_2O_5$	60N $60P_2O_5$	60N $60P_2O_5$	0, 20, 40 60, 80N $60P_2O_5$

[1] All the trials were carried out under both Rainfed and Irrigated conditions except for the N Fertilizer Trial (Rainfed Only).

The following high yielding varieties were used in the trials: Stork "S" and Cocorit 71 (durum wheat), Haramoun and Arvand (bread wheat) and Beecher and Arivat x Local D-8 (barley). All six varieties were grown under rainfed conditions in the seed rate, row spacing and sowing date trials; the two barley varieties were not included when these trials were carried out

under irrigation (see below) because of their tendency to lodge. However the two barley varieties were the only ones included in the observation trial to study the effect of nitrogen fertilizer under rainfed conditions.

The trials were carried out on a split-plot design with four replications. Varieties were randomised in the main plots, and the sub-plots contained the agronomic practices. Weeds were controlled both by hand and by chemical means over all plots.

The seed rate, row spacing and sowing date trials were conducted under both rainfed conditions and irrigation. The irrigated trials included one supplementary irrigation, equivalent to about 100 mm of rainfall, at the heading to anthesis stage. The nitrogen fertilization trial was carried out only under rainfed conditions. Rainfed and irrigated trials were grown in different fields, and were thus grown on slightly different soils. The results could not therefore be used to determine the effects of irrigation on cereal grain yield.

In general the rainfall conditions were good. Although most of the effective rainfall came late, there was no moisture stress in the plots until the heading stage. The recorded values of the total rainfall for each month are given in Table 2. The total rainfall for this growing season was 336 mm.

Table 2. Rainfall in the 1977 - 78 Growing Season

Month	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	Total
Rainfall(mm)	37	0	110	99	50	37	3	0	0	336

Data collected at ICARDA's Tel Hadya Weather Station.

In the seed rate trial the seed rates used were 70, 100 and 130 kg /ha For each seed rate six rows, 5 metres in length, were grown. The rows were spaced at 28 cm, and the middle four rows were harvested.

In the row spacing trial the three row spacings used were 16, 24 and 32 cm. The other conditions of the trial are given in Table 1. Each row was 5m in length and eight rows were planted at 16cm spacings, six at 24cm and five at 32cm. The outer rows of each (spacing) plot were removed before harvesting, so that six, four and three rows were harvested for the 16, 24 and 32cm spacings respectively. Therefore the area harvested ($4.8m^2$) was the same in all spacings. The sowing of the 24 and 32cm spacings was done by drill, while that of the 16cm spacing was done by hand due to technical problems at the time of sowing.

The sowing date trial incorporated three sowing dates. These were 13th November (early), 27th December (medium) and 22nd January (late). The seed and fertilizer rates were the same as for the row spacing trial, and six rows, each 5m long, were grown 28cm apart. In the 'early' sowings seeds were sown in dry ground, and did not germinate until December 12th. In the 'medium' and 'late' sowings the seeds were sown in wet soil.

In the nitrogen fertilizer trial the rates of nitrogen fertilization used were 0, 20, 40, 60 and 80 kg N/ha. Phosphate was also applied at the rate of 60 kg P_2O_5/ha. As mentioned before, only the two barley varieties were employed in this trial, Arivat x Local D-8 at all five rates and in two replications and Beecher at the four lowest rates (0, 20, 40 and 60 kg N/ha) in only one replication. The trial was carried out under rainfed conditions only, and further details are given in Table 1.

In all cases the following data were recorded:

grain yield per plot
number of grain-bearing tillers per 5m row
weight of 200 grains
percentage of vitreous kernels (durum wheat only)

The first three of these were converted to, and tabulated as, grain yield per ha, tillers per m^2 and 1000-grain weight respectively. The number of grains per spike, or grain number per tiller, was calculated from the equation:-

grain yield = tiller number x grain no. per tiller x grain weight.

RESULTS

Results are presented under headings for each agronomic practice investigated, and are summarised for both rainfed and irrigated trials where relevant. Detailed tables of results obtained with each crop variety are presented as Appendices, while a summary of the overall performance of each variety is given in Table 6 and in the text.

Rainfed Seed Rate Trial

This trial showed that the rate at which seeds were sown significantly affected the performance of the crops tested. As can be seen from Table 3, the grain yields using 130 kg/ha seed rate were on average significantly higher than those obtained when the two lower seed rates were used. However, for three of the varieties tested (Cocorit 71 durum wheat, Haramoun bread wheat and Beecher barley) this difference in grain yield was not significant (see Appendix 2). There was a small average increase in grain yield from 70 to 100 kg/ha seed rate, but again this was not significant.

Table 3. The Effect of Seed Rate on the Growth of two Durum Wheat, two Bread Wheat and two Barley Varieties. Rainfed Trial.

Seed Rate (kg/ha)	Grain Yield (kg/ha)	Tiller No./m^2	1000 grain Wt.(g)	No. of grains /Spike	% Vit.[1]
70	1165	137	36.0	23.6	86.9
100	1255	176	35.0	20.4	84.7
130	1461	207	35.0	20.2	76.8
Mean	1294	173	35.3	21.4	82.8
SE ±	49	57	0.39	-	4.5

[1] Vitreousness was recorded for the two durum wheat varieties only. All other figures quoted are average values of six cereal varieties.

As might be expected the increased grain yields with increased seed rate were due to the greater number of tillers produced. The mean tiller number for all the varieties tested increased from 137 to 207 tillers per m^2 (Table 3) and there were no exceptions to this trend (Appendix 2). In contrast, the average grain weight for all the varieties tested was not affected by seed rate (Table 3). From 70 to 100 and 130 kg/ha seed rate there was a small decrease in the number of grains per spike (23.6 to 20.4 and 20.2 respectively). Higher rates also resulted in a decrease in vitreousness.

To summarise, this trial showed that an increase in seed rate produced more tillers, these having smaller spikes. The increased tillering more than compensated for reduced spike size, the net effect being increased grain yield.

Irrigated Seed Rate Trial

As mentioned in the previous chapter, only the four wheat varieties were tested in this trial. It was found that seed rate had no significant effect on grain yield for any of the varieties tested.

Table 4 shows that higher seed rates produced more tillers per m^2, as was found with the rainfed trial. However there was a simultaneous decrease in the number of grains per spike, resulting in no significant change in grain yield for the three seed rates applied. The differences in 1000-grain weight were insignificant between seed rates, but there was again a decrease in vitreousness associated with the increase in seed rate. The results obtained from each variety are given in Appendix 3. For durum wheat higher seed rates had the disadvantage of producing a lower %ge vitreousness.

Table 4. The Effect of Seed Rate on the Growth of two Durum Wheat and two Bread Wheat Varieties.

Seed Rate (kg/ha)	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt.(g)	No. of grains /Spike	% Vit.[1]
70	2091	167	41.3	30.3	80.2
100	2059	180	41.3	27.7	67.1
130	2200	219	40.9	24.6	65.9
Mean	2117	189	41.2	27.5	71.1
SE ±	93	42	0.52	-	5.0

1 See Table 3.
All other figures quoted are average values of four wheat varieties.

Rainfed Row Spacing Trial

Table 5 shows that there were no significant differences in grain yield for different row spacings when the mean yields of the six varieties were compared, although there was a tendency for lower yields with increased row spacing. Stork 'S' durum wheat did produce significantly higher yields of grain at 16 cm row spacing compared to 24 and 32 cm (Appendix 4).

Table 5. The Effect of Row Spacing on the Growth of two Durum Wheat, two Bread Wheat and two Barley Varieties.

Row Spacing (cm)	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grains Wt. (g)	No. of grains /Spike	% Vit.[1]
16	1471	191	35.9	21.5	89.1
24	1454	177	36.6	22.4	95.4
32	1348	175	35.3	21.8	96.3
Mean	1424	181	35.9	21.9	93.6
SE $\pm$	69	9	0.56	-	3.8

[1] See Table 3.
All other figures quoted are average values of six cereal varieties.

This overall picture was reflected in the other data collected which showed that there were no significant differences between row spacings for tiller number (despite a tendency for more tillers from narrower rows), 1000-grain weight or number of grains per spike. Vitreousness was also unaffected by changes in row spacing.

Irrigated Row Spacing Trial

The results of this trial are presented in Table 6 and Appendix 5, and show that, as with the rainfed trial, there were no significant differences between row spacings for mean values of grain yield, tiller number 1000-grain weight, number of grains per spike and vitreousness.

With Stork 'S' durum wheat there was a small increase in grain yield with increased row spacing (not significant) and no change in vitreousness; on the other hand Cocorit 71 durum wheat showed no change in yield but a large and significant decrease in vitreousness with increased row spacing. The breadwheat variety Arvand gave an interesting result in that when it was sown at 24 cm row spacing there was a very high grain yield (2856 kg/ha) compared to the 16 and 32 cm row spacings (2185 and 1898 kg/ha respectively).

Despite the varietal differences mentioned above, on average there was no appreciable effect of row spacing on the growth and mean yields of the crops tested.

Table 6. The Effect of Row Spacing on the Growth of two Durum Wheat and two Bread Wheat Varieties.

Row Spacing (cm)	Grain Yield (kg/ha)	Tiller No. $/m^2$	1000 grain Wt. (g)	No. of grains /Spike	% Vit.[1]
16	2179	202	40.9	26.4	62.3
24	2225	185	42.4	28.4	50.2
32	2150	181	41.9	28.4	53.1
Mean	2185	189	41.7	27.7	55.2
SE ±	91	7	0.71	-	4.8

[1] See Table 3.
All other figures quoted are average values of four wheat varieties.

Rainfed Sowing Date Trial

The emergence of plants sown on the early sowing date (November 13th) in these trials began on December 12th after heavy rains at the beginning of the month. In general the early and medium (December 27th) sowings produced good stands, but the stands from the late sowings (January 22nd) of barley were poor and of wheat were almost nil. As a result, at harvesting only a few grains of seed were obtained from the late sown wheat. Yield data for these plots of the four varieties of wheat were therefore not recorded.

In all plots the plants from the early sowings reached heading and maturity earlier than those from the medium (or late) sowings.

There was a significant variety x sowing date interaction for yield. The yields of early sown varieties were higher than those of medium sown ones by a percentage varying with variety from 17% to 73% (Appendix 6). Late sown barley produced about half the yield of early sown, while, as mentioned above, the wheat varieties yielded nil when sown late.

It can be seen from Table 7 that the large differences in grain yields between early and late sown crops were not due to tiller number or 1000-grain weight, and that there was no significant change in %ge vitreousness for durum wheat. However, the average number of grains per spike for early sown crops was 27.9, and for medium sown ones only 19.0, showing that the decrease in grain yield from early to late sowing was primarily due to this character.

Table 7. The Effect of Sowing Date on the Growth of two Durum Wheat, two Bread Wheat and two Barley Varieties. Rainfed Trial.

Sowing Date (Day/Month)	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt. (g)	No. of grains /Spike	% Vit. [1]
13/11	1913	192	35.8	27.9	95.6
27/12	1256	191	34.6	19.0	99.2
Mean	1585	192	35.2	23.5	97.4
SE $\pm$	48	5	0.6	-	1.5

[1] See Table 3.
All other figures quoted are average values from all six cereal varieties.

The effect of late sowing on barley yields can be seen in Appendix 6. The data shows that the large reduction in yields from early to late sowing was due to not only a reduced number of grains per spike, but also to a reduced number of tillers. The reduction from medium to late sowing was due primarily to a reduced number of tillers.

Irrigated Sowing Date Trial

As in the rainfed trials, early sowing of wheat gave higher grain yields than medium sowing, and late sowing gave nil yields (Table 8). As in the other irrigated trials the two barley varieties were not included.

The differences in grain yields between early and medium sowings in this irrigated trial were mainly due to a much smaller average number of grains per spike in the medium sown crops, 20.1, compared to early sown ones, 31.0. There was also a small reduction in the 1000-grain weight values, which were 42.9 g for early sown and 39.3g for medium sown wheat crops. However, the medium sown durum wheat varieties gave a significantly higher %ge vitreousness compared to when they were sown early.

The main advantage of early sowing was therefore shown to be a much higher grain yield, due to a greater number of grains per spike. The grains also tended to be larger.

Table 8. The Effect of Sowing Date on the Growth of two Durum Wheat and two Bread Wheat Varieties. Irrigated Trial.

Sowing Date (Day/Month)	Grain Yield (kg/ha)	Tiller No /m	1000 grain Wt.(g)	No.of grains /Spike	% Vit. [1]
13/11	2383	179	42.9	31	65.6
27/12	1485	188	39.3	20	88.6
Mean	1934	184	41.1	26	77.1
SE ±	125	14	0.4	-	3.6

[1] See Table 3.
All other figures quoted are average values of four wheat varieties.

Nitrogen Fertilizer Trial

Only the two barley varieties were tested in this trial, these having been grown under rainfed conditions. Arivat x Local D-8 variety was grown in two replications and at all the N rates given in Table 2, whereas there was only one replication for Beecher at the following four rates: 0, 20, 40, and 60 kg/ha. The results of this trial are given in Fig. 1, and show that there were dramatic increases in grain yield due to nitrogen fertilization. The trial showed that application of nitrogen fertilizer at rates as low as 20 kg/ha increased barley yields by about 50% compared to plants which received no added nitrogen. Application of 60 kg N/ha gave yields equivalent to 3.2 t/ha, more than twice the yields obtained (about 1.5 t/ha) when no fertilizer was added.

Comparison of Varieties

Within each of the seed rate, row spacing and sowing date trials it was possible to compare the three species and the six varieties used. The mean values of grain yields, tiller number, 1000-grain weight, number of grains per spike and %ge vitreousness for each variety are given in Table 9 (rainfed trials) and Table 10 (irrigated trials).

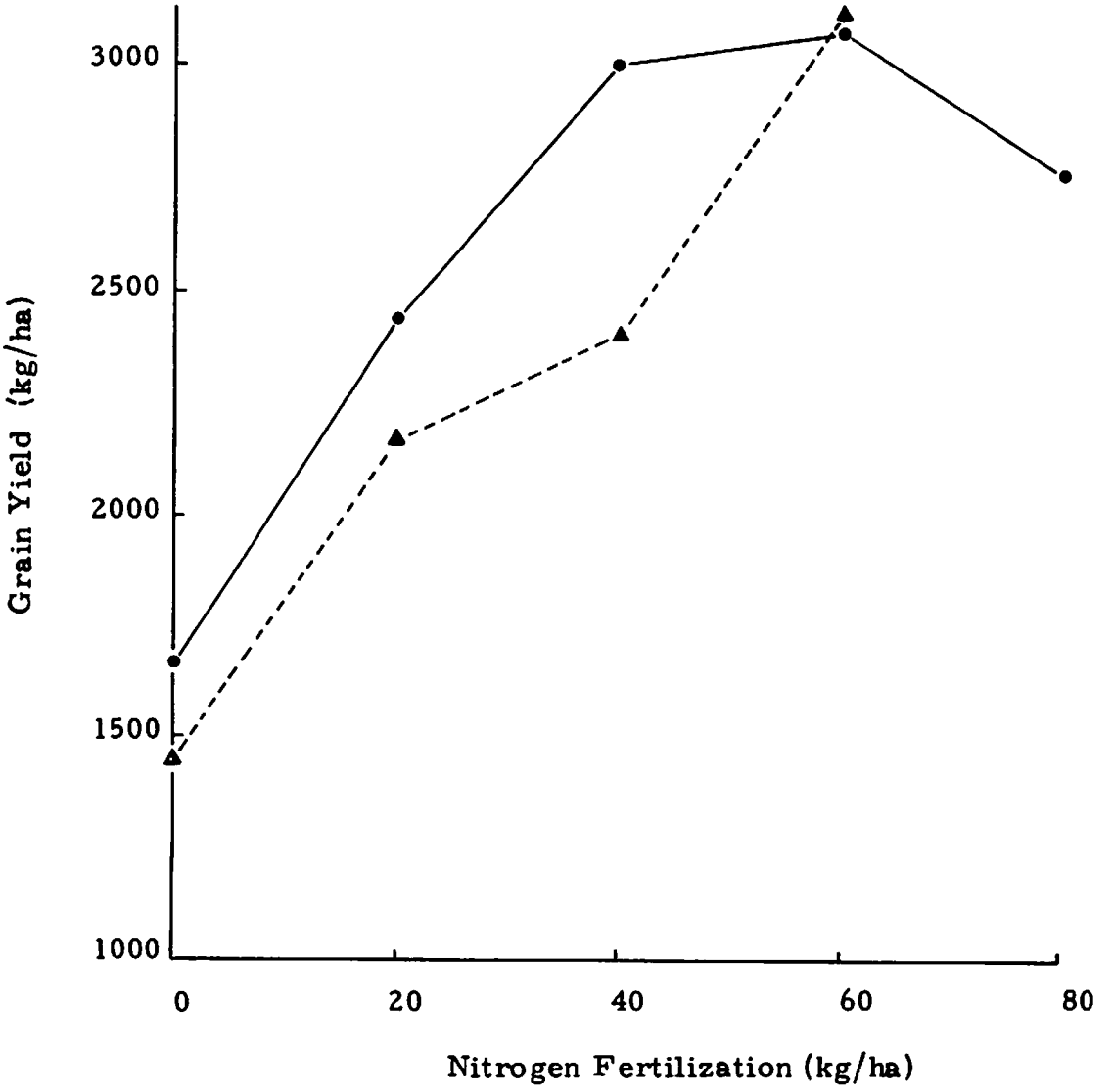
a) Rainfed Trials

Under rainfed conditions in the three trials mentioned above, barley consistently outyielded the two wheat varieties. The highest yielding barley variety produced on average 2,242 kg/ha grain yield, which is equivalent to 101% more than the best bread wheat and 105% more than the best durum wheat variety. Within each species the differences between each variety were small.

Table 9 shows that the increases in grain yields for the barley varieties were primarily due to increased tillering and/or increased grain weight and/or increased number of grains per spike. For Beecher barley the high yields appeared to be due to high grain weight, while for Arivat x Local D-8 they were a result of high tillering and a large number of grains per tiller.

The results of these trials are in broad agreement with those obtained from studies under rainfed conditions in Cyprus, in that barley gave significantly higher yields than wheat.

Fig. 1. The Effect of Nitrogen Fertilization on Grain Yield of Two Barley Varieties.



● : Arivat x Local D-8, mean values from two replications.

▲ : Beecher, one replication.

This trial was carried out under rainfed conditions.

Table 9. A Summary of the Performance of Each Variety in Three Rainfed Trials.[1]

Variety		Grain Yield (kg/ha)	Tiller No. /m^2	1000 grain Wt.(g)	No.of grains /Spike	% Vit.
Durum Wheat	(Stork 'S'	1089	136	38	21.1	95.9
	) Cocorit 71	1001	144	37	18.4	80.5
Bread wheat	(Haramoun	1113	210	26	20.4	-
	) Arvand	1176	164	34	21.1	-
Barley	(Beecher	1985	201	44	22.4	-
	)Arivat x Local D-8	2242	234	33	29.0	-

[1] The rainfed trials summarised in this table are those of Seed Rate, Row Spacing and Sowing Date.

b) Irrigated Trials

For reasons stated in the introduction, barley was not included in any of the irrigated trials. Bread wheat performed slighly better than durum wheat in terms of grain yield. The average value of grain yields for each wheat species in the three irrigated trials were 1942 and 2216 kg/ha for durum and bread wheat respectively (Table 10). In general durum wheat produced larger grains but fewer tillers than bread wheat.

The Effect of Irrigation

When comparing the results of the rainfed and the irrigated trials it is important to remember that differences may arise due to differences in soil fertility between the two fields in which the trials were carried out. However, the results do suggest that only one irrigation, at the heading stage, has a dramatic effect on the grain yield of the wheat varieties tested.

The mean yield of the four wheat varieties increased from 1095 to 2079 kg/ha from the rain fed to the irrigated trials. There were improvements in all the yield components (tiller number, 1000-grain weight, and number of grains per spike) in the irrigated trials. Table 10 also shows that vitreousness of durum wheat grains was lower under irrigation than under rainfed conditions. This is likely to be due simply to the increase in grain yield which effectively reduces the amount of nitrogen available to each grain unit.

Table 10. A Summary of the Performance of Each Variety in the Three Irrigated Trials.[1]

Variety		Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt. (g)	No. of grains /Spike	% Vit.
Durum Wheat	(Stork 'S'	1730	147	44	26.8	79.6
	) Cocorit 71	2153	100	46	29.2	46.6
Bread Wheat	(Haramoun	2278	242	33	28.5	-
	) Arvand	2153	225	41	23.3	-

[1] The irrigated trials summarised in this table are those of Seed Rate, Row Spacing and Sowing Date.

DISCUSSION AND CONCLUSIONS

The results presented in this paper highlight several ways in which increases in cereal yields could be obtained.

The results of the seed rate trials suggest that increases in seed rate can increase grain yields under rainfed but not irrigated conditions. As it is difficult to prepare good seed beds in rainfed areas, increased seed rates are likely to be more efficient in utilising the space, nutrients and moisture. It was found that individual varieties responded differently to the variations in seed rate. Special emphasis should therefore be given to the optimum seed rate requirements for each new variety. There was not found to be any increase in lodging of crops within the range of the seed rates studied, but there was a reduction in vitreousness of durum wheat grains at higher seed rates due to the higher yields obtained.

In contrast the variations in row spacing appeared to have no significant effects on the growth of the barley and wheat crops tested. There was however a tendency for increased yields with narrower row spacing, but as the 16 cm spaced rows were sown by hand and the others by drill it was decided to repeat the trial in the 1978-79 growing season so that all rows could be sown by drill.

The investigation showed that sowing date is a very important agronomic consideration in the growth of cereal crops in the agroclimatic conditions of the Tel Hadya area. It was found that early sowing was of great advantage to the growth of the crops and enabled the plants to develop their root systems before the cold winter months. Thus the crops reached maturity earlier thereby avoiding the drought conditions which are common in the area in early spring. Another important finding of this trial was that barley performed better than wheat when sown late. Therefore barley may be a good choice of crop if for any reason there is a delay in clearing the preceeding summer crop (e.g. cotton) so that planting is not possible before the end of the year. The adverse effect of late sowing on yields was mainly due to a reduction in the number of grains per tiller. The anthesis of late sown plants coincided with the early spring moisture stress period, apparently causing a reduction in fertility.

The preliminary study of the effects of different rates of nitrogen fertilization on the growth of two varieties of barley showed that very large increases in grain yields can be produced by relatively low rates of fertilizer application (20 to 40 kg N/ha). On the strength of these results a much more comprehensive trial is being set up during the 1978-79 growing season.

Comparison of the two crop species used in the trials underlined the importance of barley in the rainfed areas of the region. When grown under the same conditions as wheat, barley outyielded all the wheat varieties by a significant percentage. In addition barley was less affected by late sowing (January 22nd) than wheat.

The results of these trials were encouraging. They showed that of the factors studied seed rate, sowing date and nitrogen fertilization had the greatest effect on cereal yields. In particular they suggest that the best cereal yields in the dry areas may be obtained by using high seed rates, by sowing early and by applying moderate doses of nitrogen fertilizer.

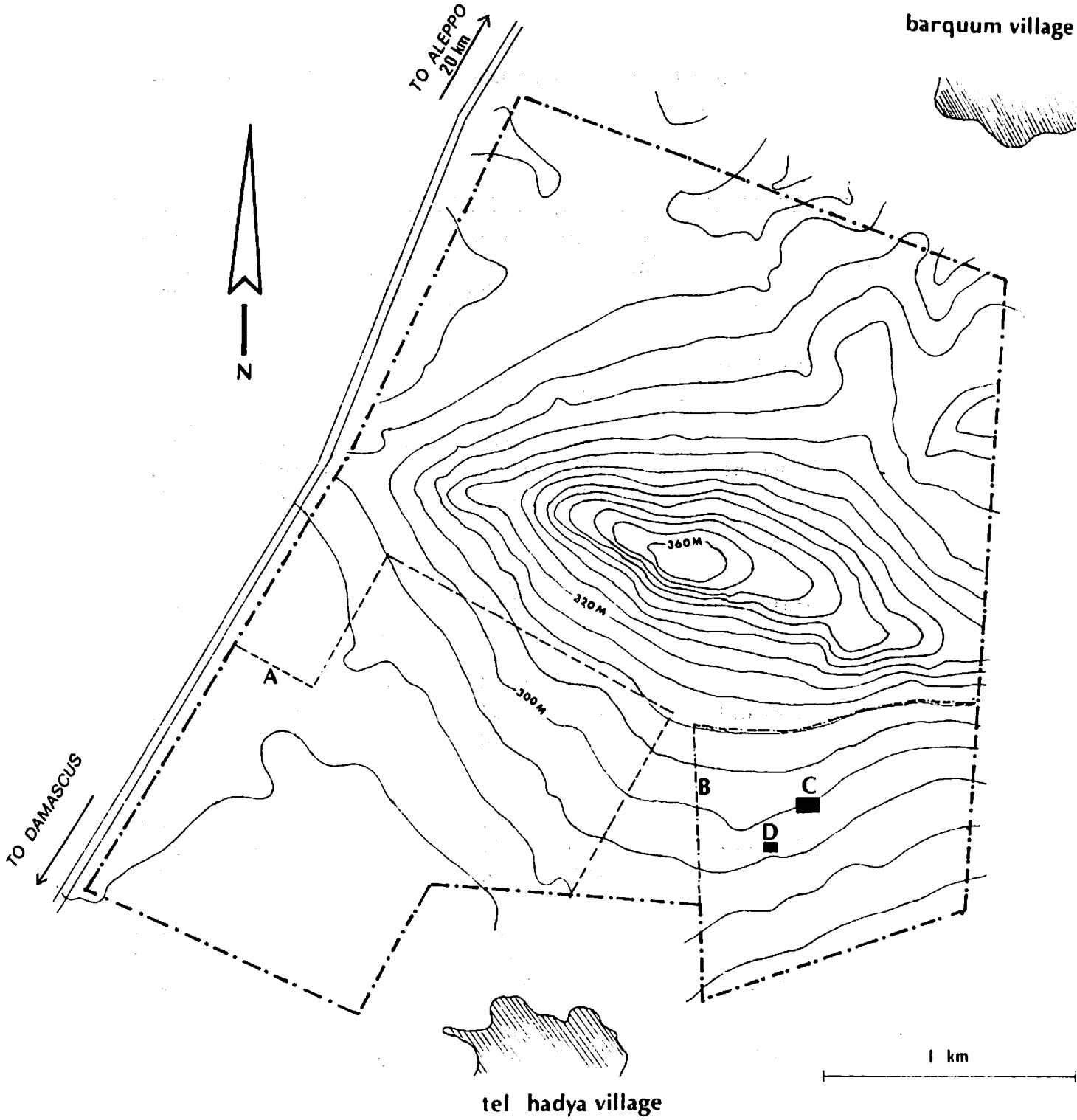
Suggestions for Further Work

Agronomic studies such as the one described in this paper have their limitations in that they are relevant only to the particular genetic material used and to the environmental conditions experienced. Such studies should therefore be continued and expanded to cover other agroclimatic conditions. It is hoped that similar trials will be set up in other areas and in other countries of the Near East region.

The effects of one agronomic practice are not independent of those of another. Useful information could therefore be obtained by studying the interaction between the practices studied in this trial. Such studies have been incorporated into the trials sown at Tel Hadya for the 1978-79 growing season.

APPENDICES

Appendix 1. Map of ICARDA's Tel Hadya Research Station.



— Boundary of the site.

A — Boundary of the permanent research plots (from 1978)

B — Boundary of the research plots used in 1977-78 season.

— 5m contour intervals

C — Location of the rainfed trials described in their paper.

D — Location of the irrigated trials .

Appendix 2.

The Effect of Seed Rate on the Growth of Six Cereal Varieties. Rainfed Trial.

Variety		Seed Rate (kg/ha)	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt.(g)	No. of grains /Spike	% Vit.
Durum wheat	(Stork 'S')	70	724	86	37.8	22.3	96.9
		100	872	127	35.7	17.2	93.5
		130	1126	145	36.9	21.0	93.6
	( ) (Cocorit 71	70	943	123	37.0	20.7	76.9
		100	1002	147	38.2	17.8	75.9
		130	859	160	37.7	14.2	60.0
Bread wheat	(Haramoun)	70	889	139	25.8	24.8	-
		100	887	208	25.0	17.1	-
		130	1122	275	25.7	15.9	-
	( ) (Arvand	70	1089	135	33.3	24.2	-
		100	1367	161	34.4	24.7	-
		130	1428	206	33.3	20.8	-
Barley	(Beecher)	70	1722	167	47.7	21.6	-
		100	1631	181	42.2	21.4	-
		130	1924	225	43.0	19.9	-
	( ) (Arivat x Local D-8	70	1626	170	34.4	27.8	-
		100	1770	234	34.1	22.2	-
		130	2306	227	33.1	30.7	-
	SE $\pm$		121	14	0.94	-	6.4

Appendix 3.

The Effect of Seed Rate on the Growth of Four Wheat Varieties. Irrigated Trial.

Variety	Seed Rate (kg/ha)	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt.(g)	No. of grains /Spike	% Vit.
	70	1731	123	43.3	32.5	92.5
(Stork 'S'	100	1720	116	46.6	31.8	86.9
)	130	2002	157	44.1	28.9	80.9
Durum						
wheat)	70	2087	131	46.8	34.0	68.0
(Cocorit 71	100	2241	183	45.4	27.0	47.3
	130	2337	183	46.3	27.6	50.8
	700	2493	231	34.2	31.6	-
(Haramoun	100	2143	249	31.8	27.1	-
Bread)	130	2435	313	32.4	24.0	-
wheat(						
)	70	2054	183	40.8	27.5	-
(Arvand	100	2131	173	41.3	29.8	-
	130	2028	220	40.8	22.6	-
SE $\pm$		187	8.5	1.04	-	7.0

Appendix 4.

The Effect of Row Spacing on the Growth of Six Cereal Varieties. Rainfed Trial.

Variety	Row Spacing (cm)	Grain Yield (kg/ha)	Tiller No$_2$ /m^2	1000 grain Wt.(g)	No.of grains /Spike	% Vit.
	16	1510	134	35.3	31.9	97.3
(Stork 'S'	24	1121	134	40.0	20.9	97.0
Durum	32	1188	123	39.0	24.8	97.2
wheat(						
)	16	719	128	36.3	15.5	80.8
(Cocorit 71	24	1037	159	36.1	18.1	93.8
	32	844	140	36.1	16.7	95.5
	16	1110	242	26.1	17.6	-
(Haramoun	24	1344	214	28.8	21.8	-
Bread)	32	1152	223	25.1	20.6	-
wheat(						
)	16	1114	177	35.8	17.6	-
(Arvand	24	1002	152	32.1	20.6	-
	32	865	149	32.4	17.9	-
	16	1875	194	45.9	21.1	-
(Beecher	24	1742	182	48.7	19.7	-
)	32	1996	201	45.2	22.0	-
Barley						
)	16	2504	271	35.6	26.0	-
(Arivat x	24	2479	223	34.1	32.6	-
Local D-8	32	2048	214	34.1	28.1	-
SE $\pm$		170	21.5	1.4	-	5.4

Appendix 5.

The Effect of Row Spacing on the Growth of Four Cereal Varieties. Irrigated Trial.

Variety	Row Spacing (cm)	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt.(g)	No.of grains /Spike	% Vit.
	16	1671	160	42.0	24.9	73.7
(Stork 'S'	24	1740	138	43.9	28.8	72.3
Durum	32	1871	153	44.1	27.8	71.6
wheat(						
)	16	2260	165	45.0	30.5	50.9
(Cocorit 71	24	1988	142	47.3	29.6	28.2
	32	2321	163	48.1	29.6	34.5
	16	2598	238	34.8	31.4	-
(Haramoun	24	2315	234	35.9	27.6	-
Bread	32	2517	247	33.6	30.4	-
wheat(						
)	16	2185	245	41.8	21.3	-
(Arvand	24	2856	227	42.4	29.7	-
	32	1898	163	41.8	27.9	-
SE $\pm$		181	14.7	1.4	-	6.8

Appendix 6

The Effect of Sowing Date on the Growth of Six Cereal Varieties. Rainfed Trial.

Variety	Sowing Date [1]	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt.(g)	No. of grains /Spike	% Vit.
	E	1339	139	38.6	26.0	99.2
(Stork 'S'	M	780	181	37.7	11.4	99.1
Durum	L	nil	-	-	-	-
wheat(						
)	E	1509	159	39.1	24.3	91.9
(Cocorit 71	M	896	138	38.0	17.1	99.3
	L	nil	-	-	-	-
	E	1365	213	27.0	23.7	-
(Haramoun	M	974	179	25.9	21.0	-
Bread)	L	nil	-	-	-	-
wheat(						
)	E	1689	176	37.6	25.1	-
(Arvand	M	787	159	31.3	15.8	-
	L	nil	-	-	-	-
	E	2507	210	40.2	29.7	-
(Beecher	M	2141	230	43.1	21.6	-
	L	1391	174	40.9	19.5	-
Barley						
)	E	3026	254	32.2	37.0	-
(Arivat x	M	1946	366	31.4	16.9	-
Local D-8	L	1583	188	31.8	26.5	-
SE $\pm$		118	13.5	1.48	-	2.2

[1] The varieties were sown on the following dates:-

November 13th	(E/early)
December 27th	(M/medium)
January 22nd	(L/late)

Appendix 7.

The Effect of Sowing Date on the Growth of Four Cereal Varieties. Irrigated Trial.

Variety	Sowing Date [1]	Grain Yield (kg/ha)	Tiller No $/m^2$	1000 grain Wt. (g)	No. of grains /Spike	% Vit.
	E	1772	142	45.4	27.5	73.9
(Stork 'S'	M	1452	170	43.0	20.0	93.7
Durum	L	nil	-	-	-	-
wheat(						
)	E	2537	144	48.1	36.6	57.4
(Cocorit 71	M	1563	173	43.5	20.8	83.5
	L	nil	-	-	-	-
	E	2398	227	34.4	30.7	–
(Haramoun	M	1602	219	30.2	24.2	–
Bread	L	nil	-	-	-	-
wheat(						
)	E	2826	203	43.6	31.9	–
(Arvand	M	1326	190	40.3	17.3	–
	L	nil	-	-	-	-
SE ±		250	28	0.78	-	5.1

[1] The three sowing dates were those given in Appendix 6.