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Soybean production under various ecological conditions with special reference to North Africa

Sojabohnen unter verschiedenen ökologischen Bedingungen mit besonderer Berücksichtigung der Verhältnisse in Nordafrika.

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1. Introduction and bibliography

In the warm climates soybean production (Glycine max. L.) is mainly concentrated in Asia and South America (FAO, 1981). In Africa this production occupies a secondary place, 0,26% of the annual crops.
The soybean is described as a short–day plant (Garner and Allard, 1930; Rudorf, 1935; Scheibe, 1953, Johnson, 1961; Jabil, 1973; Liebhard, 1977). Among the varieties exist, however, clear quantitative differences in the short–day reaction (Rudorf, 1935; Schuster and Jobehdar–Hoharnejad, 1975; Liebhard, 1977).
The development and the grain production of soybeans is greatly influenced by the temperature (Rust, 1954/55, van Schaik and Probst, 1958; Enken, 1959; Weber, 1968, Thompson, 1970; Lawn and Byth, 1973; Major et al., 1975, Hoharnejad, 1975; Soldati and Keller, 1977; Kopp, 1975).
Lack of water during different growing stages also influences the grain production. Runge and Odell (1960) observed that the soybean yield increased significantly when high precipitation took place during the flowering and grain filling period. Doss et al. (1974) and Sionet and Kramer (1977) obtained similar results. They emphasize the importance of the supply of water in the grain formation period.
Cultivation can take place in almost all types of soil, however fertile loamy soils are to be preferred (Jalil, 1971). The ideal pH–value is between 6 and 6,5 (Hinson and Hartwig, 1977).
Schuster (1971) reviewed the influence locations and sowing times and other variable factors that influence the quality of soybeans.
The aim of the experiments in North Africa was to cultivate soybeans as a summer crop with irrigation. The idea was to test the suitability and the production capacity of selected varieties at different sowing times.

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2. Materials and Methods

These experiments were carried out under extremely different ecological conditions.

The following varieties were used:

Altona (Canada) Amsoy (USA–Centre)
Caloria (FRG)
Corsoy (USA–Centre)
Gieso (FRG)
Merit (USA–North)
Prota (FRG)
The varieties Corsoy and Amsoy could only be tested in the warm locations, in Turkey and North Africa. The experiments were carried out in a randomized block design with four repetitions. The plot size was 30 m^2 with plants/m^2 with irrigation (Turkey, Tunisia and Morocco) and 20 m^2 with 60 plants/m^2 without irrigation (Gross Gerau, Vienna). The quantity of irrigation was determined by the usual local needs, as a rule 20–40 mm per week. In Tunesia four different sowing times (March, April, May, June) were tested.

The seed was not inoculated with Rhizobium in all areas, however, it was treated with TMTD. Besides the usual local basic application with Phosphorous and Potassium a nitrogen fertilizer of 80 Kg N/ha in Gross–Gerau and Vienna and 60 Kg N/ha in the warm locations was applied.
The quantitative and qualitative 1976 results, as well as the statistics evaluation of 1975 and 1976 yields are included in the present results. Failures in some places restrict the orthogonal kernel to five varieties.
The analysis of the seed ingredients of the corn was done using the following methods:

Crude protein: Kjedahl – N x 6,25
Crude fat: Measurement with the Newport Analyser
Fatty acid: Gascromaticaly with Natriummethylat in Methanol

3. Results of the experiment and discussion

1. Grain production

The grain production of two years in five locations with five varieties are presented in tabel 1. In the mean the Vienna and Gross–Gerau locations obtained the highest yields, with 19,6 ie 14, 4 dt/ha, whereas Bornava and Rabat with 5,3 ie 6,8 dt/ha appear at the end of the yield scale. Ghardimaou obtained with 14,8 dt/ha relative satisfactory results.
The effect of the locations, as well as the interactionferences which are not statistically significant.
If we compare the ecological conditions of the locations (see annex) we can state that between the locations in Europe and Turkey on the one hand, and North Africa on the other, there are considerable differences in the medium daily temperature and medium precipitation. The differences between the two North Africa locations Ghardimaou and Rabat with 17,9° C and 16,3° C respectively and 460 mm and 510 mm respectively, are relatively small. The pronounced differences of yield between Morocco and Tunisia cannot be explained by these small differences in the weather conditions, as an experiment in Morocco shows (see figure 1). Tessaut, with its low precipitation, has, with the exception of the Amsoy variety, the highest yield. The marked differences of yield find their explanation in the

differences of soil and incidences of disease and other variable factors, especially in the supply of water. This means that farming management has to be rethought.
In Tunisia and Morocco the soybeans are sown from spring until summer. The growing period coincides, in the main, with the arid summertime. The supply of water ist therefore the limiting factor.

FIGURE 1 - INFLUENCE OF THE LOCATION ON SOYBEAN IN MOROCCO IN 1976

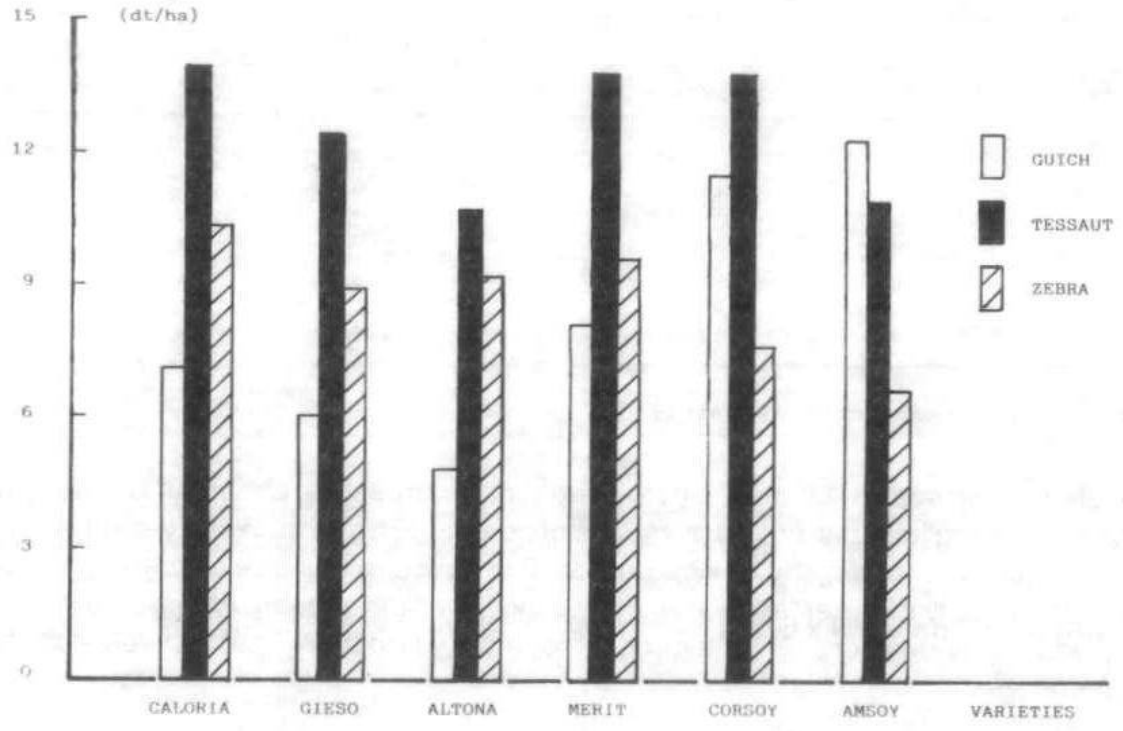


Table 1: Grain production (dt/ha)* of five soybean varieties grown at different locations (Average values of two production years)

	Location					
Variety	Gross-Gerau FRG	Vienna Austria	Bornova Turkey	Ghardimaou Tunisia	Rabat Morocco	Average
Altona	13.8	15.6	6.4	15.1	5.7	11.3
Caloria	15.0	17.5	4.3	13.0	6.9	11.3
Gieso	13.9	20.3	5.6	13.5	7.1	12.1
Merit	16.3	25.2	6.9	15.2	6.5	14.0
Prota	12.8	19.6	3.3	17.2	8.0	12.2
Average	14.4	19.6	5.3	14.8	6.8	

	Variety	Location	Year	Interaction Variety/Location	Interaction Variety/Year	Interaction Location/Year
F-Test	1.75	51.86++	0.99	1.06	0.97	5.23+
LSD	2.62	2.66	1.66	5.86	3.71	3.71

* 1 dt/ha = 100 kg/ha

Early sowings in March/April can save water, as we can see by an experiment carried out in Tunisia (see table 2). In this time of the year there is sufficient soil water and until the beginning of May one can rely on precipitation. As a rule irrigation becomes necessary from May onwards. The early spring sowing has the further advantage of being relatively cold, thus making possible the sprouting and development in the juvenile period without irrigation.

Table 2: Soybean production (dt/ha) from the sowing time experiment in Tunisia (1976)

	Time of sowing		
Variety	April	Mai	June*
Altona	14.0	11.1	--
Amsoy	17.3	17.8	--
Caloria	14.8	11.3	--
Corsoy	12.8	13.8	--
Gieso	10.4	14.6	--
Merit	16.0	15.1	--
Prota	19.3	15.8	--
Average	14.8	14.2	

* No production detection possible

By the late sowing season (June) the prevailing temperatures are about 40° C. The sprouting and the sowing are guaranteed by means of constant irrigation. Weekly sprinkling (20-40 mm) is kept up until the end of September. The soybean has a relatively high dependence on the supply of water, especially during the flowering season. Afterwards irrigation can be reduced under North African conditions, even when there is a relatively abundant growth of leaves.

These findings are compatible Runge's and Odell's results (1960). However Doss et al. (1974) as well as Doss and Thurlow (1974) are of the opinion that the water availability, after the flowering season (in other words during the grain filling period) is important to obtain high yields.

The time when the irrigation should be ceased depends on the varieties and the respective stage of development of the crop. The demand for water and the irrigation costs could be reduced by the selection of suitable varieties and the most suitable sowing time.

2. Seed ingredients

The effect of the locations and the year of experiment is clear on the seed ingredients (see table 3).

The influence of the varieties is highly significant in the F–test in so far as crude fat and palmitin/stearin is concerned. The clearest effect is given by the locations and the years as well as their interactions. This means that the quality of the grains produced in this experiment was especially influenced by the environment.

The influences of the location on the seed ingredients of soybean have been frequently described (Howell and Cartter, 1953, 1958; Collins and Sedgwick, 1959; Howell and Collins, 1957; White, Quackenbush and Probst, 1961; Schuster, 1971; Schuster and Mar-

quard, 1972; Marquard, Schuster and Hoharnejad, 1980).
An essential influence seems to be the effect of the temperature. Low temperatures seem to favour the synthesis and storage of fat (Zeller, 1957) while the protein is reduced.

Table 3: Influence of the experiment factors on the seed ingredients of soybeans (F-Test)

	Fat	Crude Protein	Palmitin and Stearin	Olein acid	Linol acid	Linolenic acid
Variety	++		++			
Location	++		++	++	++	++
Year		++	++	++	++	
Variety/Location			+			
Variety/Year						
Location/Year	++		++	++		

++ Highly significant

Table 4: Crude protein content of soybeans in % D.M.C.
(Average values from two production years)

	Location				
Variety	Gross-Gerau FRG	Vienna Austria	Bornova Turkey	Ghardimaou Tunisia	Average
Altona	41.1	40.5	37.1	37.1	39.0
Caloria	37.0	38.7	39.6	37.3	38.2
Gieso	10.6	37.5	34.8	34.4	36.8
Merit	37.3	38.0	38.3	36.4	37.5
Prota	37.7	35.8	36.8	34.0	36.1
Average	38.7	38.1	37.3	35.8	

	Variety	Location	Year	Interaction Variety/Location	Interaction Variety/Year	Interaction Location/Year
F-Test	1.70	2.63	13.57++	0.80	1.46	1.40
LSD	2.69	2.40	1.70	5.37	3.80	3.40

* 1 dt/ha = 100 kg/ha

The crude protein contents values are presented in table 4. The relatively warm locations of Turkey and Tunisia indicate a lower crude protein content than Vienna and Gross-Gerau. The mean differences of the varieties are between 36,1% (Prota) and 39% (Altona), but these are not statistically significant.
Between the years there are highly significant differences which underlines the predominant influence of the weather conditions. Enken (1959), for example, referred to pronounced influences of the years on the protein content. In a dry year the crude protein content was increased and in a humid one it was reduced. According to Urano, Nagase and Uguchi (1958), the protein content increases when the supply of water at the beginning of the vegetation period is reduced and increased later on. The crude protein content must, however, be seen in its interaction with the fat content, which is often negative (Johnson, 1961; Hackbarth, 1962).

Table 5: Crude fat content in % D.M.C. (Average values from two production years)

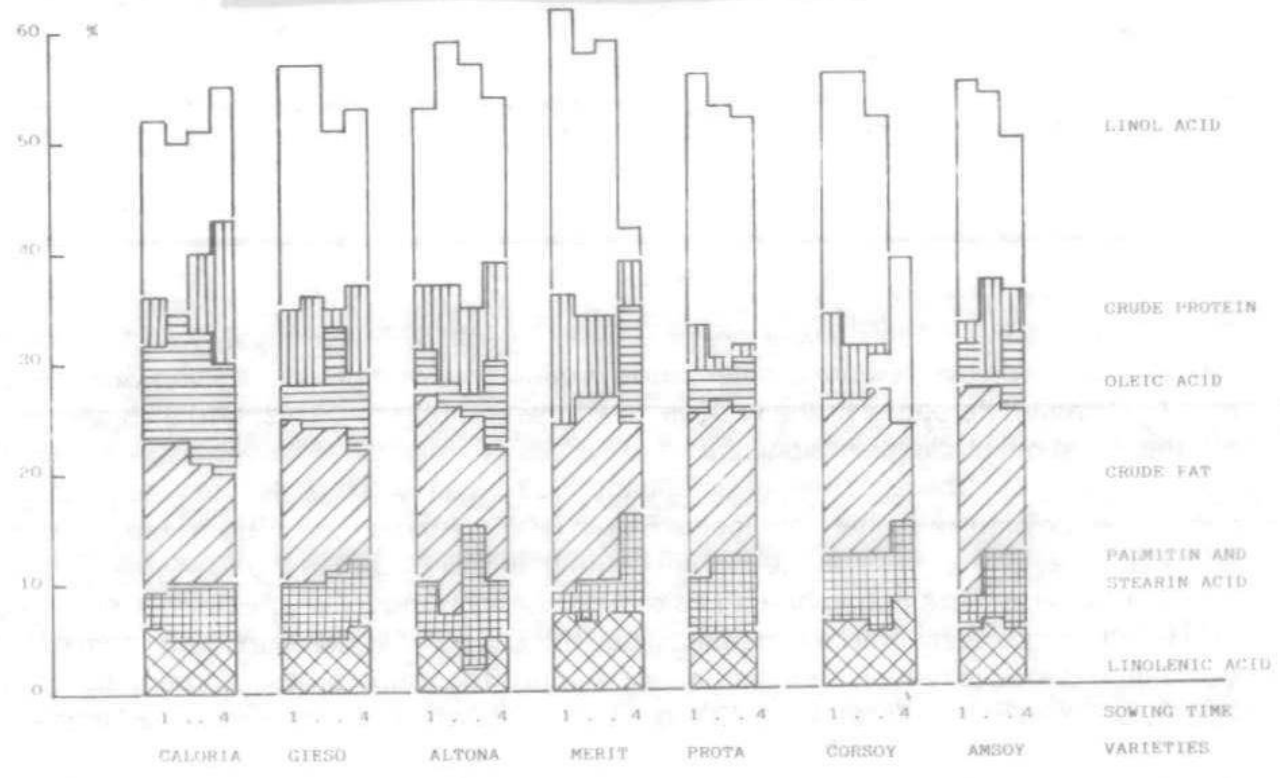
Variety	Location					
	Gross-Gerau FRG	Vienna Austria	Bornova Turkey	Ghardimaou Tunisia	Rabat Morocco	Average
Altona	20.7	20.7	22.9	25.6	20.3	23.0
Caloria	18.2	19.5	20.5	21.5	20.6	19.9
Gieso	19.3	20.3	23.3	24.0	21.3	21.6
Merit	21.3	21.3	23.9	26.5	24.0	23.4
Prota	19.4	21.1	23.4	25.0	22.1	22.2
Average	19.8	20.6	22.8	24.5	21.7	

	Variety	Location	Year	Interaction Variety/Location	Interaction Variety/Year	Interaction Location/Year
F-Test	24.00++	57.52	0.25	1.97	2.71	18.48++
LSD	0.75	0.75	0.47	1.68	1.06	1.06

* 1 dt/ha = 100 kg/ha

By the fat content (see table 5) the varieties and the differences of locations as well as the interaction location/year are statistically confirmed. The fat content increases from the colder locations (Gross–Gerau with 19,8%) to the warmer ones and reaches in Tunisia in the mean of the varieties 24,5%. When comparing the varieties we find that the greatest difference in fat content is between Caloria with 19,9% and Merit with 23,4% in the mean of the locations and the years of production.

FIGURE 2 – INGREDIENTS OF SOYBEANS (% IN D.M.C. TOTAL FAT ACID = 100) IN FOUR SOWING TIMES IN TUNISISA, 1976



The interaction between the varieties in Tunisia, especially Morocco, are relatively clear. The composition of the seed ingredients was, for that reason, tested in Tunisia and Morocco by a sowing time experiment. The results of Morocco are not unfortunately, of much value. For the experiment carried out in Tunisia a general view over the possible dependences and interactions of the sowing times is reproduced in figure 2.

The variability of the varieties depending on the sowing time is most strongly expressed by the crude fat and crude protein content. The negative relationship between the two characteristics are distinct for all varieties. A low crude fat content is related to a high crude protein content.

While the varieties Caloria, Gieso and Altona with the latest sowing time and corresponding highest temperatures register a decrease in their fat content and an increase in the crude protein, this relationship is not apparent with the other varieties. According to Streuber (1961) the moderate European climatic conditions and late sowing times influence very slightly the oil content, whereas the crude protein content decreases with the late sowing time and increase again by the very late sowing time.

According to Donavan, Marr and Carson (1967) together with the temperature and the duration of the sun the supply of water is important for the fat and the protein content of the soybeans. The supply of water in North Africa seems also to have an influence of the compositions of the seed ingredients. The saturated part of the fatty acids increases as a rule, with the exception of the Altona variety, from the first to the second sowing time and is then to stay at this level. This means that also in North Africa, with increasing temperature and dry conditions during the vegetation time, the production of Palmitin and Stearin acid will be increased, as it is described by Howell and Collins (1957), White et al. (1961) as well as Schuster (1971) for European and other locations. On the other hand it will accordingly be stated that in warm dry locations the unsaturated fatty acid portion decreases. In the sowing time experiment mentioned the linolenic acid content clearly falls also by the late sowing time and increasing summer temperature, with the exception of the Caloria variety, whereas the corresponding olein acid content increases. By the linolenic acid, marked differences among the varieties and sowing times are possible to identify , but these, however, do not show any tendency. The correlation between the high temperatures and the linol acid and the linolenic acid content, presented by different authors as negative (Weiss et al., 1952; Collins and Howell, 1957) can here be confirmed in the tendency for the linol acid.
Highly significant interactions between the locations and the influence of years were observed through the experiments carried out by Marquard and Schuster (1980) with the same varieties affecting the olein acid, the linol– and the linolenic acid. This means that significant differences concerning the unsaturated fat acids were also mainly the result of environment influences.
The results show that dependent on the the sowing time, different qualitative compositions come about. These can be recognized as clear reactions to the forms of cultivation which should be for specific technical production and technical use purposes. These qualitive aspects must be taken into consideration in large scale production in North Africa. For this reasons there is a need for close quality control over the whole complex of qualitative compositons in the development of large scale production.

The question then arises: can soybeans be cultivated in large areas in this region?

On the one hand the increase of animal husbandry (Poultry, dairy stock) will considerably increase the need for protein concentrates. Meanwhile the increasing foreign exchange expenditure should not be in the long term tolerable. On the other hand one should not underestimate the cost of irrigation and America's price competition in exports. Furthermore it happens that the problem of processing of soybeans has not jet been solved and therefore relatively high capital investiments have to be made into technical facilities.

When one, however, decide to exploit the potential of soybeans with irrigation as a Spring and Summer crop in North Africa, appropriate production practices must be developed. In the area under irrigation spring/summer soybean production in an adequate crop rotation would be most suitable. The soybeans could follow the winter crops such as wheat, oats, sugar or fodder beet and have a positive action upon the other crops.

The sensitivity of soybeans to salt water irrigation should be carefully tested under North African conditions. On soils which are not salty this would create the possibility of a more effective explotation of the potential of this crop.

4. Summary

In 1975 and 1976 field trials with seven soybean varieties were carried out in Gross–Gerau (Rhein–Main Region), Vienna (Marchfeld), Bornova (Ege–Region, Turkey), Ghardimaou (Upper Medjerda Valey) and Zebra (Agadir, Morocco).

1. The trial locations Vienna, Gross–Gerau and Ghardimaou (Tunisia) obtained the highest yields in the mean of the varieties and seasons: 19,6 14,4 and 14,8 dt/ha. The trial locations in Turkey and Morocco, on the other hand, obtained relatively low average yields: 5,3 and 6,8 dt/ha. The effect of the locations as well as the interactions locations/seasons are highly significant and indicate therefore the influence of the ecological conditions. The yield differences between the locations are mainly influenced by the supply of water. Early sowing in March/April could reduce the application of water.

2. As for the seed ingredients, the effect of the locations and seasons and their interactions is also evident. The relatively warmer locations obtained a lower protein–content than in Vienna and Gross–Gerau. The influence of the varieties is more pronounced in the crude–fat–content and the saturated fatty acids. The crude–fat–content increases with higher temperatures and reaches in Tunisia 24,5% on the average of the varieties. With later sowing time, increasing temperatures and drought conditions, the linolenic acid–content is reduced, while the olein–acid–content increases. There are relatively pronounced differences in the linolenic–acid–content between the varieties and sowing times, but without showing any trend.

3. The presented results show significant reactions between the ecological, varieties and agronomical methods, which should be made use of for production objectives.

Zusammenfassung

In den Jahren 1975 und 1976 wurden Feldversuche mit sieben Sommersojabohnen (drei deutsche, eine kanadische und drei US–amerikanische) in Groß–Gerau (Rhein,Main–Gebiet), Wien (Marchfeld), Bornova (Ege–Gebiet, Türkei), Ghardimaou (Ob. Medjerda Tal, Tunesien) Rabat (Marokko) Tessaout (Marrakesch, Marokko) und Zebra (Agadir, Marokko), durchgeführt.

1. Bei den Kornerträgen erzielten Wien und Groß–Gerau im Mittel der Sorten und Anbaujahre mit 19,6 bzw. 14,4 dt/ha die höchsten Erträge, während die Standorte in der Türkei und Marokko mit 5,3 bzw. 6,8 dt/ha im unteren Bereich der Ertragsskala liegen. Die Wirkung der Standorte sowie die Wechselwirkungen Standorte/Versuchsjahre sind hochsignifikant und deuten damit auf den beherrschenden Einfluß der Umweltbedingungen hin. Die Ertragsunterschiede zwischen den Standorten sind in erster Linie auf die Wasserversorgung zurückzuführen. Frühsaaten im März/April können wassersparend produzieren.

2. Auch bei den Inhaltsstoffen werden die Wirkungen der Standorte, Versuchsjahre und deren Wechselwirkungen deutlich. Die relativ warmen Standorte wiesen einen niedrigeren Rohproteingehalt auf als Wien und Groß–Gerau. Der Einfluß der Sorten tritt beim Rohfett und den gesättigten Fettsäuren am deutlichsten hervor. Der Rohfettgehalt nimmt von den kühleren zu den wärmeren Standorten zu und erreicht in Tunesien im Sortenmittel 24,45%. Mit späterer Saatzeit, zunehmender Sommertemperatur und begleitender Trokkenheit fällt in der Regel der Linolsäuregehalt ab, während der Ölsäuregehalt entsprechend ansteigt. Bei der Linolsäure sind relativ ausgeprägte Unterschiede zwischen den Sorten und Saatzeiten feststellbar, die jedoch keine klare Tendenz erkennen lassen.

3. In den vorliegenden Ergebnissen sind deutliche Reaktionen auf Standorte, Umwelteinflüsse, Sorten und Anbaumodalitäten zu erkennen, die für spezifische produktions– und verarbeitungstechnische Ziele auszunutzen sind.

Ecological characterization of the trial locations

	Location						
Country	Gross-Gerau FRG	Vienna Austria	Bornova Turkey	Ghardimaou Tunisia	Rabat Morocco	Tessaout Morocco	Zebra Morocco
Region	Rhein-Main Gebiet	March-feld	Ege-Gebiet	Ob. Mejer-da Tal	Rabat	Marra-kesch	Agadir
Hight above sea level (m)	91	60	147	28	10	60	100
Soil type	humos sand	Tscher-nosem	Alluvium	Alluvium	Alluvium	sandy loam	sand
pH-value water	6.5	4.0	6.8	7.6	7.2	6.7	6.2
Mean daily temp. °C	9.5	9.4	17.5	17.9	16.3	17.6	16.6
Mean annual precipita-tion (mm)	590	541	704	460	510	390	430

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