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Characterization of Moroccan *Aegilops* spp. for germplasm enhancement

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تحديد خصائص الحشائش البرية Aegilops المغربية النافعة في التحسين الوراثي للقمح

يتأثر تنوع القمح الطري والقمح الصلب في المغرب بظاهرة الحث الوراثي، كما أن حساسية الزراعات الجديدة للأمراض يحد من الإنتاج. لذا فإن إدخال جنات جديدة مقاومة للأمراض انطلاقا من أصناف تنتمي إلى نفس السلالة تبقى الوسيلة الوحيدة لوقاية هذه الزراعات دون الإسهام في تلوث البيئة. أسفرت معاينة أكثر من 200 موقع عن جمع 149 سلالة من نوع Aegilops منها أربعة أصناف. كلها متعددة العدد الصبغي و أبان تقييم الخصائص المورفولوجية لهذه الأنواع وكذا مقاومتها للأمراض عن تنوع كبير داخل المكون الوراثي لهذه الحشائش البرية المحلية. وهكذا تميزت Ae.geniculata بتنوع في التبكير و النمو النباتي.Ae.ventricosa تتميز بأوراق طويلة ومقاومتها لمرض الصدأ وذبابة هيس.Ae.triuncialis تتميز بأوراق قصيرة وتحملها للفيروسات ومرض الصدأ مع حساسية اتجاه ذبابة هيس و Ae.neglecta تتميز بتبكير في الاسبال ومقاومة البياض الدقيقي

الكلمات المفتاحية : تنوع– خصائص مورفولوجية– مقاومة الأمراض– الحشائش البرية– Aegilops–المغرب

Caractérisation des variétés marocaines d'*Aegilops* spp.

Le but de cet article est de décrire la variation existante entre 149 accessions des espèces d'*Aegilops* collectées dans différentes régions du Maroc, d'examiner la distribution des variations morphophysiologiques et de résistance, et de déterminer la fréquence des caractères recherchés parmi les espèces. Les données prélevées au cours des essais expérimentaux ont été analysées à l'aide de l'analyse factorielle discriminante (DFA). Les trois premiers axes ont pu expliquer la totalité de la variation (Pr<5%). L'estimation des distances de Mahalobis a montré le rapprochement entre *Ae. geniculata* and *Ae. triuncialis*. La distribution des différentes accessions dans de nouveaux groupes a montré que 86,6% de celles-ci ont été affectées dans leur propre espèce. Treize accessions d'*Ae. geniculata* ont été placées dans le groupe d'*Ae. triuncialis* confirmant le rapprochement entre ces deux espèces. La plus grande variation a été celle d'*Ae. geniculata* pour les caractères précocité, étalement et densité. *Aegilops ventricosa* a été différenciée des autres espèces par la longueur de ses feuilles, sa tolérance pour la rouille foliaire et sa résistance à la cécidomyie. La quatrième espèce, *Ae. neglecta* a été la plus précoce et a combiné entre au moins trois types de résistance Les espèces spontanées resteront dans le réservoir génétique universel pour l'amélioration végétale. Elles doivent être préservées pour une durabilité des systèmes de production.

Mots clés : *Aegilops* spp.- Collection - Diversité - Analyse multivariée - Source de résistance

Characterization of Moroccan *Aegilops* spp. for germplasm enhancement

The objective of the present paper is to describe the existing variation among 149 accessions of *Aegilops* species collected across Morocco, to examine the distribution of the morphophysiological and resistance variations, and to determine the frequency of valuable characters among species. Data recorded during the experiment were used to perform a discrimination factorial analysis (DFA). The first three axe account for the total variation (Pr<5%). The estimation of the Mahalobis distances showed closeness between *Ae. geniculata* and *Ae. triuncialis*. The distribution of the accessions into computed new groups showed that 86.6% of the entries were affected to their own species. Thirteen accessions from *Ae. geniculata* were put into *Ae. triuncialis* group proving the close similarity between those two species. The largest variation was that of *Ae. geniculata* for earliness, plant spreading and density. *Aegilops ventricosa* was differentiated from the other species by it's long leaves size and it's tolerance to leaf rust and resistance to Hessian fly. The fourth species *Ae. neglecta* was the earliest and combine between at least three different resistance. Natural alien germplasm will remain an universal genetic pool for crop improvement that needs to be preserved for crop production sustainability.

Key words : *Aegilops* spp. - Collection - Diversity - Multivariate analysis - Source of resistance

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INTRODUCTION

Genetic erosion has been considerably accelerated and became evident in many regions around the world. In Morocco, new cultivar introduction and distribution has increased for both durum and common wheats. In large agricultural areas, traditional agricultural systems were totally replaced by new techniques based on improved cultivars, chemical use for fertilization and for pests and weeds control. Only mountains that are difficult to reach and far from urbane centers are still protecting traditional practices. The protection of the biological diversity in those lands is fundamental for sustainable agriculture.

Aegilops spp. has close relation with cultivated wheats (Kihara, 1937 ; Sears, 1941). For crop improvement, the use of wild germplasm becomes necessary. Increasing attention has been given to the *Aegilops* spp. as it's the closest genus to *Triticum* spp. and it may provide better adaptation to local biotic and abiotic environment which has been developed over a long period of time. With the advanced biotechnological tools, new possibilities are arising to incorporate genetic material from wild gene pool into cultivated wheat cultivars.

The study aimed to describe the variation existing in a local wild collection of *Aegilops* spp. Using a multivariate analysis, we intended to examine the distribution of the morphological variation, assess the influence of geographic features of the collecting sites and determine the frequency of the valuable characteristics.

MATERIALS AND METHODS

All accessions used in this study were collected July 1994 and July 1995 during the exploration of the genus *Aegilops*. The major zones prospected were the Northern area of Rif mountains, the central plateaus of Saïs and Zaeir, the High and Middle Atlas mountains and the Western coastal area from South of Tanger to North of Agadir (Figure 1). A total of 200 sites were visited and 149 accessions collected. Most accessions were from sites whose altitude ranged mainly between 500 to 1700 m. The *Aegilops* species are very well spread in the Middle Atlas.

All the 149 accessions were grown in the field in 1996-1997 on a sandy soil. The experiment consisted of one randomized plot. Each accession was grown in a 50 cm row of three individual plants. The following characteristics were observed : plant density, plant spreading, heading date, flag leaf and second leaf length and width, glaucescence, red pigmentation, reaction to major diseases such virus, powdery mildew, rust and Hessian fly.

The principal components analysis was performed using adjusted values of the recorded data. This analysis allowed to test the significance of the morphological variations within and between species. It discriminates between traits, computes new clusters on the basis of the best probability and assess the appurtenance to a group and the influence of the species on the accession characteristics. The statistical program used for the analyses is the STATITICF.

RESULTS AND DISCUSSION

Aegilops are annual grasses usually growing in tufts. They are found in diverse habitats, on and around mountains, on the central plateau and along the coastal zones where water is not a limiting factor. Variation in the environment seemed to influence significantly plant development. The genus *Aegilops* seems to have preference for disturbed habitats and is frequently found along road sides, at the edges of cultivation, and as a weed (Van Slageren, 1995). They become rare to absent on arid and poor soil.

Four species all polyploids and probably only tetraploïds were found during the prospecting trip around the country. *Aegilops geniculata* is the most widespread species (115 acc.). It was found in most examined sites throughout *Aegilops* spp. distribution area. *Aegilops triuncialis* is also widespread but less than *Ae. geniculata*. *Aegilops triuncialis* (25 acc.) seemed to tolerate less marginal conditions. The two other species were rare and were found only on specific niches. *Aegilops ventricosa* (7 acc.) develops on intermediate to high elevation sites in protected and humid places. The taxa carrying D genome were reported to be better adapted to cold than most species. This genome is probably responsible also for the poor performance and resistance to rust infection observed in this species (Hammer, 1987). *Aegilops neglecta* (2 acc.) seems to prefer coastal zones and never grows in dense stands but rather in loosely dispersed population.

ABBREVIATIONS
VR = very resistant ; R = resistant ; MR = moderate resistant ; S = susceptible ; L = length ; D = diameter.

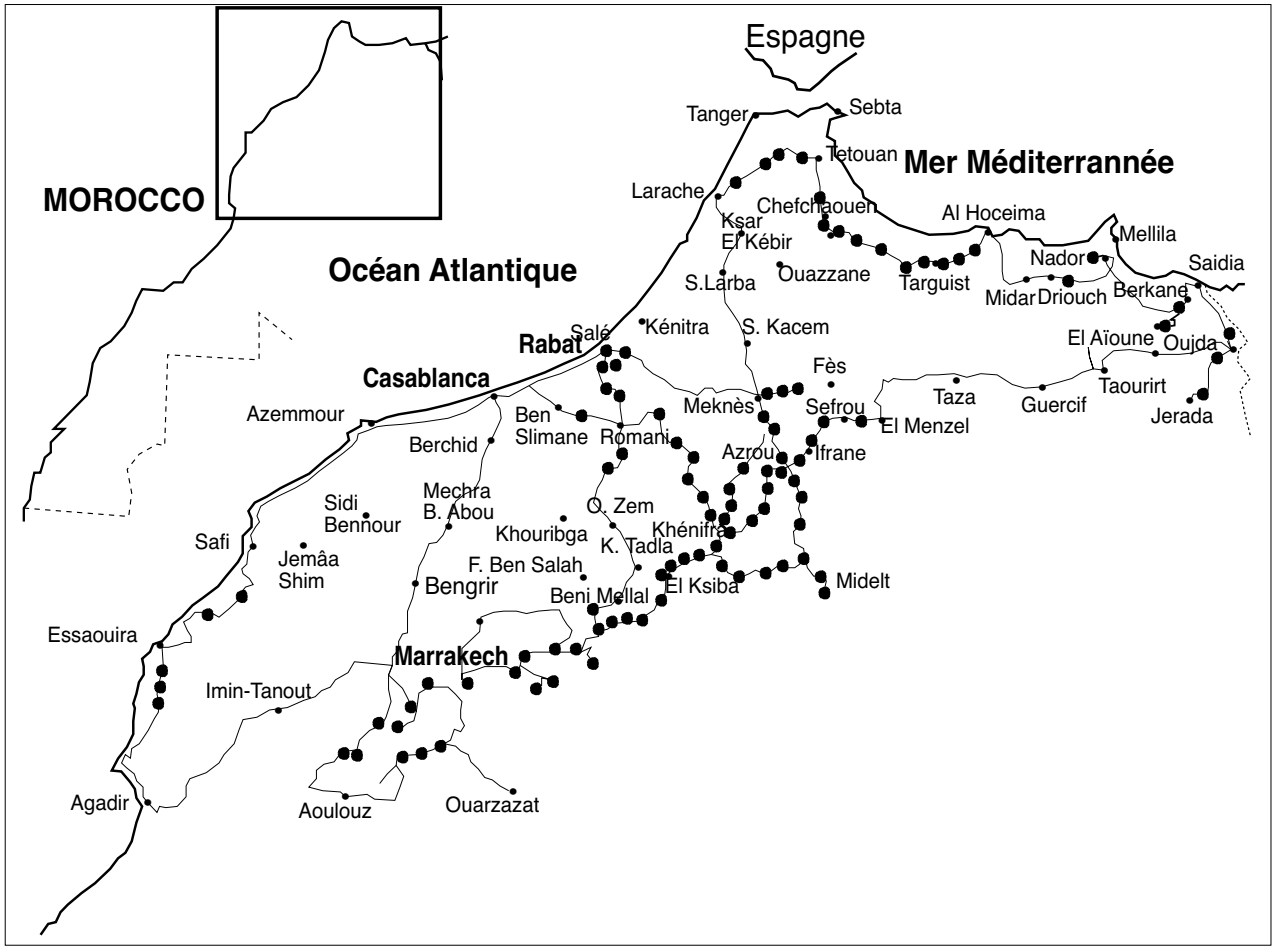

Figure 1. Mains areas prospected and collecting sites for *Aegilops* species (Benlhabib)

Data on morphological features recorded during the experiment were used to perform the Discriminating Factorial Analysis (DFA). This analysis is more adapted to quantitative traits. Qualitative data were adjusted in a way that they could be considered as quantitative. The values scored in percentage were transformed by Arc Sinus function to reduce the difference between individuals and stabilize the variance. The DFA analysis allow to differentiate between traits used in the evaluation, computed new homogeneous groups on the basis of the optimal probability. The first three main axes accounted for the total variation in the analysis (Pr.<5%). The first and second axes represented up to 87.2% of the variation (Table 1).

Table 1. Significance of the discriminating axis in the Factorial Discriminate Analysis

	Variation cum.	Ddl	Probability	Correlation
Axis 1	59.6	45	0.00	0.575
Axis 2	87.2	28	0.00	0.3847
Axis 3	100	13	0.08	0.2252

The correlation matrix showed that the best linkages were those between the length and the width of the flag and second leaves respectively (r = 0.616 and r = 0.403), the first leaf length and the second leaf width, the spreading of the plant and its density (r = 0.709) and also between leaf glaucescence and the susceptibility to the virus (r = 0.550).

The estimated values of the Mahalonobis distance showed that *Ae. geniculata* and *Ae. triuncialis* are the closest species (d = 1.7464). The *Ae. ventricosa* is located further from *Ae. geniculata* (d = 3.3838) but more further from *Ae. neglecta* (d = 5.3210). This is also in good concordance with DFA analysis, as showed clearly on figure 2.

The distribution of the accessions into the defined new groups showed that 86.6% of the entries were affected to their own species. Only 18 out of 149 were miss classified. Thirteen accessions from *Ae. geniculata* were put in *Ae. triuncialis* group.

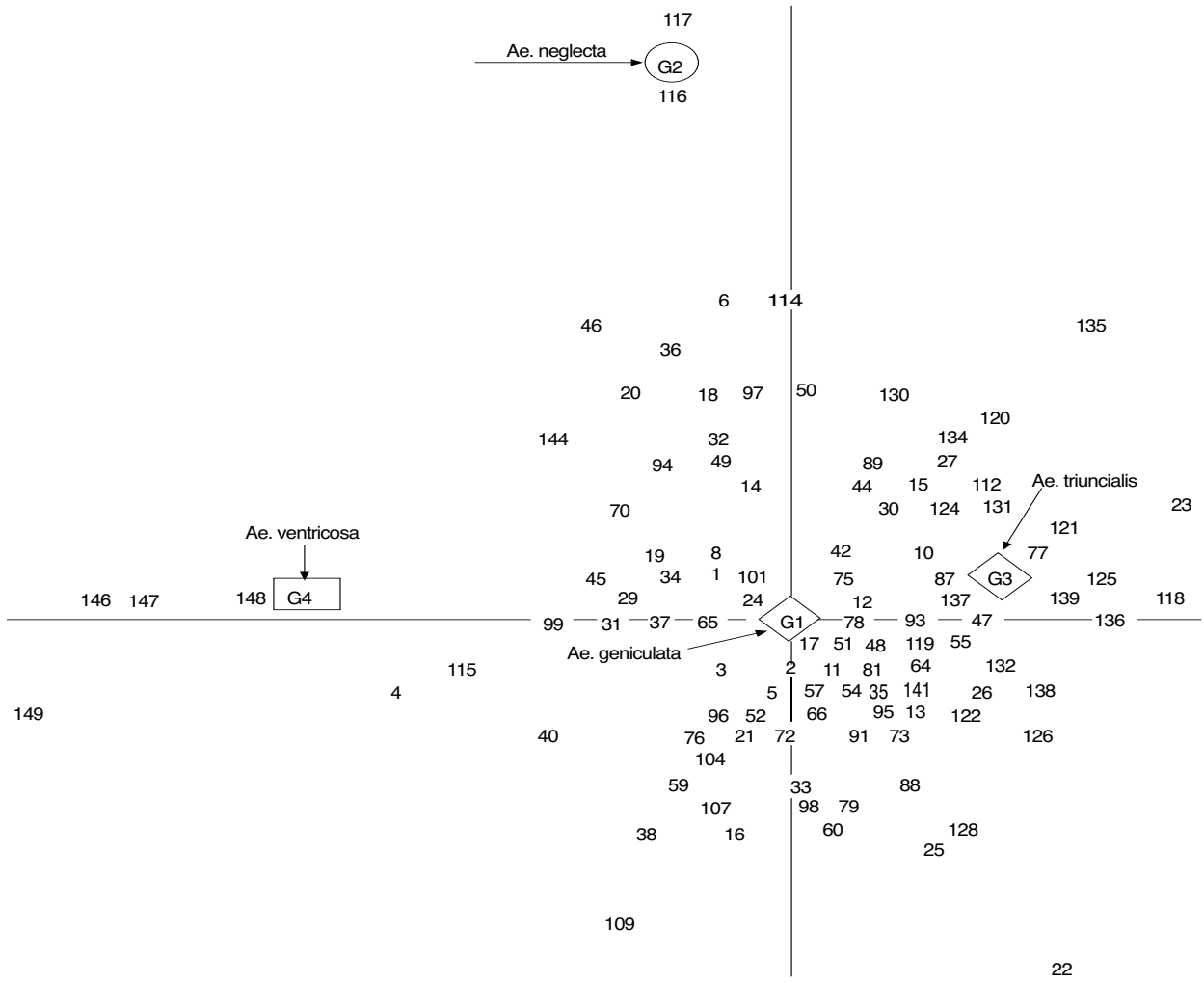

Figure 2. Accession and specy distribution according to factorial discrimination analisis, axes 1-3

This overlapping between these two species shows again their similarity as is proved by the Mahalonobis distance.

The morphological diversity of the local *Aegilops* germplasm was confirmed. The statistical analysis used demonstrates highly significant differences (Table 2).

The morphological features contribution to the total variation showed that all traits were significant. The plant spreading and density, the flag and 2nd leaf length and width, and the sensitivity to rust and Hessian fly were highly discriminating characters (Pr.<1%). Their variation coefficients were also significant.

The largest variation was that found in *Ae. geniculata* for earliness, plant spreading and density. This variation among accessions of this species could be explained by the eco-geographical

Table 2. Significance of the discriminating traits in the Factorial Discriminate Analysis

	Average	Residual variation	F	Probability value
Density	2.060	0.547	9.19	0.00
Days to flowering	181.470	181.340	5.95	0.08
Plant diameter	66.423	253.996	9.71	0.00
First leaf length	4.680	2.896	29.52	0.00
First leaf width	0.390	0.010	6.33	0.05
Second leaf length	6.464	5.707	21.55	0.00
Second leaf width	0.360	0.007	2.21	8.86
Glaucescence	1.611	0.383	5.07	0.24
Red pigmentation	1.550	0.363	5.79	0.10
Reaction to virus	1.396	0.430	4.14	0.77
Reaction to powdery mildew	5.550	3.728	5.92	0.09
Reaction to rust	2.208	4.127	7.12	0.02
Reaction to hessian fly	1.121	0.288	9.47	0.00

F = Fisher Snedecor value

diversity of the sites of origin as stated by Allard (1988). Morocco has very diversified climates as all the variants of the Mediterranean regime can be found (UNESCO-FAO, 1963).

On the first principal component, the accessions were distributed on the basis of their flag and second leaf size and also their susceptibility to Hessian fly. *Aegilops ventricosa* species was nicely differentiated from the others by this first axis (cos^2 = 0.8073). It was distinguished for its long leaves (L = 10.55 cm and L = 13.50 cm), its high tolerance to rust (85.7% VR and 14.3% R) and Hessian fly (85.7% R and 14.3% S), its moderate tolerance to the virus (42.8% R and 28.6% MR) and the absence of red pigment. Resistance to virus in this species was reported previously by Dhaliwal *et al.* (1993) and Zaharieva (1995).

Aegilops triuncialis which was projected on the positive side of the axis, is characterized by its short leaves (L = 4.108 and L = 5.712 cm), its resistance to virus (96% R), its tolerance to rust (32% VR and 32% R) and susceptibility to Hessian fly (88% S). One accession of *Ae. triuncialis* revealed resistant to BYDV in Makkouk *et al.* (1994) paper.

The 149 accessions were distributed on the axis 2 on the basis of their shoot spreading and their density. Most *Ae. geniculata* accessions have the smallest occupation in the space (D = 62.79 cm) and the lowest density (only 1.904 when the others have an index of 2.760).

The axis 3 is correlated to earliness and the resistance to powdery mildew. The *Aegilops neglecta* was the earliest with only 144 days to heading and 100% resistance to the powdery mildew. Both accessions of this later species were combining resistance to at least three different diseases.

The evaluation for disease resistance displayed the dominance of the *Ae. ventricosa* accessions which showed the highest frequencies for the four pathogens tested. *Aegilops triuncialis* is the poorest species. Most of its accessions were sensitive to at least three pathogens. Unfortunately, genetic transfer also seemed to be very difficult from *Ae. triuncialis* to cultivated wheat ; through all the crosses we made, we failed to develop interspecific hybrids. Genetic introgression of alien DNA was however possible with the other *Aegilops* species where hybrids were produced.

Because of our actual lack in applying advanced molecular techniques to introduce favorable genes directly into wheat genome, classical genetic transfer tool through interspecific hybridization will remains the major method for gene introgression. Natural alien species will also remain an universal genetic reservoir for the humanity that we have to be aware to preserve for the future generations.

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