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**PHENOLOGY AND MORPHO-PHYSIOLOGY OF OASIS
WHEAT (TRITICUM) AND POSSIBILITIES FOR THEIR
VALORIZATION AFTER CROSS BREEDING**

THESIS

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My father who inspired me to pursue this PhD. Career

My mother, the source of strength in the toughest moments

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ABBREVIATIONS LIST

PH :	Plant height
PL:	Peduncle length
AL:	Awns length
ED:	Ear density
Nb N:	Number of nods
NS:	Number of spikelets per spike
FLA:	Flag leaf area
HT:	Number of herbaceous tillers
ST:	Number of spike tillers
Nb G/S:	Number of grains per spike
Nb S/pot:	Number of spikes per pot
Nb S/m ² :	Number of spikes per m ²
Gr/plant:	Number of grains per plant
TGW:	Thousand grains weight
GY:	Grain yield
Chl:	Chlorophyll content
RWC:	Relative water content
MDA:	Malondialdehyde
AA:	Total amino acid content
EL:	Electrolyte leakage
H ₂ O ₂ :	Hydrogen peroxide
Pro:	Proline content
Sug:	Total soluble sugars content
Cart:	Catenoids content
Na ⁺ :	Sodium ions content
K ⁺ :	Potassium ions content
K ⁺ /Na ⁺ :	Selectivity of potassium ions over sodium ions
SFW:	Shoot fresh weight
RFW:	Root fresh weight
SDW:	Shoot dry weight
RDW:	Root dry weight

LIST OF ABBREVIATIONS

SL:	Shoot length
RL:	Root length
MFVS:	Membership function value of salt tolerance
STC:	Stress tolerance coefficient
H _{MP} :	Mid-parent heterosis
H _{BP} :	Better-parent heterosis
SCA:	Specific combining ability
GCA:	General combining ability
SGCA:	Sum of general combining ability
<i>Per se</i> :	Mean performance of parents
HYB:	Mean performance of hybrids
EC:	Electrical conductivity
LSD:	Least significant difference
DMSO:	Dimethyl sulfoxide
NaCl:	Sodium Chloride
TCA:	Trichloroacetic acid
TBA:	Thiobarbituric acid
KI:	Potassium iodide
SSA:	Sulfosalysilic acid
GAA	Glacia acetic acid
CRBD:	Complete randomized block design

Abstract

Wheat landraces sourced from Algerian Saharan oases constitute valuable genetic resources for breeding resilient genotypes in response to environmental stress and climate variability. This study aimed to assess the phenological, morpho-physiological, and agronomic characteristics of 10 Saharan oasis landraces. Furthermore, salt tolerance was evaluated using the membership function value for salt tolerance (MFVS) at 150 mM NaCl, incorporating physiological, agronomic, and biochemical markers. The selected landraces were subsequently integrated into a Line \times Tester mating design with other wheat varieties, with the landraces designated as testers and the varieties designated as lines.

The first experiment revealed substantial phenotypic diversity among the Saharan oasis wheat landraces, encompassing traits related to productivity, adaptation, and phenology. This diverse array of characteristics underscores the potential of these landraces as valuable genetic resources for breeding programs focused on creating segregating progenies with enriched genetic diversity and enhanced agronomic traits. The results of the second study identified Oum Rokba Elhamra, Khellouf, and Zeghlou landraces as the most tolerant, while Bourione was classified as the most sensitive one. The salt-tolerant and moderately tolerant wheat landraces maintained stable yields under saline stress conditions. Regression models revealed that for bread wheat, AA and GY accounted for most of the variation in MFVS, whereas for durum wheat, Gr.plant⁻¹ and Na⁺ explained the majority of the observed differences. The results of Line \times Tester analysis revealed existence F₁ hybrids crosses have tapped into a wider range of genetic diversity. Data demonstrated that H_B10 and H_D6 expressed the highest number of favorable heterosis. The analysis revealed that non-additive genetic effects played a dominant role in determining the inheritance patterns of all studied traits except in FLA and SL in bread wheat and FLA, PH, AL, HT, ST, and HD in durum wheat. Correlation analysis revealed that GCA values of parental lines and testers HYB can be more effectively predicted based on GCA of parental lines in almost all traits. Evaluating the effect of salinity of F₂ hybrids and their parents' performance and genetic parameters revealed that all the studied traits were governed by non-additive genes under control and stress conditions except Pro in durum wheat. Desirable heterotic effects for salt-related traits was registered in the two species where some appeared to be consistent under both conditions. In bread wheat, most 71% and 56% of hybrids with significant SCA were obtained from parents with different GCA status (poor \times good or good \times bad) under control and salinity conditions, respectively. For durum wheat, 65% were obtained from parents with different GCA status under control, while upon exposure to stress 75% of were derived from good \times good combiners or poor \times poor combiners.

Key words: Saharan oasis wheat, adaptation, production, salt tolerance, line \times tester, heterosis, general combining ability, specific combining ability.

Résumé

Les variétés locales de blé issues des oasis sahariennes Algériennes constituent des ressources génétiques précieuses pour la sélection de génotypes résilients face au stress environnemental et à la variabilité climatique. Cette étude est visée à évaluer les caractéristiques phénologiques, morpho-physiologiques et agronomiques de 10 variétés locales originaires des oasis Sahariennes. De plus, la tolérance au sel a été évaluée à l'aide de la valeur de fonction d'appartenance pour la tolérance au sel (MFVS) à 150 mM NaCl, en intégrant des marqueurs physiologiques, agronomiques et biochimiques. Les variétés locales sélectionnées ont ensuite été intégrées dans un schéma de croisement Ligne × Testeur impliquant des variétés commerciales et patrimoniales, les variétés locales étant désignées comme testeurs et les variétés commerciales comme lignées.

La première expérience a révélé une diversité phénotypique substantielle parmi les variétés locales de blé des oasis sahariennes, englobant des caractères liés à la productivité, à l'adaptation et à la phénologie. Cette diversité de caractéristiques souligne le potentiel de ces variétés locales en tant que ressources génétiques précieuses pour les programmes de sélection visant à créer des descendance ségrégantes avec une diversité génétique enrichie et des caractères agronomiques améliorés. Les résultats de la deuxième étude ont identifié les variétés locales Oum Rokba Elhamra, Khellouf et Zeghlou comme les plus tolérantes, tandis que Bourione a été classée comme la plus sensible. Les variétés locales de blé tolérantes et modérément tolérantes au stress salin ont maintenu des rendements stables dans des conditions de stress salin. Les modèles de régression ont révélé que pour le blé tendre, AA et GY expliquaient la majeure partie de la variation de MFVS, tandis que pour le blé dur, Gr. plant⁻¹ et Na⁺ expliquaient la majorité des différences observées. Les résultats de l'analyse Ligne × Testeur ont révélé l'existence d'hybrides F1 ayant exploité une plus grande diversité génétique. Les données ont démontré que H_B10 et H_B6 exprimaient le plus grand nombre d'hétérosis favorables. L'analyse a révélé que les effets génétiques non additifs jouaient un rôle dominant dans la détermination des modèles d'hérédité de tous les caractères étudiés, sauf pour FLA et SL chez le blé tendre et FLA, PH, AL, HT, ST et HD chez le blé dur. L'analyse de corrélation a révélé que les valeurs GCA des lignes parentales et des testeurs HYB peuvent être prédites plus efficacement sur la base de la GCA des lignes parentales pour presque tous les caractères. L'évaluation de l'effet de la salinité sur les performances des hybrides F₂ et de leurs parents et les paramètres génétiques a révélé que tous les caractères étudiés étaient gouvernés par des gènes non additifs dans des conditions de contrôle et de stress, sauf Pro chez le blé dur. Des effets hétérotiques souhaitables pour les caractères liés au sel ont été enregistrés chez les deux espèces, certains semblant être cohérents dans les deux conditions. Chez le blé tendre, la plupart des hybrides (71% et 56%) avec une SCA significative ont été obtenus à partir de parents avec différents statuts GCA (faible × bon ou bon × mauvais) dans des conditions de contrôle et de salinité, respectivement. Pour le blé dur, 65% ont été obtenus à partir de parents avec différents statuts GCA en condition de contrôle, tandis qu'en situation de stress, 75% provenaient de combineurs bon × bon ou faible × faible.

Mots clés : Blé oasiens, adaptation, production, stress salin, hétérosis, lignée × testeur, aptitude générale à la combinaison, aptitude spécifique à la combinaison

الملخص

تشكل سلالات القمح التي يعود أصلها لواحات الصحراء الجزائرية مورداً وراثياً قيماً لتحسين استجابة الأنماط الوراثية لإجهاد الوسط والاختلافات المناخية. تهدف هذه الدراسة إلى تقييم الخصائص الفينولوجية والمورفوفسيولوجية والزراعية لـ 10 سلالات محلية يعود أصلها إلى واحات الصحراء الجزائرية. بالإضافة إلى ذلك، تم تقييم تحمل الملوحة باستخدام تابع الانتماء لتحمل الملوحة (MFVS) عند 150 ملليمول من كلوريد الصوديوم، عن طريق دمج المؤشرات الفسيولوجية والزراعية والبيوكيميائية. لاحقاً، تم دمج سلالات الواحات المحلية المختارة في مخطط تهجين سلالة × فاحص مع أصناف محلية أخرى، حيث تم تعيين سلالات الواحات المحلية كفاحص والأصناف المحلية الأخرى كسلالة.

كشفت التجربة الأولى عن وجود تنوع ظاهري معنوي بين السلالات المحلية لقمح الواحات الصحراوية، بما في ذلك الصفات المتعلقة بالإنتاجية والتكيف والفينولوجيا. تشير هذه النتائج إلى إمكانية استغلال هذه السلالات المحلية كموارد وراثية قيمة لبرامج التحسين. حددت نتائج الدراسة الثانية السلالات أم ركبة الحمراء، خلوف وزغول كأكثر السلالات تحملاً للملوحة من بين السلالات المدروسة، بينما تم تصنيف بوربون كأكثر السلالات حساسية. حافظت السلالات المحلية المتحملة والمتحملة بشكل معتدل للملوحة على حاصل حبوب مستقر تحت ظروف الإجهاد الملحي. كشفت نماذج الانحدار أن معظم التباين الملاحظ في قيمة MFVS عائد إلى محتوى الأحماض الأمينية والمردود في القمح اللين، بينما في القمح الصلب، فسر كل من عدد الحبوب ومحتوى أيونات الصوديوم غالبية الاختلافات الملحوظة في قيمة MFVS.

كشفت نتائج التحليل الوراثي أن تصميم سلالة × فاحص نتج عنه هجن F₁ ذات نطاق واسع من التنوع الوراثي. أفادت البيانات أن الهجن 10H_B و 6H_B حصلاً على أعلى عددٍ من القيم المعنوية للتفوق الهجين المرغوب. أسفرت نتائج التحليل على أهمية الفعل الوراثي غير التراكمي في توريث جميع الصفات المدروسة باستثناء مساحة الورثة العلم وطول السنبل في القمح اللين ومساحة الورقة العلم، طول النبات، طول السفا، عدد الإشتاءات الخضرية والسنبلية، و عدد الأيام للإسبال في القمح الصلب. كشف تحليل الارتباط أن قيم القوة العامة للتوافق للسلالات الأبوية تعد وسيلة فعالة للتنبؤ بقيم HYB لمعظم الصفات تقريباً.

كشفت تقييم تأثير الملوحة على أداء هجن F₁ وأبائهم خلال مرحلة نمو البادرات أن توريث جميع الصفات كان محكوماً بالفعل اللاتراكمي تحت الظروف العادية والملوحة باستثناء صفة محتوى البرولين في هجن وآباء القمح الصلب. تم تسجيل تأثيرات تفوق هجين مرغوبة للصفات المتعلقة بالملوحة في النوعين حيث أظهرت بعض هذه التأثيرات ثباتاً في التعبير في وجود وفي غياب الملوحة. في القمح اللين، كانت معظم الهجن التي حصلت على قيم معنوية لقدرة التوافق الخاصة ناتجة عن آباء ذوي حالة مختلفة من قدرة التوافق العامة (جيد × سيء، سيء × سيء) بنسبة 71% و 56% تحت الظروف العادية وظروف الإجهاد، على التوالي. بينما في القمح الصلب، 65% من الهجن التي حصلت على قيم قدرة توافق خاصة معنوية كانت ناتجة عن آباء بحالة مماثلة لقدرة التوافق العامة تحت الظروف العادية، في حين أن التعرض للإجهاد الملحي أسفر على نسبة كبيرة من الهجن بقيم معنوية لقدرة التوافق الخاصة (75%) ناتجة عن آباء بحالة مختلفة لقدرة التوافق العامة (جيد × سيء، سيء × سيء).

الكلمات المفتاحية: قمح الواحات، الإنتاجية، التكيف، الإجهاد الملحي، سلالة × فاحص، قوة الهجين، القدرة العامة على التوافق، القدرة الخاصة على التوافق