

引进春小麦品种(系)萌发期耐盐性综合评价*

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摘要: 为科学评价引进春小麦品种(系)的抗盐性, 并为新疆春小麦抗旱品种的选育提供参考. 选择引自哈萨克斯坦的116份春小麦品种(系)作为材料, 设置去离子水对照(0% NaCl)、1%和2% NaCl溶液3个浓度处理, 探究引进春小麦品种(系)萌发期耐盐性. 测定不同盐胁迫下各材料的芽长、胚芽鞘长、根长、芽鲜重、芽干重、根鲜重和根干重等耐盐性指标, 计算耐盐性综合评价值(D值)并开展相关性分析、主成分分析和聚类分析. 结果表明: 不同品种(系)、不同生长部位对盐胁迫的敏感度存在差异, 2% NaCl溶液处理下所有材料均无法正常发芽, 1% NaCl溶液处理下对胚芽鞘生长影响较小, 对根和芽生长影响较大. 通过聚类分析将材料分为耐盐型、中间型和敏感型, 其中: Д Б Т-10 (CM1428)、Д 12 З р и т р о с п е р м н м (CM1429)的耐盐性综合评价值分别达到0.816和0.784, 耐盐性表现最优; 另外, К о л у м б и я (K-58014) (CM1352) 和 Л ю т е с ц е н с 2145-7-83 (CM1374) 2个品种的耐盐性综合评价值大于0.7, 为耐盐性品种的选育提供参考.

关键词: 春小麦; 萌发期; 耐盐性; 综合评价

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0 引言

土壤盐碱化作为全球性生态问题, 其危害主要源于易溶性盐分在土壤表层的累积过程. 这不仅直接抑制农作物根系吸收、光合作用等生理过程, 导致减产甚至绝收^[1-2], 还会影响植被生长, 破坏植被群落结构, 甚至可能造成生态环境恶化. 我国盐渍化土地资源约为3 666.7万公顷^[3], 其中具备农业生产改良潜力的面积接近666.7万公顷, 这些潜在可改良区域主要集中于我国西北地区. 近年来, 国内盐渍化耕地的空间分布呈现持续扩展趋势, 土壤盐碱化程度亦不断加剧. 在西北干旱-半干旱区域, 受灌溉管理不当和生态脆弱性等因素影响, 农田次生盐渍化现象正成为制约农业可持续发展的突出问题, 其影响范围与危害程度均呈显著增长态势. 新疆各种类型的盐渍化土壤总面积达1 336.1万公顷, 约占全国总盐渍化土壤面积的36%^[4], 因修复困难长期处于撂荒状态. 这种土地退化现象对区域可持续发展已构成重大挑战: 据生产调查统计, 轻度盐化土缺苗减产10%~20%, 中度盐化土缺苗减产20%~50%, 重度盐化土缺苗减产50%~80%^[5]. 小麦作为新疆主要粮食作物, 其2024年播种面积达117万公顷^[6], 在保障区域粮食安全中具有不可替代的地位. 因此, 改造现有盐碱耕地、多措并举防治耕地次生盐碱化, 同时培育优良抗逆品种以抵御新疆特殊盐碱环境, 对稳步拓展农业生产空间、提升耕地利用质量、保障多元化食物供给等具有重要战略意义. 前人研究指出, 作物萌发期、苗期是整个发育过程的基础阶段^[7-13], 极易遭受逆境胁迫伤害, 且逆境胁迫对这两个发育阶段的损伤具有不可逆性, 会通过影响根系构建和光合器官发育等关键过程, 最终显著降低作物产量^[14-16]. 基于此, 萌发期耐盐性鉴定已成为作物抗逆种质筛选的重要

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研究方向. 当前应对盐碱危害存在双重困境: 一方面, 土壤改良工程面临修复周期长、单位成本高等现实问题; 另一方面, 传统全生育期耐盐性鉴定存在周期长、环境干扰大、通量低等问题. 本研究基于新疆特殊生态背景, 遵循“以种适地”的治理策略: 通过设置去离子水对照组(0% NaCl)和1% NaCl溶液、2% NaCl溶液进行梯度胁迫模拟, 系统评估116份引进春小麦品种(系)萌发期的耐盐响应特征. 相较于传统方法, 萌发期耐盐性鉴定具有显著优势: 1) 试验周期明显缩短; 2) 单次处理样本量得以提升; 3) 环境变量可控性增强. 这种高效筛选模式为盐碱地适生品种选育提供了快捷的技术路径.

1 材料与方法

1.1 材料

选择引自哈萨克斯坦的116份春小麦种质资源为材料, 由国家中亚特色作物种质资源中期库提供, 于2022年4月进行萌发试验.

1.2 方法

1.2.1 试验设计

将待测种子样品充分混合后, 选择籽粒饱满、大小一致、完整无破损、无虫蛀的种子100粒, 分成2份, 每份50粒. 以4层滤纸为发芽床, 选用15 cm×15 cm×6 cm的发芽盒, 设置去离子水对照组和1% NaCl溶液、2% NaCl溶液, 每个处理重复3次. 2% NaCl溶液处理下所有材料均无法正常发芽, 故不进行讨论. 将装有种子的发芽盒放入培养箱中, 在20 °C、相对湿度(60±5)%、每天12 h光照(光照强度1 000 lx)的条件下培养. 第8天停止培养, 随机抽取10株幼苗, 测定芽长、根长、胚芽鞘长、芽鲜重、根鲜重、芽干重和根干重.

1.2.2 测定指标

- 1) 芽长. 芽顶部到种子的长度. 随机选取一个发芽盒中的10株幼苗测量芽长(精确到0.01 cm).
- 2) 胚芽鞘长. 胚芽鞘顶部到种子的长度. 随机选取一个发芽盒中10株幼苗测量胚芽鞘长(精确到0.01 cm).
- 3) 根长. 随机选取一个发芽盒中10株幼苗测量最长根的长度(精确到0.01 cm).
- 4) 芽鲜重. 随机选取一个发芽盒中10株幼苗的芽称重(精确到0.01 g).
- 5) 根鲜重. 随机选取一个发芽盒中10株幼苗的根(包括初生根和次生根)称重(精确到0.01 g).
- 6) 芽干重. 于烘箱中105 °C杀青0.5 h, 80 °C烘干48 h至恒重, 对芽称重(精确到0.001 g).
- 7) 根干重. 于烘箱中105 °C杀青0.5 h, 80 °C烘干48 h至恒重, 对根称重(精确到0.001 g).

1.3 数据处理

利用耐盐系数以及耐盐性综合评价 D 值对小麦品种的耐盐性进行评价, 计算方式为

$$\text{各指标的耐盐系数} = \frac{\text{盐处理下的测定值}}{\text{对照条件下的测定值}}, \quad (1)$$

$$U(X_i) = \frac{U(X_i - X_{\min})}{U(X_{\max} - X_{\min})}, \quad (2)$$

式中: U 为各指标的隶属函数值; X_i 为第 i 个品种的指标测定值; X_{\max} 和 X_{\min} 为参试品种某一指标的最大值和最小值. 记 W_i 为第 i 个公因子在所有公因子中的重要程度, 计算方式为

$$W_i = \frac{P_i}{\sum_{i=1}^n P_i}, \quad (3)$$

式中: P_i 为各品种第 i 个指标与耐盐系数间的相关系数, 表示各品种第 i 个公因子的贡献率. 记 D 为各材料在盐胁迫下利用综合指标评价所得的耐盐性综合评价值, 计算方式为

$$D = \sum_{i=1}^n [U(X_i) \times W_i], \quad (4)$$

D 值越大表示综合耐盐性越高.

基于Excel 2010和SPSS 19.0进行描述性统计分析、主成分分析和聚类分析, 使用GraphPad绘图.

2 结果与分析

2.1 盐胁迫下萌发指标

研究表明,在1% NaCl溶液处理下,对照组芽长为108.63~187.34 mm,平均145.06 mm;胁迫处理下的芽长为13.37~88.00 mm,平均56.78 mm,芽生长普遍受到抑制,其中CM1352、CM1356、CM1381、CM1382、CM1426、CM1428、CM1429、CM1445和CM1454芽长均在80 mm以上;对照组胚芽鞘长为22.13~41.76 mm,平均31.75 mm;胁迫处理下的胚芽鞘长为12.52~43.62 mm,平均31.29 mm,胚芽鞘生长受盐胁迫影响小;对照组根长为95.51~152.73 mm,平均123.19 mm,胁迫处理下根长为16.76~53.95 mm,平均34.60 mm,其中CM1327和CM1336根长下降幅度较大,受盐胁迫影响较大;对照组芽鲜重为0.52~1.30 g,平均0.91 g,胁迫处理下的芽鲜重为0.09~0.56 g,平均0.34 g,相比对照组明显受到抑制,其中CM1352、CM1357、CM1388、CM1428和CM1445约为0.5 g,高于其他品种;对照组根鲜重为0.17~1.01 g,平均0.63 g,胁迫下为0.12~0.62 g,平均0.33 g,其中CM1332、CM1349、CM1381和CM1427明显高于其他品种;对照组芽干重为0.08~0.14 g,平均0.11 g,胁迫处理为0.02~0.08 g,平均为0.06 g,其中CM1348、CM1352、C1355和CM1443约为0.08 g,明显高于其他品种;对照组根干重为0.05~0.20 g,平均0.08 g,胁迫处理下为0.02~0.08 g,平均0.05 g,其中CM1344最高。

在1% NaCl溶液处理下,各指标测量值总体上均呈下降趋势,相比对照组芽长下降了60.85%,胚芽鞘长下降了1.45%,根长下降了71.91%,芽鲜重下降了62.24%,根鲜重下降了47.62%,芽干重下降了44.93%,根干重下降了37.50%。不同指标对盐胁迫的敏感度不同:胚芽鞘生长受影响较小,根和芽生长受影响较大。详见表1。

表 1 1% NaCl胁迫下芽期耐盐性指标比较

处理	指标	芽长/mm	胚芽鞘长/mm	根长/mm	芽鲜重/g	根鲜重/g	芽干重/g	根干重/g
		SL	CL	RL	SFW	RFW	SDW	RDW
CK	MAX	187.34	41.76	152.73	1.30	1.01	0.14	0.20
	MIN	108.63	22.13	95.51	0.52	0.17	0.08	0.05
	MEAN	145.06	31.75	123.19	0.91	0.63	0.11	0.08
	SD	15.91	4.25	11.08	0.16	0.15	0.01	0.02
	CV/%	10.97	13.40	9.00	17.50	24.58	12.52	23.89
T	MAX	88.00	43.62	53.95	0.56	0.62	0.08	0.08
	MIN	13.37	12.52	16.76	0.09	0.12	0.02	0.02
	MEAN	56.78	31.29	34.60	0.34	0.33	0.06	0.05
	SD	18.51	6.45	7.37	0.10	0.09	0.01	0.01
	CV/%	32.60	20.62	21.29	28.78	27.00	24.75	21.76
T-CK ($T_{MEAN}-CK_{MEAN}$)		-88.28	-0.46	-88.59	-0.57	-0.30	-0.05	-0.03
$T_{MEAN}-CK_{MEAN}/\%$		60.85↓	1.45↓	71.91↓	62.24↓	47.62↓	44.93↓	37.50↓

2.2 不同指标耐盐系数比较

研究表明,在1% NaCl溶液处理下,参试材料芽长的耐盐系数为0.096~0.749,其中耐盐系数大于0.7的材料有2个,分别是CM1352和CM1429,耐盐系数小于0.6的材料有108个;参试材料胚芽鞘长的耐盐系数为0.402~1.501,其中耐盐系数大于1.0的材料有63个,耐盐系数为0.8~1.0的材料有30个;根长的耐盐系数为0.142~0.479,其中耐盐系数大于0.4的材料有6个,分别是CM1347、CM1427、CM1428、CM1429、CM1437和CM1443;芽鲜重的耐盐系数为0.102~0.979,其中耐盐系数大于0.7的材料有6个,分别是CM1426、CM1428、CM1429、CM1430、CM1433和CM1438,耐盐系数小于0.6的材料有106个;根鲜重的耐盐系数为0.223~1.663,其中大于1.0的材料有4个,分别是CM1398、CM1400、CM1440和CM1442,耐盐系数为0.6~1.0的材料有37个;芽干重的耐盐系数为0.164~1.024,其中耐盐系数大于0.8的材料有8个,分别是CM1346、CM1348、CM1355、CM1428、CM1429、CM1433、CM1443和CM1444,耐盐系数小于0.6的材料有68个;根干重的耐盐系数为0.328~1.224,耐盐系数大于1.0的材料有5个,分别是CM1319、CM1329、CM1350、CM1361和CM1441,耐盐系数小于0.6的材料有39个。详见表2。

表 2 不同指标耐盐系数

编号	芽长	胚芽 鞘长	根长	芽鲜重	根鲜重	芽干重	根干重	编号	芽长	胚芽 鞘长	根长	芽鲜重	根鲜重	芽干重	根干重
CM1319	0.345	0.991	0.213	0.426	0.762	0.573	1.212	CM1377	0.180	0.677	0.270	0.216	0.732	0.323	0.682
CM1320	0.198	1.012	0.225	0.288	0.311	0.369	0.929	CM1378	0.413	0.854	0.309	0.392	0.889	0.559	0.857
CM1321	0.412	1.130	0.252	0.454	0.641	0.488	0.932	CM1379	0.277	0.836	0.287	0.228	0.625	0.473	0.683
CM1322	0.162	1.020	0.242	0.151	0.811	0.330	0.919	CM1380	0.429	1.023	0.361	0.364	0.466	0.527	0.494
CM1323	0.363	1.069	0.278	0.357	0.591	0.440	0.554	CM1381	0.617	1.117	0.336	0.408	0.605	0.735	0.639
CM1324	0.357	1.064	0.213	0.365	0.546	0.517	0.806	CM1382	0.678	1.374	0.370	0.469	0.484	0.786	0.517
CM1325	0.422	0.954	0.199	0.518	0.513	0.505	0.852	CM1383	0.498	1.501	0.307	0.421	0.468	0.619	0.706
CM1326	0.161	0.645	0.149	0.207	0.577	0.276	0.632	CM1384	0.496	1.427	0.218	0.363	0.375	0.479	0.500
CM1327	0.181	0.761	0.173	0.240	0.815	0.286	0.706	CM1385	0.508	1.466	0.298	0.410	0.449	0.625	0.579
CM1328	0.131	0.529	0.169	0.162	0.742	0.208	0.797	CM1386	0.390	1.381	0.313	0.393	0.544	0.593	0.592
CM1329	0.177	0.774	0.255	0.246	0.767	0.469	1.224	CM1387	0.481	1.432	0.288	0.436	0.563	0.568	0.584
CM1330	0.118	0.483	0.205	0.145	0.598	0.179	0.625	CM1388	0.329	1.208	0.273	0.533	0.398	0.534	0.688
CM1331	0.096	0.402	0.142	0.102	0.521	0.164	0.845	CM1389	0.495	1.247	0.380	0.315	0.773	0.630	0.861
CM1332	0.339	0.860	0.290	0.291	0.612	0.407	0.761	CM1390	0.363	1.415	0.250	0.432	0.374	0.496	0.605
CM1333	0.135	0.456	0.235	0.162	0.577	0.216	0.967	CM1391	0.422	1.313	0.247	0.371	0.505	0.621	0.632
CM1334	0.169	0.607	0.148	0.219	0.462	0.306	0.800	CM1392	0.300	1.020	0.241	0.260	0.257	0.523	0.638
CM1335	0.237	0.881	0.208	0.305	0.536	0.450	0.891	CM1393	0.477	1.199	0.270	0.330	0.442	0.547	0.719
CM1336	0.320	0.902	0.208	0.362	0.601	0.449	0.671	CM1394	0.352	1.255	0.246	0.380	0.346	0.533	0.534
CM1337	0.212	0.931	0.179	0.249	0.342	0.375	0.855	CM1395	0.458	1.350	0.291	0.374	0.396	0.617	0.722
CM1338	0.234	0.938	0.196	0.266	0.437	0.370	0.855	CM1396	0.484	1.449	0.313	0.344	0.546	0.596	0.328
CM1339	0.260	0.735	0.182	0.222	0.503	0.354	0.867	CM1397	0.369	1.088	0.270	0.301	0.412	0.438	0.587
CM1340	0.171	0.856	0.182	0.286	0.465	0.386	0.902	CM1398	0.330	1.246	0.270	0.425	1.663	0.500	0.551
CM1341	0.258	0.908	0.233	0.242	0.318	0.325	0.901	CM1399	0.398	1.326	0.294	0.365	0.699	0.472	0.560
CM1342	0.121	0.510	0.203	0.136	0.360	0.265	0.708	CM1400	0.320	1.273	0.216	0.366	1.011	0.386	0.606
CM1343	0.142	0.480	0.163	0.165	0.299	0.314	0.878	CM1422	0.495	1.129	0.279	0.479	0.634	0.656	0.500
CM1344	0.263	0.989	0.177	0.259	0.321	0.372	0.762	CM1423	0.493	1.045	0.236	0.294	0.373	0.698	0.600
CM1345	0.494	1.140	0.286	0.432	0.439	0.565	0.809	CM1424	0.524	1.060	0.330	0.581	0.773	0.653	0.696
CM1346	0.636	0.997	0.376	0.529	0.906	0.821	0.921	CM1425	0.609	1.141	0.315	0.598	0.397	0.641	0.458
CM1347	0.511	1.057	0.438	0.518	0.893	0.727	0.750	CM1426	0.544	1.159	0.343	0.851	0.534	0.697	0.452
CM1348	0.552	1.037	0.330	0.652	0.731	0.853	0.797	CM1427	0.533	0.997	0.409	0.554	0.690	0.697	0.591
CM1349	0.538	1.135	0.301	0.526	0.707	0.793	0.757	CM1428	0.662	1.176	0.479	0.979	0.642	0.865	0.615
CM1350	0.509	1.069	0.286	0.463	0.577	0.660	1.063	CM1429	0.738	1.152	0.467	0.827	0.728	0.853	0.754
CM1351	0.499	0.690	0.246	0.521	0.591	0.740	0.701	CM1430	0.623	1.191	0.361	0.709	0.501	0.792	0.507
CM1352	0.749	1.308	0.370	0.653	0.673	0.774	0.343	CM1431	0.529	0.872	0.312	0.678	0.546	0.682	0.400
CM1353	0.453	1.004	0.389	0.452	0.695	0.714	0.936	CM1432	0.548	1.255	0.337	0.541	0.472	0.653	0.435
CM1354	0.442	0.966	0.321	0.518	0.552	0.595	0.617	CM1433	0.510	1.048	0.315	0.703	0.579	0.829	0.485
CM1355	0.510	1.013	0.359	0.601	0.638	0.816	0.824	CM1434	0.467	1.226	0.342	0.399	0.503	0.598	0.479
CM1356	0.549	0.917	0.345	0.588	0.499	0.718	0.788	CM1437	0.563	1.162	0.431	0.433	0.498	0.652	0.512
CM1357	0.499	0.982	0.281	0.580	0.661	0.653	0.746	CM1438	0.525	1.150	0.321	0.725	0.612	0.713	0.532
CM1358	0.407	0.996	0.331	0.441	0.618	0.607	0.538	CM1439	0.405	1.038	0.228	0.312	0.632	0.603	0.716
CM1359	0.253	0.950	0.239	0.361	0.464	0.505	0.759	CM1440	0.434	1.128	0.260	0.487	1.047	0.477	0.640
CM1360	0.300	0.790	0.248	0.297	0.518	0.466	0.563	CM1441	0.470	1.029	0.293	0.344	0.326	0.650	1.047
CM1361	0.219	0.715	0.225	0.255	0.656	0.420	1.163	CM1442	0.371	1.055	0.327	0.449	1.428	0.635	0.704
CM1362	0.170	0.652	0.191	0.224	0.399	0.370	0.542	CM1443	0.487	1.101	0.403	0.353	0.616	1.024	0.530
CM1363	0.322	0.817	0.276	0.257	0.420	0.446	0.768	CM1444	0.464	1.168	0.351	0.427	0.406	0.908	0.648

续表 2

编号	芽长	胚芽鞘长	根长	芽鲜重	根鲜重	芽干重	根干重	编号	芽长	胚芽鞘长	根长	芽鲜重	根鲜重	芽干重	根干重
CM1364	0.348	0.872	0.276	0.339	0.377	0.567	0.696	CM1445	0.509	1.080	0.343	0.584	0.612	0.605	0.564
CM1365	0.460	0.802	0.294	0.517	0.628	0.755	0.903	CM1446	0.342	0.871	0.360	0.351	0.231	0.676	0.877
CM1366	0.326	0.811	0.291	0.331	0.412	0.492	0.549	CM1447	0.472	0.977	0.376	0.328	0.223	0.570	0.721
CM1367	0.247	0.750	0.282	0.264	0.323	0.367	0.533	CM1448	0.361	1.027	0.320	0.419	0.557	0.512	0.592
CM1368	0.377	0.675	0.202	0.340	0.390	0.643	0.500	CM1449	0.414	1.168	0.355	0.322	0.838	0.570	0.544
CM1369	0.375	0.880	0.320	0.353	0.329	0.464	0.913	CM1451	0.417	1.109	0.285	0.226	0.241	0.603	0.817
CM1370	0.386	0.767	0.260	0.284	0.305	0.536	0.582	CM1452	0.510	1.059	0.300	0.357	0.515	0.615	0.679
CM1371	0.394	0.849	0.282	0.352	0.460	0.621	0.754	CM1453	0.461	1.174	0.357	0.384	0.724	0.546	0.535
CM1372	0.365	0.763	0.239	0.317	0.305	0.592	0.864	CM1454	0.564	1.222	0.269	0.430	0.505	0.742	0.709
CM1373	0.305	0.709	0.245	0.325	0.510	0.500	0.833	CM1455	0.484	1.160	0.332	0.328	0.305	0.686	0.747
CM1374	0.370	0.774	0.312	0.469	0.561	0.508	0.842	CM1456	0.460	1.061	0.283	0.468	0.432	0.612	0.531
CM1375	0.286	0.708	0.256	0.278	0.534	0.457	0.722	CM1457	0.369	0.893	0.246	0.280	0.488	0.492	0.462
CM1376	0.357	1.048	0.275	0.353	0.493	0.500	0.845	CM1458	0.433	0.977	0.348	0.394	0.644	0.551	0.552

2.3 小麦萌发期耐盐系数的相关性分析

为探究小麦芽期各表型指标耐盐系数间的关系,对小麦芽期各表型指标耐盐系数进行了相关性分析,详见表3。除根鲜重与根干重外,其余各表型指标的耐盐系数两两之间均互为极显著正相关;根干重除与根鲜重耐盐系数相关性不显著外,与其余指标均存在显著或极显著负相关;根鲜重耐盐系数与各指标相关性均不显著。

表 3 萌发期耐盐系数的相关性分析

	芽长 SL	胚芽鞘长 CL	根长 RL	芽鲜重 SFW	根鲜重 RFW	芽干重 SDW	根干重 RDW
芽长SL	1						
胚芽鞘长CL	0.647**	1					
根长RL	0.767**	0.476**	1				
芽鲜重SFW	0.797**	0.474**	0.653**	1			
根鲜重RFW	0.056	0.032	-0.023	0.167	1		
芽干重SDW	0.874**	0.538**	0.750**	0.748**	0.140	1	
根干重RDW	-0.367**	-0.382**	-0.280**	-0.292**	0.080	-0.228*	1

注:*表示在0.05水平显著相关,**表示在0.01水平极显著相关

2.4 小麦芽期耐盐性的综合性评价

对参试材料芽期各指标的耐盐系数进行主成分分析,选择2个独立的主成分作为耐盐鉴定综合指标,详见表4。第1主成分中起主要作用的指标是:芽长(0.935)、芽鲜重(0.854)、根长(0.837),第2主成分中起主要作用的指标是:根鲜重(0.706)。

采用主成分分析得到的因子得分值作为鉴定小麦芽期和苗期耐盐性的综合指标,通过计算各指标的隶属函数值和权重值,最终得出116个小麦品种在芽期的综合评价D值,即各品种的综合耐盐能力,详见表5。供试小麦材料萌发期耐盐性综合评价D值的变化范围为0.047~0.816,其中CM1428(Д Б Т-10)的耐盐性最强,CM1331(Б К-143-85)耐盐性最弱。

对D值采用平方欧氏距离进行系统聚类分析(图1),将品种分为3个不同耐盐类型,分别为耐盐型、中间型和敏感型。其中:耐盐型占品种总数的56.90%(66个),D值范围为0.310~0.820;中间型占品种总数的29.31%(34个),D值范围为0.130~0.700;敏感型占品种总数的13.79%(16个),D值范围为0.050~0.260。

表 4 供试材料芽期各指标主成分分析

项目	主成分	
	PC1	PC2
芽长	0.935	0.021
胚芽鞘长	0.732	-0.213
根长	0.837	0.028
芽鲜重	0.854	0.200
根鲜重	0.070	0.706
芽干重	0.402	0.434
根干重	-0.492	0.574
特征值	3.249	1.102
贡献率/%	46.417	15.750
累积贡献率/%	46.417	62.167

表 5 供试材料耐盐性的综合评价(D值)

编号	D值	排序	编号	D值	排序	编号	D值	排序
CM1319	0.348	78	CM1358	0.460	46	CM1397	0.360	75
CM1320	0.246	96	CM1359	0.309	85	CM1398	0.467	41
CM1321	0.413	64	CM1360	0.300	90	CM1399	0.444	54
CM1322	0.228	102	CM1361	0.223	103	CM1400	0.377	70
CM1323	0.387	69	CM1362	0.180	107	CM1422	0.489	38
CM1324	0.343	80	CM1363	0.301	89	CM1423	0.387	67
CM1325	0.607	8	CM1364	0.348	77	CM1424	0.549	20
CM1326	0.147	108	CM1365	0.454	50	CM1425	0.569	16
CM1327	0.198	106	CM1366	0.343	79	CM1426	0.652	6
CM1328	0.120	112	CM1367	0.275	94	CM1427	0.585	12
CM1329	0.237	99	CM1368	0.306	86	CM1428	0.816	1
CM1330	0.124	111	CM1369	0.368	73	CM1429	0.784	2
CM1331	0.047	116	CM1370	0.321	83	CM1430	0.652	5
CM1332	0.335	81	CM1371	0.372	71	CM1431	0.550	19
CM1333	0.094	115	CM1372	0.305	87	CM1432	0.564	17
CM1334	0.137	109	CM1373	0.292	92	CM1433	0.580	15
CM1335	0.258	95	CM1374	0.713	3	CM1434	0.494	35
CM1336	0.313	84	CM1375	0.280	93	CM1437	0.580	14
CM1337	0.209	104	CM1376	0.368	72	CM1438	0.597	9
CM1338	0.236	100	CM1377	0.237	98	CM1439	0.362	74
CM1339	0.132	110	CM1378	0.418	62	CM1440	0.463	43
CM1340	0.206	105	CM1379	0.302	88	CM1441	0.404	65
CM1341	0.243	97	CM1380	0.454	49	CM1442	0.491	37
CM1342	0.116	113	CM1381	0.536	24	CM1443	0.542	22
CM1343	0.098	114	CM1382	0.622	7	CM1444	0.510	27
CM1344	0.235	101	CM1383	0.511	26	CM1445	0.548	21
CM1345	0.453	51	CM1384	0.427	58	CM1446	0.391	66
CM1346	0.597	11	CM1385	0.506	29	CM1447	0.443	55
CM1347	0.597	10	CM1386	0.466	42	CM1448	0.426	59
CM1348	0.583	13	CM1387	0.497	32	CM1449	0.468	40
CM1349	0.532	25	CM1388	0.431	57	CM1451	0.358	76
CM1350	0.462	44	CM1389	0.503	30	CM1452	0.447	53

续表 5

编号	D值	排序	编号	D值	排序	编号	D值	排序
CM1351	0.432	56	CM1390	0.421	61	CM1453	0.496	34
CM1352	0.705	4	CM1391	0.422	60	CM1454	0.492	36
CM1353	0.509	28	CM1392	0.299	91	CM1455	0.452	52
CM1354	0.478	39	CM1393	0.417	63	CM1456	0.456	47
CM1355	0.561	18	CM1394	0.387	68	CM1457	0.331	82
CM1356	0.539	23	CM1395	0.455	48	CM1458	0.460	45
CM1357	0.497	33	CM1396	0.498	31			

3 讨论

萌发期是小麦发育的起始阶段,该时期耐盐性强弱是决定小麦能否在盐碱地出苗的关键^[17-18],小麦耐盐性属于多基因控制的数量性状,是遗传性和环境条件共同作用的结果^[19].本研究采用1% NaCl溶液对引进的116份春小麦品种(系)资源进行芽期耐盐性鉴定评价,结果表明盐胁迫下胚芽鞘长与根长和芽长呈极显著正相关($P<0.01$),鉴于此,盐胁迫对小麦胚芽鞘的影响可作为筛选耐盐品种的指标,该研究结果与王芳等^[20]的研究结果一致.本研究中小麦根系对盐胁迫的敏感性高于胚芽,与前人研究结果^[21-22]不同,前人试验NaCl溶液浓度均为200 mmol·L⁻¹,敏感度较高,浓度较大可能会造成结果不同.此外,本试验所使用的国外引进品种与国内品种存在差异也会造成结果不同.胡润慧等^[23]研究表明盐与干旱同时胁迫处理

下的小麦幼苗地上部干重下降幅度较大,与本研究结果存在部分相似.朱建峰等^[24]认为耐盐性强弱与干物质积累有关,耐盐性高的品种干物质积累量与对照的差异不明显,而耐盐性较弱的品种与对照的差异达到了显著或极显著水平.有研究表明小麦生长各个阶段的耐盐性表现不完全一致^[25],故本试验小麦芽期耐盐性还需要通过田间试验进一步验证.

利用多元分析综合评价作物的抗逆性,可以弥补单一指标评价作物耐盐性的片面性,从而提高评价的准确性^[26].采用隶属函数法综合多个指标得到D值,进而依据D值对供试品种抗逆性进行排序^[27].库尼都孜阿依·吐尔汗等^[28]利用此方法对新疆冬小麦品种(系)进行聚类分析,按耐盐性强弱分为高耐型(6个)、耐盐型(15个)、中耐型(16个)、敏感型(18个)和高敏感型(21个)5类.彭智等^[29]计算各相关性状的隶属函数值、权重值和耐盐综合评价D值,将321份材料的耐盐性分为高耐、耐盐、中耐、敏感和高感等类型,筛选出芽期高耐盐材料21份,苗期高耐盐材料18份.吴秀宁等^[30]利用隶属函数法对黑小麦品种耐盐性进行聚类分析并综合评价,将7份黑小麦品种的耐盐性分为高耐盐型、中等耐盐型和弱耐盐型3类.张鸿等^[31]对177份春小麦进行了芽期和苗期的耐盐性鉴定,将供试材料分为3类,芽期和苗期耐盐性均较好的品种有30份,芽期或苗期耐盐性较好的品种46份,芽期与苗期耐盐性都敏感的品种101份.刘彤彤等^[32]对山西省各麦区主推的40个小麦品种进行芽期和苗期的耐盐性鉴定,筛选出在两个时期都属于耐盐型品种5个,都属于中间型品种8个,都属于敏感型品种2个.陈春舟等^[33]对16份小麦材料进行苗期抗旱性和耐盐性的鉴定结果分为2类,筛选出3个耐盐抗旱品种、3个敏感型品种.李凤勤^[34]将205份小麦品种划分成了4类;王维^[35]将157份小麦资源分成5类.本研究基于D值和聚类分析将引进的116份春小麦材料分为3类:耐盐型材料66份,其中D值超过0.7的品种3个,分别为CM1352、CM1428、CM1429;中间型材料34份,其中D值超过0.45的品种4个,分别是CM1374、CM1380、CM1398、CM1442;敏感型材料16份,其中D值小于0.1的品种3个,分别是CM1322、CM1331、CM1333.

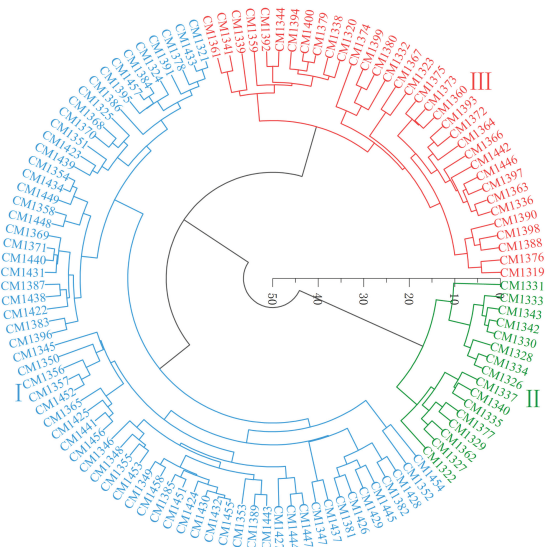


图1 引进春小麦资源D值聚类分析结果

4 结论

在盐胁迫条件下,引进116份春小麦资源的芽长、胚芽鞘长、根长、芽鲜重、根鲜重、芽干重和根干重的测量值均有不同程度的下降,芽长和根长均受盐胁迫影响较大,其中:Д Б Т-10 (CM1428)、Д 12 З р и т р о с п е р м н м (CM1429) 2个品种耐盐性最好,萌发期耐盐性综合评价 D 值分别为0.816和0.784;另外,К о л у м б и я (К-58014) (CM1352)、Л ю т е с ц е н с 2145-7-83 (CM1374) 耐盐性综合评价 D 值超过0.7. 这些材料可为耐盐性品种的选育提供参考.

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Comprehensive Evaluation of Salinity Tolerance in Introduced Spring Wheat Varieties (Lines) Genotypes at Germination

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Abstract: The purpose of this study is to scientifically evaluate the salt resistance of imported spring wheat varieties (lines) from Kazakhstan, and to offer references for the breeding of drought-resistant spring wheat varieties in Xinjiang. 116 spring wheat varieties introduced from Kazakhstan are selected as materials, 0% (deionized water control), 1%, and 2% NaCl solution are used as stress treatment to explore the differences in shoot length, coleoptile length, root length, fresh weight, dry weight, root dry weight, bud dry weight of introduced spring wheat varieties under salt stress during the bud stage, and conduct correlation analysis, principal component analysis, and cluster analysis on the comprehensive evaluation values (*D*-values) of salt tolerance of these indicators. The results show that different traits have different sensitivities to salt stress, with growth of coleoptiles is less affected than other characters, under treatment with 2% NaCl, none of the materials exhibits normal germination, treatment with 1% NaCl has a relatively minor effect on coleoptile growth, roots and buds are more affected than other characters. The salt-tolerance of materials can be divided into salt tolerance type, medium type, and sensitivity type through cluster analysis. Д Б Т-10 (CM1428) and Д 12 З р и т р о с п е р м н м (CM1429) have best salt tolerance, with *D*-values of 0.816 and 0.784. The salt tolerance coefficients of К о л у м б и я (K-58014) (CM1352) and Л ю т е с ц е н с 2145-7-83 (CM1374) exceeding 0.7. The materials provide a reference for the cultivation of salt-alkali tolerant varieties.

Key words: spring wheat; germination period; salt tolerance; integrated evaluation

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سىرتتىن كىرگۈزۈلگەن يازغى بۇغداي سورتلىرىنىڭ بىخلىنىش مەزگىلىدىكى شورغا چىدامچانلىقىنى ئۇنىۋېرسال باھالاش

لى شۆرۈي¹، شياۋ جىڭ¹، شۈ لې²، ۋاڭ لې²، ما يەنمىڭ¹

1. شىنجاڭ ئۇيغۇر ئاپتونوم رايونلۇق يېزا ئىگىلىك پەنلەر ئاكادېمىيەسى زىرائەت تەتقىقات ئورنى / دۆلەتلىك ئوتتۇرا ئاسىيا خاس زىرائەت ئۇرۇق پىلازمىسى بايلىقى ئوتتۇرا مەزگىللىك ئامبىرى، ئۈرۈمچى 830091؛ 2. شىنجاڭ ئۇيغۇر ئاپتونوم رايونلۇق يېزا ئىگىلىك پەنلەر ئاكادېمىيەسى، ئۈرۈمچى 830091

1. مەقسەت

جۇڭگو شىنجاڭدىكى شورلاشقان ئېتىز كۆلىمى پۈتۈن دۆلىتىمىزدىكى كۆلەمنىڭ %36.8 نى ئىگىلەيدۇ. يازغى بۇغداي شىنجاڭدىكى ئاساسلىق ئاشلىق زىرائەتى بولغاچقا، شورغا چىداملىق يازغى بۇغداي سورتىنى يېتىشتۈرۈش ئاشلىق بىخەتەرلىكىگە كاپالەتلىك قىلىشتا مۇھىم ئەھمىيەتكە ئىگە. بۇ ماقالىدە، سىرتتىن كىرگۈزۈلگەن يازغى بۇغداي سورتلىرىنىڭ شورغا چىدامچانلىقىنى باھالاش، شۇنداقلا شىنجاڭدا شورغا چىداملىق يازغى بۇغداي سورتلىرىنى تاللاپ يېتىشتۈرۈشنى ئىلمىي ئاساس بىلەن تەمىنلەش مەقسەت قىلىندى.

2. ماتېرىيال ۋە ئۇسۇل

ماتېرىيال: قازاقىستاندىن كىرگۈزۈلگەن 116 خىل يازغى بۇغداي سورتى (دۆلەتلىك ئوتتۇرا ئاسىيا ئالا - ھىدە زىرائەتلەر سورت بايلىقى ئوتتۇرا مەزگىللىك ئامبىرى تەمىنلىگەن) تاللىنىپ، 2022 - يىلى 4 - ئايدا بىخلىنىدۇرۇش سىنىقى ئىشلەندى.

تەجرىبە لايىھەسى: توقلۇق دەرىجىسى بىردەك بولغان 50 دانە ئۇرۇق بىر گۇرۇپپا قىلىندى، تۆت قەۋەتلىك سۈزگۈچ قەغەز دە بىخلىنىدۇرۇش كاندۇكى ياسىلىپ، بىخلىنىدۇرۇش ساندۇقىغا سېلىندى. سېلىشتۇرما گۇرۇپپا (%0 لىك NaCl ئېرىتمىسى)، %1 لىك NaCl ئېرىتمىسى گۇرۇپپىسى، %2 لىك NaCl ئېرىتمىسى گۇرۇپپىسى - سىدىن ئىبارەت ئۈچ خىل بىر تەرەپ قىلىش گۇرۇپپىسى ئورۇنلاشتۇرۇلدى، ھەر بىر خىل بىر تەرەپ قىلىش ئۈچ قېتىم تەكرارلاندى. مايسا تېمپېراتۇرىسى 20°C ، نىسپىي نەملىكى $(5 \pm 60)\%$ ، كۈندىلىك يورۇتۇش ۋاقتى 12 سائەت (يورۇقلۇق كۈچىنىشى 1000 lx) بولغان ئۆستۈرۈش ساندۇقىدا يېتىشتۈرۈلۈپ، 8 - كۈنى يېتىشتۈرۈش توختىتىلدى.

ئۆلچىمىدىغان كۆرسەتكۈچلەر: ئىختىيارى ھالدا 10 تۈپ يۇمران مايسا تاللىنىپ، بىخ ئۇزۇنلۇقى، تۆرەلمە بىخ غىلاپىنىڭ ئۇزۇنلۇقى، يىلتىز ئۇزۇنلۇقى، بىخنىڭ ھۆل ئېغىرلىقى، بىخنىڭ قۇرۇق ئېغىرلىقى (80°C تا قۇرۇتۇلغان تۇراقلىق ئېغىرلىقى)، قۇرۇق يىلتىز ئېغىرلىقى (0°C تا قۇرۇتۇلغان تۇراقلىق ئېغىرلىقى) قاتار - لىق يەتتە خىل كۆرسەتكۈچ ئۆلچەندى.

3. نەتىجە

%2 لىك NaCl دا بىر تەرەپ قىلغاندا بارلىق سورتلار نورمال بىخلىنالمىدى؛ %1 لىك NaCl دا بىر تەرەپ

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قىلغاندا ئۆلچەنگەن قىممەتلەردە تۆۋەنلەش كۆرۈلدى، بۇنىڭ ئىچىدە بىخنىڭ ئۆسۈشى %60.85، يىلتىزنىڭ ئۆسۈشى %71.91 تۆۋەنلىگەن بولۇپ، نىسبەتەن چوڭ تەسىرگە ئۇچرىغان، تۆرەلمە بىخ غىلاپىنىڭ ئۆسۈشى پەقەتلا %1.45 تۆۋەنلىگەن بولۇپ، نىسبەتەن ئاز تەسىرگە ئۇچرىغان. قىسمەن سورتلار (مەسىلەن: CM1428، CM1429 قاتارلىقلار) %1 لىك NaCl دا بىر تەرەپ قىلغاندا يەنىلا نىسبەتەن يۇقىرى كۆرسەتكۈچ قىممىتىنى ساقلىغان (بىخ ئۇزۇنلۇقى 80 mm دىن يۇقىرى، بىخنىڭ ھۆل ئېغىرلىقى 0.5 گىرام ئەتراپىدا).

%1 لىك NaCl دا بىر تەرەپ قىلغاندا، بىخ ئۇزۇنلۇقىنىڭ شورغا چىدامچانلىق كۆرسەتكۈچى 0.7 دىن يۇقىرى. سورت CM1428 ۋە CM1429 دىن ئىبارەت ئىككىلا خىل؛ تۆرەلمە بىخ غىلاپى ئۇزۇنلۇقىنىڭ شورغا چىدامچانلىق كۆرسەتكۈچى 1 دىن يۇقىرى سورت 63 خىل؛ يىلتىزنىڭ ھۆل ئېغىرلىقى ۋە قۇرۇق ئېغىرلىقىدىن باشقا ئالامەتلەرنىڭ شورغا چىدامچانلىق كۆرسەتكۈچى كۆپىنچە روشەن ئاكتىپ باغلىنىشچانلىقىنى ئىپادىلىدى.

ئاساسلىق تەركىبلەرنى ئانالىز قىلىشتا ئىككى خىل ئاساسىي تەركىب ئېلىندى (بىرىنچى ئاساسىي تەركىب بىخ ئۇزۇنلۇقى، بىخنىڭ ھۆل ئېغىرلىقى قاتارلىق كۆرسەتكۈچلەرنى، ئىككىنچى ئاساسىي تەركىب يىلتىزنىڭ ھۆل ئېغىرلىقىنى ئۆز ئىچىگە ئالىدۇ). D قىممىتىنىڭ دائىرىسى 0.816 - 0.047 بولدى، بۇنىڭ ئىچىدە CM1428 نىڭ D قىممىتى 0.816، CM1429 نىڭ D قىممىتى 0.784 بولۇپ، شورغا چىدامچانلىقى ئەڭ ياخشى. كىلۇستېر ئانالىزى قىلىنغان سورتلار شورغا چىدامچان تىپ (67 بولۇپ %57.76 نى ئىگىلىگەن)، شورغا چىدامچانلىقى ئوتتۇرا تىپ (33 بولۇپ %28.45 نى ئىگىلىگەن)، شورغا سەزگۈر تىپ (16 بولۇپ %13.79 نى ئىگىلىگەن) تىن ئىبارەت ئۈچ تىپقا بۆلۈندى.

4. خۇلاسە

ئوخشاش بولمىغان يازغى بۇغداي سورتلىرى ھەم ئوخشاش بولمىغان ئۆستۈرۈش ئورۇنلىرىنىڭ شور تەھدىتىگە سەزگۈرلۈكىدە پەرق كۆرۈلگەن، يەنى %2 لىك NaCl دا بىر تەرەپ قىلغاندا بارلىق سورتلارنىڭ نورمال بىخلىنىشى چەكلىمىگە ئۇچرىغان؛ %1 لىك NaCl دا بىر تەرەپ قىلغاندا تۆرەلمە بىخ غىلاپىنىڭ ئۆسۈشى تەسىرگە ئاز ئۇچرىغان، يىلتىز ۋە بىخنىڭ ئۆسۈشى كۆرۈنەرلىك چەكلىمىگە ئۇچرىغان. ئۈنۈپرسال باھالاش، تاللاش ئارقىلىق شورغا ئەڭ چىداملىق سورتلاردىن CM1428، CM1429 (D قىممىتى ئايرىم - ئايرىم ھالدا 0.816، 0.784)، شۇنداقلا شورغا چىداملىق كۆرسەتكۈچى 0.7 دىن يۇقىرى بولغان سورتلاردىن CM1352، CM1374 تاللاپ چىقىلىپ، شورغا چىداملىق سورت يېتىشتۈرۈش ئۈچۈن ئەلا سۈپەتلىك سورت بايلىقى تەمىنلەندى.

5. يېڭىلىق يارىتىش نۇقتىسى

بىرىنچى، ماقالىدە بىخلىنىش مەزگىلى مەركەز قىلىنىپ شورغا چىدامچانلىقى باھالاندى، ئەنئەنىۋى ئۆسۈلدىكى پۈتكۈل ئۆسۈپ يېتىلىش مەزگىلىنى باھالاشقا سېلىشتۇرغاندا، بۇ ئۆسۈلنىڭ دەۋرىيلىكى قىسقا، ئەۋرىشكە مىقدارى كۆپ، مۇھىت ئۆزگىرىشىنى ياخشى كونترول قىلغىلى بولۇشتەك ئەۋزەللىكلىرى بار. ئىككىنچى، جۇڭگو شىنجاڭنىڭ شورلاشقان ئېكولوگىيەسىگە بىرلەشتۈرۈپ، قازاقىستاندىن كىرگۈزۈلگەن يازغى بۇغداي سورتلىرى باھالاندى، بۇ تېرىش، باشقۇرۇش ئىستراتېگىيەسىدە تېگىشلىك رول ئوينىغۇسى. ئۈچىنچى، شورغا چىدامچانلىق كوئېففىتسېنتى، D قىممىتىنى ئاساسىي تەركىبلەر بىلەن بىرلەشتۈرۈپ ئانالىز قىلىش، تۈرلەر بويىچە توپلاپ ئانالىز قىلىش قاتارلىق كۆپ خىل ۋاسىتىلەر قوللىنىلىپ، شورغا چىدامچانلىقىنى باھالاشنىڭ توغرىلىق دەرىجىسى ئاشۇرۇلدى.

ئاچقۇچلۇق سۆزلەر: يازغى بۇغداي؛ بىخلىنىش مەزگىلى؛ شورغا چىدامچانلىقى؛ ئۈنۈپرسال باھالاش