Onion Breeding Research at New Mexico State University

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Abstract

Since 1977, the Onion Breeding program at New Mexico State University has been developing locally-adapted cultivars and has been conducting research on bolting, pink root, soluble solids, pungency, cold hardiness, and interspecific hybridization. Current research involves bolting and planting date, cold hardiness, and heritability of bolting, pink root, and Fusarium basal rot resistance, percentage of single centers, and soluble solids content. We are in the process of developing a seedling screening procedure for Fusarium basal rot. Breeding lines in our program, as well as short-day accessions from the National Plant Germplasm System, are being screened for resistance using this procedure. Bolting-resistant and bolting-susceptible short-day cultivars were planted on four September dates that were one week apart. Bolting and growth rate of these cultivars were measured for the different planting dates. The Farmington Science Center in Farmington, NM is being used as a site for cold hardiness screening, because it receives colder winter temperatures than Las Cruces, NM. For three fall-planted, intermediate-day, open-pollinated white populations, heritability of bolting, pink root, and Fusarium basal rot resistance, and percentage of single centers was determined from half-sib families.

Introduction

- New Mexico supplies over 50% summer non-storage onions (late May - early Aug.) in the U.S. (U.S.D.A., 2000).
- Short- and intermediate-day cultivars. Fall-seeded, spring transplanted, spring-seeded crops.
- Pink root, Fusarium basal rot (FBR), and bacterial soft rots are disease problems.
- Fall-seeded crop susceptible to bolting.
- NMSU onion breeding program has developed 20 cultivars since 1981. High bulb yield and quality, pink root resistance, bolting resistance, low pungency, various maturity dates, percent single centers are breeding objectives.
- Research has focused on bolting, pink root, pungency, cultural practices, single centers, trait heritability.

Current research

- Screening onion germplasm for FBR resistance/susceptibility
- Plant growth, bolting, and bulb yield of fall-planted cultivars differing in bolting susceptibility planted on 4 dates.
- Screening NMSU cultivars for cold hardiness
- Heritability of bolting, pink root, and FBR resistance and percentage of single centers in 3 open-pollinated lines

Materials and Methods

Bolting and planting date

- 'NuMex Mesa', 'Daybreak', 'NuMex Sweetpak', 'Texas Early White' - most to least bolting resistant
- Planted 9, 16, 23, and 30 Sept. 2000 in Las Cruces, NM.
- Plant height, leaf number measured monthly from ten plants/plot.
- Bolting, maturity date, disease resistance, bulb yield, percentage of single centers recorded.

Screening lines for Fusarium basal rot resistance

- Screening NMSU breeding lines, short and intermediate-day varieties, short-day onion accessions in NPGS.
- Using FBR seedling screening method (Krueger et al., 1989).
- Seeds planted in silica sand infested with *Fusarium oxysporum* Schlecht. f. sp. *cepae* (Hans.) Snyder & Hansen.
- Number of surviving seedlings counted, level of resistance determined at 4 weeks.

Cold hardiness screening

- Fall-planted 'NuMex' varieties evaluated for cold hardiness at the Farmington Agricultural Science Center in Farmington, NM. Evaluating site for potential in cold hardiness screening.
- Seeds planted in late Aug. or early Sept.
- Plant number/plot in Nov. and May. Percent survival calculated.

Heritability of bolting, pink root, and FBR resistance, and percent single centers

- 96, 30, 24 half-sib families generated for NMSU 99-99, 99-31, and 99-1000, respectively.
- NMSU 99-31, 99-99, 99-1000 - fall-planted, intermediate-day, bolting and pink root resistant, white scale, round globe, high SC, high SS, open-pollinated, Ben Shemen x Southport White Globe.
- Fall-planted, 4 reps/family, 2.5m plot, 2 rows/plot
- Bolting, maturity date, disease resistance, percentage of single centers recorded.
- Bulbs selected from each plot, best half-sib families selected.
- Heritability using half-sib family analysis (Wall et al., 1996) based on single plant and plot means (Table 1).

Table 1. Models for half-sib family analysis used to calculate heritability estimates

Source of variation	df	MS	Expected mean squares
		Individual plants	
Replicates	r-1		
Among half-sib families	b-1	M1	$\sigma^2_\omega + k\sigma^2_\rho + rk\sigma^2_\beta$
Error (reps × families)	(r-1)(b-1)	M2	$\sigma^2_\omega + k\sigma^2_\rho$
Within half-sib families	rb(k-1)	M3	σ^2_ω
Corrected total	n-1		
		Plot means	
Replicates	r-1		
Among half-sib families	b-1	M1	$\sigma^2_\omega + r\sigma^2_\beta$
Error	(r-1)(b-1)	M2	σ^2_ω
Corrected total	n-1		

1) σ^2_β = M1-M2/rk = variance among half-sib families.
M1 = mean square of half-sib families.
M2 = mean square error.
r = number of replications
k = number of individuals sampled in a half-sib family per replication
2) $\sigma^2_A = 4\sigma^2_\beta$ = additive genetic variance
σ^2_β = variance among half-sib families
3) $h^2 = \frac{\sigma^2_A}{\sigma^2_A + \sigma^2_\rho + \sigma^2_\omega}$
σ^2_ρ = M2-M3/k = variance due to interaction of half-sib families within replication
σ^2_ω = M3 = variance within a half-sib family line

Results

Bolting and planting date

- For 9 Sept. 2000 planting date, plant height and leaf number were similar among cultivars at each observation time while a difference in bolting was observed among cultivars (Table 2). Bolting resistance is not being conferred by a reduction in plant size.
- For each cultivar, plant height and leaf number were greater for plants that were planted at the first or second planting date as compared to plants planted at the later dates (Table 3). This difference in height and number occurred at the first three to four observations; however, at later observations, plant height and leaf number were similar among plants planted at different dates.
- In general, cultivars exhibited less bolting, later maturity dates, and an increase in bulb yield with a delay in planting (Table 4).

Screening lines for FBR resistance

- To date, 50 breeding lines and accessions have been screened using this method and only PI 578126 ('Serrana') appears to be moderately resistant to FBR (Table 5).

Cold hardiness screening

- For the past two years, Farmington winter climate has been mild and no reduction in plant stands.

Heritability of bolting, pink root, and FBR resistance, and percent single centers

- Bolting resistance - NMSU 99-99 (0.66 ± 0.21), NMSU 99-31 (0.88 ± 0.36), NMSU 99-1000 (0.90 ± 0.40)
- Pink root resistance - NMSU 99-99 (0.15 ± 0.06), NMSU 99-31 (0.14 ± 0.12), NMSU 99-1000 (0.20 ± 0.14) - individual plants
  NMSU 99-99 (0.53 ± 0.21), NMSU 99-31 (0.45 ± 0.38), NMSU 99-1000 (0.60 ± 0.41) - plot means rating
  NMSU 99-99 (0.56 ± 0.21), NMSU 99-31 (0.28 ± 0.39), NMSU 99-1000 (0.55 ± 0.41) - plot means percent
- FBR resistance - NMSU 99-99 (0.07 ± 0.03), NMSU 99-31 (0.02 ± 0.03), NMSU 99-1000 (0.12 ± 0.07) - individual plants
  NMSU 99-99 (0.57 ± 0.21), NMSU 99-31 (0.25 ± 0.39), NMSU 99-1000 (0.69 ± 0.41) - plot means rating
  NMSU 99-99 (0.45 ± 0.21), NMSU 99-31 (0.43 ± 0.38), NMSU 99-1000 (0.55 ± 0.41) - plot means percent
- Percent single centers - NMSU 99-99 (0.69 ± 0.21)

Table 2. Plant and yield characteristics of four cultivars planted on 9 September 1999 at the Fabian Garcia Agricultural Science Center in Las Cruces, NM

	Plant height (cm) at days after planting						
Cultivar	60	90	119	150	180	210	241
NuMex Mesa	23.0	19.8	18.4	23.2	38.8	64.4	64.1
Daybreak	23.5	22.8	20.8	25.7	43.0	70.5	70.3
NuMex Sweetpak	24.0	24.3	22.0	26.2	39.5	67.3	67.7
Texas Early White	23.5	21.3	21.5	24.9	41.0	67.9	68.8
Mean	23.5	22.0	20.7	25.0	40.6	67.5	67.7
LSD (5%)	NS	NS	NS	NS	NS	NS	NS
	Leaf number						
NuMex Mesa	4.0	3.7	3.2	4.0	5.7	8.0	7.9
Daybreak	4.2	4.2	3.2	4.1	6.0	7.7	8.4
NuMex Sweetpak	4.0	3.8	3.5	4.2	5.7	8.1	8.3
Texas Early White	4.0	3.8	3.4	4.0	6.0	7.6	8.0
Mean	4.0	3.9	3.3	4.0	5.8	7.9	8.1
LSD (5%)	NS	NS	NS	NS	NS	NS	NS

	Maturity date[z]	Seedstalks (%)[y]	Marketable yield (t ha^{-1})[x]	Average bulb weight (g)[w]
NuMex Mesa	May 14	1.6	46.2	269
Daybreak	May 14	11.3	41.0	277
NuMex Sweetpak	May 15	32.5	30.6	275
Texas Early White	May 16	40.3	22.0	219
Mean	May 14	21.4	35.8	263
LSD (5%)	NS	9.9***	8.2***	NS

NS, ***Nonsignificant, and significant at P=0.001, respectively.
[z]A plot was considered matured when 80% of the tops were down.
[y]The percentage of seedstalks was determined at harvest and calculated by dividing the number of plants with seedstalks by 80 plants per plot.
[x]Marketable yield was calculated by weighing the marketable bulbs per plot and adjusting the plot size to one ha.
[w]Average bulb weight was calculated by dividing the marketable bulb weight by the number of marketable bulbs.

Literature Cited

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Table 3. Plant height and leaf number of four cultivars planted on four dates at the Fabian Garcia Agricultural Science Center in Las Cruces, NM

	Plant height (cm) at days after planting						
Planting date	60	90	119	150	180	210	241
9 Sept. 1999	23.5	22.0	20.7	25.0	40.6	67.5	67.7
16 Sept. 1999	14.5	14.0	14.3	21.4	37.9	65.9	67.2
23 Sept. 1999	13.0	12.5	14.7	22.8	40.8	71.0	66.9
30 Sept. 1999	10.5	10.3	13.6	22.3	45.3	67.4	63.3
Mean	15.2	14.7	15.8	22.8	41.1	68.0	66.3
LSD (5%)	1.0***	1.5***	1.1***	1.4***	2.8***	NS	3.1*
	Leaf number						
9 Sept. 1999	4.0	3.9	3.3	4.0	5.8	7.9	8.1
16 Sept. 1999	2.9	2.9	2.7	3.5	5.3	7.5	8.2
23 Sept. 1999	2.9	2.6	2.7	3.7	5.8	8.6	8.6
30 Sept. 1999	2.3	2.3	2.8	3.7	6.1	8.7	8.2
Mean	3.0	2.9	2.9	3.7	5.8	8.2	8.3
LSD (5%)	0.1***	0.2***	0.1***	0.2***	0.3***	0.4***	NS

NS, *,***Nonsignificant, significant at P=0.05, P=0.001, respectively.

Table 4. Yield characteristics of four cultivars planted on four dates at the Fabian Garcia Agricultural Science Center in Las Cruces, NM

Planting date	Maturity date[z]	Seedstalks (%)[y]	Marketable yield (t ha^{-1})[x]	Average bulb weight (g)[w]
		NuMex Mesa		
9 Sept. 1999	May 14	1.6	46.2	269
16 Sept. 1999	May 18	0.6	32.3	207
23 Sept. 1999	May 23	0.9	43.8	260
30 Sept. 1999	May 30	0.0	41.2	257
Mean	May 21	0.8	40.9	248
LSD (5%)	2***	NS	8.7*	NS
		Daybreak		
9 Sept. 1999	May 14	11.3	41.0	277
16 Sept. 1999	May 17	3.4	46.7	262
23 Sept. 1999	May 23	2.5	50.2	330
30 Sept. 1999	May 30	0.3	45.3	307
Mean	May 14	21.4	35.8	263
LSD (5%)	2***	4.3**	NS	NS
		NuMex Sweetpak		
9 Sept. 1999	May 15	32.5	30.6	275
16 Sept. 1999	May 17	11.3	40.4	259
23 Sept. 1999	May 23	8.8	43.8	286
30 Sept. 1999	May 30	2.8	59.6	342
Mean	May 21	13.8	43.6	290
LSD (5%)	2***	8.7***	9.9***	24***
		Texas Early White		
9 Sept. 1999	May 16	40.3	22.0	219
16 Sept. 1999	May 17	6.9	31.9	221
23 Sept. 1999	May 23	10.3	36.2	253
30 Sept. 1999	May 30	0.9	33.4	257
Mean	May 21	14.6	31.5	239
LSD (5%)	1***	9.6***	6.4**	NS

NS, *,**,***Nonsignificant, significant at P=0.05, P=0.01, P=0.001, respectively.

Table 5. Short-day onion accessions evaluated for Fusarium basal rot resistance.

Accession	Survival (%)	Accession	Survival (%)
G 28933 Texas Early	19.2	PI 546070 Yellow Bermuda	25.7
PI 164807	32.6	PI 546078 L 303 A	41.2
PI 165498	0.0	PI 546110 Early Texas Yellow Grano	5.8
PI 209561	1.8	PI 546128 White Creole	14.6
PI 214146	21.8	PI 546140 San Joaquin	1.0
PI 236025	2.8	PI 546160 L 036 Yellow	3.1
PI 256324	42.9	PI 546161 S-1 White Grano	59.6
PI 258957	0.6	PI 546166 Crystal White Wax	44.1
PI 261591	7.7	PI 546170 White Grano	23.1
PI 264319	34.1	PI 546261 Texas Grano 502 PRR	39.0
PI 272255 De Wildt	0.9	PI 546306 Contessa	36.9
PI 273626 1871	5.9	PI 546324 Everest	34.4
PI 288274 310	25.7	PI 546327 Texas Early Grano 438	54.2
PI 289688 Early Lockyer White	18.3	PI 548814 Redbone	35.8
PI 289690	0.8	PI 554613 NuMex Starlite	28.5
PI 342943 Pompei	6.3	PI 577801 Texas Early White	40.6
PI 377901 Atjar	4.4	PI 578126 Serrana	72.1
PI 414932 Pyramid	16.1	PI 583821 Red Star	6.3
PI 433314 Dragon Eye Hybrid O-Y	0.0	PI 595635 NuMex Crispy	35.4
PI 433345 374 H	0.0	PI 595636 NuMex Dulce	4.7
PI 522166 Okhotzk F1	0.0	PI 595637 NuMex Luna	31.7
PI 537590 Texas Grano 1015Y	24.2	PI 595638 NuMex Mesa	7.1
PI 537593 Texas Grano 1105Y	6.6	PI 595639 NuMex Vado	11.9