Evaluation of Short-Day Onion Cultivars for Bulb Firmness and Associated Traits

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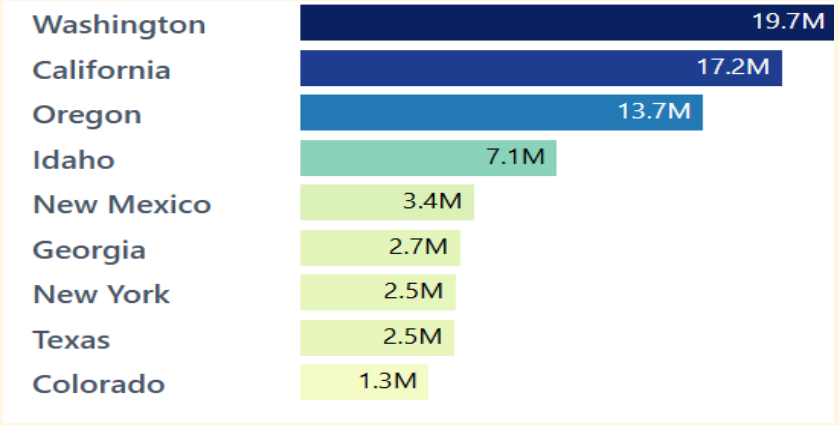
Onion characteristics in New Mexico

In 2024:

- New Mexico ranked as the fifth-largest onion producer in the United States.
- Onions represented the one vegetable crop that produced the highest income for New Mexico generating $180 millions in revenue.

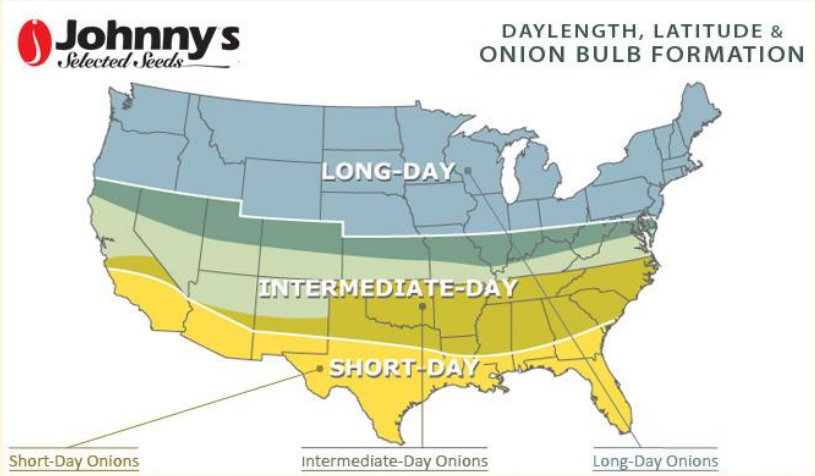


World Population Review. (n.d.)

Two types of onion crops in New Mexico:

- An autumn-sown, short-day overwintering crop
- A winter-sown, intermediate-day crop

New Mexico growers have specialized in **fresh market onions,** which have **higher quality standards** than onions destined for processing into onion rings.



Johnny's Selected Seeds. (n.d.).

short-day onions

characteristics

- Higher water content
- Lower bulb firmness

consequences

High bulb damage % at harvesting

Growers rely on hand harvesting to minimize yield loss, but this approach significantly increases labor costs

new challenge

Competition from cheaper, imported short-day onions produced in countries with lower labor costs

Steps for mechanical harvesting adoption in Southern U.S.?

- Selecting suitable cultivars
- Adopting appropriate cultural practices
- Modifying harvesting systems to reduce bulb damage
- Conducting economic evaluations
- Offering support to facilitate the transition.

Objectives

To identify currently available short-day onion cultivars with **superior bulb firmness** and **adaptation to the environmental conditions** of New Mexico.

To screen currently available short-day onion cultivars for **various traits** and understand their **relationship with firmness.**

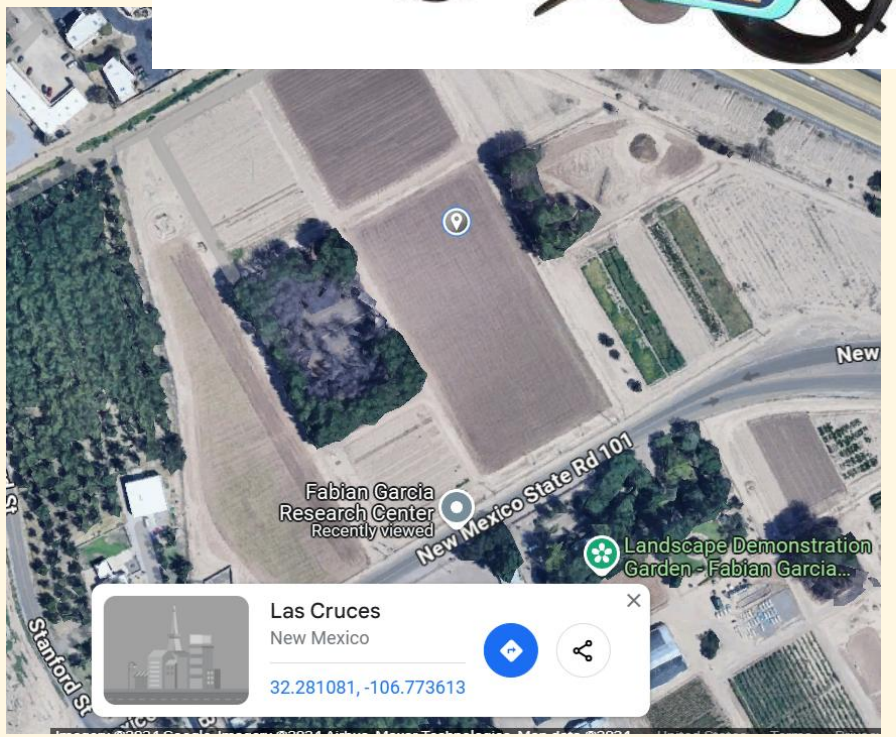
Study Site and Study Time

- Fabian Garcia Research Center, New Mexico State University, Las Cruces, NM, United States

- Sowing: fall 2024 (first irrigation day October 2, 2024)

- Harvesting: summer 2025

- Direct seeding (with a mechanical seed planter), two rows per bed with 10–15 cm spacing between seeds in each row.



Entries (21) – 224-245 days

(1). Cisne Blanco (Hazera)

(2). Don Victor (Nunhems)

(3). Dulciana (Nunhems)

(4). Duster (Bayer)

(5). EMY 70043-55 (Emerald Seeds)

(6). EMY 71507 (Emerald Seeds)

(7). EMY 71623 (Emerald Seeds)

(8). EMY 72195 (Emerald Seeds)

(9). H10265 (Hazera)

(10). H10266 (Hazera)

(11). Hellcat (Bayer)

(12). Mata Hari (Nunhems)

(13). Nomad (Bayer)

(14). NuMex Camino (NMSU 19-13)

(15). NUN 1213 (Nunhems)

(16). NUN 1216 (Nunhems)

(17). OSYS22-0834 (Crookham)

(18). SVNN1049 (Bayer)

(19). SVNN1071 (Bayer)

(20). SVNN1127 (Bayer)

(21). Torro Rosso (Hazera)

- Randomized complete block design with three replications per cultivar (one replication per block).
- Furrow irrigation was used.
- Bulbs were manually harvested at 80% tops down (maturity day).
- All marketable bulbs were harvested from each plot and stored in plastic crates in a warehouse away from the sun.
- Plant traits were measured 2 to 7 days after harvesting.

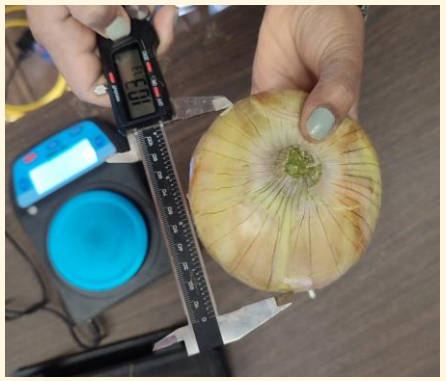
Data taken in the field

bolting onions per plot

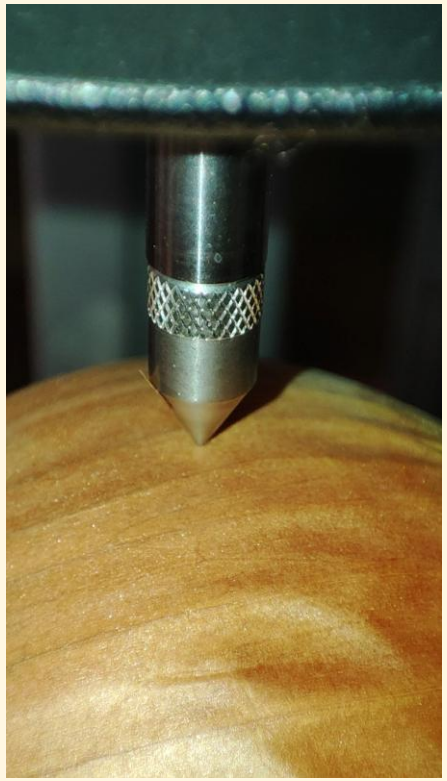
bulbs affected by fusarium basal rot per plot

# of marketable bulbs harvested

10 average bulbs per plot



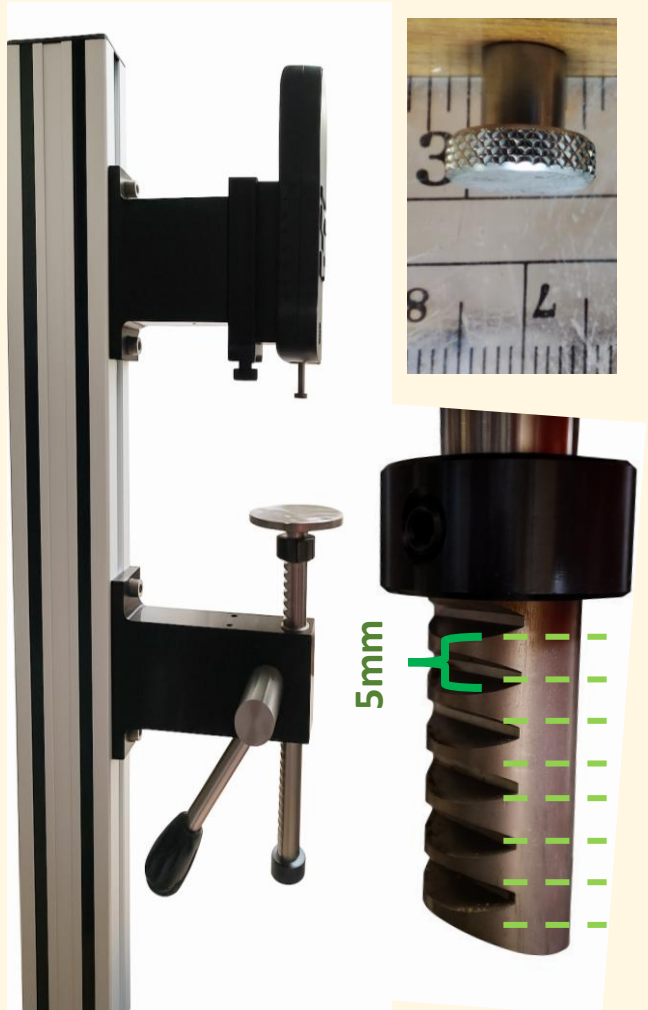
Weight(g), height(cm), and diameter(cm)



- Puncture force with a conical probe (N)
- Measured with Chatillon Digital Force Gauge DF3 50N
- 2 measurements per bulb

Number of dry scale layers were counted and removed

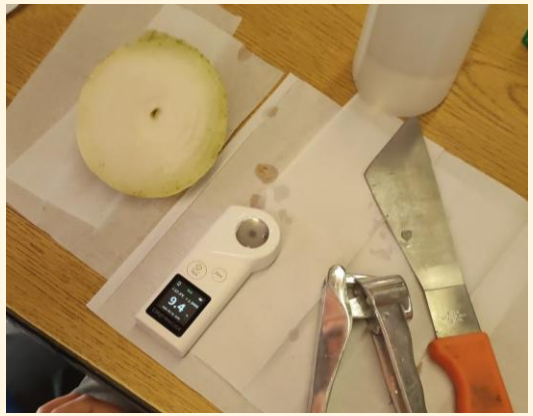
- Puncture force with flat probe [N].
- Measured with Chatillon Digital Force Gauge DF3 250N.
- 2 measurements per bulb



Durometer measurement
(2 measurements per bulb)

Hand squeezing rating
(1-9)

- Number of fleshy scale layers
- Number of centers
- Thickness of the thickest fleshy scale layer



Soluble solids %

END

First scientific questions

Is there significant difference in bulb firmness among short-day onion cultivars evaluated?

Statistical approach

- A Mixed Model Analysis was performed in SAS Software
- Cultivars as a fixed effect
- Replications as a random effect.

Second scientific questions

If differences exist, which cultivars show the highest firmness and best adaptation to New Mexico's growing conditions?

Analysis approach:

- An index was created to identify the firmest and most adapted onions to NM
- Variables were standardized

$$Z = (x - mean)/std$$

- $C1 = abs(\text{Z when } X_1{=}0)$
- $C2 = abs(\text{Z when } X_2{=}0)$

Index =

- C1 * % Bolting number/plot
- C2 * % Bulb affected by fusarium basal rot/plot
+ Bulb weight
+ average puncture force conical probe
+ average puncture force flat probe
+ average durometer measurement
+ hand squeezing rating

Third scientific questions

Is there correlation between bulb firmness and other bulb traits?

Statistical approach

Pearson Correlation analysis in R Software

BULB TRAITS

1) Bulb weight
2) Bulb Size
   a) Bulb height
   b) Bulb diameter
   c) Bulb shape index
3) Number of dry scales
4) Number of fleshy scales
5) Thickness of the thickest fleshy scale layer
6) Number of growing points
7) Soluble solids %

Bulb firmness

1) Puncture force with conical probe
2) Puncture force with flat probe
3) Durometer measurement
4) Hand squeezing rating (1-9)

1 Is there a significant difference in bulb firmness?

Yes

Cultivar	Puncture force conical probe (N)	Puncture force flat probe (N)	Durometer measurement	Hand squeezing rating
Cisne Blanco	54.90 ± 1.87	150.9 ± 4.5	71.3 ± 1.5	8.9 ± 0.2
Don Victor	38.90 ± 1.87	120.9 ± 4.5	65.8 ± 1.5	7.0 ± 0.2
Dulciana	32.99 ± 1.87	110.8 ± 4.5	64.8 ± 1.5	6.5 ± 0.2
Duster	39.16 ± 1.87	129.4 ± 4.5	64.8 ± 1.5	6.6 ± 0.2
EMY 70043-55	40.54 ± 1.87	133.9 ± 4.5	68.2 ± 1.5	7.5 ± 0.2
EMY 71507	41.44 ± 1.87	131.5 ± 4.5	65.1 ± 1.5	7.4 ± 0.2
EMY 71623	41.79 ± 1.87	130.6 ± 4.5	65.4 ± 1.5	7.8 ± 0.2
EMY 72195	41.74 ± 1.87	141.5 ± 4.5	65.7 ± 1.5	7.9 ± 0.2
H10265	40.57 ± 1.87	131.1 ± 4.5	67.5 ± 1.5	7.8 ± 0.2
H10266	41.19 ± 1.87	124.1 ± 4.5	65.9 ± 1.5	7.6 ± 0.2
Hellcat	37.21 ± 1.87	125.9 ± 4.5	65.3 ± 1.5	6.7 ± 0.2
Mata Hari	51.98 ± 1.87	132.8 ± 4.5	73.0 ± 1.5	8.5 ± 0.2
Nomad	45.04 ± 1.87	130.4 ± 4.5	66.5 ± 1.5	6.8 ± 0.2
NuMex Camino	43.67 ± 1.87	131.7 ± 4.5	67.0 ± 1.5	7.4 ± 0.2
NUN 1213	43.77 ± 2.29	129.6 ± 5.5	68.2 ± 1.9	7.5 ± 0.3
NUN 1216	36.89 ± 1.87	114.0 ± 4.5	66.6 ± 1.5	6.8 ± 0.2
OSYS22-0834	41.26 ± 1.87	125.0 ± 4.5	68.5 ± 1.5	6.7 ± 0.2
SVNN1049	37.68 ± 1.87	124.0 ± 4.5	64.4 ± 1.5	7.0 ± 0.2
SVNN1071	43.50 ± 1.87	127.1 ± 4.5	69.0 ± 1.5	6.9 ± 0.2
SVNN1127	37.03 ± 1.87	120.2 ± 4.5	65.6 ± 1.5	6.8 ± 0.2
Torro Rosso	47.44 ± 1.87	126.5 ± 4.5	71.7 ± 1.5	8.2 ± 0.2
P-value (ANOVA)	*<0.0001*	*<0.0003*	*0.007*	*<0.0001*

2

Index values for different cultivars for New Mexico

Cultivar	Index (firmness only)	Index (env + firm)
Cisne Blanco	9.294	7.430
Mata Hari	6.698	4.524
NUN 1213	1.207	3.059
SVNN1071	0.285	0.648
OSYS22-0834	-0.913	0.561
NuMex Camino	0.787	0.503
Torro Rosso	4.074	-0.413
EMY 70043-55	1.070	-0.772
EMY 71623	0.231	-1.915
H10265	0.913	-2.202
Don Victor	-2.519	-2.307

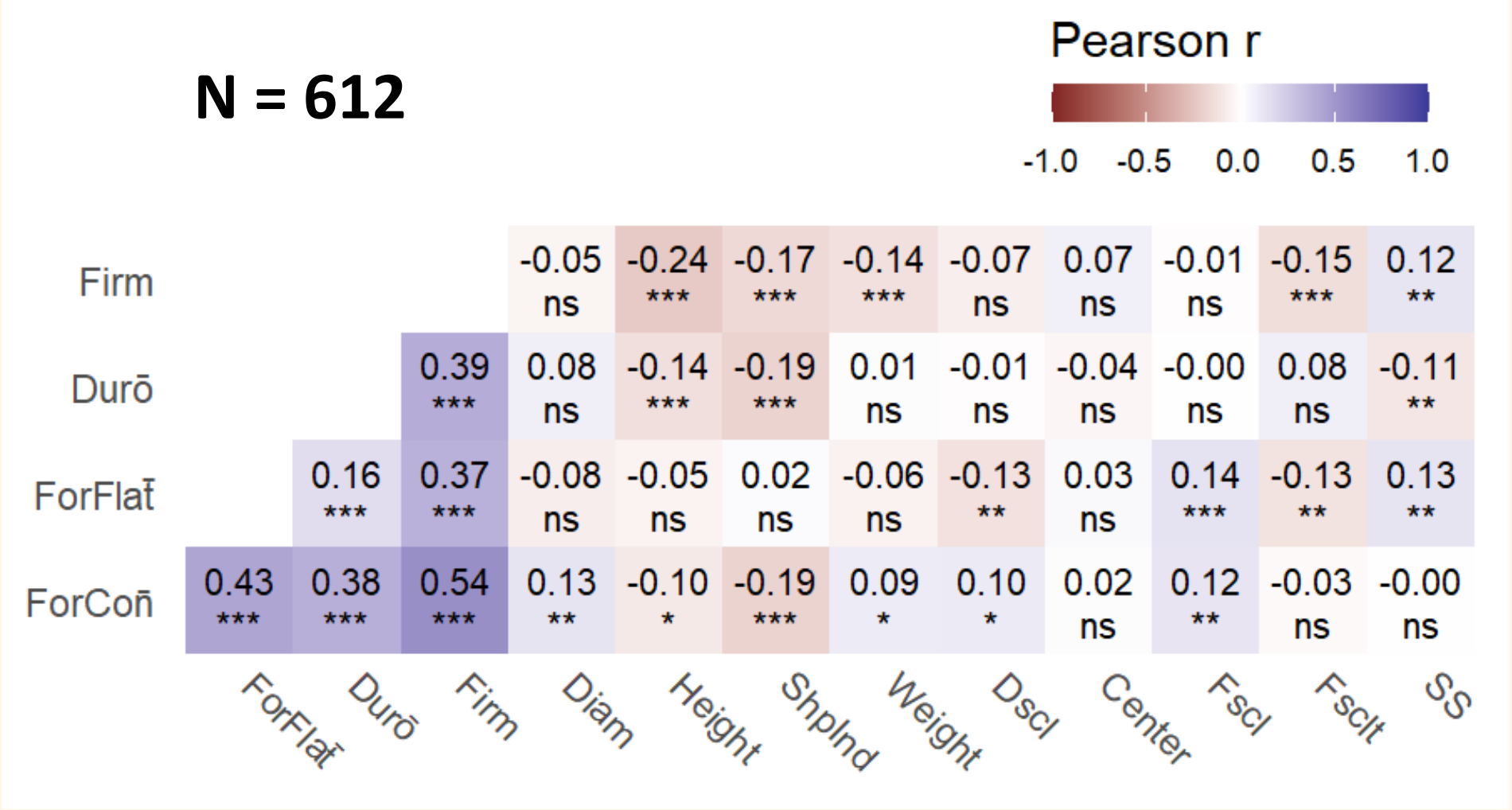
Cultivar	Index (firmness only)	Index (env + firm)
Nomad	-0.207	-2.507
EMY 72195	1.768	-2.563
H10266	-0.743	-2.569
NUN 1216	-3.695	-4.419
Hellcat	-2.929	-4.527
SVNN1127	-3.356	-4.777
EMY 71507	-0.462	-5.140
SVNN1049	-2.976	-5.466
Dulciana	-6.037	-6.288
Duster	-2.492	-6.375

- *Cultivar highlighting:* gray for white onion cultivar, red for red onion cultivars, and yellow for yellow onion cultivars
- *Index highlighting:* green for values over mean + 0.5 std, and orange for values under mean - 0.5 std

3 Is there a correlation between firmness and other bulb traits?

No, there is no significant correlation

$p < 0.001 \sim$ "***",
$p < 0.01 \sim$ "**",
$p < 0.05 \sim$ "*",
TRUE $\sim$ "NS"



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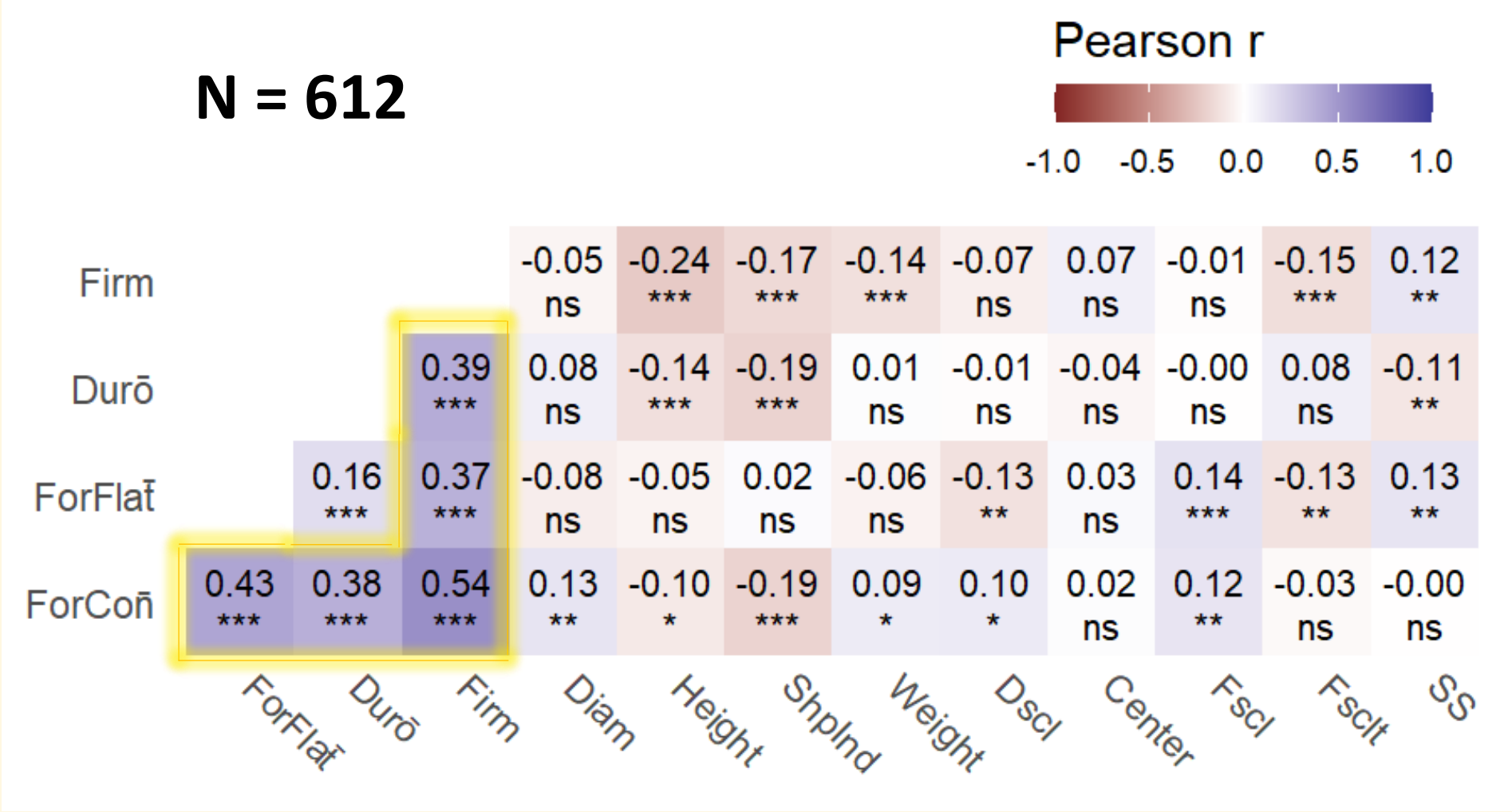
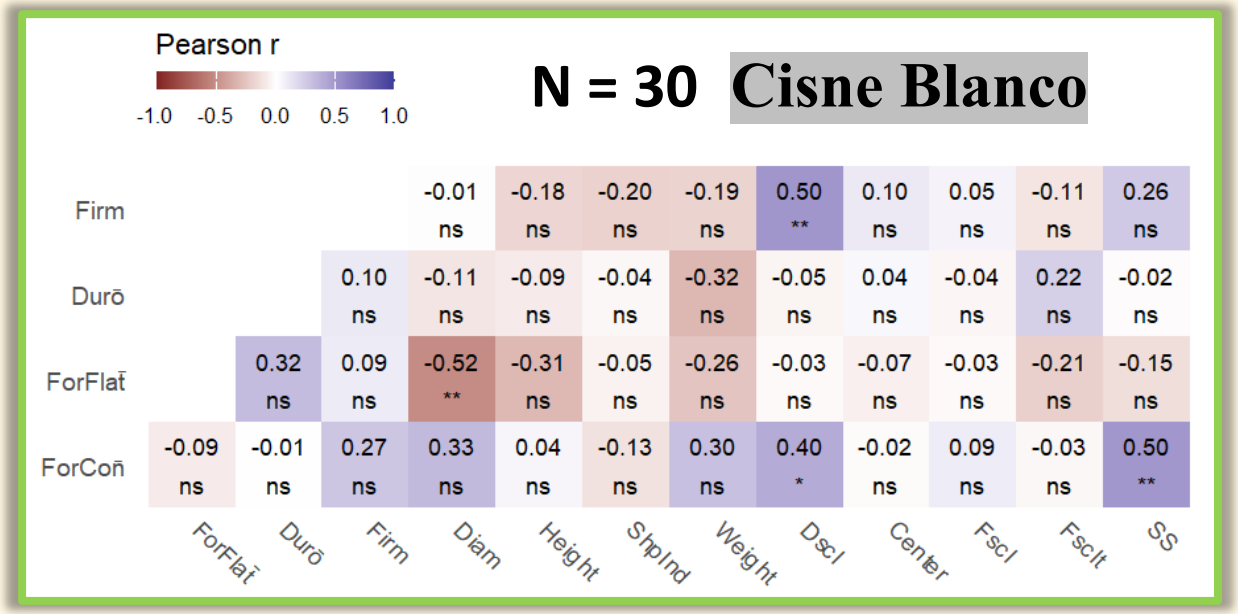
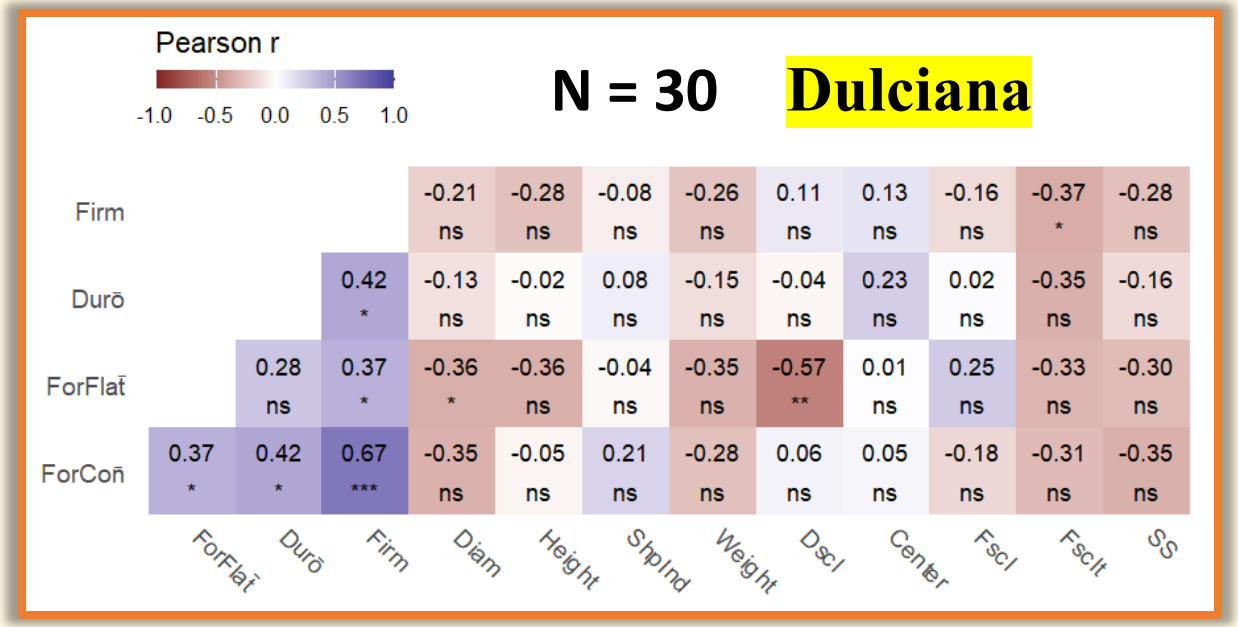
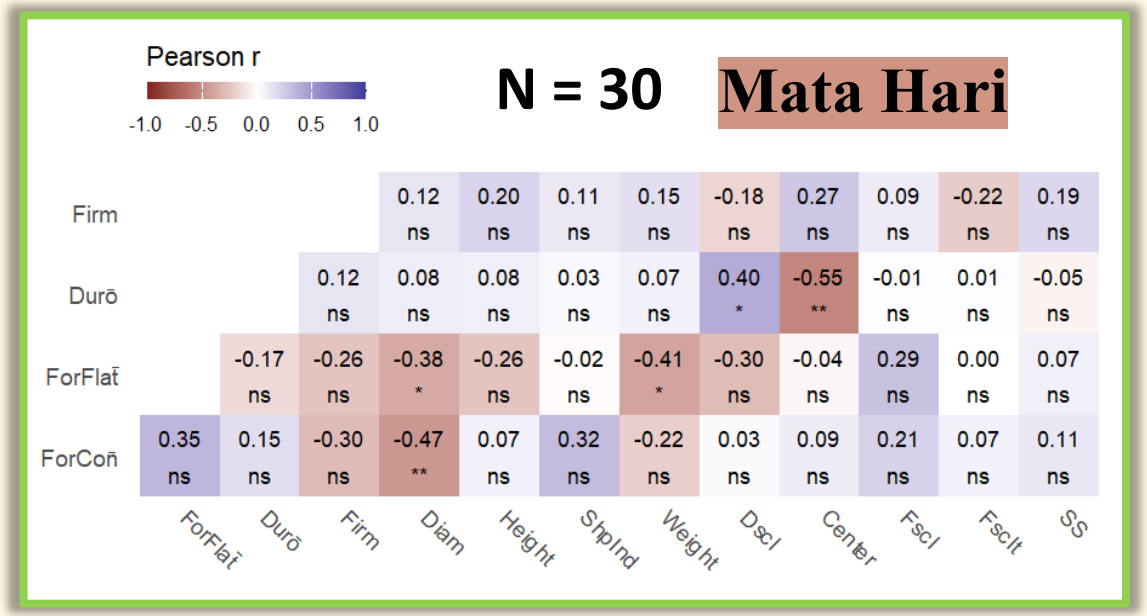
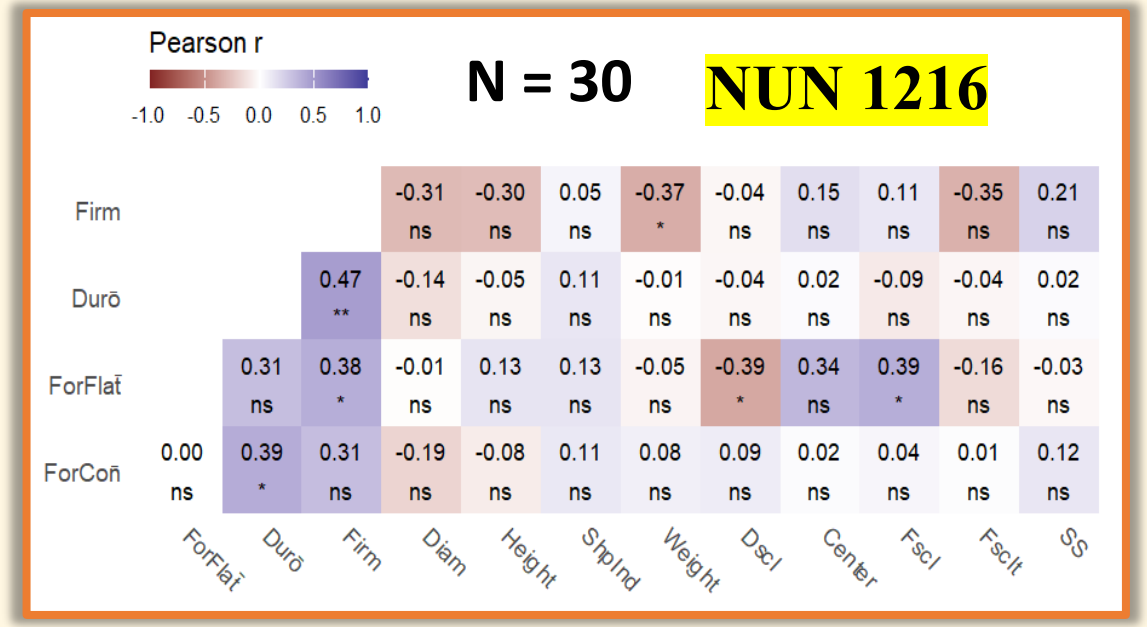



Pearson r
-1.0 -0.5 0.0 0.5 1.0
N = 30
Cisne Blanco
Firm -0.01 ns -0.18 ns -0.20 ns -0.19 ns 0.50 ** 0.10 ns 0.05 ns -0.11 ns 0.26 ns
Durō 0.10 ns -0.11 ns -0.09 ns -0.04 ns -0.32 ns -0.05 ns 0.04 ns -0.04 ns 0.22 ns -0.02 ns
ForFlat̄ 0.32 ns 0.09 ns -0.52 ** -0.31 ns -0.05 ns -0.26 ns -0.03 ns -0.07 ns -0.03 ns -0.21 ns -0.15 ns
ForCoñ -0.09 ns -0.01 ns 0.27 ns 0.33 ns 0.04 ns -0.13 ns 0.30 ns 0.40 * -0.02 ns 0.09 ns -0.03 ns 0.50 **
ForFlat̄ Durō Firm Diam Height ShpInd Weight DscI Center FscI FscIt SS


Pearson r
-1.0 -0.5 0.0 0.5 1.0
N = 30
Dulciana
Firm -0.21 ns -0.28 ns -0.08 ns -0.26 ns 0.11 ns 0.13 ns -0.16 ns -0.37 * -0.28 ns
Durō 0.42 * -0.13 ns -0.02 ns 0.08 ns -0.15 ns -0.04 ns 0.23 ns 0.02 ns -0.35 ns -0.16 ns
ForFlat̄ 0.28 ns 0.37 * -0.36 * -0.36 ns -0.04 ns -0.35 ns -0.57 ** 0.01 ns 0.25 ns -0.33 ns -0.30 ns
ForCoñ 0.37 * 0.42 * 0.67 *** -0.35 ns -0.05 ns 0.21 ns -0.28 ns 0.06 ns 0.05 ns -0.18 ns -0.31 ns -0.35 ns
ForFlat̄ Durō Firm Diam Height ShpInd Weight DscI Center FscI FscIt SS


Pearson r
-1.0 -0.5 0.0 0.5 1.0
N = 30
Mata Hari
Firm 0.12 ns 0.20 ns 0.11 ns 0.15 ns -0.18 ns 0.27 ns 0.09 ns -0.22 ns 0.19 ns
Durō 0.12 ns 0.08 ns 0.08 ns 0.03 ns 0.07 ns 0.40 * -0.55 ** -0.01 ns 0.01 ns -0.05 ns
ForFlat̄ -0.17 ns -0.26 ns -0.38 * -0.26 ns -0.02 ns -0.41 * -0.30 ns -0.04 ns 0.29 ns 0.00 ns 0.07 ns
ForCoñ 0.35 ns 0.15 ns -0.30 ns -0.47 ** 0.07 ns 0.32 ns -0.22 ns 0.03 ns 0.09 ns 0.21 ns 0.07 ns 0.11 ns
ForFlat̄ Durō Firm Diam Height ShpInd Weight DscI Center FscI FscIt SS


Pearson r
-1.0 -0.5 0.0 0.5 1.0
N = 30
NUN 1216
Firm -0.31 ns -0.30 ns 0.05 ns -0.37 * -0.04 ns 0.15 ns 0.11 ns -0.35 ns 0.21 ns
Durō 0.47 ** -0.14 ns -0.05 ns 0.11 ns -0.01 ns -0.04 ns 0.02 ns -0.09 ns -0.04 ns 0.02 ns
ForFlat̄ 0.31 ns 0.38 * -0.01 ns 0.13 ns 0.13 ns -0.05 ns -0.39 * 0.34 ns 0.39 * -0.16 ns -0.03 ns
ForCoñ 0.00 ns 0.39 * 0.31 ns -0.19 ns -0.08 ns 0.11 ns 0.08 ns 0.09 ns 0.02 ns 0.04 ns 0.01 ns 0.12 ns
ForFlat̄ Durō Firm Diam Height ShpInd Weight DscI Center FscI FscIt SS

1. There are significant differences in firmness among cultivars.

   Implication: There is potential for some cultivars already available in the market to be used by growers in the transition to mechanical harvesting.

2. According to the index results, these are the six firmest and best-adapted cultivars to New Mexico:

   Cisne Blanco, Mata Hari, NUN 1213, SVNN1071, OSYS22-0834, and NuMex Camino.

3. There is no correlation between firmness and the other morphological and textural traits, but there may be variation in these relationships that are inherent to each cultivar's genetics.

Future Work

- Mimic forces experienced by bulbs during mechanical harvest.
- Standardize firmness measurement protocols for onions using probe-based instruments.
- Test firmest cultivars with a mechanical harvesting simulator.
- Test whether firmer bulbs experience lower damage rates during mechanical harvest.

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Thank you!

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