SCIENTIFIC NOTE

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LLEUQUE-INIA, NEW HIGH YIELD SPRING DURUM WHEAT VARIETY FOR CHILE

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ABSTRACT

The Lleuque-INIA spring durum wheat variety (*Triticum turgidum* var. *durum* L.) originated from a cross carried out by the Instituto de Investigaciones Agropecuarias (INIA), National Wheat Program, in the Centro Regional de Investigación La Platina, Santiago, Chile, in 1993. This variety has an upright growth habit in the seedling stage; the adult plant is of medium height and varies between 80 and 90 cm. The spike is medium-sized, white, and exhibits long whitish awns along its full length. The grain is large-sized, elongated, golden yellow, and vitreous. The variety was sown in mid-August in the Santa Rosa Experimental Station (36°31' S; 71°54' W), Chillán, head emergence occurred between 89 and 91 d after sowing, and was 6 to 8 d later than 'Llareta-INIA' and 'Corcolén-INIA'. In La Platina, 'Lleuque-INIA' had a mean yield of 16.7 and 20.8% higher than vars. Llareta-INIA and Corcolén-INIA, respectively, whereas the yield was higher in Chillán by 10.3 and 10.1%, respectively. On the other hand, in Yungay located in the Ñuble foothills, 'Lleuque-INIA' yield exceeded 'Llareta-INIA' by 13.07% and var. Corcolén-INIA by 16.97%. In Humán, var. Lleuque-INIA yield exceeded the control vars. Llareta-INIA and Corcolén-INIA by 15.23 and 24.03%, respectively. Lleuque-INIA variety is a type of wheat with good hectoliter weight, good wet gluten content (%), and a protein value mean fluctuating between 10.47 and 12.3%.

Key words: Durum wheat, *Triticum turgidum* var. *durum*, Lleuque-INIA.

Durum wheat (*Triticum turgidum* var. *durum* L.) in Chile is destined to the manufacture of noodles and pasta. It has large-sized grains, a vitreous aspect, hard texture, high hectoliter weight, and yellow pigment. This cereal has been cultivated in Chile since the 1950s and represents about 10% of the area sown with bread wheat. The traditional cultivation area has been moved from the central-northern zone of the country to the central-southern zone. 'Lleuque-INIA' is the first released product variety of the selection carried out in the central-southern zone of the country.

Origin

'Lleuque-INIA' is a spring durum wheat variety originated from a cross carried out in 1993 by the National Wheat Program of Instituto de Investigaciones Agropecuarias (INIA) in the Centro Regional de Investigación (Regional Research Center) (CRI) La Platina (33°34' S; 70°38' W), Santiago, Chile. A mass selection was carried out in 1995 on the F_2 generation. The F_3 to F_5 selection stages were carried out between 1996 and 1998 using the pedigree method. A preliminary yield trial was evaluated in 1999 and included in the main yield trial in the year 2000. Regional bread wheat trials of CRI La Platina were studied in 2001 and 2002. Standard bread wheat trials of CRI-Quilamapu (36°31' S; 71°54' W) were studied between 2004 and 2008. These trials were registered in 2005 and 2006 as variety trials applying for Registration of Varieties Suitable for Certification (RVSC), condition required by the Ministry of Agriculture through the Servicio Agrícola y Ganadero (Agriculture and Livestock Service). The experimental line for all these trials was identified as V-116.

Crossing and pedigree

The following is the genealogy of Lleuque-INIA:
YEL'S'/BAR'S'/3/GR'S'/AFN//CR'S'/5/DOM'S'//CR'S'*2/GS'S'/3/SCO'S'/4/HORA/6/LAP76/GULL'S'/7/LICAN
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Morphological description of the plant

This durum wheat habitually develops in the spring and has an upright growth habit in the seedling stage (Figure 1). The adult plant is of medium height and varies between 80 and 90 cm (Figure 2). Glaucocity of the flag leaf sheath is medium. The leaf blade (underside) of the flag leaf exhibits nil or weak glaucocity. Glaucocity is medium in the spike neck during anthesis. Stalk medulla is medium and has low to moderate resistance to lodging.

Spike and grain characteristics

The spike is medium-sized, compact, white, and with high glaucocity in anthesis, has parallel edges, and exhibits long whitish awns along its full length (Figure 3). The peak of the lower glume is very long and the bottom does not exhibit hairiness.

The grain is large-sized, elongated, golden yellow, and vitreous. The weight of 1000 seeds is 65 to 70 g.

Figure 1. Lleuque-INIA planted in Chillan. Santa Rosa Experimental Station.

Figure 2. Adult plant of Lleuque-INIA planted in Yungay, a location of the foothills of Ñuble province.

Figure 3. Spike of Lleuque-INIA at anthesis.

Agronomic and phytopathological characteristics

The variety was sown in mid-August in the Santa Rosa Experimental Station (36°31' S; 71°54' W), Chillán, head emergence occurred between 89 and 91 d after sowing, and was 6 to 8 d later than 'Llareta-INIA' (Ramírez *et al*., 1997) and 'Corcolén-INIA'.

Up to the 2008-2009 season, 'Lleuque-INIA' showed resistance to stripe rust (*Puccinia striiformis* West. f. sp. *tritici*), leaf rust (*Puccinia triticina* Erikss.), and resistance to moderate resistance to powdery mildew caused by the *Blumeria graminis* DC. f. sp. *tritici* Marchal fungus (Tables 1 and 2).

Grain yield

From 2004 to 2008, 'Lleuque-INIA' was evaluated in standard trials conducted in irrigated soils in the provinces of Santiago (CRI La Platina, 33º34' S; 70º38' W), Ñuble (Santa Rosa Experimental Station, 36°31' S; 71°54' W), and Yungay (Ñuble foothills 37º08' S; 72º0' W), and Bío Bío (Humán Experimental Center in Los Ángeles 37º26' S; 72º14' W). 'Lleuque-INIA' had a mean yield of 16.7 and 20.8% higher than the vars. Llareta-INIA and Corcolén-INIA, respectively, in La Platina. Yield in Chillán was 10.3 and 10.1% higher than 'Llareta-INIA' and 'Corcolén-INIA', respectively. On the other hand, 'Lleuque-INIA' yield in Yungay was higher than 'Llareta-INIA' by 13.07% and 'Corcolén-INIA' by 16.97%. 'Lleuque-INIA' yield in Humán was also higher than the control vars. Llareta-INIA and Corcolén-INIA by 15.23 and 24.03%, respectively (Table 3).

Table 1. Behavior of stripe rust (*Puccinia striiformis*), leaf rust (*P. triticina*), and powdery mildew (*Blumeria graminis*) of cv. Lleuque-INIA compared to control cv. Llareta-INIA in four irrigated locations and five agricultural cycles.

		Lleuque-INIA			Llareta-INIA		
Location	Year	Yellow rust[1]	Leaf rust[1]	Powdery mildew[2]	Yellow rust[1]	Leaf rust[1]	Powdery mildew[2]
La Platina	2004	0	0	2	0	0	3
	2005	0	0	0	0	0	0
	2006	0	0	0	0	0	0
	2007	0	0	0	0	0	0
	2008	0	0	0	0	0	0
Chillán	2004	0	0	0	0	0	7
	2005	TMR	0	0	TMR	0	0
	2006	0	0	0	TMR	0	0
	2007	0	0	0	0	0	0
	2008	0	0	0	0	0	0
Yungay	2004	0	0	4	0	0	8
	2005	0	0	0	0	0	0
	2006	0	0	0	0	0	0
	2007	0	0	0	0	0	0
	2008	0	0	0	0	0	0
Humán	2004	0	0	2	0	0	6
	2005	0	0	0	0	0	0
	2006	0	0	0	5MS	0	0
	2007	5MR	0	0	TMS	0	0
	2008	0	0	0	0	0	0

[1]Values according to modified Cobb Scale (Peterson *et al*., 1984) where attack intensity can vary between 0 and 100% (T = traces), plant reaction can be: resistant (R), moderately resistant (MR), moderately susceptible (MS), or susceptible (S).
[2]Values Saari and Prescott (1975) scale. Scale from 1 to 9.

Table 2. Behavior of stripe rust (*Puccinia striiformis*), leaf rust (*P. triticina*), and powdery mildew (*Blumeria graminis*) of cv. Lleuque-INIA compared to control cv. Corcolén-INIA in four irrigated locations and five agricultural cycles.

		Lleuque-INIA			Llareta-INIA		
Location	Year	Yellow rust[1]	Leaf rust[1]	Powdery mildew[2]	Yellow rust[1]	Leaf rust[1]	Powdery mildew[2]
La Platina	2004	0	0	2	0	0	2
	2005	0	0	0	0	0	0
	2006	0	0	0	0	0	0
	2007	0	0	0	0	0	0
	2008	0	0	0	0	0	0
Chillán	2004	0	0	0	0	0	4
	2005	TMR	0	0	TMR	0	0
	2006	0	0	0	TMS	0	0
	2007	0	0	0	5MS	0	0
	2008	0	0	0	0	0	0
Yungay	2004	0	0	4	0	0	6
	2005	0	0	0	0	0	0
	2006	0	0	0	0	0	0
	2007	0	0	0	0	0	0
	2008	0	0	0	0	0	0
Humán	2004	0	0	2	0	0	4
	2005	0	0	0	5MS	0	0
	2006	0	0	0	10MS	0	0
	2007	5MR	0	0	TMS	0	0
	2008	0	0	0	0	0	0

[1]Values according to modified Cobb Scale (Peterson *et al*., 1984) where attack intensity can vary between 0 and 100% (T = traces), plant reaction can be: resistant (R), moderately resistant (MR), moderately susceptible (MS), or susceptible (S).
[2]Values Saari and Prescott Scale (1975). Scale from 1 to 9.

Table 3. Grain yield of cv. Lleuque-INIA compared to control cvs. Llareta-INIA and Corcolén-INIA standard trials conducted in four irrigated locations from 2004 to 2008.

Location	Year	Cultivars		
		Lleuque-INIA	Llareta-INIA	Corcolén-INIA
		t ha^{-1}		
La Platina	2004	5.31a	4.93b	3.84c
	2005	6.55a	4.91b	5.09b
	2006	4.33a	4.12a	4.34a
	2007	9.62a	10.14a	9.33a
	2008	7.49a	4.44b	4.95b
	Mean	6.66	5.71	5.51
Chillán	2004	12.01a	8.84c	10.23b
	2005	9.98a	10.22a	8.74b
	2006	7.17a	6.33b	6.91a
	2007	10.51a	9.72a	8.71b
	2008	9.29a	9.25a	9.87a
	Mean	9.79	8.87	8.89
Yungay	2004	8.14a	6.36b	7.70a
	2005	8.34b	9.78a	8.42b
	2006	10.89a	8.72b	9.09b
	2007	8.16a	7.49a	6.06b
	2008	9.12a	7.14b	6.89b
	Mean	8.93	7.89	7.63
Humán	2004	12.25a	9.29a	9.89a
	2005	12.36a	11.59a	9.68b
	2006	11.65a	10.68a	10.80a
	2007	9.81a	9.35a	7.77b
	2008	8.51a	6.44b	5.85b
	Mean	10.92	9.47	8.79

Different letters between cultivars for each year and location are statistically different at $P < 0.01$.

Table 4. Hectoliter weight of cv. Lleuque-INIA compared to control cvs. Llareta-INIA and Corcolén-INIA standard trials conducted in four irrigated locations from 2004 to 2008.

Location	Year	Cultivars		
		Lleuque-INIA	Llareta-INIA	Corcolén-INIA
		kg hL^{-1}		
La Platina	2004	77.60	79.90	79.20
	2005	84.15	84.38	84.98
	2006	81.04	82.12	82.31
	2007	83.68	85.52	85.30
	2008	82.36	82.44	83.22
	Mean	81.77	82.87	83.00
Chillán	2004	85.01	85.61	86.46
	2005	82.33	83.88	83.75
	2006	83.90	85.42	85.68
	2007	85.46	86.86	86.28
	2008	87.67	88.12	87.83
	Mean	84.87	85.98	86.00
Yungay	2004	79.59	80.25	81.55
	2005	83.52	83.89	83.86
	2006	84.64	85.04	85.77
	2007	82.98	84.64	83.96
	2008	83.99	84.75	84.85
	Mean	82.94	83.71	83.99
Humán	2004	82.76	82.48	83.48
	2005	84.50	85.32	84.82
	2006	84.32	85.22	85.69
	2007	87.31	87.20	86.81
	2008	85.11	86.70	86.22
	Mean	84.80	85.38	85.40

Mean values of four replicates.

Quality

Lleuque-INIA is a variety of wheat with mean hectoliter weight between 81 and 84 kg hL^{-1}, wet gluten mean percentages between 28.83 and 35.66%, and mean protein values fluctuating between 10.47 and 12.3% (Tables 4, 5, and 6). In La Platina, hectoliter weight was low for the three varieties in 2004 because of viruses (Table 4). The grain showed a very low yellow berry percentage (Table 7) and very low incidence of black tip (Table 8). Low levels of black tip over time in the different locations must also be highlighted.

Cultivation area and sowing dates

Data obtained in the regional and standard trials allow recommending 'Lleuque-INIA' for the zone between the Metropolitan Region to the Bío Bío Region.

Sowing in irrigated soils is recommended between June and August. This variety can be sown earlier than the vars. Llareta-INIA and Corcolén-INIA.

Table 5. Wet gluten of cv. Lleuque-INIA compared to control cvs. Llareta-INIA and Corcolén-INIA standard trials conducted in four irrigated locations from 2004 to 2008.

Location	Year	Cultivars		
		Lleuque-INIA	Llareta-INIA	Corcolén-INIA
		%		
La Platina	2004	34.14	37.17	35.33
	2005	23.49	35.36	25.96
	2006	31.72	32.52	29.54
	2007	26.30	28.00	22.70
	2008	28.50	29.40	25.90
	Mean	28.83	32.49	27.89
Chillán	2004	40.29	42.31	38.00
	2005	25.63	38.97	33.99
	2006	31.67	35.45	32.83
	2007	26.80	33.40	38.20
	2008	20.40	27.85	23.85
	Mean	28.96	35.59	33.37
Yungay	2004	32.06	30.88	28.99
	2005	46.68	49.25	49.43
	2006	33.26	38.22	34.30
	2007	34.90	35.10	42.60
	2008	28.90	40.15	34.90
	Mean	35.16	38.72	38.04
Humán	2004	37.60	34.53	36.20
	2005	44.78	39.61	44.46
	2006	34.45	42.81	40.05
	2007	38.00	40.80	39.00
	2008	23.45	29.40	29.50
	Mean	35.66	39.44	37.84

Wet gluten (%): < 20 low, 21-25 normal, 26-30 good, > 30 very good.
Mean values of two replicates.

Table 6. Protein of cv. Lleuque-INIA compared to control cvs. Llareta-INIA and Corcolén-INIA standard trials conducted in four irrigated locations from 2004 to 2008.

Location	Year	Cultivars		
		Lleuque-INIA	Llareta-INIA	Corcolén-INIA
		%		
La Platina	2006	12.60	12.60	12.10
	2007	11.10	11.20	10.75
	2008	12.80	13.60	12.50
	Mean	12.17	12.47	11.78
Chillán	2006	11.60	11.90	11.70
	2007	10.10	10.90	11.80
	2008	9.70	11.00	10.80
	Mean	10.47	11.27	11.43
Yungay	2006	11.55	12.10	12.05
	2007	11.80	11.65	12.60
	2008	11.30	12.80	12.40
	Mean	11.55	12.18	12.35
Humán	2006	12.65	13.30	12.85
	2007	12.45	13.25	13.75
	2008	11.80	12.10	11.20
	Mean	12.30	12.88	12.60

Protein (%): < 8 low; 8.1 to 9.5 normal; 9.6 to 11 good.
Mean values of two replicates.

Table 7. Yellow berry (%) of cv. Lleuque-INIA compared to control cvs. Llareta-INIA and Corcolén-INIA standard trials conducted in four irrigated locations from 2004 to 2008.

Location	Year	Cultivars		
		Lleuque-INIA	Llareta-INIA	Corcolén-INIA
		%		
La Platina	2004	5	1	5
	2005	10	5	5
	2006	1	0	5
	2007	10	5	10
	2008	0	0	0
	Mean	5.2	2.2	5.0
Chillán	2004	5	5	5
	2005	20	20	20
	2006	5	1	1
	2007	10	5	2
	2008	20	5	30
	Mean	12	7.2	11.6
Yungay	2004	0	0	0
	2005	0	0	0
	2006	20	20	20
	2007	0	2	0
	2008	0	0	0
	Mean	4	4.4	4
Humán	2004	0	0	0
	2005	0	0	0
	2006	5	0	1
	2007	0	0	0
	2008	5	0	0
	Mean	2	0	0.2

Mean values of two replicates.
From each sample, 50 g of grain was weighed and the grains with and without yellow berries were separated. The percentage was calculated by weight differences.

Table 8. Black tip (%) of cv. Lleuque-INIA compared to control cvs. Llareta-INIA and Corcolén-INIA standard trials conducted in four irrigated locations from 2004 to 2008.

Location	Year	Cultivars		
		Lleuque-INIA	Llareta-INIA	Corcolén-INIA
		%		
La Platina	2004	5	5	10
	2005	1	1	1
	2006	0	0	1
	2007	0	5	5
	2008	0	0	0
	Mean	1.2	2.2	3.4
Chillán	2004	0	0	1
	2005	1	5	1
	2006	0	0	0
	2007	0	0	5
	2008	0	0	0
	Mean	0.2	1	1.4
Yungay	2004	0	0	0
	2005	1	10	10
	2006	0	10	5
	2007	2	5	5
	2008	0	0	0
	Mean	0.6	5	4
Humán	2004	1	1	1
	2005	1	10	10
	2006	5	10	5
	2007	5	10	15
	2008	0	0	0
	Mean	2.4	6.2	6.2

Mean values of two replicates.
From each sample 50 g of grain were weight and separated the grain with and without black tip. Percentage was calculated by weight differences.

CONCLUSIONS

This is a new spring durum wheat variety with a high yield potential, mean hectoliter weight values between 81 and 84 kg hL^{-1}, wet gluten percentages between 28.83 and 35.66%, and mean protein values fluctuating between 10.47% and 12.3%. The var. Lleuque-INIA has exhibited resistance to stripe rust, leaf rust, stem rust, and a low to moderate resistance to powdery mildew.

The sowing zone for this variety stretches from the Metropolitan Region to the Bío Bío Region between June and August in irrigated soils.

RESUMEN

Lleuque-INIA, nueva variedad de trigo candeal de primavera de alto potencial de rendimiento para Chile. La variedad de trigo candeal (*Triticum turgidum* var. *durum* L.) de primavera Lleuque-INIA proviene de un cruzamiento efectuado el año 1993 por el Programa Nacional de Trigo del Instituto de Investigaciones Agropecuarias INIA en el Centro Regional de Investigación La Platina, Santiago, Chile. Es un trigo con hábito de crecimiento erecto al estado de plántula, la planta adulta es de altura mediana y varía entre 80 y 90 cm. La espiga es de tamaño medio, compacta, de color blanco, presenta barbas largas de color blanquizco en toda su extensión. El grano es de tamaño grande, de forma alargada, color amarillo dorado y vítreo. Sembrado a mediados de agosto en el Campo Experimental Santa Rosa (36°31' S; 71°54' O), Chillán, la emisión de espigas ocurre entre los 89 y 91 días después de la siembra, siendo entre 6 a 8 días más tardío que 'Llareta-INIA' y 'Corcolén-INIA'. En La Platina 'Lleuque-INIA' tuvo un rendimiento medio 16,7% y 20,8% superior a la vars. Llareta-INIA y Corcolén-INIA, respectivamente; en la localidad de Chillán este rendimiento fue superior en 10,3% y 10,1%, respectivamente; por otro lado en Yungay, precordillera de Ñuble, el rendimiento de 'Lleuque-INIA' superó a 'Llareta-INIA' en 13,07% y a la var. Corcolén-INIA en 16,97%. En la localidad de Humán el rendimiento de la var. Lleuque-INIA también superó en 15,23% y 24,03% a las variedades testigo Llareta-INIA y Corcolén-INIA, respectivamente. La var. Lleuque-INIA es un trigo de buen peso del hectolitro, buen contenido de gluten húmedo (%) y con valores medios de proteína que fluctúan entre 10,47% y 12,3%.

Palabras clave: trigo candeal, trigo duro, *Triticum turgidum* var. *durum*, Lleuque-INIA.

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