‘Cougar’ Quinoa

Figure 1. Cougar at maturity stage

‘Cougar’ (39-64) quinoa (*Chenopodium quinoa*) cultivar developed and tested as QuF9839-64, was co-released in 2023 by Washington State University (WSU) and Brigham Young University (BYU). The name ‘Cougar’ was chosen to reflect the decade-long collaborative efforts of researchers at WSU and BYU. Scientists at WSU and BYU worked closely together to develop this quinoa variety, and the name Cougar (the mascot of both WSU and BYU) embodies this fruitful collaboration built on mutual goals, trust, and the open sharing of germplasm.

Breeding Team

Brigham Young University: Dr. Rick Jellen, Dr. Jeff Maughan
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Parentage, Breeding History, and Line Selection in the USA

Cougar (39-64) was developed from a cross between ‘NL6’ and ‘0654’. Crosses occurred in July 2004. The F_1 seed was grown in 8-inch diameter round pots in the greenhouse at Brigham Young University (Provo, Utah) in Sunshine Mix II (Sun Gro, Bellevue, WA, USA) supplemented with Osmocote fertilizers (Scotts, Marysville, OH, USA) under broad-spectrum halogen lamps, with 12-h photoperiods and daytime temperatures of 20°C and nighttime temperatures of 18°C. The F_1 plant was allowed to reach physiological maturity and then threshed. A total of 100 F_2 seeds were planted separately in 4-inch diameter pots and advanced to the $F_{7:8}$ generation using a single-seed decent protocol (one seed per head) under conditions described previously from 2006-2011.

In 2014, approximately 980 $F_{7:8}$ breeding lines from four distinct populations were planted as 1.5-m headrows at Tukey Organic Farm at Washington State University in Pullman, WA. Two years of vigorous selection for seed yield, early maturity, tolerance to lodging, adaptation to long day photoperiod, and other agronomic traits led to the selection of Cougar for further testing in Rwanda.

Evaluation in Replicated Yield Trials in Rwanda

Cougar was evaluated in Rwanda from 2016 to 2021 for seed yield and agronomic traits of interest including days to flowering, days to maturity, and plant height. The trials were conducted in two of Rwanda’s major agroclimatic zones: the Eastern lowland region, Ngoma and Kirehe Districts, Eastern Province, and the Northern highland region, Musanze and Burera Districts, Northern Province. The Eastern lowlands range from 1,000 to 1,500 m.a.s.l., receive mean average rainfall ranging from 740 to 1,000 mm, and mean annual temperatures between 19 and 22°C. The highlands—which include the Congo-Nile Ridge and volcanic chains of Birunga—range from 2,000 to 4,500 m.a.s.l., receive 1,300 to 1,550 mm annual rainfall, and mean annual temperature range between 10 and 14°C (Gotanegre et al., 1974; Ilunga et al., 2004; REMA, 2015; Ilunga & Muhire, 2010; David et al., 2011; Muhire et al., 2015).

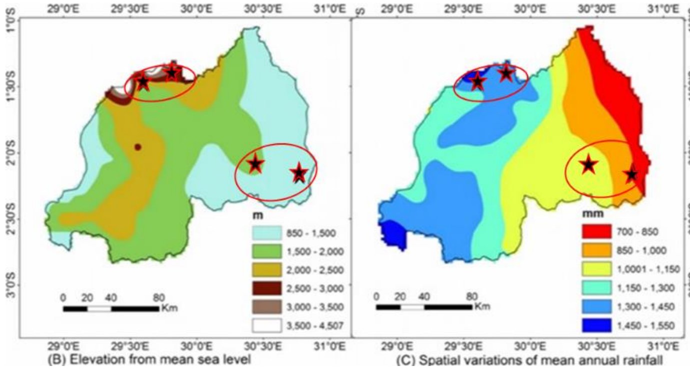

Figure 2. Elevation from mean sea level and spatial variations of mean annual rainfall of locations where Cougar quinoa variety trials were conducted in Rwanda (marked red circles) and black stars with red outlines represents Districts. Source (Muhire et al., 2015).

From 2016 to 2017, Cougar was grown alongside other nineteen quinoa cultivars in a randomized complete block design (RCBD) with four replicates in the Eastern lowlands and Northern highlands in Rwanda. Each plot was hand planted into two rows, in 4 × 1.2 m plots, using 5 g seed per plot (Habiyaremye et al., 2022). Phenotypic data were recorded according to Sosa-Zuniga et al. (2017) and Stanschewski et al. (2021). Days to flowering, days to maturity, and plant height were recorded according to Habiyaremye et al. (2022). Grain yield was measured as the weight of the grain harvested from the whole plot. The plots were harvested individually using sickles to cut the stems of the plants. All plants were bundled and threshed by hand. The seeds were processed by winnowing, using the wind to separate smaller particles and immature seeds from the mature seeds and for the final removal of any foreign plant material.

From 2017 to 2021, Cougar was evaluated on 52 farms in Rwanda. Of the 52 farms, 42 were located in the Eastern lowland region and 10 in the Northern highland region. A comparison of cultivars' grain yield and agronomic performance was conducted using ‘QQ74’, ‘Kaslaea’, ‘NL-6’, and ‘Titicaca’ as control cultivars. These cultivars were all new to Rwanda but have been evaluated in other locations worldwide. Seed yield evaluations were based on grain harvested from each farm.

Seed Purification and Increase

In February 2022, Cougar was sown in a 5 × 20 m strip at one of the QuinoaHub farms situated in Kigabiro Cell, Murama Sector, Ngoma District, Eastern Province for the elimination of off types. Identified off types were rogued and rows that appeared uniform and clean were harvested and bulked and planted in October 2022, creating foundation seed.

Figure 3. From left to right are Cougar at flowering and maturity stages, respectively, in Ngoma District, Eastern Province of Rwanda in 2022.

Grain Yield, Days to Flowering, Days to Maturity, and Plant Height

When tested in Rwanda from 2016 to 2021 Eastern lowland region, Cougar had a mean grain yield higher than the control cultivars Kaslaea, Titicaca, and NL-6, and equal to that of QQ74 (Table 1).

In the Northern highland region, Cougar had a grain yield higher than Titicaca and similar to QQ74, Kaslaea, and NL-6 (Table 2).

Table 1. Mean grain yield, days to flowering, days to maturity, and plant height of quinoa cultivar Cougar, QQ74, Kaslaea, NL-6, and Titicaca in replicated field trials and farming communities in Eastern lowland region (Ngoma and Kirehe) in Rwanda 2016-2021.

Cultivars	GY (kg ha^{-1})	DF (day)	DM (day)	PH (cm)
Cougar	1,337 a	45 a	90 c	78
QQ74	1,158 ab	41 bc	89 d	84
Kaslaea	993 b	42 b	117 b	73
NL-6	932 b	41 bc	130 a	73
Titicaca	929 b	40 c	85 e	77
LSD ($p < 0.05$)	336	1.428	1.307	30

GY: Grain yield; DF, days to flowering; DM, days to maturity; PH, plant height; LSD: least significant difference. LSD comparisons are significant at the 0.05 level. Dissimilar letters in a column are significantly different at $p \leq 0.05$.

When comparing cultivars across all years and locations, the results showed a difference in grain yield between Cougar and control cultivars (Table 3). Cougar, QQ74, Kaslaea, and NL-6, were higher yielding than Titicaca (Table 4)

Cougar was the latest flowering cultivar in both locations across all years (Table 1, 2). However, days to flowering and days to maturity differed between Eastern lowland and Northern highland regions; on average days to flowering of Cougar were 45 and 50 days in the Eastern lowland and Northern highland regions, respectively (Table 3). Across all locations and years, the earliest flowering cultivars were Titicaca and NL-6 with an average of 42 days each (Table 4). Cougar was among the early maturing cultivars with an average of 101 days to maturity in the Northern highland region (Table 2).

Table 2. Mean grain yield, days to flowering, days to maturity, and plant height of quinoa cultivar Cougar, QQ74, Kaslaea, NL-6, and Titicaca in replicated field trials and farming communities in the Northern highland region (Musanze and Burera) in Rwanda 2016-2021.

Cultivars	GY (kg ha^{-1})	DF (day)	DM (day)	PH (cm)
Cougar	1,731 a	50 a	101 c	113 ab
QQ74	2,021 a	48 ab	98 c	114 a
Kaslaea	2,005 a	47 b	116 b	98 bc
NL-6	2,015 a	43 c	126 a	88 cd
Titicaca	1,178 b	43 c	96 c	75 d
LSD ($p < 0.05$)	426	2	6	16

GY: Grain yield; DF, days to flowering; DM, days to maturity; PH, plant height; LSD: least significant difference. LSD comparisons are significant at the 0.05 level. Dissimilar letters in a column are significantly different at $p \leq 0.05$.

In the Eastern lowland, there was no significant difference in plant height among cultivars (Table 1). However, in the Northern highland region there was a difference in plant heights among cultivars, Cougar was among the tallest cultivars with an average of 113 cm while Titicaca and NL-6 were the shortest varieties with an average of 75 and 88 cm, respectively (Table 2). Location significantly affected the plant height of all cultivars, except for Titicaca (Table 3).

Table 3. Location differences in grain yield, days to flowering, days to maturity, and plant height of quinoa cultivar Cougar, QQ74, Kaslaea, NL-6, and Titicaca, across all years.

Cultivars	GY (kg ha^{-1})		DF (day)		DM (day)		PH (cm)	
	L	H	L	H	L	H	L	H
Cougar	1,337	1,731	45	50	91	101	78	113
QQ74	1,158	2,021	41	48	89	98	84	114
Kaslaea	993	2,005	42	47	117	116	74	98
NL-6	932	2,015	41	43	130	126	73	88
Titicaca	929	1,178	40	43	85	96	77	75
Mean	1,070	1,790	42	46	102	107	77	98
LSD (p <0.05)	148		1		2		11	

GY: Grain yield; DF, days to flowering; DM, days to maturity; PH, plant height; L, lowland; H, highland; LSD: least significant difference. LSD comparisons are significant at the 0.05 level.

When comparing cultivars across all locations and years, Cougar and QQ74 were the tallest cultivars, and Titicaca, and NL-6 were the shortest cultivars (Table 4).

Table 4. Mean grain yield, days to flowering, days to maturity, and plant height of Cougar, QQ74, Kaslaea, NL-6, and Titicaca across all locations and years.

Cultivars	GY (kg ha^{-1})	DF (day)	DM (day)	PH (cm)
Cougar	1468 a	47 a	96 c	95 ab
QQ74	1446 a	45 b	93 cd	99 a
Kaslaea	1332 a	45 b	116 b	86 abc
NL-6	1299 ab	42 c	128 a	80 bc
Titicaca	1014 b	42 c	90 d	76 c
LSD (p < 0.05)	295'	2	4	18

GY: Grain yield; DF, days to flowering; DM, days to maturity; PH, plant height; LSD: least significant difference. LSD comparisons are significant at the 0.05 level. Dissimilar letters in a column are significantly different at $p \leq 0.05$.

Consumption and Use

Cougar serves as a multi-purpose crop for vegetable, grain, and livestock feed production. Growers consume its nutritious leaves and grains; both its leaves and grains are used in different dishes and are also used to make various food and drink products. The straws are used as livestock feed.

The purple and green-leafed trait found in Cougar was an attractive trait to Rwandan farmers and played a vital role in the adoption of quinoa as a new crop in Rwanda. The purple and green color of quinoa leaves is also an important trait to many farmers because it helps them to identify quinoa from its closely related, green-leafed weed species, lambsquarter (*Chenopodium album*).

Availability

Foundation seeds will be available from QuinoaHub Ltd (www.QuinoaHub.com) to farmers starting in September 2023.

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