Quadrilateral vs bilateral VSP – An alternative option to maintain yield?

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Training & re-training

Why do Colorado vineyards have such low yields?

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Training & re-training

Why do Colorado vineyards have such low yields?

Cold

What contributes to low yields?

- Cold temperature injury

But there are also other factors:

- Management issues
  - Variety / site selection
  - Vineyard setup

    (vine x row spacing; trellis / training system)
  - Vine pruning / training
  - Low vine vigour

What contributes to low yields?

- Cold temperature injury
  - Damage to fruitful (primary, secondary) buds
  - Loss of cordons / canes
  - Loss of trunks
  - Loss of vines

Other factors besides cold that contribute

- Management issues
  - Variety / site selection
    - Cold-sensitive varieties in cold sites
  - Vineyard setup
    - Small total canopy size per acre:
      - Low vine densities
      - Trellis/training systems

Other factors besides cold that contribute

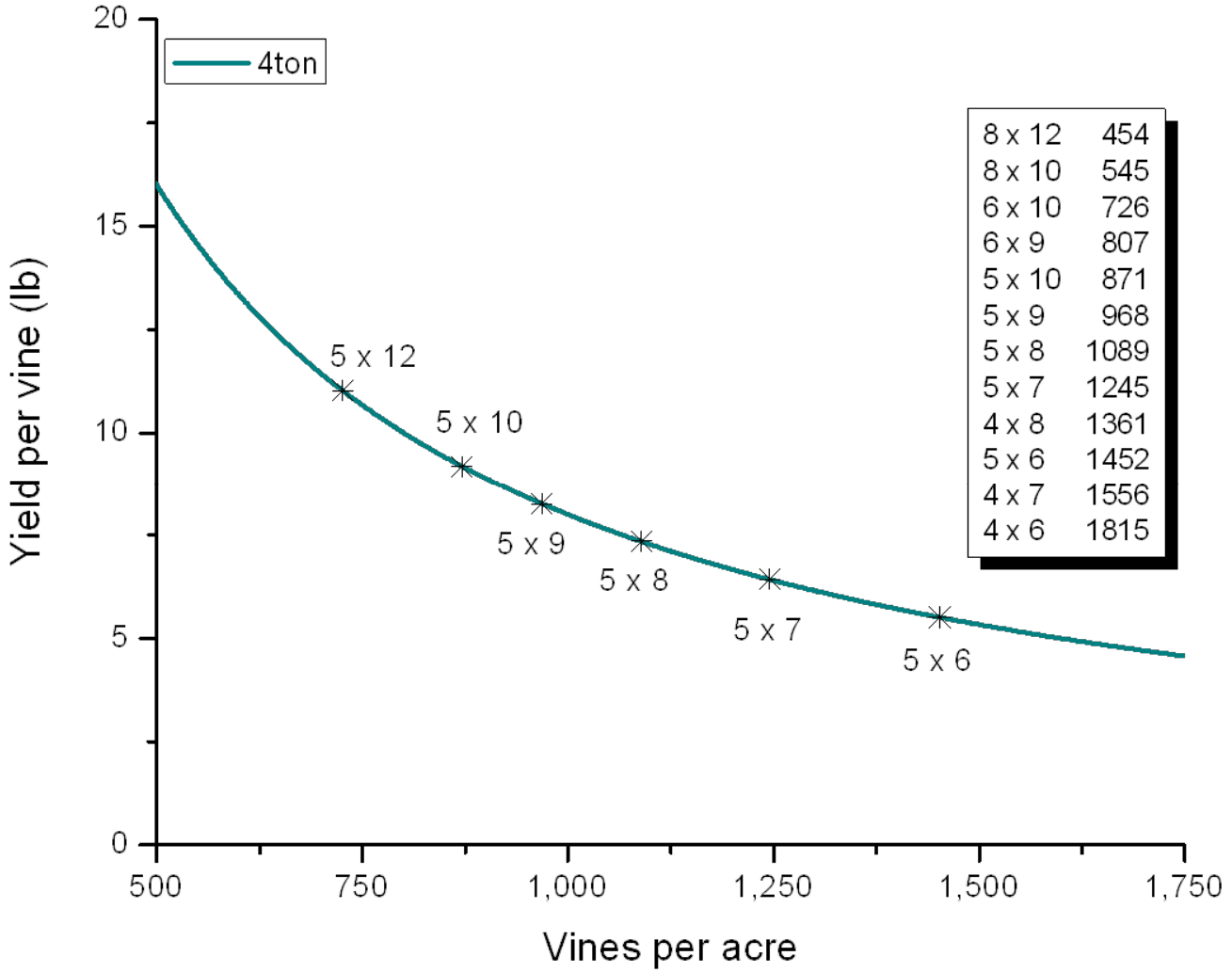
- Management issues
  - Vine pruning / training
    - Pruning too aggressive (low bud number)
    - Single-trunk vines
  - Low vine vigour
    - Nutrient deficiencies
    - Water stress
    - Excessive crop load in previous year(s)
    - Inappropriate vine spacing

Vine densities

Vine spacing (ft)	Row spacing (ft)	Vine density (vines/acre)
5	12	726
5	10	871
5	9	968
5	8	1,089
5	7	1,245
5	6	1,452

Vine densities

- Target yield of 4 ton/acre



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Low vine densities

- For a target yield of 4 ton/acre we need
  - 11.0 lb/vine at 5’ x 12’
  - 9.18 lb/vine at 5’ x 10’
  - 8.26 lb/vine at 5’ x 9’
  - 7.35 lb/vine at 5’ x 8’
  - 6.43 lb/vine at 5’ x 7’
  - 5.50 lb/vine at 5’ x 6’

Row / canopy length

Vine spacing (ft)	Row spacing (ft)	Row length (ft/acre)
5	12	3,630
5	10	4,356
5	9	4,840
5	8	5,445
5	7	6,225
5	6	7,260

Relationship between canopy length & yield

A vineyard with a 10 foot row spacing has 4,356 ft of row (=canopy) length per acre. For a target yield of 4 ton/acre we need to produce 1.84 lb/ft of row:

4,356 ft/acre * 1.84 lb/ft ~ 8,000 lb/acre (5’ x 10’)

At closer row spacings we need less lb/ft for the same per-acre yield as there are more feet of canopy per acre:

5,445 ft/acre * 1.47 lb/ft ~ 8,000 lb/acre (5’ x 8’)

7,260 ft/acre * 1.10 lb/ft ~ 8,000 lb/acre (5’ x 6’)

Relationship between canopy length & yield

Scenario: A Syrah vineyard trained to VSP. Vines are cordon-trained and spur-pruned, leaving three 2-bud spurs per foot. Average bunch weight is ¼ lb.

There is no cold injury (100 % bud break of primary buds). Fruitfulness is high, averaging 2 clusters per shoot.

What yield can we expect?

Relationship between canopy length & yield

Three 2-bud spurs per foot produce 6 shoots per foot.

Six shoots per foot produce 12 bunches per foot.

12 bunches * ¼ lb per bunch = 3 lb/ft

3 lb/ft * 4,356 ft/acre = 13,068 lb/acre (~6.5 ton/acre)

3 lb/ft * 5,445 ft/acre = 16,335 lb/acre (~8.2 ton/acre)

3 lb/ft * 7,260 ft/acre = 21,780 lb/acre (~10.9 ton/acre)

But is this realistic?

Relationship between canopy length & yield

These are not realistic assumptions:

There is no cold injury

100 % bud break of primary buds

Fruitfulness is high, averaging 2 clusters per shoot

There is 100 % canopy fill within the vineyard

Relationship between canopy length & yield

Looking back to all surveys since 2000, Syrah in Mesa County has averaged 2.7 ton/acre, and has never reached an annual average of 4 ton/acre.

At the wide spacing of 5’ x 10’ a yield of 4 ton/acre is only 61.5 % of our theoretical yield.

In other words, even in the best vintages Syrah is at least 40 % below the potential (and this is true for all other varieties).

Why? And how do we change that?

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What contributes to low yields?

- Cold temperature injury

- Management issues
  - Variety / site selection
  - Vineyard setup

    (vine x row spacing; trellis / training system)
  - Vine pruning / training
  - Low vine vigour

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Which ones are easy to address?

- Cold temperature injury

- Management issues
  - Variety / site selection
  - Vineyard setup

    (vine x row spacing; trellis / training system)
  - Vine pruning / training
  - Low vine vigour

Bi- versus quadrilateral cordon/cane

Bilateral cordon with spur pruning is the standard pruning method in Colorado.

Our observations with bilateral cordon indicate that shoot density is often well below optimum, even when bud damage due to cold injury is taken into consideration prior to pruning.

We are looking for means to increase bud/shoot number per vine other than longer or more spurs on the cordons.

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Bi- versus quadrilateral cordon/cane

Why not just leave spurs longer and/or leave more spurs on the cordon?

Bi- versus quadrilateral cordon/cane

Bi- versus quadrilateral cordon/cane

In 2011, we started an experiment to compare the standard bilateral to a quadrilateral system.

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Objective

Increase yield via an increase of shoot density (= decrease of canopy gaps).

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Materials and Methods

Two field sites in 2011

- Vineyard A
  - Syrah
  - Planted in 2001, 5’ x 9’ (968 vines per acre)
  - VSP
- Vineyard B
  - Tempranillo
  - Planted in 2009, 5’ x 2 m (1,328 vines per acre)
  - VSP

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Materials and Methods

At site A, a second (higher) cordon wire was added in 2 rows, and an additional two canes/vine were trained to that wire.

At site B, four pairs of rows were selected prior to pruning. For each pair, a second (higher) cordon wire was added to one row, and an additional two canes/vine were trained to that wire.

Fruit was harvested separately from lower and upper wire.

Materials and Methods

Harvest measurements (per row & wire)

- Bunch number
- Yield

Other measurements

- Vine number (per row)
- Number of buds retained (separate for lower & upper wire)
- Number of shoots (separate for lower & upper wire)
- Number of vines used for each treatment (~70 %)

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Quadrilateral cane – Syrah 2011

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Quadrilateral cane – Syrah 2011

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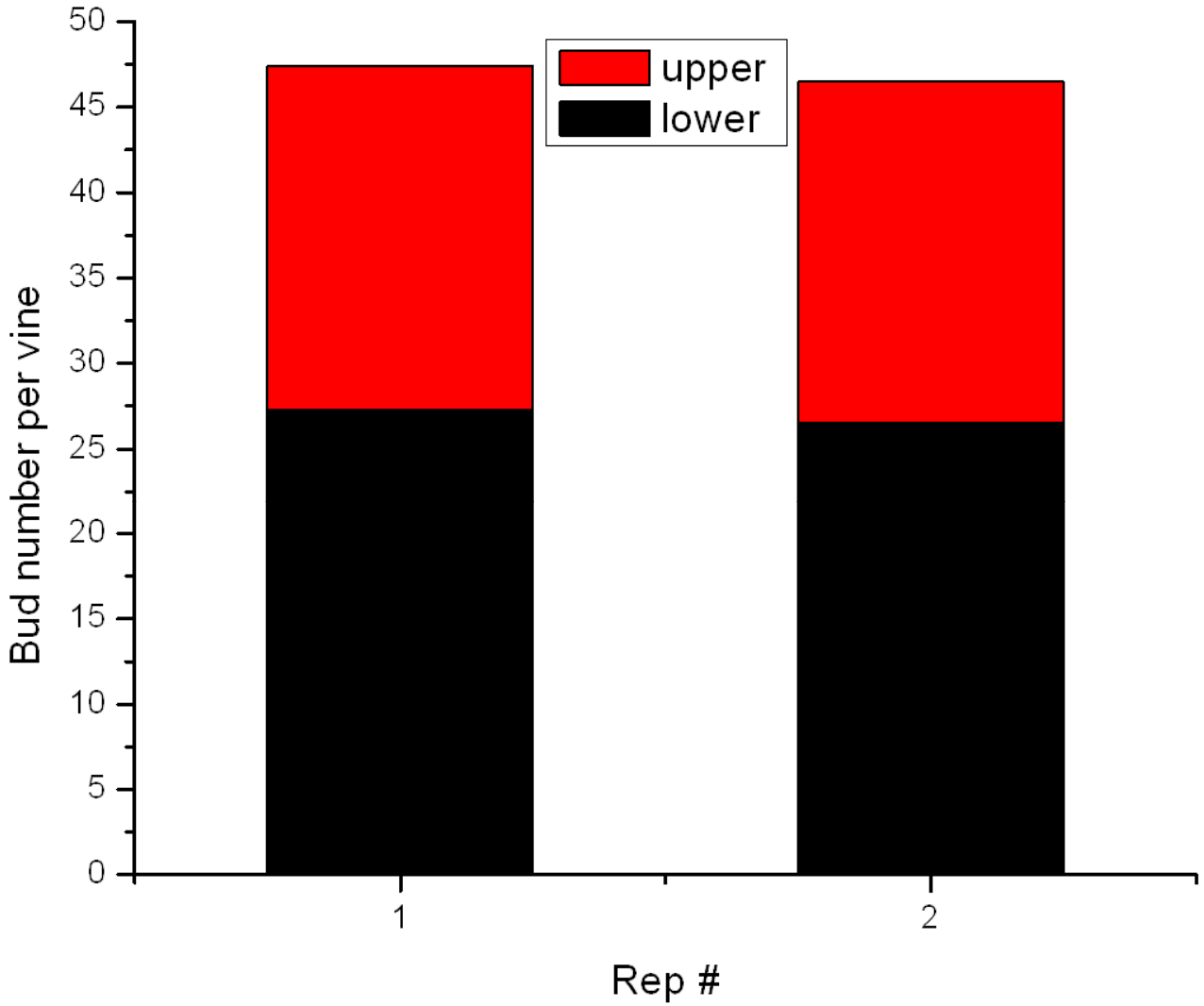
Results – Syrah 2011



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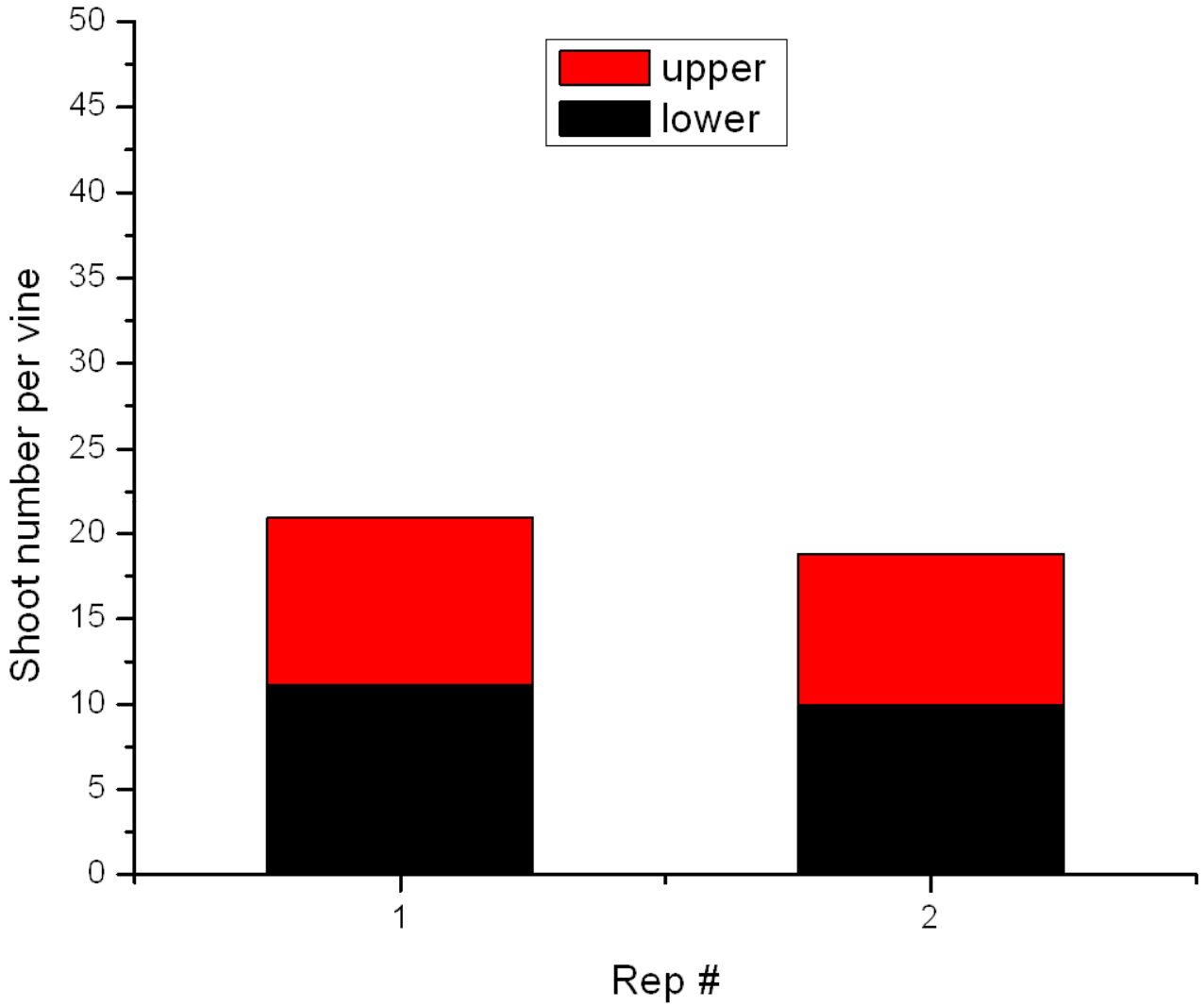
Results – Syrah 2011



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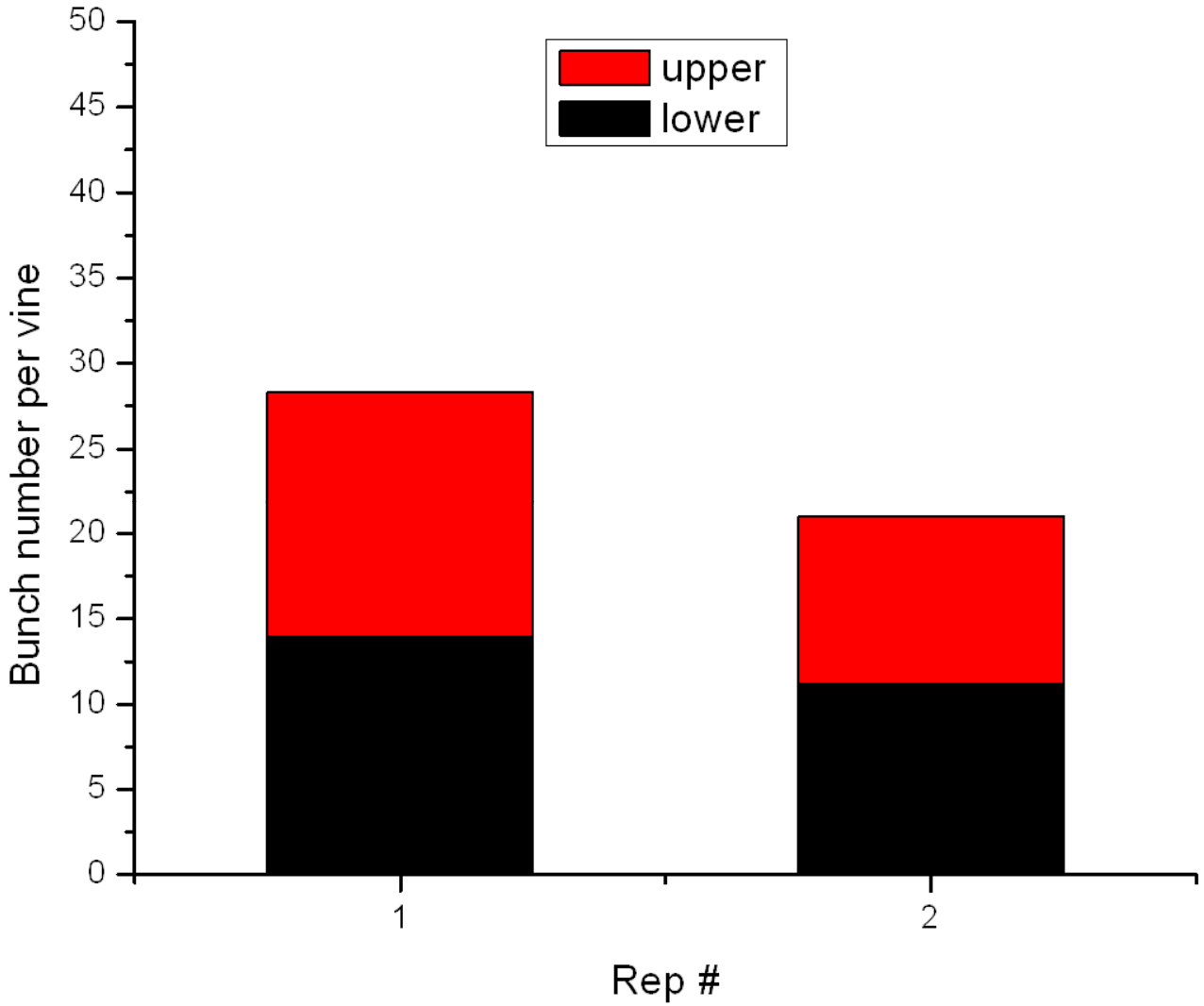
Results – Syrah 2011



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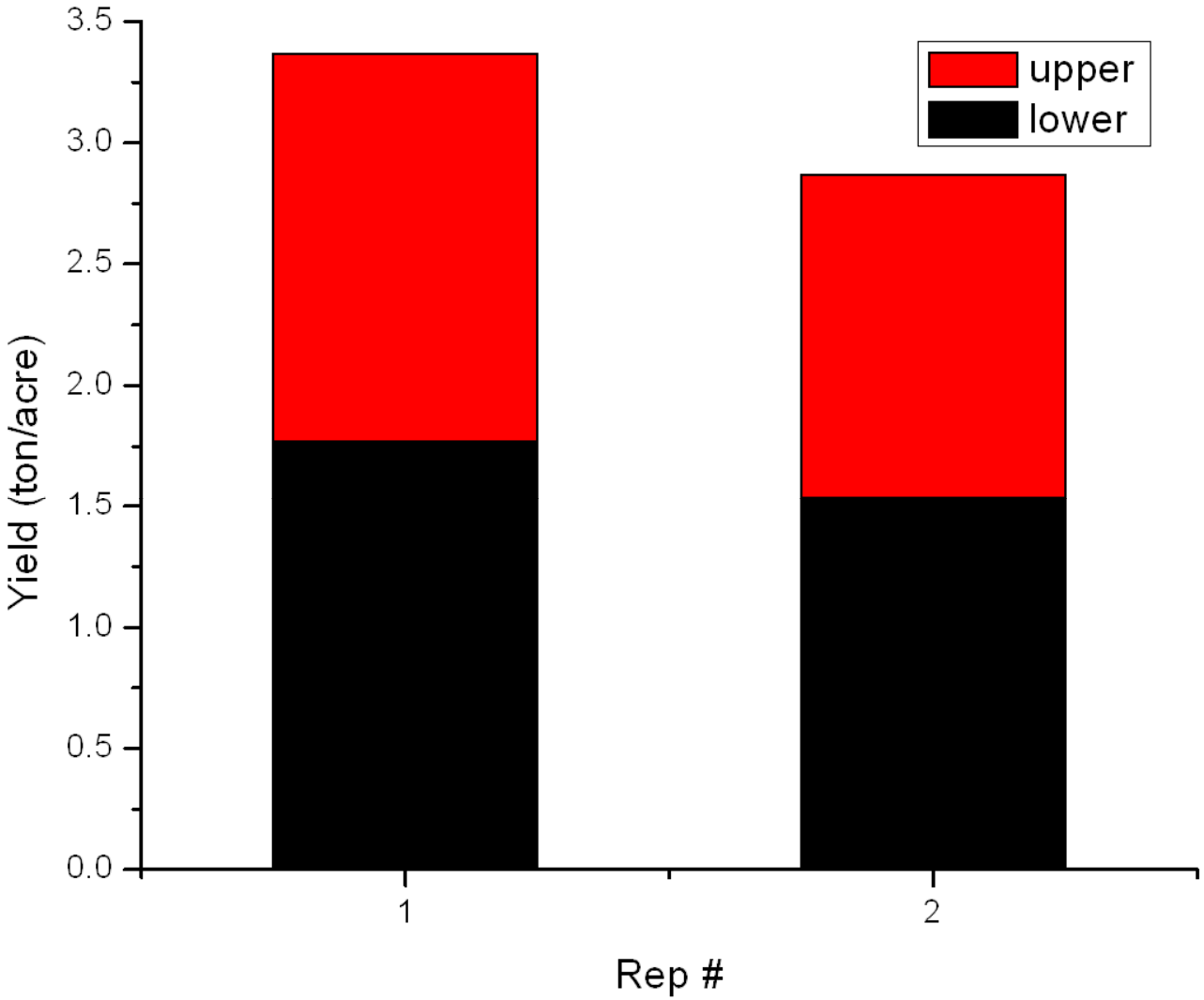
Results – Syrah 2011



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Results – Syrah 2011

The change from bi- to quadrilateral training resulted in

- 74 % more buds
- 89 % more shoots
- 67 % more bunches
- 88 % more yield

In a year when both percentage bud break (42 %) and fruitfulness (1.24 bunches/shoot) was low.

YIELD WAS STILL <4 TON/ACRE

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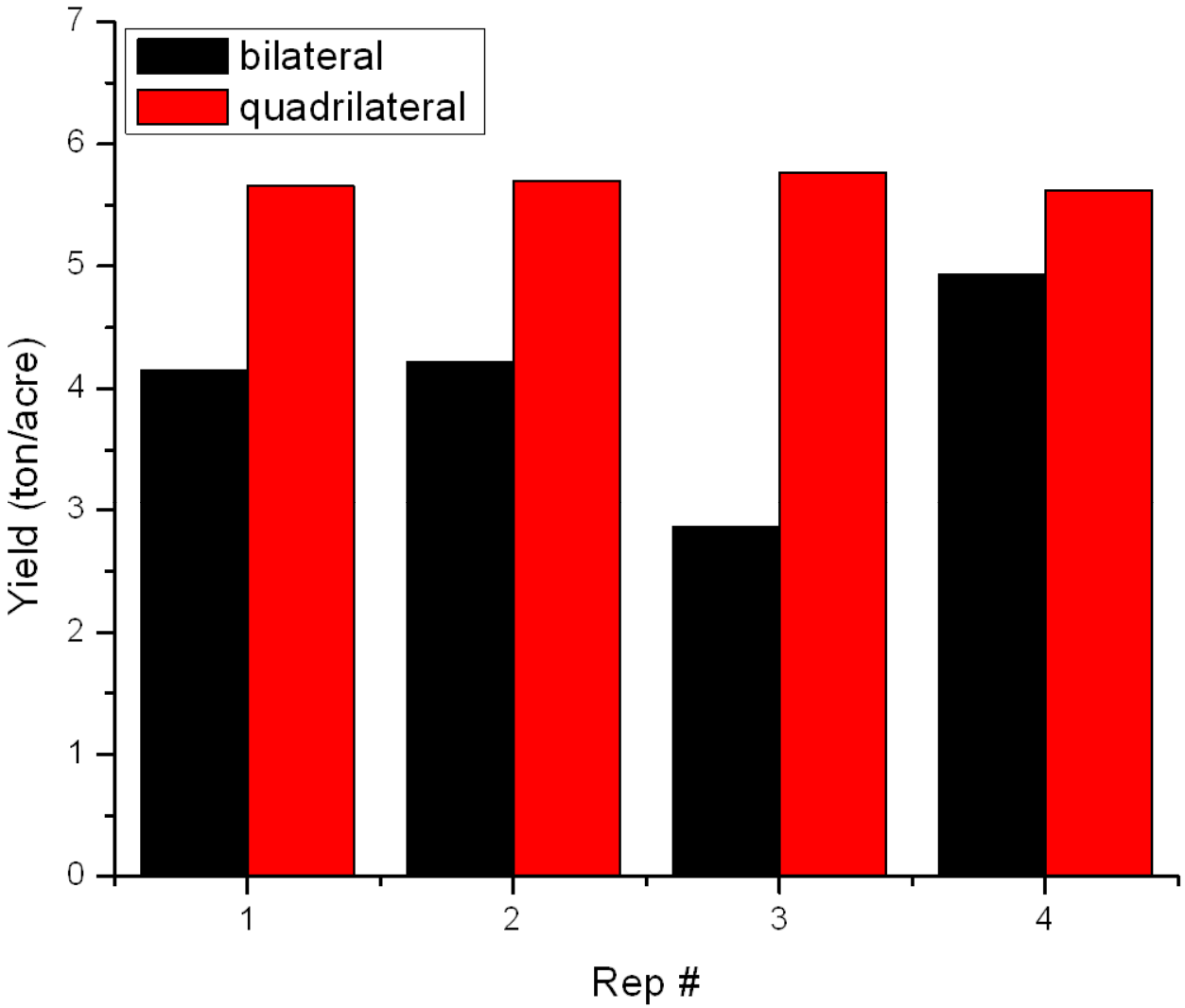
Results – Tempranillo 2011



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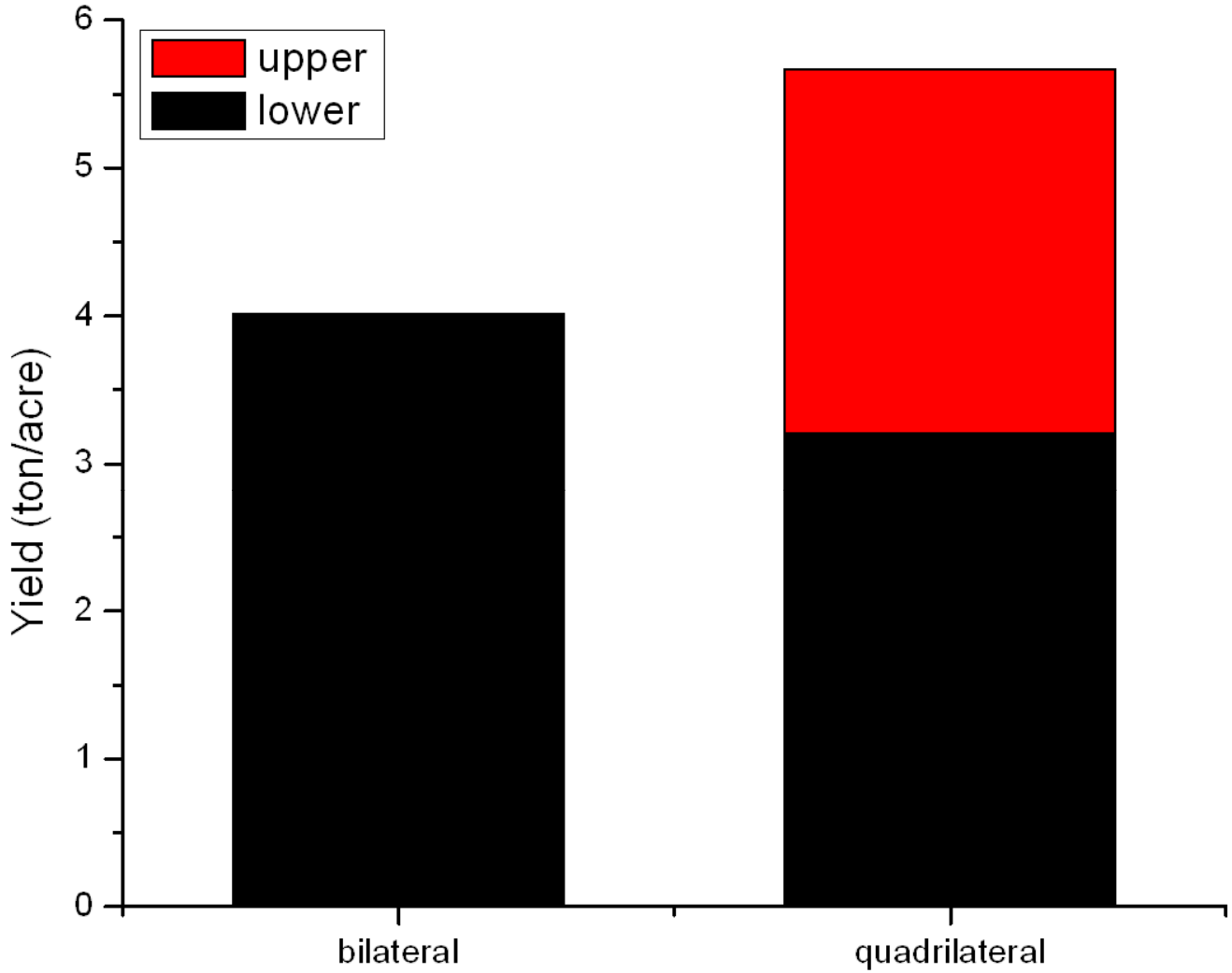
Results – Tempranillo 2011



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Results – Tempranillo 2011

The change from bi- to quadrilateral training resulted in

- 55 % more buds
- 62 % more shoots
- 56 % more bunches
- 41 % more yield

In a year when both percentage bud break (36 %) and fruitfulness (1.28 bunches/shoot) was low.

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Bi- versus quadrilateral cordon/cane

The 2011 growing season was unusual.

First, vines are still recovering from the Dec. 2009 cold event.

Second, cold events in early January and again early February resulted in ~30 % dead primary buds.

Third, a late spring freeze (May 1 and 2) led to further bud injury right at the time of bud break.

Combined, this led to very low percentage final bud break (42 % in Syrah; 36 % in Tempranillo) and very low shoot densities with bilateral training (2.1 shoots/ft for Syrah; 2.0 shoots/ft for Tempranillo).

Bi- versus quadrilateral cordon/cane

The 2011 growing season was unusual (cont.)

- Hence, almost doubling the number of buds retained after pruning did not cause excessive shoot densities but resulted in shoot densities much closer to the desired values (4 – 6 shoots/ft for non-divided canopies) and a significant yield increase.
- In years when bud cold injury is minimal and percentage bud break is high, bud and/or early shoot thinning would be required to avoid excessive shoot densities.
- However, in our Syrah block low shoot densities have been the norm – not the exception – and we will continue to evaluate quadri- versus bilateral training with our VSP trellis for at least another 2 years.

Quadrilateral vs bilateral VSP – The second year (2012)

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Materials and Methods

Three field sites in 2012

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  - Syrah
  - Planted in 2001, 5’ x 9’ (968 vines per acre)
  - VSP
- Vineyard B
  - Tempranillo
  - Planted in 2009, 5’ x 2 m (1,328 vines per acre)
  - VSP
- Vineyard C
  - Gewürztraminer
  - Planted in 2007, 5’ x 8’ (1,089 vines per acre)
  - VSP

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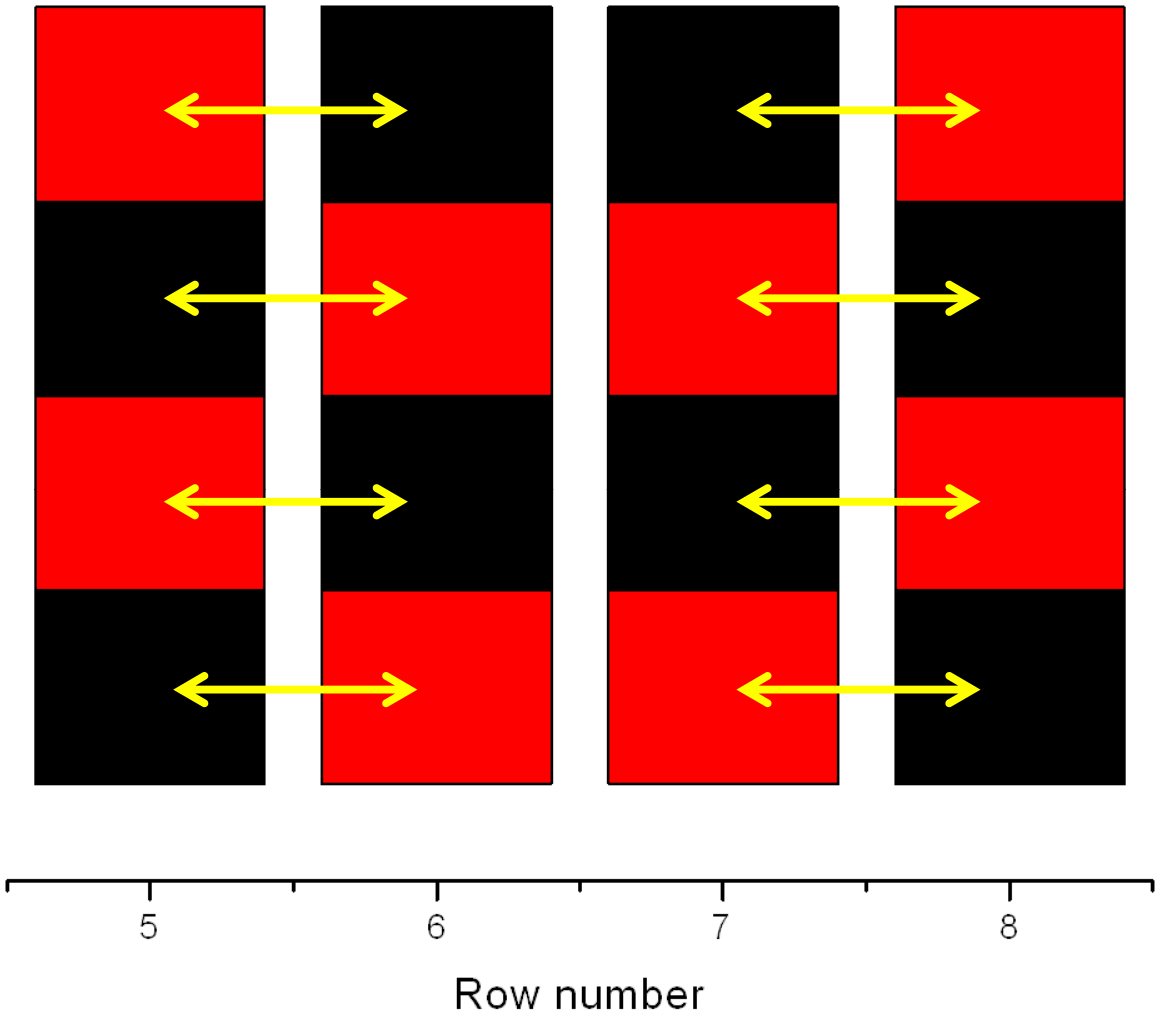
Materials and Methods

In 2012, some methodology was changed:

At site B, detailed measurements were made in four (out of 12) central panels with yield data collected on entire rows.

At site C, four 6-vine panels in the center of four adjacent rows were selected prior to pruning. Treatments (bi- or quadrilateral) were alternated between panels down rows #5 and #7, with opposing treatments in rows #6 and #4, respectively (paired comparison with 8 reps).

Materials and Methods



Materials and Methods

Harvest measurements (per row or panel & wire)

- Bunch number
- Yield

Other measurements

- Vine number
- Number of buds retained (separate for lower & upper wire)
- Number of shoots (separate for lower & upper wire)
- Number of vines used for each treatment (~70 % at site A; close to 100 % in selected panels at B and C)

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Quadrilateral cane – Syrah, Jan 2012

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B2C2 after pre-pruning – Syrah, Feb 2012

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B2C2 at bud break – Syrah, 1 May 2012

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B2C2 at bloom – Syrah, 31 May 2012

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B2C2 at harvest – Syrah, 12 Sep 2012

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B2C2 at harvest – Syrah, 12 Sep 2012

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B2C2 upper canes harvested – Syrah, 2012

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B2C2 after harvest – Syrah, 12 Sep 2012

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B2C2 after harvest - Syrah

Upper canes
54 bunches
13.4 lb
1.95 lb/ft

Lower cordons
38 bunches
10.1 lb
1.36 lb/ft

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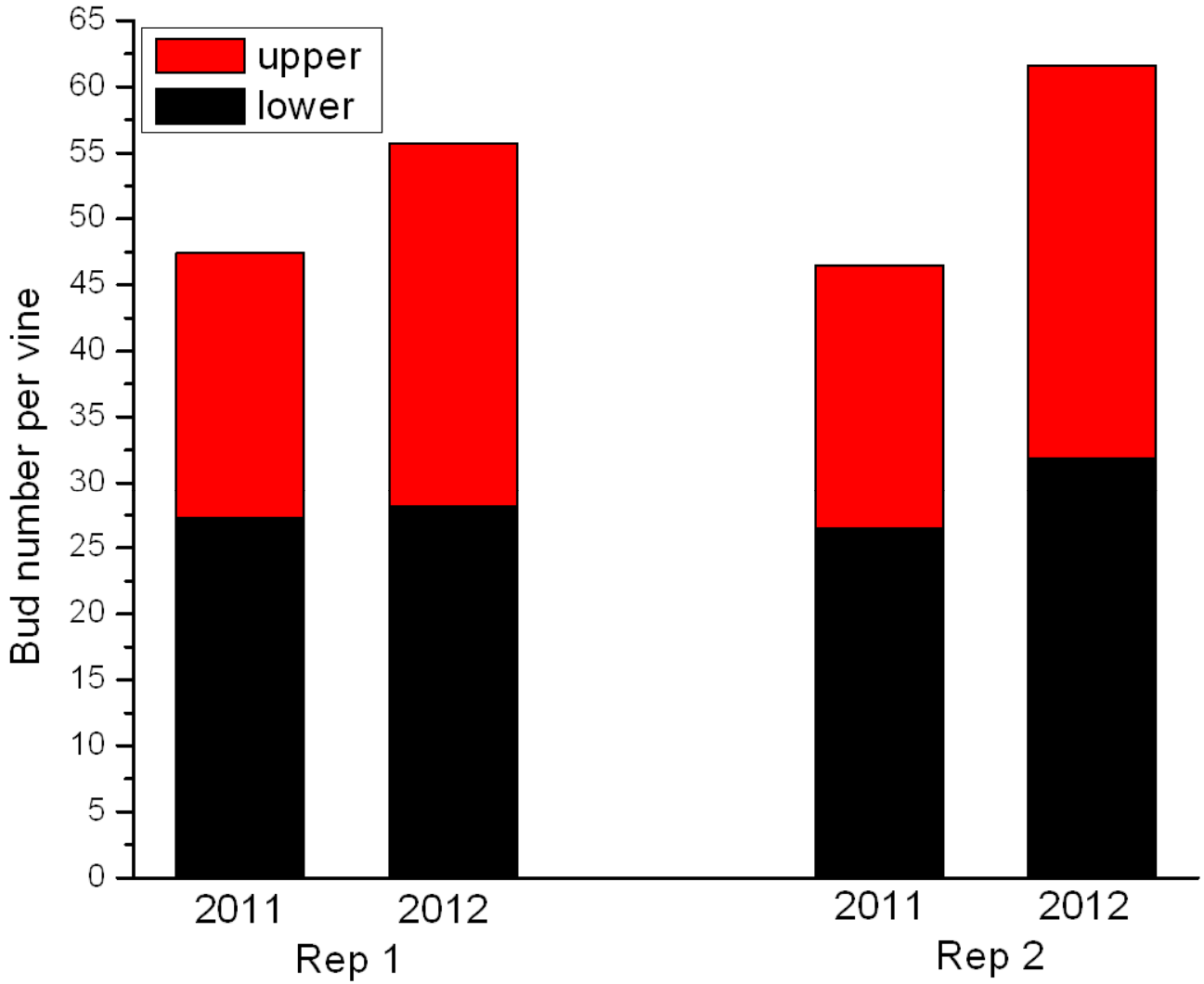
Results – Syrah 2012



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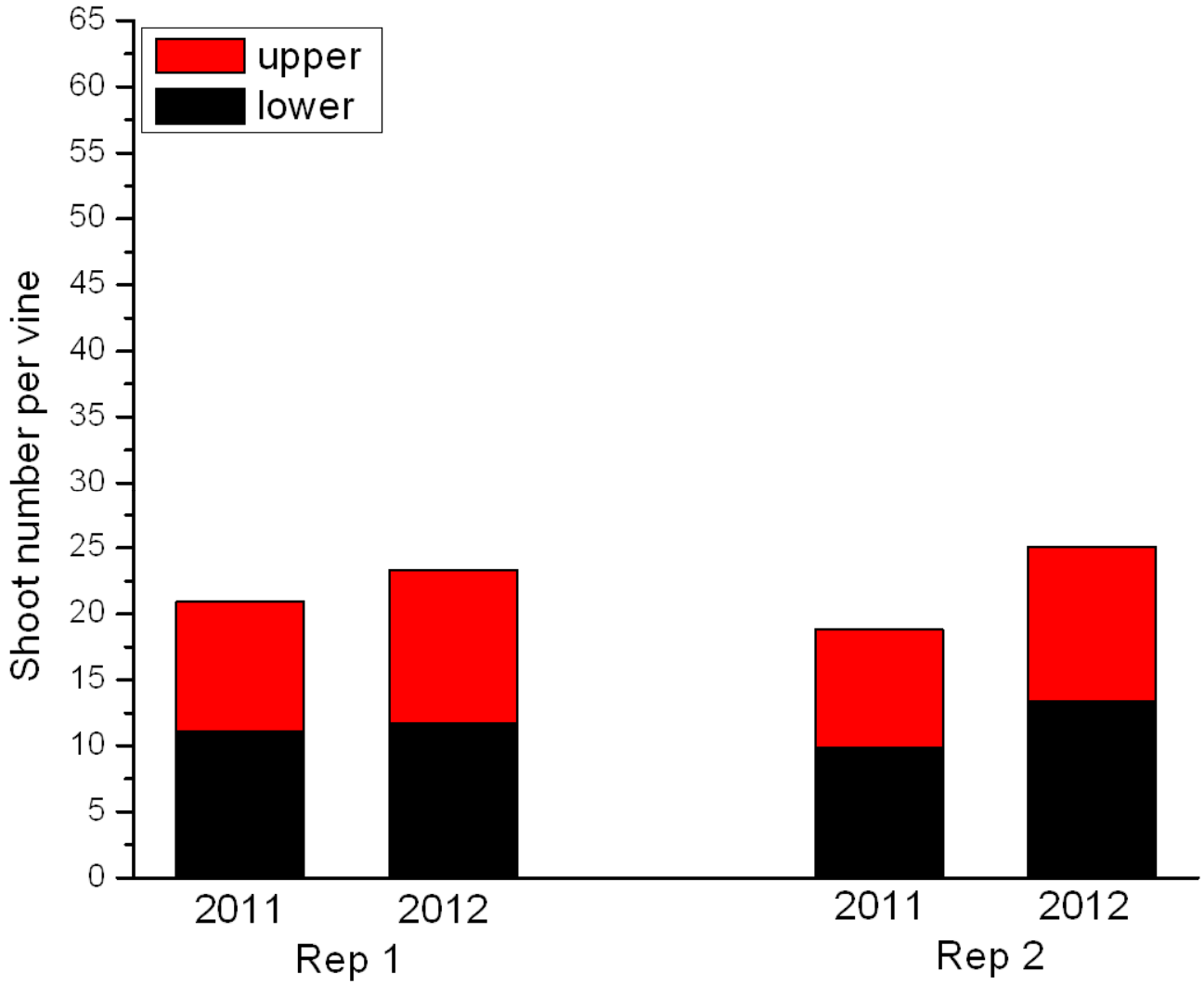
Results – Syrah 2012



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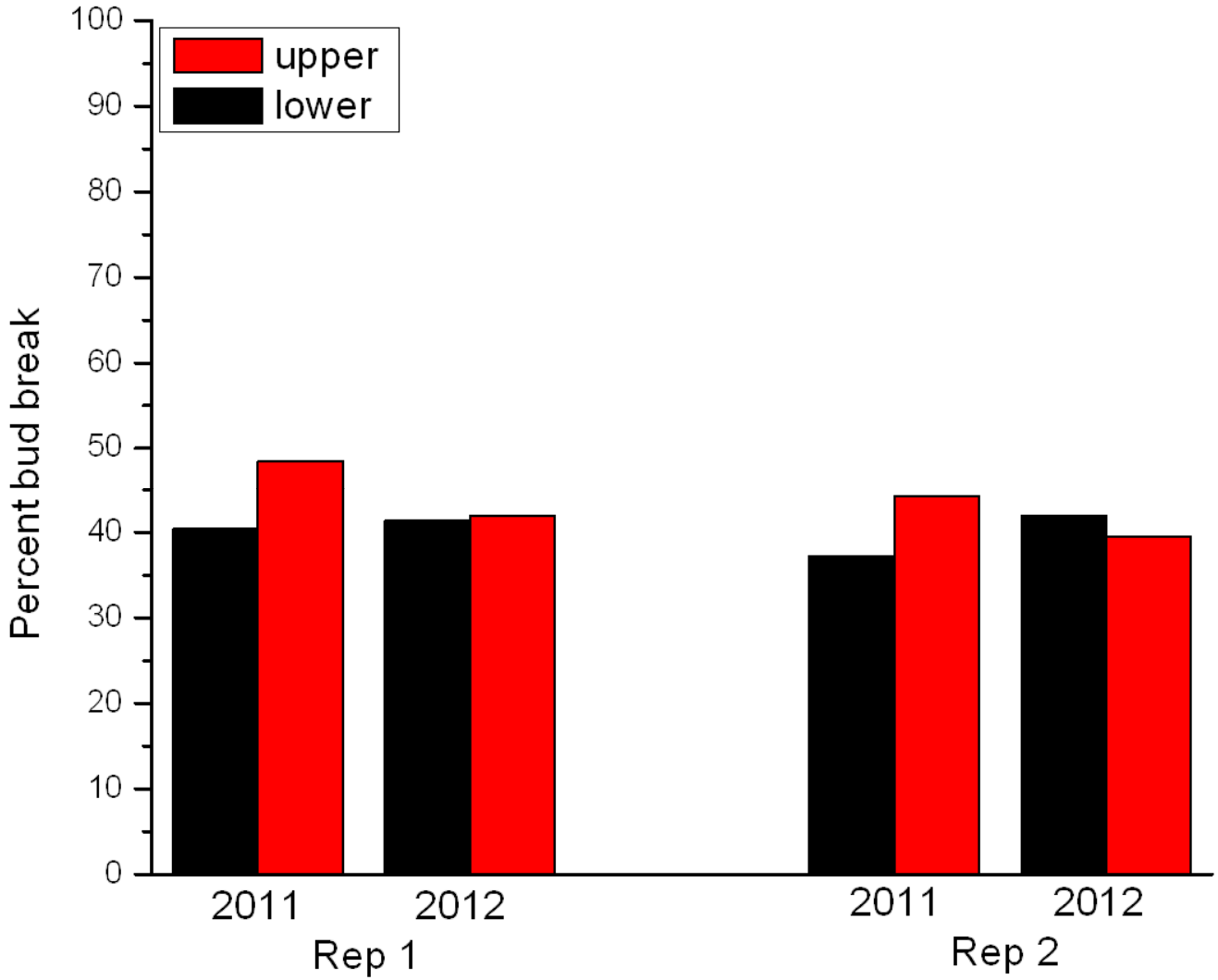
Results – Syrah 2012



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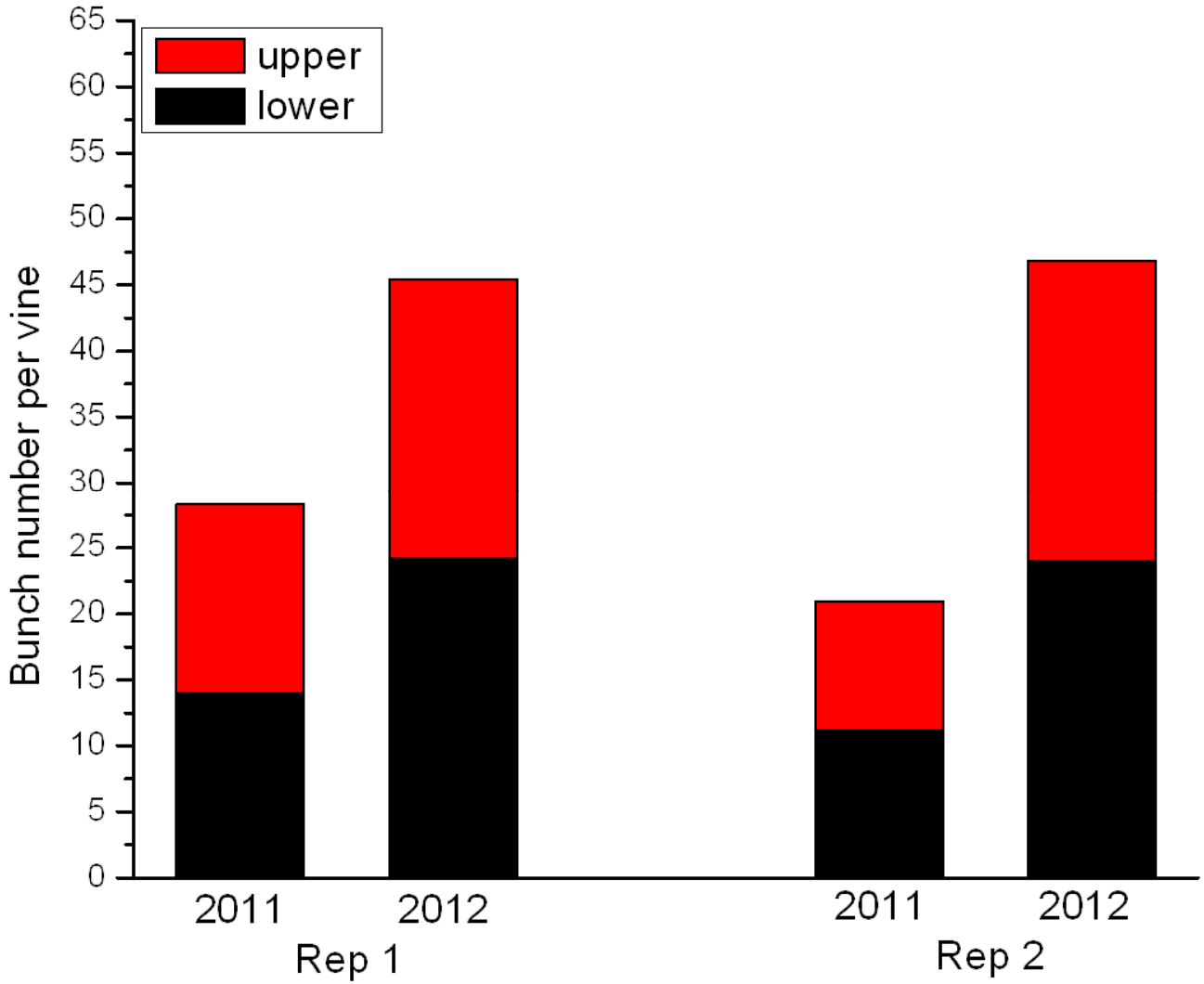
Results – Syrah 2012



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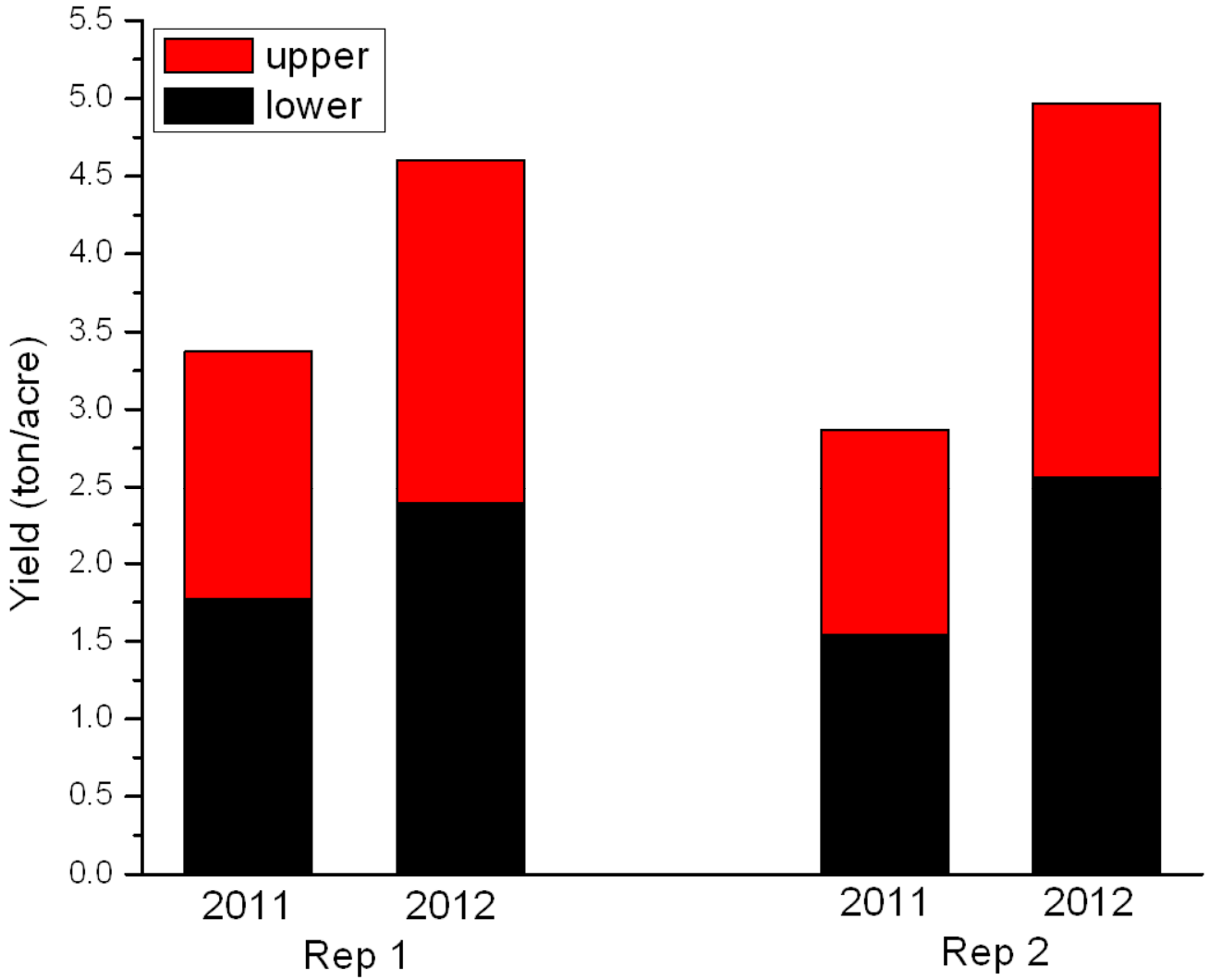
Results – Syrah 2012



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Syrah 2012 versus 2011

Slight increase in nodes retained after pruning.

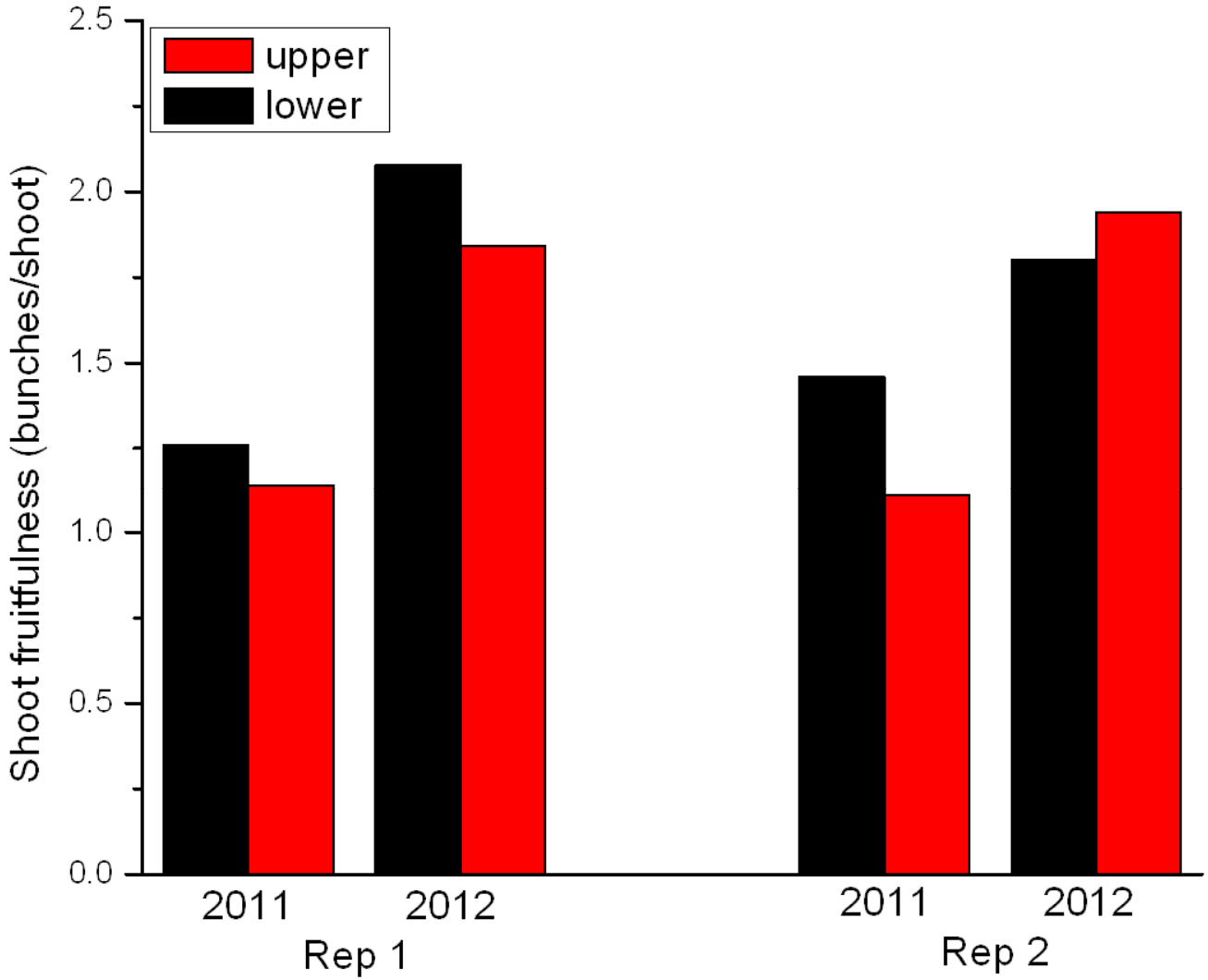
Almost identical percentage bud break.

Hence, only a slight increase in shoot number per vine.

But a large increase in bunch number per vine, and thus yield, with no changes in mean bunch and berry weights.

How do we explain this large yield increase?

Results – Syrah 2012



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Syrah 2012 versus 2011

The primary reason for the much higher yield in 2012 was NOT

Higher bud number / shoot number / percentage bud break

But higher shoot fruitfulness, most likely the outcome of a much higher percentage of primary shoots in 2012.

Quadrilateral cane – Syrah, Dec 2012

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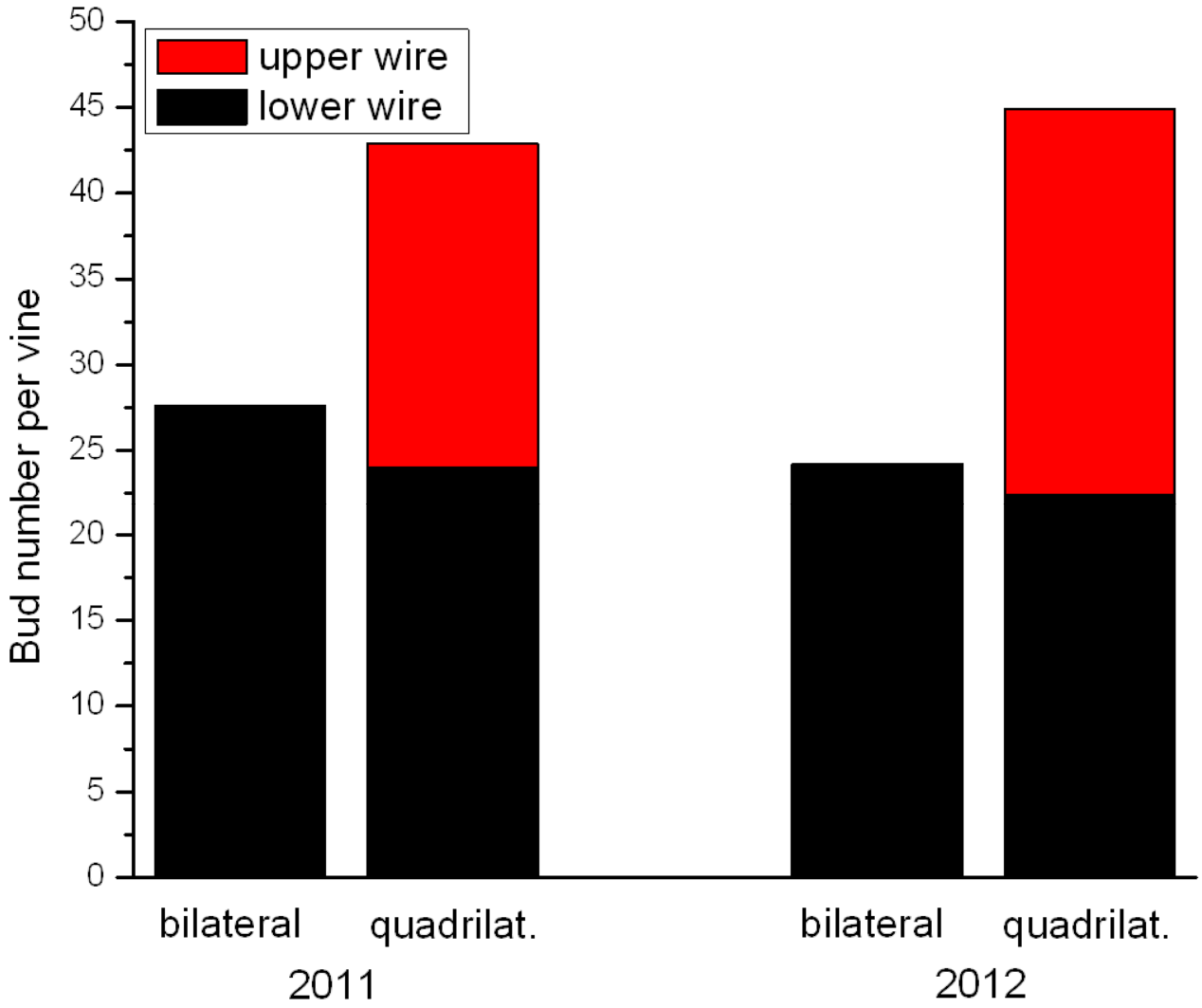
Results – Tempranillo 2012



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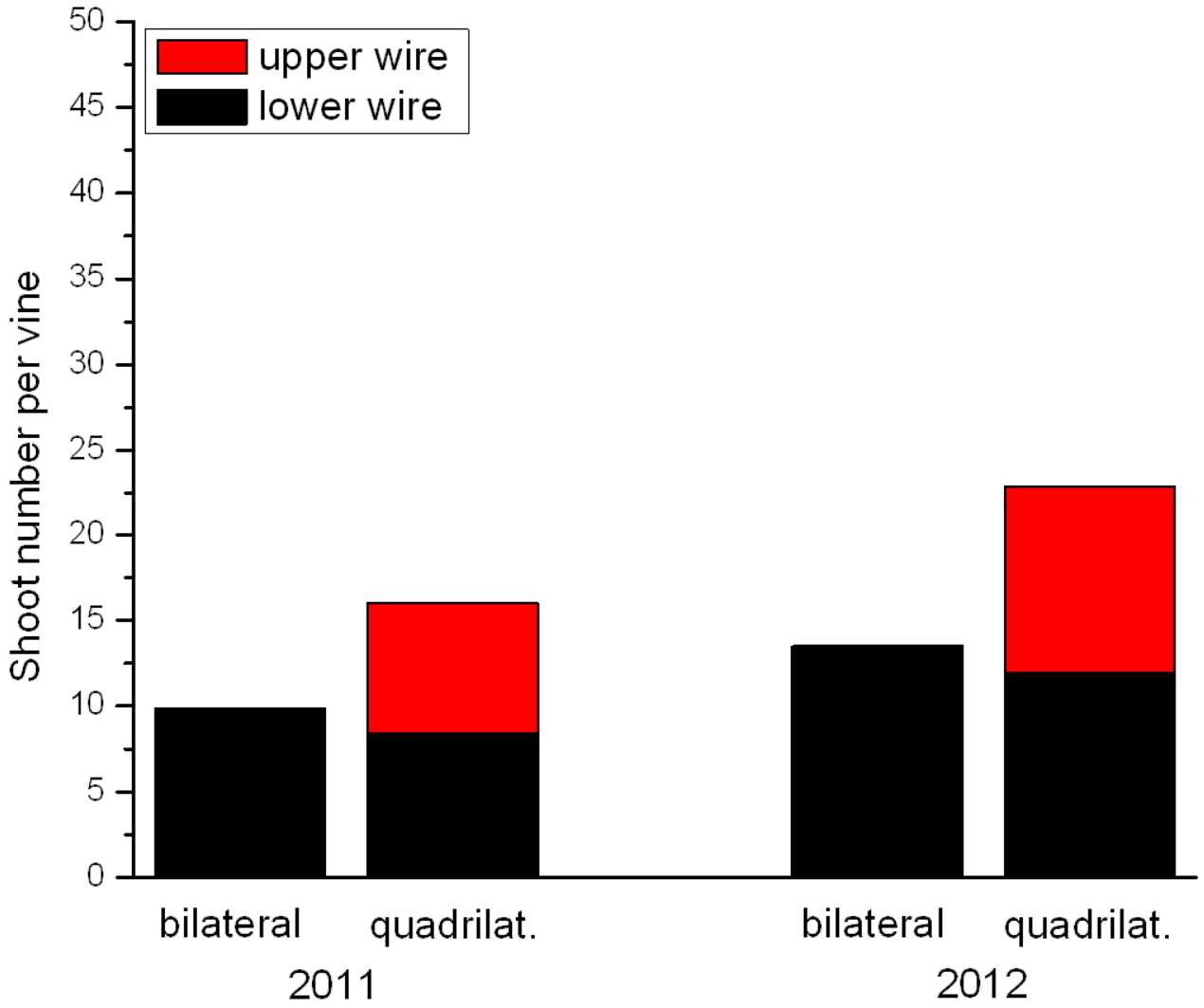
Results – Tempranillo 2012



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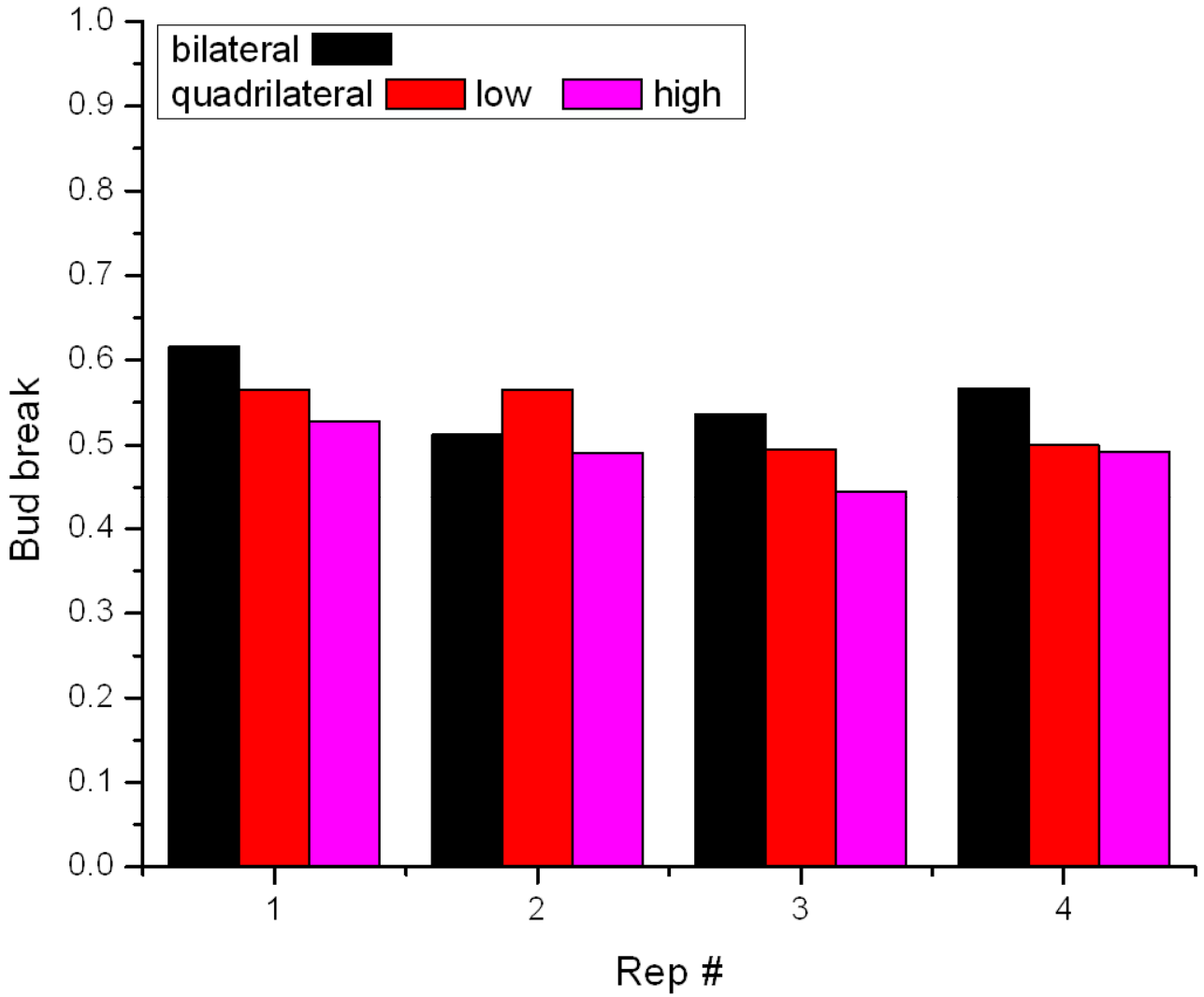
Results – Tempranillo 2012



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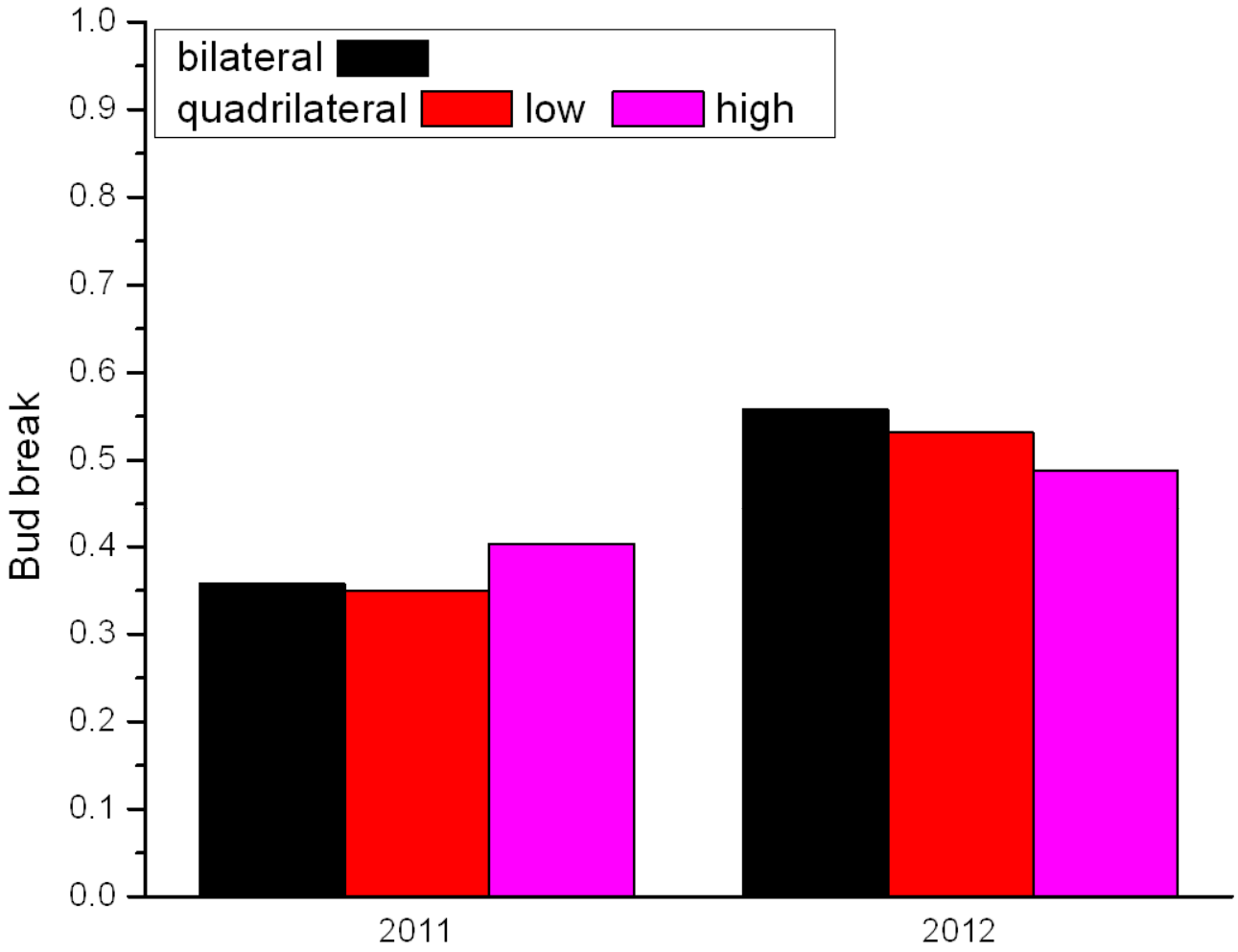
Results – Tempranillo 2012



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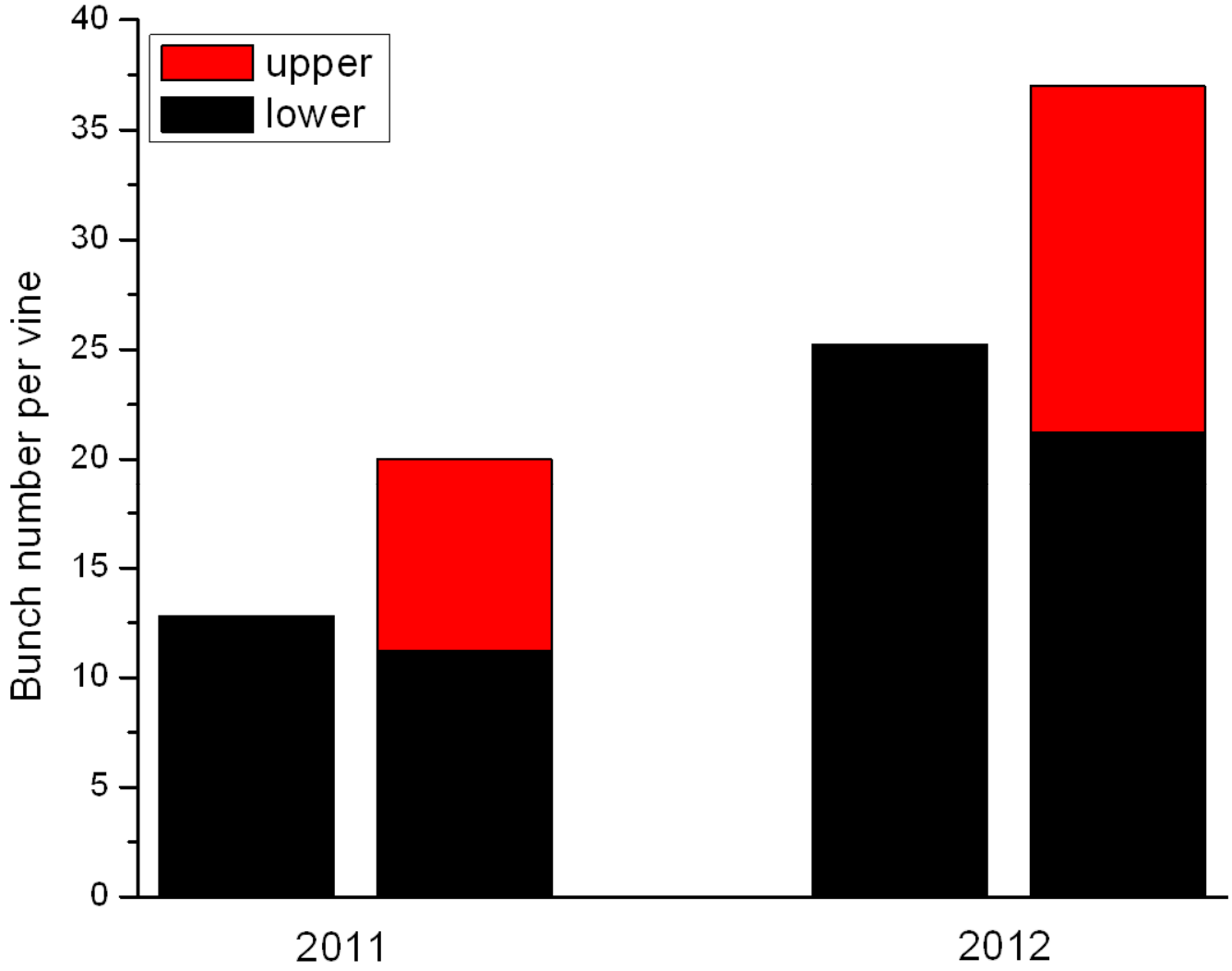
Results – Tempranillo 2012



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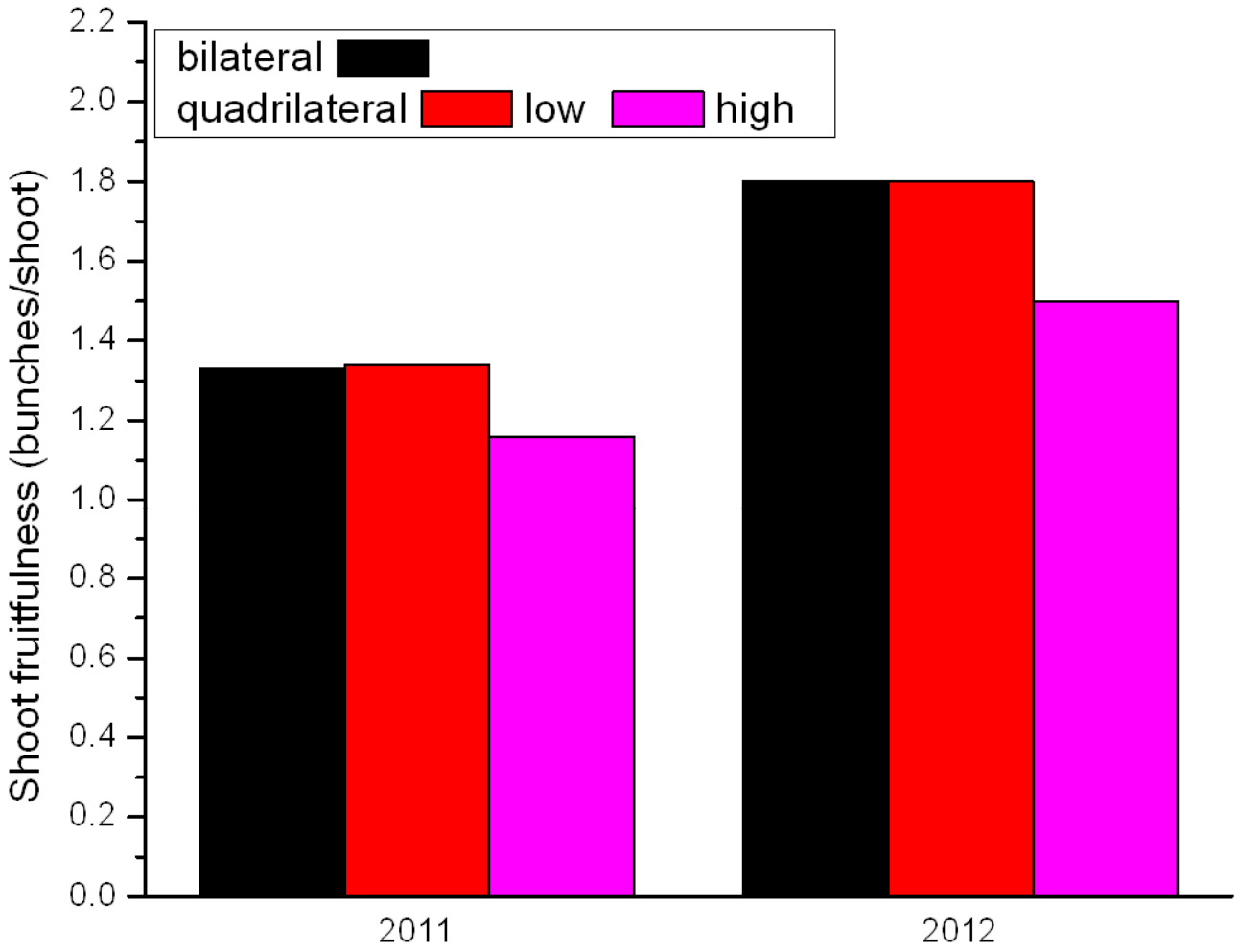
Results – Tempranillo 2012



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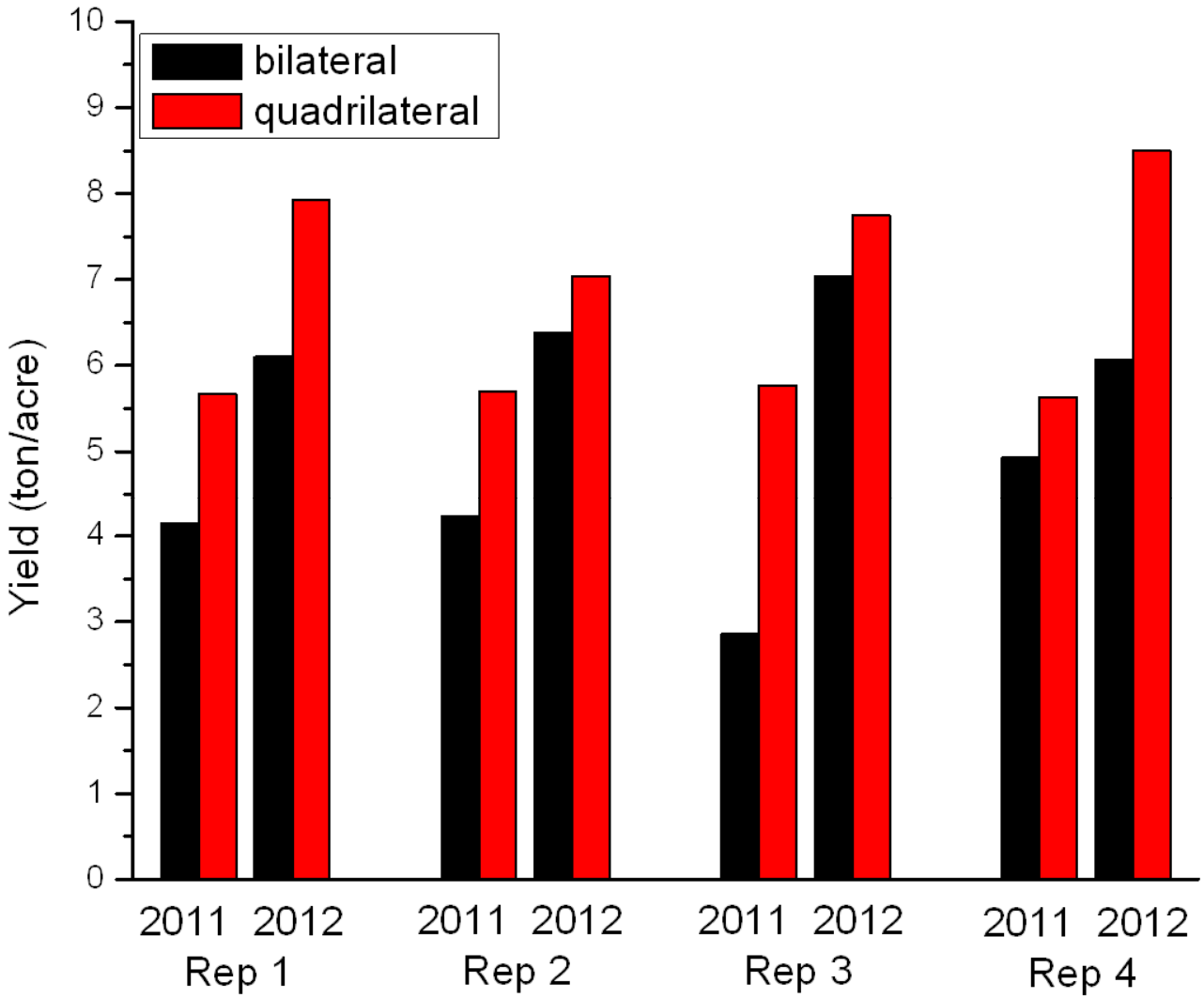
Results – Tempranillo 2012



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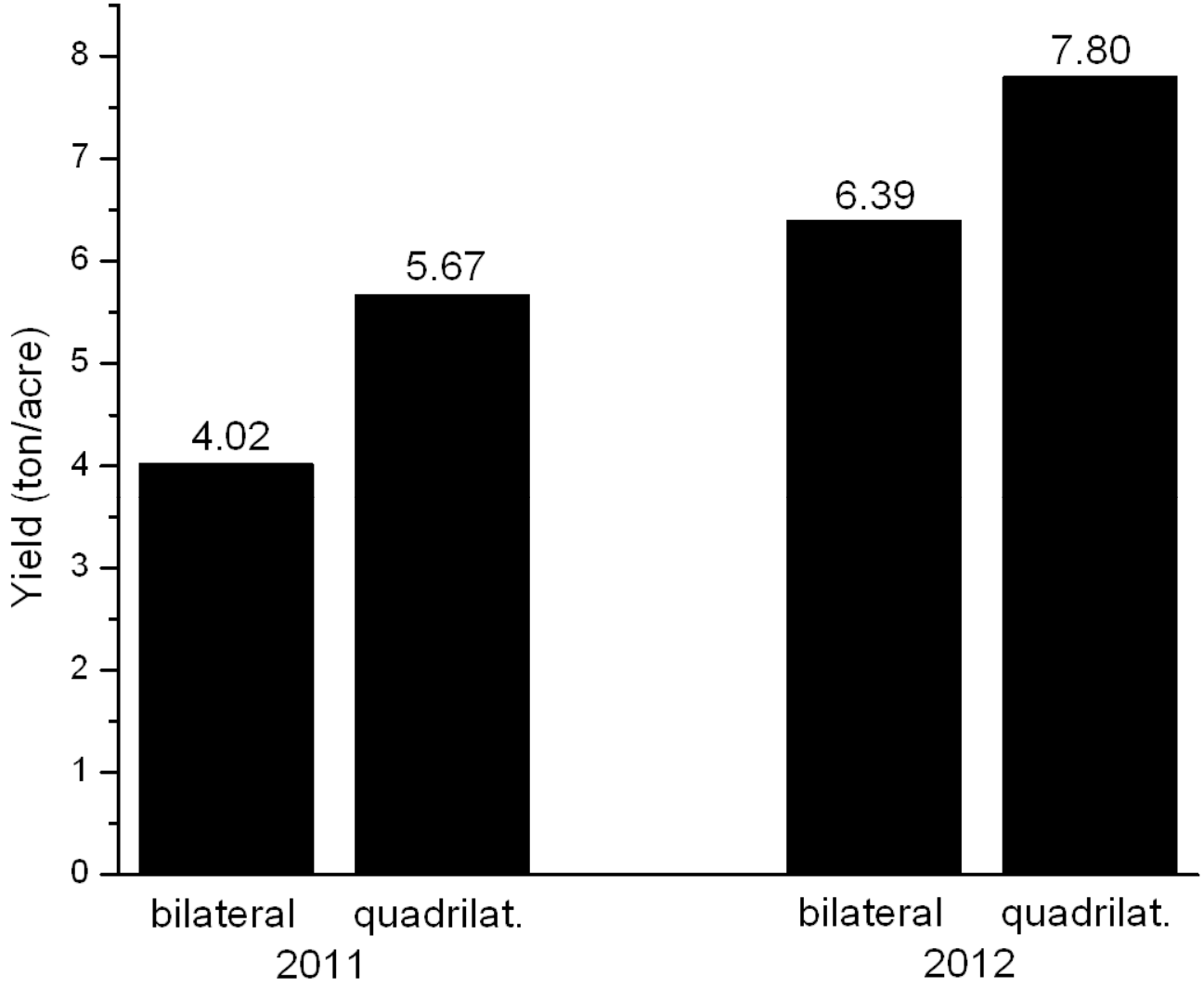
Results – Tempranillo 2012



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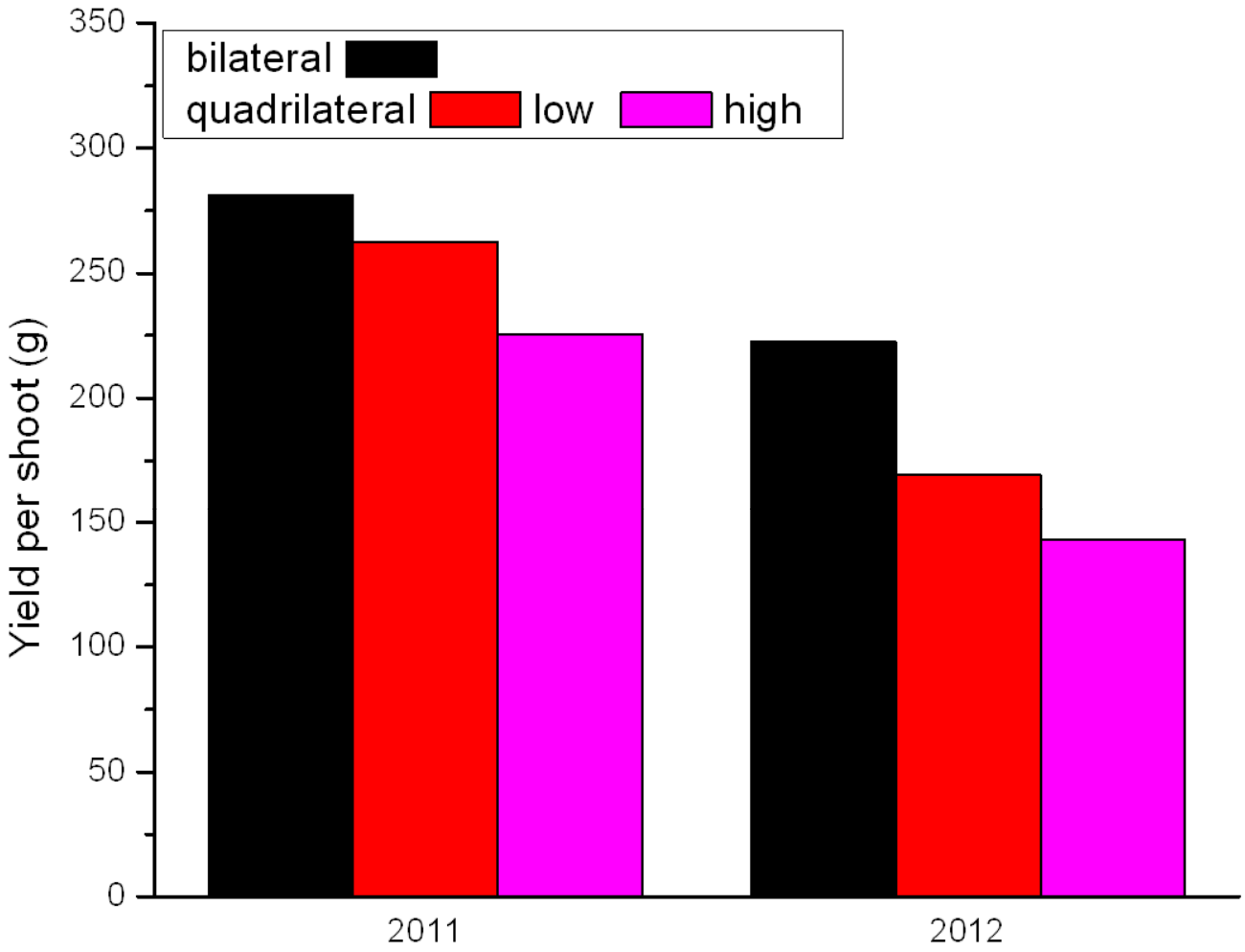
Results – Tempranillo 2012



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Tempranillo 2012 versus 2011

Large increase (~50 %) in nodes retained after pruning.

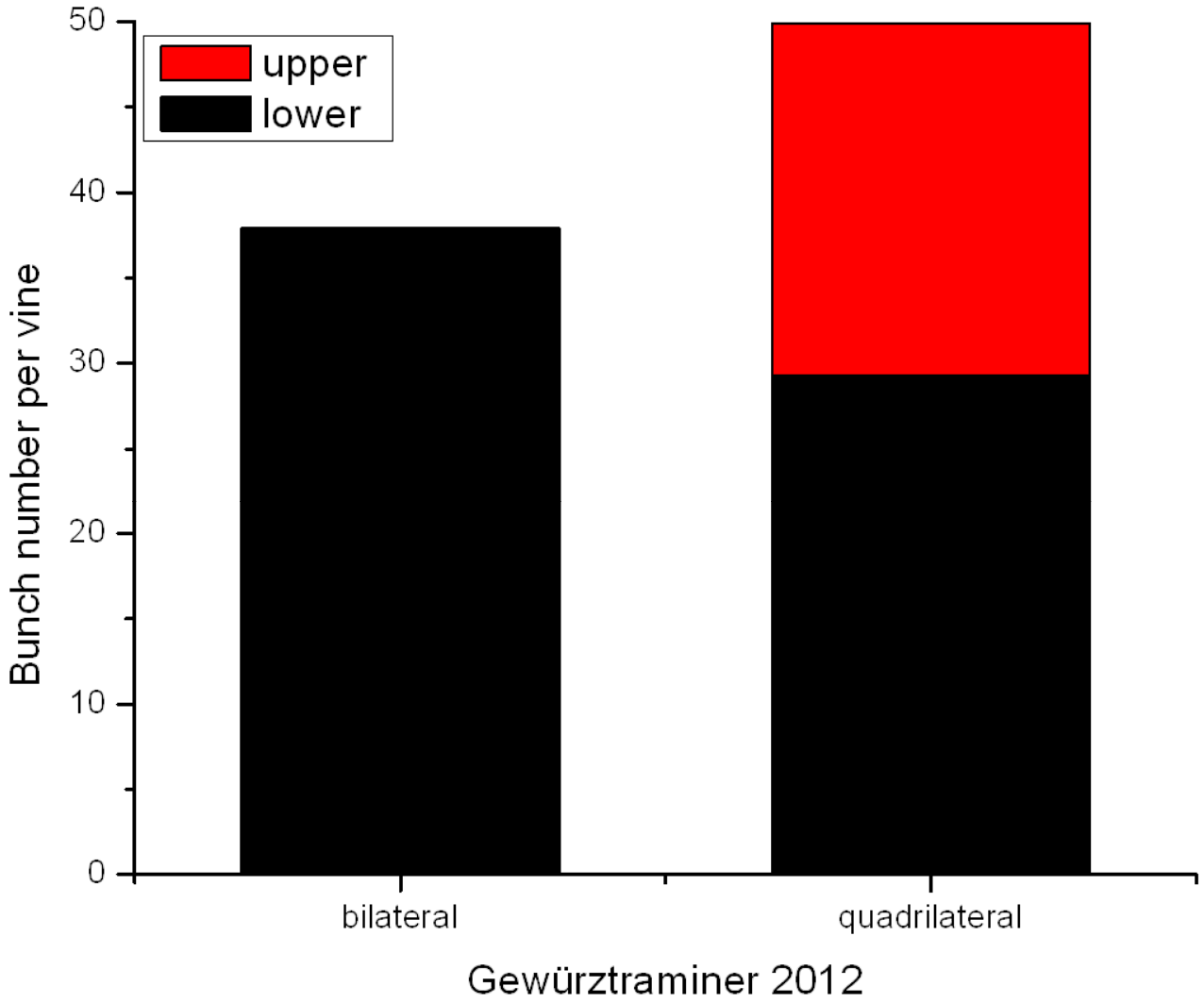
Higher percentage bud break.

Hence, a large increase in shoot number per vine.

A higher shoot fruitfulness causing a large increase in bunch number per vine (but a decrease in bunch weight).

Yield increase of >2 ton/acre.

Results – Gewürztraminer 2012



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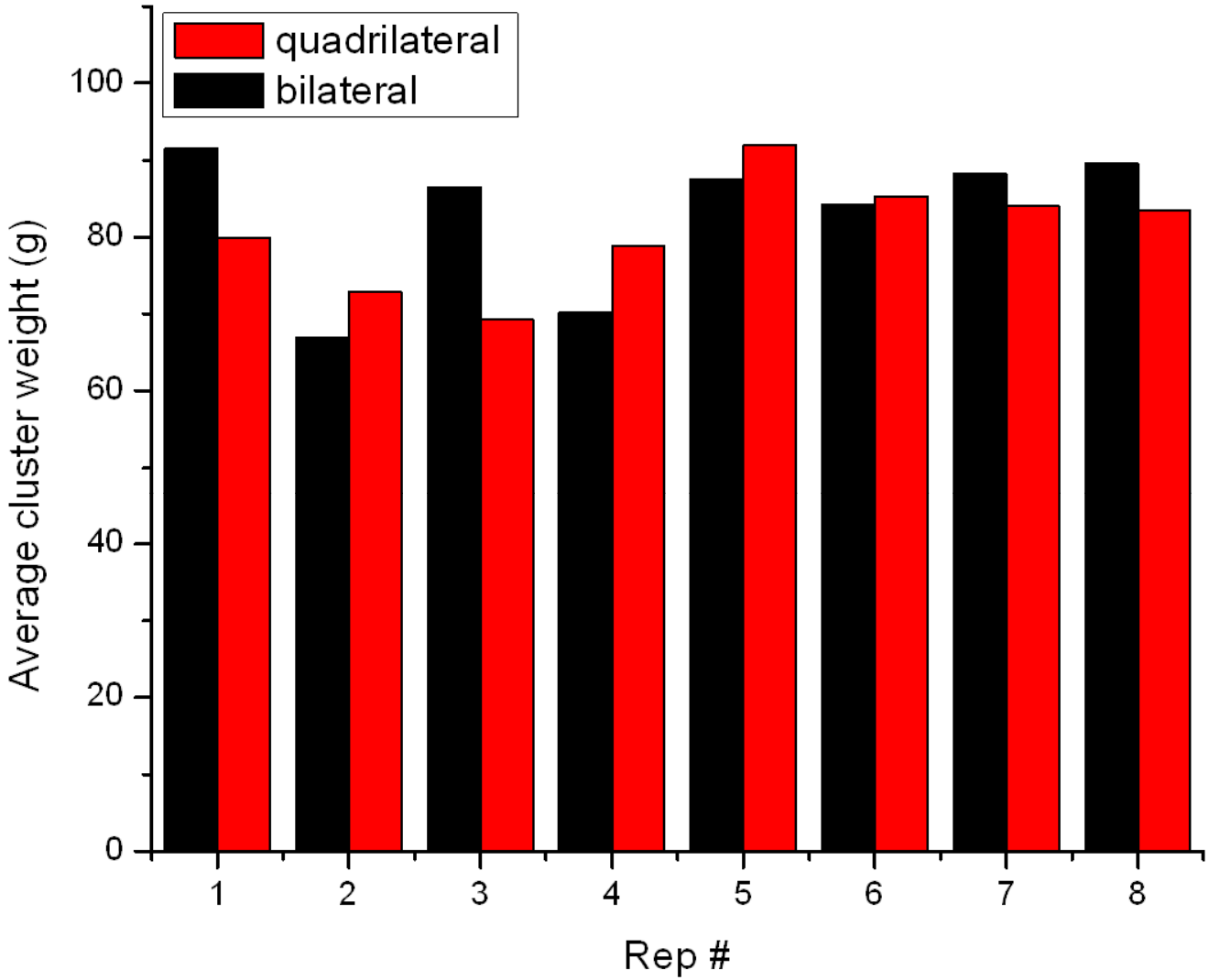
Results – Gewürztraminer 2012



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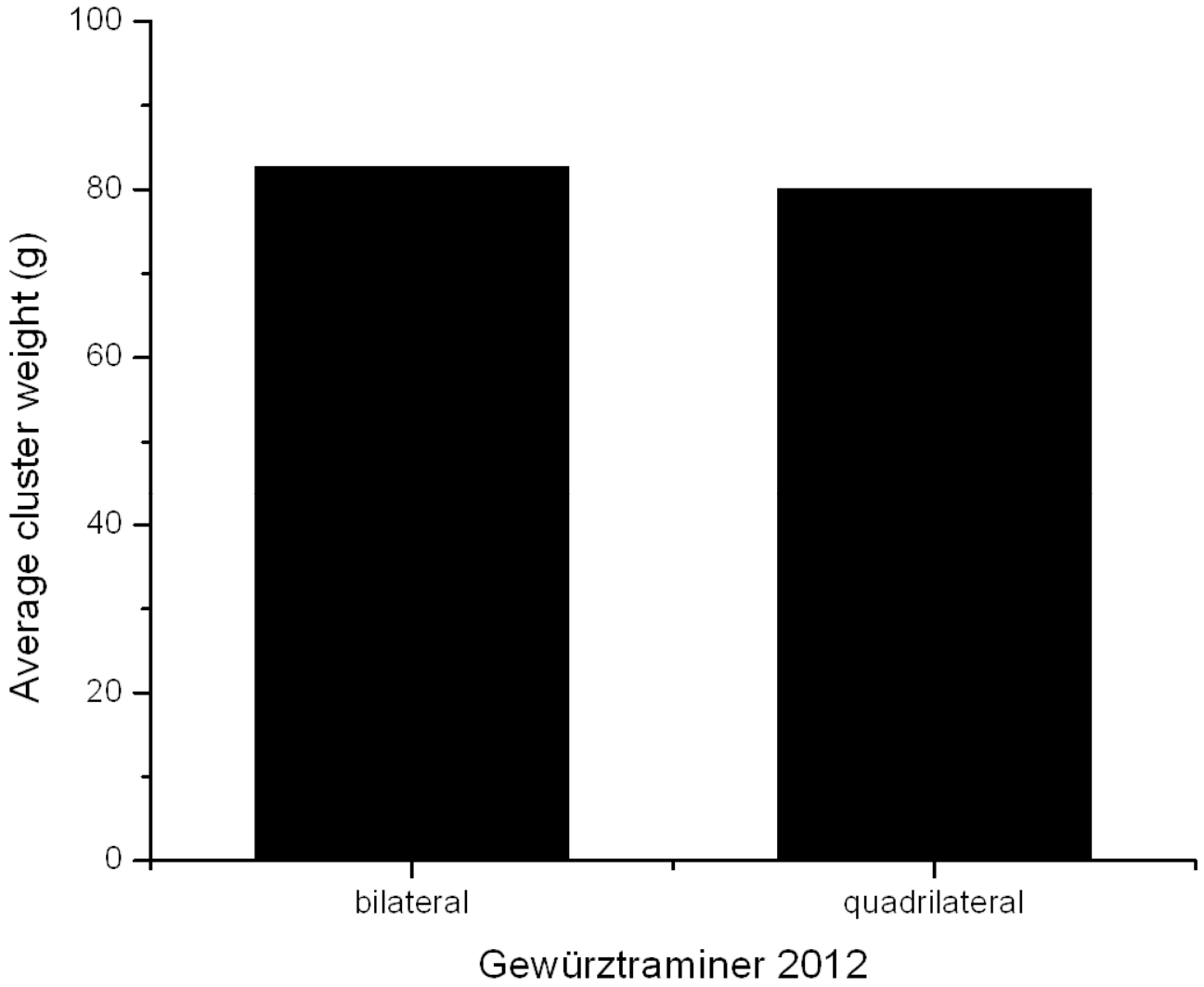
Results – Gewürztraminer 2012



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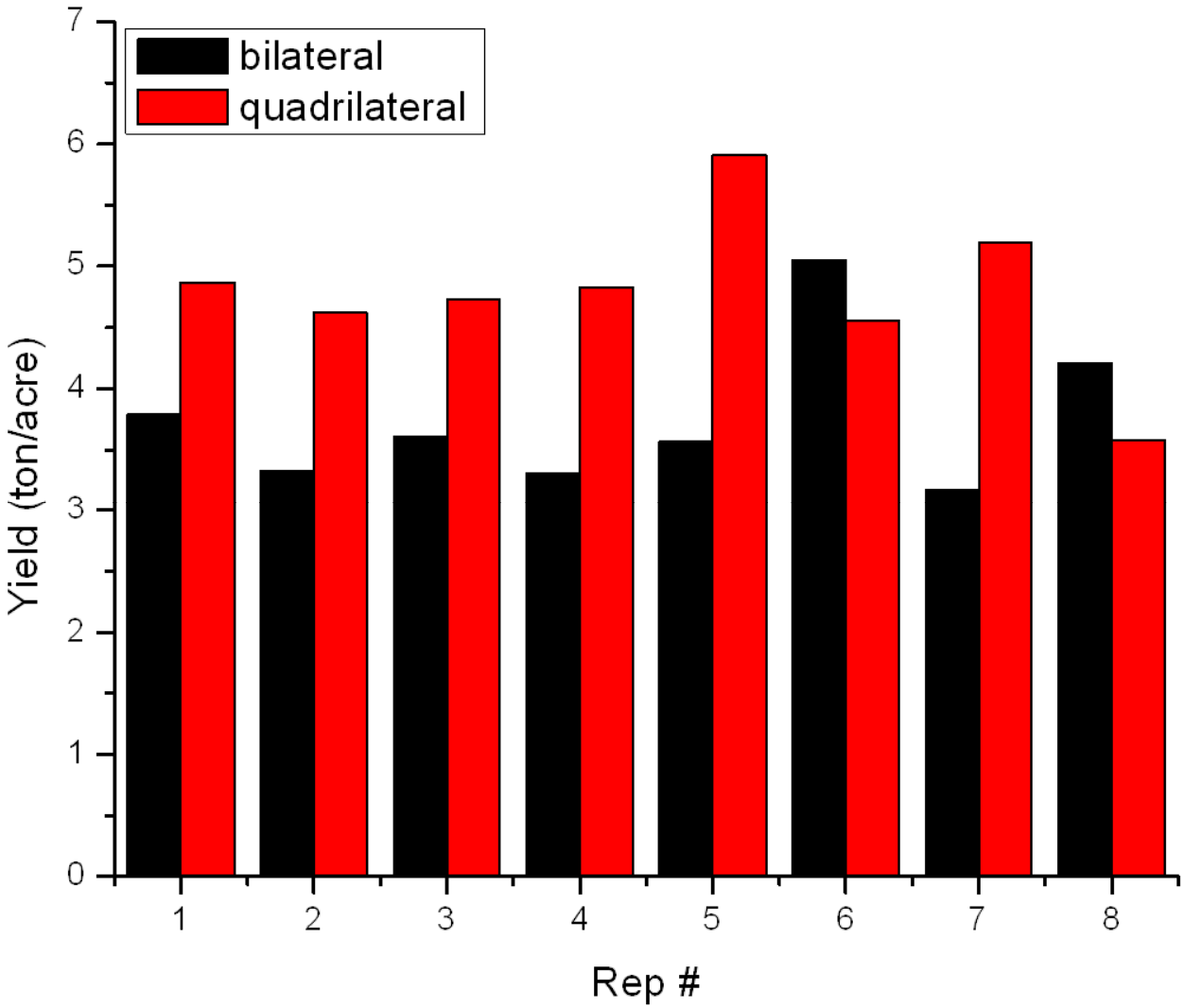

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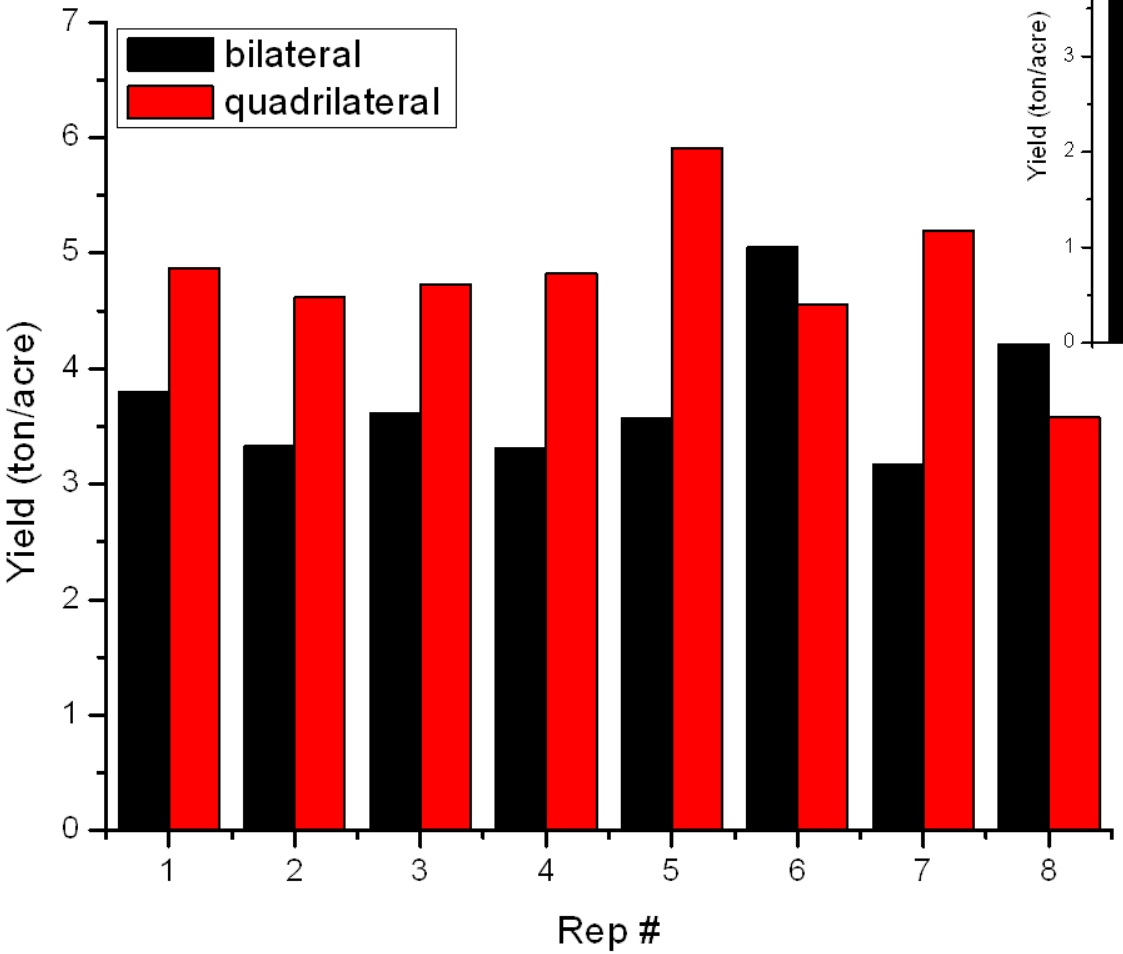
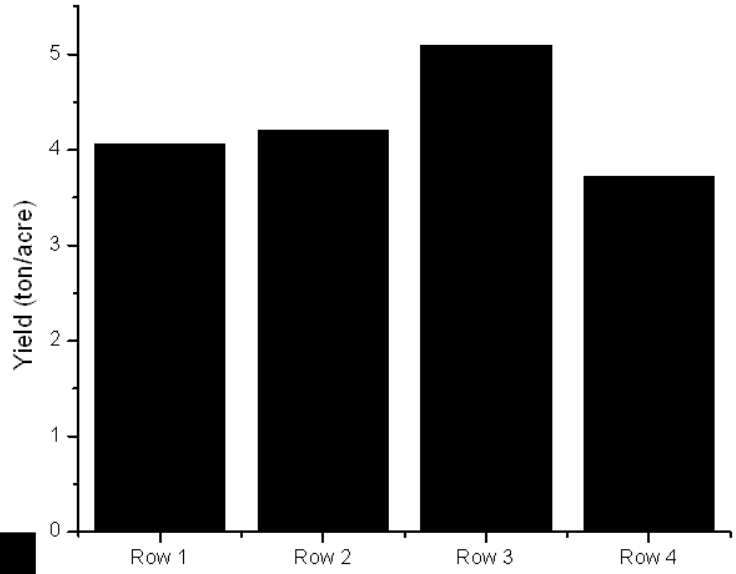
Results – Gewürztraminer 2012





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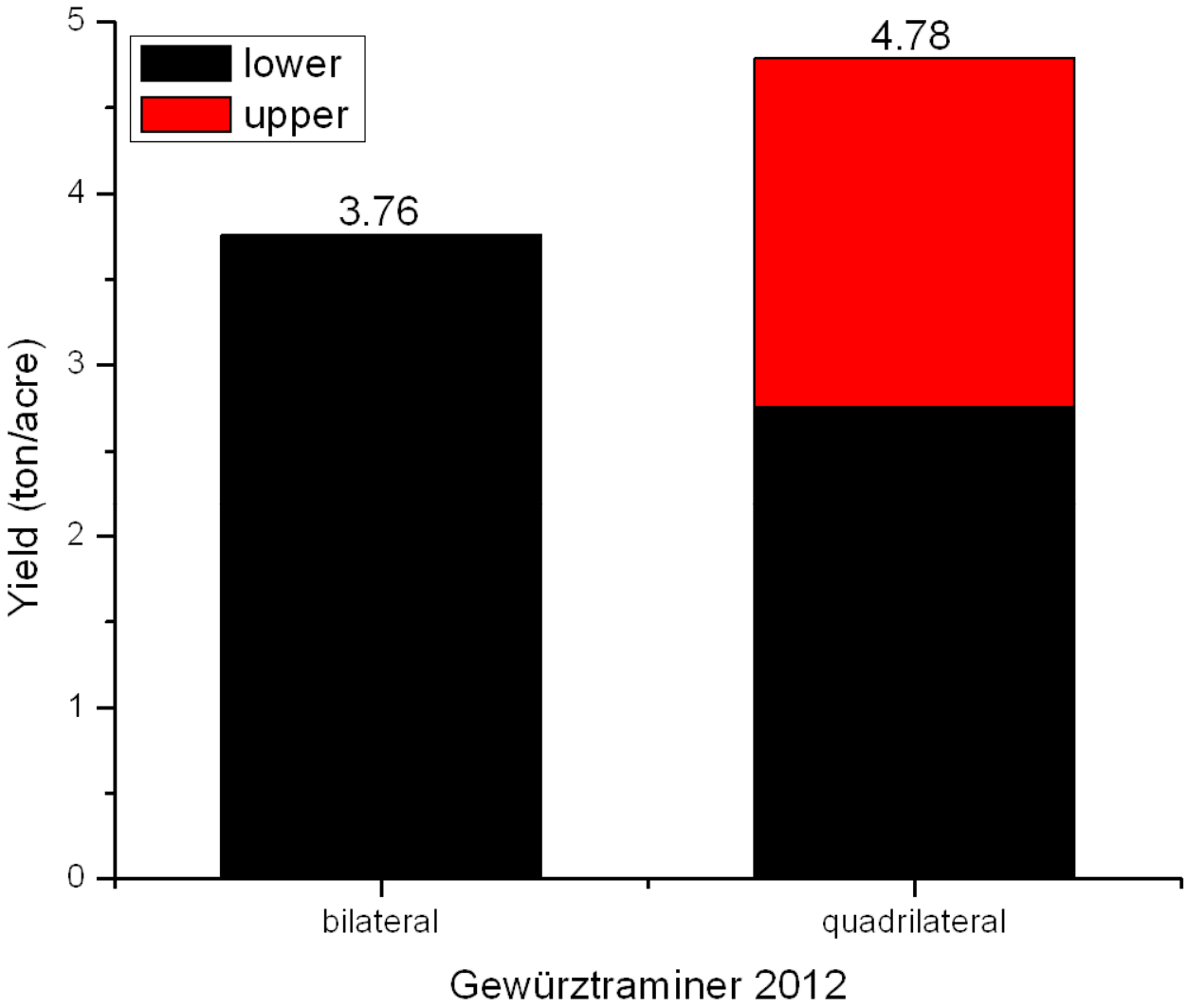
Results – Gewürztraminer 2012



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Results – Gewürztraminer 2012

The change from bi- to quadrilateral training resulted in

- 73 % more buds
- 55 % more shoots
- 31 % more bunches
- 27 % more yield

In a year when percentage bud break (55 %) was low and fruitfulness (1.70 bunches/shoot) was moderate.

YIELD WAS INCREASED BY 1 TON/ACRE

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Quadrilateral vs bilateral VSP – The third year (2013)

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Bi- versus quadrilateral cordon/cane

The 2013 growing season.

A series of extreme cold temperature events occurred in late December 2012 and mid January 2013.

Those cold events caused 100 % vine dieback to the ground in the Gewürztraminer and Tempranillo blocks, and ~50 vine dieback in the Syrah (lower dieback in the Syrah presumably due to use of wind machine during the events).

So in 2013 we set up a trial with Cabernet Franc.

In addition to trunk injuries we found very high bud damage in Syrah (~70 % dead fruitful buds) after January, but only minor damage in the Cabernet Franc. However, two late spring freezes are thought to have caused significant bud damage in the Cabernet Franc.

Materials and Methods

Two field sites in 2013

- Vineyard A
  - Syrah
  - Planted in 2001, 5’ x 9’ (968 vines per acre)
  - VSP
- Vineyard B
  - Cabernet Franc
  - Planted in 2009, 5’ x 2 m (1,328 vines per acre)
  - VSP

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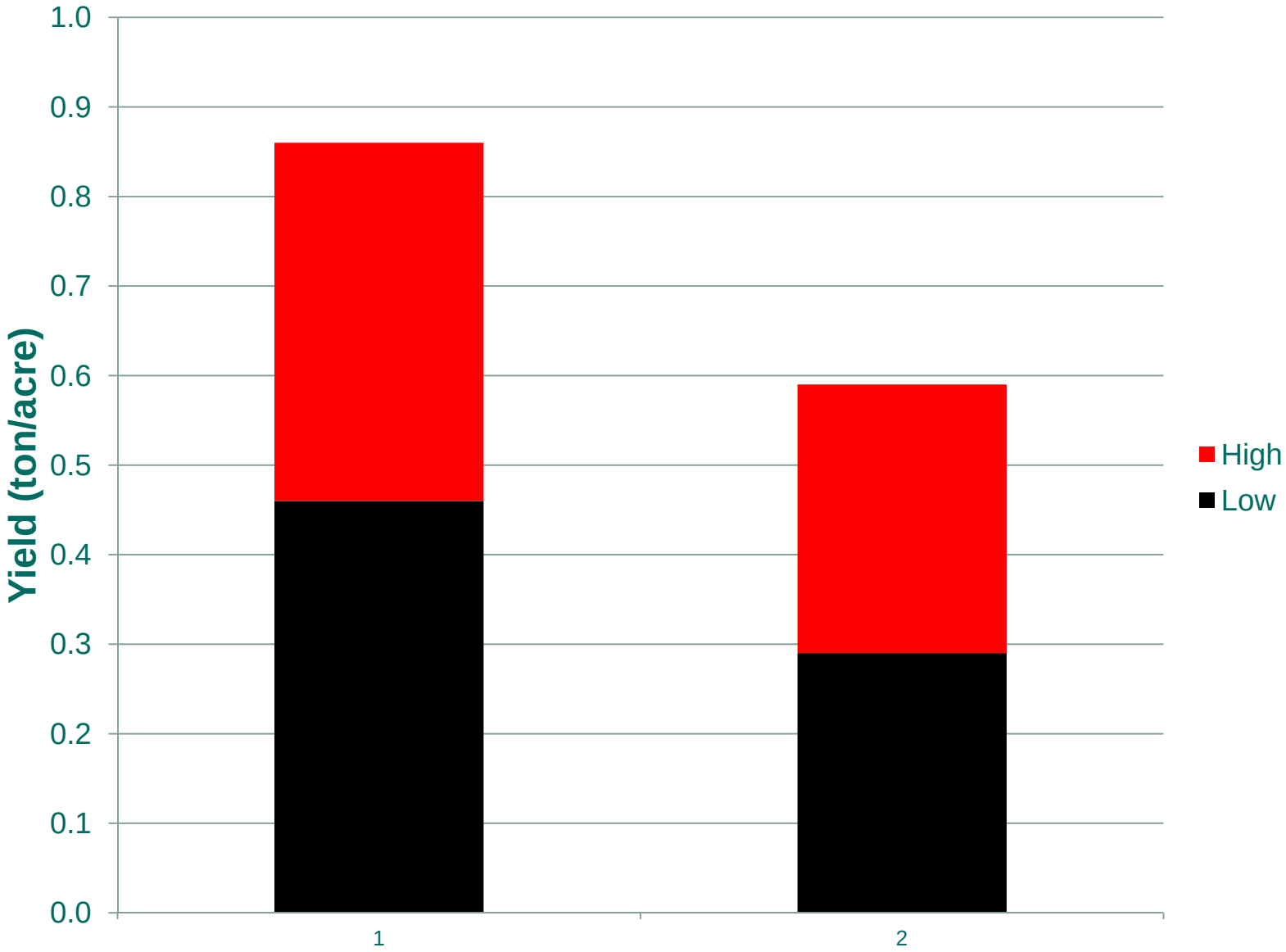
Results – Syrah 2013



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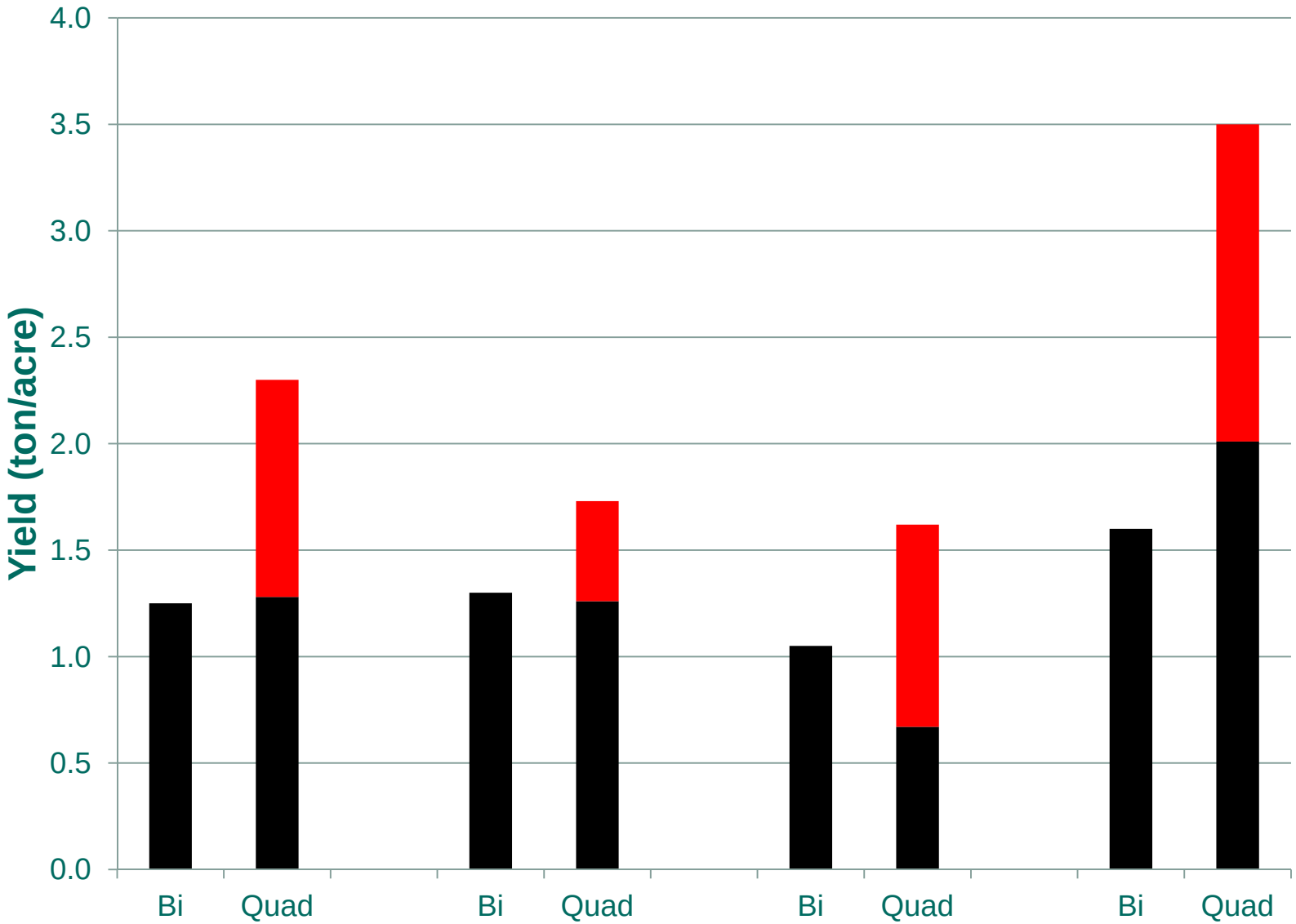
Results – Cabernet Franc 2013



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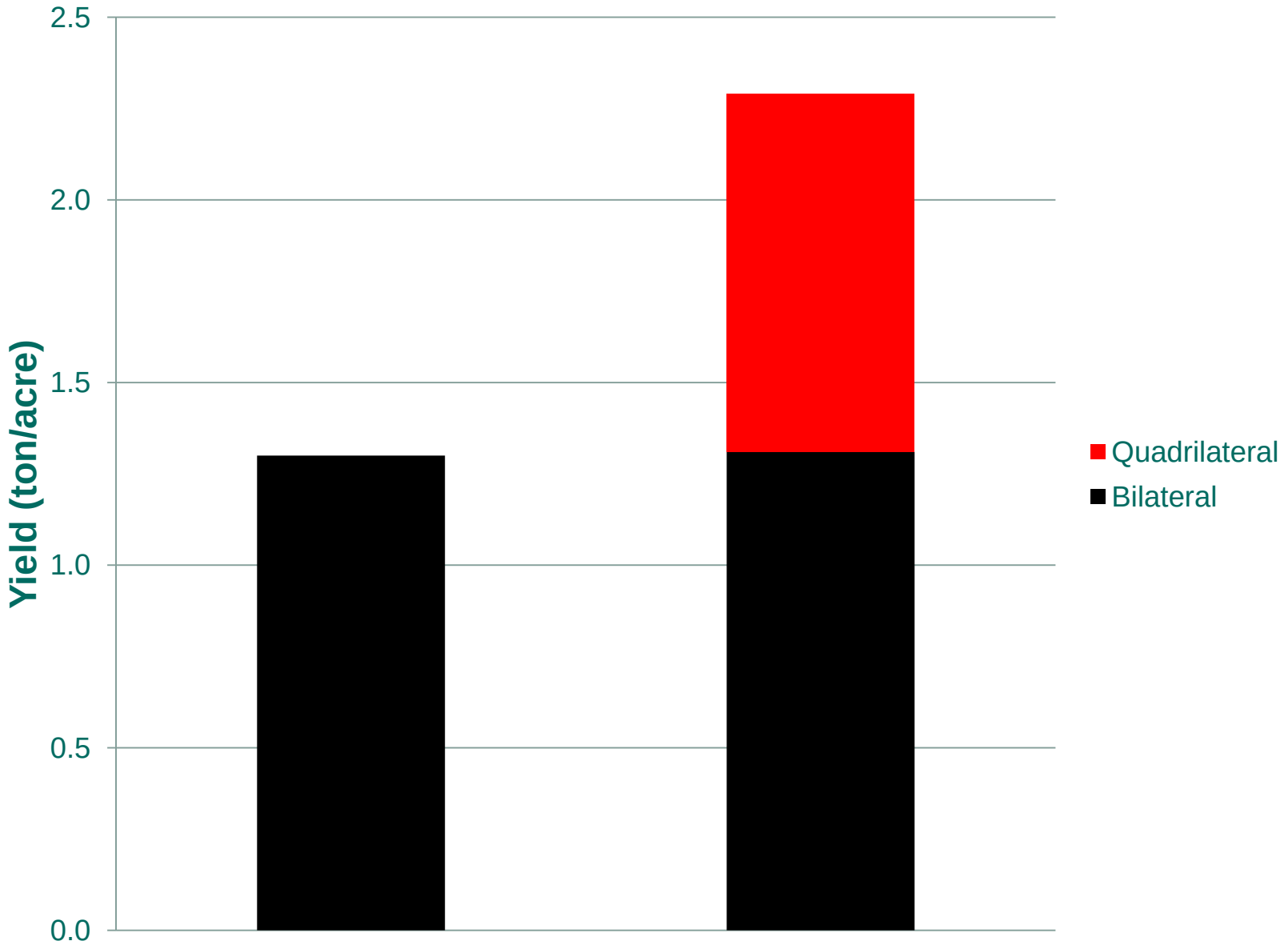
Results – Cabernet Franc 2013



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Thank you for your attention

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