Cover Crops and minimum tillage – efficency to the evironment and soil erosion; Field trials 1994 - 2019

Rosner,J. a.K. W. Deix: Office of the Lower Austrian Provincial Government, 3109 St.Pölten - Austria

Klik,A. University of Agricultural Science, Department of Soil Physics and Rural Water Management, Muthgasse 18, 1190 Wien – Austria

Breiner M.: Farmer, 2136 Laa an der Thaya, Austria



Experimental sites



Interrillerosion





Hüttendorf near Mistelbach – 40 km North Vienna Mai 2016



Damages of communal facilities → high costs of removal → legal effect



Perched water table

in the depression





or





Direct drilling ⇒ erosion control



Winderosion Marchfeld Northeast Vienna





Sandgrains are abrasive
and damage the onion







Soilsolidification by seeding black oat into winter – onion
Then sprayed with a Herbicide (Gaminicide)

Soil erosion in potatoes



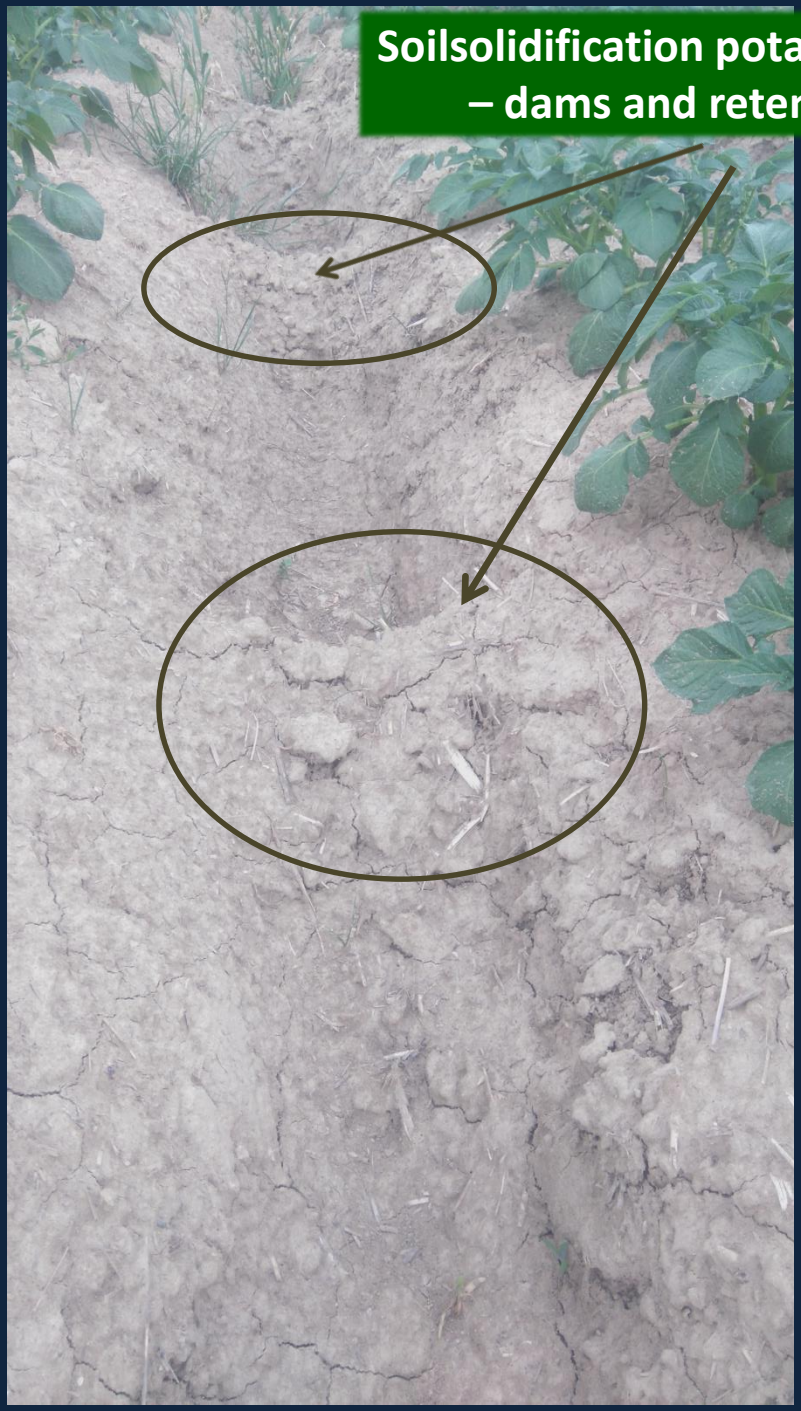

Deposition of fertilizer- and pesticide residues

Soilsolidification potatoes by seeding black oat in potato - dams





Soilsolidification potatoes by seeding black oat in potato – dams and retention ridges between the dams





SOLUTION ⇒

Direct drilling without disc harrow in front of seeder

No till drill into straw of winter wheat

Yellow mustard + California bluebell – Phacelia as cover crops

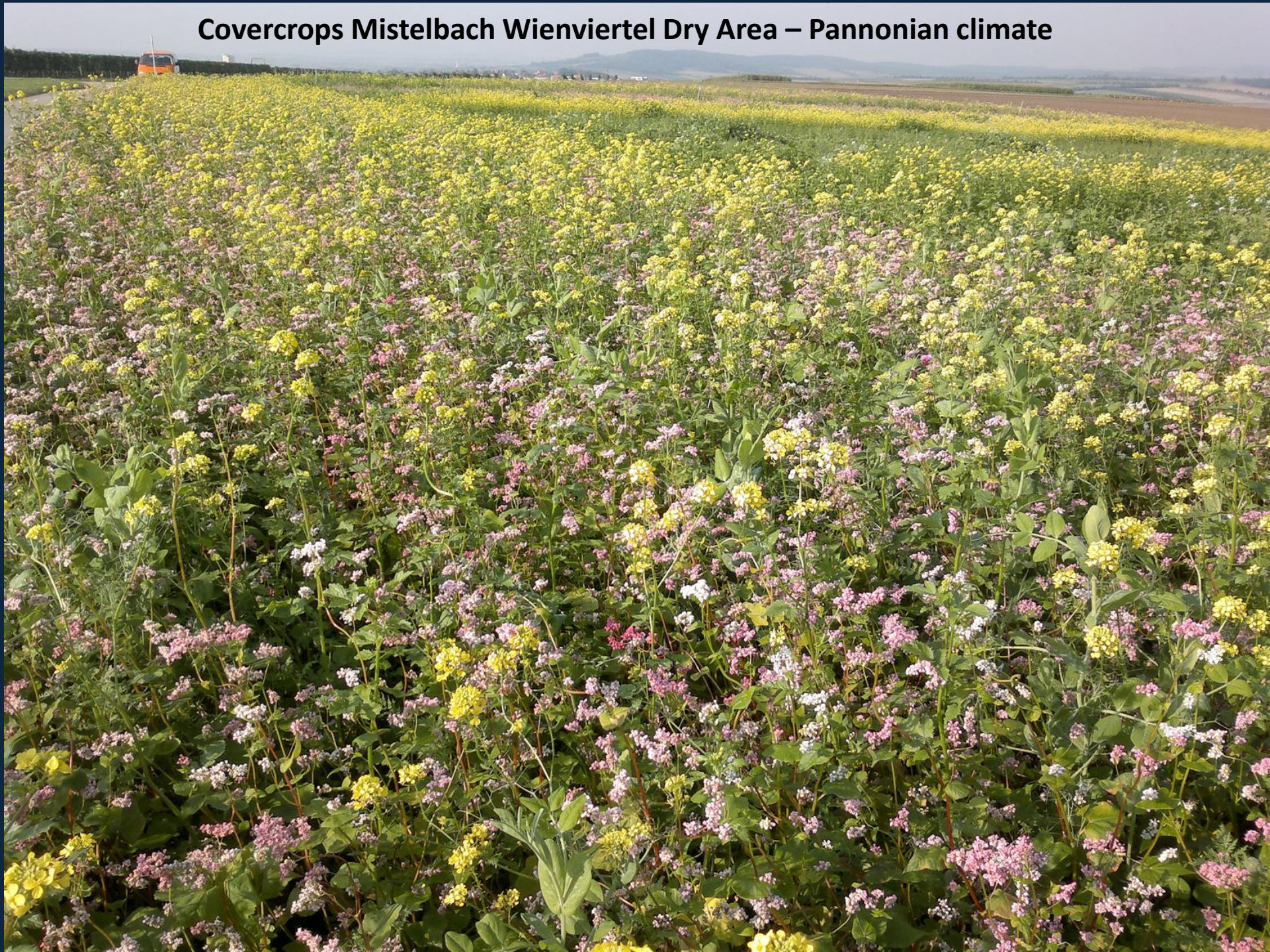




and mulchseed of covercrops



Covercrops Mistelbach Wienviertel Dry Area – Pannonian climate



seeding winterwheat Mistelbach October










End of February



April 30 th





NoTill Sowing Cover Crops into stubbles





Developement
cover crops
Hollabrunn 4
weeks after seed





27. September 2010









Directseed winterrye into yellow mustard + California Bluebell cover crops



Variants

- Directseed 03.10.2011
- Directseed + Round up 26.09.2011
- Knife roller – Directseed 28.09.2011
- Knife roller + Round up – Direktsaat
- Mulchshredder – Directseed
- Mulchshredder + Round uo – Directseed
- Mulchshrtedder – discharrow - Mulchseed





Variety

Minello 90 %

+

Dukato 10 %

300 K/m²

Directseed without Round up (Glyphosate)





Coulterdiscs cut residues

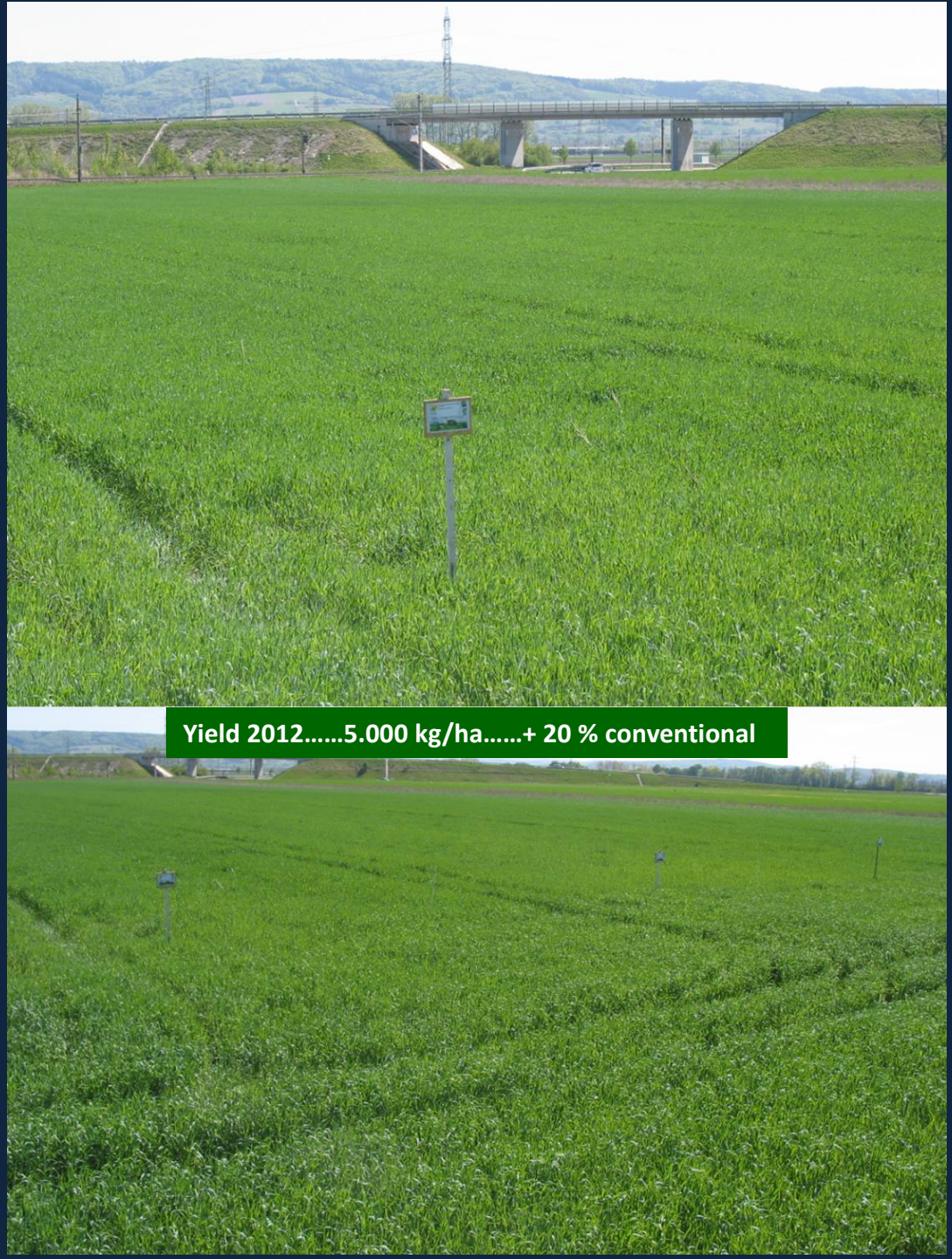




Direktseed without Round up

Coulterdiscs instead of discharrow




Yield 2012……5.000 kg/ha……+ 20 % conventional



Seed winterwheat into legume – cover crops
Tulln Oktober 12th 2012 without Glyphosate





Direct drilling without seed
currycomb and coulter discs Tulln
October 2012
→ Roller after seed



Without – with currycomb









Field emergence direct drilling winterwheat into legume cover crops without Glyphosate Tulln November 5th2012





April 15th 2013 Winter wheat tillering



May 27th 2013
BBCH 49
Before ear emergence









Shred & Plow → Decomposition bacteria in the soil + anaerobic digestion → Less yield & high production costs



Anaerobic Zone
with
decomposition

Sowing winterbarley Ochtober 2nd into covercrops without Glyphosate
Previous crop: oilseedrape



Sowing winterbarley Ochtober 2nd into covercrops without Glyphosate
Previous crop: oilseedrape



Sowing winterbarley Ochtober 2nd into covercrops without Glyphosate
Previous crop: oilseedrape















Emergency October



Sowing cover crops Tulln August
Heavy soil with > 60 % clay




AMAZONE
Cirrus 3003 Compact









Root development
cover crops

Cover Crops in wheat - stubbles





honeyplants in October





NoTill Winter wheat November





NoTill Winter wheat November





Spring









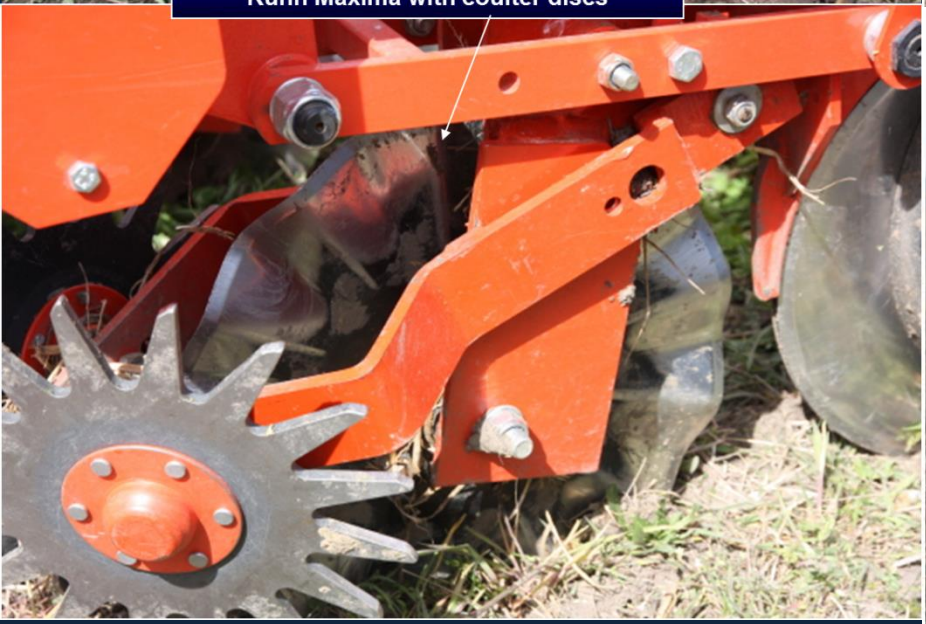
No Tillage - Directseeding in Sout America with simple seeder equipment







Kuhn Maxima with coulter discs



Väderstad Tempo





Cornplanting into residues of cover crops



Per ha in the soil:

25 t flora

5 t fauna

⇒

Corresponding

6 livestock units

Work for the farmer


Cionventional tillage
with plow
22/09/2009


NoTill
22/09/2009

International tendencies in Tillage

- 1989..... 10 Mio ha No Till

- 2001..... 65 Mio. ha No Till
- 2002..... 68 Mio. ha No Till
- 2004..... 72 Mio. ha No Till
- 2006……. 90 Mio. ha No Till
- 2020…….>130 Mio. ha No Till

- Countries:

USA (35 Mio. ha), Canada (12 Mio. ha), Brasil, Argentina – Latin America > 60 Mio. ha, Australia (> 10 Mio. ha)

More than 98 % of the No Till land in these countries

Reasons for No Till

- Lowering of production cost
- Fewer passes – less work time → less soil compaction
- Increased productivity – cultivation of larger area possible
- Reduction of fuel consumption

(250 l → < 80 l/ha)

- Lower machine use
- Prevention of wind – water – tillage erosion
- Increased humus content
- Improved water retention
- better aggregate stabiltity by higher content of Glomalin (Glycoprotein) – better carrying capacity for heavy machinery
- Better yield
- Lower carbon dioxide release from the soil → climate – and soil alliances
- Carbon storage in the soil





Fielddemonstrations Directseeding Mulchseed

Amazone Tineseeder after sugarbeet harvest sowing winter wheat





Amazone Tineseeder after sugarbee tharvest

Väderstad Seedhawk Tineseeder




VÄDERSTAD
VÄDERSTAD

> 30 % residues on the surface……mulchseed
> 70 % residues on the surface……NoTillage





Drilling winterwheat into straw residues corn in dry pannonian area


JOHN DEERE
6534
HORSCH





Cover crop management

Frost effect

chop



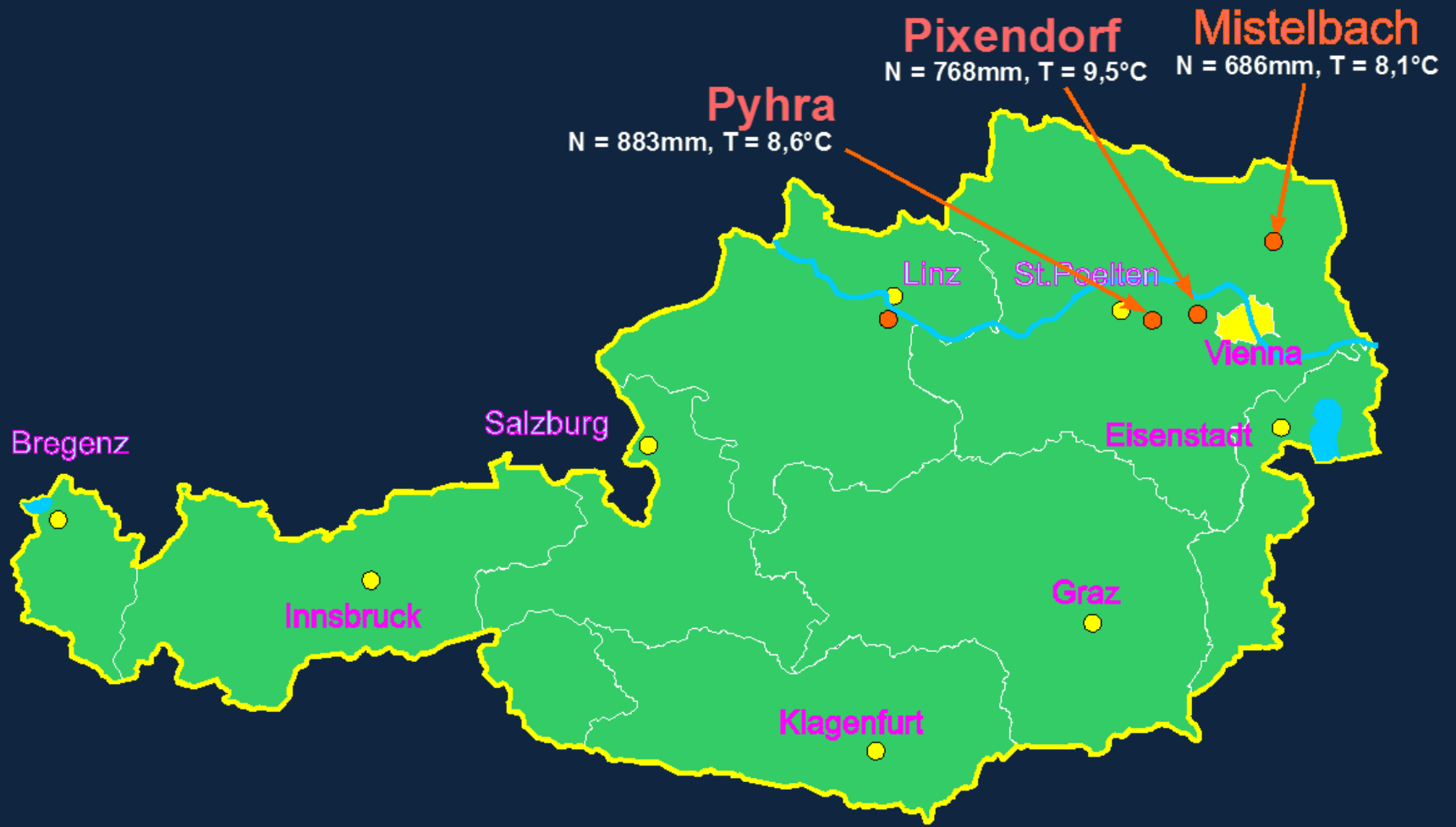
Cover crop roller to shred the cover crops with low fuel consumption





Soil erosion measurement sites Austria

(Klik et al)



Experiments started in 1994

soil texture: sandy silt - loamy silt

plot size: 60 m² (4 by 15 m)

slope: 5 - 16 %

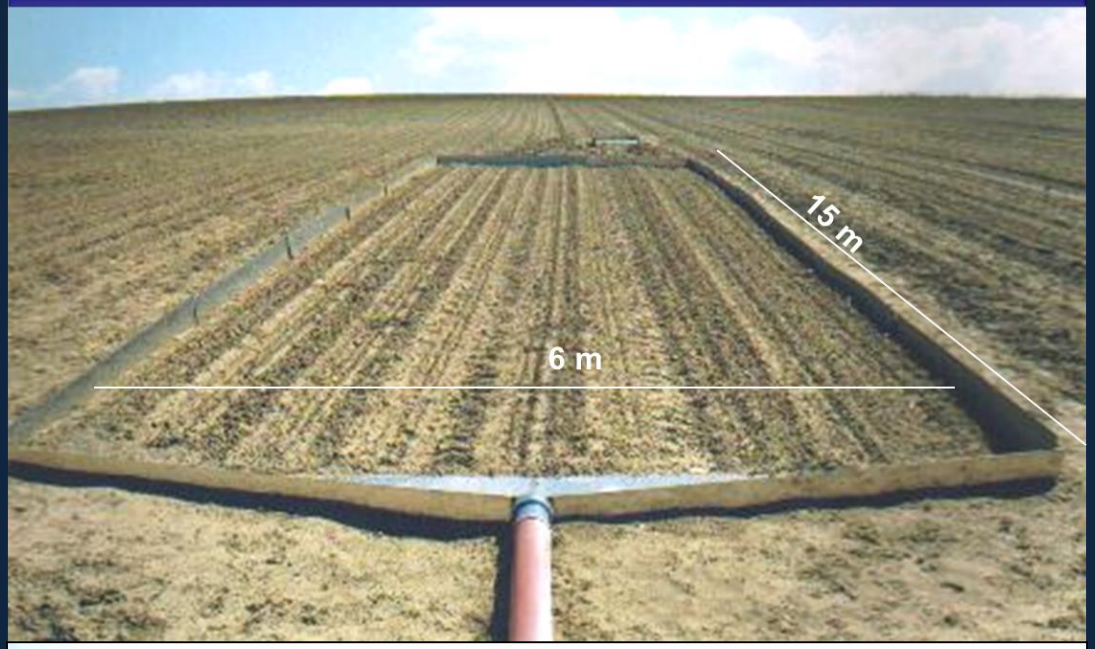
crop rotation: corn - winter wheat

corn - winter wheat - sugar -beets – summer barley - sunflower - winter wheat

Summer harvest - cover crop → spring cultivation

Parameters investigated: runoff, soil loss, nutrients, pesticides - herbicides,

Erosion plots





Landwirtschaftliche Fachschule Mistelbach

Grassed waterways










Sample divider

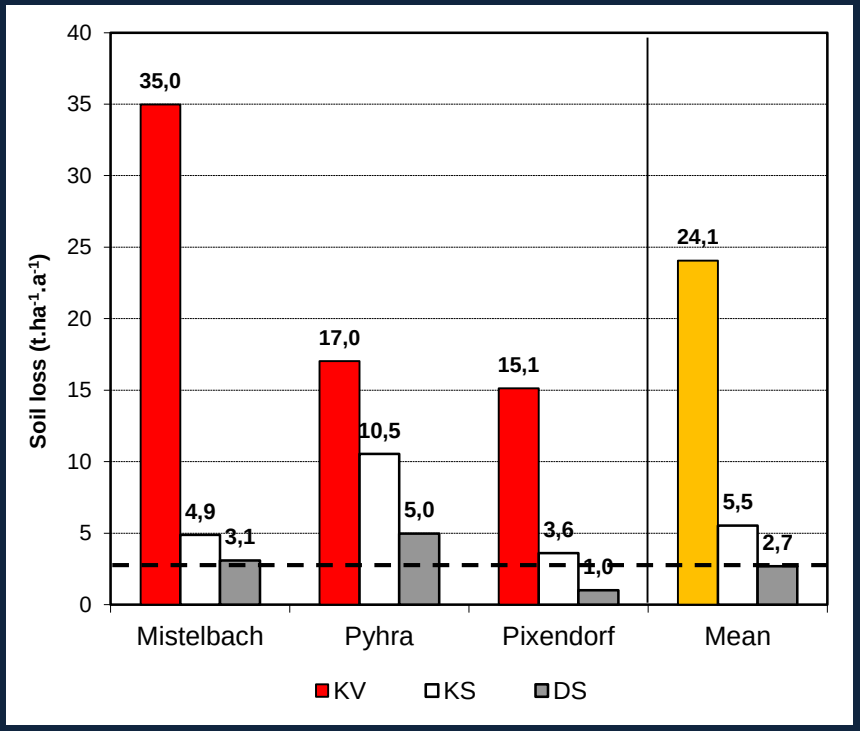

Sedimentcollector
3 % sampled – divided by tubes

Soil Loss Average 1994 - 2015
Influence to surfacerunoff and soilloss

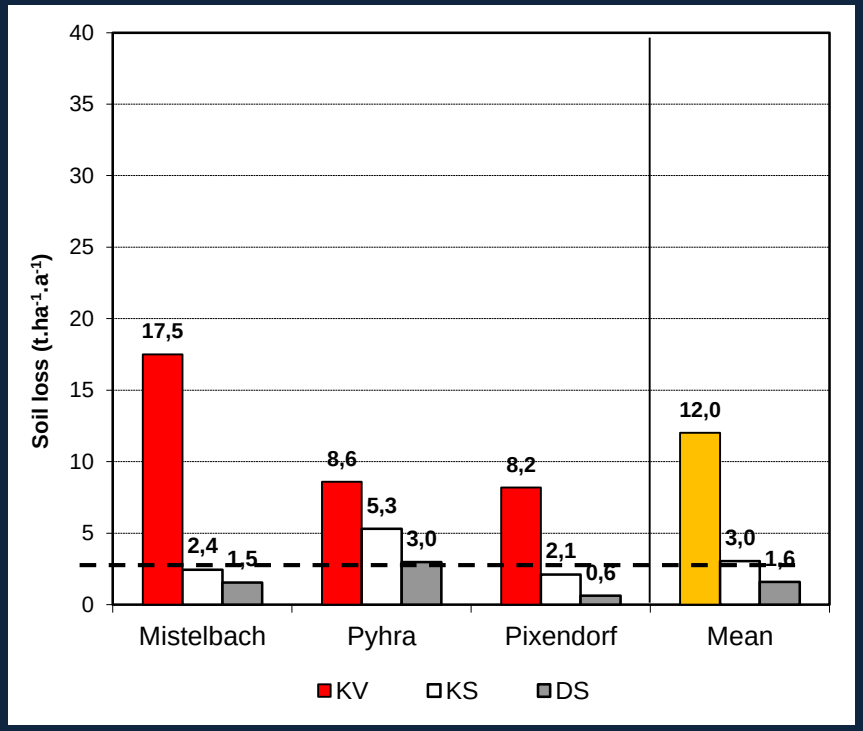
Annual rainfall:

Mistelbach 550 mm/year
Pyhra 750 mm/year
Pixendorf 600 mm/year

Only row crops
(corn, sunflowers, sugarbeets)



Whole crop rotation row crops - drillseed



Klik 2016

soilloss – values weighted to conventional tillage with plow

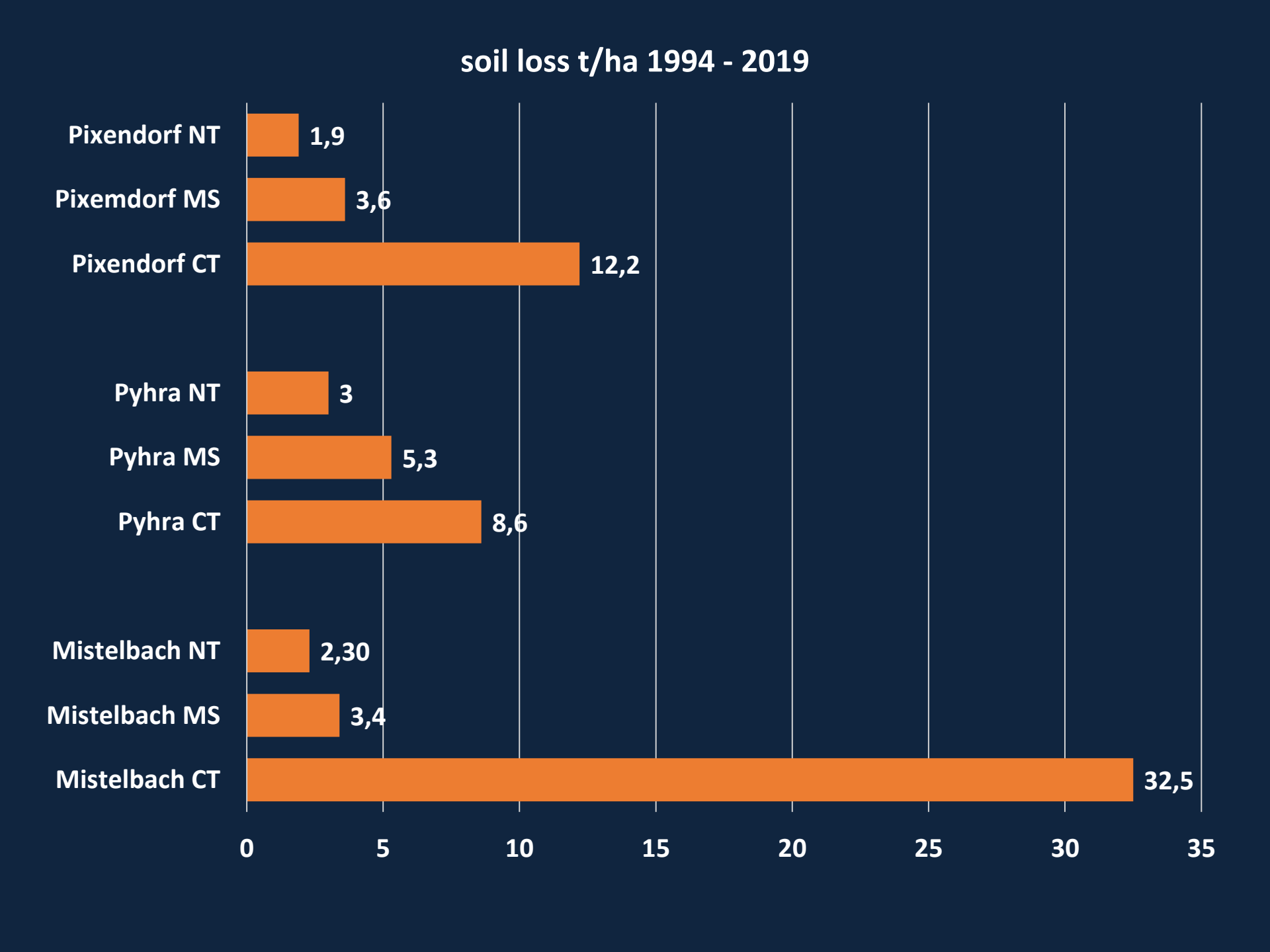
Klik et al. Univ. f. BOKU 1994 - 2019

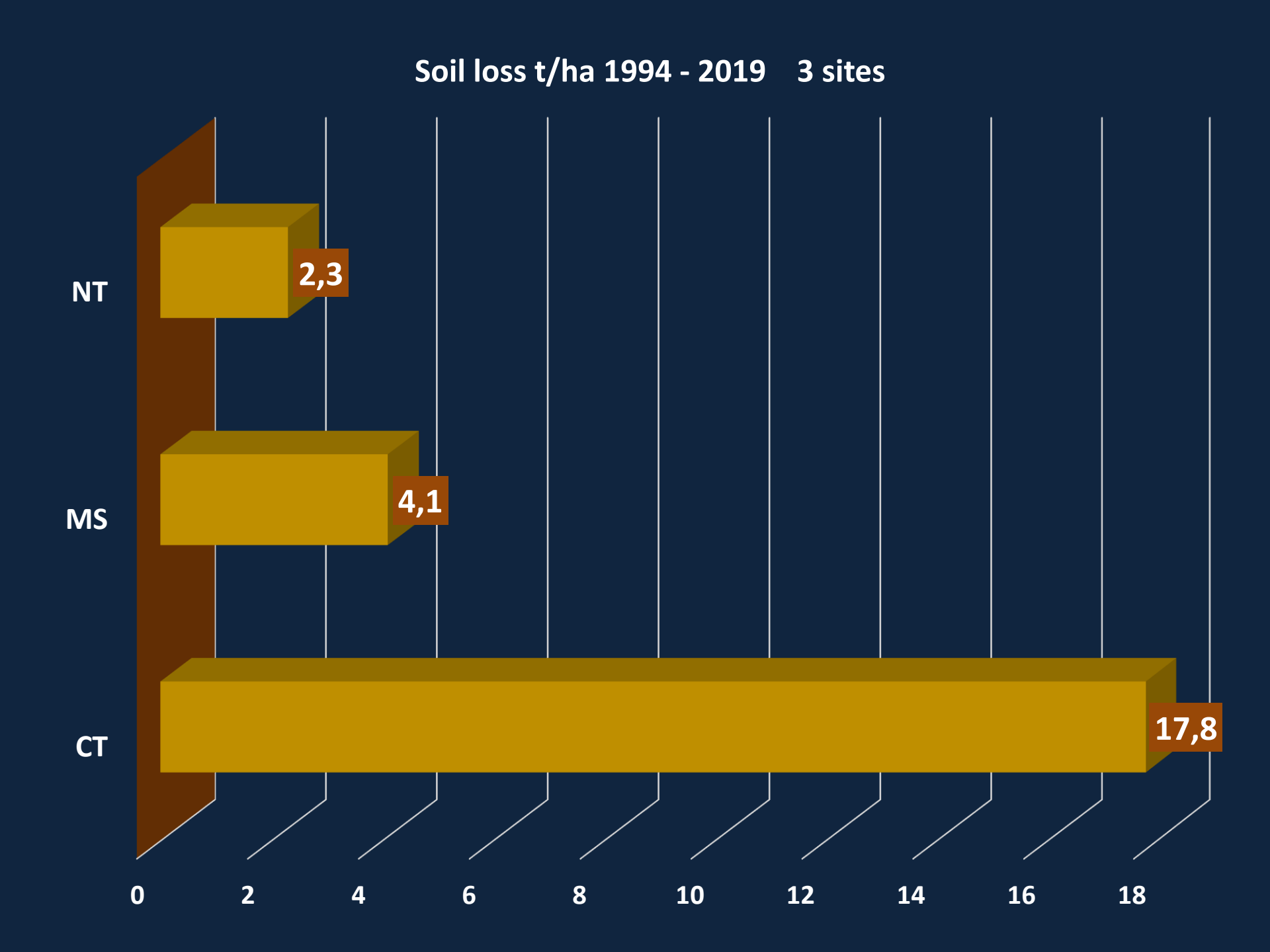
	soil loss t/ha	runoff mm	N loss kg/ha	P loss kg/ha	Corg loss kg/ha
Mistelbach CT	32,5	19,5	48,1	28,7	315
Mistelbach MS	3,4	8,7	6,6	3,3	44
Mistelbach NT	2,30	10	5,2	2,1	32
Pyhra CT	8,6	26,1	18,4	6,7	102
Pyhra MS	5,3	29,4	18,7	3,8	67
Pyhra NT	3	31,7	9,4	2,3	43
Pixendorf CT	12,2	35,8	13,3	7,2	105
Pixemdorf MS	3,6	26,9	4,5	2,1	40
Pixendorf NT	1,9	14,3	1,6	0,7	12
Ø all sites					
CT	17,8	27,1	26,6	14,2	174
MS	4,1	21,7	9,3	3,1	50,3
NT	2,3	18,7	5,4	1,7	29

CT Convetional tillage
MS Mulchseed
NT No Tillage

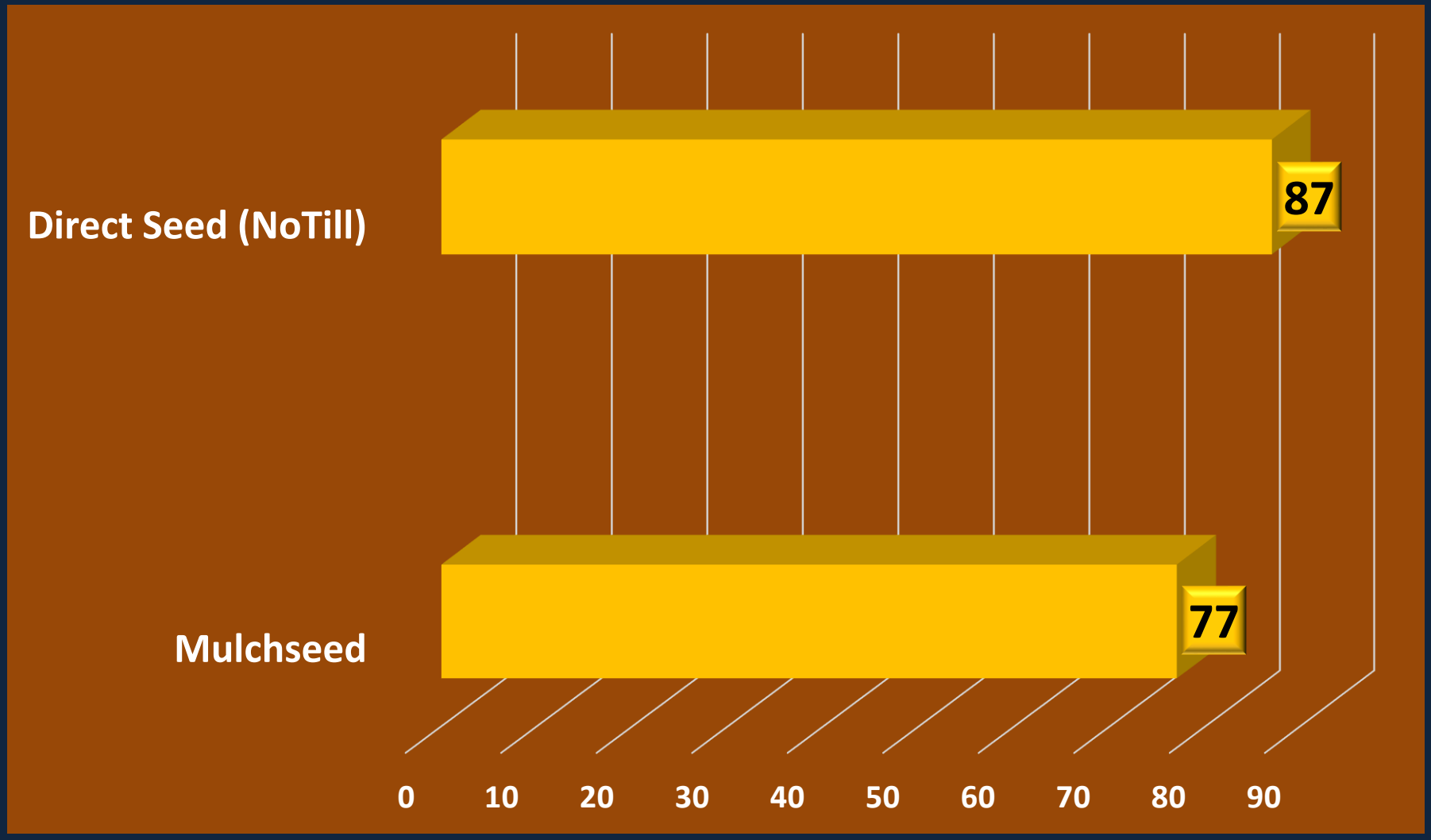
herbicide – values weighted to conventional tillage with plow
Klik et al. Univ. f. BOKU 1994 - 2019

	Conventional	Mulchseed	Directseeding
Herbizideloss			
Herbizidloss % sprayed	2,20	1,00	0,60
Reduction % sprayed herbicides		55,00	73,00
Herbizideloss			
In runoff	1,7	0,8	0,2
Reduction		53	88
Herbizideloss			
In sediment	0,29	0,18	0,01
Reduction		38	97


soil loss t/ha 1994 - 2019
Pixendorf NT
1,9
Pixemdorf MS
3,6
Pixendorf CT
12,2
Pyhra NT
3
Pyhra MS
5,3
Pyhra CT
8,6
Mistelbach NT
2,30
Mistelbach MS
3,4
Mistelbach CT
32,5
0
5
10
15
20
25
30
35


Soil loss t/ha 1994 - 2019 3 sites
NT
MS
CT
2,3
4,1
17,8
0
2
4
6
8
10
12
14
16
18

Soil loss reduction % 1994 – 2019



Pixendorf, August 2nd 2005

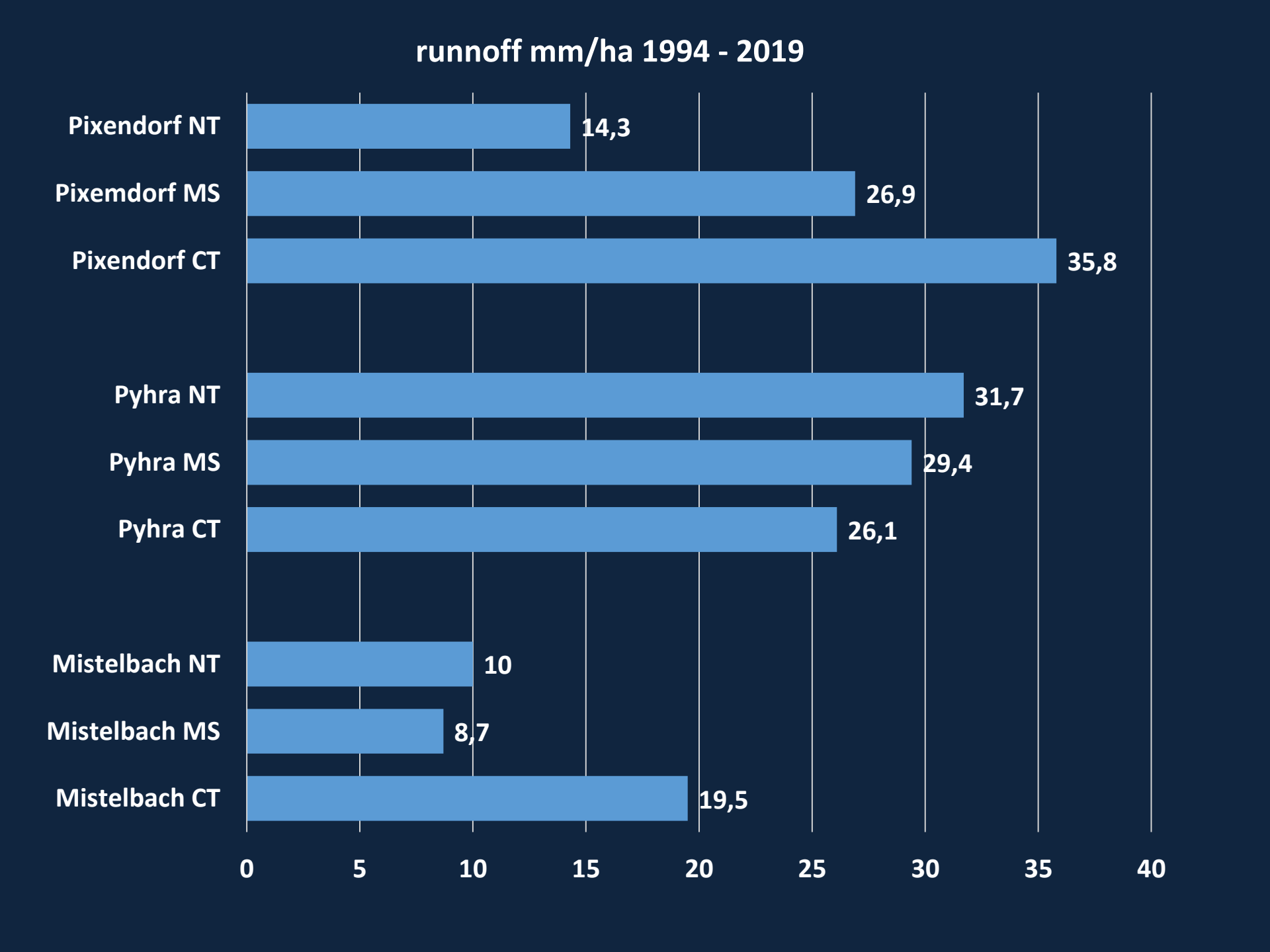


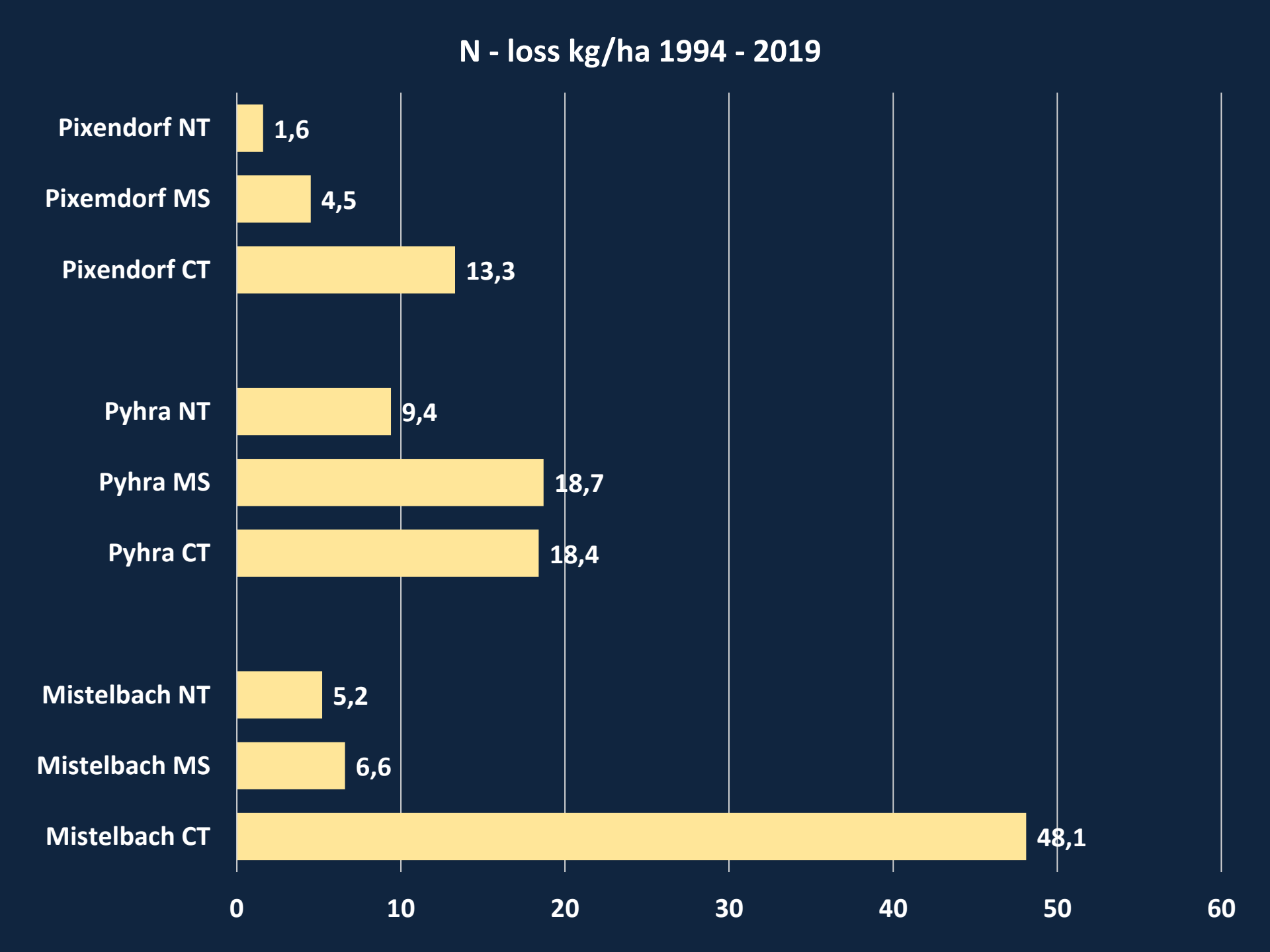


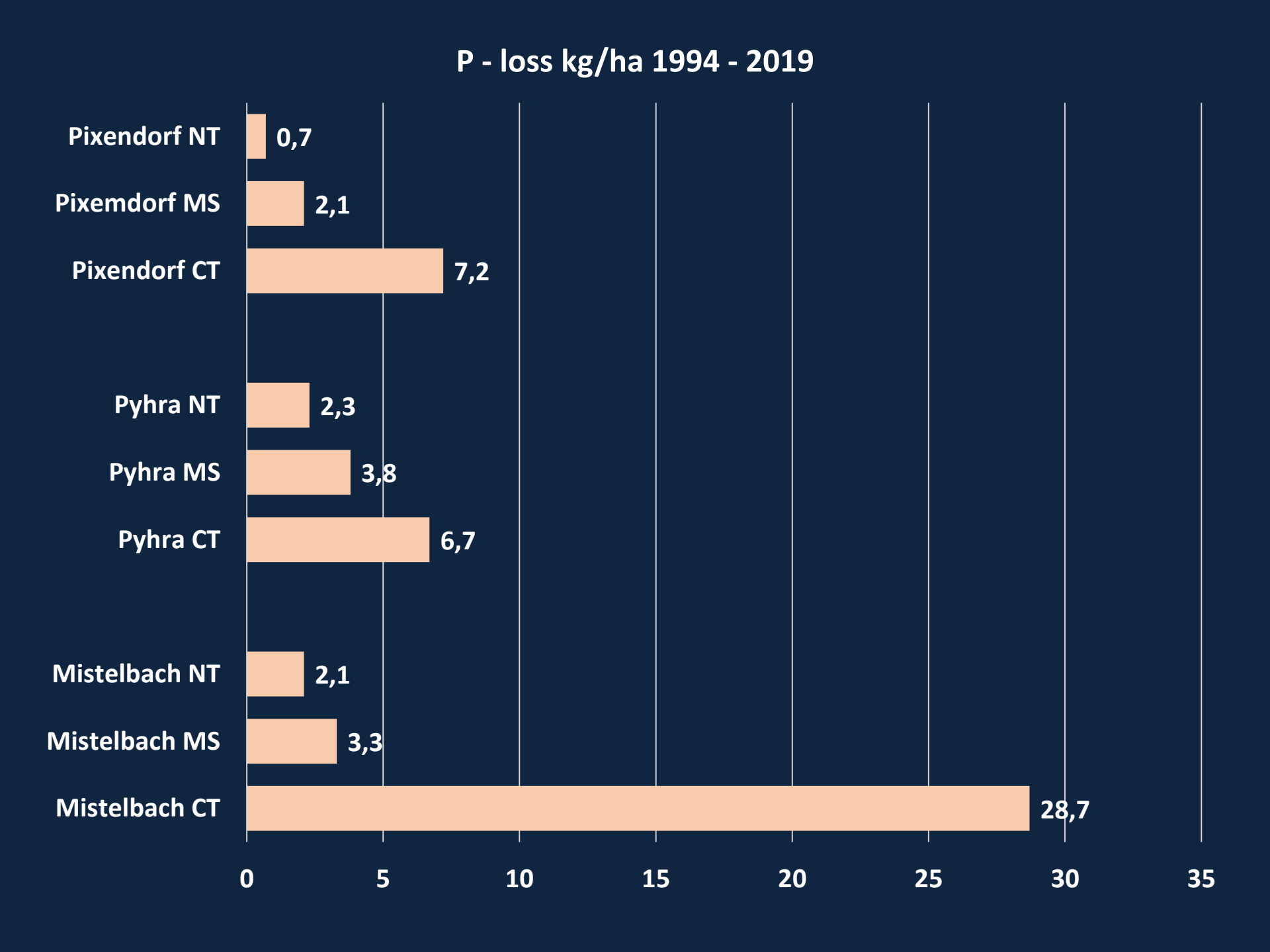


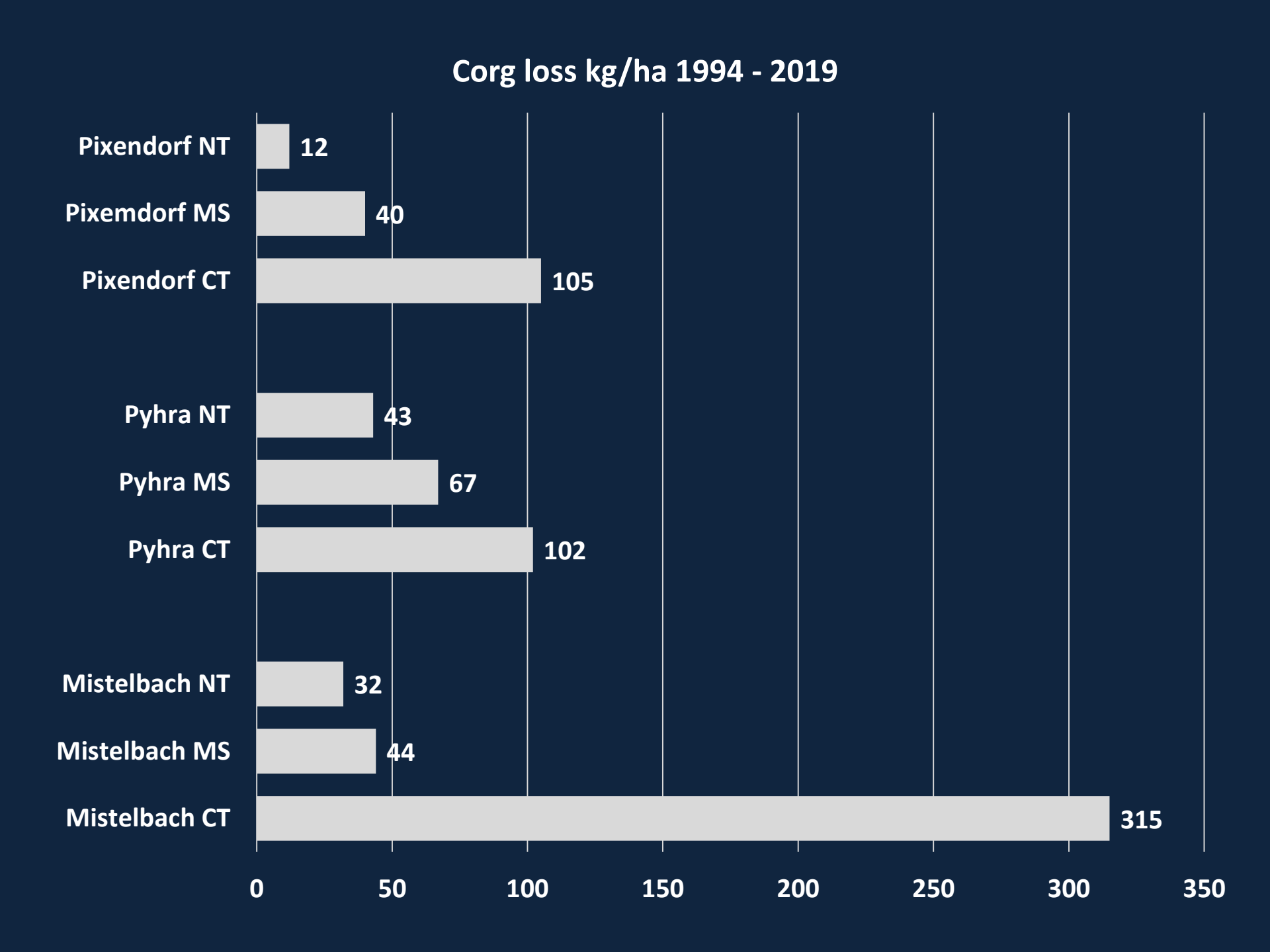
DS: direct seeding | **CS: conservation tillage** | **CT: conventional tillage**

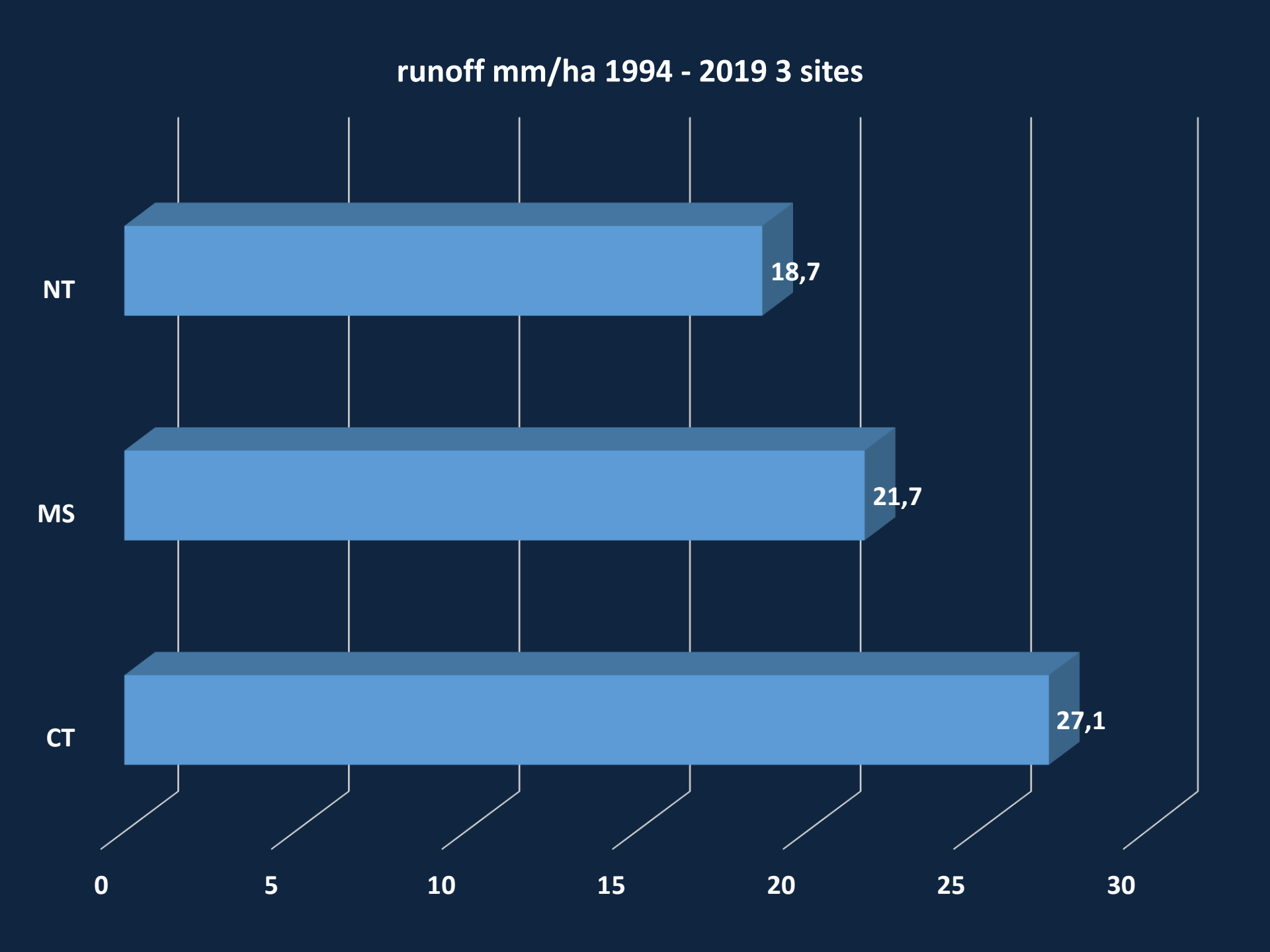
Klik 2015

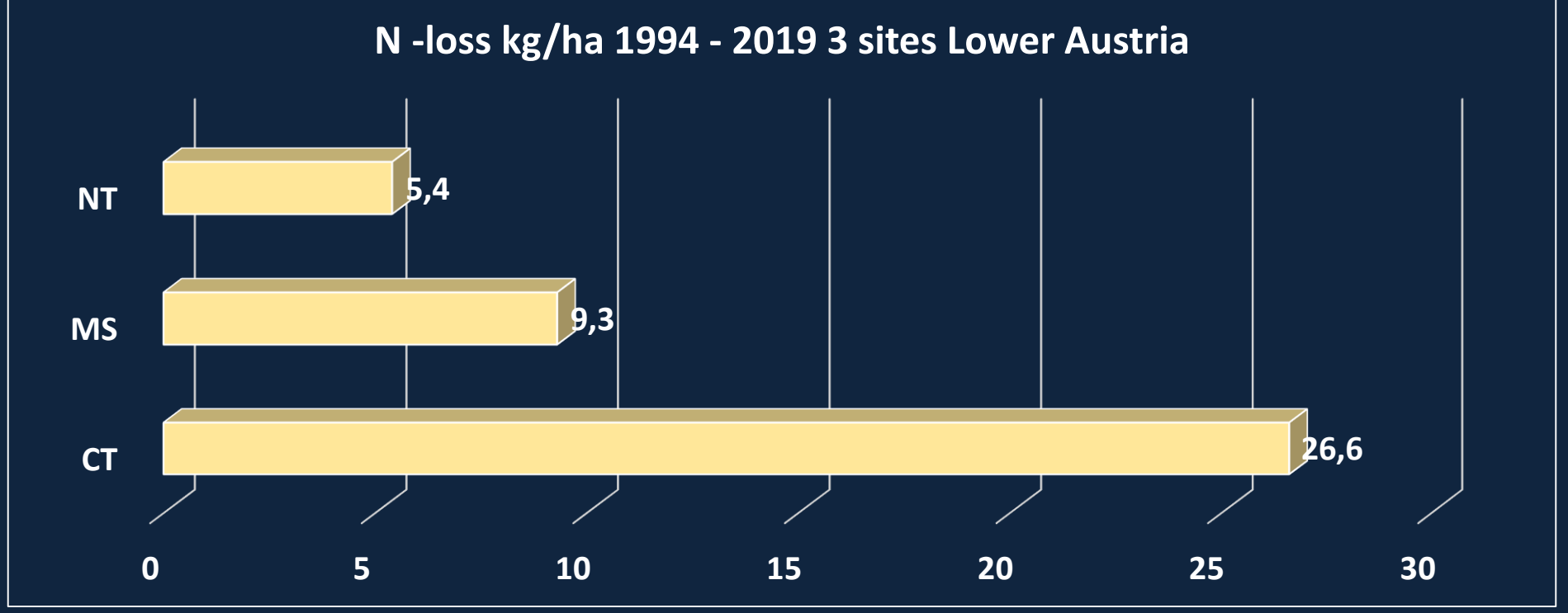

runnoff mm/ha 1994 - 2019
Pixendorf NT
14,3
Pixemdorf MS
26,9
Pixendorf CT
35,8
Pyhra NT
31,7
Pyhra MS
29,4
Pyhra CT
26,1
Mistelbach NT
10
Mistelbach MS
8,7
Mistelbach CT
19,5
0
5
10
15
20
25
30
35
40

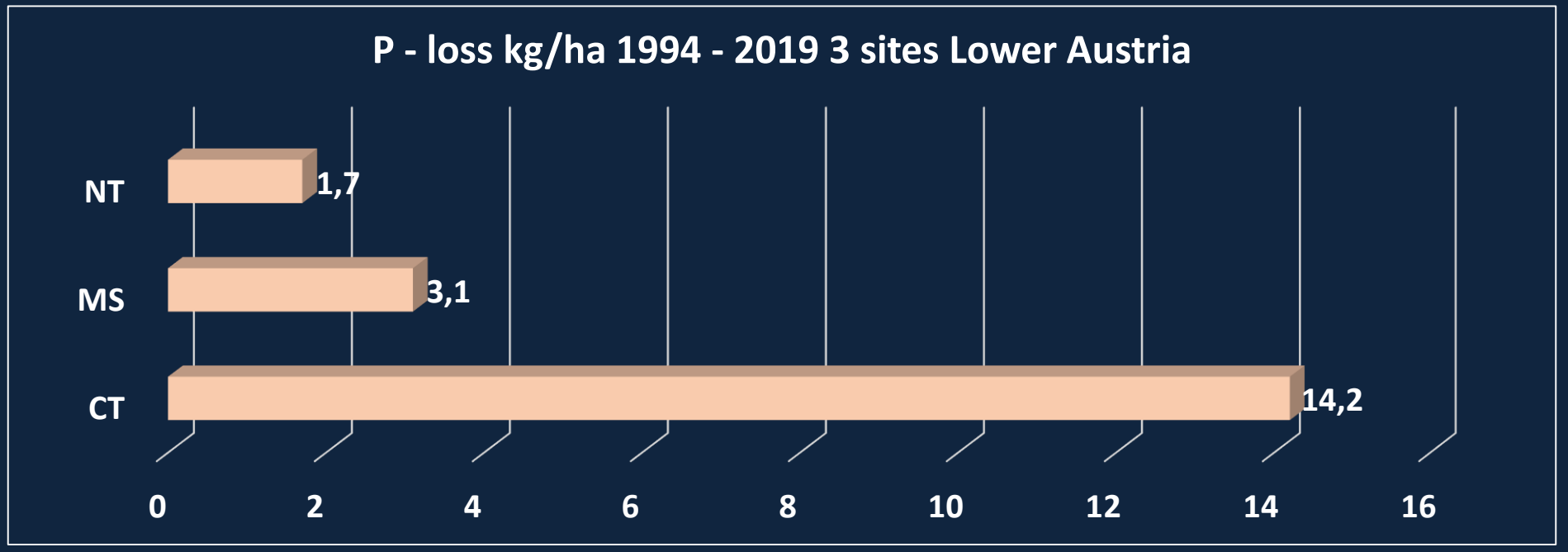

N - loss kg/ha 1994 - 2019
Pixendorf NT
1,6
Pixemdorf MS
4,5
Pixendorf CT
13,3
Pyhra NT
9,4
Pyhra MS
18,7
Pyhra CT
18,4
Mistelbach NT
5,2
Mistelbach MS
6,6
Mistelbach CT
48,1
0
10
20
30
40
50
60

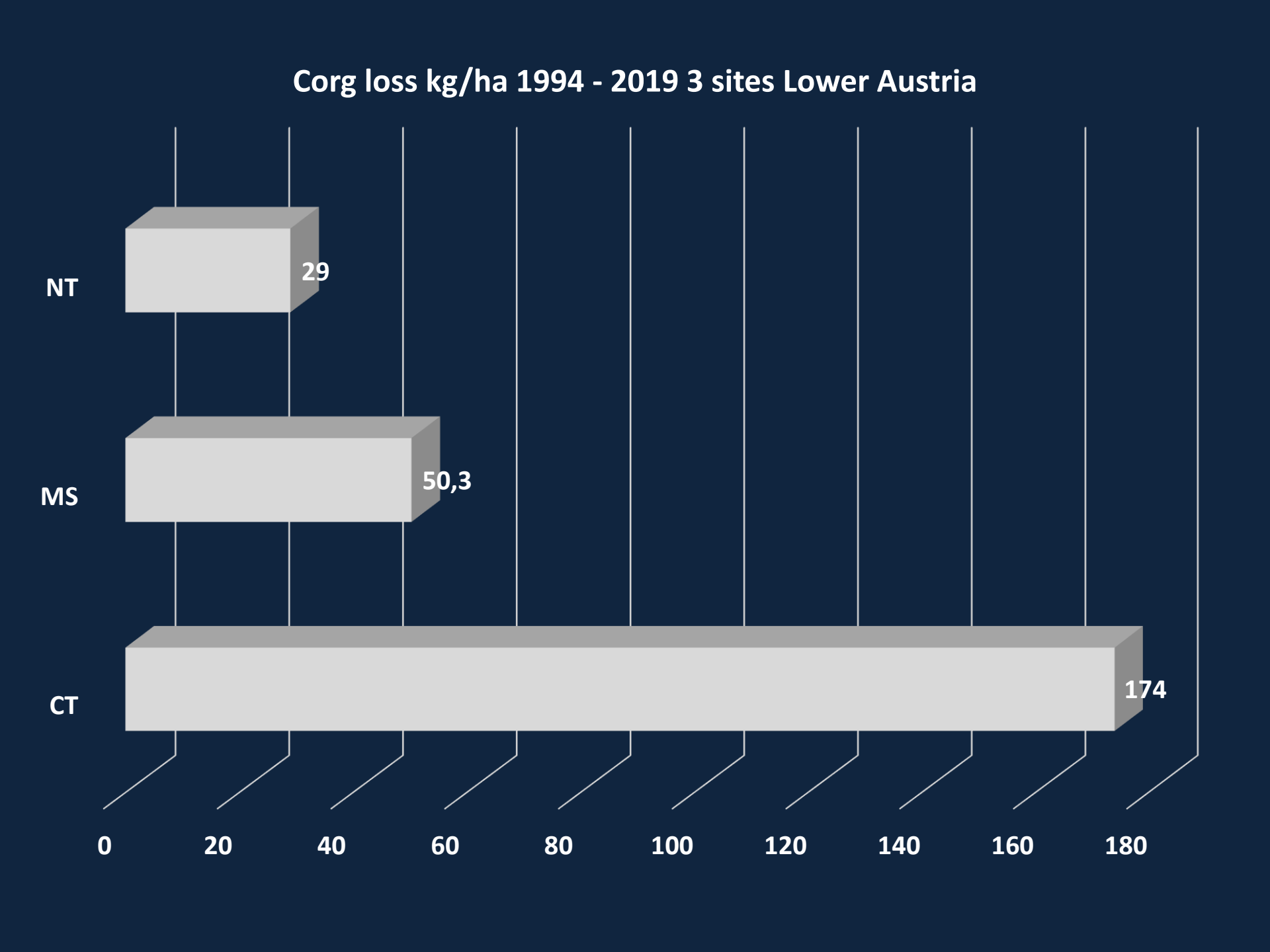

P - loss kg/ha 1994 - 2019
Pixendorf NT
0,7
Pixemdorf MS
2,1
Pixendorf CT
7,2
Pyhra NT
2,3
Pyhra MS
3,8
Pyhra CT
6,7
Mistelbach NT
2,1
Mistelbach MS
3,3
Mistelbach CT
28,7
0
5
10
15
20
25
30
35


Corg loss kg/ha 1994 - 2019
Pixendorf NT
12
Pixemdorf MS
40
Pixendorf CT
105
Pyhra NT
43
Pyhra MS
67
Pyhra CT
102
Mistelbach NT
32
Mistelbach MS
44
Mistelbach CT
315
0
50
100
150
200
250
300
350


runoff mm/ha 1994 - 2019 3 sites
NT
MS
CT
18,7
21,7
27,1
0
5
10
15
20
25
30

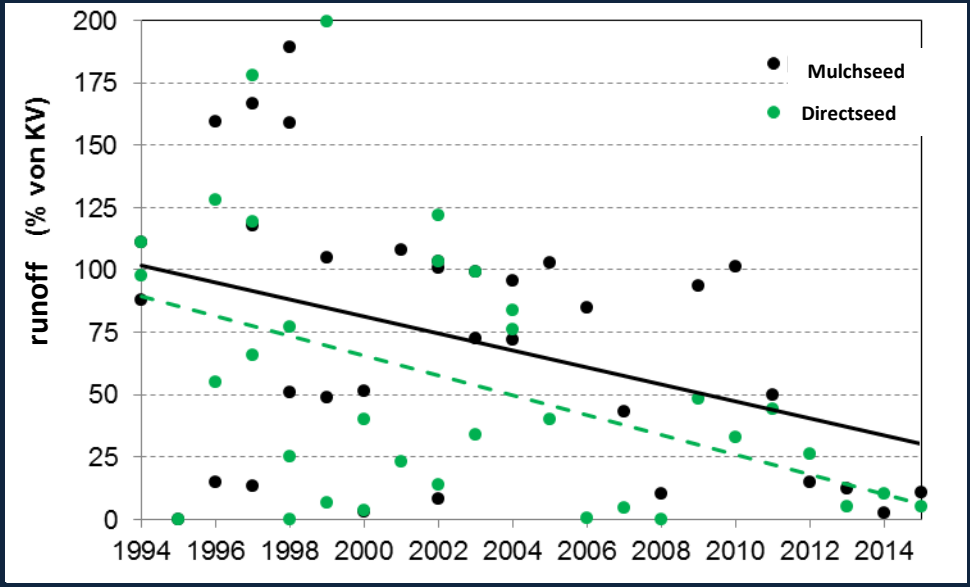

N -loss kg/ha 1994 - 2019 3 sites Lower Austria
NT
MS
CT
5,4
9,3
26,6
0
5
10
15
20
25
30


P - loss kg/ha 1994 - 2019 3 sites Lower Austria
NT
MS
CT
1,7
3,1
14,2
0
2
4
6
8
10
12
14
16

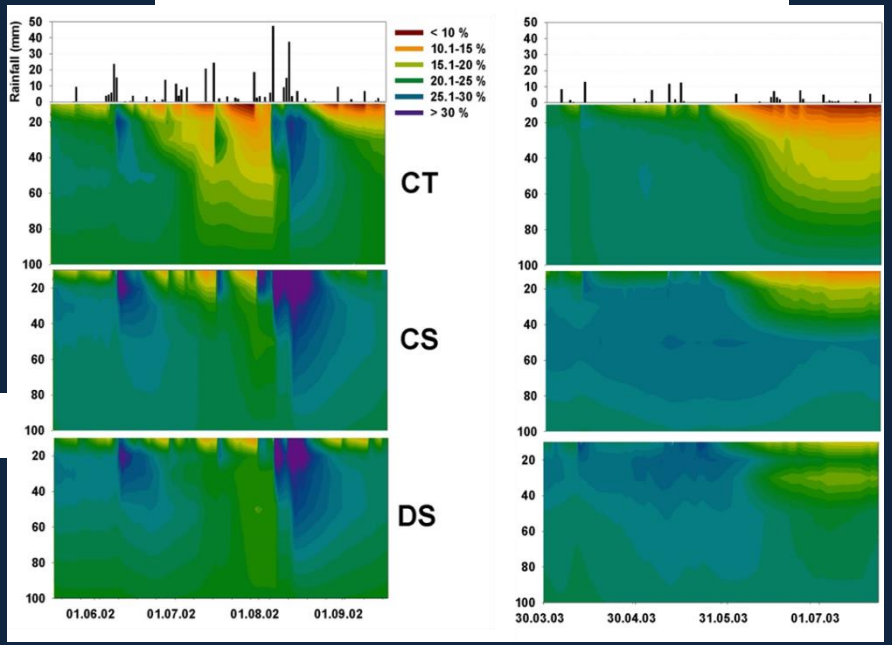

Corg loss kg/ha 1994 - 2019 3 sites Lower Austria
NT
29
MS
50,3
CT
174
0
20
40
60
80
100
120
140
160
180

Runoff and Infiltration 1994 - 2015

Infiltration and runoff



soilmoisture in Mistelbach
VP 2002 (corn) und 2003 (Winterwheat)



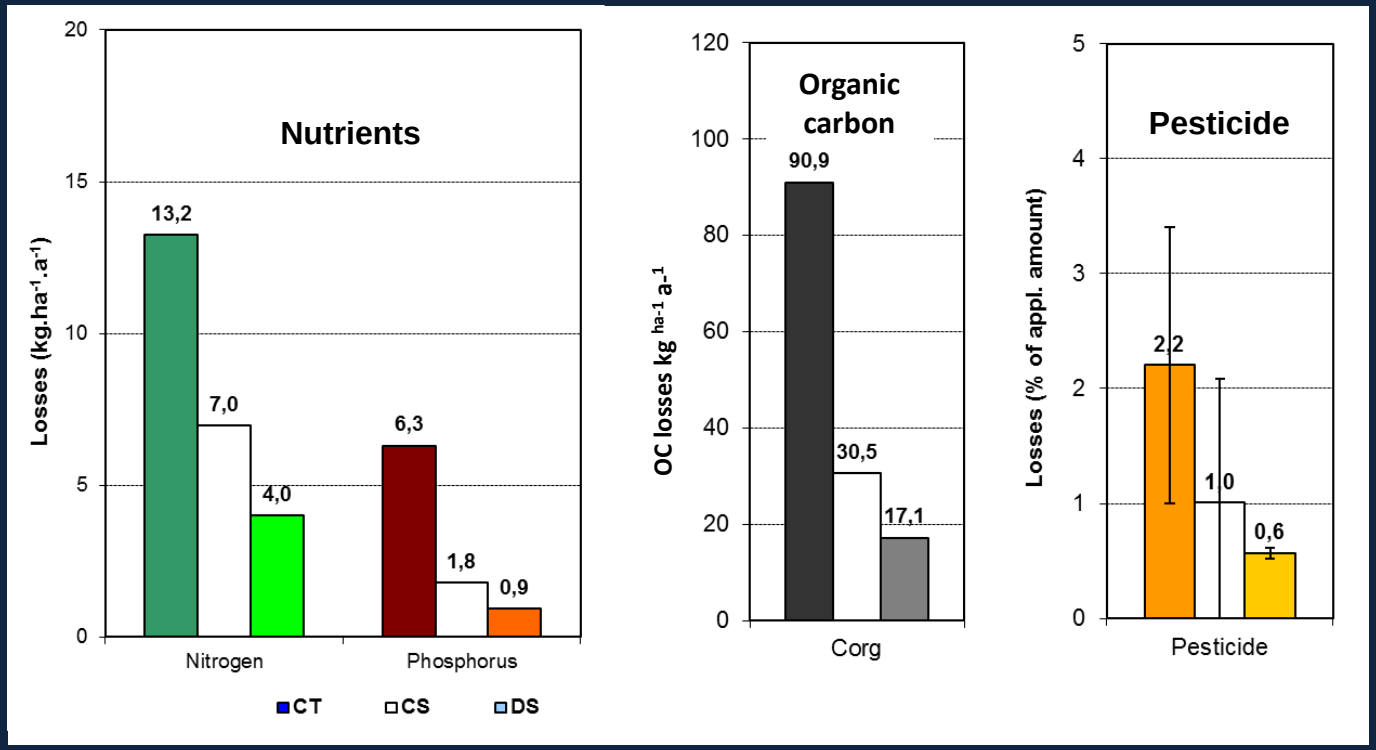
Number and Amaount of the runoffevents (N = 140)

	Average runoff (mm)			Median runoff (mm)			Number runoff events		
	KV	KS	DS	KV	KS	DS	KV	KS	DS
Pixendorf	4,8	3,6	2,7	1,2	0,8	0,5	**91**	**97**	**73**
Mistelbach	4,0	3,3	4,0	0,5	0,3	0,4	**49**	**36**	**32**
Pyhra	6,8	6,7	9,5	0,9	0,6	0,4	**24**	**22**	**20**

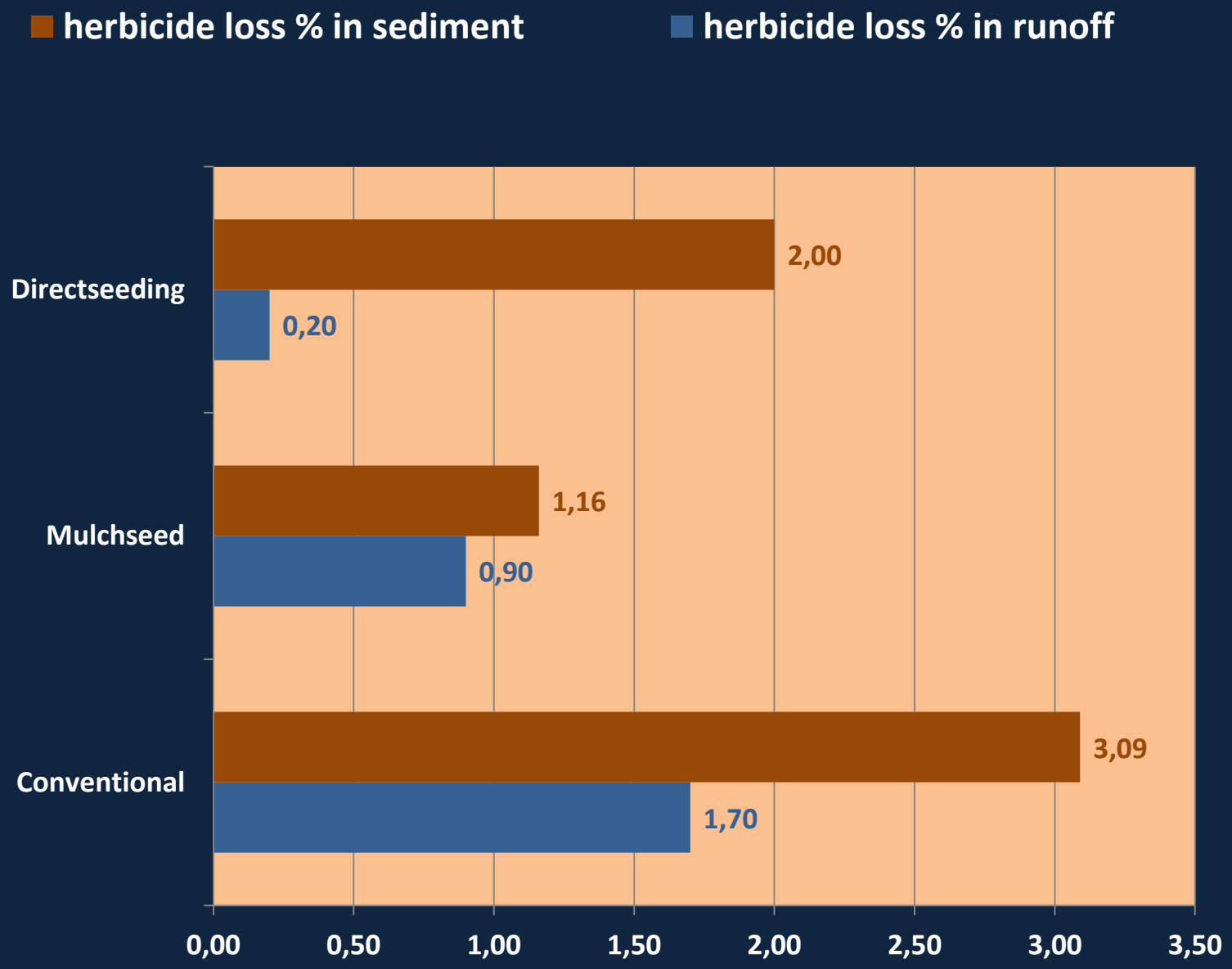
Klik 2015

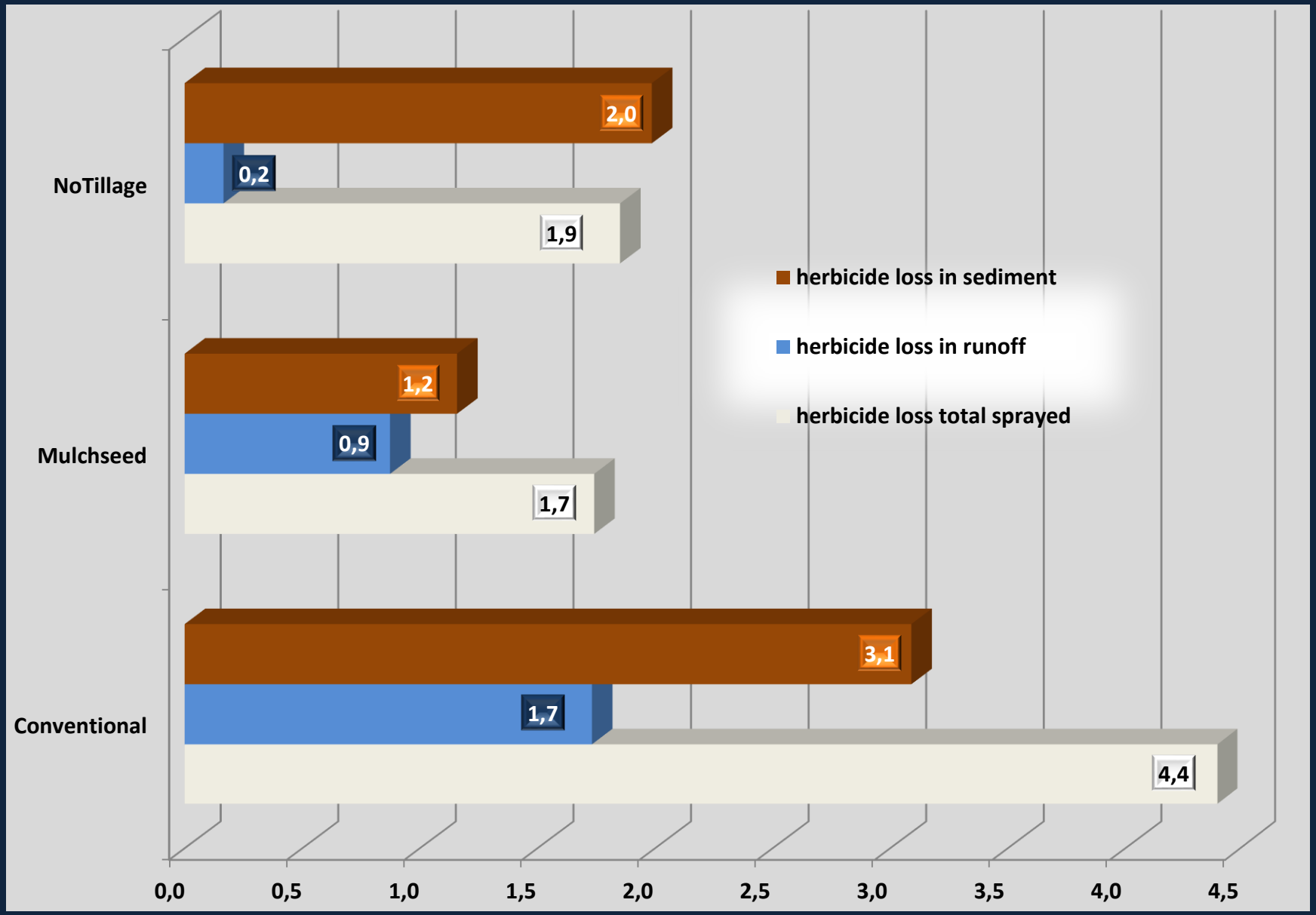
Effect of nutrient and pesticide loss

average 1994 - 2019



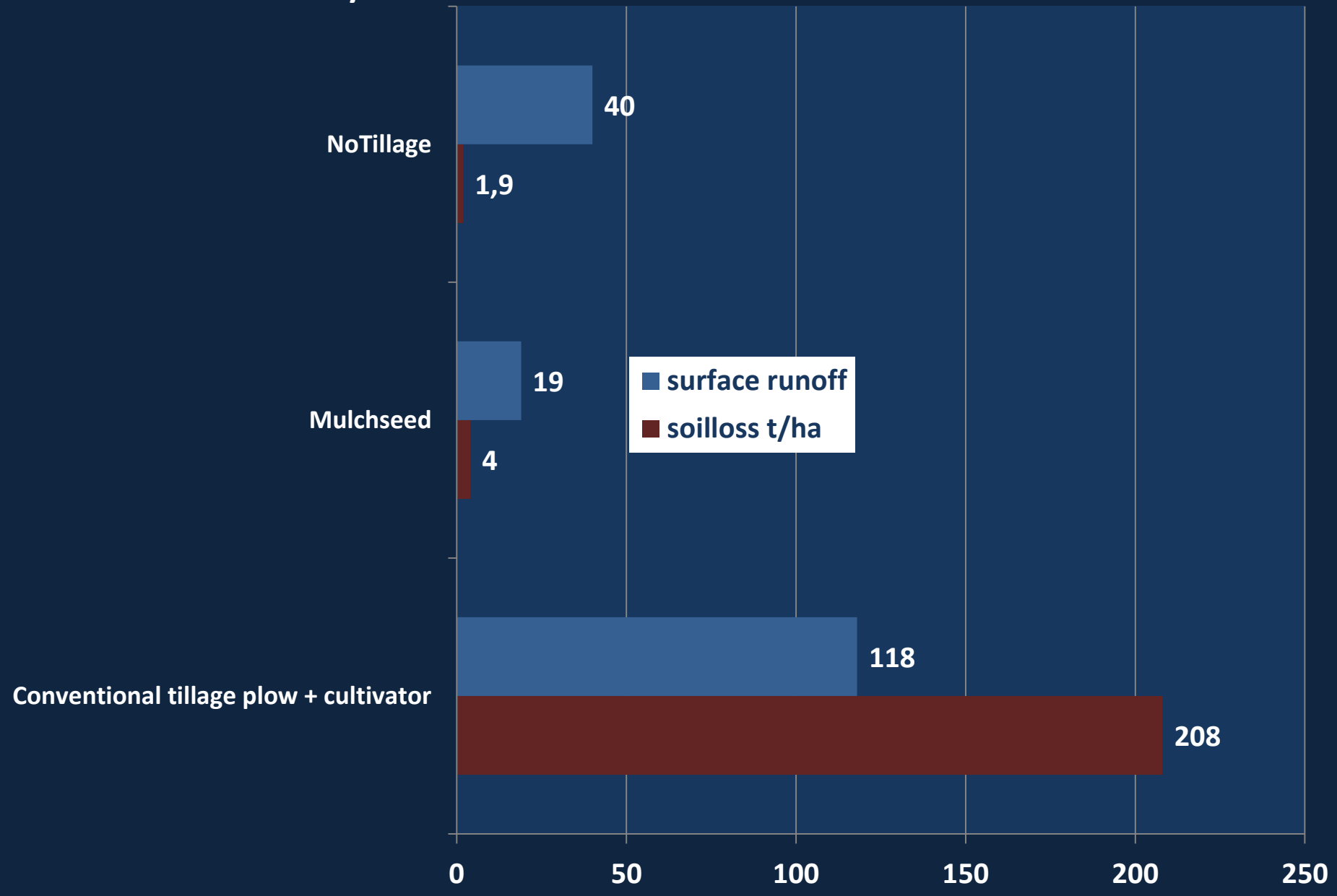
Klik 2020


herbicide loss % in sediment
herbicide loss % in runoff
Directseeding
Mulchseed
Conventional
2,00
0,20
1,16
0,90
3,09
1,70
0,00
0,50
1,00
1,50
2,00
2,50
3,00
3,50


NoTillage
Mulchseed
Conventional
2,0
0,2
1,9
1,2
0,9
1,7
3,1
1,7
4,4
herbicide loss in sediment
herbicide loss in runoff
herbicide loss total sprayed
0,0
0,5
1,0
1,5
2,0
2,5
3,0
3,5
4,0
4,5

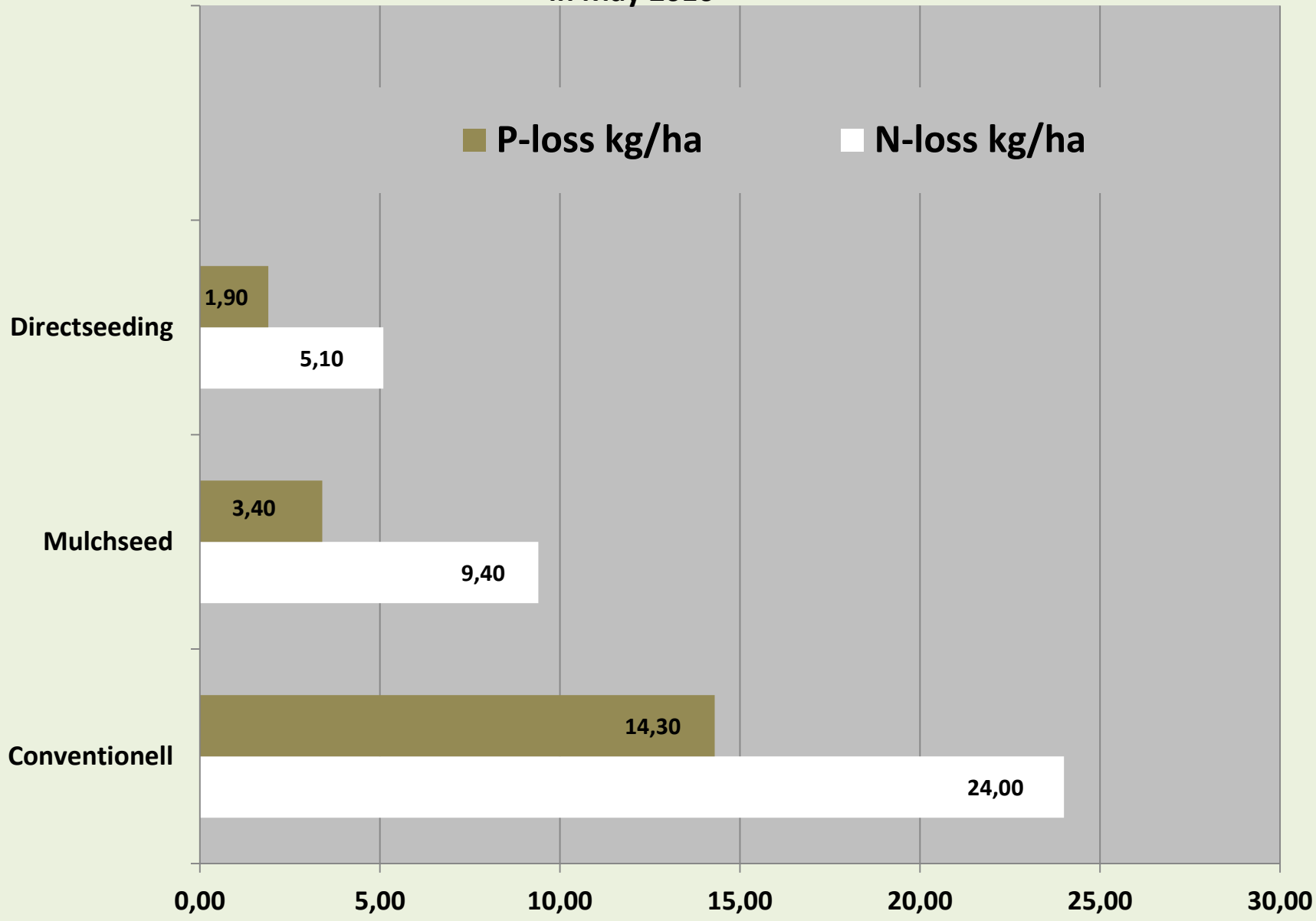
Klik 2018

Erosion Plots Mistelbach – 40 km North Vienna, dry climate 600mm/year Results 2016
3 stormevents in May



Klik 2017

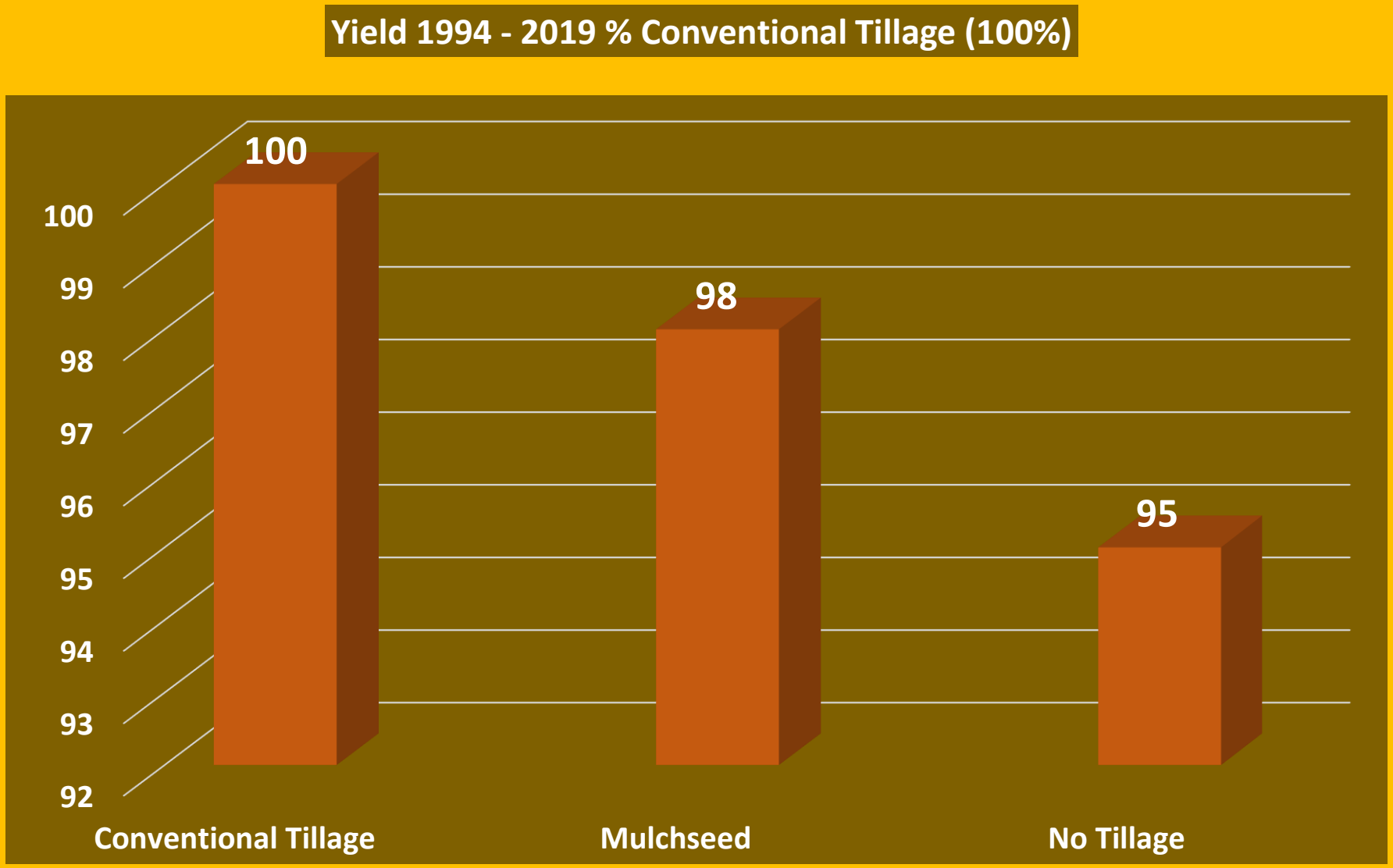
Erosion Plots Mistelbach – 40 km North Vienna, dry climate 600mm/year Results 2016 - 3 stormevents in May 2016



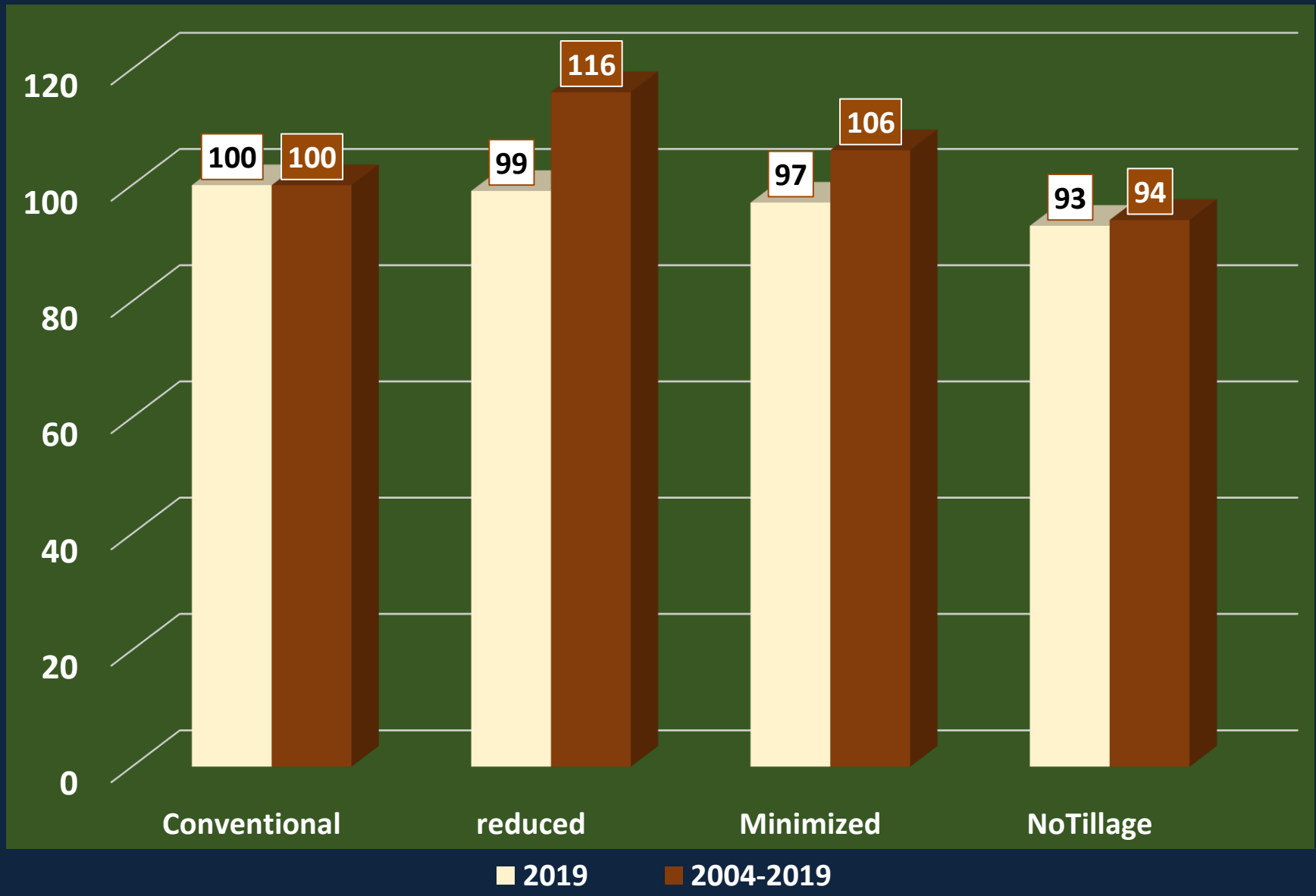
Yield in % Conventional 1994 – 2019
Mistelbach - Pyhra(St.Pölten) - Pixendorf(Tulln)

Variants 1994-2019	Pyhra	Mistelbach	Pixendorf until 2016
Conventional plow - without covercrops	100	100	100
Convetional wirh cover crops (Californian blue bell, mustard, cress	97	100	105
Mulchseed without cover crops, crop residuals	93	97	107
Mulchseed + cover crops (mustard, oilradish, mungbean, californian bluebell)	99	99	105
Mulchseed + cover crops vetchling, vetch, egyptian clover)	104	96	109
No Tillage + cover crops (Californian bluebell, mustard, cress)	99	91	104
No Tillage + cover crops (perennial rye)	93	91	96
No Tillage + cover crops (summer barley)	99	98	108

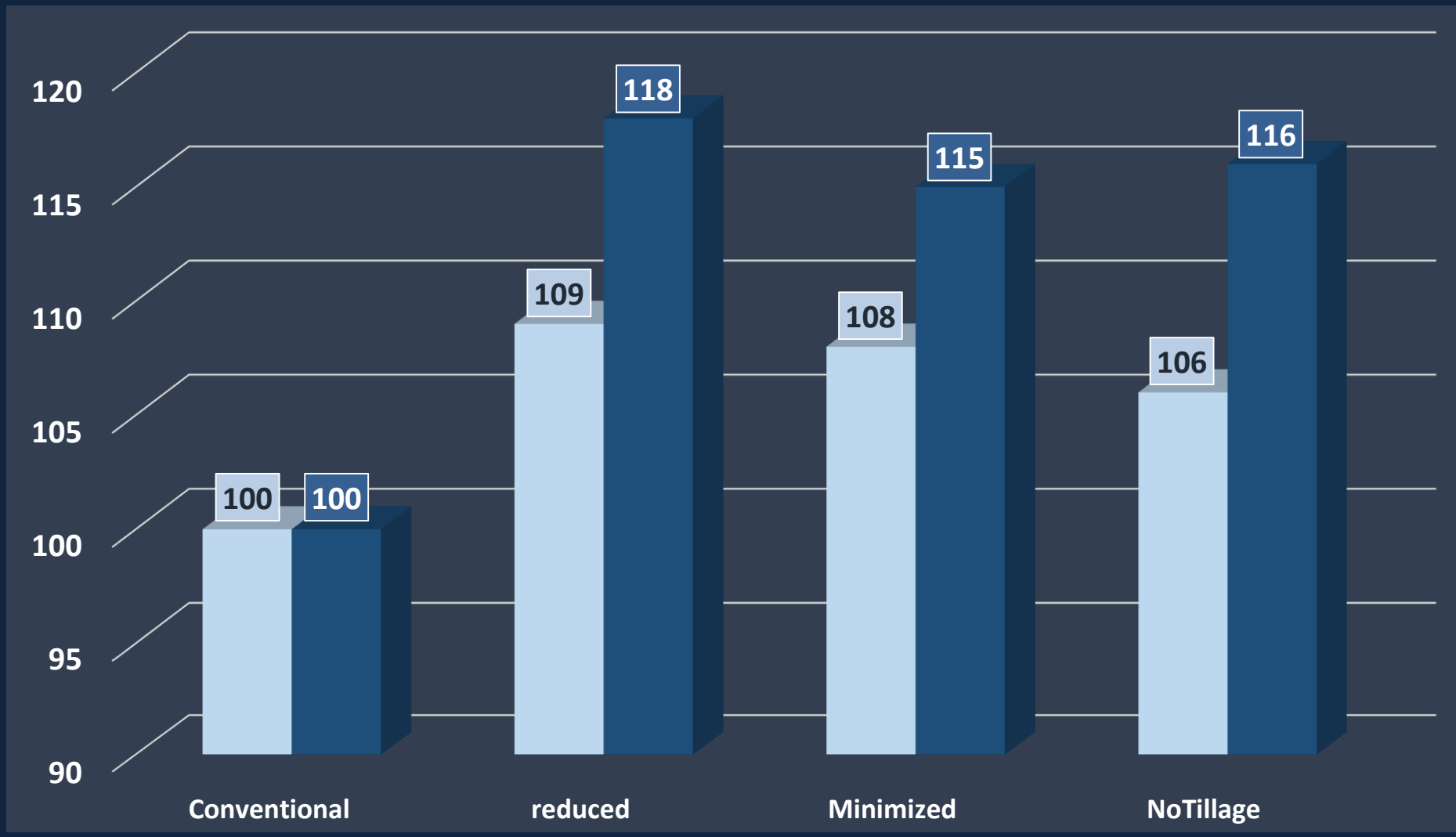
Yield erosion plots 1994 - 2019



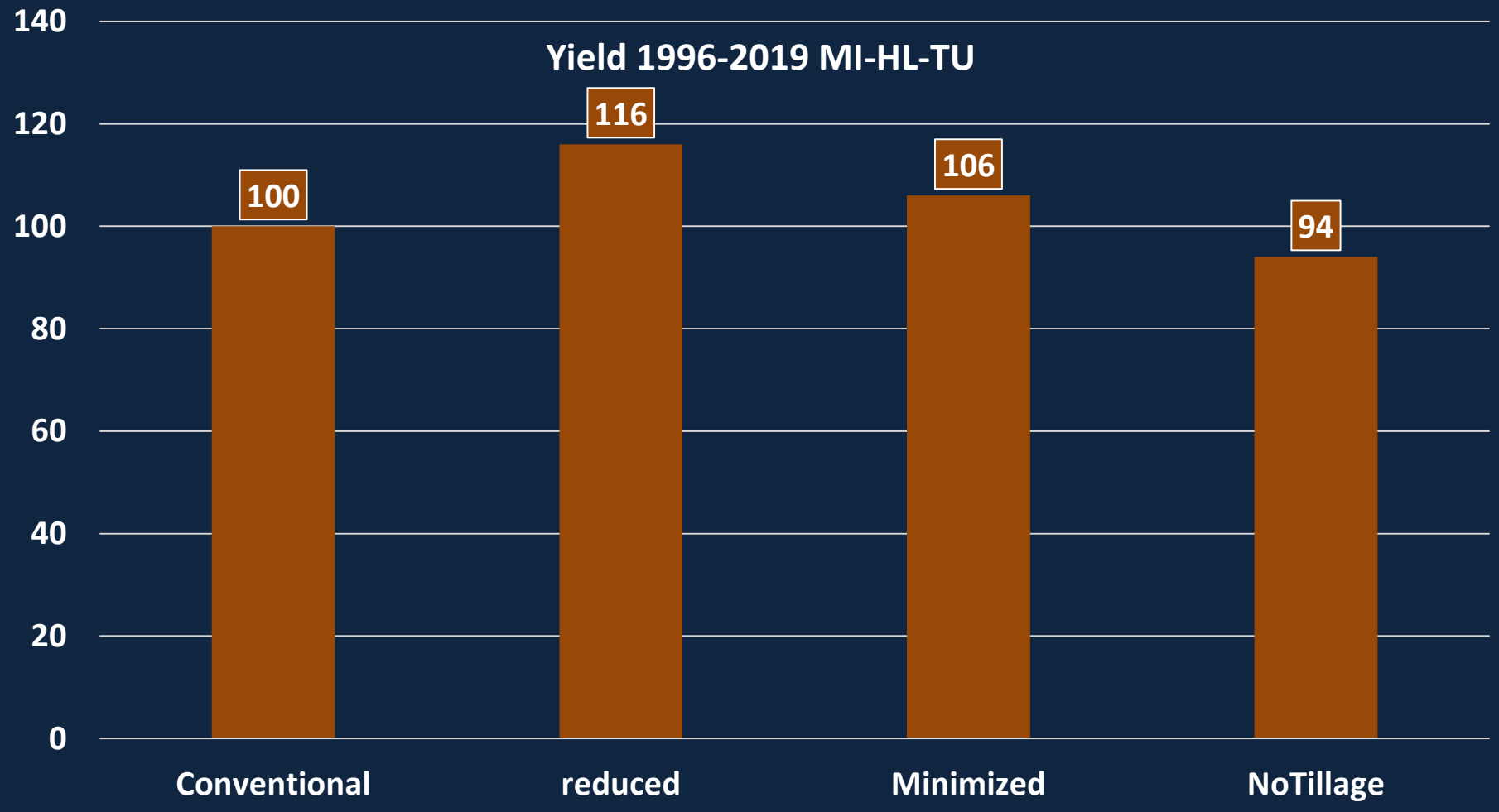
Yield tillage trial % conventional tillage 1996 - 2019



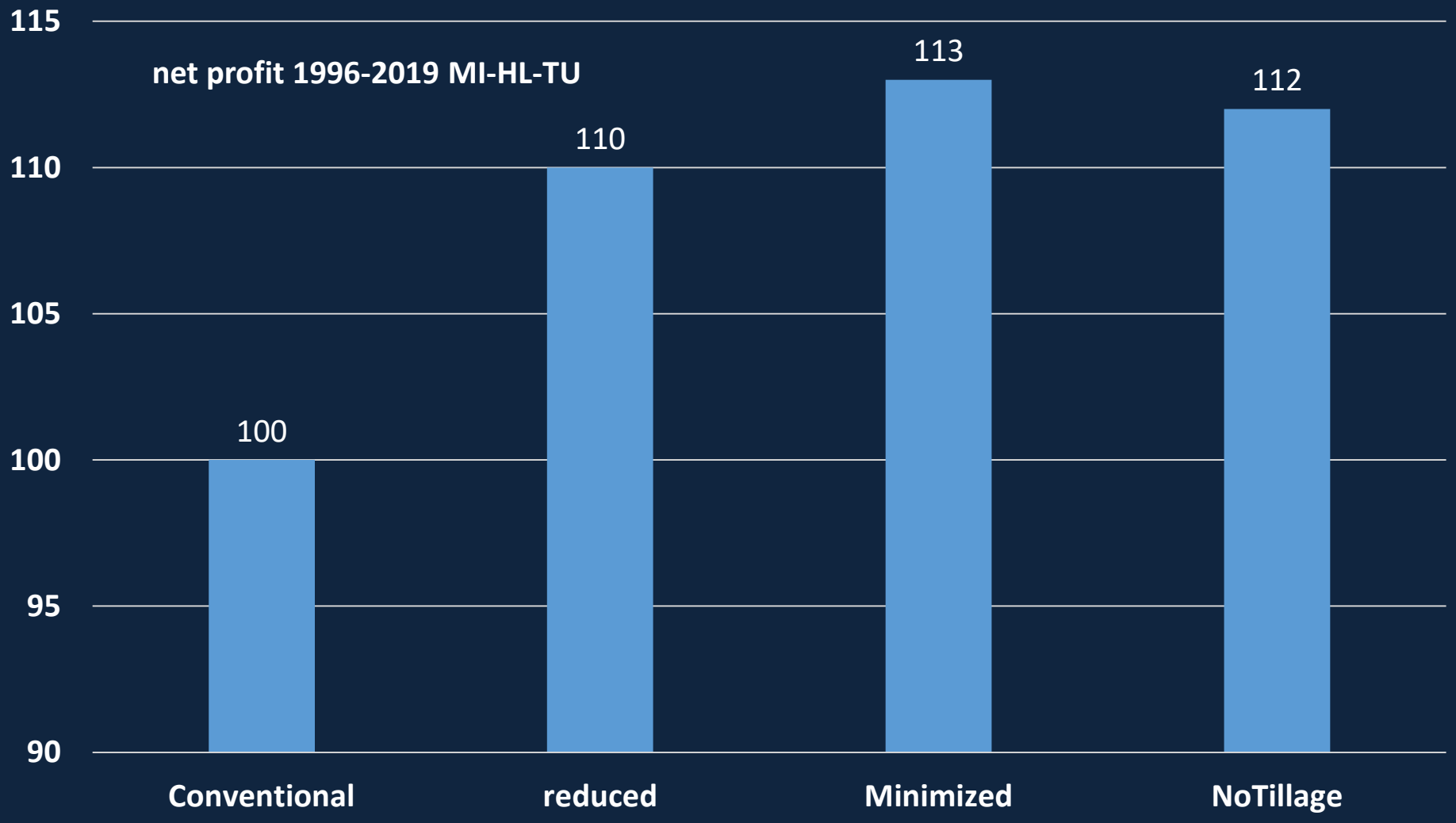
net profit tillage trial % conventional tillage 1996 - 2019



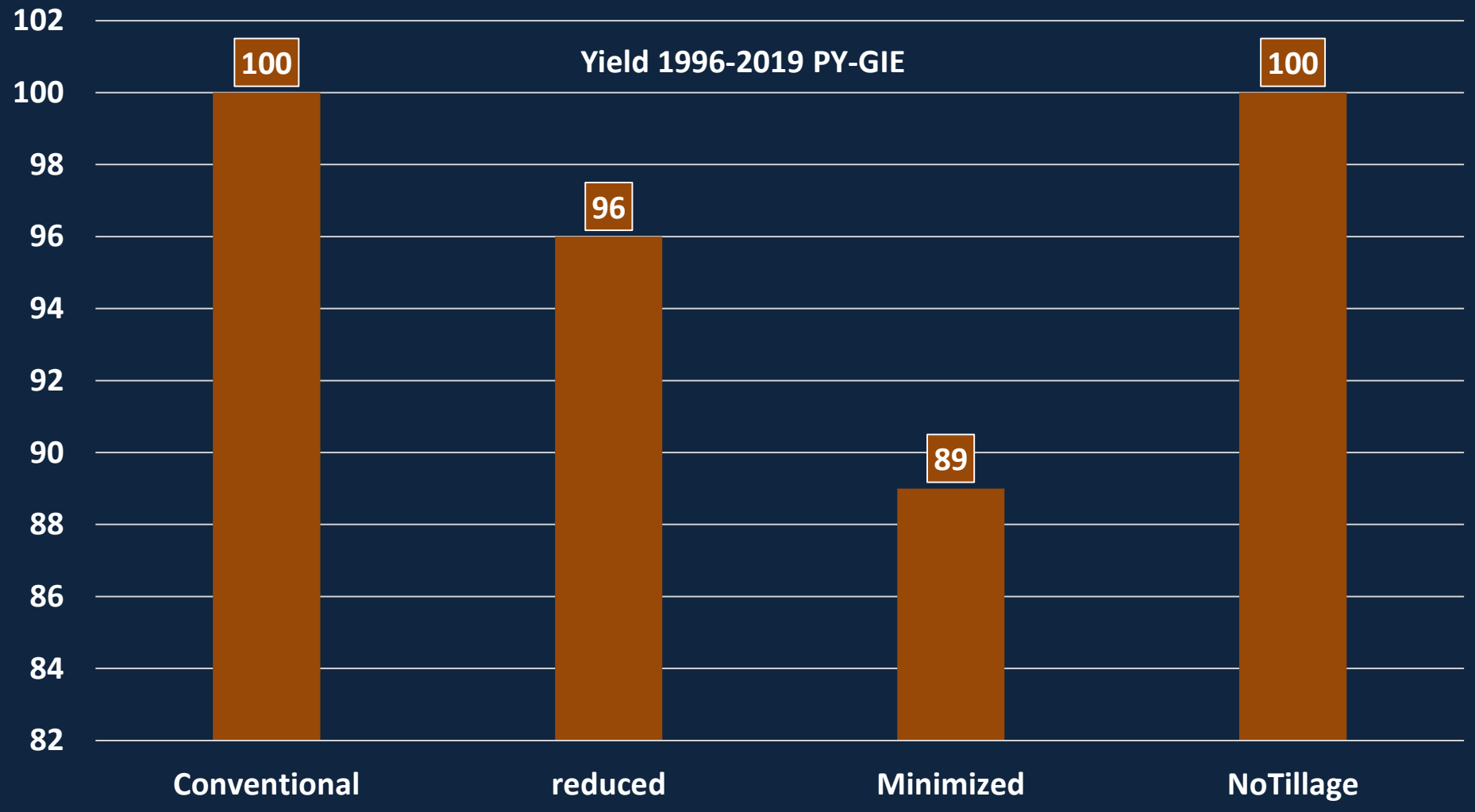
Yield tillage trial % conventional tillage 1996 – 2019 semiarid area



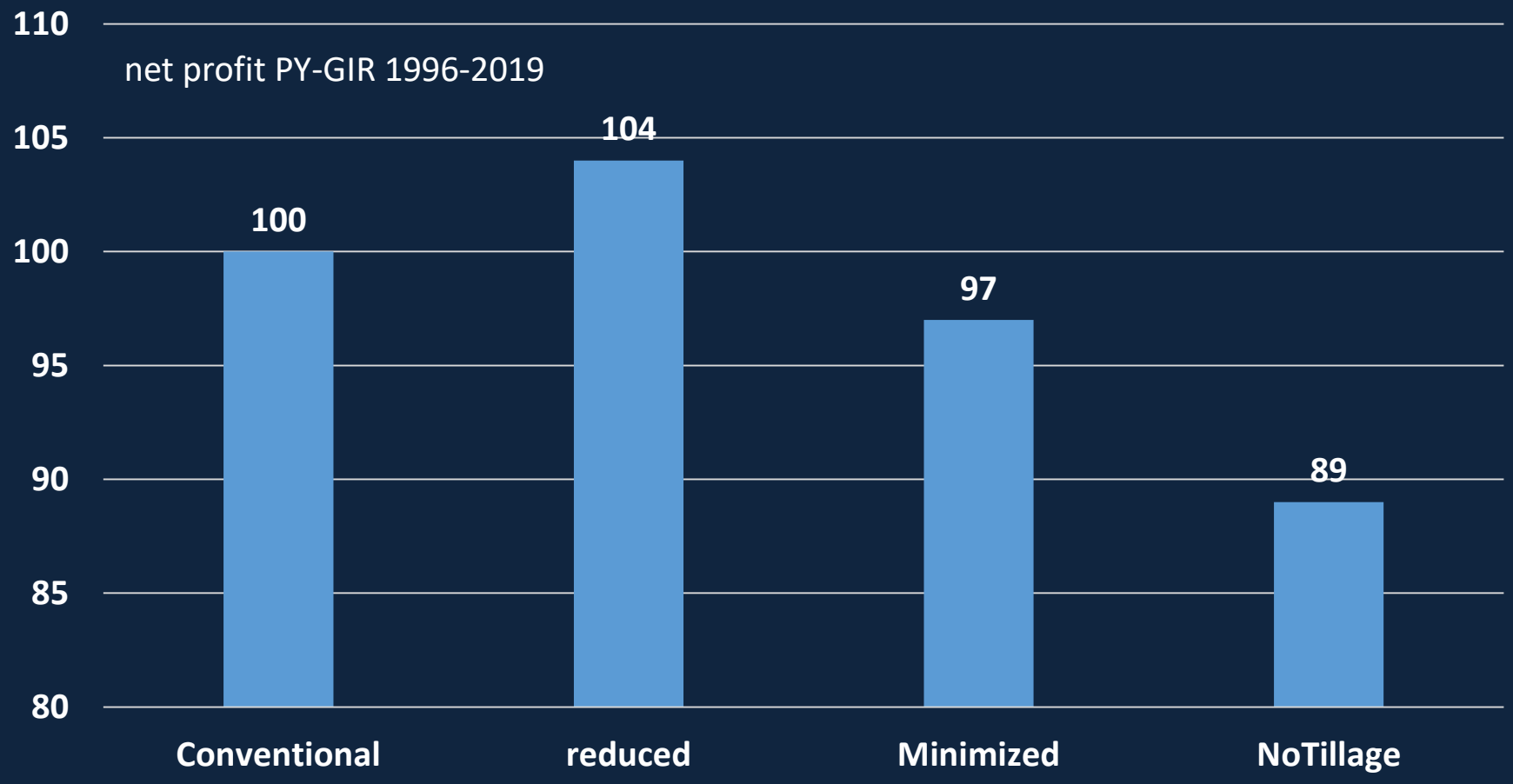
net profit tillage trial % conventional tillage 1996 – 2019 semiarid area



Yield tillage trial % conventional tillage 1996 – 2019 moderate wetland



net profit tillage trial % conventional tillage 1996 – 2019 moderate wetland



Soil compaction

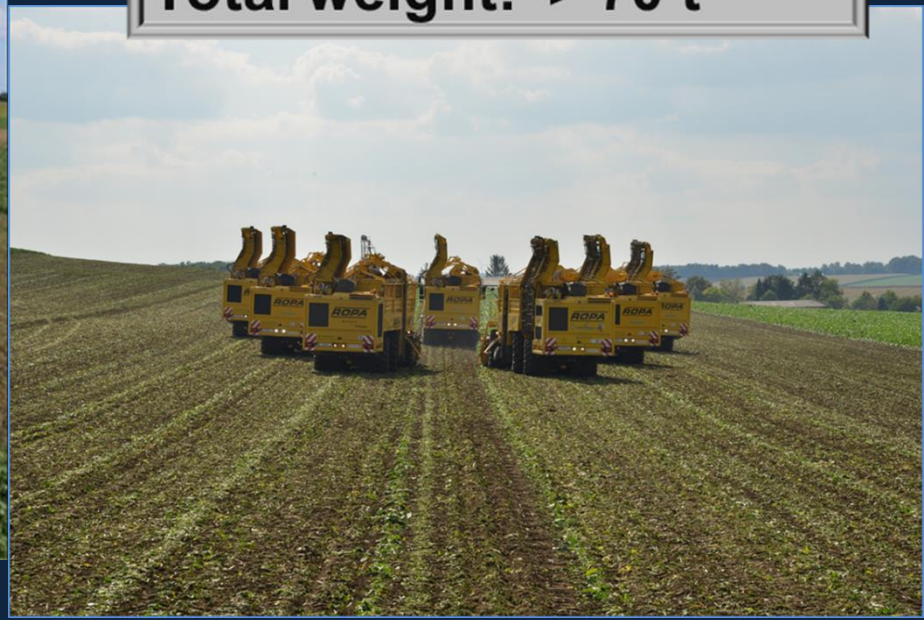


Sugar beet harvest – soil compaction





Sugar Beet harvester
Tare weight: 40 t
Tank volume: > 30 t
Total weight: > 70 t

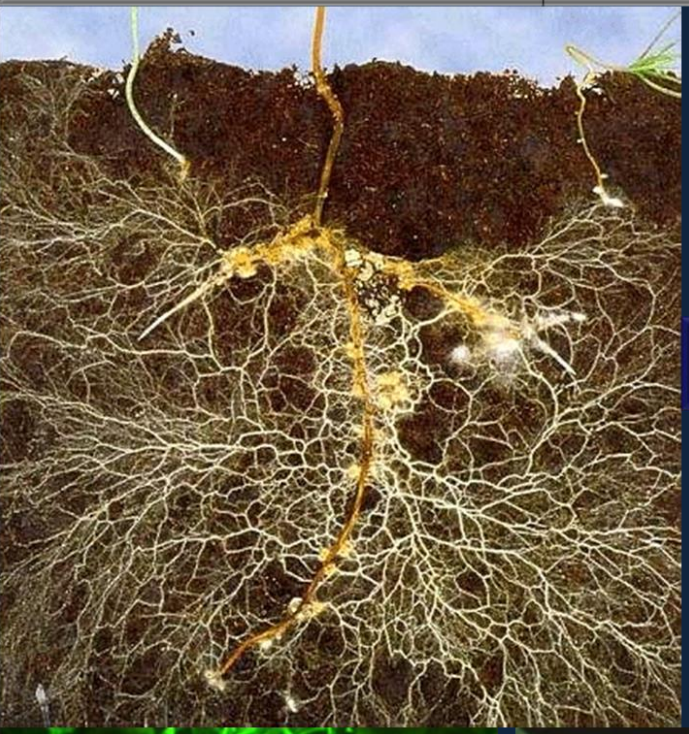


Glomalin is a glycoprotein produced abundantly on hyphae and spores of arbuscular mycorrhizal (AM) fungi in soil and in roots. Glomalin was discovered in 1996 by Sara F. Wright, a scientist at the USDA Agricultural Research Service.[1] The name comes from Glomales, an order of fungi.[2]

The specific protein glomalin has not yet been isolated and described.[4] However, glomalin-related soil proteins (GRSP) have been identifi ed using a monoclonal antibody (Mab32B11) raised against crushed AMF spores. It is defined by its extraction conditions and reaction with the antibody Mab32B11.

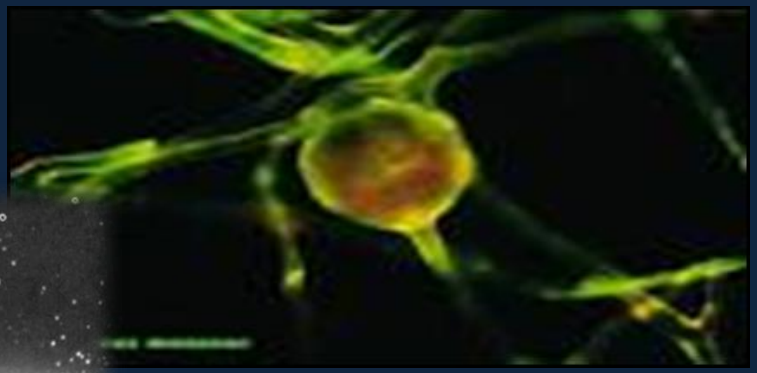
The discoverer of glomalin, Sara Wright, thinks the "glomalin molecule is a clump of small glycoproteins with iron and other ions attached... glomalin contains form 1 to 9% tightly bound iron.... We've seen glomalin on the ouside of hyphae, and we believe this is how the hyphae seal themselves so they can carry water and nutrients. It may also be what gives them the rigidity they need to span the air spaces between soil particles."

Glomalin takes 7 -42 years to biodegrade.[1]

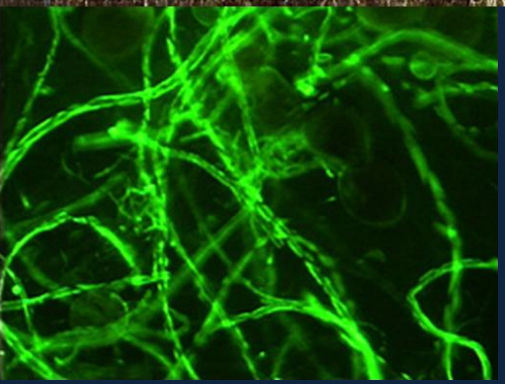


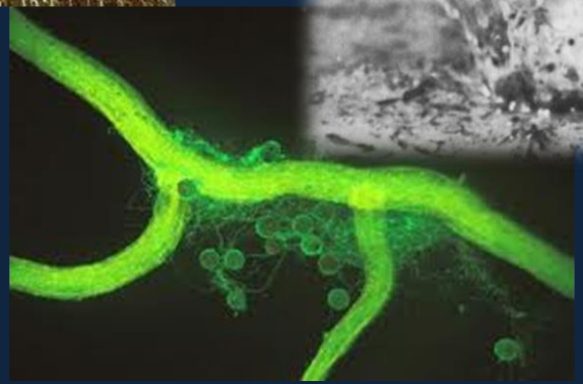


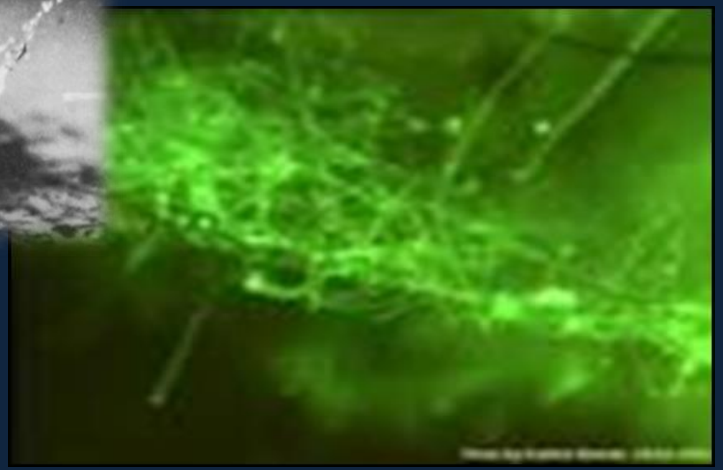
GLOMALIN

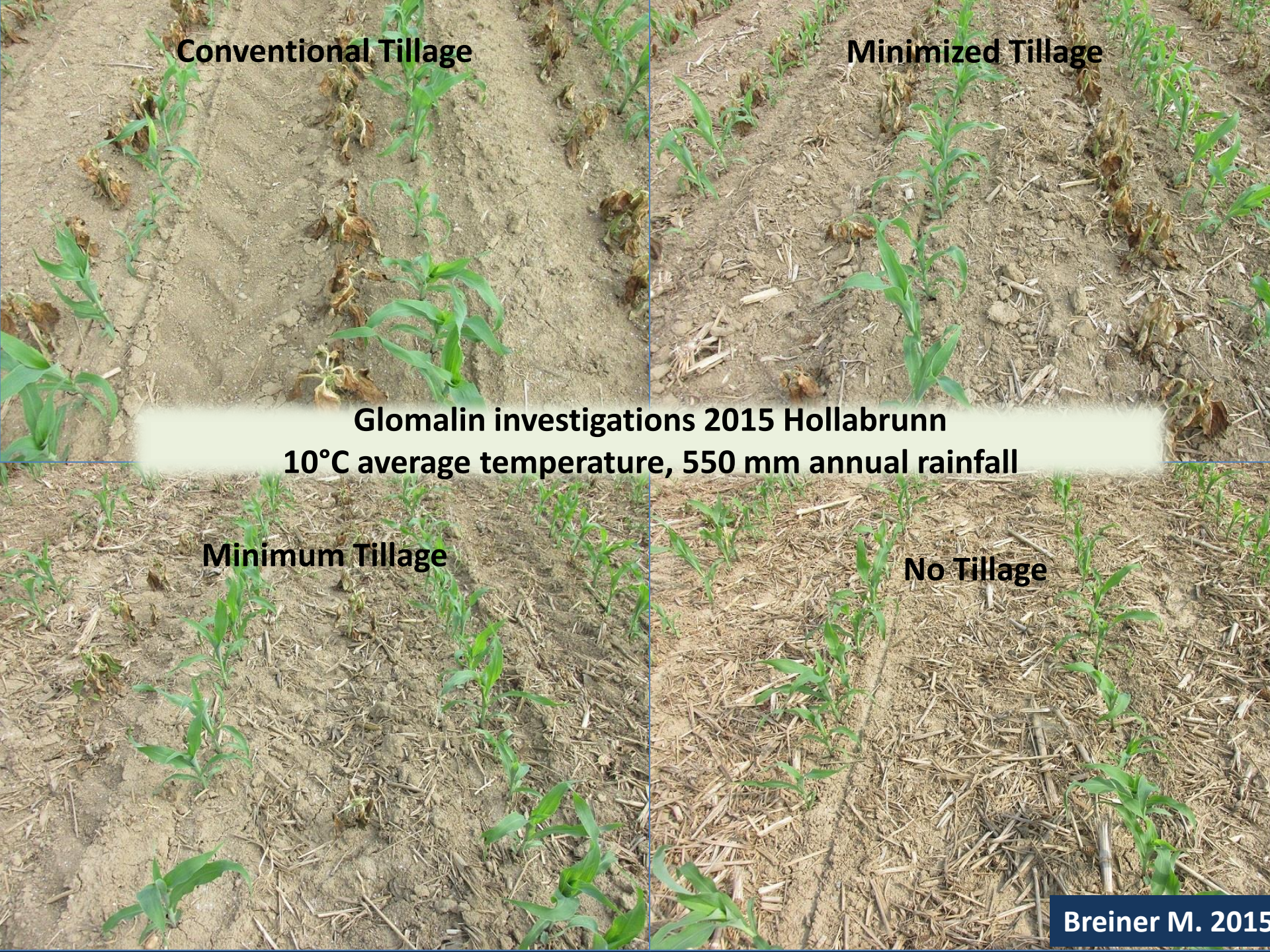


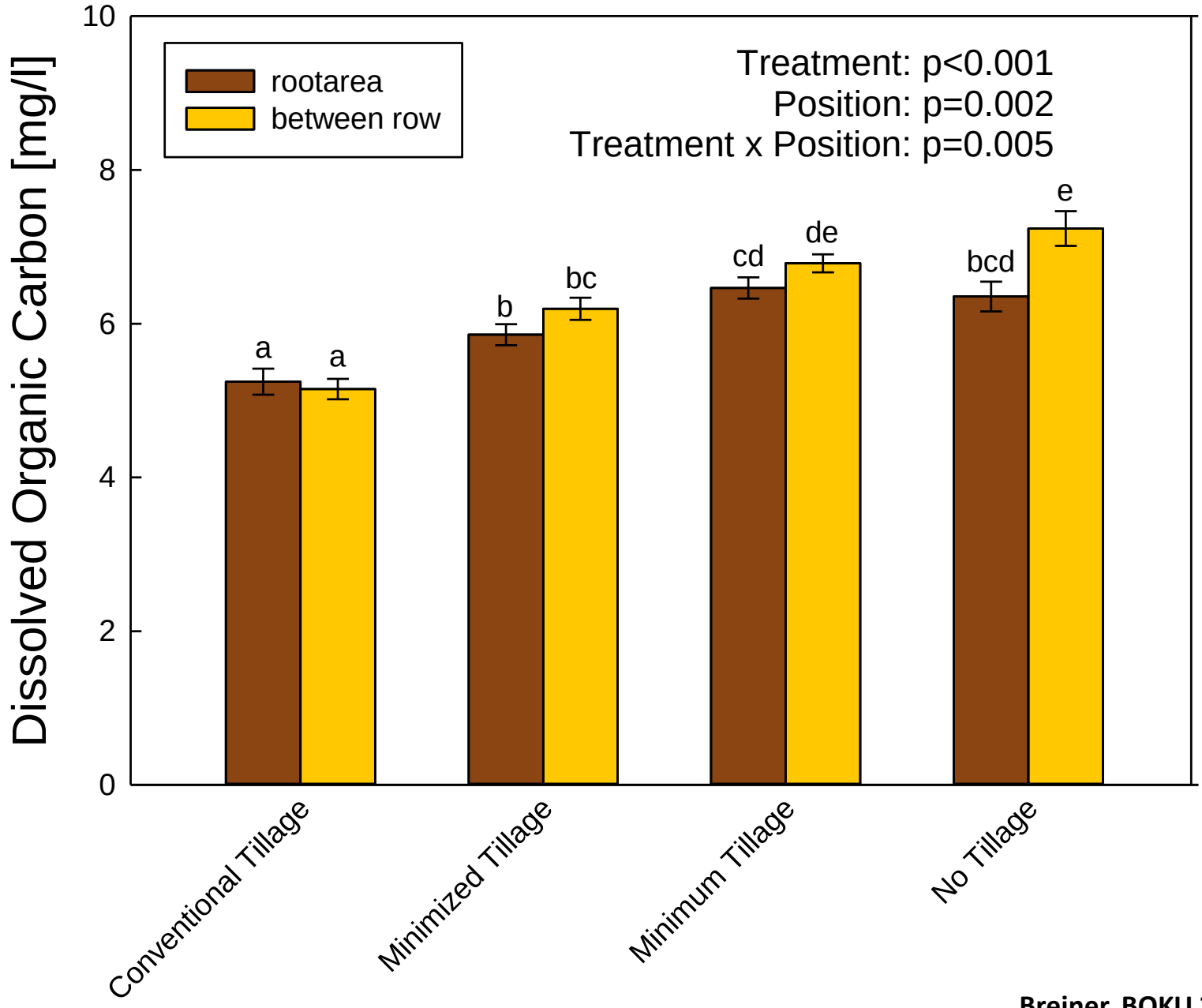




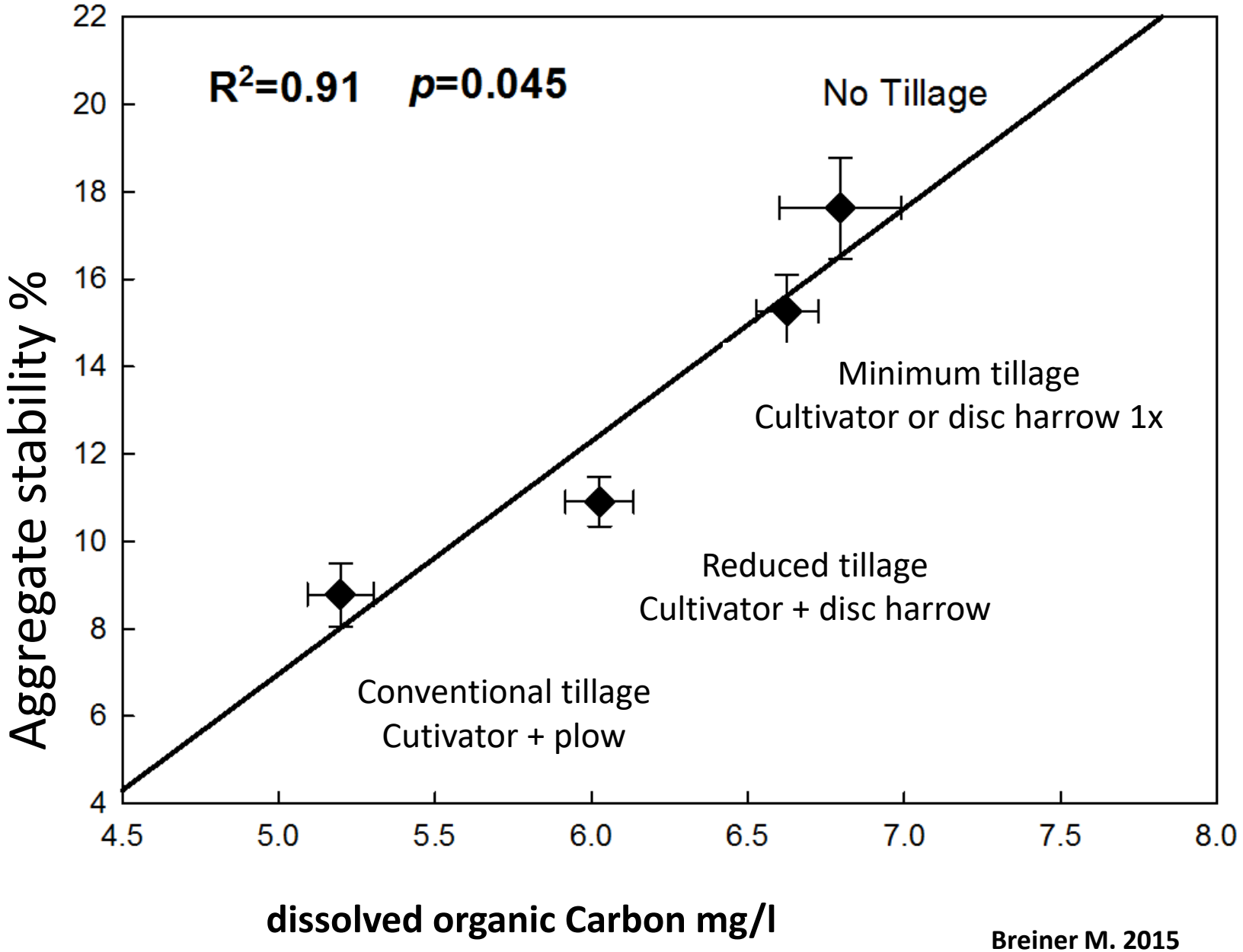




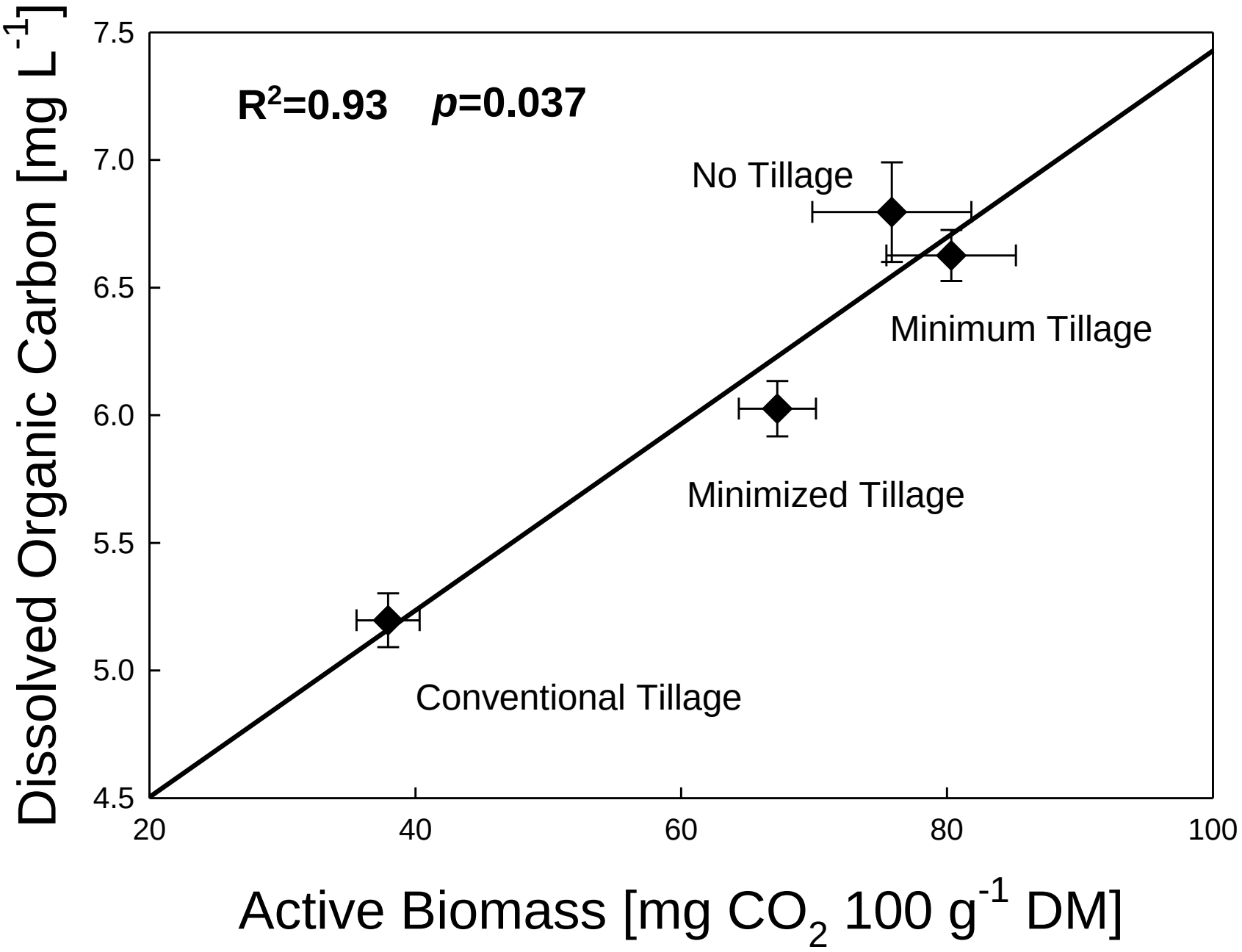

Conventional Tillage
Minimized Tillage
Glomalin investigations 2015 Hollabrunn
10°C average temperature, 550 mm annual rainfall
Minimum Tillage
No Tillage
Breiner M. 2015

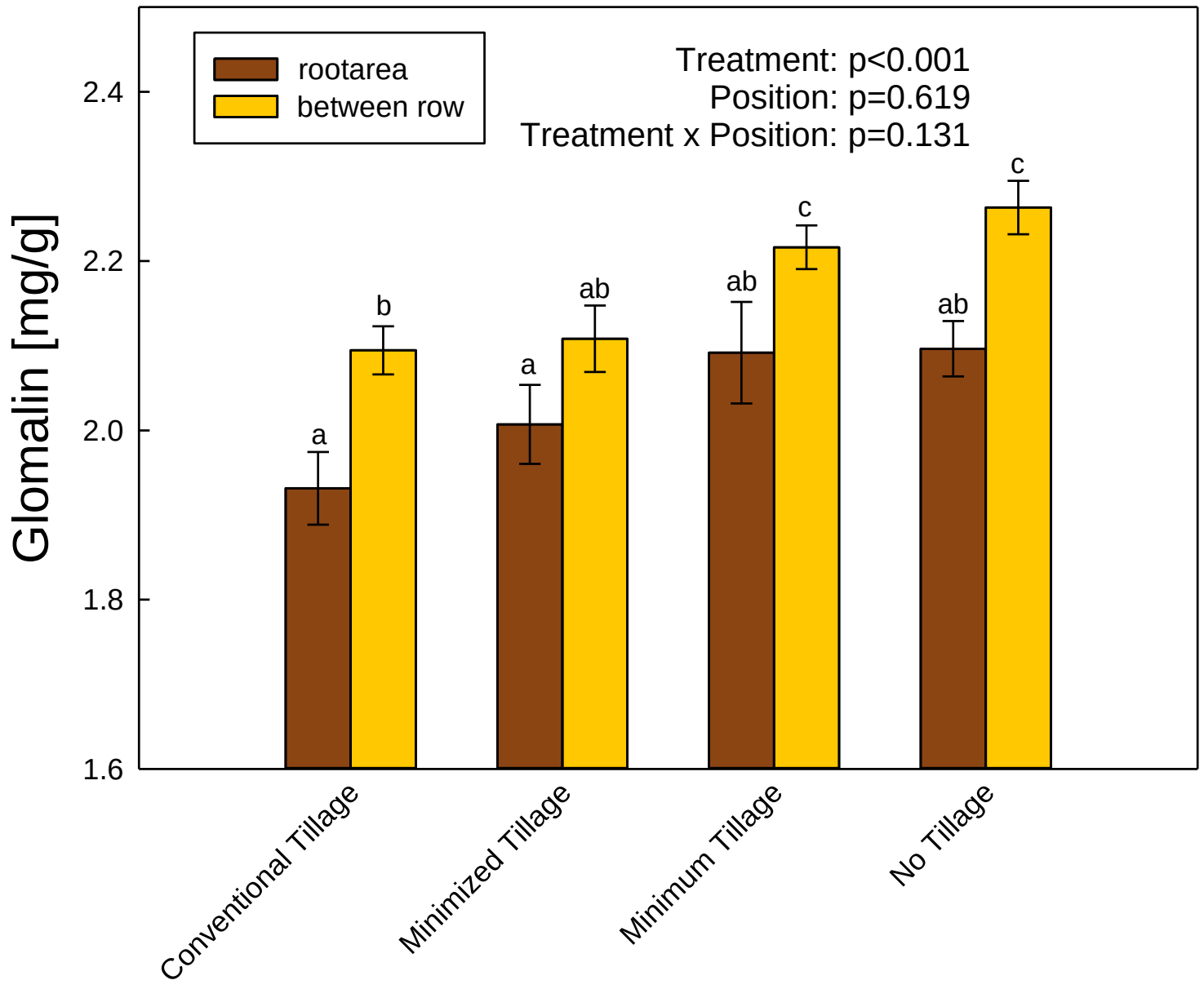


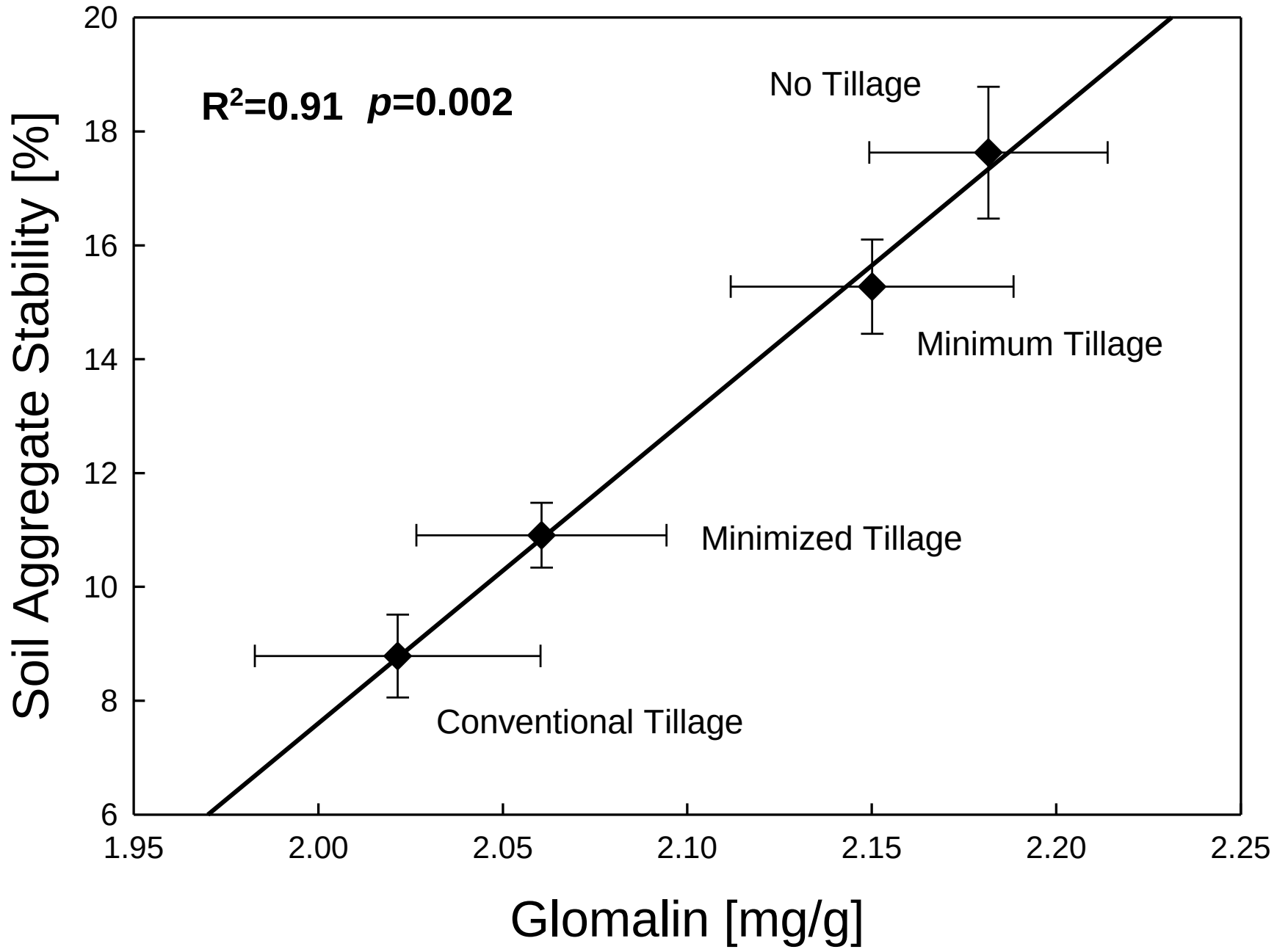
Breiner, BOKU 2015

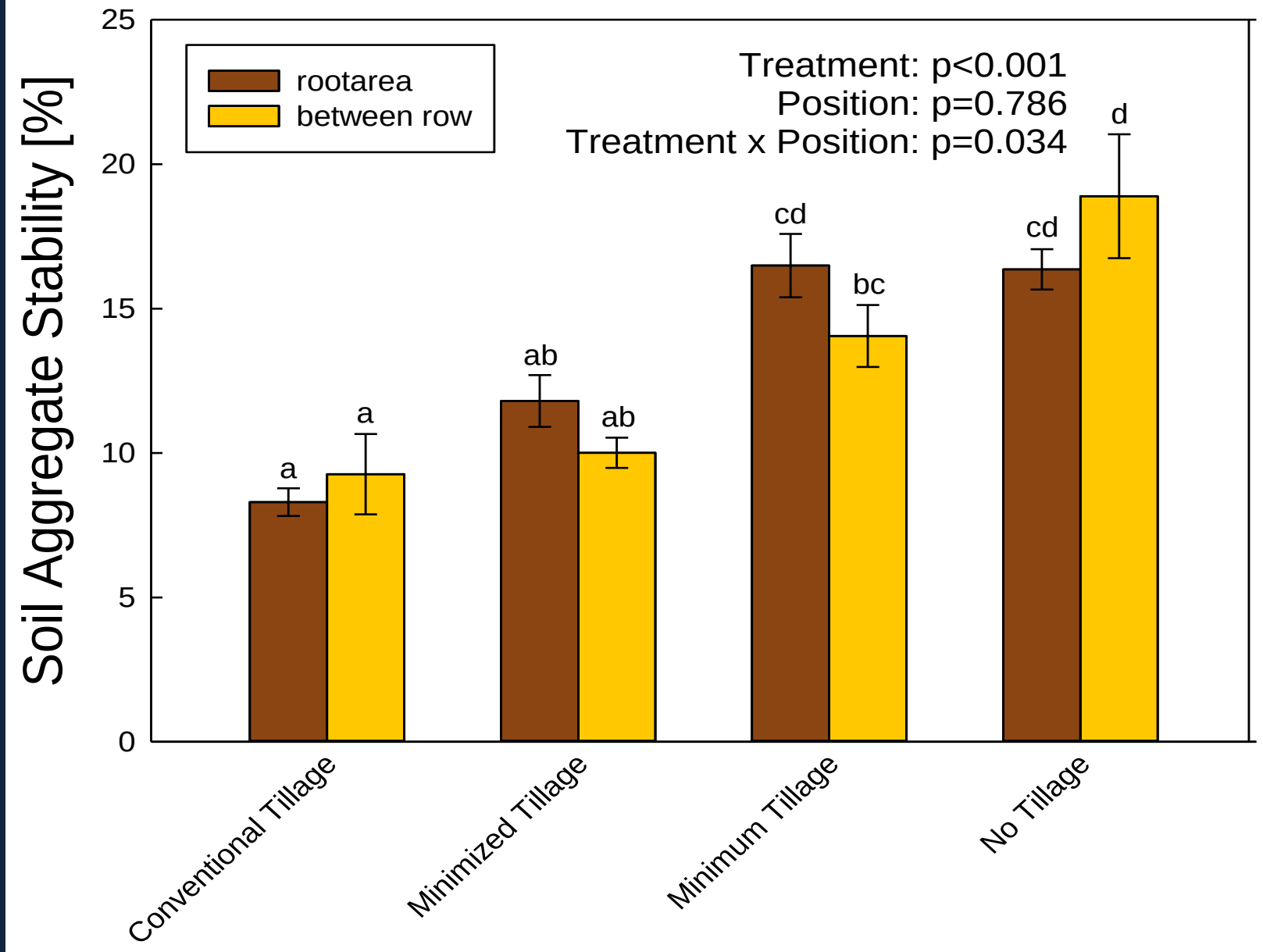


Breiner M. 2015


Dissolved Organic Carbon [mg L-1]
7.5
7.0
6.5
6.0
5.5
5.0
4.5
R2=0.93 p=0.037
No Tillage
Minimum Tillage
Minimized Tillage
Conventional Tillage
20
40
60
80
100
Active Biomass [mg CO2 100 g-1 DM]


rootarea
between row
Treatment: p<0.001
Position: p=0.619
Treatment x Position: p=0.131
Glomalin [mg/g]
2.4
2.2
2.0
1.8
1.6
a
b
a
ab
ab
c
ab
c
Conventional Tillage
Minimized Tillage
Minimum Tillage
No Tillage


R^2=0.91 p=0.002
No Tillage
Minimum Tillage
Minimized Tillage
Conventional Tillage
Soil Aggregate Stability [%]
Glomalin [mg/g]
20
18
16
14
12
10
8
6
1.95
2.00
2.05
2.10
2.15
2.20
2.25


Soil Aggregate Stability [%]
25
20
15
10
5
0
rootarea
between row
Treatment: p<0.001
Position: p=0.786
Treatment x Position: p=0.034
a
a
ab
ab
cd
bc
cd
d
Conventional Tillage
Minimized Tillage
Minimum Tillage
No Tillage

Conclusion

- Mulch –and direct –seeding systems are fully developed and go well in practice.

- With the economical benefits we must not forget the nutrient – pesticide and soil movement (erosion).

- Cereal – maize crop rotation needs a shallow mulch of crop residuals for a fast decomposition as a phytosanitary need.

- After harvest the growth of volunteer cereals has to be interrupted, they stand for a green bridge for plant diseases like barley yellow dwarf virus or Fusarium sp. and pests like aphids as a vector for the virus/nanovirus – apply light cultivator or disc-harrow

- An immediate seeding of cover crops after harvest for a good development of the green manure is recommended

- The production of Mycotoxins by Fusarium disease (Dry Rot)is to be interrupted by shallow soil tillage and an adopted crop rotation. Fungicides can be applied to reduce Mycotoxins.
- Cornborer can be sprayed – reduction of Mycotxines DON and ZON

- A reduction of the costs is possible and necessary.

- A prescription is not possible and depends from the crop rotation and natural situation on the farm.

Thank you for your attention

Results:
www.landimpulse.at/versuche/downloads

