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Traction Improvement: Ballasting, Tires, & Inflation Pressure

Davis-Purdue Ag Center Field Day
2009
Purdue University

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Outline

- WHY (background information)
  - Introductory (miscellaneous) information
  - Speed & implement size
  - Ballasting (weight & placement)
  - Tire size
  - Tire pressure
- HOW & WHAT (getting it right on your farm)
  - Spreadsheet demonstration
  - On-site example

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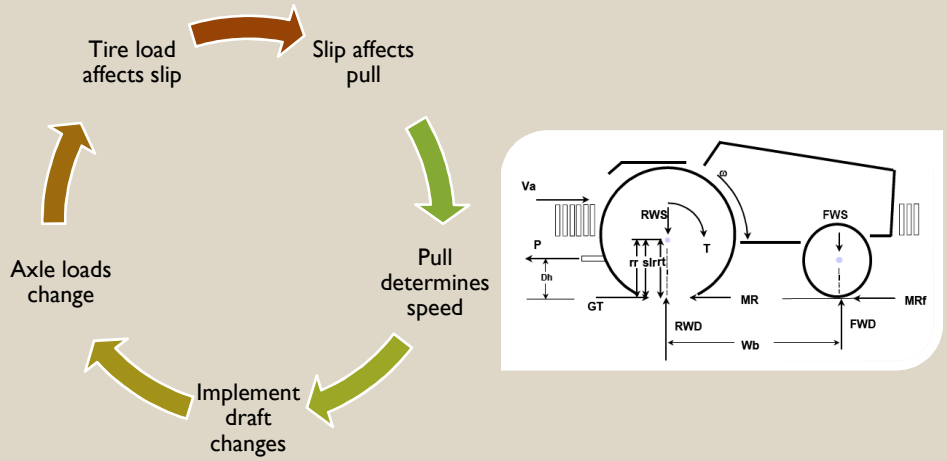
Let me confuse you first



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Tractive efficiency affects

- Tire wear
- Fuel consumption
- Time for the work
  - Machine time
  - Labor
  - Timeliness

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On Slip …

- Some is good
- Optimal level depends on
  - Tires
  - Soil
- Controlled by
  - Pull/weight ratio
  - Tire selection & inflation

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Speed & Implement Size

- Implement too large
  - Power limited, so you go slow
  - Traction limited, so you ballast too heavy
  - More soil compaction than you ought to have
  - Continual high torque, high force situation causes too much stress (premature failures)

- Implement too small
  - You tend to go too fast
  - Wasted power
  - *Might* be okay if you shift up, throttle back

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Effects of soil conditions

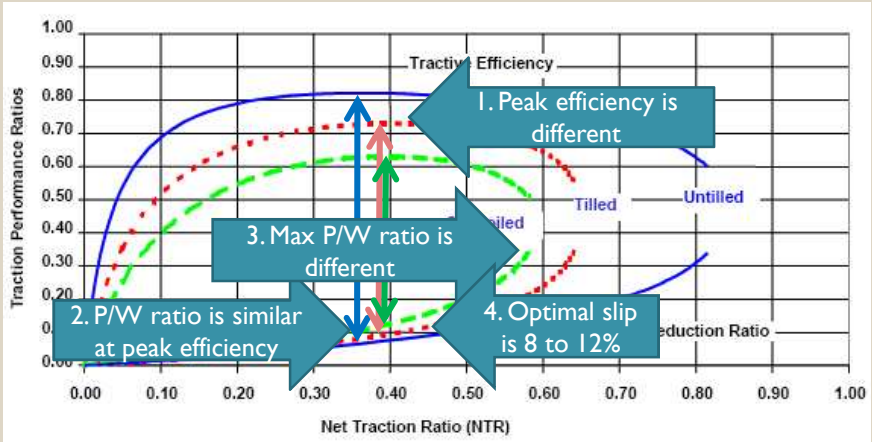

Figure 27. Performance of 20.8R42 dual tires on three surfaces (8300 kg axle load, 83 kPa tire pressure).

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Different soil conditions, all at 12% slip

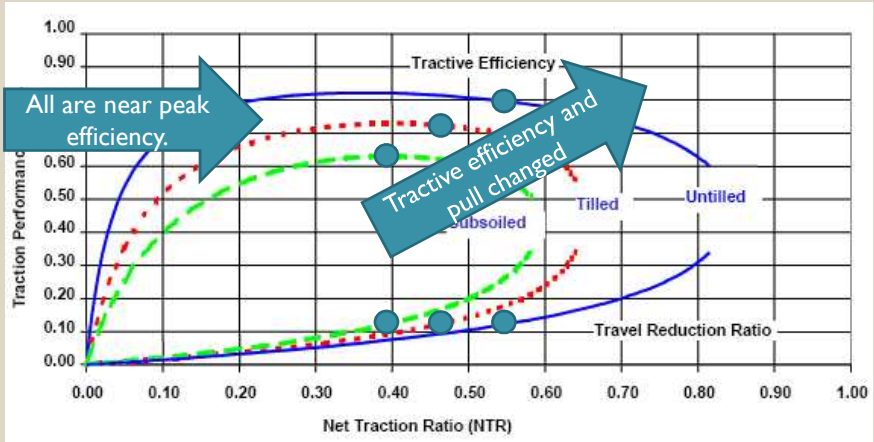

Figure 27. Performance of 20.8R42 dual tires on three surfaces (8300 kg axle load, 83 kPa tire pressure).

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Same chart & analysis … 8% slip

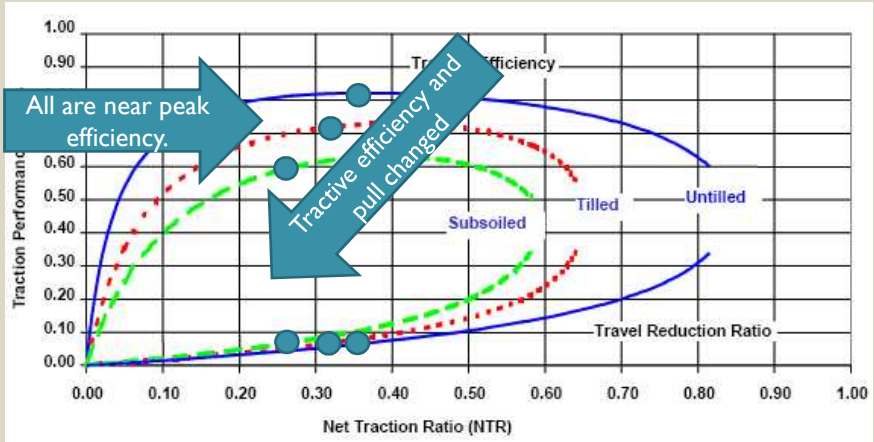

Figure 27. Performance of 20.8R42 dual tires on three surfaces (8300 kg axle load, 83 kPa tire pressure).

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Soil conditions

- Affect maximum pull, slip, & tractive efficiency
- Do not significantly affect (near peak efficiency) the pull/weight ratio
- At 8-12% slip, with other conditions correct (tire size, inflation pressure, ballast), responses are relatively flat.
- **Why is 12% slip better than 8%?**

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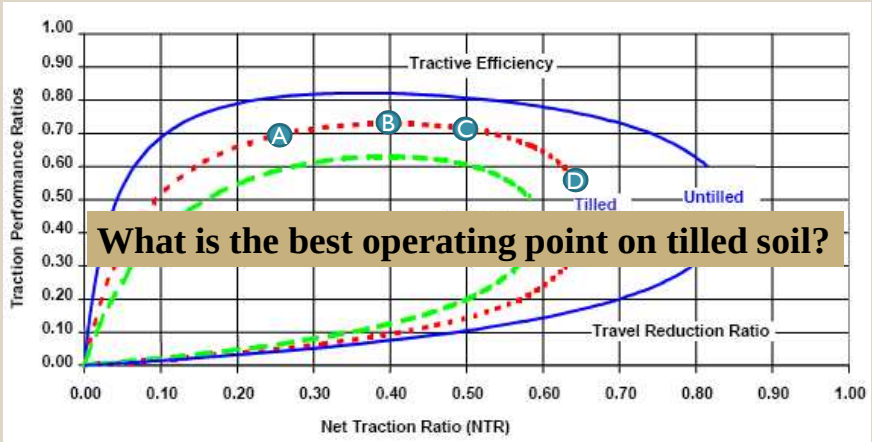
A ***trick,*** practical question



What is the best operating point on tilled soil?

Figure 27. Performance of 20.8R42 dual tires on three surfaces (8300 kg axle load, 83 kPa tire pressure).

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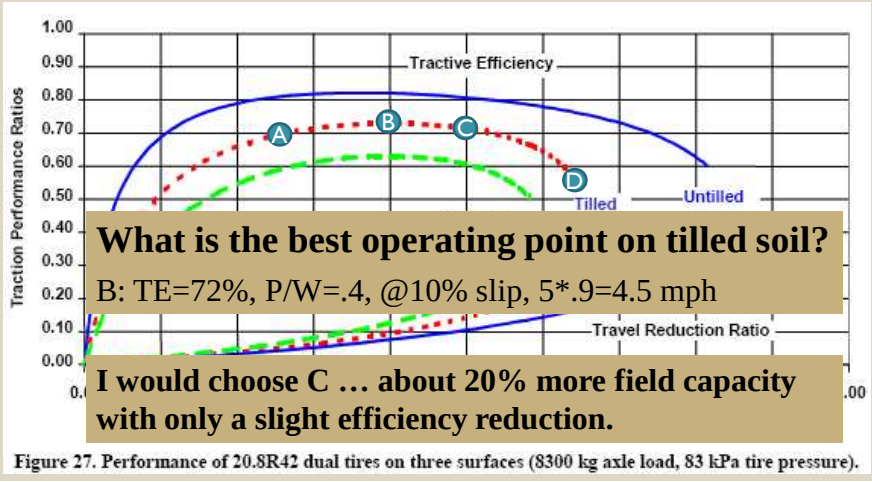
A ***trick,*** practical question



What is the best operating point on tilled soil?

B: TE=72%, P/W=.4, @10% slip, 5*.9=4.5 mph

I would choose C … about 20% more field capacity with only a slight efficiency reduction.

Figure 27. Performance of 20.8R42 dual tires on three surfaces (8300 kg axle load, 83 kPa tire pressure).

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Improper weight

- The ideal situation is to be power, traction, and speed limited simultaneously
- Improper weight (or implement size) wastes at least one dimension
  - Too much weight:
    - Excessive rolling resistance
    - Excessive compaction
  - Too little weight:
    - Excessive slip
    - Insufficient pull

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Different weight (tire load) & pressure

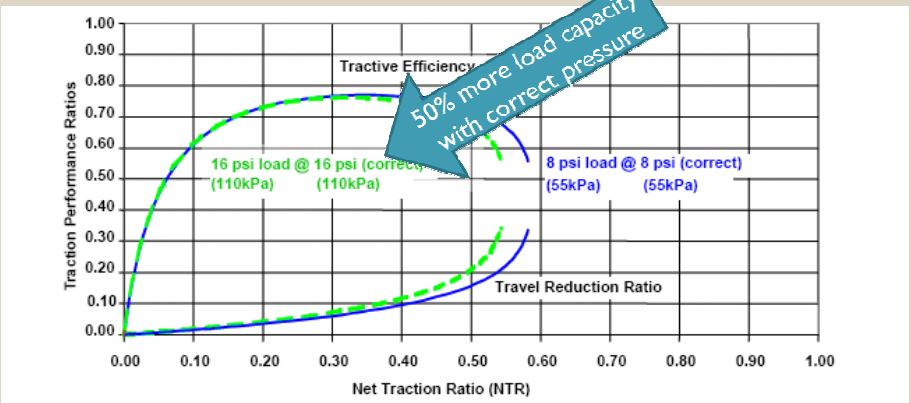

Figure 30. Performance of single tire (Goodyear 520/85R46 DTR) at two weights with correct pressures in tilled (loose) tractive conditions.

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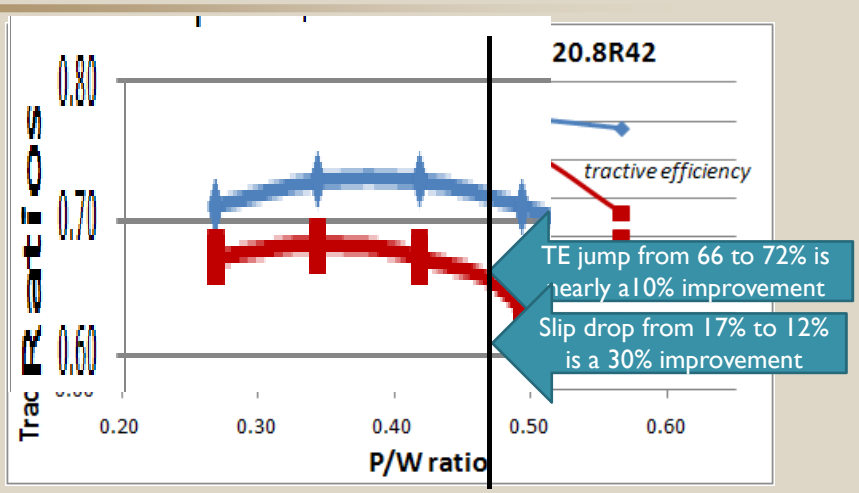
Improper weight location



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Tire selection

- Radials
- Bigger is better
- Diameter helps more than width
  - Larger footprint (longer, not wider)
  - Less rolling resistance

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Different tire size (with correct pressure)

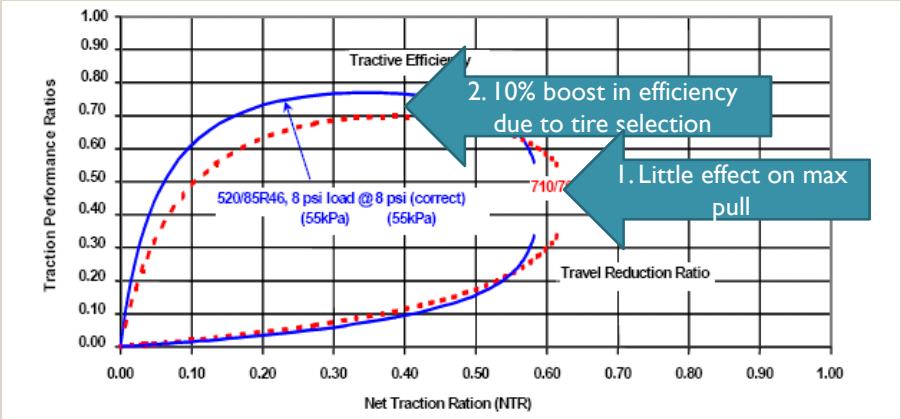

Figure 29. Performance of two sizes of single tires at correct inflation pressures in tilled (loose) tractive conditions.

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Improper tire inflation

- Inflation too low
  - Bust a bead
  - Rim slip
  - Tire failure
- Inflation too high
  - Excessive soil compaction
  - Lower pull
  - Higher slip
  - Lower tractive efficiency

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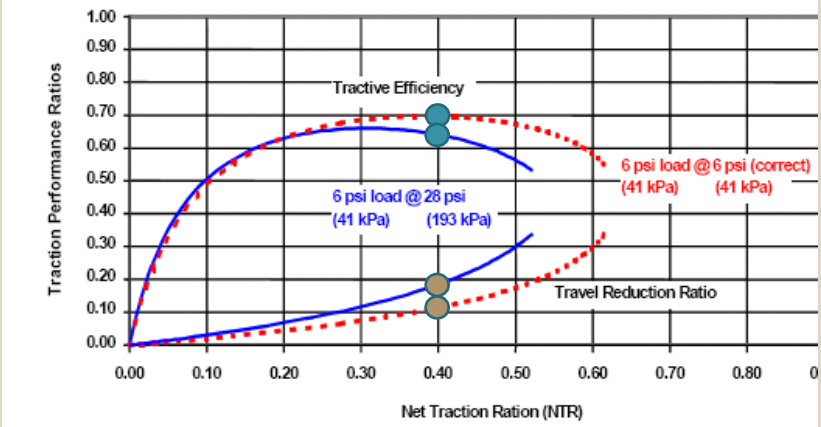
On Magnitude – what is 7 out of 70?



Performance of single tire (Firestone 710/70R38 ATR) at two inflation pressures in tilled (loose) tractive conditions.

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Different tire pressure & load

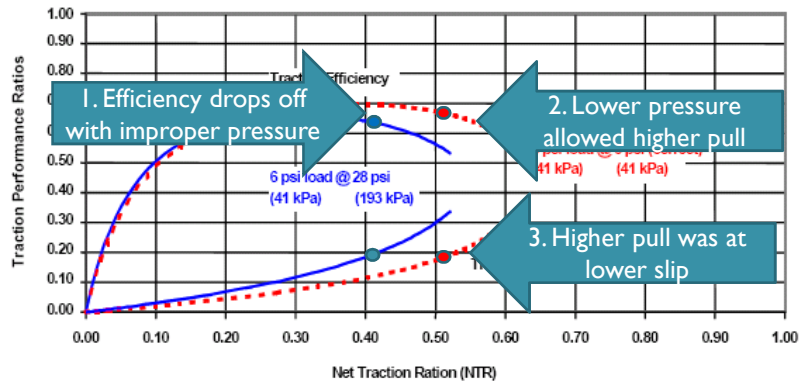

Figure 28. Performance of single tire (Firestone 710/70R38 ATR) at two inflation pressures in tilled (loose) tractive conditions.

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Summary (especially in soft or tilled soil)…

- Proper
  - Weight (& location of weight)
  - Tire size
  - Tire pressure
- Leads to:
  - Lower slip (higher capacity, less time)
  - Higher tractive efficiency (lower fuel usage)
  - More pull (larger implements, higher capacity, less time)

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On the web…

https://engineering.ecn.purdue.edu/~dbuckmas/

On the "OUTREACH RELATED" tab

- This presentation
- Ballast Assistant spreadsheet
- Ballast Assistant "tutorial video"

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For a perfect day …

- Wake up next to the love of my life
- Drive through the Indiana countryside
- Hear a couple hours of my favorite music
- Have an excellent lunch
- Talk about tractors, horsepower, etc.

- Use Microsoft Excel …

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From: Firestone load/inflation tables

TABLE A
Radial Ply Symbol-Marked
Agricultural Tractor Drive Wheel Tires

FOR A8 AND B SPEED SYMBOL TIRES
TIRES USED AS SINGLES

Basic Tire Load Ratings for Tire Selection **MAXIMUM SPE**

TIRE TYPE NOMENCLATURE

Code No.	Tire Type
R-1	Drive Wheel, Regular Tread
R-1W	Drive Wheel, Wet Traction Tread
R-3	Drive Wheel, Shallow Tread
R-4	Industrial Tractor, Drive Wheel, Intermediate Tread

TIRE SIZE		TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES														
	psi	6	8	10	*12	14	16	18	20	22	24	26	28	30	36
	kPa	40	60	70	*80	100	110	120	140	150	160	180	190	210	250
								*			* *			* * *	* * * *
16.9R30	lbs.	2200	2600	3000	3300	3640	3860	**4180 (130)**	4400	4680	**5080 (137)**	5200	5360	**5680 (141)**	**6150 (144)**
	kg.	1000	1180	1360	1500	1650	1750	**1900 (130)**	2000	2120	**2300 (137)**	2360	2430	**2575 (141)**	**2800 (144)**
20.8R42	lbs.	3740	4540	5080	5680	6150	6800	**7150 (149)**	7600	8050	**8550 (155)**	8800	9350	**9650 (159)**	
	kg.	1700	2060	2300	2575	2800	3075	**3250 (149)**	3450	3650					

3: At higher transport speeds (above 20mph) and lower pressures (less than 12 psi) increased inflation pressure may be required for vehicle stability.

4: When used as Duals, tire loads must be reduced 12%; when used as Triples, tire loads must be reduced 18%.

Duals

Rear 20.8R42, 3160 lb (3600 lookup), ~~6~~ 8 psi

Front 16.9R30, 2110 lb (2400 lookup), ~~7~~ 9 psi

Singles

Rear 20.8R42, 6320 lb, ~~15~~ 17 psi

Front 16.9R30, 4220 lb, ~~19~~ 21 psi

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From: Goodyear Farm Tire Handbook

LOAD & INFLATION TABLE (LBS.@PSI)

Radial Ply - Symbol Marked
Conventional Size Agricultural Tractor Drive Wheel Tires
Used in Field Service and Speeds Up To 25 MPH

(TIRE MUST ALSO MEET TIRE PTO HORSEPOWER CAPACITY, SEE TABLE OF CONTENTS)

Maximum Speed - 25 MPH

Tire Size		TIRE LOAD LIMITS (LBS.) AT VARIOUS COLD INFLATION PRESSURES (PSI)															
	Inflation (psi)	6	7	8	9	10	12	14	16	18	20	22	24	26	28	30	35
	Symbol									★			★★			★★★	
18.4R42	LI/ss									143 A8			148 A8				
	SINGLE (LBS.)	3080	3420	3740	3960	4180	4680	5080	5520	6000	6400	6600	6950				
	DUAL (LBS.)	2710	3010	3290	3480	3680	4120	4470	4860	5280	5630	5810	6120				
	TRIPLE (LBS.)	2530	2800	3070	3250	3430	3840	4170	4530	4920	5250	5410	5700				

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From: Firestone load/inflation tables

TABLE L
Diagonal (Bias) Ply Agricultural Tractor Steering Wheel Tires Used in Field Service (Including Hillside Combines)

TIRE TYPE NOMENCLATURE

Code No.	Tire Type
F-1	Agricultural Single Rib Tread
F-2	Agricultural Multiple-Rib Tread
F-3	Industrial Multiple-Rib Tread

Basic Tire Load Ratings for Tire Selection
MAXIMUM SPEED - 25 MPH (40 KM/H) — SPEED SYMBOL A8

TIRE SIZE		TIRE LOAD LIMITS AT VARIOUS COLD INFLATION PRESSURES												
	psi	24	28	32	36	40	44	48	52	56	60	64	68	
	kPa	170	190	220	250	280	300	330	360	390	410	440	470	
14L-16.1 SL	lbs.	2270	**2540 (6)**	2830	**3000 (8)**	3200	**3420 (10)**	3640	**3860 (12)**					

NOTES: 1: Figures in parentheses denote ply rating for which bold face loads and inflations are maximum.