Growth and Development of Wheat, as Related to N and P

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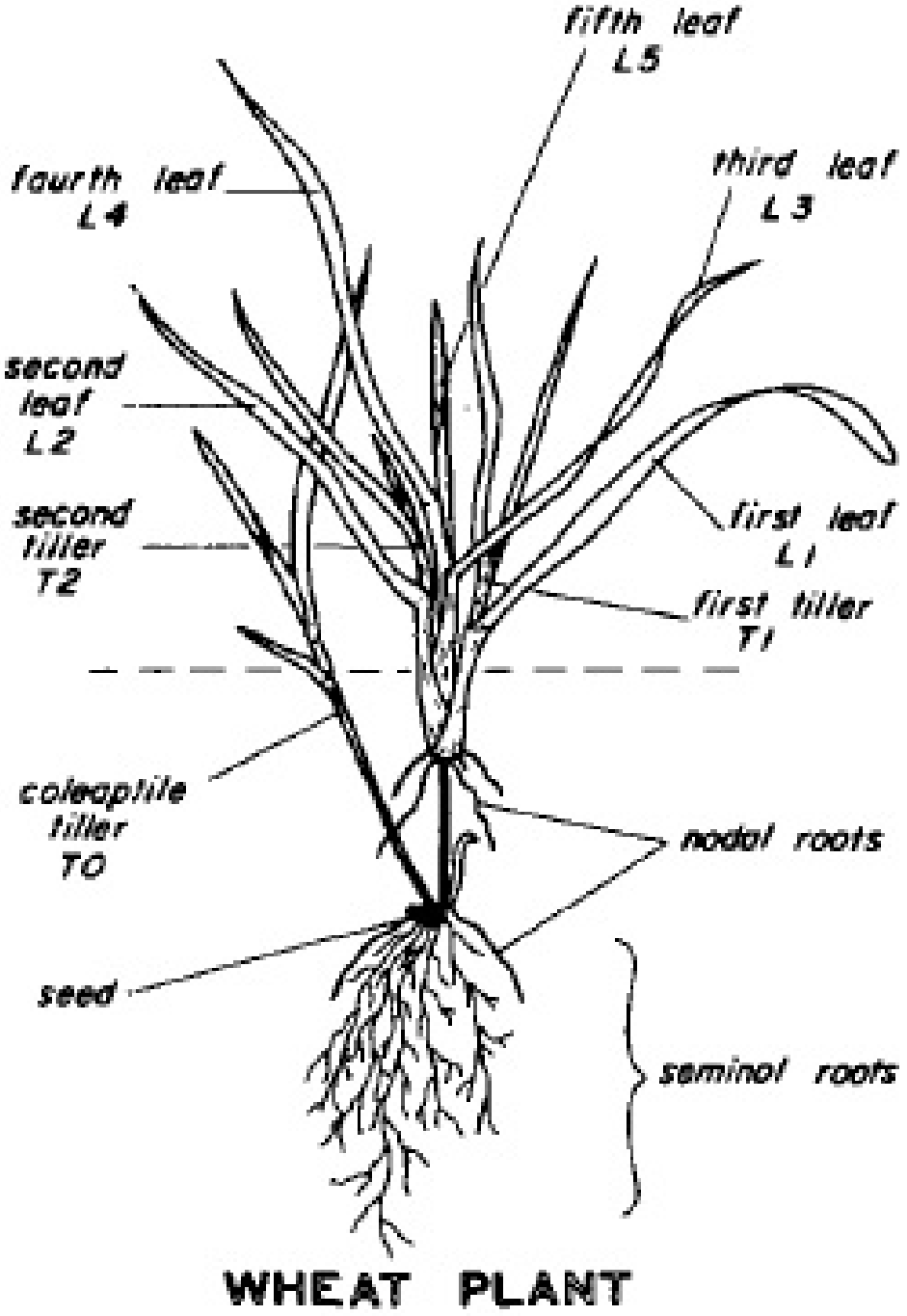
- Why is hard red spring wheat so well adapted for the semi-arid regions of the Northern Great Plains?
- Obvious reason
  - Shorter season crop, lower water requirement
- Not-so-obvious reasons
  - 1. Establishes its yield potential early
  - 2. Adjusts yield potential downwards in a systematic way, in response to heat/water stress

- 1. Establishes yield potential early
  - Tillering begins very early
  - Head size (hopefully) established before hot weather arrives
- 2. Systematically adjusts yield components in relation to heat/water stress
  - Size of plant, size of heads reduced by early stress
  - Systematic tiller abortion later in the season—less productive tillers go first
  - There is no single “choke point” that makes or breaks the crop

- So, how does this all work?
- Credit goes to Dr. Betty Klepper and team (USDA-ARS, Pendeleton, OR)
- 1985…five of us from NDSU went to be trained by Betty and crew for a week



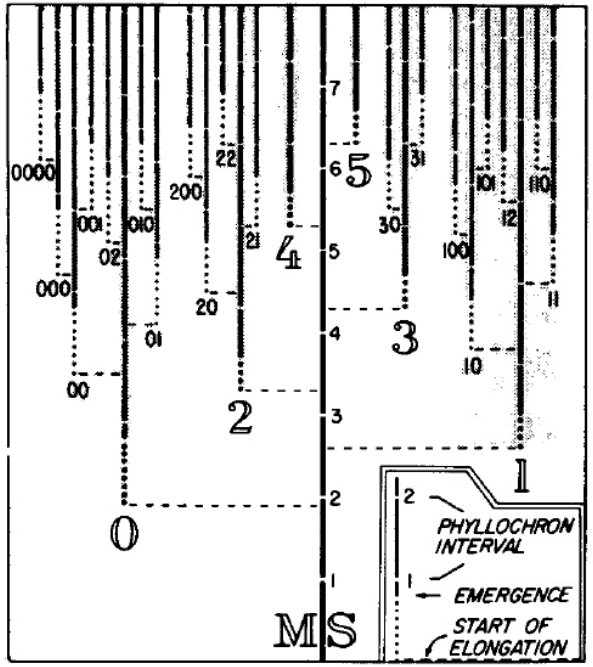


Fig. 2. Relationships of leaf and tiller production in winter wheat based on data for 'Stephens' wheat. The passage of phenological time is measured in elapsed phyllochrons which are numerically equivalent to the main stem Haun stage.

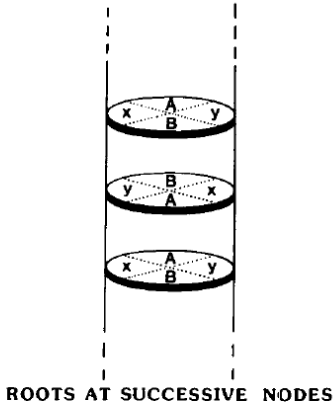
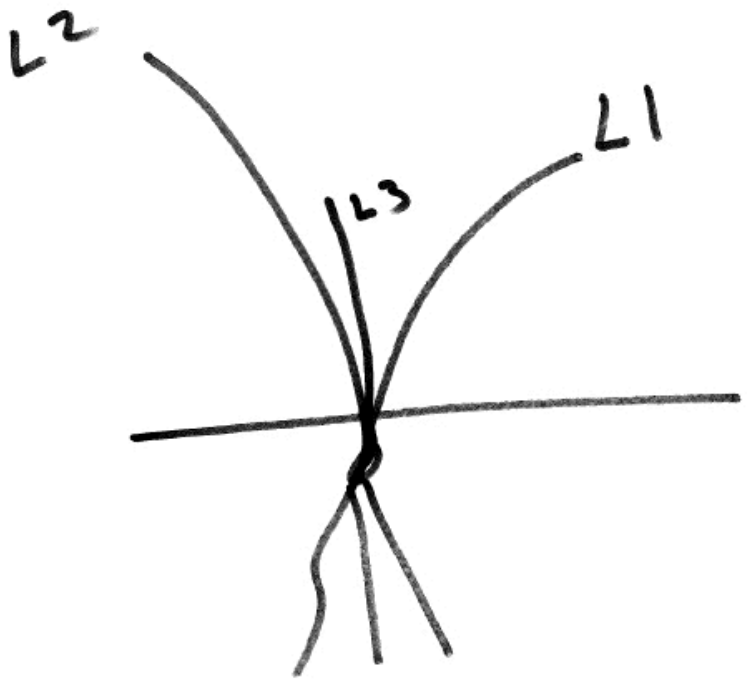


Fig. 1. Orientation of naming quadrants at successive nodes on a plant.

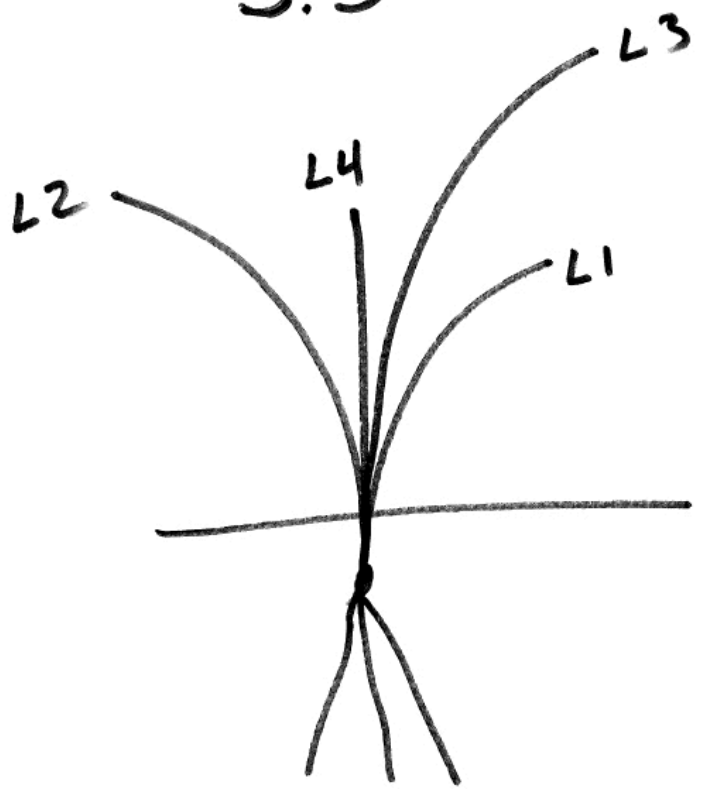
- The “Klepper-Haun” system of describing wheat development
- Main stem controls the sequence of plant vegetative development
- Certain, very precise things happen at very specific stages of growth
- The “clock” of the plant is the main stem Haun stage, the “phyllochron”

- The Haun stage
  - The above-ground parts of a wheat plant consist of a main stem, and a variable number of tillers
  - J. Haun developed this method at the Dickinson Experiment Station
  - Very precise, up until flag leaf emergence

2.5



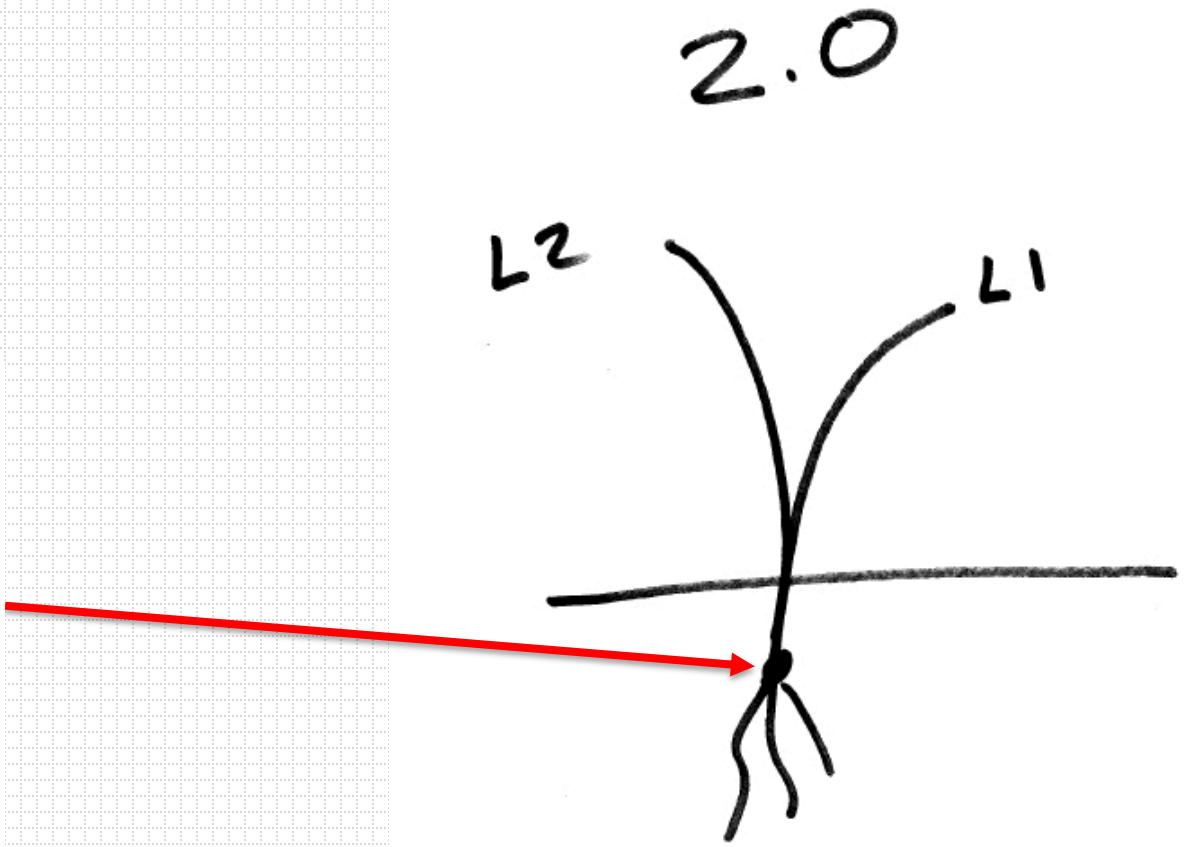
3.5



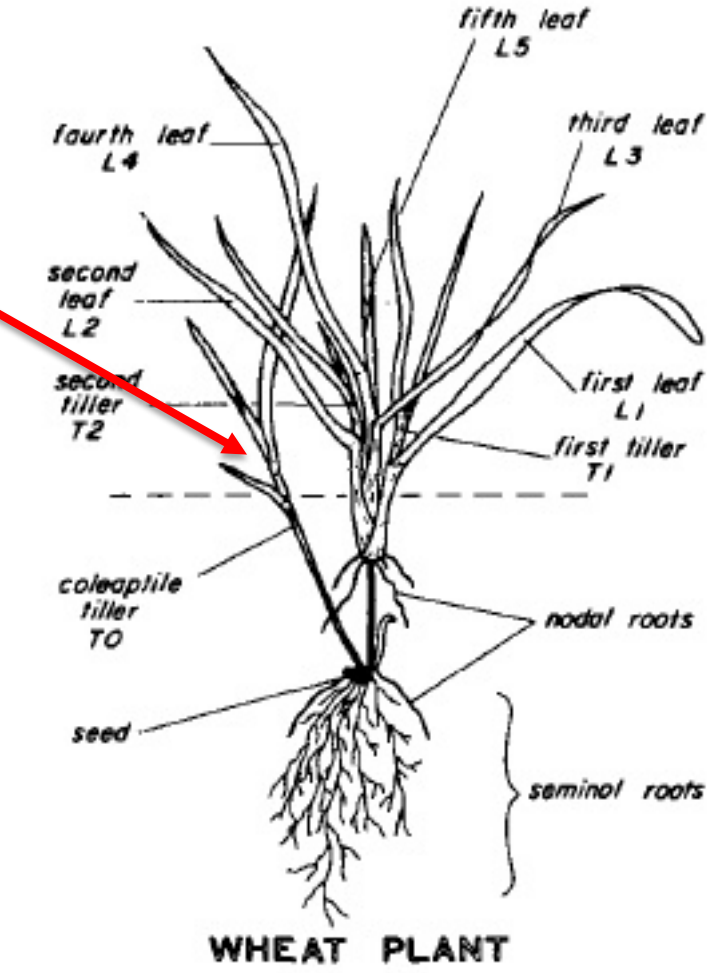
- Critical “decisions” and tillering
- The main stem evaluates its health and makes decisions at exact Haun stages
- 2.0…
- 2.5…
- 3.5…

- There aren’t any ”do-overs”

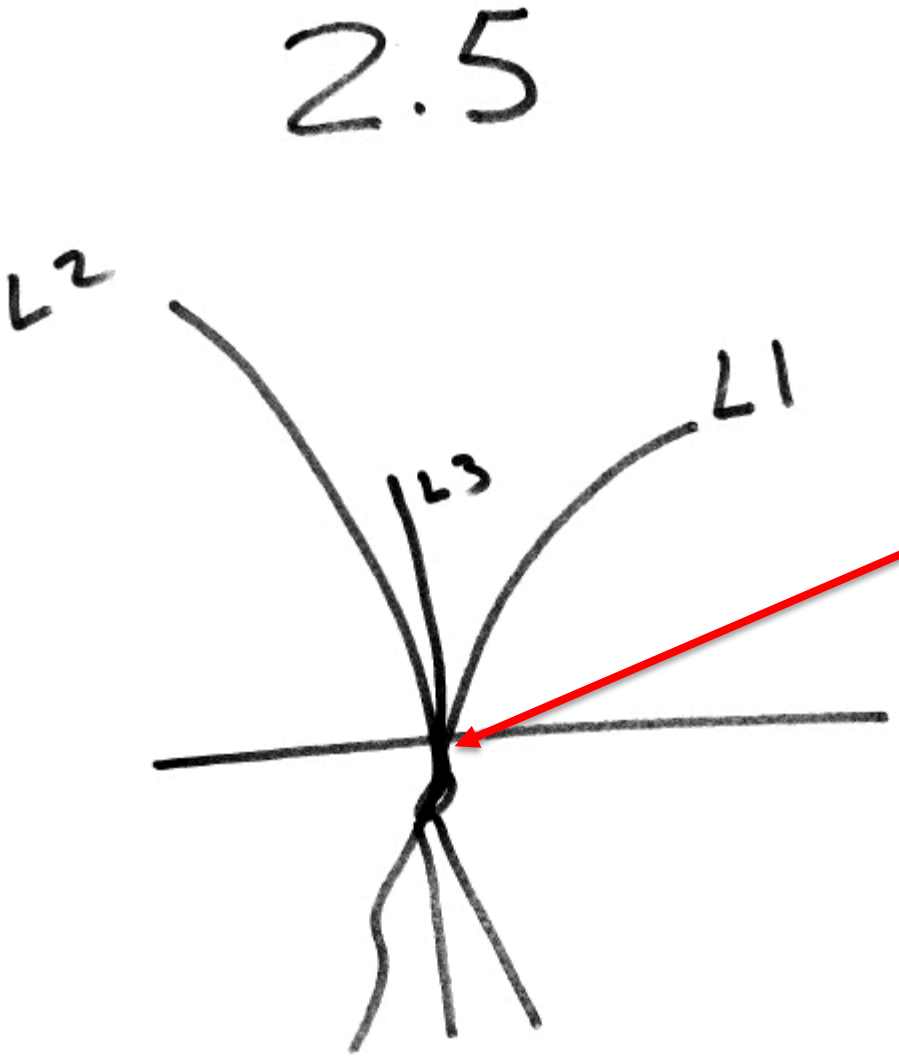
At the seed piece, there are three nodes. One can become a tiller, two can become roots. The tiller is termed the “T0” tiller



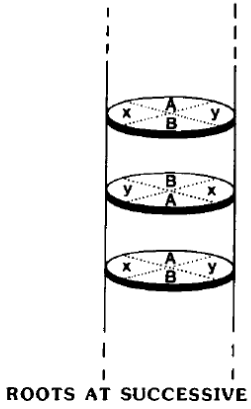
- The T0 tiller is commonly not initiated in most of our HRSW varieties, or if it is initiated, it is not vigorous



- Haun stage 2.5, 2-3 days later…a BIG decision gets made…that day

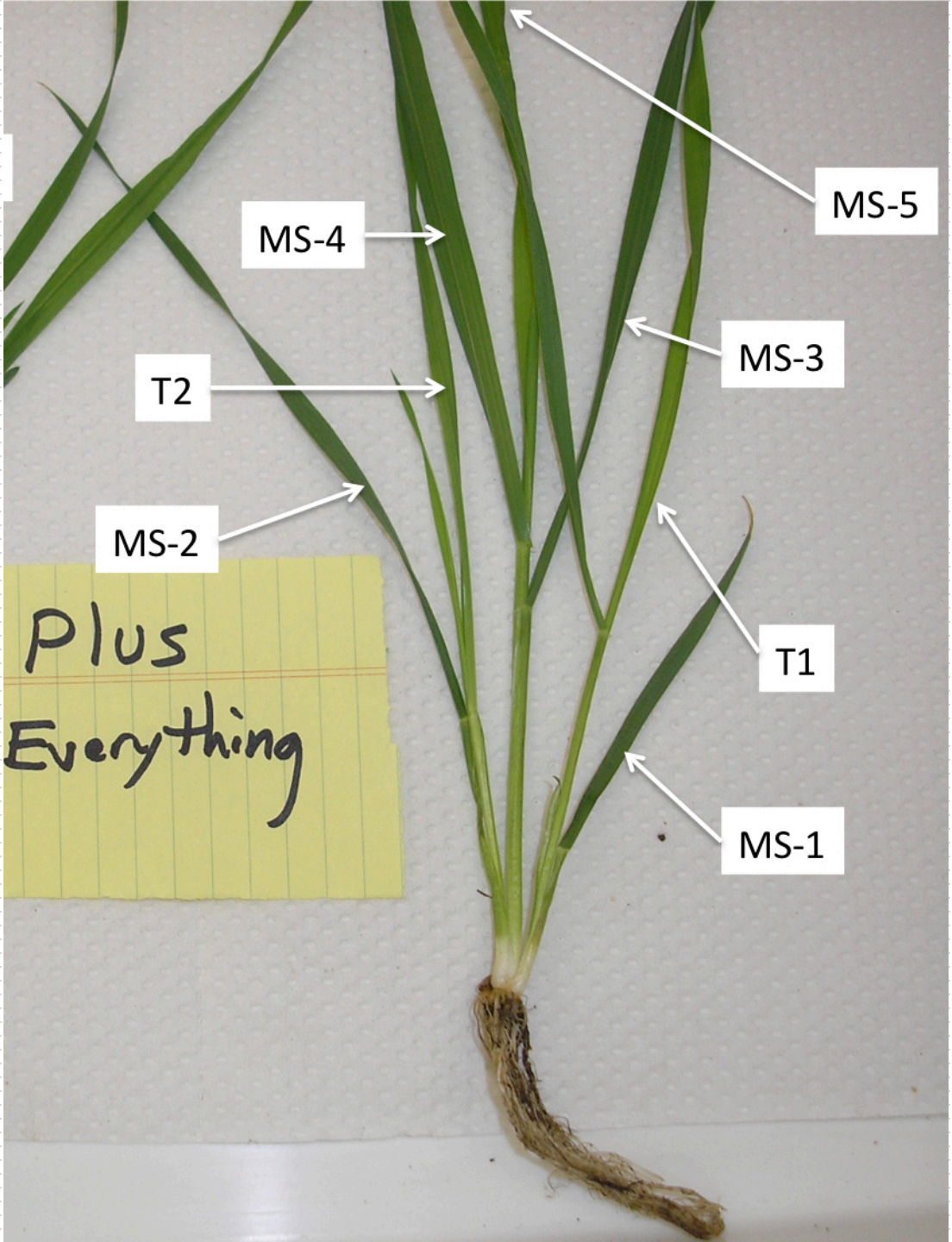


At the base of Leaf 1
there are 5 nodes,
1 for a tiller, 4 for roots.
If the tiller is formed,
it is termed the “T1”
tiller.



ROOTS AT SUCCESSIVE NODES

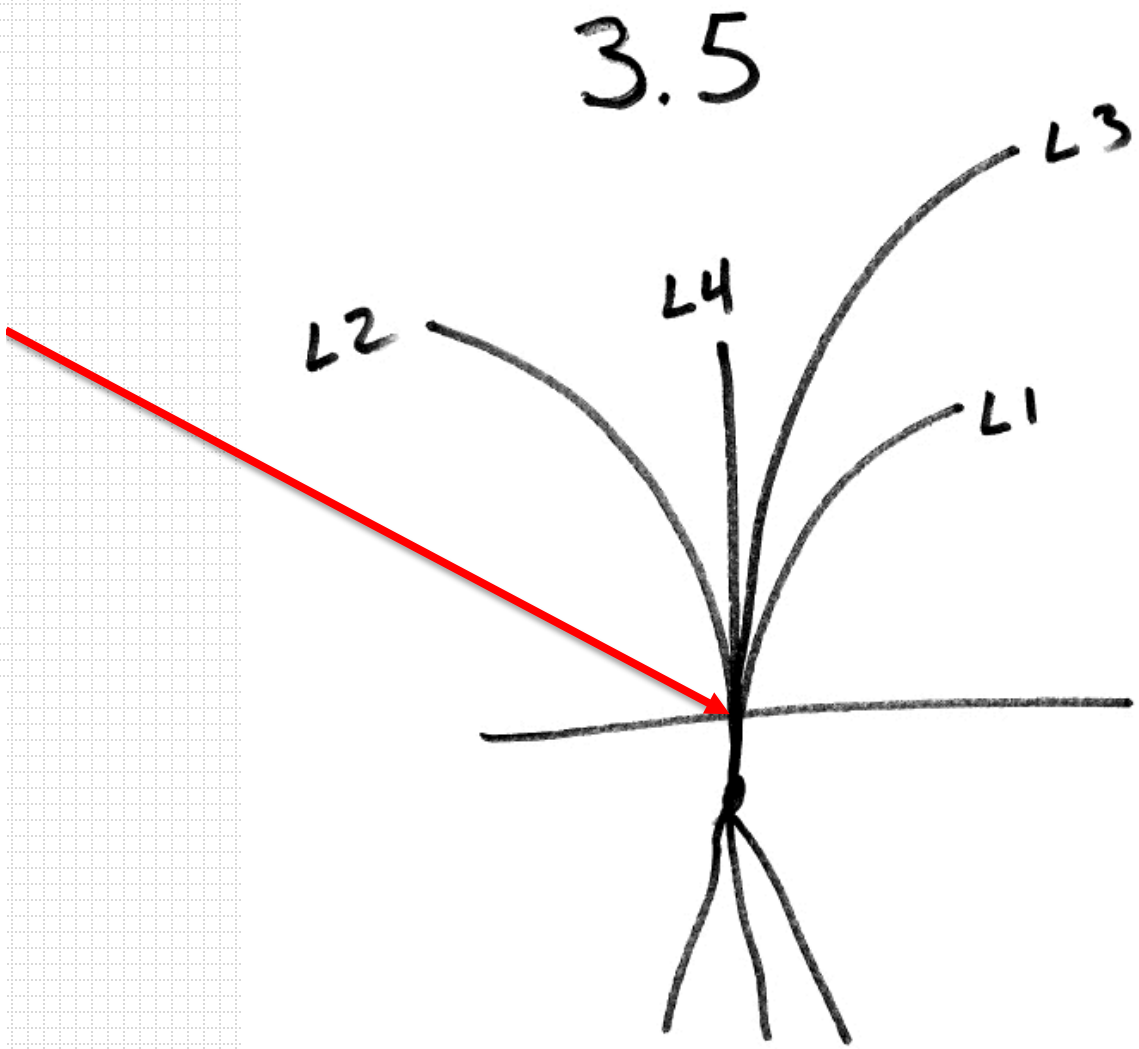
Fig. 1. Orientation of naming quadrants at successive nodes on a plant.

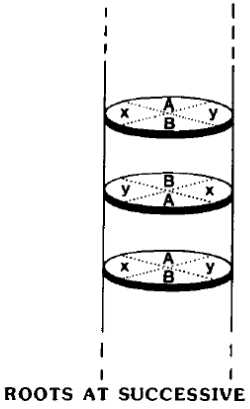

MS-5
MS-4
MS-3
T2
MS-2
Plus
Everything
T1
MS-1

- T1 tiller
- Initiated at Haun stage 2.5
- Forms at the base of MS leaf 1
- Important tiller for grain production
- Reasons it isn’t produced
  - Too deep seeding, hard seedbed
  - N deficiency
  - P deficiency
- If it’s not there, probably some of the roots were not initiated, either.

- About a week later, Haun stage 3.5

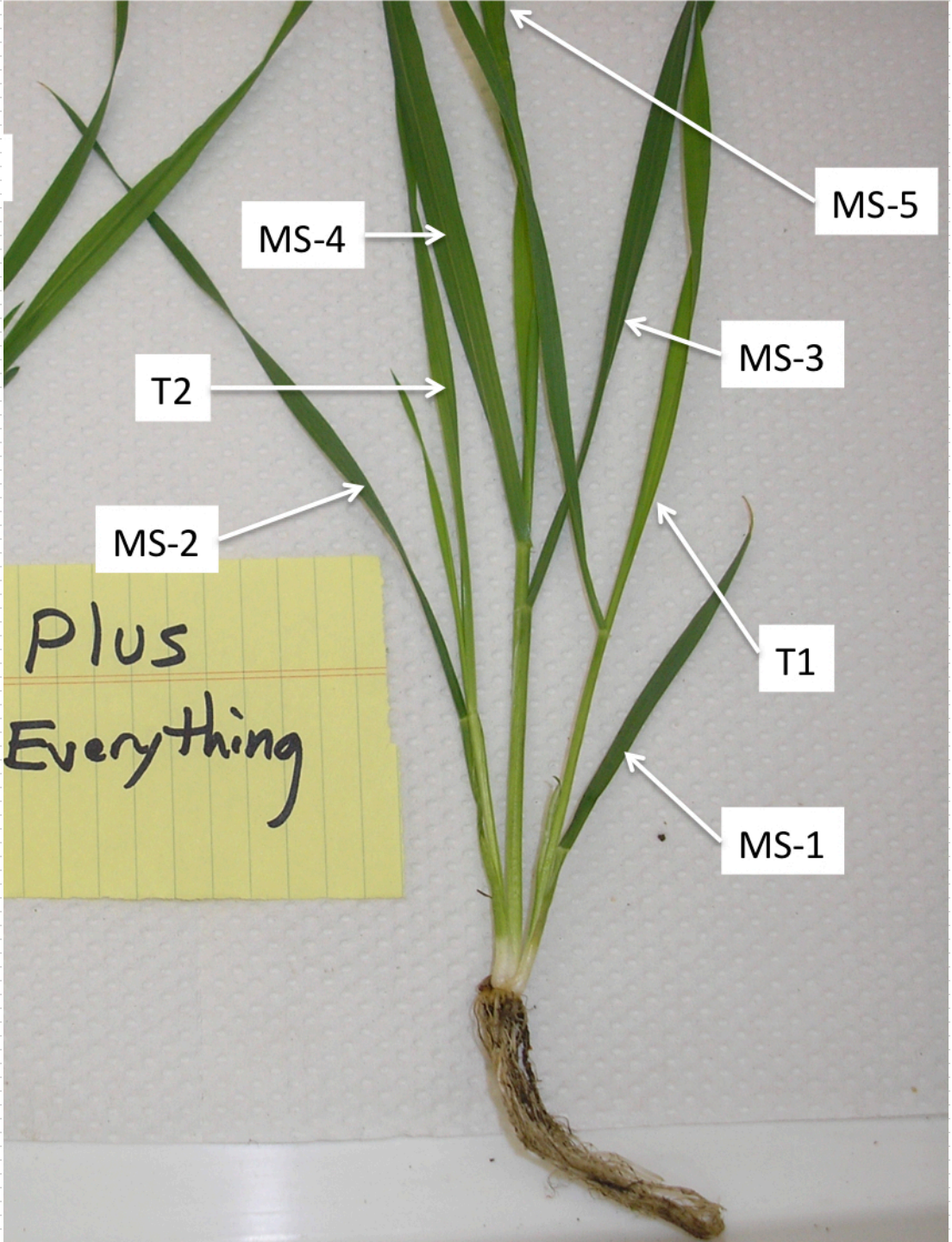
At the base of Leaf 2 there are 5 nodes,
1 can become a tiller
4 can become roots.
The tiller that forms is termed the “T2” tiller.





ROOTS AT SUCCESSIVE NODES

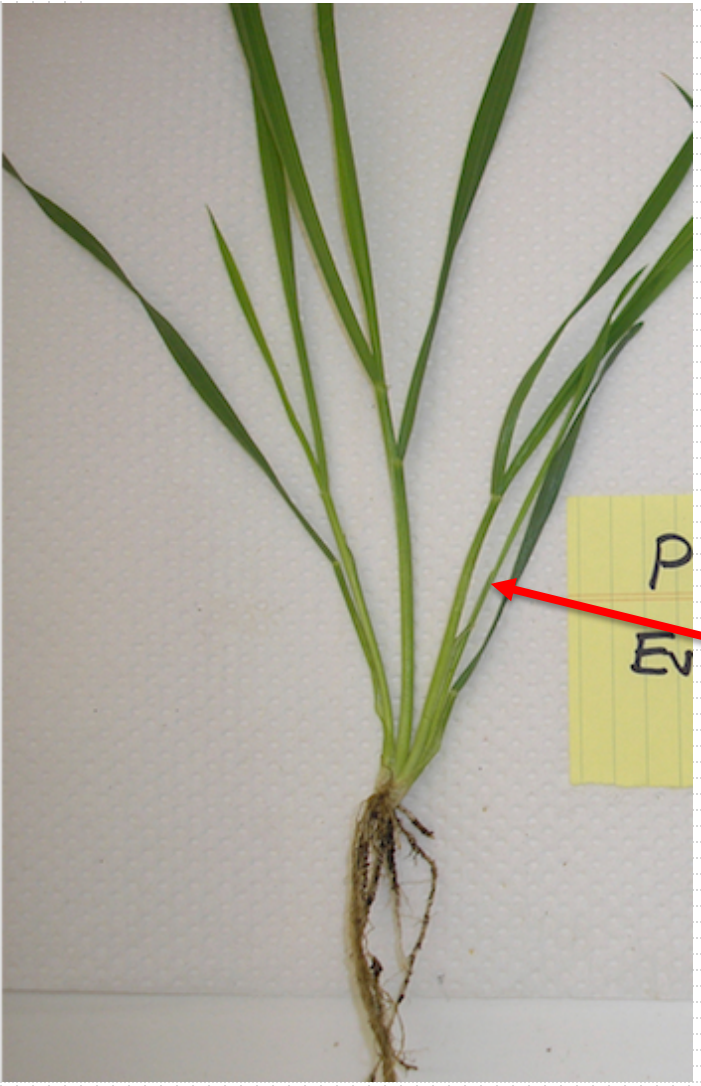
Fig. 1. Orientation of naming quadrants at successive nodes on a plant.


MS-5
MS-4
MS-3
T2
MS-2
Plus
Everything
T1
MS-1

- T2 tiller
- Initiated at MS Haun stage of 3.5
- A very important tiller for grain production
- Reasons for lack of initiation
  - N deficiency
  - P deficiency
  - Only one year (1988) I observed lack of T2 tillering due to heat/drought stress
- Again, if it's not there, likely some of the roots not initiated, either

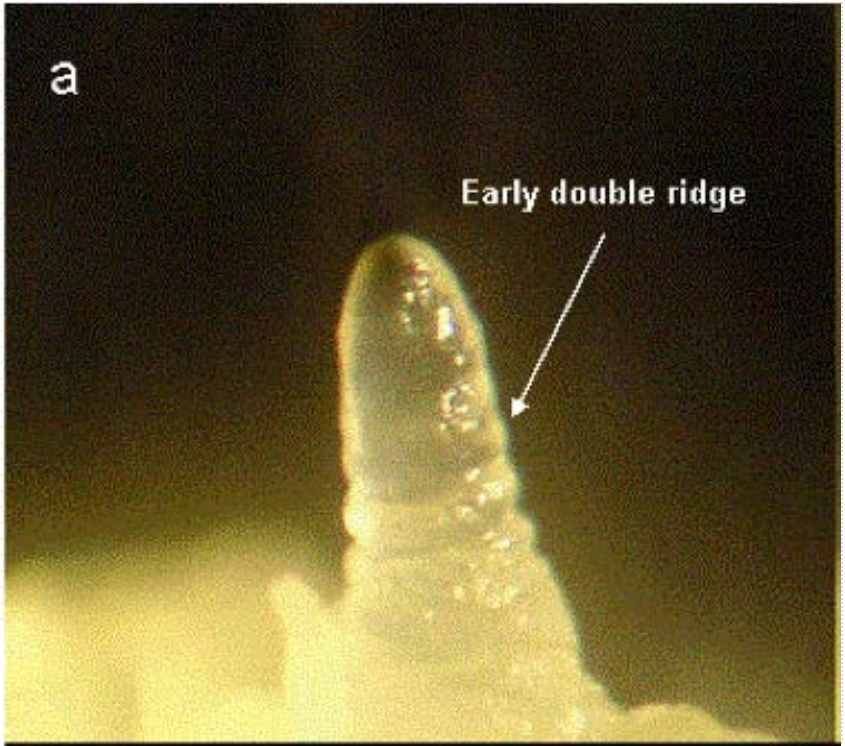
- Other tillers
- T3 tillers can be formed
- Sub-tillers can be formed
  - T10, T11
  - T20, T21
- Usually these later tillers produce little with regards to grain yield. The sub-tiller that springs from the base of the T1 tiller, (T10) sometimes contributes to yield

- T10, probably the only sub-tiller that can contribute to final yield…sometimes



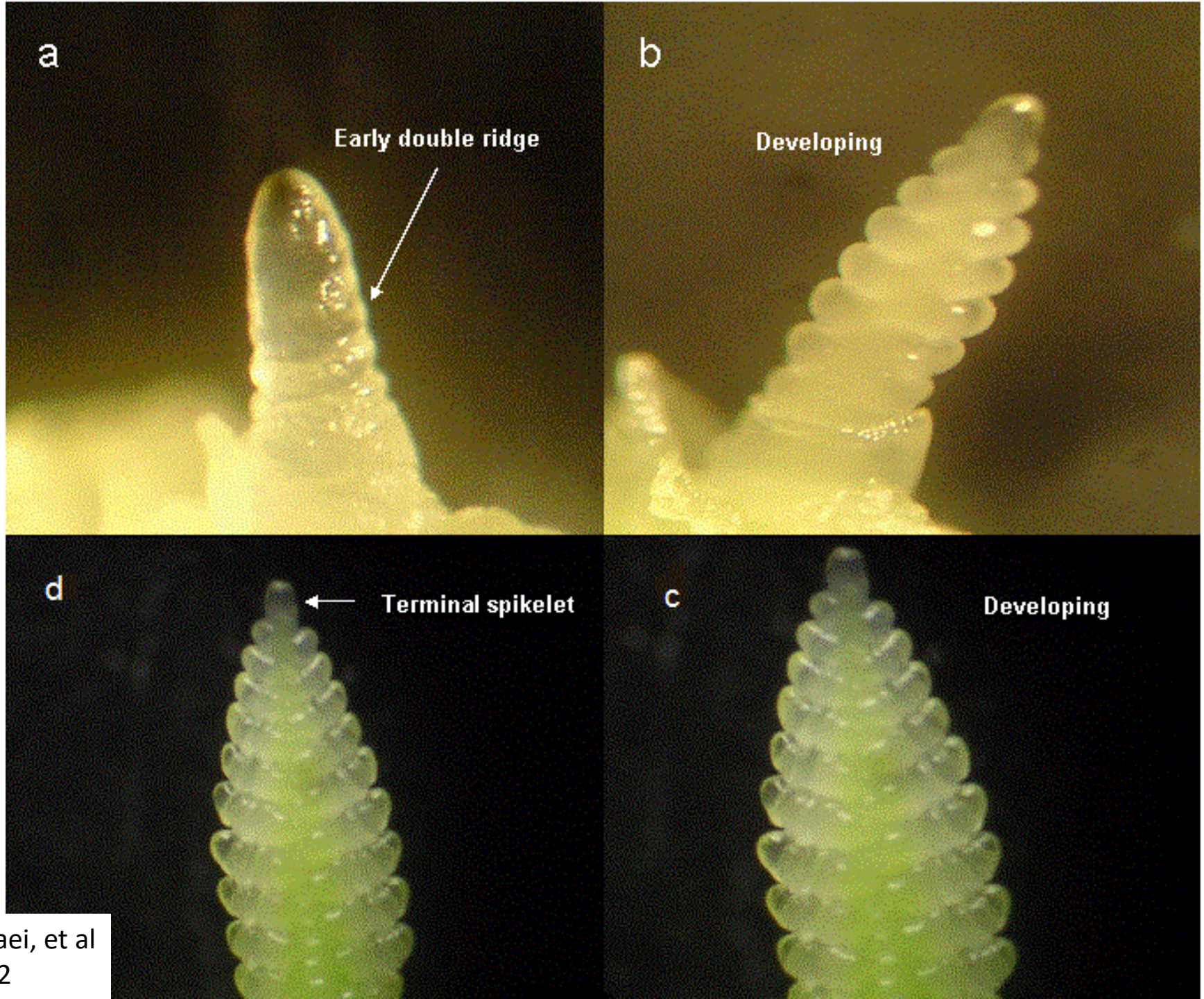
T10 tiller, from the base of Leaf 1, analogous to the T0 tiller on the main stem

- Two other big events
- Haun stage ~~4, “double ridge”
  - Growing point stops making nodes for leaves, starts making nodes for spikelets
  - With water/heat stress, will happen earlier
    - And, you’ll get 7 leaf plants in the field



Rasaei, et al 2012

- Between Haun stage ~~4-6, growing point is making spikelets
- Haun stage ~~6, “terminal spikelet” is formed
- Terminal spikelet---growing point stops making potential spikelets



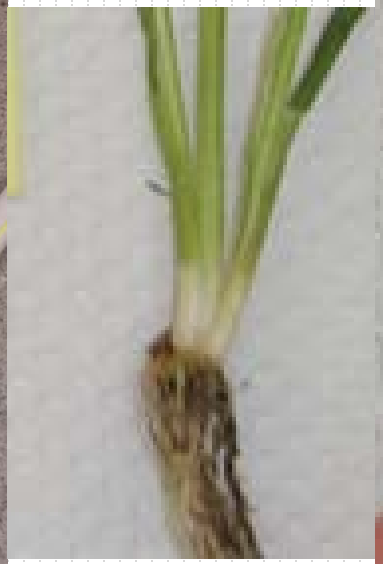
Rasaei, et al 2012

- So Haun stages 4-6 very important
  - Hot and/or dry, things happen earlier, and the interval is shortened
  - Smaller heads, fewer spikelets
  - Possibly 7 leaf plants

  - Cool and moist, the interval is maximized
  - Larger heads
  - Normal 8-leaf plants

- Synchronization of tillers vs. main stem
  - T1 and T2 tillers are always within 1-2 days of maturity of the main stem
    - Able to comply with the main stem's command to make the terminal spikelet
  - Later tillers, usually not synchronized to the main stem, often are those flat green heads at swathing time

- Contribution of different stems to final yield
- If wheat is planted deeply enough, you can identify the main stem vs. T1/T2 tillers by feel.



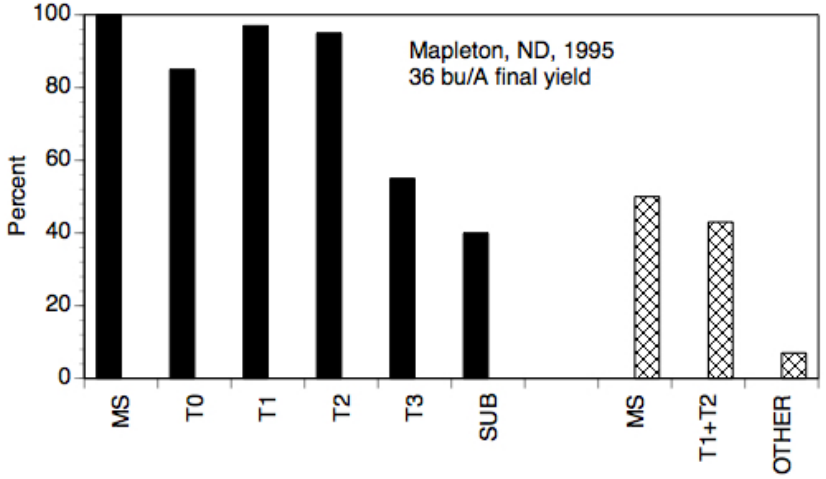
- For yields up to 70 bu/A, 90-100% of the yield comes from the combined contribution of the main stem, T1 and T2 tillers
- Following pictures are from a 2017 study in Minot, from wheat plants in the 70 bu/A range
  - I only observed 4 kinds of plants, out of hundreds dissected

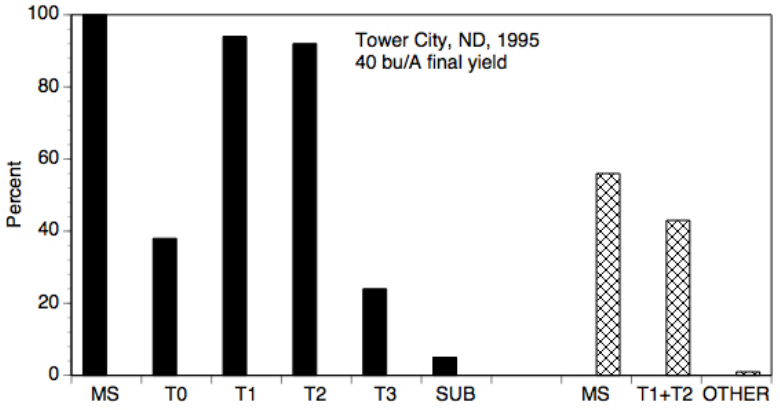
Just main stems

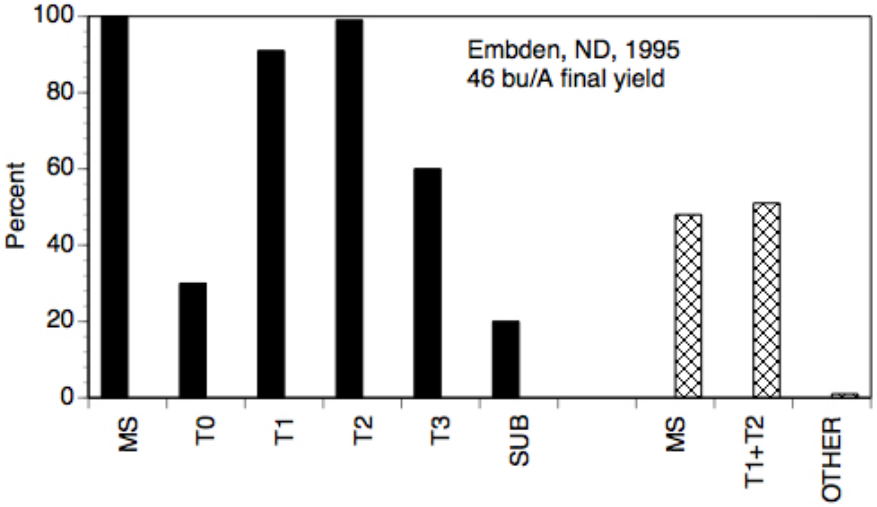
Main stem plus a T1 or a T2

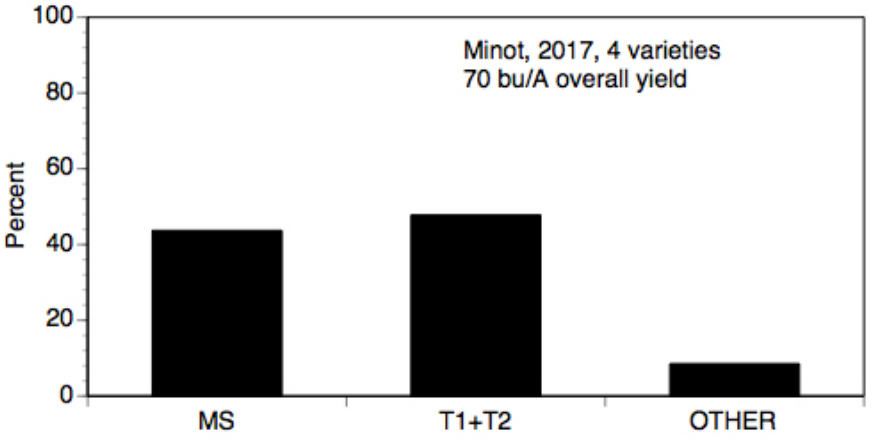
Main stem plus a T1 and a T2

Main stem plus a T1, T2, and a sub-tiller, probably T10

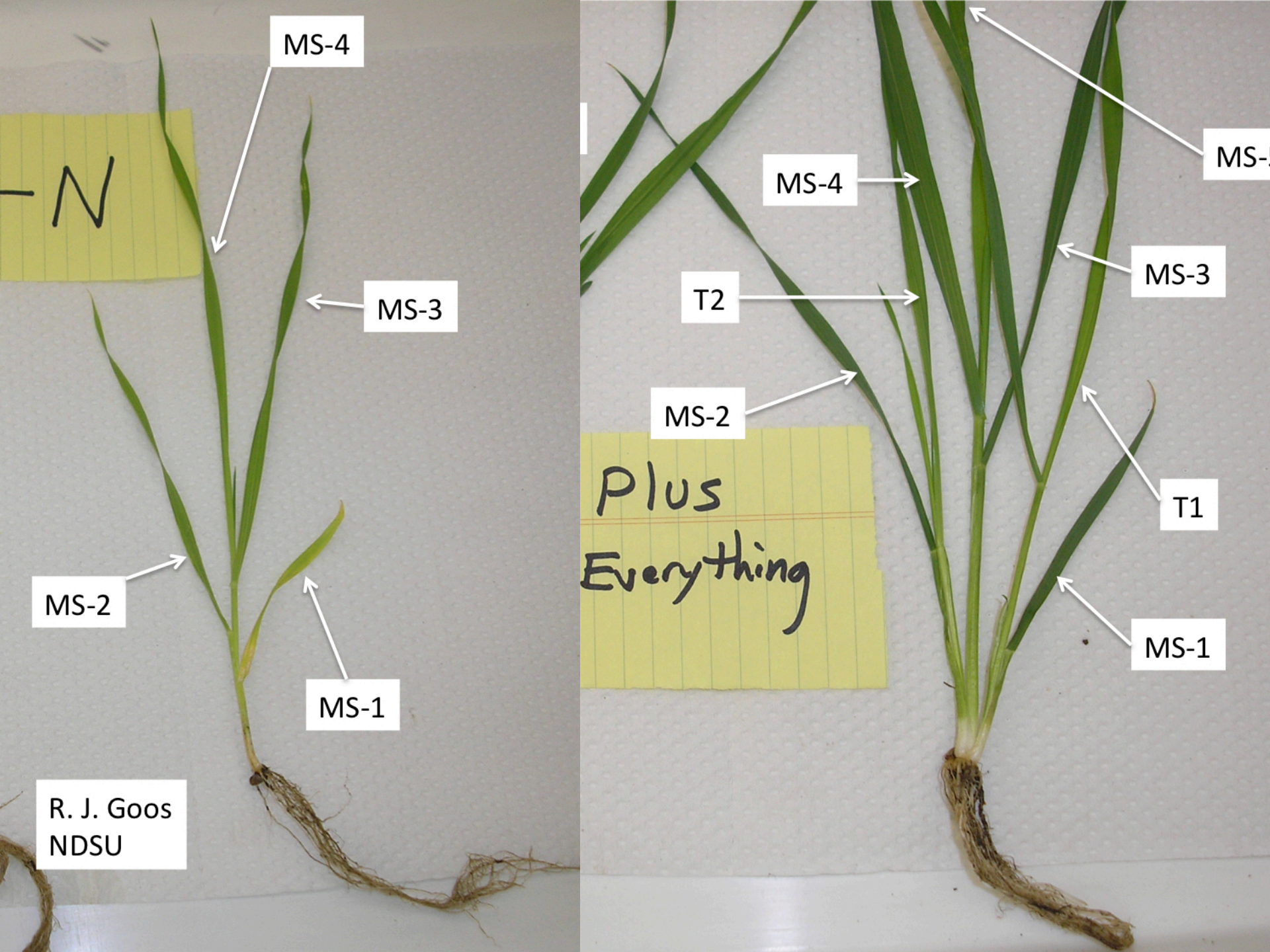

Mapleton, ND, 1995
36 bu/A final yield
Percent
100
80
60
40
20
0
MS
T0
T1
T2
T3
SUB
MS
T1+T2
OTHER

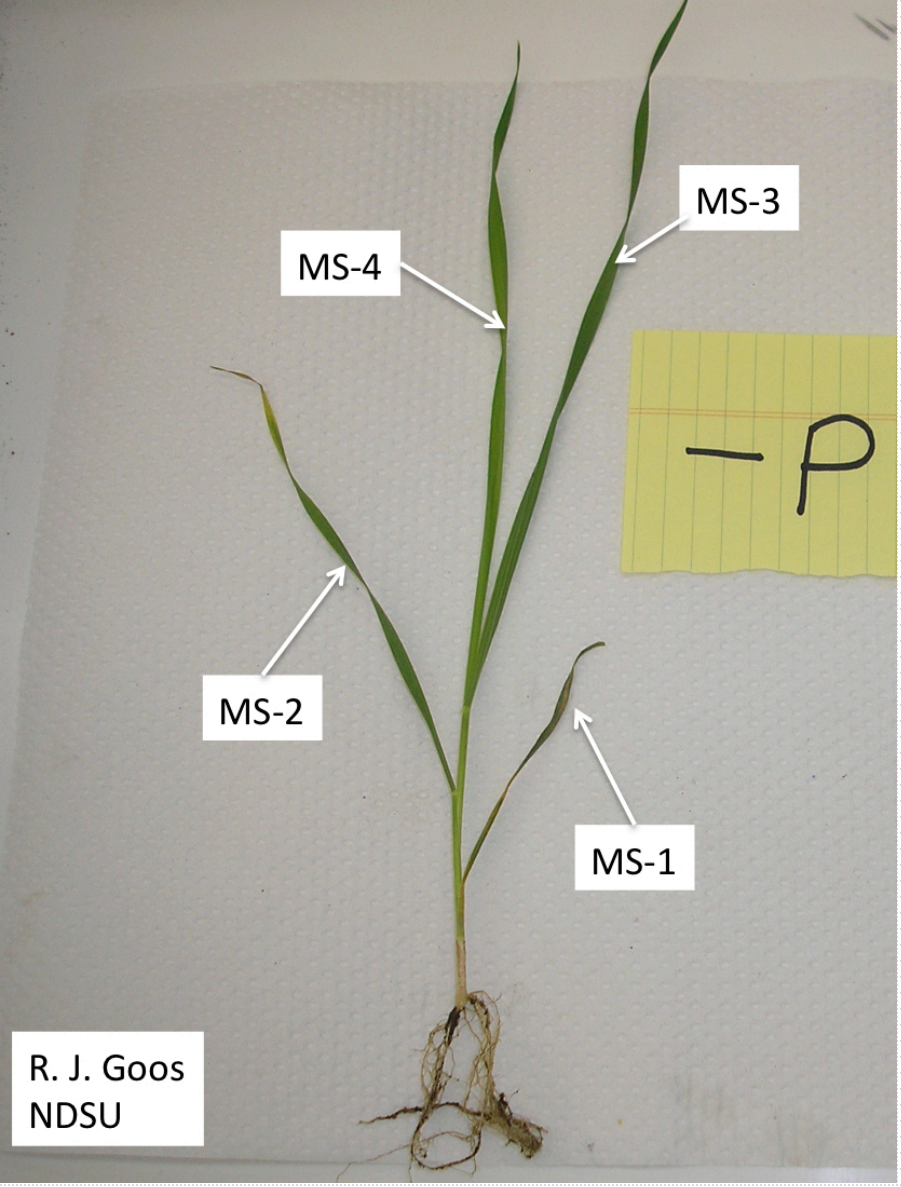

Tower City, ND, 1995
40 bu/A final yield
Percent
100
80
60
40
20
0
MS
T0
T1
T2
T3
SUB
MS
T1+T2
OTHER

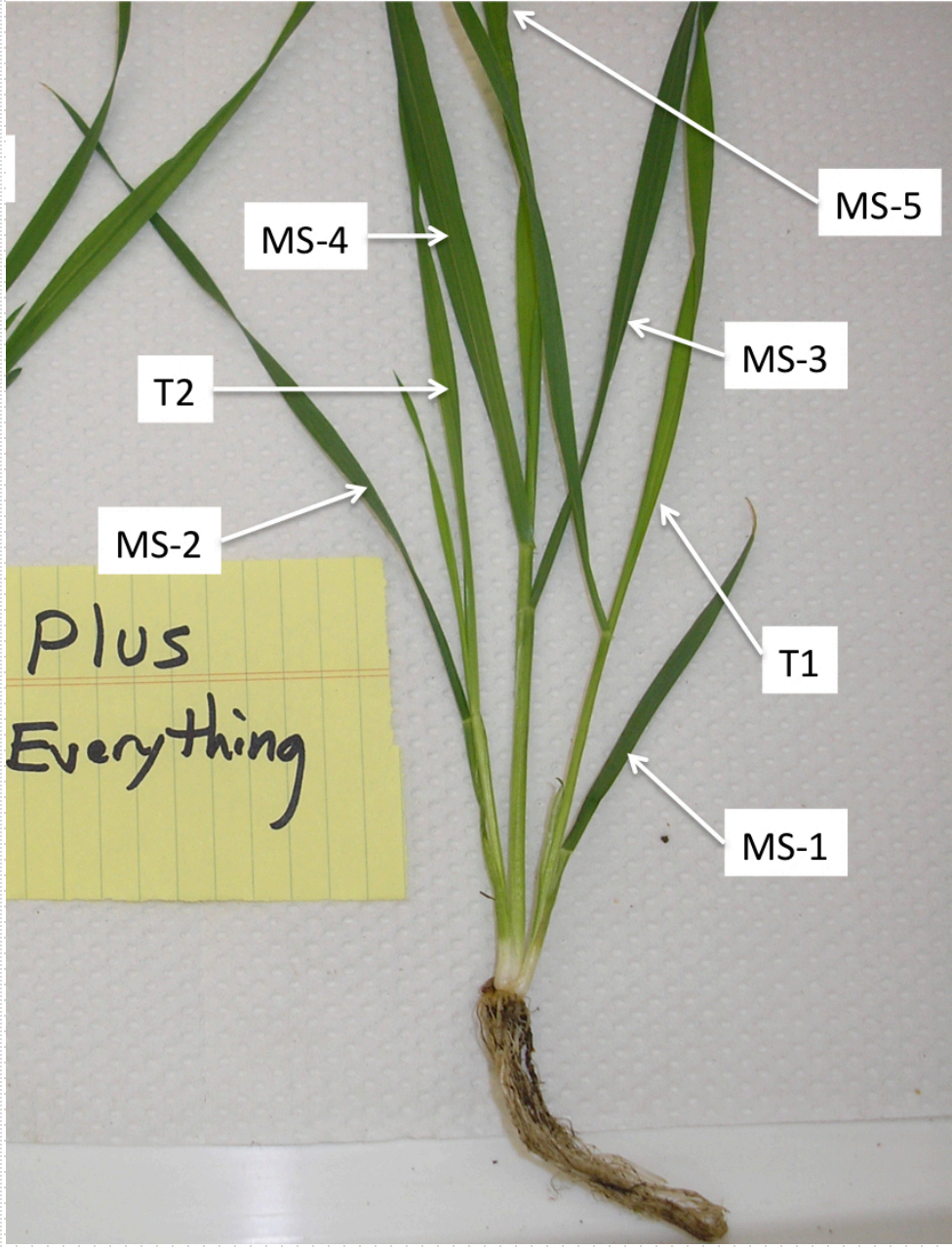

Embden, ND, 1995
46 bu/A final yield
Percent
100
80
60
40
20
0
MS
T0
T1
T2
T3
SUB
MS
T1+T2
OTHER


Minot, 2017, 4 varieties
70 bu/A overall yield
Percent
100
80
60
40
20
0
MS
T1+T2
OTHER

- So…what happens at the 2.5 and 3.5 Haun stage matters (initiation of T1 and T2 tillers)
- What happens between Haun ~4-6 stage matters (# of leaves on the main stem, head size)
- What does this have to do with N and P?
  - T1 and T2 tillers will not form if the plant is deficient in N or P


MS-4
-N
MS-3
MS-2
MS-1
R. J. Goos
NDSU
MS-4
T2
MS-2
Plus
Everything
MS-3
T1
MS-1

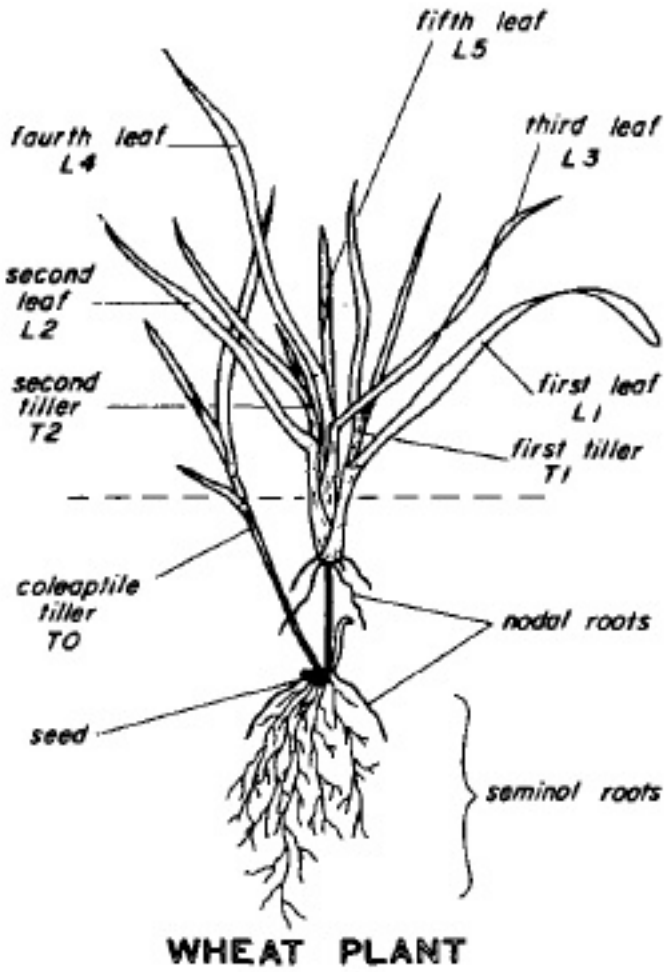

MS-4
MS-3
-P
MS-2
MS-1
R. J. Goos
NDSU


MS-5
MS-4
MS-3
T2
MS-2
Plus
Everything
T1
MS-1

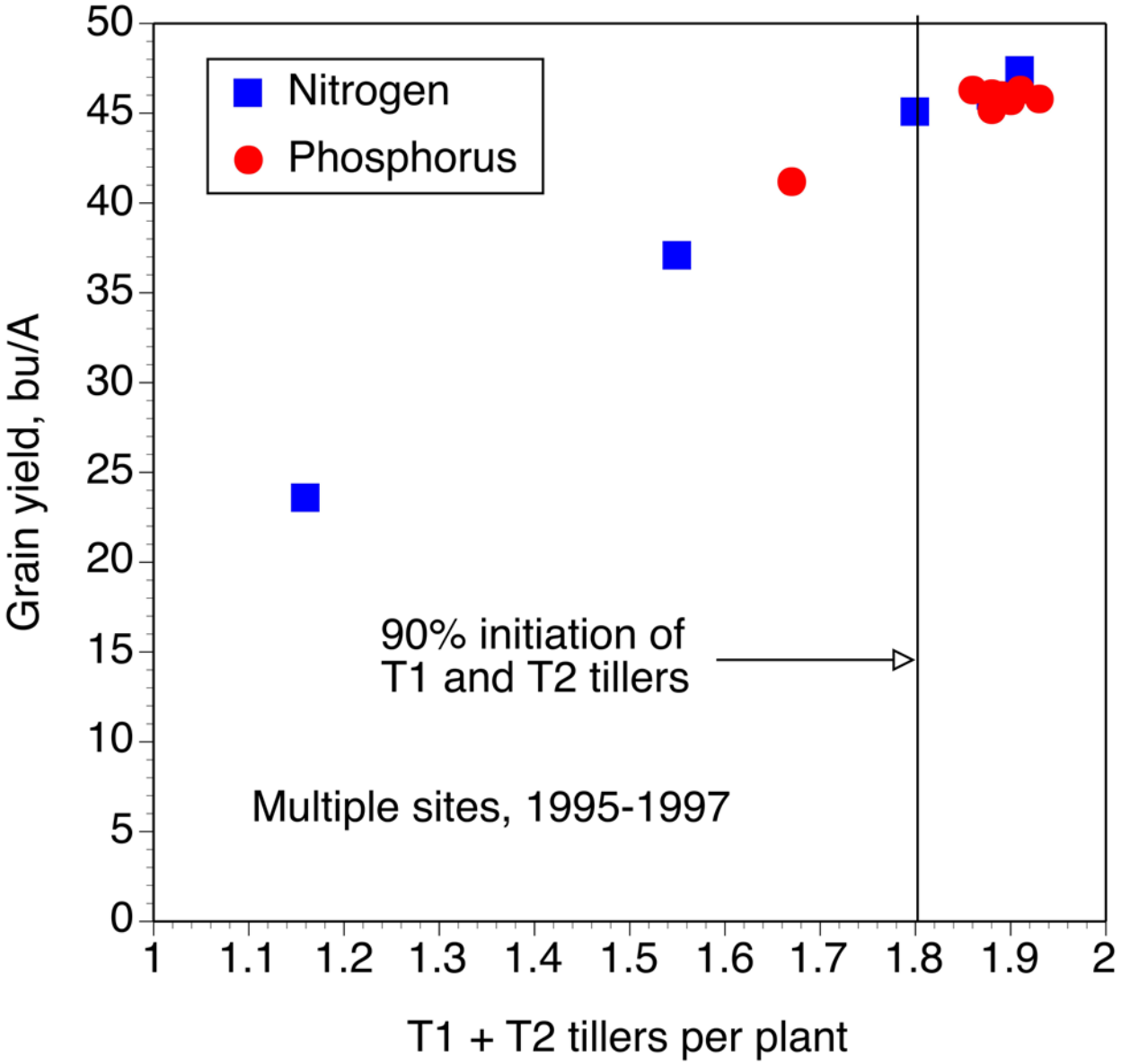

PCS
Sales


PCS
Sales

- Proper N and P management for good plant development
- Practical goal…90% initiation of T1 and T2 tillers
- Best measured at about the 4.5 Haun stage



In a series of N or P trials, 1995-1997 maximum yield was associated with 90% initiation of T1 and T2 tillers

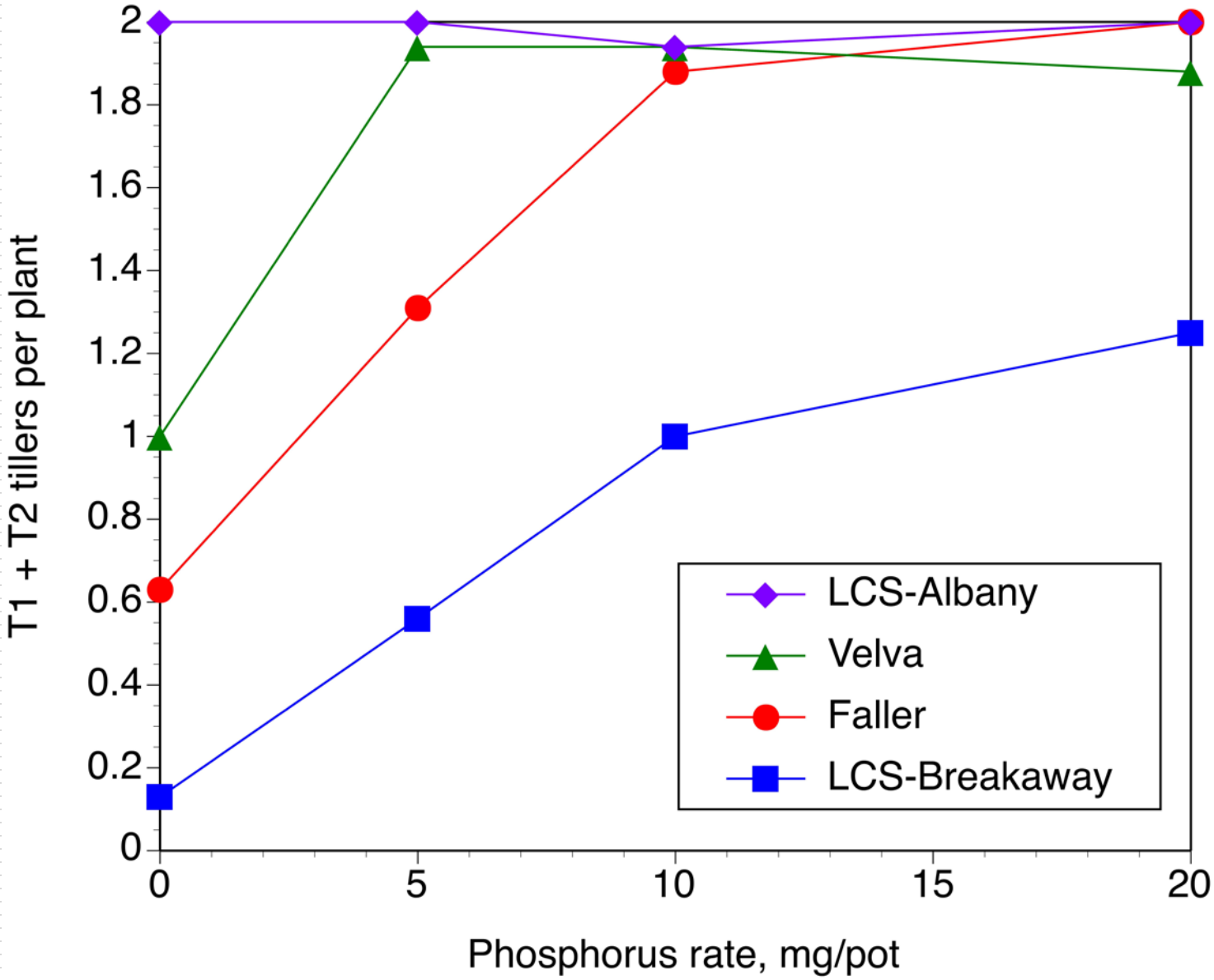


- But, since 1997, I've had other fish to fry.
- Any recent studies?

- ~80 historic and current wheat varieties were screened for P requirements for adequate T1 and T2 tillering

WS 1812 2375

And…big differences DO exist



- A very general observation…
- Rapid-growing, earlier maturing, low-tillering varieties need more P for adequate T1 + T2 tillering than slower-growing, higher-tillering varieties

- To wrap up….
- Scout your fields for T1 and T2 tiller initiation
  - If you have 90% T1 + T2 initiation, you've done many things right
- Avoid early-season N deficiency at all costs
- Starter P is still a great practice, because….


Put the P where the roots are!!!

- Thank-you for your kind attention

- This work was done off-and-on for a few decades, with too many cooperators and grant sponsors to thank individually