



A new key for recording the phenological development of indeterminate pulse crops.

Jeremy Whish, Fernanda Dreccer et al.

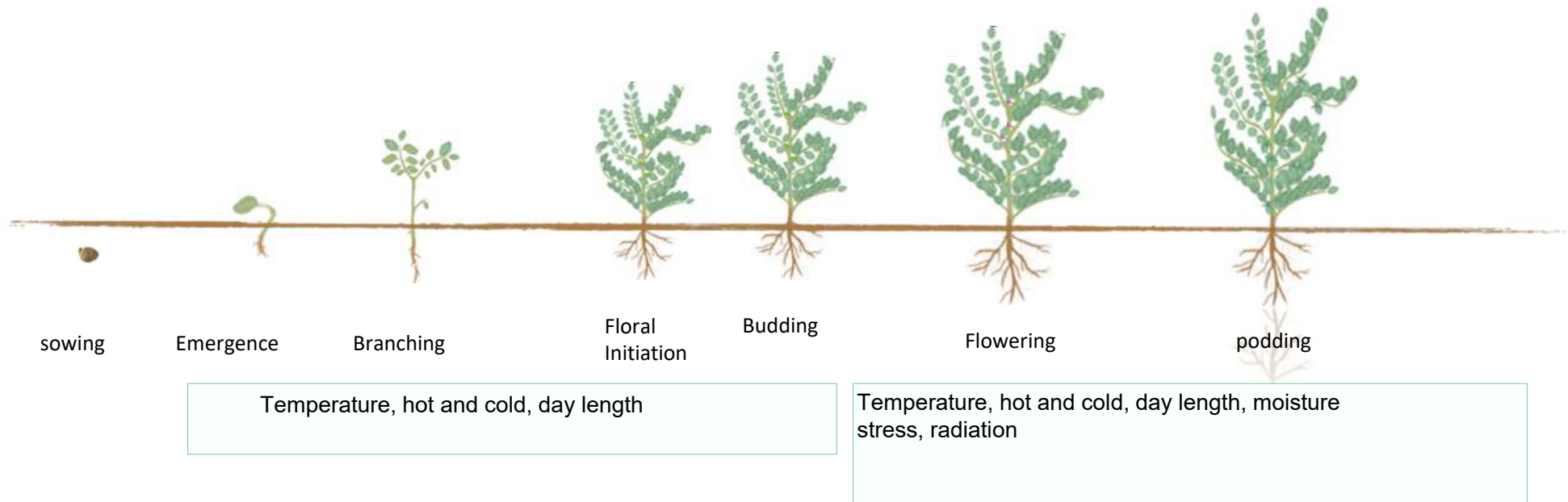


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Why do we need a developmental scale (key)?





What is wrong with the key we have ?

Plant growth and physiology [Table of Contents](#) [Feedback](#)  **GRDC**
GROWNOTES
Know what. Grow more.

October 2016

Table 1: Growth stages of a chickpea plant (Nolan 2001)

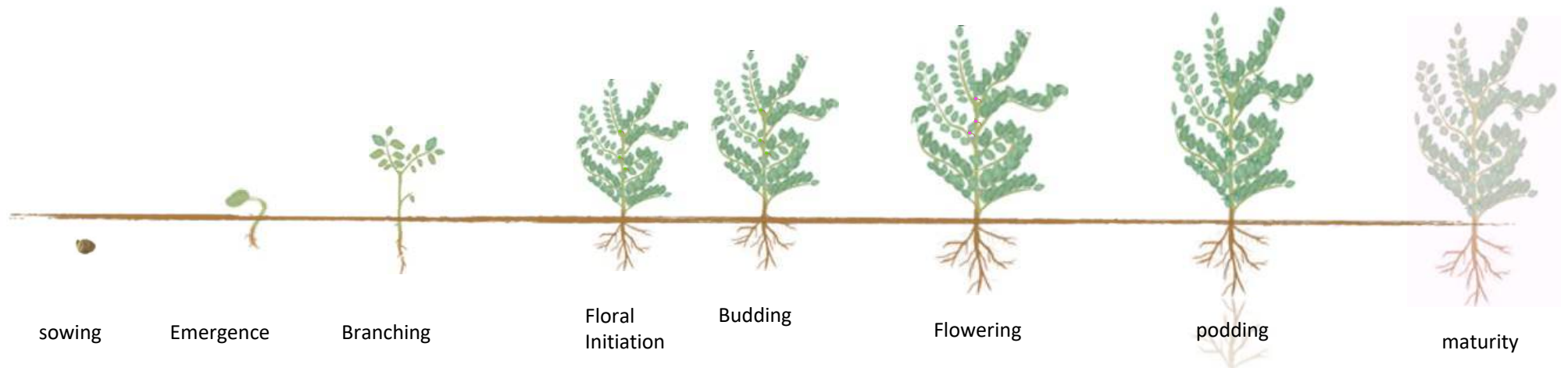
Vegetative growth stage (V-stage) in chickpeas		
Designation	Growth stage	Description
VG	Germination	Cotyledons remain underground inside the seed coat and provide energy for rapidly growing primary roots (radicle) and shoots
VE	Emergence	The plumule emerges and the first two leaves are scales. The first true leaf has two or three pairs of leaflets plus a terminal leaflet
V1	First node	Imparipinnate (terminal unpaired) leaves attached to the first node are fully expanded and flat while the 1st imparipinnate leaf attached to the upper node starts to unroll
V2	Second node	1st imparipinnate leaf attached to the second node is fully expanded and flat while the 2nd imparipinnate leaf on the upper node starts to unroll
V3	Third node	2nd imparipinnate leaf attached to the third node is fully expanded and flat while the 3rd imparipinnate leaf on the upper node starts to unroll. The bulk of the yield is found on the branches stemming from the first three nodes
V(n)	N-node	A node is counted when its imparipinnate leaf is unfolded and its leaflets are flat
Reproductive growth stage (R-stage) in chickpea		
R0	False flowering	In the transition from vegetative to include reproductive growth, a number of false flowers (called pseudo flowers) may develop from the axillary buds. These flower buds lack fully developed petals and typically appear if flowering is triggered before mean temperatures are high enough for true flowers to develop



Why do we need a developmental scale (key)?

Vegetative Period

Reproductive Period



sowing

Emergence

Branching

Floral
Initiation

Budding

Flowering

podding

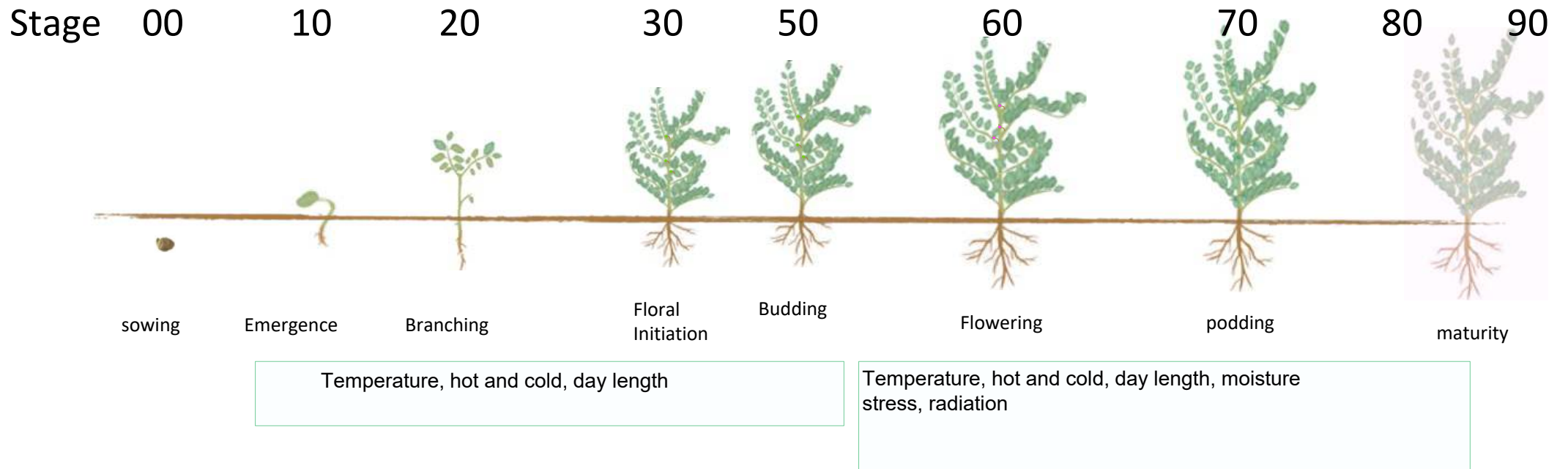
maturity

Temperature, hot and cold, day length

Temperature, hot and cold, day length, moisture stress, radiation



What is Development?





So what did we do ?





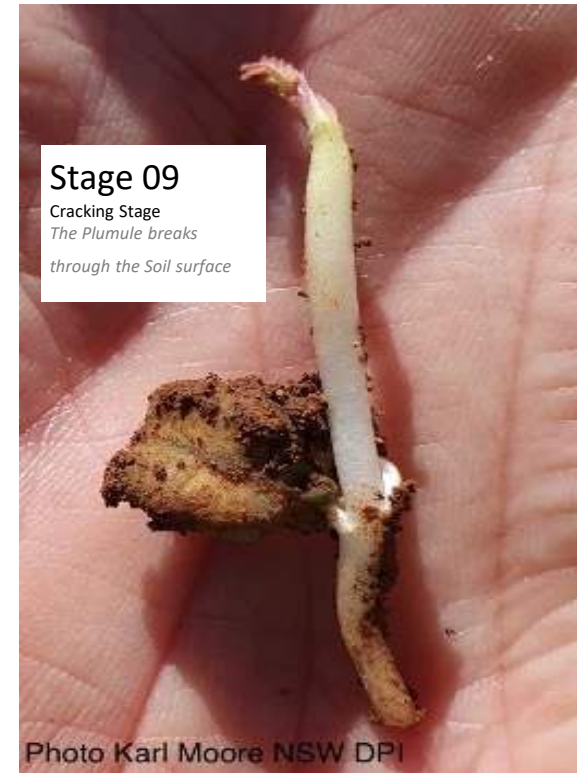
Our Goals

- The key must collect phenological data at a resolution suitable for the testing and development of crop models, specifically APSIM.
- The primary stages must be visual and easily distinguished from a photo to aid in consistency of measurement.
- The key must be suitable for both agronomic decisions, model testing and be scalable for physiological or genetic assessment.
- The key should adapt as the indeterminate nature of the plant changes from the main stem to the plant as a whole.



An adaption of the BBCH Scale.

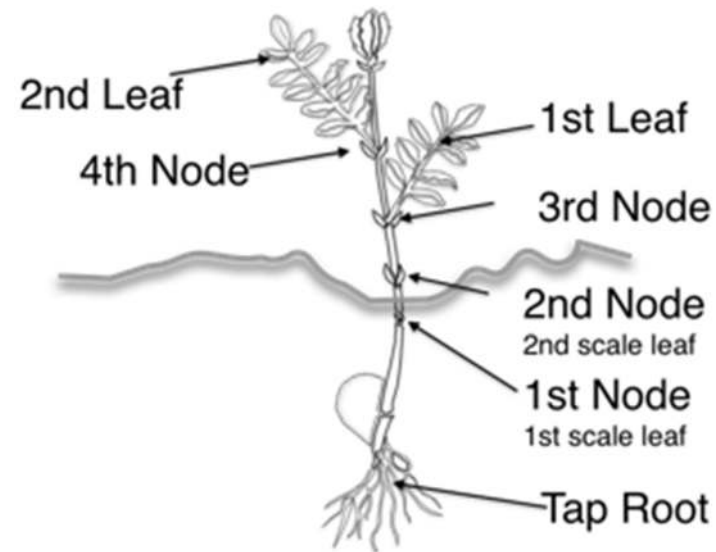
Principal growth stage 0: Germination		
2 digit	3 digit	
00	000	Dry Seed
01	001	Beginning of Seed imbibition
03	003	seed imbibition complete
05	005	Radicle emerged from seed
07	007	Shoot breaking through seed coat
08	008	Shoot growing towards soil surface; hypocotyl arch visible
09	009	The Plumule breaks through soil surface ("cracking stage")





Decimal construction

Principal growth stage 1: Leaf Development		
10	100	1st visible Node (This is the second scale leaf node) Emergence is when the pair of scale leaves at the second node are visible below the Plume. Note the scale leaves can look like a single leaf, but is described as a pair. The first node with its pair of scale leaves, usually remains below the soil surface and is only visible once the plant has been removed from the soil
11	101	First true leaf unfolded Imparipinnate leaf attached to the third node is expanded and flat, while the second imparipinnate leaf on the upper node starts to unroll. A leaf is considered a leaf when a clear petiole is present and the leaflets can be clearly distinguished as individuals. Depending on the time of day the leaflets may be flat or slightly folded.
12	102	2 true leaf unfolded on the 4 th node 3rd imparipinnate leaf on the upper node starts to unroll.
13	103	3rd true leaf unfolded on the 5 th node 4th imparipinnate leaf on the upper node starts to unroll.
16	106	6th leaf unfolded on the 8th node 7th imparipinnate leaf on the upper node starts to unroll.
	112	12th leaf unfolded on the 13th node 12th Imparipinnate leaf attached to the fourth node is fully expanded and flat while the 13th imparipinnate leaf on the upper node starts to unroll.





Defined shoot development

Stage 23

Side branching
3 branches visible on main stem

Secondary branching can be confusing

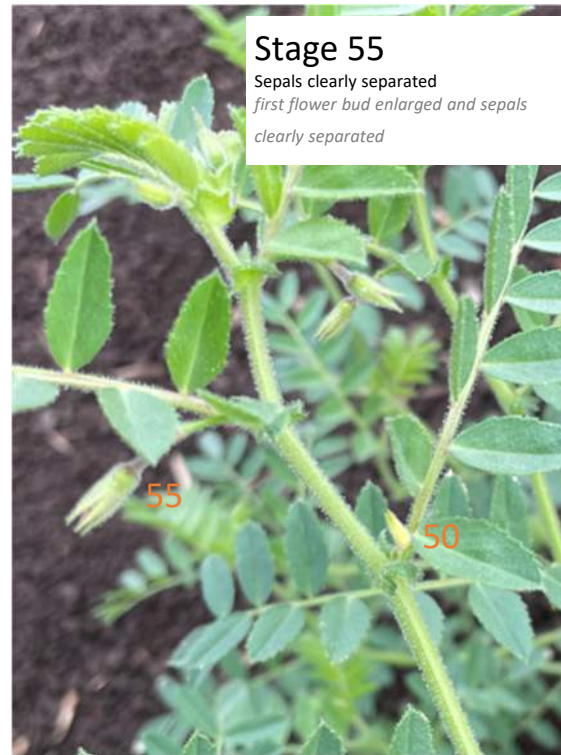


Principal growth stage 2: Side shoot Development		
20	200	No visible side shoots
21	201	Beginning of side shoot (<u>Branch</u>) development: first branch detectable. The first side shoot generally forms from a leaf node, however later side shoots may form from the scale nodes even the first subterranean scale node. It is not uncommon for the second branch to form below the first branch. A branch is distinguished from a leaf because it generally comes from the leaf axis. A branch is recorded as a branch when it is distinguishable from a leaf because it has individual leaves developing along it.
22	202	2 nd Branch present on main stem, this may occur below the first branch
23	203	3 rd Side shoot present on main stem
29	209	9th side shoot present on main stem



Focused on often overlooked stages

Principal growth stage 5: Inflorescence emergence		
50	500	First flower bud visible on an extended pedicel, this can initially be difficult to distinguish from a branch, but the bud pedicel is thinner than a leaf petiole. A bud is scored as a bud when the pedicel is around 2-5 mm long and identifiable as clearly supporting the bud
55	505	first flower bud <u>enlarged</u> and sepals clearly separated. Depending on the environment many buds do not develop to, or beyond this stage.
59	509	first flower petals visible beyond the sepals; flower buds still tubular. Flower colour visible within the bud.



Stage 55

Sepals clearly separated
first flower bud enlarged and sepals
clearly separated



Stage 55

Sepals clearly separated
first flower bud enlarged and sepals
clearly separated



Up to flowering was straight forward

Principal growth stage 6: Flowering		
60	600	First flower open, the first flowers can die due to cold, but should still be recorded as flower or dead flower
61	601	more than one flower on main stem flowers with fully open petals
63	603	more than one flower with fully open flowers on main stem and branches
65	605	Flowers on main stem, first pod developing. The indeterminate nature of peas means stage 605 is not the midpoint of flower development, but the point when the plant is producing both pods and flowers
67	607	Flowering on main stem declining more pods than flowers
69	609	End of flowering on main stem



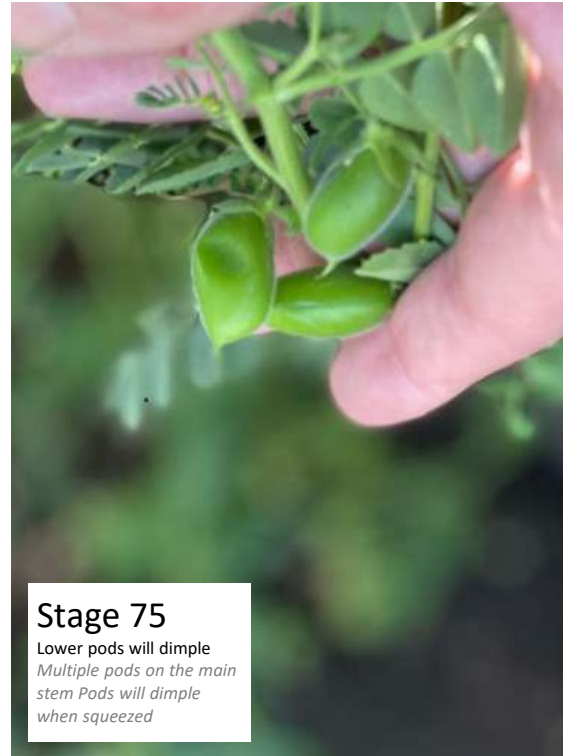
Stage 60
Sepals clearly separated
first flower bud enlarged and sepals clearly separated





Shift to assessing the whole plant

Principal growth stage 7: Development of Fruit		
70	700	First pod developing this stage overlaps with stage 65 the jointed peduncle of the senescing petals reflexes, so that the developing pod hangs beneath its subtending leaf.
71	701	1 fully expanded pod on the main stem, the jointed peduncle of the senescing petals reflexes, so that the developing pod hangs beneath its subtending leaf. Seeds fill less than half of the pod area but can be felt as a bump between the fingers. Multiple pods developing above the lower pod. Pod soft and velvet to the touch
72	702	2 or more fully expanded pod on the main stem in which seed cotyledon growth is visible when the fruit is cut in cross section seed fills more than half the pod area. Multiple pods. Smaller pods developing on the main stem just below flowers. Lower pods firm to the touch will dimple with light squeeze
73	703	Pods developing on branches. Multiple pods on the main stem lower pods fully expanded.
75	705	Multiple pods on the main stem and branches lower pods fully expanded. firm to the touch will dimple with a light squeeze
77	707	Majority of pods on the lower half of the plant are fully developed. Pods present on primary and secondary branches, lower pods ridged to touch will split along seem if squeezed too firmly. Seed filling the pod.
79	709	Majority about 80% of plant with pods that are rigid and firm to the touch with developing seeds, final top pods may be smaller and/or have been aborted. Flowers aborting or flowering ceased.



Stage 75
Lower pods will dimple
Multiple pods on the main stem
Pods will dimple when squeezed



Stage 77
Lower pods rigid to touch
Developed pods on primary and secondary branches



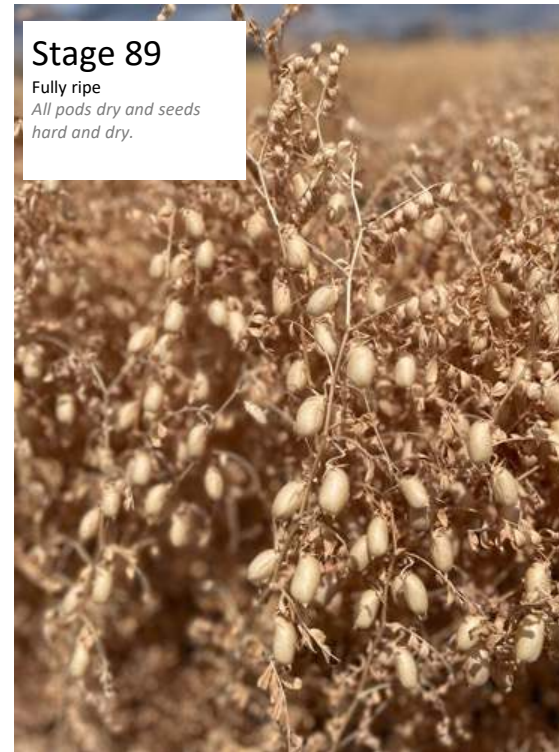
Principal growth stage 8:		
80	800	First pod with ripe seed, seed at final colour, dry and hard. Pod is a light golden colour; this stage overlaps with stage 77
81	801	10% of pods with ripe seed at final colour, dry and hard
85	805	50% of pods with ripe seed at final colour, dry and hard, pods a light golden colour
88	808	80% of pods with ripe seed at final colour, dry and hard, pods a light golden colour
89	809	Fully ripe all pods dry and hard seeds dry and hard
Principal growth stage 9: Senescence		
91	901	10% of leaves discoloured and fallen
95	905	50% of leaves discoloured and fallen
97	907	70% Above ground parts of plants dead
99	909	Harvested product.





What next ?

Principal growth stage 8:		
80	800	First pod with ripe seed, seed at final colour, dry and hard. Pod is a light golden colour; this stage overlaps with stage 77
81	801	10% of pods with ripe seed at final colour, dry and hard
85	805	50% of pods with ripe seed at final colour, dry and hard, pods a light golden colour
88	808	80% of pods with ripe seed at final colour, dry and hard, pods a light golden colour
89	809	Fully ripe all pods dry and hard seeds dry and hard
Principal growth stage 9: Senescence		
91	901	10% of leaves discoloured and fallen
95	905	50% of leaves discoloured and fallen
97	907	70% Above ground parts of plants dead
99	909	Harvested product.





Lentils

Principal growth stage 7: Development of Fruit		
70	700	First pod developing this stage overlaps with stage 65
71	701	1 fully expanded pod on the main stem, pod length satisfies the dimensions of the cultivar, the jointed peduncle of the senescing petals reflexes, so that the developing pod hangs beneath its subtending leaf. Seeds fill less than half of the pod area but can be felt as a bump between the fingers
72	702	1 fully expanded pod on the main stem in which seed cotyledon growth is visible when the fruit is cut in cross section. Seed fills more than half the pod area
73	703	Multiple pods on the main stem lower pods fully expanded, seed bump visible, pods forming on branches
75	705	Multiple pods on the main stem and branches with fully expanded lower pods completely filled with seed.
77	707	Majority of pods filling with seed on primary and secondary branches
79	709	Majority of pods have developing <u>seeds</u> , final pods may have been aborted. Flowers aborting



Stage 72

Fully expanded pod seed more than 50% of pod

Photos by Sri Siva Prasad, Jagdish Vasani and Tanika Mantra Agriculture Victoria



Stage 72

Fully expanded pod seed more than 50% of pod

Photos by Sri Siva Prasad, Jagdish Vasani and Tanika Mantra Agriculture Victoria



Stage 75

Multiple pods on the main stem

Pods on main stem and branches with fully expanded seed stage

Photos by Sri Siva Prasad, Jagdish Vasani and Tanika Mantra Agriculture Victoria



Stage 77

Majority of pods on primary and secondary branches filling with seed



Faba Bean

Principal growth stage 7: Development of Fruit	
70	First pod visible on one raceme, pod visible ~2cm in length see. This stage overlaps with Stage 65
71	1-2 pods developing along stem final length, more than one pod evident on one raceme
73	Multiple clusters of pods. Pods evident in multiple racemes on main stem and beginning on branches
75	Lower half of stems and branches with pods containing seed. Bumps visible through pod.
77	Majority of pods have reached final length
79	No new pods developing



Stage 70
First Pod visible
Pod visible ~ 2cm in length



Stage 72
Fruit development
Pods evident on 2 racemes per plant



Stage 75
Fruit development
Lower Pods reaching final length with distinct bumps visible



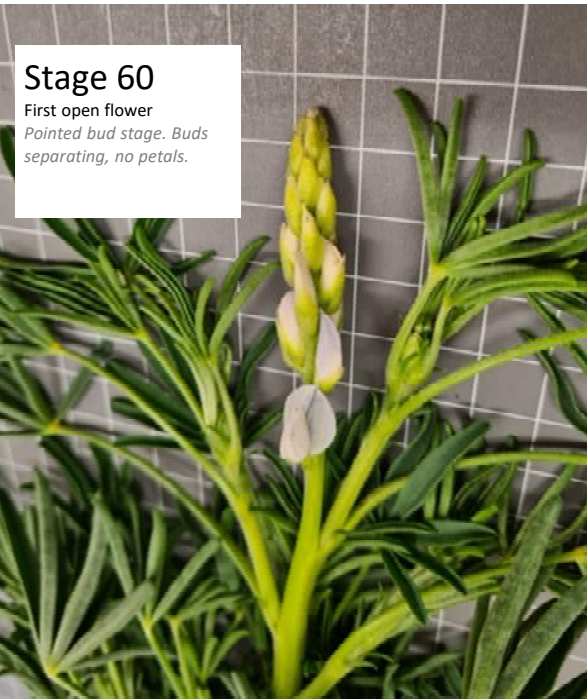
Stage 77
Fruit development
Majority of pods reach final length



Lupin

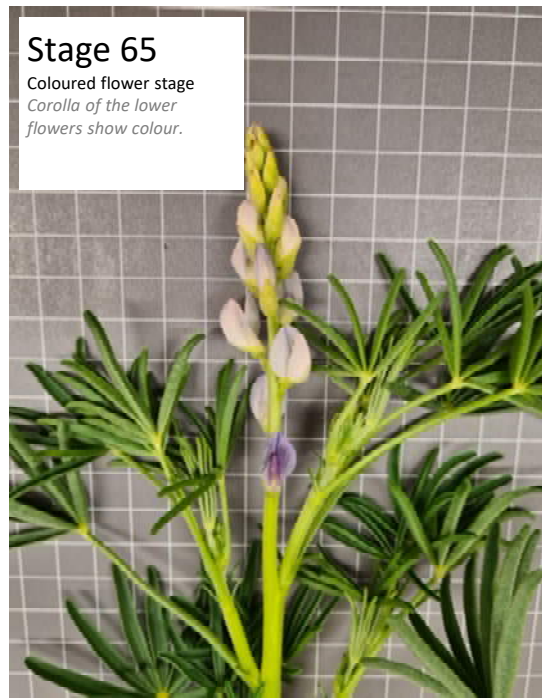
Stage 60

First open flower
Pointed bud stage. Buds separating, no petals.



Stage 65

Coloured flower stage
Corolla of the lower flowers show colour.



Stage 67

Senescent corolla stage
Lower flowers start to brown and fall.



Stage 69

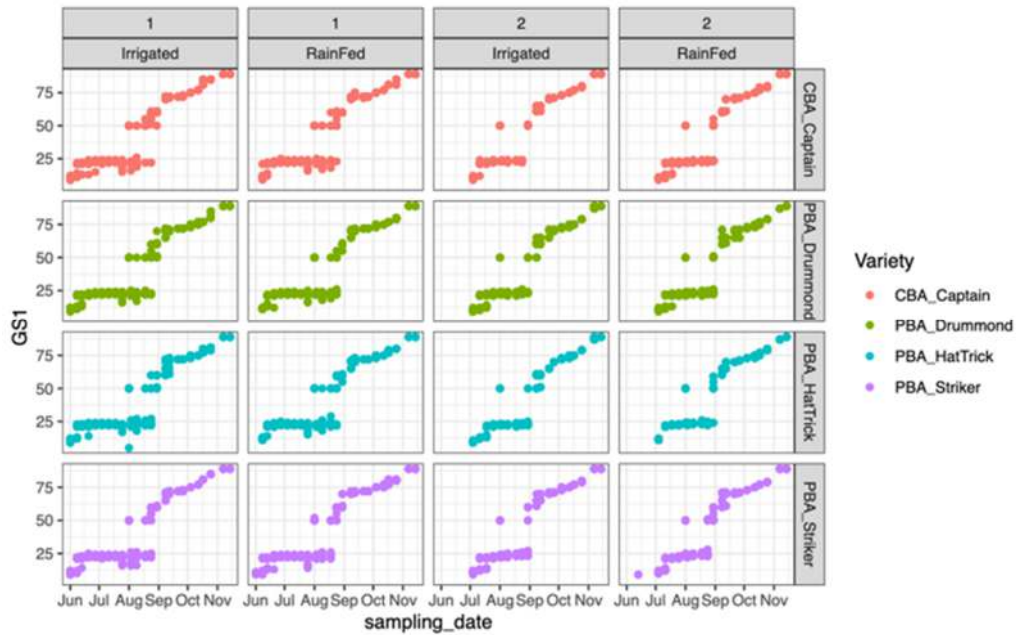
Floret abscised
Lower flowers abscised to leave developing pod.



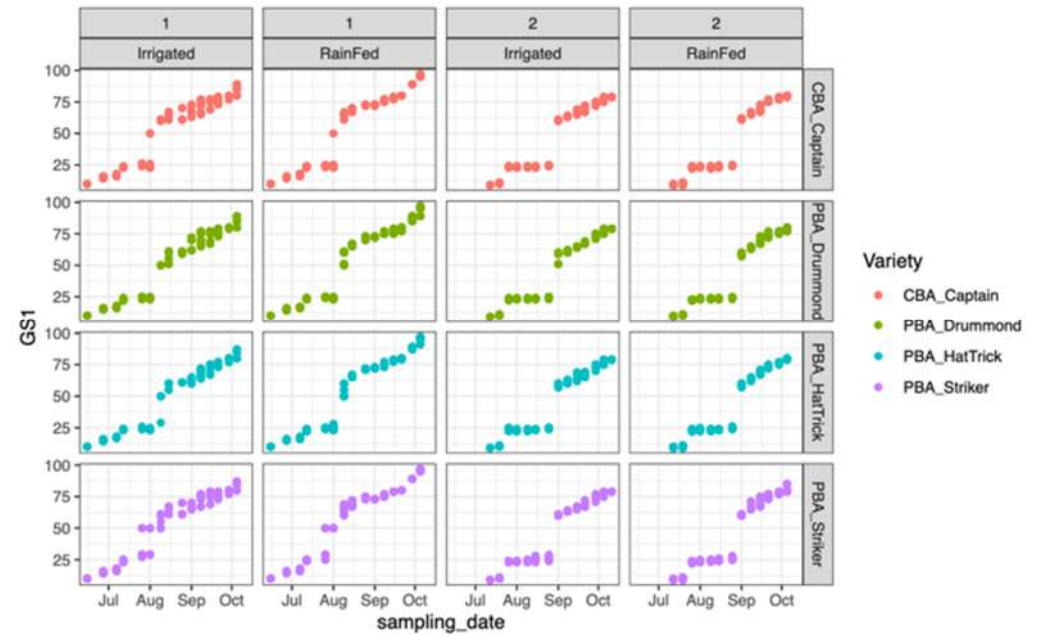


So what ?

Western Australia



Queensland





Consistency

- Fernanda Dreccer 205. [Water use and water use efficiency in chickpea during key stages for yield formation](#)
- Lia B. Olmedo Pico 206. [Lentil yield responses to high temperature](#)
- Lachlan Lake 19. [Genetics of lentil phenology and interactions with yield](#)
- Xiaoxi Li 184. [Nitrogen use efficiency of alternate farming systems in southern New South Wales – insights from four six-year experiments](#)
- Tony Swan 177. [Estimated value of legumes to crop sequences at research and commercial scale in SE NSW](#)



Thank You

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