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GRDC GROWNOTES™

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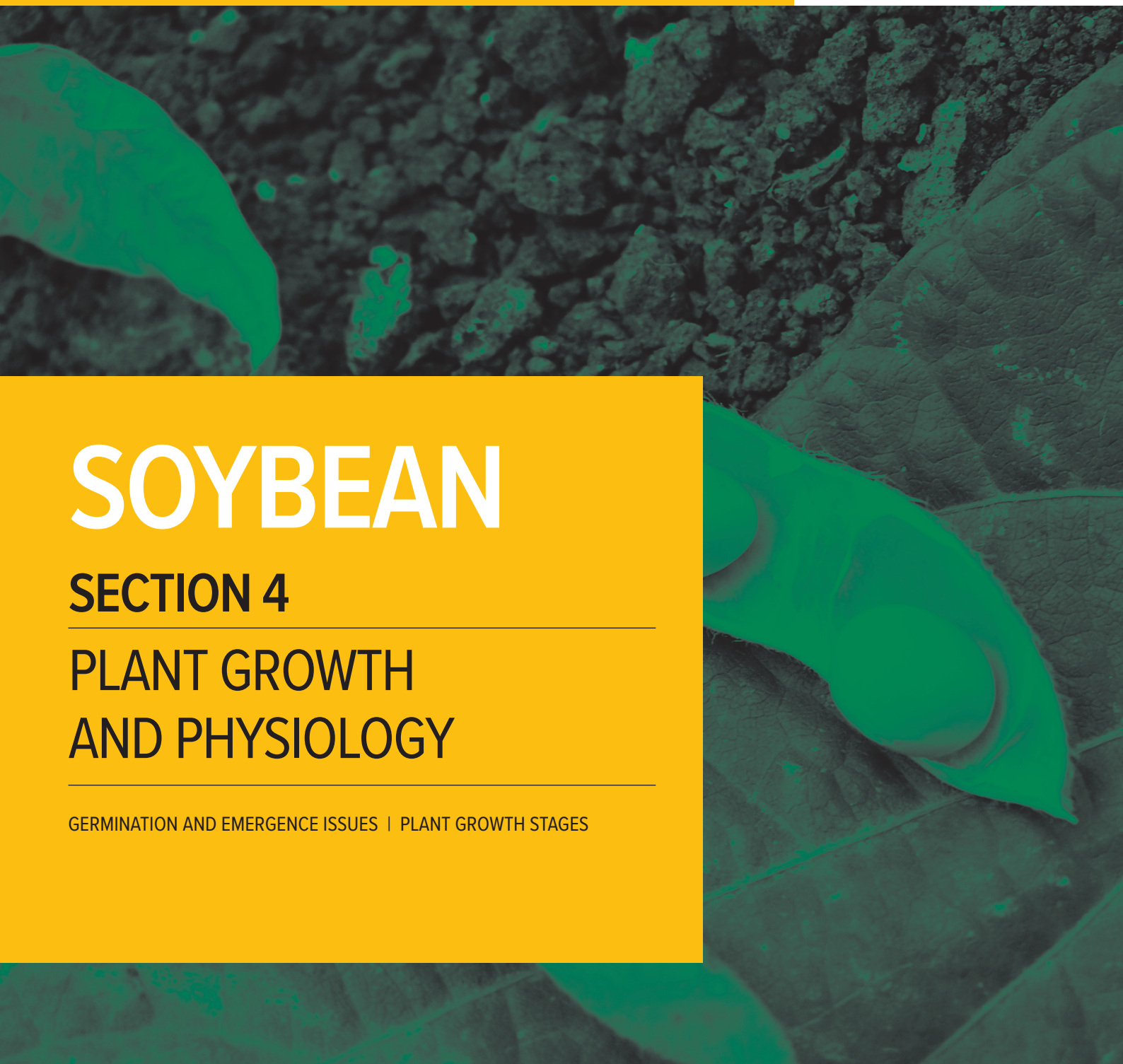

SOYBEAN

SECTION 4

PLANT GROWTH AND PHYSIOLOGY

GERMINATION AND EMERGENCE ISSUES | PLANT GROWTH STAGES

SECTION 4

Plant growth and physiology

4.1 Germination and emergence issues

At sowing, seed should be placed into moist soil to a depth of not more than 5 cm. Where moisture is deeper than this, drilling to 7.5 cm has been successful but emergence can be poor, particularly if heavy rain causes the soil to pack or crust before seedlings emerge. The use of rollers is generally not advised. Planters with press wheels which press the soil onto the sides of the seeds whilst leaving a crown of uncompacted soil for easy seedling emergence are preferred.[1]

4.2 Plant growth stages

Table 1: Growth and development definitions

Vegetative Stages	Reproductive Stages	
VE (emergence)	R1	(beginning bloom, first flower)
VC (cotyledon stage)	R2	(full bloom, flower in top 2 nodes)
V1 (first trifoliate)	R3	(beginning pod, 5 mm pod in top 4 nodes)
V2 (second trifoliate)	R4	(full pod, 20 mm pod in top 4 nodes)
V3 (third trifoliate)	R5	(3 mm seed in top 4 nodes)
V(n) (nth trifoliate)	R6	(full size seed in top 4 nodes)
V6 (flowering will soon start)	R7	(beginning maturity, one mature pod)
	R8	(full maturity, 95% of pods on the plant are mature)

4.2.1 Emergence (VE)

Soybean seed begins germination when water equal to about 50% of the seed's weight is absorbed. The radical, or primary root, is first to emerge from the seed. Shortly afterward, the hypocotyl (stem) emerges and begins growing toward the soil surface pulling the cotyledons (seed leaves) with it. This hook-shaped hypocotyl straightens once emerged and as the cotyledons unfold. Emergence (VE) normally takes five to 10 days depending on temperature, moisture conditions, variety, planting depth and soil type. As the hypocotyl arch is exposed to light and straightens, it helps to pull the cotyledons out of the ground. Epicotyl growth begins with expansion and unfolding of unifoliolate leaves.

During this time, lateral roots begin to grow from the primary root. Root hairs can be visible within five days of planting and provide the key nutrient and water absorbing functions of the plant in this early stage. The taproot will also continue growing and branching so that lateral roots can reach the centre of an 80 cm row within five to six weeks. Depending on soil type, in ideal conditions the soybean root may reach a depth of 1 to 2 metres, however the primary root mass is typically in the upper 15 to 30 cm.

Soybeans should generally be planted 25 to 40 mm deep but never deeper than 50 mmBecause the soybean must often push through crusted soil, deeper planting can

[1] NSW DPI (2007) SOYBEAN: North Coast NSW Planting Guide http://www.australianoilseeds.com/__data/assets/pdf_file/0020/7670/Soybean_North_Coast_NSW_Planting_Guide.pdf

limit plant emergence and final establishment. Maintaining soil cover levels (trash) may reduce the incidence of surface crusting thereby improving crop emergence.

Soybeans are very salt sensitive, hence fertiliser placement is important. Do not place fertiliser close to the seed or directly in the furrow as salt injury from the fertiliser may result. If fertiliser is required it should be banded 5 cm below and to the side of the planting drill. Fertiliser in the planting drill will adversely affect rhizobia survival and impact on nodulation. Soybean seed should always be inoculated with Group H inoculant to facilitate the nodulation process and allow the plant to fix its own nitrogen.[2]

4.2.2 Cotyledon stage (VC)

The VC stage commences when the unifoliolate leaves are fully expanded. During the VC stage, the cotyledons supply the nutrient needs of the young plant (for about 7 to 10 days). The cotyledons will lose about 70% of their dry weight from this nutrient reallocation. If one cotyledon is lost during this time, there is little effect on the growth rate of the plant. However, loss of both cotyledons at or soon after VE can reduce yields by 8-9%. Later, after the V1 stage, photosynthesis in the developing leaves allows the plant to sustain itself. New vegetative stages will now begin appearing approximately three to five days apart until the V5 stage and then two to three days apart from V5 to shortly after R5 when node number usually reaches a maximum.[3]

4.2.3 First trifoliate (V1)

This stage is achieved when the first trifoliate leaf is fully emerged and opened. The vegetative stages following VC are defined and numbered by the number of fully-developed leaf nodes on the main stem (the stage is numbered by the fully-developed trifoliate leaves). Trifoliate leaves on branches are not counted when determining the vegetative stages, only the trifoliate leaves off the main stem are used in the count.[4]

4.2.4 Second node (V2)

Plants are 15 to 20 cm tall and have three nodes with two unfolded leaflets. Active nitrogen fixation from the root nodules is just beginning to occur. Most of these root nodules are within 25 cm of the soil surface with each nodule holding millions of bacteria. Nodules that are pink or red inside are active in nitrogen fixation. White, grey or green nodules are not efficiently fixing nitrogen. The top 15 cm of soil will now have soybean lateral roots rapidly developing. Any cultivation for weed control should be no deeper than absolutely necessary to minimise root pruning.[5]

4.2.5 Third to fifth nodes (V3-V5)

Soybean plants at V3 are 18 to 25 cm tall with four nodes and three unfolded leaflets. Depending upon the growth habit of the variety, the number of branches seen on the plant may increase at this point, particularly if growing in a wider row spacing and in crops with lower plant population. Up to six branches are normally developed under field conditions in branched (rather than upright) varieties with the largest branch being the main stem. V5 stage is approximately one week from R1/first flower.

Plants at V5 stage are 25-30 cm tall with six nodes of unfolded leaflets. At V5, the plant normally has axillary buds in the top stem that will develop into flower clusters (racemes). At V5, the total number of nodes that the plant can produce is established. With indeterminate soybeans, this total is higher than the number of nodes that will fully develop, however, the extra axillary buds on indeterminate varieties can allow the plant to recuperate from hail or wind that may damage some of the buds.

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2 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

3 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

4 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

5 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

Although the stem apex (main growing point) is dominant, damage to this growing point will stimulate axillary buds lower on the plant to branch and grow profusely. Thus, soybeans are capable of producing new branches and leaves at this stage even after hail destroys almost all the above ground foliage as long as at least one axillary bud remains intact. However, if the plant is broken off below the cotyledonary node, the plant cannot recover as no axillary buds are located below this node.[6]

4.2.6 Sixth node (V6)

Soybeans are around 30-35 cm tall at this stage with seven nodes of unfolded leaflets. By this stage the cotyledons and unifoliolate leaves may have senesced and dropped from the plant. New stages are quickly unfolding every two to three days. Lateral roots have crossed over the row underground in any rows 80 cm or less. The plant is still capable of recovering from leaf damage at this stage. In general, soybean plants can tolerate up to 35% leaf loss prior to flowering without appreciable losses to grain yield, however, this decreases to just 15% once flowering commences. [7]

4.2.7 Beginning bloom (R1)

At least one flower is located at any node on the main stem. Plants should be around to 35-45 cm tall. Soybean flowering always initiates on the third to sixth node on the main stem depending on the vegetative stage at which flowering begins. Soybean commences flowering in response to lengthening hours of darkness and different varieties respond at different times. The time taken to commence flowering (i.e. the amount of time spent in the vegetative phase of growth) then influences the time for the crop to reach maturity, mature plant height and grain yield. Selection of an appropriate variety and suitable sowing time for your location is critical to achieve a high yielding crop.

Flower initiation progresses up and down the plant, with branches also flowering eventually. Within each raceme, the flowering will occur from the base to the tip, so basal pods are always more mature. Once again dominance of the primary racemes is seen over secondary racemes on the plant; however, secondary racemes can develop adjacent to primary racemes on the same axil. At this growth stage vertical roots are rapidly growing and will continue until R4-R5, as are secondary roots and root hairs nearer the soil surface.[8]

4.2.8 Full bloom (R2)

Soybean plants are around 45–50 cm tall at the beginning of full bloom. An open flower is seen at one of the two top nodes of the main stem. At least one of these two upper nodes shows a fully developed leaf. At this stage, the soybean has accumulated about 25% of its total dry weight and nutrients and has obtained about 50% of its mature height. About 50% of the total mature node number has been established. Very rapid accumulation of N, P, K and dry matter is now occurring and will continue through V6. Roots may reach across 100 cm wide rows. The appearance of new flowers on the plant begins to slow between R2.5-R3 and will be complete by R5. Major lateral roots have turned downward in the soil and nitrogen fixation by root nodules is increasing rapidly.[9]

4.2.9 Beginning pod (R3)

Plants can be up to 60-80 cm tall at this stage and have a pod on the upper four nodes of 5mm long. Temperature or moisture stress at this time can affect yield through

6 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

7 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

8 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

9 Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

total pod number, bean number per pod or seed size. Partial compensation with only temporary stress can occur in soybeans, but as the plant matures from R1 to R5.5 the ability to compensate decreases. Very favourable conditions will result in greater pod number per plant at this time. Since 60-75% of most flowers typically abort on soybean, any stress that increases this abortion will greatly influence yield. Half of most flowers are lost before pods begin developing and the other half are due to pod abortion. However, the long flowering period of soybeans is one reason that soybean can compensate for lost flowers.[10]

4.2.10 Full pod (R4)

Rapid pod growth and the beginning of seed development mark the beginning of the full pod stage known as R4. Dry weight of pods is greatly increased from R4-R5. At this stage of growth a pod that is at least 12 mm long is present on at least one of the four upper nodes of the main stem. This stage is the most crucial period for grain yield. Any stress to the crop from R4-R6 causes more yield reduction than at any other time. Late pod formation at R4.5 to early seed fill at R5.5 is most critical. Yield reduction at this time is mainly due to fewer pods being set. This is a critical period to consider irrigation, which must be applied if required to reduce yield losses. The last flowering will occur at the main stem tip (through R5).[11]

4.2.11 Beginning seed (R5)

Seed filling during this growth stage places significant demands for water and nutrients on the plant. Redistribution of nutrients in the plant occurs with the soybean providing about 50% of the necessary N, P and K from the plant's vegetative parts and about 50% from N fixation and nutrient uptake by the roots. Leaf loss of 100% at this stage will reduce yields by 80%; the plant is less able to compensate from stress and vegetative damage. Stresses at this stage of growth can lower grain yields by reducing pod number and the number of beans per pod, or by reducing seed size.

This stage has seed at least 3 mm long in one of the pods on one of the four upper nodes of the main stem. During R5, the plant attains its maximum height, node number and leaf area. Nitrogen fixation peaks and begins to drop. Seeds continue a steady period of dry weight accumulation. As R5 concludes, nutrient accumulation peaks in the leaves and then begins the process of redistributing to the seed. Seed accumulation will continue until shortly after R6.5, with about 80% of total seed dry weight being accomplished.[12]

4.2.12 Full seed (R6)

R6 is also known as the "green bean" stage or beginning full seed stage. Total pod weight peaks during this stage. Growth rate of the beans is rapid during this stage and peaks at R7. At the beginning of this stage a pod containing a green seed that fills the pod cavity is present on at least one of the four top nodes of the main stem. Rapid leaf yellowing commences following R6 until R8, when all leaves have fallen. Within R6, three to six trifoliate leaves may fall from the lowest nodes on the plant prior to leaf yellowing. Root growth is complete at around R6.5.[13]

4.2.13 Beginning maturity (R7)

R7 commences with one normal pod on the main stem obtaining mature colour (e.g. brown or tan). Dry matter begins to peak in individual seeds. This occurs when all green colouring is lost from both the seeds and the pods (they appear pale yellow). Seeds

[10] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[11] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[12] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[13] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

contain about 60% moisture at physiological maturity. Stress at this stage or later has little effect on yield unless the pods are physically damaged, dropped to the ground or seeds are shattered from the pods.[14]

4.2.14 Full maturity (R8)

R8 represents full maturity of the soybean plant with 95% of the pods at their mature colour. Five to 10 days of good drying weather after this stage is required for the grain to reach less than 15% moisture. Mature soybean grain will lose moisture rapidly with warm and dry weather.

Harvest usually occurs at weeks 18–20. At this time, 95% of the pods are brown/tan, and the grain moisture is within the range of 15 to 18% in coastal environments and 13 to 15% in inland environments. Grain receival standards and storage require grain moisture level of 12 to 13%. Harvest soybeans as soon as possible to maximise grain quality by reducing the risk of damage from wet weather or harvest losses from over-dry grain.[15]

Soybeans commence flowering in response to lengthening hours of darkness, which has an effect on the time to maturity, mature plant height and yield. Soybean plant growth must achieve full canopy cover by the start of flowering or by mid flowering.

[14] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production

[15] Australian Oilseeds Federation (2013), Better Soybeans manual http://www.australianoilseeds.com/soy_australia/Soybean_Production