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SAFFLOWER

SECTION 4

PLANT GROWTH AND PHYSIOLOGY

EFFECT OF TEMPERATURE, PHOTOPERIOD AND CLIMATE EFFECTS ON PLANT GROWTH AND PHYSIOLOGY | PLANT GROWTH STAGES

Plant growth and physiology

Safflower is an erect, winter/spring-growing annual herb that resembles a thistle. Along with sunflower, it belongs to the daisy plant family (Asteraceae). Despite being related to saffron thistle, safflower will not become a weed because the seeds have no dormancy and plants are easily controlled by cultivation and hormone herbicides. Cross-pollination between safflower and saffron thistle produces only sterile seed. After emergence, safflower plants slowly develop a rosette of basal leaves (Figure 1).

Figure 1: *Rosette stage of safflower.*

Photo: Nick Wachsmann

As day length and temperature increase, a fast-growing, central woody stem develops (Figure 2), reaching maximum height around the time of flowering. Depending on variety, management and growing conditions, the maximum height is reached at the start of flowering and may be 30–150 cm. A strong taproot begins to develop during the rosette stage and can penetrate deeper into the subsoil than roots of many other crops. In one comparison, safflower roots were found to a depth of 2.1 m, whereas nearby wheat roots extended to only 1.4 m.

Figure 2: *Stem elongation stage of safflower.*

Photo: Nick Wachsmann

Lateral branches develop once stems are ~20–40 cm high, and these lateral branches may in turn branch to produce secondary and tertiary branches. The central main stem is often referred to as the terminal stem, with the first level of branching known as primary branches. The extent of branching is dependent on variety, sowing rate and growing conditions. Leaves are arranged on both sides of the stem, often at uneven intervals. Leaf dimensions vary greatly between varieties and with distribution on individual plants.

Typically, leaves are 2.5–5 cm wide and 10–15 cm long. The margins of lower leaves range from being almost entire to deeply serrated, and leaves terminate with acuminate tips. Upper leaves forming the bracts that surround the flowers are usually short, stiff and ovate to obovate, and they terminate in a spine. Upper leaves frequently also possess spines on the margins, and although spineless varieties do exist, they are not widely grown commercially. The spines make the crop difficult to walkthrough; however, they also act as a deterrent to animals such as pigs and kangaroos.

Buds are borne on the ends of branches (Figure 3), and each composite flower head (capitulum) contains 20–180 individual florets. Depending on variety, crop management and growing conditions, each plant can develop 3–50 or more flower heads of 1.25–4.0 cm diameter. Flowering commences with terminal flower heads (central stem), followed sequentially by primary, secondary and sometimes tertiary branch flower heads. Individual florets usually flower for 3–4 days, and the whole flowering period can range from <10 days to >4 weeks. Commercial varieties are largely self-pollinated, with <10% outcrossing.

Figure 3: *Early flowering stage of safflower.*

Photo: Nick Wachsmann

The amount of outcrossing is increased by the presence of insect pollinators, but the presence of bees is unlikely to increase yield by >5%. Flowers are commonly yellow, orange or red, but white and cream forms also exist. Each flower head commonly contains15–50 seeds; however, the number can exceed 100. [1]

4.1 Effect of temperature, photoperiod and climate effects on plant growth and physiology

Despite a relatively high water requirement, safflower is not tolerant of waterlogging, especially when air temperatures are >20°C. Older crops are more susceptible than younger crops. Waterlogging for >48 hours can starve roots of oxygen and kill crops, in addition to favouring the development of root diseases such as Phytophthora root rot. Heavy rain and high humidity during the reproductive phase can inhibit pollination, encourage diseases, discolour seed and cause seeds to sprout in the capitula. Overall, safflower is best adapted to higher rainfall, cereal-growing regions with a dry climate during late spring and early summer, where water demands can be supplied from stored subsoil reserves. Care should be taken when irrigating crops, especially after flowering, to avoid waterlogging.

4.1.1 Temperature

Safflower will emerge at soil temperatures >4°C, but 15°C is considered optimal. It tolerates frosts to –7°C during the rosette stage, but frosts <–4°C can damage the growing point and can split stems during stem elongation and branching. Provided damage is not extensive, the plant can partially compensate by producing new shoots from below the damaged area. Crops sown very early are most susceptible, especially where frosts in late winter follow a period of mild weather favouring the early initiation of stem elongation. Risk can be minimised by sowing later, but many growers tend to overreact and plant far too late, which results in yield losses much greater than would likely be caused by frost. Safflower matures during December and January, when temperatures are often high in traditional cereal-growing regions. It can tolerate these temperatures if sufficient moisture is available. Experiments on irrigated crops in the Ord River region of Western Australia have demonstrated that

1 N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy

mean daily temperatures >26°C during flowering and seed growth do depress yield and oil content. Other research from the United States has shown that safflower can tolerate up to 46°C, but that yields tend to be highest when daytime temperatures during flowering remain <32°C.

4.1.2 Wind and hail

Safflower has better tolerance of wind and hail than cereals. Hail can severely damage young and succulent plants, but as they become stiff and woody towards flowering, they develop more resistance. Safflower resists lodging. Although ripe plants do not shatter, they are prone to feeding damage from birds. [2]

4.2 Plant growth stages

4.2.1 Emergence and early growth

Safflower normally emerges 1–3 weeks after sowing. Emergence is slower under low temperatures, increasing the risk of insect damage and disease. Germination is epigeal, which means that, as for canola or lupins, the shoot carrying the seed emerges above the soil, where the cotyledons expand and act as the first leaves. The first true leaves then emerge, forming a rosette. During the rosette stage, safflower can tolerate frosts to –7°C. Crops should be monitored for establishment pests such as redlegged earth mite during this period. Growth during the rosette stage is initially slow; it occurs in winter with short daylengths and cold temperatures. This stage can last for several weeks and varies with location and sowing date. For the same sowing date, the rosette stage is normally longer in southern than northern Australia.

4.2.2 Stem elongation and branching

With increasing temperature and daylength towards the end of winter and spring, plants grow more rapidly and the central stem begins to elongate and branch. Frosts below –4°C at this growth stage can cause stem splitting and death of the growing point, and although plants often recover to some extent by producing new shoots from below the damaged areas, yield is likely to be penalised. The number of branches produced is an important determinant of yield, because each branch eventually terminates in a flower head. Early sowing allows more time for a large rosette and an extensive branch structure to develop, creating high yield potential. However, excessive vegetative growth increases crop water use early in the season and can lead to the depletion of soil moisture before maturity, decreasing yield. Delayed sowing (e.g. August) reduces the period of the rosette and branching growth stages. This results in fewer flower heads per plant, which lowers yield potential, but can be partially overcome by increasing sowing rates. A development scale for safflower is shown in Figure 4.

2 N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy

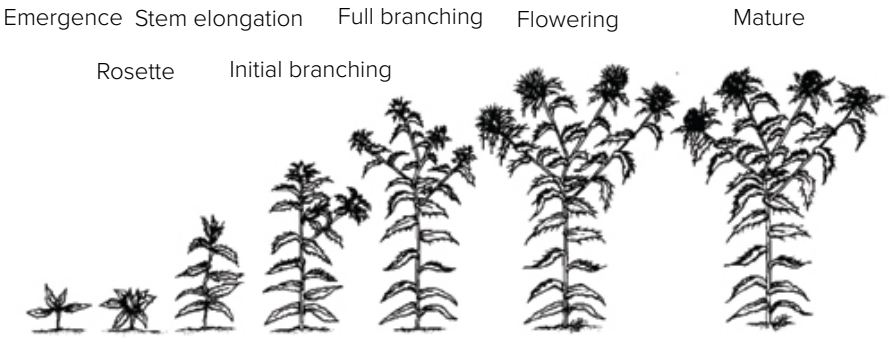

Figure 4: *The development of a safflower plant.*

Source: Kaffka and Kearney 1998

4.2.3 Flowering to maturity

Flowering generally coincides with wheat harvest in most cereal-growing areas. It is more influenced by daylength than by time of sowing. The period from the end of flowering to maturity is usually 4 weeks, so safflower is normally ready to harvest 4–6 weeks after wheat. The need for long days before the crop will flower forces flowering and seed growth into a period of high temperatures and, often, dry conditions in late spring or early summer. Safflower can tolerate these conditions if demand for water can be supplied from soil reserves, but where these reserves are depleted, low yields can be expected. As plants mature, they become stiff and woody and therefore are reasonably tolerant of wind and hail. However, excess rain may reduce yield and oil quality by inhibiting pollination, discolouring seed, promoting disease and/or causing ripe seeds to sprout in the heads. The total period from sowing to harvest maturity varies with variety, location, sowing time and growing conditions; for June or July sowings, it may be ~26–31 weeks. [3]

3 N Wachsmann, T Potter, R Byrne, S Knights (2010) Raising the bar with better safflower agronomy. Agronomic information and safflower case studies. GRDC, http://www.grdc.com.au/BetterSafflowerAgronomy