Western Murray Land Improvement Group

WMLIG

An Introduction to Industrial Hemp

Information for Farmers

Budgets

Community-based Value Chain Development

HEMP FARMING SYSTEMS

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An Introduction to Industrial Hemp

Hemp characteristics

Hemp (*Cannabis sativa)* originated in eastern Asia, perhaps in and around what is now Afghanistan, but it is no longer known in the wild state. It has been cultivated since the dawn of agriculture in the northern Hemisphere. In fact, since the glaciers of the last ice age retreated northwards in southern Europe and North Africa 9-10 000 years ago.

The first farming communities must have been pleased to find this plant. This is because hemp is a multifunctional plant species with unique and commercially significant applications. The seeds are produced in commercially relevant quantities and have a good flavour. We also know that the flour and oil are full of essential amino acids and healthy fatty acids and provide significant amounts of vitamins and minerals. The rotted ('retted') stems can be made to release fibre for cloth and rope making. It is more than likely that the tribal 'medical providers' have picked up on the medicinal value of the leaf-bud exudates, including their narcotic and analgesic benefits.

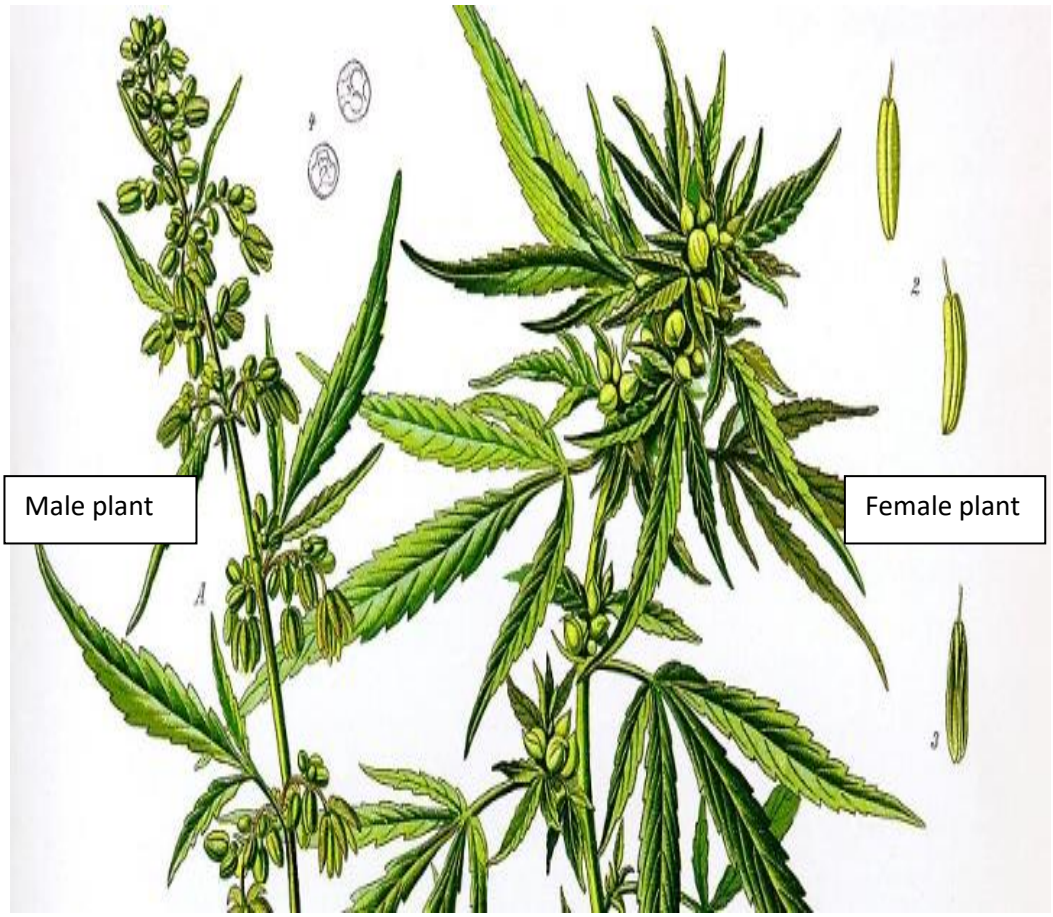
Hemp was so important before the industrial revolution that the first European settlers of North America were granted access to farm land on the understanding that they would supply hemp fibre from two acres of their land. Also, the TOR of one Captain James Cook included the task of finding a viable substitute for industrial hemp and/or to find a place in this great southern land to grow it. He had his eye on Botany Bay for that purpose.

This crop emerged three weeks previously: plants are about 30 cm tall in this picture

The stems, though slender, are immensely strong. This is because of the properties of the fibres that surround the central core of the stem. They are the longest, lightest, and strongest natural fibres known. This is why ropes made of hemp fibres and sails made of hemp cloth (canvas) were the mainstay of the world's shipping industry, until steam replaced sail.

The pith or central core of the stems also has special properties that are, for instance, currently valued by the construction industry for making rather special building blocks and moulded walls.

In the world of hemp, the (outer) fibres are called *bast* and the core tissue (the pith of the stem) is the *hurd* or sometimes *shives*. The bast and the hurd plus the leaves and roots are lumped together as the biomass. The seeds are called seeds when they are grown to be resown and grain when they are grown for food or for oil expulsion.



Male plants (left) are generally taller and more slender than the female plants (on right). They flower first and are therefore positioned so that gravity and the wind will ensure that their pollen will fall on the female flowers. The female plant in the illustration has ripe seeds in the dried flower in the lower two axils, while the upper axils have flowers that are open for pollination and, at the tip, there are flowers that are just developing.

There are at least 2000 varieties, of which only a few have strong narcotic or significant pharmaceutical properties. We usually distinguish between *industrial hemp* which is grown for the properties of the biomass, seed and grain and *medicinal hemp* which has high levels of cannabinoids in the exudates of the small hairs that cover the terminal leaves and flower buds. The plants that provide the (mostly) illegal narcotic tetrahydrocannabidol (THC) are virtually identical to industrial hemp plants, except that the latter have, by definition and legislation, less than 0.35% in NSW and Victoria. The critical concentration may be different in other states and territories.

Hemp was originally mainly dioecious, meaning that some plants in a population had only male flowers and the rest had female flowers. Monoecious varieties with male and female flowers on one plant are now available in Australia. This is of significance to farmers who want to grow grain, because there are no 'valueless' (= seed-free) male plants in a crop.

The male flowers are attractive to honey bees and some wild bee species. It is assumed that they are collecting the abundant pollen to feed their brood, because there is no record of any nectar production by female flowers. As far as we have seen, bees mainly hang around male flowers. Bee keepers consider that the presence of a flowering hemp crop adds value to their operations. Unfortunately, grain and seed crops are attractive to *Heliothis* (corn grub) species and that the caterpillars can considerably reduce grain yields. Growers who consider applying pesticides to kill these caterpillars are strongly advised to go in an organic direction and apply a formulation of BT-- *Bacillus thuringiensis* --or the nuclear polyhedrosis virus). In the same vein, insecticide seed treatment with a neonicotinoid insecticide will also lead to the demise of many bees – if not entire hives.

Another technical term that applies to industrial hemp is *indeterminate.* This means that there is no clear cut off point to the end of the flowering period and therefore to seed development. Skill is needed to work out when a grain crop should be harvested to maximise yield and minimise the number of ripe (hard) seeds falling to the ground (shattering). This problem is familiar to farmers who grow mustards/brassicas, such as canola.

Plants stop growing in height when the reproductive phase starts. Plants divert the N, P, K etc. brought up from the soil from the tips of the stems to the flowers and seeds.

Many varieties (but not all) are day-length (or night-length) sensitive. This means that flowering is triggered when the day to night ratio reaches a specific point. Varieties differ in their response to day length. In southern Australia, photoperiod sensitive varieties are triggered from late January through to early Match. The implication is that farmers who want to grow a tall (biomass or dual purpose) crop should sow early in spring, to give their crops time to accumulate biomass before the day length trigger is reached. On the other hand, farmers growing grain crops should sow later – perhaps late November – so that they have shorter stalks to deal with when they get the headers in to harvest their crops. The current trend though is for dual purpose crops to enhance cash returns. These produce perhaps more than 1 MT/ha of seed plus 3-4 MT/ha of stalks. They are best sown later than the conventional biomass crop. But farmers must be certain that they have access to harvesters that can collect seed and deal with the stronger stems.

It should be mentioned that we do not know what regulates flowering in some varieties. Date of sowing and environmental conditions (drought and excessive rain) are almost certainly involved. The variability in Australia's climate from North to South and year to year and the diversity of the germplasm that is available, mean that it is going to take a few years for the agricultural research community to garner the knowledge that Australian farmers need, to match their needs to a specific variety.

Regulatory frame work

A few genetic variants of *Cannabis sativa* have 'mind altering' properties. But for this, there would be so much more of this plant grown around the world, including in Australia. Industrial hemp became officially legal in Australia (NSW) in 2008, but there is still a lot of legislation restricting or regulating people who want to grow it. Each state and territory has its own set of rules.

The *Hemp Industry Act 2008* (the Act), allows the cultivation and supply **of Industrial Hemp - Cannabis sativa (low THC)** stems and seed production in NSW — under regulated conditions.

THC, tetrahydrocannabinol, is the mind-altering substance present in marijuana. Although the plants looks the same, low THC or industrial hemp, as the name infers, has very low concentrations of THC and is of no value as a source of the drug. This is the fundamental difference between industrial hemp and marijuana.

Please also note that low THC industrial hemp is not the same as the medical cannabis that is grown to access the various pharmaceutical cannabinoids that some hemp plants can produce

in harvestable quantities. This document is limited to providing information about industrial hemp, because the medical hemp varieties require different production methods and are covered by different (federal) legislation[1].

The licensing regulations for industrial hemp and application forms for NSW can be accessed from: Application for a licence to cultivate and supply low THC hemp (DOCX, 86.01 KB)
With help from:
Guidelines to assist in preparing an application for a licence (PDF, 424.75 KB)
The 29 page Licensing Manual can be accessed from:
https://www.dpi.nsw.gov.au/__data/assets/pdf_file/0006/799008/hemp-industry-licence-manual.pdf/
This manual might seem a bit lengthy, but it explains clearly the various stages in the process and the responsibilities of the grower and of the Department of Agriculture. It includes all the documents farmers need to record the source of seed, the crop history, visitors to the crop, application fees, THC testing and its sale and more.

The manual includes the following *statement*: *"Low THC hemp has been around for many years and has a wide range of uses including oil for use in dog food, fibre for use as a substitute for fibreglass, and many other products. Low THC hemp has the added advantage of being considered an environmentally friendly crop, as it requires less irrigation water and agricultural chemicals than other fibre crops. A low THC hemp industry in NSW will soon be a reality with the backing of farmers, industry and government."* **Although these comments reflect the time before the industry got under way and there are a couple of issues that are debatable (for instance the comment on irrigation), Hemp Farming Systems (HFS) would like to applaud the NSW Department of Agriculture for its early support for the pioneers of this crop and its industry.**

Crops have to be inspected before they are harvested to check that the levels of THC in the leaves is less than 1%. (Victoria currently limits THC levels to 0.35%, but they may be increased shortly – written in January 2022).

Complying with the regulations is essential and it costs time and money. Farmers are advised to check through the various fee structures so that they do not get a nasty surprise when they receive an invoice for THC clearance, and license fees, etc.

[1] The Australian Government, through the Office of Drug Control, is responsible for the production and supply of cannabinoids for human therapeutic purposes.
https://www.dpi.nsw.gov.au/agriculture/broadacre-crops/summer-crops/hemp/nsw-hemp-industry

Potential growers whose farms are in Victoria can access parallel information and documentation from:
https://agriculture.vic.gov.au/crops-and-horticulture/cannabis-in-victoria/industrial-hemp/

Varieties

HFS does not recommend specific varieties, because they are often proprietary items and we feel that we cannot promote one company's products against another.

These are the main suppliers in alphabetical order:
Ecofibre (NSW) https://ecofibre.com
Hemp Farms Australia (QLD) https://hempfarmsaustralia.com.au/ supplies varieties developed by Agrifibres http://agrifibre.com
HempGro (WA, including a range of France varieties) www.hempgro.com.au
Midland Seeds (Tasmania/NZ) https://www.midlandsnz.com/seed-au

There are suppliers who focus on marketing imported seed or local Australian produced varieties (ask HFS for details).

Growing Industrial Hemp

Field selection

It is absolutely essential to check that the field has not been sprayed with a residual herbicide for at least a year. This is so to be on the safe side: not all herbicides give a bad reaction to hemp crops and the degree of reaction to different products varies between varieties.

Soil characteristics

Best soil type: Soil that can be described as well drained clayey loam to sandy loam is best. Subsoil compaction or a pan can cause problems. A high organic matter content is a bonus Hemp seedlings are not robust and have difficulty bursting through a crust, smearing, sand drifts and clods. A fine tilth to provide firm soil-seed contact is the ideal. Sand blasting also kills young plants. But we have helped farmers grow good crops on heavy cracking clay and on what amounted to sand dunes.

These newly emerged seedlings have forced their way through the crust on this clay soil. About 50% did not make it. The seeder did not break the

pH: 6.5 to 7.0 is the optimum range.

Salinity: A range of hemp varieties were grown in trials at Loxton on the lower Murray in South Australia, salt concentration in irrigation water = 300 mg/L, which is in the medium range (175-500 mg/L) and at Kybybolite (irrigation water 2000 mg/L, which is in the 'very high' range of 1500-3500 mg/L**).** Those grown at Loxton were apparently normal, but the plants at Kybybolite had scorched leaves and were unthrifty after overhead irrigation. These are the most reliable data that we have to date relating specifically to hemp growing in field conditions. We would not recommend farmers to irrigate hemp crops with water that has more than moderate salinity but there is a lot more to be learned on this topic. Breeding for salt tolerance is also underway and shows promise.

Climate and water

Temperature

Most of the varieties that will be offered to farmers in Victoria and NSW originated in temperate regions of the northern hemisphere. Mid-spring to late autumn temperatures will not be an impediment in the Western Murray, although we know that soil surface temperatures of >40°C may impede germination, and seedlings will die if the soil reaches 50°C. However, **frost** kills the flowers and developing seed. This can be turned into an advantage, because even a light frosting can scorch the leaves and bracts which stops the terminal flowers of grain crops from developing, meaning that the harvest date of the rest of the seed is easier to pick.

Alternatively, farmers growing biomass crops can ensure a long growing season by sowing just as the final frosts are over, because the seedlings seem to be more frost tolerant than the flowers. Note that hemp seeds reflect their temperate origin by being able to germinate at 10°C which is low for a summer crop.

Irrigation

Hemp cannot grow without water. The notion that it can is a myth. Farmers focusing on long season/late maturing biomass crops in low summer rainfall regions should be prepared to apply 4-5 ML/ha. Obviously, if it rains, less irrigation will be required. If the crop is dense and is more than 4 m tall and the weather is hot, windy and dry, it could need more than a total of 5 ML/ha.

Drip irrigation is the most efficient, but is the most expensive to set up. A centre pivot or a lateral move irrigator is next best. A travelling 'gun' irrigator is satisfactory, but the large droplets can cause crusting and seedling damage. Surface irrigation needs to be supported by accurate laser levelling on steeper slopes of <1/1000. Flatt(er) land needs to be formed into raised beds to avoid or minimize ponding and waterlogging. Slope is a critical factor, because rain or irrigation water need to be 'on and off' as quickly as possible, preferably in not much more than 6 h. Flood irrigation will result in water logging unless the slope is adequate and the soil is light and well drained.

It is emphasized that whilst irrigation can be essential, it can also kill plants if it stands (ponding). This means that depressions should be filled in. Seedlings and young plants will die if they are exposed to standing water for just a day. Established plants are a little more tolerant to water logging, but will die in low spots that allow water to stand. We do not know if the cause of death is an infection by a soil borne disease or by a physical factor – or a combination of both.

Whilst too much water will suppress a crop when the plants are in the seedling stage, too little will also stunt growth. *Seeds should be sown into moist soil with good soil/seed contact.* Press wheels are therefore a good idea. The soil should be pre-irrigated before sowing, perhaps 0.5 ML/ha, unless, obviously, rainfall has come at the right time.

It is also stressed that soil moisture levels need to be checked throughout the duration of the crop, because hemp plants have a high rate of evapotranspiration (up to 12 mm per day for a well grown crop).

> Sugar cane takes two years to reach its full height of 3-4 m and needs up to 2500 mm water to achieve that kind of biomass. Hemp plants grown for biomass can reach 5 m in 5 months – they definitely need a regular supply of water – from the heavens or by irrigation.

Crops that do not have adequate water simply do not grow well and come into flower early, which means that vegetative growth (stem lengthening) ceases. An impediment to root penetration such as a plough pan will also stunt growth.

Fertilizers

Hemp crops need to be 'well fed'. Potato growers and horticulturalists don't blink when told how much hemp crops need when it comes to fertilizer and water requirements, but farmers who are accustomed to winter cereals and pasture usually blink twice.

The data in the following table was derived from a dryland crop in Manitoba, Canada. The sowing rate was 39 kg/ha. The biomass yield was 12 MT/ha, total dry matter and the grain yield was 1042 kg/ha. Note that these data are the amounts of the elements that were removed from the field by the crops.

Element	**Partition**	**kg /ha removed**
Nitrogen	Biomass/stems	160
	Grain	40
	Total	**200**
Phosphorus	Biomass/stems	26
	Grain	19
	Total	**47**
Potassium	Biomass/stems	200
	Grain	12
	Total	**212**
Sulphur	Biomass/stems	12
	Grain	3
	Total	15
Calcium	Total	110
Magnesium	Total	58
Micronutrients	Order of magnitude	Fe>Mn>B> Zn>Cu

These data were published by reputable Canadian scientists.

This was a dryland crop and the yields are better than many dual purpose irrigated crops in Australia. That tells us several things:

- Plants were made available sufficient crop nutrients,
- They had adequate rain when it was needed, and
- A well adapted variety was sown at an appropriate density (39 kg/ha).

The implication is that if similarly high yielding crops are the objective, the appropriate amount of fertilizer needs to be applied to supply such a crop's requirements. This is the amount listed

in the table above plus 20% more, because the roots are not 100% efficient and not every kg of fertilizer applied will be accessible to the plant. Note also that the contribution of the nutrient uptake that was needed by the roots was not included in the Canadian data.

Most soils retain some fertility from one crop to the next, and incoming organic matter from crop residues is valuable in this respect. However, if a farmer knows that a hemp crop is going to need a certain amount of fertilizer for it to achieve its potential, it is logical to supply it before and/or during the time the crop is in the soil.

The Canadian data can be interpreted to mean that a crop should be supplied with:
200 kg N
50 kg P
200 kg K (probably best as potassium sulphate to boost the sulfur levels)
20 kg micronutrient mix (or specific trace elements if serious deficiencies are listed).

It is best not to apply all the fertilizer at once. Incremental application is effective and offsets any risk of leaching via heavy rain or surface irrigation. Fertilizer should be applied when the soil is first worked over (to ensure early release of nutrients), at sowing, and after sowing as top dressing or as foliar applications or in the irrigation water. Note that seedling leaves can 'burn' if exposed to more than 20 units of N if it is applied with the seed.

This regime is similar to the **Ecofibre** standard of 150 N 60 P 150 K (kg/ha) as recommended in its growers' guide. It rightly added silica to the mix (presumably 'plant available silica', not as sand), but suitable products may not be readily available.

Good fertilization can be achieved by applying mono- or di-ammonium phosphate (MAP and DAP), plus urea and potassium sulphate, plus micronutrients (trace elements).

Mono ammonium phosphate **MAP** (for alkaline soils: if pH = <4.5) = $(NH_4)H_2PO_4$. 100 kg has 10 kg N and 22 kg P.
Diammonium phosphate **DAP** (for acid soils: if pH is 7.5-8) = $((NH_4)_2)(HPO)_4$. 100 kg has 18 kg N and 20 kg P.
Urea = $CO(NH_2)_2$. 100 kg has 47 kg N.
Potassium sulphate = K_2SO_4. 100 kg provides 45 kg potassium and 18 kg of sulphur.

Ag Lime supplies calcium as carbonate. The quality is related to the source. It can have impurities. Quick breakdown is preferable, so that a fine textured product should be looked for.

Gypsum supplies calcium as sulphate for soil physical treatments and is preferred for clay soil where crusting is likely or where poor internal drainage will lead to water logging, especially in sodic soils .
Dolomite supplies magnesium and calcium as carbonates. The amount needed varies according to the quality of the product.

Soil tests

Farmers should have the nutrient levels of their future hemp field tested quite soon (less than two months) before they intend to sow. We know that some testing laboratories give valuable information about what the readings should be (normal or acceptable ranges). These are the labs to go to. The only problem is that they often assume that the next crop is going to be whatever was there before, which is not likely to be hemp. Even If they are asked to make recommendations for hemp they may not be able to be specific, which is why detailed information is provided below. Other than basic major nutrient NPKS data, the soil analysis must contain the following:

1) **pH:** If the pH is less than 6, add lime @1 MT/ha; if less than 5, add 2 MT lime. If the soil is alkaline (pH more than 7.5 – 8), add 1-2 MT gypsum + magnesium sulphate.

2) **Calcium and magnesium:** hemp plants need calcium and magnesium, and their levels are often depleted. If the pH is low, lime application @ 1-2 MT/ha is the standard. If magnesium is also, low switch to dolomite. If dolomite is not available, add magnesium sulphate to the lime. (The Ca:Mg ratio should be more than 2).

3) **Carbon:** If soil carbon is low (< 2.5%, the organic matter equivalent is 4%), seek a source of 10 to 20 MT/ha of compost/mulch/composted manure; apply and work in early in the soil preparation process. Extra urea could be added because microbes in the carbon source can remove the nitrogen that was intended for the crop plants. Consider doing the same when the hemp is harvested. It will give long term nutrient benefits and will enhance the water holding capacity of the soil from day 1.

This regime supports good hemp crops. It supports biomass crops that will grow 1 m/month. All fields are different, so if the soil test shows a deficiency of specific nutrients, the regime should be adjusted. Trial strips of additional fertilizers will tell farmers if they have applied enough. Deficiency can be remedied as top dressing or 'remembered for next time'. Leaf analysis should be sought if signs of nutrient deficiency symptoms become serious.

Soil preparation and weed management

Pre sowing

As early as possible: a) get the seed bed ready, meaning prepare a fine tilth with no clods and b) and get soil ameliorants compost/lime/gypsum etc., and fertilizer well worked in. Do not apply all the N fertilizer too close to sowing, because it can scorch the leaves of the seedlings: no more than 20 kg N at sowing (above).

Herbicides. Weed management is critical at this stage. It is necessary to kill standing pasture, weeds, and volunteer re-growth or whatever has emerged since the previous crop. If cultivation alone is not likely to be sufficient, glyphosate or Basta (with no residual additives) will fix this, but it takes 2 weeks to kill the weeds. Dead plants should be turned in and the field should be re-worked to a fine tilth.

These are the herbicides of note:

Bromocide (Bromoxynil) is the only post-emergence herbicide that is effective against broad-leaf weeds that is permitted (APVMA) for application to hemp crops. It does have some phytotoxicity issues (leaf burn, stunting and death), even at the low rate of 0.75 L/ha, if applied to crops of some varieties. Most plants grow out of it. A trial strip is advisable for first time users. It should be applied when both weeds and hemp seedlings are small (six leaf minimum). The highest recommended dilution should be adopted. It should only be applied when the air temperature is less than 25°C.

Pendemethalin (Stomp) is the only residual pre-emerge or post sowing broad spectrum (grass and broadleaf) herbicide permitted. Low rates (max 1.5 L/ha on loam and clay soil, and even lower on light soils or where there are sandy patches on the surface of clay soils.

Trifluralin/Treflan is registered, but it can cause seedling death especially if the soil is waterlogged, and it can be problematic in crops that follow.

Go to **https://apvma.gov.au** for details.

Seed treatment

The seed should be treated with thiram or a similar fungicide to protect it from soil or seed-borne diseases. This should be a routine procedure. Seed is often treated by the supplier, but check out details of when and with what. The container has instructions about how to treat seed. A cement mixer or seed auger could be useful.

Treatment of seed with an additional insecticide formulation should be considered if there is a residual white grub, wireworm or cutworm population. It is worth taking a shovel in hand and digging around before sowing. The presence of birds such as coorawongs or magpies feeding in the field should arouse suspicions, especially after cultivating. *Neonicotinoid insecticides based on imidacloprid should not be considered, because they will kill the brood of the bees that collect pollen from the male flowers.*

The occasional wilting or dead seedling may be found. Inspection will reveal that the root or shoot has been damaged. A response is not needed because this is allowed for by sowing extra seeds (below). If a serious attack on the germinating crop is apparent – say 10% seedling loss over an extensive area, the application of a granular insecticide followed by irrigation may be called for: **https://apvma.gov.au.**

Sowing

Pre sowing *Germination tests are essential, because seed quality can change over time (up and down).* Growers are advised to carry out their own germination test on each batch of seed that they intend to sow. Just lay out 100 seeds on moist kitchen paper in a plastic container. Keep it moist with a water spray (not wet) and count the number of seeds that germinate and shoot during 5-7 days in a warm room (+/-25°C).

The current targets are a minimum of 100 seedlings per sq m for biomass crops and over 75 plants per sq m for grain, seed and or dual purpose crops. Refinement of these recommendations is possible in the future.

This table is an example of what might be the situation. Each farmer should make his or her own table along these lines:

Target number of seedlings/sq m	100	
Allow for germination %age (example) 85%)	85	118/sq m
Allow for miscellaneous losses (10-20%)	15	**135/sq m**
Seed weight as number seeds/1000g (example)	**40000**	
(this weight is often provided)		
Seed weight per seed (g)	0.025	
or weight of 100 seeds (g) (self-measured)	2.5 g/100	
Weight of one seed g	2.5/100	0.025
Weight seed g/sq m	= 2.5x135	338
Weight of seeds /ha (g)	3.38 x10000	33824
Weight of seeds /ha (kg)	=33824/1000	**33.8**

Any reputable seeder that is handled by an experienced operator and that delivers evenly spaced seeds, and covers them at the desired depth and then presses the soil over the seed without causing smearing, is suitable for sowing an industrial hemp crop.

'Sow into moisture preferred ' and press down the soil. Sowing depth is 15-25 mm. Any deeper and the shoots will not be able to reach the surface and any less increases the risk of drying out. If there is a risk of high soil surface temperatures (say 40-50°) it is worth the risk of sowing deeper.

The space between the rows should be as small as possible: 175 - 200 mm is OK. 200 mm means there has to be about 45 mm between seeds to sow 130 seeds /sq m.

Direct drilling (no tillage) will be successful if weed management is not an issue (go for non-residual contact herbicides) and if there is no soil compaction and no risk of seedling loss caused by insects living in the litter of previous crops (e.g., Rutherglen bugs) or left over in the soil (e.g. wireworms) . Appropriate sowing equipment will have good stubble clearance.

Crop protection

Biological constraints

Weeds are usually the worst biological constraint in Australian hemp crops (see above under field preparation). There are no fixed rules: each field is different. Weed management needs to be rigorous before and just after sowing (as above). Once a crop is established it grows quickly (1 m/month) and cuts off light at the soil surface meaning that germinating weeds are not able to 'take off'. High sowing density is essential (above). Attempts to save money by holding back on the sowing rate have allowed weeds to take over whole crops. Border areas need to be cleaned up during crop development, because climbing weeds can invade dense stands and cause problems (blockages) when harvesting, for instance. Contamination of harvested seed can also be a problem created by weeds growing in and around the crop: *Chenopodium album* (fat hen, goosefoot) is one of the worst in this regard.

Diseases (soil borne) are not likely to be a serious constraint if the advice on crop rotation is heeded and if low spots in the field are filled in so that water has no chance of accumulating. It is not unusual for odd plants to wilt and die. Pulling up the dead plant will often reveal a white fungal growth around the top of the root. This is likely to be *Schlerotinia schlerotorum*. Plant loss because of this or similar diseases will not be high (and is anticipated when calculating the sowing rate). But their presence is a warning that a potentially more damaging infestation could arise and is one of the reasons for not following a hemp crop with another one.

A crop growing near a vineyard in a wet summer and autumn may be as risk from an infestation of Botrytis grey mould and/or powdery mildew. Fungicides are available, e.g., Filan, Ecocarb, and Dithane, that will stem this infestation if they can be identified and applied soon enough. https://apvma.gov.au

Insects. Industrial hemp has insect pests, but none are specific to hemp -- anywhere in the world. This is presumably because the hard outer tissues and some of the many secondary chemicals in the leaves protect it from insect attack. However, hemp is attacked by groups of general pests that have a wide range of crop hosts. The Australian cohort focuses mainly on the seed heads (and sometimes the seedlings). *Helicoverpa armigera* (Heliothis -- cotton bollworm) and *H. punctigera* (native budworm) are the most damaging. They find and colonize dispersed hemp crops without difficulty and are among the most damaging of all pests in Australia. They are resistant to many insecticides.

It is rare to visit a grain crop during the reproductive phase without finding *Helicoverpa* caterpillars. They are often accompanied by *Nysius vinitor, the* Rutherglen bug, and *Nezara viridula*, the green vegetable bug, which can be similarly pandemic, but probably less damaging.

Then there is a further group of species that is diverse, sporadic, potentially very damaging, and even more difficult to define in economic terms: leaf beetles *(Monoleptis australis*), mirids *(Creontiades pallida),* a stem borer (cerambycid beetle), seed collecting ants, wireworms, and perhaps other soil insects. Even red legged earth mites *(Halotydeus destructor)* have severely damaged spring crops. Then there is another group of insects found on hemp plants that are 'probably just visiting' from weeds etc. They include cabbage white butterflies (*Pieris rapae*) and miscellaneous grass moths.

HFS is available to provide specialist advice on the identity and management of insect pests, diseases and weeds that appear to be reducing the yield potential of hemp crops.

Prevention is better than cure:

- Check the soil for potential pests before sowing
- Walk the crop as soon as flowers appear to check for Helicoverpa eggs and young caterpillars.

NSW has a diagnostic service for potential pests at Orange and for diseases at Elizabeth Macarthur Agricultural Institute in Menangle.

Harvesting and drying

See accompanying file dealing exclusively with harvesting of grain and biomass and equipment.

Newly harvested seed/grain has to be cleaned, dried and then cooled straight after harvest otherwise it will 'cook', rot and die. It is exothermic – it produces its own heat and virtually cooks itself. This means: into the truck off the header, cleaned of leaf fragments etc., and taken straight to the seed cleaner.

Hemp in a crop rotation

Hemp after hemp is strongly advised against because: a) hemp is hungry, in terms of the nutrients it takes up and the soil needs to recover and b) soil borne diseases of hemp, such as *Schlerotinia schlerotorum,* build up. A minimum of 2 years between hemp sowings is advised.

For the western Murray River Valley area, a winter crop can follow a hemp crop that is harvested between late summer and early winter. Canola or pulses directly drilled into hemp stubble is preferable, especially if on raised permanent beds with controlled traffic. Wheel ruts and compaction will reduce the yields of future hemp crops.

Hemp is an excellent summer rotation crop, because weeds cannot grow in the shade under well grown crops. The leaves produce many natural oils and cannabinoids and terpinoid. These are believed to suppress weeds (and diseases) when the fallen leaves decompose. There are reports to the effect that hemp is immune to *Phytophthera* spp (root and stem rots). Experimental support for this observation would be welcome. The fallen lower leaves, stubble and roots obviously add carbon to the soil surface. It would be logical to include grain legumes in the rotation if hemp is grown as a source of food protein to facilitate continuity of processing and to increase soil N naturally.

Industrial hemp can be absorbed into rotations with existing systems:

- Rice on beds with winter crops (cereal/faba bean/canola) in years of moderate to high water price, when water requirements for rice are excessive.

- Alternating with other summer crops, on beds or sown on flat soil on sloping fields (maize grain/silage, sunflowers, sorghum, soybean) or ex livestock pasture paddocks of steeper sloped lucerne and summer pastures, or flatter sub-clover paddocks hilled up onto raised beds.

It is assumed that little cotton is sown this far South.