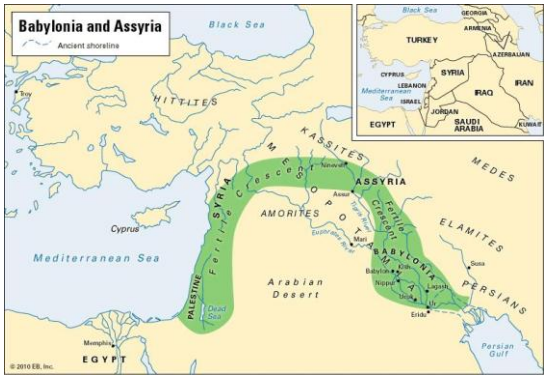
MULTI - SPECIES PASTURE CROPPING

PROFITABLE REGENERATIVE AGRICULTURE

COLIN SEIS

Farming History.

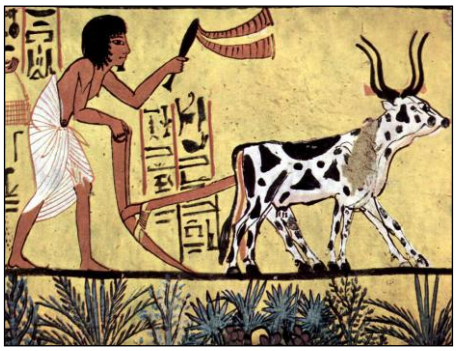
Around 12,000 years ago, as the last ice age was retreating, the climatic conditions were very dry and very cold around Western Asia, in what is commonly called the Fertile Crescent. This extreme weather killed much of the wildlife the early hunter-gatherers lived on and forced the people to eat seeds of grass from their grasslands, which they eventually learned to grow and then harvest later in the season.



Agriculture was born.

One of those grasses was a starchy seeded plant called einkorn wheat (Triticum boeoticum) which was first domesticated approximately 9000 years ago, on the gentle volcanic slopes of Karaca Dag in south-east Turkey, in an area where a number of Neolithic farming villages have been found.

Over 10,000 years ago the "Sumerian" people of Mesopotamia, developed and practised agriculture on the alluvial plains of the Tigress and Euphrates Rivers. Mesopotamia includes most of modern-day Iraq, parts of Syria, Iran, and Turkey.The very early methods used to plant crops around the Fertile Crescent are not known but is assumed the method used to prepare the soil for planting would have originally been prehistoric digging sticks. Over time these digging sticks were modified and eventually fitted with handles for pulling and pushing. However, the domestication of oxen in Mesopotamia as early as 8000 years ago provided the Sumerians with the draft power necessary to develop an animal-drawn scratch plough called an Ard. The Ard was dragged through the topsoil to cut a shallow furrow suitable for most cereal crops.



A method of sowing seeds invented by the Mesopotamians, about 3500 years ago, was a

major technological achievement. It revolutionised agriculture by carrying out the tasks of seeding and ploughing simultaneously, by dropping seed down a tube into the furrow that the plough created.

The original einkorn wheat was harvested by hand from what was primarily perennial grassland. These seeds were saved and eventually sown as a single species much like wheat is grown today. This was the fore -runner of modern western agriculture where crops are grown as a monoculture of one species.

The reasons wheat has been grown as a monoculture over the centuries are numerous and include ease of harvesting, where all species are ripe at the same time, the timing of planting and being able to better manage weed populations with cultivation and selective herbicides.

Is growing a plant as a monoculture the best way to grow a crop? Nature functions with a complex assortment of plant, animal, insect and microbial diversity and does not function as a single species.

Did we get agriculture wrong from day one? Shouldn't agriculture function closer to Natures design?

Multi - Species Pasture Cropping

Since its inception in the mid-1990s by Colin Seis and Daryl Cluff , 'Pasture Cropping' has been practised with the use of a variety of crops ranging from wheat, barley, oats, cereal rye, lupins, and canola. Summer crops have been sown with millet, cow peas, lablab and sorghum. Both winter and summer crops have usually been sown as a single species into perennial grassland or pasture, not as a mixture of species.

'Pasture cropping' with a single species sown into perennial grassland or perennial pasture, goes a long way toward addressing the problems associated with monoculture crop planting. It has achieved great success by improving soil structure, increasing soil carbon, improving nutrient cycling and more efficient use of water while producing good crops for grain and /or forage. It has also been shown that the technique will increase perennial grass numbers and species diversity.

Research data from the USA has shown that a mix of annual species sown as a crop is better than monocultures for improving soil carbon, soil biology, and soil structure as well as providing improved forage quality for grazing livestock. Multiple species crops can also be used as a soil biology primer, disease and weed control and carbon building technique. USA

research has also shown including flowering plants in a crop mix will increase insect diversity, which can control insect attack on crops.

Cover cropping can be described as sowing a crop with the main purpose being to prepare the soil for the main crop to be planted the following season. It has been developed to combat some of the problems associated with conventional zero-till cropping techniques like herbicide resistant weeds, declining soil carbon, declining water holding capacity, and poor nutrient cycling.

Cover cropping' had its origin as 'green manuring' which has been an agricultural practice among European farmers for more than two thousand years. Green manuring is the practice of growing a crop specifically to be ploughed into the soil to benefit the following crop with the addition of organic matter and nitrogen to the soil. This very successful custom has become less popular with the advent of artificial nitrogen fertiliser and its practice has almost been discontinued with the development of industrialised agriculture. Interest in green manuring and cover cropping has had resurgence in recent years as fertiliser prices have increased along with a growing awareness of ecological damage chemical fertilisers and agricultural chemicals have on farms and the environment.

Since 2011 Colin Seis has been developing 'Multi-Species Pasture Cropping' with the aim of producing better quality animal forage and improving soil health even more than single species 'pasture cropping' does.

'Multi-Species Pasture Cropping' is 'Pasture Cropping', or sowing crops into perennial pasture/grassland, using two and up to ten species of the annual, crop as a crop mixture. 'Multi-Species Pasture Cropping' uses a group of plant species that produce good quality forage, have a range of different root systems, includes, legume species, flowing plants and species that will add organic matter to the soil surface and in the soil as root mass. The plant mixture also produces a variety of plant root exudates which feed a more diverse range of soil micro-organisms which further enhances soil health and soil carbon. When a multi-species crop is planted into diverse grassland it further encourages more beneficial organisms, has fewer pests and diseases, and more sustained crop yields.
The multi-species crop can also be used as a soil primer for a crop the following season. This can be achieved with the addition of plants intended for this outcome.
The technique has the added advantage of being able to still harvest a grain crop after the multi-species crop is grazed.

The reasons for growing multispecies pasture crops can be very diverse.

Improved grazing benefits

Faster fattening time, faster growth rates, less dietary problems with scouring and bloating, and healthier animals, can be achieved with a more diverse range of plants to choose from.

Interrupt pest and disease life cycles.

The use of multispecies crops, when used in conjunction with 'pasture cropping' can help to interrupt the life cycle of many fungal, bacterial, insect or nematode pests. To interrupt pest life cycles, it is important to select crops of different families so that they do not harbour pests that can negatively impact the crop or pasture that will follow.

Multi- species crops may also attract beneficial organisms that prey upon or parasitize pest species. Some cultivars of brassica crops and pearl millet have been shown to suppress harmful nematode populations.

By including flowering plants in a multispecies crop mix, a more diverse range of insects will be attracted which can, in turn, reduce the numbers of harmful insects. When a diverse range of plants, including cereal crops, flowering plants, legumes and brassica are combined and incorporated with perennial pastures in 'multi-species pasture cropping', it will start to improve the ecology of the whole farm and move the farm closer to functioning as an ecosystem.

Provide weed control.

Several plant combinations can be considered "smother" crops because they are used to control or suppress weeds. Crops that give the best results are those that are quick to germinate, provide rapid ground cover and form thick canopies. These crops compete with weeds for water, sunlight, space, rooting zone and nutrients. Some examples of these crops are Japanese millet, sorghum and brassia

Crops, such as cereal rye, hairy vetch, and brassica are reported to have allelopathic properties. These crops produce compounds when they are growing or decomposing that inhibits germination, especially of weeds that have small seeds.

Nutrients

Deep rooted crops like radish and turnip have the ability to extract nutrients from the deep soil horizons and bring them to the surface, near the root zones of subsequent crops. Some plants are also known for their ability to extract nutrients that are not readily available to other plants. An example of this is the uptake of soil phosphorus by buckwheat and oats.

The addition of legume species like vetch, field pea and cowpea can increase plant available nitrogen through nitrogen fixation and combinations of nitrogen rich vetch and pea with rye, barley or oats can be ‘pasture cropped for maximum cover and biomass, weed suppression, and beneficial habitat. Their balanced carbon-to-nitrogen (C:N) ratio also maximises soil organic matter formation and provides season-long slow-release Nitrogen.

Young, fresh crop materials (including legumes) contain readily available compounds which serve as food for soil micro-organisms. This stimulates soil biological activity and leads to enhanced mineralisation (release of nutrients from decomposing organic matter for plant uptake). Soil biological activity will also make nutrients more readily available for crop uptake.

The properties of the multi-species crop residues are therefore very important as they have a direct influence on the outcome of organic matter decomposition (humification and mineralisation) and other plant nutrition dynamics. Young and succulent crops with a low C:N ratio will feed soil microorganisms, while a mature, fibrous green manure crop such as cereal straw will form stable organic matter but provide less stimulation of soil biological activity. Good ground cover provided by the multi- species crop and perennial grass will not only protect the soil surface but will also favourably impact upon microorganism development in the area located near the roots (rhizosphere). Roots from living crops and grass release compounds (exudates) that sustain and stimulate Mycorrhizal fungi and other microorganisms.

Plant species used.

Both winter multi-species crops and summer multi-species crops can be grown. The groups of plants that are used in a ‘multi-species mix can be cereals, legumes, brassicas flowering plants and many different forbs and herbs. The number and types of plants are almost unlimited but can be from two species to fifteen or more species in a mix, depending on what the grower is trying to achieve.

Winter crops

Cereals

Cereal crops like oats, wheat, triticale and barley are the primary crop species used for winter multi-species crops. They are sown as all ‘pasture crops’ are planted, using ‘pasture

cropping' techniques with a zero till/ direct drill seeders at normal depth of 25mm-50mm and usually into moist soil with appropriated fertiliser application if required.

As with most crops grown as a monoculture, a cereal crop like oats can produce large volumes of forage but it does have its problems. All cereals in the vegetative stage under good growing conditions are highly digestible and often contain 80%–85% moisture (15%–20% dry matter). The resultant scouring is regarded as normal when livestock are grazing on highly digestible, high-moisture, green feed. Adding hay or roughage to the diet is the usual method of combating this problem, but with a 'pasture cropped' paddock that has roughage from dormant perennial pasture this is not usually a problem. Adding multiple species to a forage crop reduces this problem even further by giving the animals a more diverse diet. Similar types of dietary problems can occur when grazing many forage crops as a monoculture. Brassica, when grazed as a single species can cause nitrate poisoning and photosensitisation

Legumes

Legumes like vetch, field pea and lupin for winter crops and cowpeas and lablab for summer crops can be included in the species mix to improve stock feed quality and increase plant available nitrogen for the following crop. The amount of nitrogen produced will depend on the percentage of legumes in the mix and the timing of grazing. Managed well 50% of the nitrogen produced by a multi-species crop can be available to the next crop, and adding a cereal crop with legumes and/or brassicas will help "slow down" the release of the N in the spring making it more slowly released for the following crop or pasture.

Annual vetch

Is excellent stock feed and performs well on a wide range of soils, Vetch can fix over 100 kg of nitrogen / ha and releases about half of it to the following crop or pasture. Vetches also make soil phosphorus (P) more available and provide excellent habitat for beneficial insects that eat or parasitize insect pests.

The soft seeded varieties are more suitable as a forage crop

Field Pea

There are several types of field pea grown in Australia. Dun types are the most common; they usually have purple or faintly pink flowers and

seeds that have yellow cotyledons and mixture of either green or brown seed coats.
A relatively new forage field pea called PBA Hayman is a late flowering and late maturity conventional pea suitable for forage production as a potential alternative to vetch. It is considered a forage only pea, producing small white seed and yielding 30-80% of grain varieties depending on seasonal conditions. Field peas provide substantial benefit like weed management, root and foliar disease management and the addition of nitrogen through nitrogen fixation to the soil.

Brassica

Forage brassica is extremely valuable, high protein, and highly digestible feed source. The are many types of brassica and some of the older varieties like swede, turnip and kale can be used along with the newer grazing varieties that are often a cross between two species.(e.g. Winfred is a cross between turnip and kale.) Some varieties like daikon radish and turnip can be used as "biological sub-soilers". Used strategically, their deep tap roots can break up plough pans and compacted soil horizons and are excellent for improving soil structure. Most brassica is very good at scavenging and conserving soluble soil nitrogen, as well as choking out weeds through rapid canopy closure and root exudates.

Brassica species have no association with Mycorrhizal fungi and used as a single species can have negative effects on soil microbial diversity but when used with a diverse mix of plants they can have a positive influence soil microbiology as well as soil structure and soil health.

Some of the species used for winter multi-species crops

Cereals	Legumes	Brassica	Other
Oats	Field pea	Forage Brassica	Annual ryegrass
Wheat	vetch	Radish	
Barley	Lupin	Turnip	
Triticale	Clover	Swede	
Cereal rye		Kale	

Summer Crops

Where conditions are suitable for growing summer forage crops like millet and cowpeas they can be planted in the same manner as multispecies winter crops.

Where the majority of pasture species are winter growing perennial or annual species a summer forage crop can be sown using the same ‘multispecies pasture cropping’ technique and sown when the ground temperature is around 16-18 degrees Celsius at 9 a.m.

Millet

Millet is an ideal base for a multi-species summer mix, having high heat and drought tolerance and is usually low-cost seed to purchase. It has less dry matter production than forage sorghum but higher quality feed for smaller animals such as sheep. It also has better fattening potential than sorghum but can be more difficult to establish than the larger seeded sorghums. It can be grazed 5 to 7 weeks after sowing but does not stand harsh grazing. There is no prussic acid poisoning risk, but there is a photosensitization risk. Millet can run rapidly to head in hotter weather so grazing management is important. It is frost sensitive, so like most summer forage crops, will not persist into the winter.

There are 3 main varieties of millet:

- Japanese millet from which shirohie has been selected.
- Pearl millet which gives similar production to forage sorghum.
- Pennisetum Millet

Forage sorghum

Is the most productive and fast growing forage and can produce large volumes of feed relatively quickly. It tolerates heat and drought, but requires warm soil.

Forage sorghum gives good weed control through competition and strong allelopathy and its deep fibrous roots are excellent for managing hardpans and poorly structured soil. As a general guide, it can be sown when the threat of frost has gone and soil temperatures have reached at least 16°C at sowing depth at 9 am.

Graze carefully, once the crop is well established, 50 cm high and unstressed. If the crop is stressed, there is a high risk of Prussic acid and/or nitrate poisoning. Forage sorghum can usually be grazed eight weeks after sowing. Most forage sorghum varieties are more suitable for cattle than sheep.

Cowpeas (*Vigna unguiculata*) and lablab (*Lablab purpureus*) are fast growing, annual, summer forage legumes. They are excellent quality crops for fattening both sheep and cattle and can significantly improve soil nitrogen levels by nitrogen fixation. Both cowpeas and lablab are tolerant of drought and heat and do best under warm, humid conditions, with temperatures between 20°C and 30°C. Cowpeas and lablab do very well on a wide variety of soils from light sandy soils through to well-drained, heavier-textured soils, with lablab more suitable for heavy soils.

Cowpea is excellent stock feed and a versatile summer legume that fixes lots of N and provides food and habitat for beneficial insects and suppresses pest nematodes. It also rapidly shades out weeds and is tolerant of hot, dry conditions.
Caloona and Poona are the main forage varieties grown.

Lablab Bean

Is a viny, summer growing annual legume that is excellent stock feed and a good supplier of soil nitrogen.
Rongai and Highworth are the two main commercial forage varieties. Both are very similar in appearance and agronomic performance. Rongai has the longer growing season.

Sowing

Cowpeas and lablab should be sown at a depth of 4 to 6 cm into moist soil with good seed-soil contact when soil temperatures reach a steady 18°C at 9 am. In most districts, these legumes can be sown for forage from mid-October to early January with the earlier sowings usually producing the most feed.

As a monoculture, cowpeas are usually sown at 10 to 14 kg/ha and lablab at 15 to 20 kg/ha with inoculated seed to ensure good nodulation and nitrogen fixation in the soil. These rates could be halved or less when sown as a multispecies mix

Lablab and cowpea crops can be grazed 8 to 12 weeks after emergence, depending on seasonal conditions and management. Crops should be allowed to reach a full canopy and a height of about half a metre before grazing.

Buckwheat

Buckwheat is a broadleaf plant belonging to the Polygonaceae family and bears no relationship to true wheat. Originating in Asia, buckwheat has been grown in Australia since the early 1980s. Buckwheat is a summer growing annual crop. Its short life cycle, rapid canopy closure, and weed suppression make it suitable for a summer mix. Buckwheat makes soil Phosphorus more available. It is also one of the best nectar sources for beneficial insects.

Sunflower (*Helianthus annuus* L.)

Sunflowers are deeply rooted summer growing broad leaf annual plants that are very effective at 'mining' mobile nutrients deep in the soil profile and making them available other plants. That same deep tap root makes it drought tolerant and good at helping to improve soil structure.
Surprisingly sunflowers are reported as being good stock feed with the sunflower head containing the most feed value, followed by the top, middle, and bottom thirds of the stalk.
The flowers are excellent bird and insect attractants.

Forage Brassica

Forage Brassica is an excellent addition to a summer multispecies mix in Southern Australia. It will supply very good stock feed, cycle nutrients and control many weed species.

Some of the species used for summer multi-species crops

Grass	Legume	Broadleaf	Other
	e		
Japanese Millet	Cow Pea	Sunflower	Forage Brassica
Pearl millet	Lab –Lab Bean	Buckwheat	
Pennisetum Millet	Soybean		
Forage Sorghum			
Maize			

The varieties used in a 'multi-species pasture crop' mix will depend on what is trying to be achieved. On poorly structured soil with a hardpan, some brassica species like daikon radish

or turnip could be included to help improve the soil structure. On dysfunctional soil that is lacking nutrients, vetch and field pea can be included for their soil nitrogen benefits. If a grain harvest of oats is required, the addition plants like brassica and field pea that do not recover after 3-4 grazings will allow oats to produce grain without competition.

From my experience, a large range of compatible plants is almost always better than fewer plant species but the type of plant and number of plant species used can depend on the cost of seed.

Sowing mixed species.

Because of the variable size of seed it can be more difficult to sow a mix of seeds than one variety. A method used to achieve this is, the larger, similar size seed like oats, wheat and pea can be sown through a normal seed box. Smaller forage brassica, radish and millet can be sown through a small seed or pasture box by dropping the seed in the drill row and allowing the press wheels to push the seed into the soil.

When sowing with a disc seed drill, all of the seed can be mixed and sown together because a disc drill will not plant too deep.

The rate of each seed variety is usually sown at a lower rate in the mix. E.g. normal oats rate is reduced and most of the other species are sown at half rates or less. If a cereal grain harvest is required plants like forage brassica will require sowing at a lower rate of 1-2 kg/ha to prevent shading of the cereal crop and slowing growth of the cereal and the cereal crop sown at a higher rate.

Grazing Mixed species

From research data and my own experience, sheep and cattle perform better on a mix of forage species when compared to a single species crop. The benefits that I have observed are faster fattening time, faster growth rates and less dietary problems with scouring and bloating.

Grazing a crop consisting of a mix of 5 to 6 species is different to grazing a single species crop because management of the grazing event should focus on the plant that is the slowest grower to allow maximum grazing value from all of the species in the mix. The number of grazing events during the life of the crop could be 3 or 4 depending on rainfall, time of

sowing, the severity of each graze, and whether grain harvested is planned. If grain is not a priority at least one more graze could be achieved.

As with grazing pasture, sufficient plant leaf is required to be left on the plant to allow the plant to recover and grow to optimum height before re-grazing. The second and future grazing events should not be done until all of the species are fully recovered. This could be 3-5 weeks depending on rainfall and the severity of the previous graze.

If a cereal grain harvest is required, plant selection and grazing events need to be carefully managed. The addition of plants like forage brassica and field pea, that will not tolerate as much grazing as oats create the opportunity to purposely graze the brassica and field pea to reduce competition for oats and allow it to make grain.

Weed Control

Weed control with 'multi-species pasture crop' is similar to a 'pasture crop' with a single species such as oats. Grazing of the grassland/pasture is essential pre-sowing.

Livestock are a very important component of 'Pasture Cropping' and 'multi-species pasture cropping'. Large mobs of sheep or cattle (sheep @ 100 – 200 sheep / Ha) are carefully used in a time controlled or rotational grazing method, to manage weeds, create litter and mulch and prepare areas for cropping. Using stock in this manner is not only a very effective weed controller it is also a very efficient method of running stock over the whole farm.

If the height of the perennial grasses is more than 300mm (one foot) they may shade the emerging crop as it germinates. Grazing of the pasture immediately before sowing will prevent shading and the use of animals will create mulch as well as control weeds. The preparation of the paddock in this manner does not have to be performed in one operation. It is often better to use two or three grazing events over a two or three month period.

Using animals to prepare a paddock before sowing will have the following benefits.

1. Control weeds by grazing. (consuming the plants)
2. Create litter and ground cover. This will impede weeds and also improve soil health, reduce soil water evaporation and control water and wind erosion.
3. Supply a pulse of nutrients for the crop from the manure and urine supplied by the stock.
4. The removal of dry plant material by animals and replacing it with manure and urine will help to reduce soil nitrogen depletion. If Animals (cattle or sheep) are not available in large enough numbers or not available at all, slashing (mowing) the area can be a good

option to gain a similar effect, although, without the benefit of manure and urine and the mulching effect of animals, more fertiliser may be required.

Herbicides: Herbicides can be used to control weeds, pre-sowing the crop, but must be used very carefully and selectively. It is important to know which plant a particular herbicide will kill and which plants it will not kill. It should also be assessed whether it is necessary to place controls on a weed at all if it is not going to affect the growth and quality of the crop. Glyphosate (roundup) is usually not recommended or used with 'pasture cropping' because glyphosate will kill many of the perennial species in the pasture. The use of selective herbicides or herbicides like gramoxone can be used because they will control most annual weeds and not kill perennial plants.

The use of herbicides in crop (while the crop is growing) is not an option because it is not possible to control weeds in a diverse multi-species crop without killing many of the crop species. However including species such as some types of brassica will give some weed control, as mentioned above.

Using a multi-species crop as preparation for a cash crop for grain the following season is a good option for. The multispecies crop can be used as a soil primer and will improve the soil structure, make more nutrients available through nitrogen fixation and improved nutrient cycling. The grazing animals will have added nutrients to the area with dung and urine.

Since developing 'Multi-Species Pasture Cropping' Colin Seis has achieved the following results when comparing 'Multi-Species Pasture Cropping' to single species 'Pasture Cropping' on his property Winona. Both crops were sown into native grassland.

'Multi-Species Pasture Cropping' using a mix of oats, forage brassica, annual vetch, and field pea produced:

- Produced better quality stock forage with improved fattening value and superior stock health benefits, than a single species of oats. (*The sheep did not develop scours on a mix of species.)*
- The Multi- species grew better and produced more forage than oats on its own in a dry season.
- The soil structure and water infiltration were improved.
- Fewer weeds. (*This is due to the shading effect and quick canopy closure of the faster-growing brassica species)*

- More beneficial insects observed in the crop.
- After grazing the Multi- species crop, the oats was harvested for grain.

The photos (below) show a mix of oats, forage brassica, vetch, field pea, and clover. (more species would have been better) The mixture was ‘pasture cropped’ into native grassland of about 40-50 species of predominantly warm-season (C4) grass with the addition of 40 kg/ha of DAP (7 kg of N and 7 kg of P /ha)

The aim is multi-use. Stock feed, the mix of crop species with grassland species will drive soil health and nutrient cycling faster, improve soil structure, harvest oat grain, and harvest native grass seed.

Multi-Species crop pre-grazing.

Multi-Species crop on 25th June after 2 grazings.


Above is a Multi-species Pasture Crop sown in early June 2015.

The crop was a mix of:

- 40kg/ha of Yarran oats
- 1.5 kg/ha forage brassica (Winfred)
- 1.5 kg/ha daikon radish.
- .5kg/ha turnip
- 6kg/ha annual vetch.
- 6kg/ha field pea.
- .5 kg/ha arrowleaf clover.

Pre-sowing, the paddock was sprayed with gramoxone at 1.2lt/ha to remove any annual weeds that may affect the crop, but not kill perennial grass.

40kg/ha of MAP was applied with the crop.

The crop was grazed once and sheep removed the first week of August.

The crop was harvested the first week of November, with the aim of harvesting all of the varieties of seed. This was successful with a mix of all species collected.

After rain in December, the brassica species continued to grow, producing good sheep feed until March 2016.

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