CROPQUEST

Oil seed rape: Crop report

Faisal Zahoor, Dermot Forristal, Teagasc, Oak Park , Carlow

Oil seed rape

Quick facts

- Brassica well suited to Irish climate with high seed yield potential of 5-6 tons/ha for winter sown and 3.5- 4 tons/ha for spring sown OSR.
- Grown on approximately 7500 ha in 2015 with an average yield of 4.6 t/ha. across Ireland.
- A good break crop resulting in increased yields (typically up to 1.5t/ha approx.) of the following wheat primarily by reducing incidence of "take-all.
- The oil has many uses including food uses in cooking. We currently import huge quantity of edible oil (>200,000 tonnes). The remaining 'cake' from which the oil is extracted is a high protein animal feed. Current Irish imports of animal protein are > 1.2 Mt annually
- Specific varieties have oil profiles suitable for specific markets Varieties with low erucic and glucosinolate contents including HOLL (high oleic, low linoleic) can be used for food purposes HEAR (high erucic acid rape) varieties are required for industrial use.As a combinable break-crop, it uses the same machinery as cereal production
- Yield variability is considered higher than cereals with some additional production risks.
- Development of this industry requires sustained commitment from all actors to ensure the production, processing and marketing of the crop and its processed products are developed to capture the value of the oil and its protein by-product while production is negligible.

- Research is needed in many areas including agronomy to optimise crop performance, but also variety-specific research targeted at producing quality oils for specific markets.

INTRODUCTION

Crop Description

The brassica rape crop is primarily grown for its oil. Both winter and spring types of swede rape (*Brassica napus*) are most commonly grown in Ireland. Turnip rape (*Brassica rapa*) is grown to a limited extent and current varieties are mainly spring type. OSR is an erect, annual plant with branched stems which can reach up to 1.5 m in height, with a stout taproot sometimes partly swollen. *Brassica napus (swede)* differs in its basal leaves, which are usually less hairy and bluish green (bright green in *Brassica rapa*) and by having leaf scar ridges on the tuber apex. The seeds typically take 8–10 days to emerge at 10–15°C. The cotyledons are followed by a developing rosette of leaves followed by thickening of the lower part of the stem and upper part of the root. *Brassica napus* is generally self-fertile, although insects improve seed setting.

A number of terms are used to describe oilseed rape varieties which can lead to some confusion. Varieties can be classed according to their method of production (conventional and hybrid varieties), chemical characteristics of seed (double low, HEAR, HOLL) or according to their time of sowing, maturity and canopy structure (e.g low biomass). Usually oil yield (yield adjusted for oil content) is the most important factor for variety selection but other characteristics for variety choice are resistance to lodging, earliness of flowering, earliness of maturity, oil content, glucosinolate content and resistance to diseases (HGCA, 2014).

MARKETS

Oilseed rape is a crop with very diverse end-uses (Fig. 1) supporting stable or increasing demand for rape oil. There are potential uses a variety of sectors including: human nutrition; renewable vehicle fuel; environmental friendly lubricating oil; or as raw material in the chemical industry. Furthermore, the residues from oil production are a valuable animal feed providing high energy and protein content.

Summary of oilseed rape use:

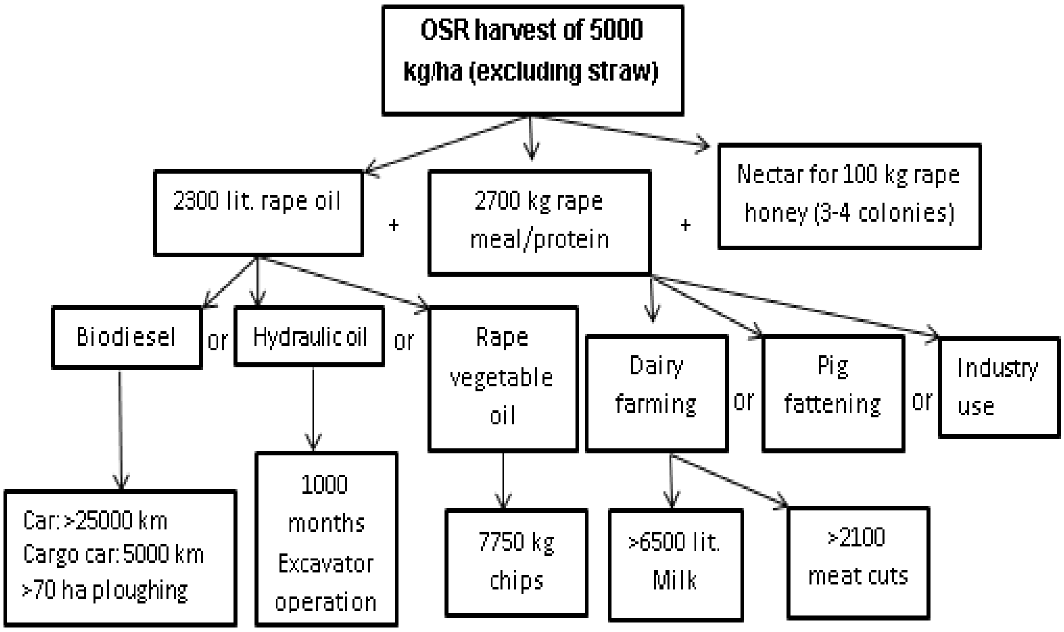

Fig. 1: Examples for possible uses of oilseed rape from a yield of 5 t/ha (A similar sketch was produced by UFOP, 2001)

OSR Products and their markets:

1. OSR oil for human consumption:

In human nutrition plant lipids and seed oils are preferable to animal fats because of their lower contents of cholesterol and their generally high proportions of unsaturated fatty acids of which linoleic acid and linolenic acid are most important (Beringer, 1977). Successful OSR breeding programs have decreased the content of potentially harmful erucic acid in the rape oil from 40% to almost 0%. Over the same period the percentages of the polyunsaturated fatty acids linoleic acid and linolenic acid of the total fatty acids has increased from 15% to 20% and from 8% to 12%, respectively (Trautwein and Erbersdobler, 1997). OSR oil has been shown to be superior to other dietary oils for frying and cooking (Gustafson *et al*., 1993).

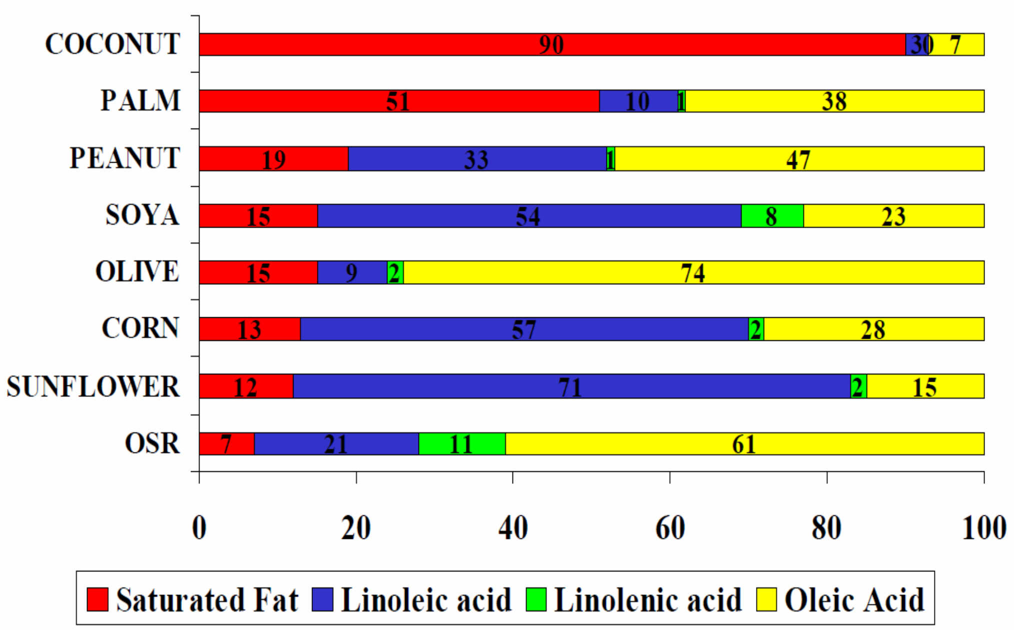

Fig. 2: Fatty acids composition (% from total) of important vegetable fats (HGCA 2014)

In 2013 Ireland imported 201,000 t of vegetable oil for food use, while of its native production of 32,000t of oilseed rape only 2,000t of oil was produced with more than 80% of the OSR exported for processing (FEDIOL, 2013).

The types of OSR used for vegetable oil production are;

a) **Double low or '00' varieties:**

The use of the term 'double-low' refers to erucic acid levels of less than 2% and glucosinolates content of less than 25 micromoles per gram of seed. These are suitable for food and feed use.

b) **High oleic, low linolenic (HOLL) use:**

HOLL oilseed rape oil is a low trans-fat fatty acid and low saturated fat vegetable oil that is stable and performs well at high temperatures making it suitable for certain bulk cooking. Linolenic and linoleic acids are ploy saturated fatty acids which are good for health but are more unstable at high temperatures so to make oils more stable at higher temperatures plant breeders developed HOLL varieties.

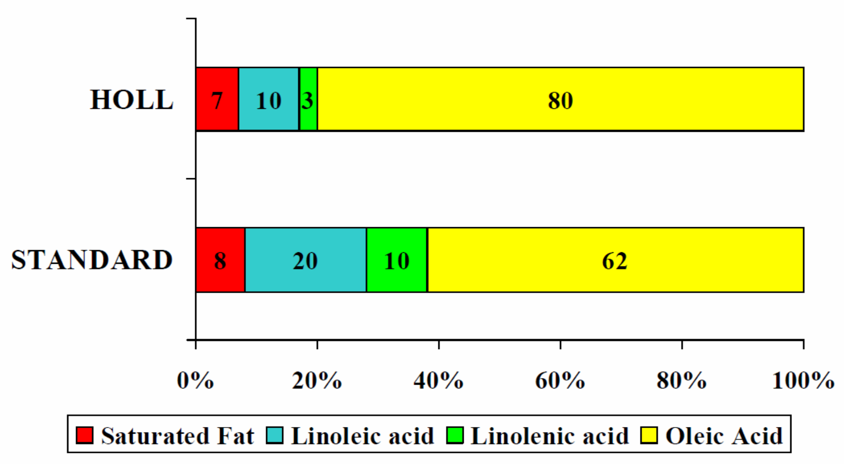

Figure 3: Standard (double low) vs HOLL varieties

2. Rapeseed protein isolate" as a Novel Food ingredient:

The European Food Safety Authority has recently allowed the use of rapeseed protein isolate (IsolexxTM), in a similar way to soya protein: a) as a source of protein, in meal replacements (formula diets), protein drinks (including "dairy analogues"), nutrition bars, soups and soup mixes, breakfast cereals, plant protein products (meat analogues), and b) for improving the texture of, bakery products, chilled or frozen processed meat products (such as patties), pasta, desserts, and other foods and in food supplements.

3. Use as Biofuels

OSR oil is also used for industrial purposes, including biofuels. Current EU goals are for 10% of transport energy to come from renewable sources by 2020. While biofuels can contribute to this target, Irish legislation does not currently support the use of natively produced vegetable oils as biofuels. Consequently the indigenous production of biofuel has ceased.

4. OSR meal in animal nutrition:

The term rape meal (or cake) describes the residue after the extraction of oil from rapeseed. This meal can be used as a high value animal food as it is particularly high in protein content in addition to its energy value. A review of studies carried out from 1976 to 2007 regarding milk production of cows fed on OSR meal compared to soybean meal or cottonseed meal showed a small but significant benefit in using OSR meal as a protein source compared to Soya or Cottonseed where Average Milk Yield (kg/day) was 27.4 versus 26.4 in case of soya or cottonseed meal (Newkirk, 2009).

Although rape meal has lower protein content than soybean meal but it can be satisfactorily used to substitute soya meal. It has a good amino acid balance with higher content of methionine, cystine, and threonine compared to soybean meal (DLGFutterwerttabelle, 1997). OSR meal also hass a higher mineral content (P, Ca, Mg, Mn and Se) and with double-low varieties the past restrictions on inclusion in rations have been eliminated and Europe being deficit in protein feed, demand for oilseed meal will likely to become stronger in future with the price tracking other protein crops. .

Fig. 4. Essential amino acid content (%) of the protein in rape and soybean meal (Bell, 1990)

In 2013 Ireland imported >1.2 million tons of protein meal, while of its native production more than 80% of the OSR was exported for processing abroad (FEDIOL, 2013).

5. Use as Lubricants:

In 2011 the European lubricants market was 7 Mt per annum (Gosalia, 2012) including 3.29 Mt of vehicle lubricants (47%), 3.01 Mt of industrial lubricants (43%), and 0.7 Mt of marine and aviation lubricants (10%). Oilseed rape can be used as a lubricant base.

Advantages of Rapeseed oil as a lubricant

OSR oils have good environmental characteristics. They are inherently biodegradable, of low ecotoxicity and toxicity towards humans, and, as they are derived from renewable resources, they result in no net carbon dioxide contribution to the atmosphere.

Natural properties which favour rapeseed oil as a lubricant

- The viscosity index is high
- Endures mechanical stresses well
- Low friction coefficient
- Good adhering characteristics to metal.
- They remain liquid even at temperatures less than -35ºC

Disadvantages:

- High price.
- Use at>100ºC challenging even with additives.
- Reduction in the efficiency of oil immersed brakes
- Staining

Oils with very high oleic levels are beginning to find uses where high oxidative stability is required.

6. Use for surface coating:

Vegetable oils are used in printing inks because they are environmentally friendly, less toxic and easier to remove than traditional petroleum based inks. The ease of de-inking is becoming more important as more paper is re cycled. Although the majority of conventional printing inks are soy-based, between 1,000t and 2,000t of OSR oil is included in printing inks in the UK annually to supply a limited demand for 'ecologically responsible inks' ((S. P. Curruthers *et al* 1995),

7. Oil derived polymers:

Whilst the majority of polymers are derived from petroleum, certain products are based upon, or incorporate vegetable oil-based derivatives. These include:

Functional additives

Rapeseed oil derivatives are used as slip, anti-block, anti-static and plasticizing agents, as stabilizers and processing aids and as flame retardants in the manufacture of plastics. Erucamide, which is derived from HEAR oil is used as a slip agent to prevent adhesion in polythene film. HEAR oil has unique properties which make it suitable Erucamide base. HEAR oil is also used in printing inks, lubricants and has a range of other applications.

Direct production of polymers Polymers can be derived from plants via bacterial fermentation of carbohydrate feedstock from double low (00) varieties. Also, rapeseed oils can be used as reactive agents in the manufacture of polyamides, polyesters and polyurethanes.

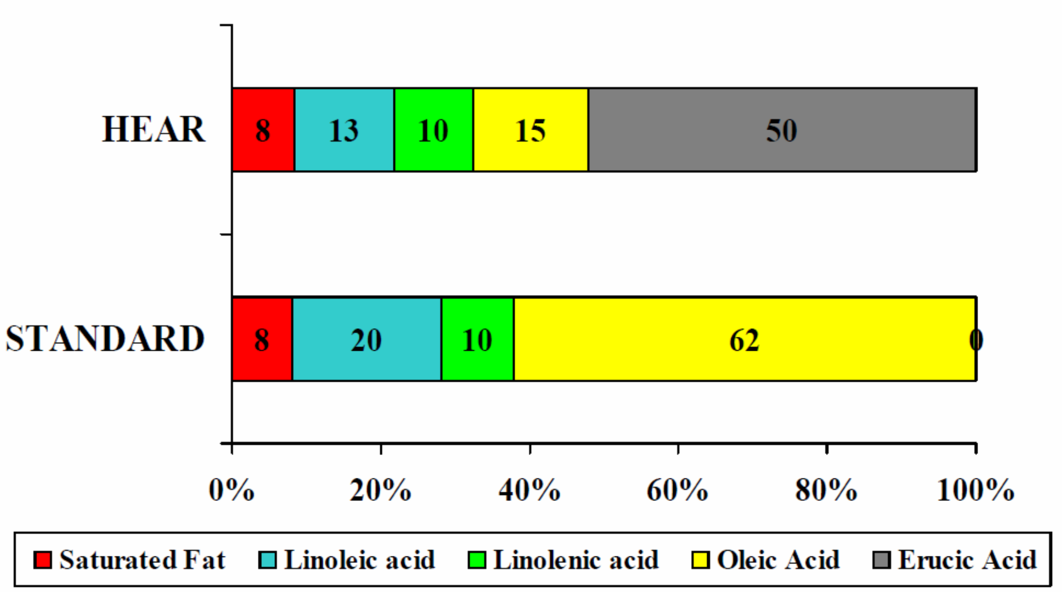

Figure 5: Standard (double low) vs HEAR varieties (used as functional additives)

8. Derivatives of OSR meal proteins

Potential non-food applications for OSR meal proteins can be bioplastics, coatings, glue, adhesive, paper and emulsifier (Antonini. et.al. 1999). Although their current usage is small, but their potential is significant.

- **Bioplastics**

  OSR proteins have thermoplastic and biodegradability properties that suit bioplastic production. However, starch derived plastics while not superior are less expensive to produce (Mohanty, 2004)

- **Adhesives**

  Isolates from OSR meal protein show high solubility in water making them highly applicable to adhesive formulations.

- **Cosmetics**

  Plant proteins can be used in cosmetic manufacture to improve stability. While the market is very small, there is high added-value potential.

- **Encapsulation agents**

  Plant proteins have promising applications as controlled release encapsulation agents for pharmaceuticals, agrochemicals and flavours.

9. Lawn care products

Trials of a rape meal based fertiliser as a lawn care product have shown effects in terms of grass colour, growth and moss reduction. (P A Wallace et al, Levington: HGCA, 1999)

10. Combustion material

The main thermic characteristics of rapeseed meal allow its utilisation as a material for combustion. Its heat output is approximately equivalent to that of charcoal and better than half of the heat output of kerosene oil.

Table 1 Energy Value of Straw per tonne at 15% Moisture

Material	Calorific Value (Mj/kg)	Energy Content (kWh)/tonne	Heating Oil Eq. (Litres)	Ash content kg/ton
Rape straw	14.3	4004	393	62

Source: Teagasc, 2010

11. Potential use in Health/Medicine:

Several of the glucosinolate compounds in oilseed rape have been found to have some cancer-preventative properties. This may offer some scope for development in the future.

10. Markets for Rapeseed Straw

Straw produced from oilseed rape can be used for animal bedding; for feed, or for combustion. As a source of fibre for industrial use, it is inferior to crops such as flax, hemp or linseed, but superior to cereal straw (and therefore suitable for some low-grade uses).

SUITABILITY FOR IRELAND

- The Irish climate is suitable for OSR. Milder winters allow the growth of winter varieties of rape (WOSR), which usually have long vegetation period and are sown from mid-August to mid-September. Spring rape can be sown from early march to late April.
- The optimal temperature for germination of WOSR is +15 ° C. If the soil temperature is > 15°C and soil moisture is sufficient, seeds germinate in 3-4 days. OSR starts germination at +3 ° C but germination under 10 ° C is slow. However, oilseed rape is generally sown from Mid-August till early September when, temperatures is around 15 15 ºC.
- Severe frosts can kill seedlings from late emerged crops impacting on spring plant numbers. (McWilliam 1998).
- WOSR is a 'long-day' plant. It requires 90 degree days for germination and 140 degree days for one pair of leaves. Plant development has been shown to be strongly influenced by sowing date, with both the time of floral initiation and the start of flowering being affected. The vegetation period of winter OSR is 210 days while spring oil seed rape is 100 days. WOSR with harvest in late July / early August has a greater yield potential than the shorter growing season spring rape which is harvested in late August or more typically September by earlier sowing (Evans and Ludeke 1987).
- While In Ireland plough–based establishment are most commonly used, the crop can be established by a range of less intensive tillage systems. Uncompact soils with good fertility are desirable for OSR. While rape will grow on free draining soils of textures ranging from sandy loams (light) to clay

loams (heavy tillage soil), moisture may be limiting on lighter soils at sowing but particularly post flowering. The optimal pH is 6.2-7.5.

- Other details of establishment in term of weed, pest and disease control and harvesting are provided in production technology section of the report.

ROTATION/BREAK CROP BENEFITS

Yield and economic benefits

- OSR is a good break crop resulting in increased yields of the following wheat by reducing incidence of 'take-all' fungus.
- Field trials in Ireland showed that wheat grown in a break crop rotation yielded 0.9t/ha (10%) more than continuous wheat, however the benefits of the break crop were greater where lower levels of nitrogen and other inputs were used. Other benefits such as spreading the workload, soil structure benefits, and the ability to control difficult grass weeds in winter oil seed rape (WOSR) are also of value (Forristal and Grant (2011).
- In northern Europe, long-term experiments indicated 10-26% increases in yield of wheat grown in rotation with brassicas compared to wheat monoculture, or wheat in rotation with other cereals such as barley, oats or rye (Schonhammer and Fischbeck 1987; Christen et al. 1992). Yield increase in wheat following OSR has also been associated with better rooting and increased extraction of water and N by the wheat (Angus et al. 1991).

Disease Control

- ***OSR could help in increasing the yield through controlling take-all fungus (Teagasc, 2009)***
- In our conditions, the primary effect of a break-crop is the reduction of take-all (*Gaemannomyces* graminis) root infection in the following crop (Christen et al., 1992). Wheat yield increased by 20-30% after oilseed rape when disease is a limiting factor (Kirkegaard et al., 2008).
- The value of break crops depend on the diseases present in particular cropping systems, the host status of the proposed break crop, and the

availability of other strategies such as tolerance, resistance or chemical control (Kirkegaard et al., 2008).

- There are also some indications that break crops may control disease by mechanisms other than non-hosting (Kirkegaard et al., 2008). Superior wheat growth following brassica break crops compared with other broad leaf break crops (Angus et al., 1991 and Kirkegaard et al., 1994).

Soil Structure

- *Strong rooting break crops like oilseed rape can improve soil structure benefitting subsequent crops in the rotation.*
- The deep penetrating tap root of OSR plants can improve soil structure and consequently the environment (Kirkegaard et al. 2008). Wheat crops growing after brassicas can extract more water and mineral nitrogen from the soil than wheat after wheat (Angus et al. 1991; Kirkegaard et al. 1994).
- Chan and Heenan (1996) reported soil following rape and lupin was more porous, had lower soil strength and had stronger, more stable aggregates than soil after barley, and the improvements related to the impacts of roots on soil aggregate formation and macro-pore creation.
- In long term studies in Germany higher yield in wheat following rape has been linked to improved root density and penetration associated with improvements in soil structure including aggregate stability and porosity, (Scho¨nhammer and Fischbeck, 1987).
- Investigations of biopores in soils under no-till OSR-wheat systems reveal the longevity and close association of previous root systems and their associated organisms with roots of current crops which can influence plant growth. (Watt et al., 2005)

Weed Control

- The inclusion of break crops in a rotation allows the good weed control options for challenging grass weeds such as black-grass, bromes and rye-grass (Ballingall, 2012) (Teagasc, 2009). By allowing integrated weed management options the inclusion of break crops within rotations can help reduce the risk of herbicide resistance. (DAF, 2011).

- Stevenson and van Kessel (1996) found significant increase in wheat yield benefit from a preceding break crop came from reduced leaf disease and weed infestation

Environmental Benefits

- Due to its early autumn establishment WOSR can take up considerable quantities of nitrogen and reduce nitrate leaching risk. In addition good plant ground cover reduces the risk of surface runoff and soil erosion over winter, thereby reducing pollution by sediment, phosphorus, and other pollutants. The early harvest of oilseed rape permits early establishment of a following crop.
- OSR provides nesting sites for birds such as reed bunting, pollen for bees and a food source and habitat for a range of wildlife (Susan and James, 2009).
- Deeper and healthier root systems of more vigorous wheat crops following break crops use around 20–30 mm more water and 30–40 kg/ha N from the subsoil below 1 m, reducing the risk of deep drainage and N leaching improving efficiency of fertiliser nitrogen use (Kirkegaard et al., 1994; Angus et al., 2011).

RESEARCH AND DEVELOPMENT STATUS

Breeding:

Yield improvement is a key breeding objective targeted by;

- Developing genotypes with high harvest index, primary and secondary branching and pod number.
- Identify combinations of genetics, husbandry and climate to maximise the traits that impact on yield, lodging and resource use efficiency.
- Develop improved varieties with key traits such as:
    - Disease resistance
    - Lodging resistance
    - Lower seed shedding losses
    - Oil yield

- Develop varieties with specific fatty acid profiles to suit a range of end-uses from healthier food oils to industrial applications.

Crop establishment: The ability of OSR to produce acceptable yield potential from variable establishment rates indicates that there is scope for optimising crop establishment systems to reduce costs. Current research is focussed on low soil disturbance systems including wide row spacing and some work on optimising N management for different establishment systems (Forristal 2015, personal communication). In future there is a need to optimise management systems for crops established differently.

Crop nutrition and growth management: UK research would suggest that too large a canopy will result in sub-optimal yield. In Ireland, growers like to produce a dense canopy that will withstand pest attack mid-winter. Consequently there is a need to optimise management for different post winter crop structures. This would include determining appropriate crop measures on which to base management and better understand of how N rate, timing and growth regulators impact on crop canopy and yield formation.

- Precision farming techniques and technologies as they have the potential to improve the timeliness and targeting of inputs or operations.

Pest, disease & weed control:

In our climate there is an urgent need to:

- Determine the role of key diseases (phoma stem canker, light leaf spot, sclerotinia, alternaria) in limiting OSR yield potential.
- Develop better monitoring and decision support systems and link with varietal resistance to improve targeting and timing of fungicides.
- Develop improved weed control strategies that provide cost effective weed control for different weed challenges.

BRIEF PRODUCTION GUIDELINES

These production guidelines are not intended to be a comprehensive production manual for growers but rather a limited source of information

Types of Oilseed rape and variety selection:

Oilseed rape and varieties in particular can be classified in a number of ways:

Oilseed rape type:

- Swede rape (Brassica napus) is the more common type grown in Ireland as either a spring or winter type.
- Turnip rape (Brassica rapa) can be grown in Ireland (usually as a spring variety) but market requirements would need to be checked.

Classification of OSR varieties:

1. Method of production

- **Conventional open-pollinated varieties** (also known as pure or in-bred lines) are quite commonly produced and seed can be easily propagated.
- **Hybrid-types** where the final variety is produced from a field cross of male and female plants.. Hybrid seed is more expensive, consequently lower seed rates may be recommended but claimed vigour difference are frequently not seen

2. On the basis of fatty acid profile & chemical characteristics

- **Double low** or '00' varieties have low erucic and glucosinolate contents necessary for food/feed use.
- **HEAR (high erucic acid rape)** varieties have high levels of erucic acid required for some industrial uses
- **HOLL (high oleic, low linoleic)** are low trans-fat varieties suitable for large-scale cooking.

Crop establishment

- Winter OSR should be sown from mid-August (north) up to mid-September (south). Typical seed rates would be 40-60 seed/m^2
- A fine, firm, level seedbed is ideal with seeding to 15mm depth.
- Plough-based establishment with subsequent sowing at 125mm row spacing is satisfactory but there is scope to reduce cost and save time by using reduced tillage systems such as min-till or shallow subsoiling (600mm row spacing).

- Spring OSR can be sown from early march to late April. While early sowing can give greater yield potential, the rapid growth of an early April sown crop can help reduce weed competition.

Crop Nutrition

- P and K should be applied based on soil testing. N requirement can be based on N index but is better applied on a canopy management approach where crop demand is estimated from canopy growth in the spring.
- Sulphur is also required for OSR.

Main Diseases of OSR and their control

OSR is subject to a number of important fungal diseases which seriously threaten production in Irish conditions.

- **Light leaf spot:** Autumn and spring foliar disease capable of damaging flowering with a 50% potential yield loss. Control options include fungicide sprays in autumn and spring and use of less susceptible varieties
- **Phoma (Stem canker):** Disease starting on leaves leading to stem canker and yield losses of up to 25% controlled by fungicide use in autumn and spring and use of less susceptible varieties.
- **Sclerotinia:** Symptoms of this disease may appear when petals are falling and petal fall on the stem can incubate the fungus. Above average temperatures and showery conditions can aggravate the situation. A good rotation could help in minimizing the outbreak.
- **Alternaria:** This incidence of this disease occurs mostly if summer is very wet and its occurrence can lead to 50% yield loses through pod shattering. Fungicides applied mid to late flowering effect control.
- **Damping off:** Damping off of seedlings is caused by various soil-borne fungi. Losses are usually small but seed treatments give some control.
- **Clubroot:** This disease is particularly prevalent in short rotations It is worse in acidic soils and is more severe in warm wet autumns and springs Lengthening rotations will control clubroot.

Weed Control

- Broad leaved weed control with OSR is challenging as herbicide options limited and the crop is very vulnerable to competition from early established weeds.
- Broad leaved weed control is best achieved with a pre-emergence application of Metazchlor based products with limited post emergence options also possible.
- Graminicides will successfully control grass weeds and volunteer cereals.

Pests:

OSR is prone to losses caused by a number of pests

- Slugs can cause considerable loss prior to or at emergence and need to be controlled by combining cultural methods with molluscides
- Pigeon grazing while tolerable in advanced crops, can cause yield loss in thin crops or if late severe grazing occurs.
- Cabbage stem flea beetles are now a considerable threat with the ban on the use of effective neo-nicotinoid seed dressings.
- Pollen beetles can also cause losses but mainly to spring sown crops. Other pests include cabbage seed weevil, cabbage aphid, and peach potato aphid

Harvesting

Oilseed rape tends to ripen unevenly and winter sown crops are usually dessicated (glyphosate or diquat) or occasionally swathed (windy areas) prior to combine harvesting. Spring sown OSR is frequently harvested directly. Combines need to be carefully set to avoid losses of the tiny seed. Side knives and header extensions can reduce harvesting losses.

Storage

- OSR seed is subject to losses from storage fungi and mites.

OSR needs to be dried to 7.5- 8% MC and quickly cooled to prevent storage losses. As resistance to airflow is different to cereals, storage height and duct spacing needs to be modified.

SWOT ANALYSIS

Strengths

- Potentially good long term demand for the crop based on increasing demand for oil and protein, and to a lesser extent speciality oils. Like all farm produced arable crops, uncontrollable changes in world supply will cause price volatility
- High yield potential in our climate. Yield potential of 5-6 tons/ha for winter sown OSR and 3.5- 4 tons/ha for spring sown OSR.
- Good break-crop for cereals allowing greater area of profitable 'first' cereals to be produced and difficult grass weeds to be controlled.
- As a combinable break-crop, it uses the same machinery as cereal production decreasing production costs.
- Good management can allow for reduced production costs through accurate targeting of fertilisers, and optimising establishment systems.
- Crop can be grown for a range of industrial and food grade markets.

Weaknesses

- Limited research and technology support specific to our soils and climate.
- Yield variability is considered higher than cereals with some additional production risks.
- Oilseed rape is still a relatively minor crop that will require sustained support from all sectors in the industry to ensure it reaches stable production levels.
- Lack of support for rape oil utilization means that the bulk of the crop must be exported for crushing.
- There is incomplete information on the use of its protein cake by-product for animal feed and its associated dietary limitations.
- The quality market at the moment for rape products is relatively small.
- It has a high production cost and profitability is influenced by high fertilizer prices. Yield potential may be reduced as production volume increases and disease losses increase.

Opportunities

- Research would help us capitalise on the high yield potential of rape., in our climate
- We have a lot of suitable sites that can be used to ensure the purity of some new food grade alternatives.
- Further development of this industry would require sustained commitment from many sectors plus incentives to have the crop crushed at home so that the protein cake remains in Ireland.
- Rape can provide a very attractive break crop to enhance the production opportunities for cereals.
- There is a potential quality market based on products for human consumption and other niche uses. Rape oil has the least saturated fat of any common edible oil almost half that of olive oil and is free of *trans*-fat and cholesterol. It is high in healthy mono-unsaturated fat.
- Rapeseed protein isolates (IsolexxTM); can now be used similar to soya protein isolates in food products with a potentially huge range of applications.
- Our green image can be harnessed to help market food grade cooking oils even in other countries.
- Potential but realistic figure in terms of additional market, value and extra area required for oilseed rape are summarised in the following table taken from Tillage Sector Development Plan (2012) that identified profitable opportunities for increased markets that exits for tillage sector. But it depends primarily on the development effort by the industry, but also on unpredicted market changes and competition for land resources.

Table 3: Summary of Growth Opportunities for Oilseed Rape in Ireland

Opportunity	Additional Market (000 tonnes)	Additional Value (Million €)	Additional Area (ha)
Food	39	11.7	7800 ha
Crushing	216	64.8	44,000 ha

Price: OSR € 300 *Source: Tillage sector development plan, 2012*

Threats

- Volatile market prices, as all vegetable oil sources compete in the same market and are influenced by energy prices.

- Failure to develop lucrative potential high-value food grade speciality oil markets.
- High yields may prove difficult to sustain as the crop increases in popularity and sources of disease infection become closer. Our lack of relevant research /development for Irish conditions.
- All sectors may not commit to the increased production and utilization of oilseed rape products.
- Increasing input costs such as fertilizer, chemicals fuel and land would reduce profitability.
- Inadequate crushing capacity would result in continued exports and the loss of some of the net benefit of the crop to the producer and the country.

REFERENCES

Angus, J. F, van Herwaarden, A. F., and Howe, G. N. (1991). Productivity and break crop effects of winter-growing oilseeds. *Aust.* J. *Exp. Agric.* 31, 669-77.

Angus, J., John Kirkegaard, Mark Peoples, Megan Ryan, Lars Ohlander and Louise Hufton. 2011. A review of break-crop benefits of brassicas. 17th Australian Research Assembly on Brassicas (ARAB), Wagga Wagga August 2011.

G. Antonini, P. Burghart, L Champolivier, J. Evrard, J. Gueguen. 1999. Evaluation of

non-food utilisation of rapeseed meal. New Horizons for an old crop. Proceedings of the 10th International Rapeseed congress, Canberra Australia.

BAER, A. & FRAUEN, M. (2003). Yield response of winter oilseed rape hybrids to sowing date, sowing density, nitrogen supply and triazol input. In Proceedings of the 11th International Rapeseed Congress, Volume 3 (Ed. H. Sprensen), pp. 887–889. Copenhagen, Denmark: The Royal Veterinary and Agricultural University.

Ballingall, M. (2012). Weed control management options in winter rape. Technical Note TN647. SAC Consulting, Sandpiper House, Inveralmond Industrial Estate, Perth PH1 3EE

Beringer, H. (1977): Effects of temperature on the synthesis of essential fatty acids and vitamin E in oil crops. Proc. of the 13th Colloquium of IPI in York, UK.

Berry P, Foulkes J, Carvalho P, Teakle G, White P, White C, Roques S. 2011. Breeding oilseed rape with a low requirement for nitrogen fertiliser. HGCA Final Project Report 479.

Berry PM, Kindred DR, and Paveley ND (2008). Quantifying the effects of fungicides and disease resistance on greenhouse gas emissions associated with wheat production. Plant Pathology Doi: 10.1111/j.1365-3059.2008.01899.x

Berry, P. M. and Spink, J. H., 2006. A physiological analysis of oilseed rape yields : Past and future. Journal of Agricultural Science (2006), 144, 381–392.

Blake J J, Spink J H. 2005. Variability of rooting in oilseed rape. Aspects of Applied Biology 73, Roots and the Soil Environment II, pp 195-198.

Bolland MDA, Gilkes RJ (1998) The chemistry and agronomic effectiveness of phosphorus fertilizers. In 'Nutrient use in crop production' (Ed. Z Rengel), pp 139-163. (The Haworth Press: New York).

BOOTH, E. J., BINGHAM, I., SUTHERLAND, K. G., ALLCROFT, D., ROBERTS, A., ELCOCK, S. & TURNER, J. (2005). Evaluation of Factors Affecting Yield Improvements in Oilseed Rape. HGCA Research Review No. 53. London: Home-Grown Cereals Authority.

Brennan, R.F., Bolland, M.D.A., Bowden, J.W., 2004. Potassium deficiency, and molybdenum deficiency and aluminium toxicity due to soil acidification have become problems for cropping sandy soils in south-western Australia. Aust. J. Exp. Agric. 44, 1031–1039.

Chalk, P.M., 1998. Dynamics of biologically fixed N in legume-cereal rotations: a review. Aust. J. Agric. Res. 49, 303–316.

Chan, K.Y., Heenan, D.P., 1996. The influence of crop rotation on soil structure and soil physical properties under conventional tillage. Soil Till. Res. 37, 113–125.

Christen, O., Sieling, K., and Hanus, H. (1992). The effect of different preceding crops on the development, growth and yield of winter wheat. Eur. J. Agron. 1, 21-8.

Cook, R.J., 1986. Interrelationships of plant health and the sustainability of agriculture, with special reference to plant diseases. Am. J. Altern. Agric. 1, 19–24.

DAF. 2011. The value of break crops in weed management. Bulletin 4822. Department of Agriculture and Food. Govt. of Westren Australia.

DSV. 2012. Establishing Oilseed Rape in Adverse Weather Conditions. Technical update. DSV United Kingdom Ltd.

Evans E.J. and Ludeke F. (1987) Effect of sowing date on the flower and pod development of four winter oilseed rape cultivars. Tests of Agrochemicals and Cultivars 8, (1987) Ann. Appl. Biol. 110 (supplement).

FEDIOL. 2013. http://www.fediol.be/

Hess L. 2012. Assessing the drought risk of oilseed rape to target future improvements to root systems. HGCA PhD Summary Report 20.

HGCA. 2014. Oilseed rape guide. Agriculture and Horticulture Development Board, UK

Hocking, P.J., 2001. Organic acids exuded from roots in phosphorus uptake and aluminium tolerance of plants in acid soils. Adv. Agron. 74, 63–97.

Hocking, P.J., Randall, P.J., 2001. Better growth and phosphorus nutrition of sorghum and wheat following organic acid secreting crops. In: Horst, W.J., et al. (Eds.), Proceedings of the 14th International Plant Nutrition Colloquium Germany. Kluwer Academic Publishers, Dordrecht, The Netherlands, pp. 548–549.

Johnston, A.M., Tanaka, D.L., Miller, P.R., Brandt, S.A., Nielsen, D.C., Lafond, G.P., Riveland, N.R., 2002. Oilseed crops for semi-arid cropping systems in the northern Great Plains. Agron. J. 94, 231–240.

Kay, B.D., 1990. Rates of change of soil structure under different cropping systems. Adv. Soil Sci. 12, 1–52.

Kightley S P J. 2010. Variety responses to nitrogen application rates in oilseed rape. Aspects of applied Biology 105, 201-206.

Kirkegaard JA, Hocking PJ, Angus JF, Howe GN, Gardner PA, 1997. Comparison of canola, indian mustard and linola in two contrasting environments. II. Break-crop and nitrogen effects on subsequent wheat crops. Field Crops Research 52, 179-91.

Kirkegaard, J. A., Gardner, P. A., Angu, J. F., and E. Koetz. (1994). Effect of Brassica Break Crops on the Growth and Yield of Wheat. Aust. J. Agric. Res., 1994, 45, 529-45

Kirkegaard, J.A., G.N. Howe and P.M. Mele, 1999: Enhanced accumulation of mineral-N following canola. Aust. J. Exper. Agric. 39, 587–593.

Kirkegaard, J.A., O. Christen, J. Krupinsky and D.B. Layzell, 2008: Break crop benefits in temperate wheat production. Field Crops Res. 107, 185-195.

Kirkegaard, J.A., P.A. Gardner, J.F. Angus and E. Koetz, 1994: Effect of Brassica break crops on the growth and yield of wheat. Aust. J. Agric. Res. 45, 529-545.

Lawes,R. A., V. V. S. R. Gupta, J. A. Kirkegaard, and D. K. Roget. 2013. Evaluating the contribution of take-all control to the break-crop effect in wheat. Crop & Pasture Science, 2013, 64, 563–572

McWilliam, S.C., Stokes, D.T., and Scott, R.K. (1998). Establishment of oilseed rape: the influence of physical characteristics of seedbeds and weather on germination, emergence and seedling survival. Project Report No. OS31, Home-Grown cereals Authority, London.

A. K. Mohantya, b, M. Misraa, b, G. Hinrichsen, Biofibres, biodegradable polymers
and biocomposites. Technical University of Berlin, Institute of Nonmetallic Materials,
Polymer Physics, Englische Str. 20, D-10587 Berlin, Germany
(Received: September 27, 1999; revised: March 2, 2000)
(Mohanty, 2004)

MORRIS, J., AUDESLEY, E., WRIGHT, I. A., MCLEOD, J., PEARN, K., ANGUS, A. & RICKARD, S. (2005). Agricultural Futures and Implications for the Environment. Main Report. Defra Research Project IS0209. Bedford: Cranfield University.

Newkirk, Rex. 2009. CANOLA MEAL Feed Industry Guide 4th Edition, Canadian International Grains Institute, Canada

Prospects for Agricultural Markets and Income in the EU 2013-2023. 2013. Agri. And Rural Devl. Section EU.

Purvis, C. E. (1990). Differential response of wheat to retained crop stubbles. I. Effect of stubble type and degree of decomposition. Aust. J. Agric. Res. 41, 225-42.

Ryan, M.H., J.A. Kirkegaard and J.F. Angus, 2006: Brassica crops stimulate soil mineral N accumulation. Aust. J. Soil Res. 44, 367-377.

SAUZET, G., REAU, R. & PALLEAU, J. (2003). Evaluation of oilseed rape crop managements with minimum tillage. In Proceedings of the 11th International Rapeseed Congress, Volume 3 (Ed. H. Sprensen), pp. 863–864. Copenhagen, Denmark: The Royal Veterinary and Agricultural University.

Scho¨nhammer, A., Fischbeck, G., 1987. Investigations on cereal crop rotations and monocultures. III. Changes in soil properties. Bayerisches Landwirt. Jahrb. 64, 681–694.

Schonhammer, A., and Fischbeck, G. (1987). Untersuchungen an getreidereichen Fruchtfolgen und GetreidemonoKulturen. I. Die Differenzierung der Ertragsleistung und deren strukturim Verlauf von es Versuchsjahren. Bayr. Landwirtsch. Jahrb. 64, 175-91.

Seymour, M., John A. Kirkegaard , Mark B. Peoples, Peter F. White and Robert J. French. 2012. Break-crop benefits to wheat in Western Australia – insights from over three decades of research. Crop & Pasture Science, 2012, 63, 1–16

SPINK, J.H. & BERRY, P. M. (2005). Yield of UK oilseed rape: physiological and technological constraints, and expectations of progress to 2010. In Proceedings of the 61st Easter School, pp. 311–334. Nottingham, UK: University of Nottingham Press.

Stevenson, F.C., van Kessel, C., 1996. A landscape-scale assessment of the nitrogen and non-nitrogen rotation benefits of pea. Soil Sci. Soc. Am. J. 60, 1797–1805.

Susan T., J. Clarke. 2009. Future of UK winter oilseed rape production. ADAS UK Ltd

Tanaka, D.L., Bauer, A., Black, A.L., 1997. Annual legume cover crops in spring wheatfallow systems. J. Prod. Agric. 10, 251–255.

Teagasc. 2006. Winter oilseed rape. Fact sheet. Tillage Specialists

UFOP (Union zur Förderung von Öl- und Proteinpflanzen e.V.) (2001): Bericht 2000/2001, Juli. IPI Bulletin No. 16. Fertilizing for High Yield and Quality Oilseed Rape. International Potash Institute, Switzerland. Pp: 13

United oilseed. 2013. Growing oilseed. Spring Edition. UK

Watt, M., Kirkegaard, J.A., Passioura, J.B., 2006. Rhizosphere biology and crop productivity: a review. Aust. J. Soil Res. 44, 299–317.

Watt, M., Kirkegaard, J.A., Rebetzke, G.J., 2005. A wheat genotype developed for rapid leaf growth copes well with the physical and biological constraints of unploughed soil. Funct. Plant Biol. 32, 695–706.