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Winter Oilseed Crop Canola in the Age of Fast Changing Climate

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Abstract

Canola is today the most widely cultivated Brassicaceae family crop species. Rape (canola) oil was a source of oil for lighting purposes in ancient times. Canola is now the second common oilseed crop in the world with greater than 12% of the world oil supply. The protein quantity and quality, and overall nutrient content of canola is quite good. Global demand for protein sources for human and animal consumption is rising with rapidly growing world population. Plant proteins are a good source for food processing as an alternative to animal proteins. Canola meal has a big potential to be used as a high protein food ingredient. Canola meal is the biodiesel industry byproduct and is abundant in major producing countries. During extracting canola oil, big quantities of meal are produced. Effect of climate change on agriculture or more specifically canola and its multidimensional bitoic and abiotic relations may sharply reduce global canola production especially in vulnerable regions. Climate change is influencing the growth period of the crops, crop growth, photosynthesis an dother importan tmetabolisms of plants, arable land acreages, soil fertility and incidence of biotic factors (pests, diseases and weeds). Forest fires in the cold country Canada, where canola production is top in the world, may be a sign to us that 18,6 million tons of canola production on 8,3 million ha area may be under a threat. This which may effect trade, indstry and consumption of a major oilseed product. Oilseeds are an important backbone in global agricultural commodity trade and economy of countries. Canola has high oil content used as a food and fuel source and its oil process co-product meal is high in protein as a feed. Here in this review some aspects related to importance of seeds of canola and canola crop responce to selected stress factors are given below.

Keywords: Canola, rapeseed, Brassica napus, utilisation, stress

INTRODUCTION

Diets based on canola (*Brassica napus*) oil reduce the levels of plasma cholesterol in comparison with saturated fatty acids containing diets (Lin et al., 2013). Crude oil of canola is mainly composed of triacylglycerols but contains also significant amounts of other minor components. Refining applications remove undesirable minor compounds but this can also significantly reduce desirable health promoting trace components of oil (Ghazani & Marangoni, 2013). Different than normal canola oil, “greenseed canola oil” is a low grade oil. Its color is green due to high chlorophyll content. Greenseed canola oil is a “waste product” and is not edible (Issariyakul & Dalai, 2010). Triacylglycerols are oils abundant in many crops (Kubatova et al., 2011), microorganisms (algae and bacteria) and animals (fats). The diversity of these compounds may be an attractive alternative to crude oil, fuels and certain industrial chemicals (carbon chain lengths from C_7 to C_{15}) (Luo et al., 2010). Canola is among first crops which are genetically modified (GM) and commercial production of its GM cultivars are at very high levels (Maheshwari et al., 2011). A concern related to release of genetically modified crops is transfer of GM traits to native species via hybridization (Schafer et al., 2011).

Canola as a protein source

Co-product of canola oil extraction is a valuable protein rich meal. Seed storage proteins (cruciferin and napin) are major proteins of canola. Others are lipid transfer proteins, oleosins and other minor proteins. Protein content of oil free canola meal is 36–40% on dry weight. Meal also contain fibre, phytates, polymeric phenolics and sinapine. Separation of proteins from these non-protein components is hard but necessary for full nutritional and functional proteins (Wanasundara et al., 2016). Canola meal is a protein sources used in dairy rations which may replace soybean meal (Maxin et al., 2013). Canola protein isolate amino acid profile is well balanced and has functional properties such as foaming, emulsifying and gelling abilities to use for human food (Tan et al., 2011). Storage proteins of canola has many nutritional and functional properties beyond edible utilisation as a renewable biopolymer (Wanasundara et al., 2016). In a study, canola meal samples were collected from 11 processing facilities in Canada over four years by Adewole et al., (2016). Average four year contents of components (g/kg dry matter) were: Crude protein 417; total dietary fiber 379; NDF 294; non-starch polysaccharides 219; lignin and polyphenols 107; sucrose 61; neutral detergent insoluble crude protein 54; fat 35; oligosaccharides 29; total phosphorus 11; non-phytate phosphorus 4. Average amino acids contents (in g/kg DM basis) were: Glutamine 67; asparagine 27; proline 27; leucine 26; arginine 23; lysine 21; glycine 18; serine 18; alanine 17; valine 17; threonine 15; phenylalanine 14; histidine 12; isoleucine 12; tyrosine 10; cystine 8; methionine 7 (Adewole et al., 2016).

Canola agriculture under ecologic change

Canola is a dryland crop in most parts of the world (Tesfamariam et al., 2010). Effects of climate change are temperature rises, flooding, drought and other events are challenges to crop production. Contribution of canola to oilseed industry is essential component of agroeconomics and trade. Multiple abiotic stresses on canola crop are resulting with agroeconomic losses worldwide (Lohani et al., 2020).

Canada, China and India have highest canola production (18,6; 13,5 and 9,3 million tonnes, respectively) and acreages (8,3; 6,6 and 6,1 million ha, respectively) in 2019 in the world. Canola seed yields were highest in Denmark, Sweden and UK (4,4; 3,6 and 3,3 t/ha, respectively) and lowest in Kazakhstan, Australia and Bangladesh (0,9; 1,1 and 1,2 t/ha, respectively) in 2019 in the world (Table 1).

Table 1. Canola production, acreages and yields of top 25 canola producer country in 2019 in the world (FAOSTAT, 2021)

No	Country	Production (million tonnes)	Acreage (million ha)	Seed Yield (t/ha)
1	Canada	18,6	8,3	2,2
2	China	13,5	6,6	2,1
3	India	9,3	6,1	1,5
4	France	3,5	1,1	3,2
5	Ukraine	3,3	1,3	2,6
6	Germany	2,8	0,9	3,3
7	Australia	2,4	2,1	1,1
8	Poland	2,3	0,9	2,6
9	Russia	2,1	1,4	1,4
10	UK	1,8	0,5	3,3
11	USA	1,6	0,8	2,0
12	Czechia	1,2	0,4	3,0
13	Hungary	0,9	0,3	3,0
14	Romania	0,8	0,4	2,3
15	Denmark	0,7	0,2	4,4
16	Lithuania	0,7	0,2	2,9
17	Belarus	0,6	0,3	1,7
18	Bulgaria	0,4	0,2	2,9
19	Slovakia	0,4	0,1	2,9
20	Latvia	0,4	0,1	2,9
21	Sweden	0,4	0,1	3,6
22	Pakistan	0,3	0,3	1,3
23	Bangladesh	0,3	0,3	1,2
24	Iran	0,3	0,1	2,1
25	Kazakhstan	0,2	0,3	0,9

Progresses in agronomy and release of new cultivars fitting well to wide range of environments have promoted the expansion of canola cultivation into new environments (Lilley et al., 2019). But global warming will probably reduce soil moisture in many regions of the world and change the conditions (Qaderi et al., 2012). Correct timing of irrigation supplemention in water scarce conditions is an approach to reducing drought stress, increase water productivity and yield of canola in drylands (Mohtashami et al., 2020). Drought stress directly inhibit establishment of seedlings in canola which result with lower plant densities and yields (Zhang et al., 2015). Instead, prolonged wet soil conditions during critical plant development stages may significantly increase risk of some plant diseases. In wet fields during flowering stage of canola, development of sclerotinia on the petals of the canola flowers is possible (McNairn et al., 2018). Canada have highest canola production and acreages in the world but in western Canada, Clubroot (*Plasmodiophora brassicae*) is an emerging threat to canola production there (Peng et al., 2011).

Rising temperatures with climate change will affect production of crops and food security. Lodging is a major reason for yield loss and quality loss in canola. Canola is more prone to anchorage failure compared to stem buckling. Root lodging due to anchorage failure will probably increase with rising temperatures. Root lodging resistance may be a priority for breeding selection to increase anchorage strength (Wu & Ma, 2018).

Fig. 1. Canola in Yunnan region, China (photographer, Anne Berlin) (Anonymus, 2012)

To escape from both drought and high temperature conditions, producing winter crops may be a good option. Winter crops are the agricultural backbone for many countries currently. Australia is an example which is in top 10 canola producing countries (Dreccer et al., 2018). Practice of dual-purpose utilisation of canola for forage during winter before canola seed production is a method developed in southern regions of Australia. Significantly high livestock production and grain/oil yield via dual-purpose winter canola was proved under high-rainfall environments. Also feasibility of dual-purpose "spring" canola with medium rainfall (450–650 mm) was commercially demonstrated (Sprague et al., 2014). High temperatures, drought and salinity are generally interconnected. Topsoil and subsoil salinity are major environmental stresses for crop production (Grewal, 2010). Canola is moderately salt-tolerant but salt stress reduces its growth, seed yield and oil content (Bandehagh et al., 2011). Plant growth promoting bacteria (PGPR) can reduce negative effects of salinity stress in canola (Banaei-Asl et al., 2015). Using halotolerant PGPR to alleviate salt stress damage is an effective method (Li et al., 2017). PGPR stimulate the growth of host plant and rhizospheric bacterial community structure (Farina et al., 2012). When exposed to abiotic or biotic stress, plants produce ethylene from precursor ACC (1-aminocyclopropane-1-carboxylate) and retards root growth and results with senescence. Many species of PGPR have ACC-deaminase enzyme which lowers the levels of ethylene (Akhgar et al., 2014). Global warming is increasing biological invasion of pests of pollinator species globally with severe harm (Cornelissen et al., 2019).

Fig. 2. Canola in Yunnan region, China (photographer, Anne Berlin) (Anonymus, 2012)

Decline of pollinator numbers continues and need of forage for insects increases. Diversifying the landscape with agricultural crops to provide forage to improve pollinator health is a way. Yellow flowers of canola have high insect activity and visit rates (Eberle et al., 2015). Global climatic change is also chancing timing and frequency of climatic events. Chilling exposure is required for temperate plants for a period of time to have freezing tolerance. During this chilling acclimation stage, biochemical, biophysical and molecular shifts occur to survive at temperatures below freezing. Alteration of protein and carbohydrate accumulation results with high amount of soluble sugars and dehydrins (cold triggered stress proteins) as a cryoprotective function. When these acclimated plants de-acclimate (exposed to warm temperatures) a rapid turnover of these carbohydrates and proteins types end elevated freezing tolerance. In certain species such as canola, in both spring and winter cultivars, re-acclimation (re-exposure to cold-acclimating temperatures) results with re-accumulation of proteins and carbohydrates. Instead, re-acclimation wheat (*Triticum aestivum*) results only with a 39% freezing tolerance recovery because winter wheat does not accumulate carbohydrates during re-acclimation. Interaction of these types of proteins with soluble carbohydrates may be responsible for freezing tolerance at re-acclimation (Trischuk et al., 2014). Contamination of soils by heavy metals is a major environmental problems in last decades in the world. In these environments, special plants have ability to grow well. Brassica plants' heavy metals phytoremediation capacity is well reported. Canola are highly tolerant Zn pollution and produce high biomass values under excess Zn (Belouchrani et al., 2016).

CONCLUSIONS

Crop yields are influenced significantly by weather conditions, growth season, sowing date, length of the growth season, crop management practices, cultivar selection and types of stresses experienced by crops. Scientific assessments of impacts of climate change on canola under different levels of ecological warming conditions are essential for effective adaptation to new conditions. Increasing temperatures, water shortages, droughts and extremes at different plant growth stages poses great challenges to the canola productivity and profitability but as a winter crop, canola has advantages over other oil crops which most of oil bearing annual crops are summer type. Performance of canola under multiple stress is another area needed to be studied more.

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