Review Paper

Effect of Fruit Position and Variable Temperature on Chemical Composition of Seeds in Brassica, Cotton, Sunflower and Maize Crops

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Abstract: The aim of current review article is to understand the effect of environmental factors on the seed chemical composition of major oilseed crops. The difference of time in flowers opening and distance from ground may affect physico-chemical characteristics of oilseed crops. Environmental temperature at the time of fertilization and subsequently anthesis influence pollen vigour, pollination progression and eventually the kernel formation and assimilate dividing between various positions. Seed traits, oil content and protein content are influenced by prevailing environmental conditions during maturity and post flowering period. Chemical composition of different oilseed crops is also affected by difference in environmental temperature during growth, planting time, irrigation, rainfall, fertilizers, growing season and planting location. Temperature showed more pronounced effect on oil content, protein, fatty acid profile and less effect on glucosinolate in brassica. Genotype, water availability, rainfall, location and siliqua position determine content and composition of oil and protein content in brassica. Increasing temperature decreases linoleic acid in cottonseed. Environmental factors, water availability and planting date affects seed composition in cotton. Temperature during seed maturation has significant influence on oil content and concentration of unsaturated fatty acid of sunflower. Seed position on head has slight influence on oil content while pronounced impact on fatty acid profile and tocopherol. Drought at seed development phase resulted a decline in oil content whereas protein content increase. Earlier planting date reduce the total saturated fatty acids and increase oil content of sunflower.

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Introduction:

The major oilseed crops include canola and rapeseed / mustard, cottonseed, sunflower and maize in Pakistan. Although the cotton crop is grown for its lint, cottonseed contributes 50 to 60 percent to local edible oil production. During the year 2011-12, the total availability of edible oil was 2.748 million tonnes. Local production of edible oil is remained 0.636 million tonnes while imports were 2.148 million tonnes. The import bill during 2011-12 stood at Rs.216.4 billion (US$ 2.426 billion). During the year 2012-13 (July-March), 1.738 million tonnes of edible oil valued at Rs.153.3billion (US$ 1.595 billion) has been imported. The local production during 2012-13 (July-March) was 0.612 million tonnes. Total availability of edible oil from all sources is provisionally estimated at 2.35 million tonnes during 2012-13 (July-March). (Anonymous 2012-13).

Environmental conditions influence the crop growth and development and are the most important yield controlling factors in the world (Franklin *et al.,* 2010). Environmental factors during flowering and seed-filling period influence grain produce and kernel composition different oilseeds (Petcu *et al.,* 2001; Monotti, 2003; Ali *et al.,* 2009; Ali *et al.,* 2010ab). Chemistry of oil differs with prevailing climatic conditions (Strecker *et al.,* 1997; Pritchard *et al.,* 2000; Roche *et al.,* 2006). Buildup of saturated fats is likewise influenced by ecological elements (Roche *et al.,* 2006; Izquierdo and Aguirrezábal, 2008). Ecological aspects like radiations from sun (Santalla *et al.,* 1995), precipitation (Pritchard *et al.,* 2000), available nitrogen (Steer and Seiler, 1990), saline conditions (Irving *et al.,* 1988) and plant vigor (Zimmer and Zimmerman, 1972) in addition to temperature showed significant impact on chemistry of oil. Post-flowering temperatures is main factor influencing oil composition of a different oilseed crops (Pritchard *et al.,* 1999). The chemistry of oil in different oilseed crops is affected by the temperature prevailing at grian maturation (Hilditch and Williams, 1964). Inconsistent ecological conditions may result in wide variation in oil quantity and composition in different oilseeds (Shafii *et al.,* 1992). Prevalence of

lower temperature at the time of maturation caused upsurges polyunsaturated fatty acids in oilseed plants (Nykter *et al.,* 2006).

Temperature is an important environmental factor affecting the fatty acid composition of different plant portions like seeds (Tremolieres *et al.,* 1978), roots (Simolenka and Kuiper, 1977) and leaves (Wilson and Crawford, 1974). Temperature differential has strong influence on proportions of different fatty acids (Matsuzaki *et al.,* 1988) and molar proportion of oleic acid increased while linoleic and linolenic acid content decreased as temperature increased. Climatic conditions, water and nitrogen availability mainly during the seed-filling stage account for most of the variations than due to genotype differences in grain protein concentration (Cooper *et al.,* 2001). Post-flowering temperature, sun rays or water supply are main factors determining the influence of nitrogen availability on grain protein content. Oil and protein are two major components of seeds in oilseed crops and are affected significantly by environmental stresses (Dehnavi and Sanavy, 2008).

Brassica

Brassica napus L. (Canola) is a member of the family Brassicaceae (mustard or cabbage family). Canola has been introduced through nutritional upgradation of oil contents by genetic alteration of Brassica cultivars, rapeseed (*Brassica campestris* and *Brassica napus*) and mustard (*Brassica juncea*) having less than 2 percent erucic acid in the oil and 30 µm glucosinolate (less than 30mg/g) or double zero cultivars (Bhowmik, 2003). It was originally bred from rapeseed in Canada. Its seed comprises of 40-45 percent oil content and 36-40% protein in meal (Amin and Khalil, 2005). The cotyledons of rapeseed (*B. napus*) showed 90 percent of total fatty acids while radicle and hypocotyl contain 6% and endosperm 4% (Li *et al.,* 2006; Ali *et al.,* 2010a). The seed contain oil content ranging from 40-45% and protein 36-40%. Oil content is normally stated as proportion of entire grain comprised of 10-20% ω-3 fatty acid, erucic acid less than 0.10 percent, oleic acid 59-62 percent, linoleic acid 18-22 percent and linolenic acid 10-12%. Canola oil has lowest point of saturation (7%) of any common edible oil and high in mono and poly-unsaturated fatty acids (93%) (Douaud, 2006). The oil chemistry of canola is predisposed by temperature at grain filling. Seeds developed and matured at elevated temperature contain greater proportion of saturated and monounsaturated fats and polyunsaturated fats in minute concentration. Saturated fats comprise about 6% while 55 to 60% oleic acid, 20 to 26% linoleic acid in canola oil (Deng and Scarth, 1998).

Canola is an annual crop, the growth and development is incessant nevertheless it is definitely divisible into simply identifiable growing phases. The life cycle of the canola plant is divided into seven standard phases; the span of every growing phase is very much predisposed through temperature, moistness, sunlit (day length), nourishment and cultivars (Colton and Skyes, 1992). During flowering and pod setting, the relative source and sink controls the convenience of assimilates essential for grain development (Diepenbrock, 2000). There is an agreement that such as assimilates are conveyed from parents to familial tissues. These are carried to the extra cellular interstellar sorting out the two generations, proceeding to uptake from the apoplast into the tissues of the embryo or endosperm (Wolswinkel, 1992). Flowering initiate by the opening of lowermost shoot on the central branch and lasts up with 3-5 or additional florets opened each day. Flowering at the bottom of the principal ancillary branch initiates 2-3 days later the first flower opens on the main stem. Fertilization occurs within 24 hours of pollination (Anonymous, 1983). The enlargement and composition of siliqua and seeds of oilseed rape takes 12 weeks after anthesis to maturity. Every plant produces 220 Silique, this number being stable throughout expansion. Numbers of seeds per siliqua ranges from 9 to 19 (Norton and Harris, 1975). Under severe environment, the number of twigs bearing flowers might be reduced and the number of flowers on each branch also less down. Extreme stress upsurges the damage of unopened buds, signaling the termination of flowering. Both genotypic and environmental parameters determine the quantity and quality of canola oil (Flagella *et al*., 2002). The environmental parameters upset the concentration of canola oil. High temperature is the most important factor that decline the seed oil content (Pritchard *et al*., 2000).

Oil and seed protein content were more affected by environmental conditions as compared to genotypic effects, while the reverse in case of glucosinolate concentration (Pritchard *et al.,* 1999). Oil quantity in canola is mainly influenced by temperature fluctuations (Hassan *et al.,* 2005). Higher oil and lesser seed protein contents correlate with lower temperatures and high precipitation in spring. Oil contents were maximum in canola from regions with cool temperature and more rain like those of Victoria and lowest in canola from the hotter regions like Mallee, or in drought years. Every 1°C increase in spring maximum temperature reduces oil content by 0.38% (Pritchard *et al*., 1999). High temperatures during the post-anthesis lessen oil quantity in canola (Walton *et al.,* 1999). Cooler and humid spring is encouraging for higher oil accumulation in canola (Hassan *et al.,* 2007).

Increase in oil content would lower protein accumulation (Pritchard *et al.,* 2000). Both location

and genotype contribute significantly to the variation in oil and protein concentrations. Areas receiving higher precipitation give considerably higher oil and protein canola than the low rainfall areas. Extended reproductive stage and lower temperature at the time of seed development stage of crop is promising for high seed yield and good quality oil in canola (Hassan *et al.,* 2005). Fatty acid composition of brassica varies with year and region (Pritchard *et al.,* 1999). Canola crop planted at central Victoria and the Wimmera and in most years, in north-east Victoria revealed higher oleic acid content (60.3±0.4%). Concentration of oleic acid declines with lower temperatures and rainfall. Low variation was observed in linoleic (19.7± 0.3%) and linolenic (10.4±0.3%) acids across regions. Concentration of linolenic acid in canola decreased with higher maximum temperatures and lower rainfall in spring season (Pritchard *et al.,* 1999). Izquierdo (2007) reported decline in quantity of oil from 50.3-36.3 percent when extent of incident rays were decreased up to 80 percent in rapeseed.

Prevailing weather has significant impact on chemical composition of oil in hybrids and in double zero cultivars (Pospisil *et al.,* 2007). Air temperature during flowering affects the quantity oil and protein and oil chemistry of rapeseed (Nagao and Yamazaki 1984). Concentration of saturated fats in low-linolenic acid (C18:3) *B. napus* is augmented by rising air temperature throughout the flowering and maturing period (Deng and Scarth, 1998). Quantity of oil and C18:3 decrease while those of C16:0 and free fatty acid is enhanced by frost damage at ripening stage in oil from canola seed (Daun *et al.,* 1985; Daun *et al.,* 1994). Greater accumulation of oil has direct relationship with ample supply of (Mailer and Cornish, 1987; Mailer and Pratley, 1990). Moisture stress at seed development stage reduces the quantity of oil (Mailer and Pratley, 1990) and oleic acid up to 7% in the *B. napus* (Champolivier and Merrien, 1996). Drought increase protein concentration and decrease oil content (Dornbos and Mullen, 1992). Water deficit conditions reduced the oil and linoleic acid concentration however increases the glucosinolate and stearic acid contents in brassica (Moghadam *et al.,* 2011). Water availability during seed filling period and mean daily temperature are main factors determining oil concentration in the seed (Skoric, 1992). Inconsistent results are reported for the influence of drought on the oil composition of low erucic acid *B. napus* (Bouchereau *et al*., 1996; Champolivier and Merrien, 1996). Increase in level of salinity resulted reduction in the quantity of polyunsaturated fatty acids whereas the content of monounsaturates increased (Bybordi *et al.,* 2010).

Environmental effects on the individual fatty acids increased with an increasing degree of unsaturation (Pritchard *et al.,* 1999). Several plants react to lower temperatures by enhancing the extent of unsaturation in the fatty acids of membrane glycerolipids and to higher temperatures by decreasing the degree of unsaturation of their membrane fatty acids (Williams *et al.,* 1988). There exist an inverse relationship among quantity of C18:1 and C18:2 (as well as C18:3 if present) with decreasing amount of unsaturation in crop plants developed at higher temperature as evident from studies conducted by Deng and Scarth (1998). The concentration of protein in seed is augmented with average maximum spring temperatures ($r=0.40$, $p<0.01$), however glucosinolate content showed no correlation with variation in climatic conditions (Pritchard *et al.,* 1999). Environmental temperature showed remarkable influence on concentration of unsaturated fatty acids mainly oleic and linoleic. Oleic acid is more influenced by higher temperature at maturity of the crop (Demurin *et al.,* 2000). Among saturated fatty acids, palmitic acid content decreases at higher temperature towards the crop maturity, whereas lesser growing degree days favor increased accumulation of stearic acid (Ahmad *et al.,* 1999). Genotypic variability along with the climatic factors affects seed oil and fatty acid contents (Solangy *et al.,* 1999). The quantity of saturated fatty acids in seed oil increased under higher temperature. Oleic and linoleic acids concentration is greater in crop matured under lesser daily temperature. Higher temperature enhances the concentration of both saturated and monounsaturated fatty acids in canola seed oil while lower daily temperature at harvest results in higher linoleic levels (Deng and Scarth, 1998). Marinkovic *et al.,* (2003) stated that genetic difference may exist for seed proteins, oil and fatty acid compositions in various genotypes under similar environmental conditions. The genotype × environment interaction plays a critical role in deciding the quantity and quality of produce.

Knowledge of environment factors, application of adequate agro-technical measures and appropriate selection of canola and sunflower, hybrids and varieties is helpful in increasing seed protein and oil contents. Maximum differences in amount of total saturated fats for the varieties under study were ascribed to difference in palmitic acid (C16:0) owing to the genetic makeup as main effect and variability in stearic acid (C18:0) due to the genotype and environment main effects. The differences due to the genotype × environment interaction were slight in relation to the main effects for the individual saturated fatty acids (McCartney *et al.,* 2004). High temperature at flowering accelerates the plant growth, reduce the time from flowering to maturity and also reduce photosynthetic resources (Hall, 1992 and Morrison,

1993). The optimum daily temperature for canola flowering is 20°C (Chen *et al*., 2005). A high temperature during flowering decreases the pollen's receptivity period, time period for pollen discharge and its viability. In canola, excessive heat throughout flowering period can early termination of flowering, result in incomplete seed setting (Angadi *et al*., 1999). Above 21-24 °C every 3 °C increase in daily temperature during flowering cause 430 kg ha^{-1} decline in canola seed yield. Higher yield and oil content is recorded in crop maturing with high precipitation and modest temperatures (10 to 15°C) at the time of grain filling (Nuttal *et al*., 1992). Gan *et al*. (2004) reported up to 54% and 87% decrease in canola seed yield with sever temperature fluctuation between 28/18 and 35/18 °C respectively. Excessive temperature is recognized to decrease grain yield in *B. napus*, which might because of reduced flowering, fruit abortion or interruptions in fertilization or post-fertilization events. Development of early flowering phase was more sensitive to elevated temperature stress than the initial pod phase (Young *et al*., 2004).

Temperature fluctuation is main factor influencing oil quantity in canola. Oleate a monounsaturated fat with an 18 C chain and a double bond accurately in the middle, has maximum prevalence to be established in plants. It is converted to linoleate with the help of desaturase enzyme (Schwartzbeck *et al*., 2001). Oleic and erucic acids undergo key alterations at the time grain maturation (Manaf and Hassan, 2006). Split application of Sulphur in different portions at grain filling result in decreased transformation of oleic acid (18:1) to erucic acid (22:1) which leads to the decreased 22:1/18:1 ratio and better-quality of the oil (Ahmed and Abdin, 2000). Sulphur levels significantly influence erucic acid (Jan *et al*., 2002; Manaf and Hassan, 2006). Level of saturated fatty acid in low-linolenic acid (C18:3) *B. napus* cultivar Stellar is augmented with increase in air temperature at flowering and maturing period (Deng and Scarth 1998). Both location and genotype showed significant impact to the variation in oil and protein quantity. Inverse relationship was recorded between oil and protein concentrations across environments, but not across genotypes (Si *et al*., 2003). The level of linolenic acid decreased slightly while the saturated fatty acids showed slight increase in concentration. Plant exposure to very high temperatures (37/25 ˚C) in the late flowering stage reduced erucic acid content from 52% to 44% in the whole plant seed. Linolenic acid fell slightly, while all other fatty acid levels increased, particularly oleic acid (12 to 17%) and eicosenoic acid (7 to 11%) (Pritchard *et al.,* 2013).

Environmental effects largely on oil and protein content relative to cultivar effects, whereas the upset noted for concentration glucosinolate. Higher oil and less seed protein quantities were connected by means of cooler temperatures and higher rainfall. Mean concentration saturated fatty acid (6.4 ±0.1%), linoleic acid (19.7± 0.3%) and linolenic acid (10.4± 0.3%) depicted inverse association with the oleic acid content. Erucic acid content account for ≤0.6% in seed from all regions (Pritchard *et al.,* 2000). Similarly, Aslam *et al.* (2009) conclude that polyunsaturated fatty acids increases and oleic acid decreases in Mediterranean-type environment, which was mainly related to growing period, rainfall is reduced from 300 mm to 150 mm. There result showed that seed protein, linoleic acid and linolenic acid increased by 3.9%, 2.0%, and 1.7% whereas oil content, oleic acid and saturated fatty acids decreased by 3.2%, 3.8% and 0.4% respectively. Higher precipitation and cool mean minimum and maximum temperatures throughout the growing period showed positive association with high oleic acid concentration.

Excessive water deficits result reduction in oil while it enhances seed protein in rapeseed (Henry and MacDonald, 1978). Gunasekera *et al.* (2006) observed significant reduction in seed setting at elevated temperature in rapeseed. Munshi and Kumari (2006) found healthier seed from lower Silique than seeds from upper Silique in rapeseed. Variation in pattern of oil filing in mustard seeds from basal to apical positions was due to the variable environmental conditions (Munshi and Kochhar, 2008). In rapeseed oil concentration rises progressively from 1st to last phases of grain filling (Bhardwaj and Hamama, 2003). Deng and Scarth (1998) concluded that high temperature produced seeds with the lowest C18:3content and highest C16:0, C18:0 and C18:1. Increase of saturated fatty acids appeared to happen early in expansion. Likewise Yaniv *et al*. (1995) studied influence of temperature on oil quality and yield parameters of high and low erucic acid Cruciferous seeds (Rapa and mustard). They found that with increase in temperature, oil content and grain yield contributing factors showed significant reduction. Elevated temperature speed up the time required for maturation of seed. The time period for synthesis of erucic acid at grain filling was influenced by the prevailing temperature.

Another comparable study was done by Gunasekera *et al*. (2006) on environment interactions for Indian mustard (*Brassica juncea* L.) and canola (*Brassica napus* L.) in Mediterranean-type environments. Their results indicate that quantity of oil in seed was inversely related to protein content in both rapeseed and canola genotypes. Generally seed yield is directly linked with oil content and increasing crop yield augmented the oil content, however protein declined with increase in yield. Percent increase in oil

per unit increase in seed yield was higher in canola as compared to mustard genotypes, however mustard genotypes showed more protein quantity per unit boost in seed yield than canola. However, Chauhan *et al*., (2010) investigated that morpho-physiological characteristics of Indian mustard (*Brassica juncea* L.) was frequently affected heat stress. They found substantial influence of high temperature on seed yield, seeds per siliqua, thousand seeds weight, leaf weight, leaf area index, harvest index, crop growth rate and chlorophyll stability. Protein content increased but also decreased oil content with high temperature.

The Silique positioned at 5-27 on the mustard (*Brassica juncea* L.) inflorescence were better and superior. Seeds from these siliqua showed extensively higher dry matter, dry weight per siliqua and oil content per seed than those located at positions 1-3 and 29-49 at ripening. The seeds obtained from siliqua at positions 27 and above on mustard inflorescence showed variation in oil chemistry as these were less mature thus, have a smaller amount storage fatty acid than the seeds in siliqua at basal end. The end results also showed that amount of glycolipids, phospholipids, oleic acid and free fatty acids were more in the seeds from siliqua position 27 and above in comparison to lower end. The amount of erucic acid was relatively lower in the seeds obtained from higher sections (Munshi and Kumari, 2006). A parallel study was conducted by Munshi and Kochhar (2008) to find out the dried material, oil quantity per seed and pod wall at early phases at top followed by mid-development phases in central positions and delayed growth phases in bottom positions. The oil content declined in proportion to pod wall with different phases of silique growth. There exists variation in oil accumulation in seeds in respect to days after flowering. The point of quick accumulation of oil in grains differ in number from 20 to 40 DAF (days after flowering) at base end to 10 to 30 DAF at central and 10 to 20 DAF at to positions. The declining trend was observed in amount of starch and total soluble sugars on percent dry weight basis in the grains and pod walls, however their buildup was highest on the basis of contents per seed at 20, 30 and 40 DAF. Maximum quantity of soluble sugars was recorded at 20, 20 and 40 DAF in upper, central and lower locations correspondingly on the base of pod wall.

Cotton Seed

Cottonseed is used as raw material for oil expelling and meat remained after oil extraction is destined for animal feed production (Hamilton *et al.,* 2004). Lipids profile generally consists of 70% unsaturated and 30% saturated fatty acids (Alfred *et al.,* 2012). Oil content in cottonseed is determined by genetic effects from the embryo and maternal plant genomes (Kohel 1980; Singh *et al.,* 1985; Ramos 1985; Dani and Kohel 1989). The dairy industry depends on whole cottonseed due to its high protein (35%) and oil (30%) composition (Arieli, 1998). Cottonseed meal is used as a feed supplement for ruminants. The use of both oil and meal is limited by the gossypol content of cottonseed (Bernardi and Goldblatt, 1980). Cottonseed produces relatively stable frying oil with potential health benefits due to distribution of saturated and unsaturated fatty acids within the oil component (O'Brien and Wakelyn, 2005).

Cottonseed oil content is a quantitative trait controlled by genes in the tetraploid embryo and tetraploid maternal plant genomes (Alfred *et al.,* 2012). Higher temperature at different phases of cotton plant including important physiological and growth stages decreases the yield (Singh *et al.,* 2007). Flowering intervals on vertical and horizontal branches are influenced by temperature (Munro and Farbrother, 1969; Reddy *et al.,* 1997a). All the squares and flowers were aborted and dropped in several upland cotton cultivars at day temperatures above 40°C (Reddy *et al.,* 1991a). In spite producing fruiting branches and squares of upland type cotton at high temperature but it did not successfully produce bolls (Reddy *et al.,* 1991b, 1992). High - temperature stress prior to and during flowering significantly influences several reproductive processes leading to decreased fruit set in cotton (Singh *et al.,* 2007).

High temperatures induced square and boll shedding and decreased boll size leading to lower cotton yield (Brown *et al.,* 1995; Reddy *et al.,* 1991a; Zeiher *et al.,* 1995). High night temperature (25°C) delayed flowering in upland cotton regardless of day temperature (Mauney, 1966). Temperatures that routinely occur in many cotton - producing regions strongly limit various physiological, bio-chemical, and growth processes (Reddy *et al.,* 1997a, b, 2004, and 2005). Varietal variation in seed composition has been well established over the years by the National Cotton Variety Trials (USDA, 2009) and studies published in books (Tharp, 1948; Cherry and Leffler, 1984) and journals (Pons *et al.,* 1953; Stansbury *et al.,* 1953, 1954; Pandey and Thejappa, 1975; Turner *et al.,* 1976; Lawhon *et al.,* 1977; Cherry, 1983; Kohel and Cherry, 1983; Lukonge *et al.,* 2007; Dowd *et al.,* 2010). Breeding cottonseed for oil content has depended mainly on phenotypic information that is used to select varieties with high seed oil content (Azhar and Ahmad 2000; Ash and Dohlman 2006; Pahlavni *et al.,* 2008). A little knowledge is available about genetic basis controlling oil content (Khan *et al.,* 2007; Wu *et al.,* 2010). Studies show that oil content in cottonseed is determined by genetic effects

from the embryo and maternal plant genomes (Singh *et al.,* 1985; Ramos, 1985; Dani and Kohel 1989). Yu *et al.,* (2012) mapped 17 QTLs on 12 chromosomes for oil content in cottonseed entirely on the basis of embryonic genome in cotton.

Gossypol content of cottonseeds vary with the locality in which the seeds are grown, and is increase in those seeds which have a high oil content (Schwartze and Alsberg , 1923). Weather conditions are important factors with more or less effect on gossypol content, depending upon the time of planting. Amount of rainfall during the growing period of the cotton plant changes the amount of oil in the seeds (Gallup, 1927). Garner *et al.,* (1914) studied the oil content of cottonseeds at different stages of maturity and found oil increase somewhat more rapidly than the growth of the seed. Cottonseed composition is recognized to be affected by variety, planting date, and irrigation, interactions between varieties and irrigation. Variety was a major source of variation for all the seed composition traits quantified (Pettigrew and Dowd, 2012). Environmental factors affect and contribute to variations in seed composition (Pons *et al.,* 1953; Turner *et al.,* 1976; Cherry, 1983; Dowd *et al.,* 2010). The amount of water available to the crop during the growing season has a profound effect on seed composition (Pons *et al.,* 1953; Stansbury *et al.,* 1953, 1954; Pettigrew and Dowd, 2011). Planting dates were found to affect seed composition. Cotton plants with different genetic makeup can also respond differently to these various environmental influences (Pettigrew and Dowd, 2012). Contribution of any genetic-by-environment interaction might be small relative to the main effects for cottonseed oil fatty acid composition (Dowd *et al.,* 2010).

The unsaturated fatty acid composition of BT (59.71%) and non-BT hybrids (59.15%) was similar. Presence of Cry1Ac gene did not affect the oil content or its profile in the BT hybrids. Six BT hybrids showed higher oleic acid than their respective non-BT version and 4 germplasm lines nearly high oil content of more than 25% (Harijan, 2009). Application of zinc increased seed yield, seed protein content, protein and oil yield and total unsaturated fatty acids (oleic and linoleic) content in cotton (Sawan *et al.,* 2001).

Sunflower

Vascular strands in sunflower extensive from the receptacle into empty achenes regularly found in longitudinal section were studied by Alkio and Grimm, (2003). The results suggested that photo assimilate were translocated from the receptacle to the pericarp and the testa of unfilled achenes. The interpretation suggested that empty achenes are both structurally and functionally connected with the vascular system of the receptacle. Similarly Alkio *et al*., (2002) concluded that the floret is characteristically connected with leaves of three neighboring orthostiches in sunflower. Photo assimilate delivery patterns demonstrated here may reflect the functional relationship between the phyllotaxy of source leaves and the position of sinks in developing inflorescences. Likewise Troncoso *et al.,* (2009) investigated that emergent sunflower seeds do not collect much starch and these depend on the sucrose supply as precursor from the mother plant to synthesize lipid. At the time of seed development in sunflower 10 and 25 days after flowering (DAF), when seeds accomplish the key phase of storage lipid synthesis, amount of the sucrose is comparatively stable seeds. So, phosphoenol pyruvate (PEP), similar to pyruvate and malate present in cytosol, might be the principal carbon source for fat biosynthesis.

A study was conducted by Baydar and Sabri, (2005) to assess changes in the content of oil, fatty acids and total tocopherol of sunflower seeds. Oil content of sunflower seeds increased appreciably with seed development, it reached to maximum (45.8%) at 35 DAF (day after flowering) in 2002 and (47.9%) at 30 DAF (day after flowering) in 2003, after which it's in progress to decline steadily upto 45 DAF (day after flowering). Linoleic acid increased drastically and oleic acid decreased notably during seed maturing process. Total tocopherol gradually decreases from 10 to 35 DAF, after 35 day after flowering gradual increase was observed. Changes in protein and oil content of field-grown *Helianthus annuus* seeds followed throughout the grain filling period were resolute by Goffner *et al*., (1988). Seeds were sampled from dissimilar zones on the flower head marginal, middle, and inner. In spite of seed position, at maturity protein and oil content accounted for around 18% and 50% of the dry weight respectively. Lipids constituted the major photosynthetic sink, reaching levels of greater than 80% of the total seed-incorporated. The change rate from free sugars to storage compounds (lipids, proteins and starch) varies according to seed place and age.

Seed situated in different whorls of sunflower at maturity there physiochemical characteristics were determined by Munshi *et al*., (2003), they found quantity of filled seeds decreases as of peripheral to central whorl, filled/unfilled seed ratio decreased from outer to inner side in head. The dry weight of kernel, seed and oil content decreased from the marginal towards the middle and central whorl. A similar experiment by Gupta *et al*. (2009) was performed to decide effect of seeds positions in different whorls of sunflower on physical and chemical composition of seeds. Weight of seeds, kernels, oil per whorl, dry weight of seeds and kernels decreased from peripheral towards centre whorl. The content of oleic acid was

lowered in inner whorls and increased linoleic acid. The fatty acid profile and chemical composition of seed is closely linked to the development of the plant.

Variability in seed weight throughout seed development in different whorls of sunflower head was recorded by Gupta *et al.,* (2009) while Kaleem and Hassan (2010) observed heavier seeds in outer circles of sunflower than in inner circle. Temperature prevailing during seed maturation resulted in significant variation in oil content (Hasan and Ahmad, 2003) concentration of oleic and linoleic acid (Baydar and Sabri, 2005). Higher temperature at maturity stage results in oil with high oleic and low linoleic acid concentration (Seiler, 1983; Lajara *et al.,* 1990). Higher temperatures during seed development in 2010 resulted with 68.38 % increasing in oleic content of the traditional sunflower hybrid (Onemli, 2012). Grain oil concentration is under genetic control in sunflower (Aguirrezabal *et al.,* 2009). Fatty acid composition of sunflower changes significantly during seed development (Baydar and Sabri, 2005). Oleic acid decreased significantly while linoleic acid increased significantly during seed maturity process (Baydar and Sabri, 2005). Tocopherol content decreases from 10-35 days after flowering after which it increases gradually. Seed position on head has little effect on oil content while it had strong effect on fatty acid profile. Linolenic acid decrease while oleic acid increase linearly from side to centre seeds. Tocopherol content was highest in seeds found at sides of head (Baydar and Sabri, 2005).

Higher oil content correlate with extreme vulnerability of oil content to prevailing environment, conversely consistent oil content of low-oil hybrids (Dosio *et al.,* 2000 ; Izquierdo *et al.,* 2008) is observed even when a slight variation in genetics as in single hereditary section (8.1 cM) can give the high-oil character (León *et al.,* 1996). Ecologically favored variability in seed oil content of sunflower is associated with alteration in embryo oil content (Santalla *et al.,* 2002; Izquierdo *et al.,* 2008). Air temperature during flowering affects the lipid profile of sunflower (Nagao and Yamazaki 1984). Temperatures above 30°C resulted in changes associated with the proportion of embryo-to-pericarp in reaction to differences in grain oil content (Rondanini *et al.,* 2003). Seed oil content in sunflower, depends upon the quantity of photosynthetically active radiation (PAR) captured per plant throughout the seed-filling phase (Andrade and Ferreiro, 1996; Dosio *et al.,* 2000; Izquierdo *et al.,* 2008). Dry matter and oil content in sunflower seed are susceptible to quantity of captured rays between 250 and 450 °C day after flowering. The span of the seed development phase showed inverse relation to temperature in sunflower (Ploschuk and Hall, 1995; Villalobos *et al.,* 1996). Elevated temperature curtails the duration required for intercepting rays and thus decreases amount of oil in seed (Aguirrezabal *et al.,* 2003). Temperature higher than 30°C, showed marked reduction in oil concentration dependent on the phase of seed filling (Rondanini *et al.,* 2003, 2006). Excessive nitrogen application can also influence quantity of oil with an upsurge in protein content (Steer *et al.,* 1984).

Environmental factors and management practices have impact on captured radiation per plant, temperature or crop photosynthesis (foliar diseases, sowing date and sowing density) have direct effects on grain oil concentration (Andrade *et al.,* 2002). The overall action of the enzyme oleoil-ACP desaturase is greatest at initial seed filling stage (Garcés *et al.,* 1992; Kabbaj *et al.,* 1996) hence; the temperature showed more pronounced impact in this period as compared to the remaining the seed-filling phase. Lowest nocturnal temperature flanked by 100 and 300 °C day afterward flowering with 6 °C basal temperature explain maximum variation in the content of oleic and linoleic acids in 2 conventional hybrids and a high-oleic hybrid (Izquierdo *et al.,* 2006 ; Izquierdo and Aguirrez ábal, 2008).

Even a short term water deficit stress can cause substantial change in physical properties and biochemical composition of sunflower seed (Ashraf and Mehmood, 1990). Esmaeilian *et al.*, (2012) revealed that drought at seed filling phase affected a reduction in concentration of oil whereas quantity of protein improved because of water deficit at flowering phase of sunflower. Drought stress resulted in significant decrease seed and oil yield of sunflower (Soleimanzadeh *et al.,* 2010). The concentration of oleic acid was reduced from 14 to 4 % while linoleic acid concentration increases in sunflower seeds grown in drought stress (Petcu *et al.,* 2001). Qualitative parameters of sunflower seeds showed that water stress caused a marked decrease in oil content and unsaturated fatty acids of oil, however this negative effect was greater in water stress at seed filling stage with respect to water stress at flowering stage. Protein content increased due to water stress at flowering stage. Drought stress at seed filling stage significantly decreased nutrient content of the seeds, whereas drought stress at flowering stage caused to increase of nutrient uptake (Esmaeilian *et al.,* 2012). Increase or decrease in oil oleic and linoleic acid contents due to water stress when applied at different growth stages could be variety specific (Ali *et al.,* 2009). Soil tillage influences sunflower oil fatty acid composition while the disease influenced oil quality and the balance oleic-linoleic fatty acids (Mirleau-Thebaud *et al.,* 2011).

Application of biofertilizer decreased the saturated fatty acids (palmitic and stearic) and increased unsaturated fatty acids (linoleic acid and oleic acid) and oil content (Akbari *et al.,* 2011). Application of K increases oil content and improves quality of oil by enhancing its linoleic acid content (Ahmad *et al.,* 1999). Drought stress caused a marked decrease in oil content and unsaturated fatty acids of oil while protein content increased due to water stress at flowering stage in sunflower (Esmaeilian *et al.,* 2012). Duration of seed development modify the oil content and fatty acid profile (Norton and Harris, 1975; Ichihara and Noda, 1980; Dornbos and McDonald, 1986; Chung *et al.,* 1995; Ishikawa *et al.,* 2001; Rahmatalla *et al.,* 2001; Bhardwaj and Hamama, 2003) hence the genetic exploration for oil content and lipid profile is interpreted by length of seed maturity (Ishikawa *et al.,* 2001). Genetic (Knowles, 1988) and environmental factors and stage of maturity of seed are major determinants of seed oil chemistry (Baydar and Sabri, 2005). Environmental temperature prevailing during seed development, influence oil content of sunflower (Goyne *et al.,* 1979; Miralles *et al.,* 1997). Oil content of sunflower showed slight decrease from grain filling to harvesting (Jasso de Rodriguez *et al.,* 2002). The ratio of oleic/linoleic acid increases under high temperature during seed maturation and it decreases under lower temperature conditions (Tremolieres *et al.,* 1982).

There exists genetic and phenotypic variation in sunflower seeds for tocopherol composition (Demurin, 1986; Demurin *et al.,* 1996). Environmental conditions showed immense influence on tocopherol content of *sunflower* seed (Kandil *et al.,* 1990; Marquard, 1990; Velasco *et al.,* 2002). The environment affects fatty acid composition of sunflower seed (Onemli, 2012). In sunflower variations in fatty acid composition is mainly related to temperature and drought (Harris *et al.,* 1978; Nagao and Yamazaki, 1984; Lajara *et al.,* 1990; Izquierdo *et al.,* 2002; Tahmasebi-enferadi *et al.,* 2004; Izquierdo *et al.,* 2006). Total saturated fatty acids and oil concentration were considerably influenced by planting date, hybrid and nitrogen rate in sunflower (Zheljazkov *et al.,* 2009). An earlier planting date may reduce the total saturated fatty acids and increase oil content of sunflower in Mississippi (Zheljazkov *et al.,* 2009). Water stress significantly increased oleic acid content in the high oleic hybrids reducing the dry matter and oil accumulation phases (Baldini *et al.,* 2002).

Planting dates also influenced oil and fatty acid composition significantly in sunflower. Overall, spring plantation accumulated higher oil and oleic acid in comparison with autumn planting. However, autumn planting accumulated less oil but higher linoleic acid which depicted an inverse relationship of oleic and linoleic acid (Hasan and Ahmad, 2003). In autumn, late August planting accumulated the maximum linoleic and the minimum oleic acid. In spring, late April planting exhibited the highest oleic and least linoleic acid (Qadir *et al.,* 2006). Ahmad and Hassan (2000) found higher oil contents in sunflower hybrids that matured and were harvested at higher temperatures of June as compared with those that matured and were harvested in April. Storage protein increase and oil profile in Sunflower were studied by Pleite *et al*., (2005), 17 and 24 days after anthesis (DAA) were preferred to represent early and late periods of oil addition. Starch content was less than 1.6% of the collective total protein and oil content during seed development. Oil increase was basically normal between 12 and 25 DAA (days after anthesis) and then stop. The main time of protein deposition was between 15 and 25 DAA but frequent up to 31 DAA. Cultivar differences in mature achene oil concentration imitate variations in pericarp amount and thickness and mature embryo oil concentration.

Maize

Maize is indigenous to Americas and for the native Americans, it has been principal food grain. Its grain constitutes about 9.7396 % grain protein, 4.85% grain oil, 9.4392% grain crude fibre, 71.966% grain starch, 11.77% embryo while fodder contains 22.988% acid detergent fibre, 51.696% neutral detergent fibre, 28.797% fodder cellulose, 40.178% fodder dry matter, 26.845% fodder crude fibre, 10.353% fodder crude protein and 9.095% fodder moisture (Ali and Ahsan 2015; Ali *et al*., 2012; Ali *et al*., 2013ab; Ali *et al*., 2014abcd; Mustafa *et al.,* 2013). Fatty acid accumulation in the endosperm, pericarp and germ portions of the developing corn kernels was analyzed by Saoussem *et al.,* (2009). They recommended that buildup array of oil content was unlike in these 3 grain portions. The quantity of oil was highest in the endosperm (2.2%), germ (34.3%) and pericarp (10.8%) portions were noticed at 20, 40 and 30 days after pollination likewise lipid accumulation, achene Structure and development in Sunflower cultivars were considered by Mantese *et al.,* (2006). Varieties differ in quantity of protein body and embryo and oil build dynamics throughout achene development lie beneath differences in oil content in embryo. Cultivar differences in protein body quantity and embryo and oil mass dynamics throughout achene growth lie beneath variations in embryo oil concentration. An experiment was conducted by Adugna and Labuschagne (2003), concluded that oil content was substantially and absolutely related with quantity of polyunsaturates (linoleic and linolenic), while it showed inverse relation with saturated (palmitic and stearic) fats.

Oil content showed weak constructive association with monounsaturated oleic acid. The same consequences were observed by Okporie and Oselebe, (2007) in Maize. Higher concentration of oil in certain cultivars of maize (*Zea mays*) is due to an enlarged embryo structure (Ekman *et al.,* 2008). It was found that oil content was definitely and considerably associated with plant and ear heights and days to silking in some varieties. Oil and plant height, ear height and days to silking propose that as protein or oil content was increased, plant and ear height was also increased and oil content also increased as maturity increased. Grain oil concentration in maize is not influenced by intercepted radiation (Andrade and Ferreiro 1996).

Conclusions

After comprehensive review it was concluded that genetics and locations showed substantial influence on oil and protein contents. Seed yield, oil contents and composition, accumulation of saturated fats, protein content are affected by prevailing environmental conditions like temperature, solar radiation, and precipitation during growth especially after anthesis. Abrupt climate changes alter both quantity and composition of oil in oilseeds. Cool temperature augments the amount of oil and polyunsaturated fats and lower protein content in oilseed crops while higher temperature upsurges the concentration of saturated and monounsaturated fats and lower oil content and polyunsaturated fats in canola. Climatic conditions have more pronounced impact on oil and protein content than glucosinolates. Low temperature and rainfall reduce oleic acid concentration in canola. Incidence of frost reduces oil content and linolenic acid and aguments palmitic acid concentration in canola. Seed at appropriate availability of water exhibit more oil while shortage reduces its concentration.

Drought at seed filling reduces oil content, oleic and linoleic acids whereas it increase protein content, glucosinoles and stearic acid in *B. napus*. Salinity reduces concentration of polyunsaturated fatty acids while enhances monounsaturates. Elevated temperature augments quantity of both saturated and monounsaturated fatty acids in canola while lower daily temperature results in higher linoleic levels. Sulphur availability has marked impact on erucic acid. Higher temperature in late flowering reduces erucuc acid. Frost at ripening augments palmitic acid while it decreases oil content and linolenic acid in canola. Oleic acid content is linearly correlated with cooler temperature and high precipitation. Oil content was higher in seed positioned at 5-27 Siliques while seed from 27 and above position revealed altered fatty acid composition. Glycolipids, phospholipids, oleic acid and free fatty acids increase in the seeds from siliqua position 27 and above while erucic acid decrease.

Cottonseed composition is affected by variety, planting date and irrigation. Quantity of gossypol in cotton seed differ with location and is higher in cultivars with high oil content. Oil content increases linearly with amount of rain. Concentration of unsaturates was similar in both BT and non-BT varieties. BT gene has no significant impact on oil content but contribute in increasing oleic acid concentration.

Oil content and tocopherol decreased from peripheral to middle and central whirls in sunflower head. Seeds from inner whirls showed higher linoleic acid and lower oleic acid. Elevated temperature at maturity increases quantity of oleic and linoleic acids in sunflower hybrids. Oleic acid decreases while linoleic acid increases in maturing seeds as well as during drought. Higher temperature limits the period for rays capture and consequently decreases oil quantity in seed. Temperature above 30°C significantly reduces oil content. Higher nitrogen and drought at grain filling increase protein and decrease oil content. Biofertilizer enhances unsaturated and reduces saturated fatty acids. Potassium increase oil content and linoleic acid. Total saturated fatty acids and oil content were significantly affected by planting date, hybrid and nitrogen rate in sunflower. Early sowing reduces the total saturated fatty acids and increase oil content of sunflower. Spring sown sunflower crop accumulated higher oil and oleic acid but less linoleic acid in comparison with autumn planting. Oil content and monounsaturates have weal relationship. Oil content showed significant realtion with olant and ear height and silking days in maize.

References

1. Adugna W, Labuschagne MT. 2003. Association of linseed characters and its variability in different environments. J. Agri. Sci. 140: 285-296.
2. Aguirrezabal LAN, Lavaud Y, Dosio GAA, Izquierdo NG, Andrade FH, González LM. 2003. Intercepted solar radiation during seed filling determines *sunflower* weight per seed and oil concentration. Crop Sci. 43:152–161.
3. Aguirrezábal LAN, Martre P, Pereyra-Irujo G, Izquierdo N, Allard V. 2009. Management and Breeding Strategies for the Improvement of Grain and Oil Quality. In: Grain, Oil and Protein Quality. N Izquierdo. Ed. Elsevier Inc. pp. 387-421
4. Ahmad R, Saeed M,Ullah E, Mahmood T. 1999. Effect of potassium on protein, oil and fatty acid contents in two autumn planted sunflower

hybrids. International j. of Agri. and Biol. 1(4):325-327.
5. Ahmad S, Hassan FU. 2000. Oil and fatty acid composition of spring sunflower under rainfed conditions. Pak. J. Bio. Sci. 4(12): 2060-2063.
6. Ahmed A, Abdin MZ. 2000. Effect of sulphur application on lipid, RNA and fatty acid content in developing seeds of rapeseed (*Brassica campestris* L.). Pl. Sci., 150: 71–76.
7. Alfred Q, Liu HY, Xu H M, Li JR, Wu JG, Zhu SJ, Shi CH. 2012.Mapping of quantitative trait loci for oil content in cottonseed kernel. J. Genet. 91(3):1-7.
8. Ali Q, Ashraf M, Anwar F. 2009. Physico-chemical attributes of seed oil from drought stressed sunflower (Helianthus annuusL.) plants. Grasas y Aceites, 60 (5), 475-481.
9. Ali Q., M. Ahsan and J. Farooq. 2010a. Genetic variability and trait association in chickpea (Cicer arietinum L.) genotypes at seedling stage. Electronic J. Pl. Br., 1 (3): 334-341.
10. Ali Q., HG Abbas, J Farooq, MHN Tahir and S Arshad. 2010b. Genetic analysis of some morphological traits of Brassica napus (Canola). Electronic J. Pl. Br., 1 (5): 1309-1319.
11. Ali Q. and Ahsan, M. 2015. Correlation analysis for various grain contributing traits of *Zea mays*. Afric. J. Agric. Res., 10(23), 2350-2354.
12. Ali Q, Ahsan M, Ali F, Aslam M, Khan NH, Munzoor M, Mustafa HSB, Muhammad S. 2013a. Heritability, heterosis and heterobeltiosis studies for morphological traits of maize (Zea mays L.) seedlings. Adv. life sci., 1(1): 52-63.
13. Ali Q, Ahsan M, Ali F, Mubashir M, Nazar HK, Shahzad MAB, Sher M and Hafiz SBM. 2013b. Genetic advance, heritability, correlation, heterosis and heterobeltiosis for morphological traits of maize (Zea mays L). Albania Agriculture Research Journal. 12 (4): 689-698.
14. Ali Q, Ali A, Ahsan M, Ali S, Khan NH, Muhammad S, Abbas HG, Nasir IA, Husnain T. 2014d. Line × Tester analysis for morpho-physiological traits of Zea mays L. seedlings. Adv. life sci., 1(4): 242-253.
15. Ali Q, Ali A, Awan MF, Tariq M, Ali S, Samiullah TR, Azam S, Din S, Ahmad M, Sharif NM, Muhammad S, Khan NH, Ahsan M, Nasir IA and Hussain T. 2014b. Combining ability analysis for various physiological, grain yield and quality traits of *Zea mays* L. Life Sci J 11(8s):540-551.
16. Ali Q, Ali A, Waseem M, Muzaffar A, Ahmad S, Ali S, Awan MF, Samiullah TR, Nasir IA, and Tayyab H. Correlation analysis for morpho-physiological traits of maize (*Zea mays* L.). Life Sci J 2014c;11(12s):9-13.
17. Ali, Q., Ali, A., Tariq, M., Sarwar, B., Ahmad, M., Awaan, M. F., & Husnain, T. 2014a. Gene Action for Various Grain and Fodder Quality Traits in Zea Mays. Journal of Food and Nutrition Research, *2*(10), 704-717.
18. Ali, Q., M. Ahsan, M.H.N. Tahir and S.M.A. Basra, 2012. Genetic evaluation of maize (*Zea mays* L.) accessions for growth related seedling traits. *IJAVMS,* 6: 164-172.
19. Alkio M, Diepenbrock W, Grimm E. 2002. Evidence for sectorial photoassimilate supply in thecapitulum of sunflower (*Helianthus annuus*). New Phytolo.156: 445–456.
20. Alkio M, Grimm E. 2003. Vascular connections between the receptacle and empty achenes in sunflower (Helianthus annuus L.) J. Exp. Bot. 54(381): 345-348.
21. Amin R, Khalil SK. 2005. Effect of pre and post-emergence herbicides and row spacing on Canola. Sarhad J. Agric. 21: 165-170.
22. Andrade FH, Echarte L, Rizzalli R, Della MA, Casanovas M. 2002. Kernel number prediction in maize under nitrogen or water stress. Crop Sci. 42:1173–1179.
23. Andrade FH, FerreiroM.A. 1996. Reproductive growth of maize, *sunflower* and soybean at different source levels during grain filling. Field Crops Res. 48:155–165.
24. Angadi SV, McConkey BG, Ulrich D, Cutforth HW, Miller PR, Entz MH, Brandt SA, Volkmar K. 1999. Developing viable cropping options for the semiarid prairies. Project Rep. Agric. Agri-Food Can., Swift Current, SK.
25. Anonymous. 2012-13. Economic Survey of Pakistan. Govt. of Pakistan, Finance and Economic Affairs Division, Islamabad, Pakistan.
26. Anonymous. 1983. Growth Stages of the Canola, Chapter 3 - Growth Stages Academic Press Canada. http://www.canolacouncil.org/chapter3.aspx.
27. Arieli A. 1998. Whole cottonseed in dairy cattle feeding: a review. Anim. Feed Sci. Tech. 72:97–110.
28. Ash M, Dohlman E. 2006. Oil crops situation and outlook yearbook. Electronic outlook report from the Economic Research Service. United States Department of Agriculture, Washington, USA.
29. Ashraf M, Mehmood S. 1990. Response of four *Brassica* species to drought stress. Environ. Expt. Bot. 30: 93-100.
30. Aslam MN, Nelson MN, Kailis SG, Bayliss KL, Speijers J, Cowling WA. 2009. Canola oil increases in polyunsaturated fatty acids and decreases in oleic acid in drought-stressed

Mediterranean-type environments. Plant Breed. 128(4): 348–355.
31. Azhar FM, Ahmad M. 2000.Inheritance pattern of cotton seed oil in diverse germplasm of *G. hirsutum* L. Pak. J. Biol. Sci. 3, 1250–1252.
32. Baldini M, Giovanardi R, Tahmasebi-Enferadi S, Vannozzi GP. 2002. Effects of water regimes on fatty acid accumulation and final fatty acid composition in the oil of standard and high oleic sunflower hybrids. Ital. J. Agron. 6:119-126.
33. Baydar H, E Sabri. 2005. Influence of seed development and seed position oil, fatty acids and total tocopherol content in sunflower. Turkish J. of Agri. Forestry. 29: 179-186.
34. Bernardi LC, Goldblatt LA. 1980. Gossypol. p. 183–237. *In* I.E. Liener (ed.) Toxic Constituents of Plant Foodstuffs. 2nd edition. Academic Press, New York, NY.
35. Bhardwaj HL, Hamama AA. 2003. Accumulation of glucosinolate, oil and erucic acid in developing Brassica seeds. Ind. Crop Prod. 17:47-51.
36. Bouchereau A, Clossais-Besnard N, Bendaoud A, Leport L, Renard M. 1996. Water stress effects on rapeseed quality. European J. of Agro. 5, 19 – 30.
37. Brown PW, Zeiher CA, Silvertooth J. 1995. Response of Upland cotton to elevated night temperatures. I. Results of field studies. In ‘‘Proceeding of the Beltwide Cotton Conferences’’ (C. P. Dugger and D. A. Richter, Eds.), p. 1129. National Cotton Council of America, Memphis, TN.
38. Bybordi A, Tabatabaei SJ, Ahmedov A. 2010. Effects of salinity on fatty acid composition of canola (Brassica napus L.). J. Food, Agric. & Environ. 8 (1): 113-115.
39. Champolivier L, Merrien A. 1996. Effects of water stress applied at different growth stages to Brassica napus L. var. oleifera on yield, yield components and seed quality. European Journal of. Agronomy 5 (3 - 4): 153 - 160.
40. Chauhan JS, Meena ML, Maheskumar S, Meena DR, Maharaj S, MeenaSS, Singh KH. 2010. Heat stress effects on Morpho-physiological characteristics of Indian mustard (*Brassica juncea* L.). http://www.australianoilseeds.com.
41. Chen C, Jackson G, Neill K, Wichman D, Johnson G, Johnson D. 2005. Determining the feasibility of early seeding canola in the Northern Great Plains. Agron. J.97: 1252–1262.
42. Cherry JP, Leffler HR. 1984. Seed. p. 511–569. *In* R.J. Kohel and C.F. Lewis (eds.) Cotton. ASA, CSSA, and SSSA, Madison, WI.
43. Cherry JP. 1983. Cottonseed oil. J. Am. Oil Chem. Soc. 60:362–367.
44. Chung HC, Yeea YJ, Kimb DH, Kimb HK, Chung DS. 1995. Changes of lipid, protein, RNA and fatty acid composition in developing sesame *(Sesamumindicum* L.) seeds. Pl. Sci. 109: 237-243.
45. Colton RT, Skyes JD. 1992. Canola (Agfact p5.2.1) NSW Agriculture, 1-52.
46. Cooper M, Woodruff DR, Phillips IG, Basford KE, Gilmour AR. 2001. Genotype-by-management interactions for grain yield and grain protein concentration of wheat. Field Crops Res. 69:47–67.
47. Dani RG, Kohel RJ. 1989. Maternal effects and generation mean analysis of seed oil content in cotton (*Gossypiumhirsutum*L.). *Theor. Appl. Genet.* 77, 569–575.
48. Daun JK, Clear KM, Williams P. 1994. Comparison of three whole seed near-infrared analyzers for measuring quality components of canola seed. J. Am. Oil Chem. Soc. 71: 1063-1068.
49. Dehnavi MM, Sanavy SAMM. 2008. Effects of withholding irrigation and Foliar Application of Zinc and Manganese on Fatty Acid Composition and Seed Oil Content in Winter Safflower. 7th International Safflower Conference, Wagga Wagga, New South Wales, Austeralia.1-6
50. Demurin Y, Škori D, Verešbaranji I, Joci S. 2000. Inheritance of increased oleic acid content in sunflower seed oil. Helia 23(32): 87-92.
51. Demurin Y, Skoric D, Kariovic D. 1996. Genetic variability of tocopherol composition in sunflower seeds as a basis of breeding for improved oil quality. Plant Breeding. 115: 33-36.
52. Demurin YN. 1986. Phenotypic variability and correlation between tocopherol content and some biochemical characters in sunflower seeds. Sci. Tech. Bull. 93: 21-24.
53. Deng, X, Scarth R. 1998. Temperature effects on fatty acidcomposition development of low-linolenic oil seed rape. (*Brassicanapus* L.), J. Amer. Oil Chem. Soc., 75 (7): 759-766.
54. Diepenbrock W. 2000. Yield analysis of winter oilseed rape (*Brassica napus* L.): A review field crop research. 67(1): 35-49.
55. Dornbos DL, Jr, Mullen R.E. 1992. Soybean seed protein and oil contents and fatty acid composition adjustments by drought and temperature. J. Am. Oil Chem. Soc. 69:228-231.
56. Dornbos DL, McDonald MB. 1986. Mass and composition of developing soybean seed at five reproductive growth stages. Crop Sci. 26:624-630.
57. Dosio GAA, Aguirrezábal LAN, Andrade FH, Pereyra VR. 2000. Solar radiation intercepted

during seed fi lling and oil production in two *sunflower* hybrids. Crop Sci. 40:1637–1644.
58. Douaud C. 2006. Canola oil gets FDA hearts health claim. http://www.nutraingredients-usa.com/news/ng.asp?n=71182-US-canola-association-Fda-health-claim.
59. Dowd MK, Boykin DL, Meredith WR, JR, Campbell BT, Bourland FM, Gannaway JR, Glass KM, Zhang J. 2010. Fatty acid profiles of cottonseed genotypes from the National Cotton Variety Trials. J. Cotton Sci. 14:64–73.
60. Ekman Å, Hayden DM, Dehesh K, Stymne S. 2008. Carbon partitioning between oil and carbohydrates in developing oat (Avena sativa L.) seeds. J Exp Bot. 59:4247–57.
61. Esmaeilian Y, Sirousmehr AR, Asghripour MR, Amiri E. 2012. Comparison of Sole and Combined Nutrient Application on Yield and Biochemical Composition of Sunflower under Water Stress. International J. of Applied Sci. and Tech. 2 (3):214-220.
62. Flagella Z, Rotunno T, Tarantino E, DI Caterina R, De Caro A. 2002. Changes in seed yield and oil fatty acid composition of high oleic sunflower (*Helianthus annuus* L.) hybrids in relation to the sowing date and the water regime. Eur. J. Agron.17: 221-230.
63. Franklin P, Gardner R, Pearce B, Mitchell RL. 2010. Physiology of crop plants. Scientific Press. 336 pp.
64. Gallup WD. 1927. The gossypol content and chemical composition of cottonseeds during certain periods of development. J. Agri. Res. 34(10): 987-992.
65. Gan Y, Angadi SV, Cutforth H, Potts D, Angadi VV, McDonald CL. 2004. Canola and mustard response to short periods of temperature and water stress at different developmental stages. Can. J. Plant Sci.84: 697-704.
66. Garcés R, Sarmiento C, Mancha M. 1992. Temperature regulation of oleatedesaturase in *sunflower* (*Helianthus annuus* L.) seeds. Planta 186:461-465.
67. Garner WW, Allard HA, Foubert CL. 1914. Oil content of seeds as affected by the nutrition of the plant. J. Agri. Res. 3:227-249.
68. Goffner DR, Cazalis C, Percie DU, Calmes SJ Cavalie G. 1988.^{14}C Photo assimilates Partitioning in Developing Sunflower Seeds. J. Exp. Bot. 39(10): 1411-1420.
69. Goyne PJ, Simpson BW, Woodruff DR, Churchett JD. 1979. Environmental influence on sunflower achene, oil content and oil quality. Aust. J. Agric. Husb. 19: 82-88.
70. Gunasekera CP, Martin LD, Siddique KHM, Walton GH. 2006. Genotype by environment interactions of Indian mustard (*Brassica juncea* L.) and canola (*Brassica napus* L.) in Mediterranean-type environments: I. Crop growth and seed yield. Eur. J. Agron.25: 1-12.
71. Gupta R, Sharma S, Munshi SK. 2009. Physical characteristics and biochemical composition of seeds influenced by their position in different whorls of sunflower head-effect of storage.Helia. 32(50): 135-144.
72. Hall, A.E, 1992. Breeding for heat tolerance. Plant Breed.Rev.**10:** 129-168.
73. Hamilton KA, Pyla PD, Breeze M, Oslon T, Li M, Robinson E. *et al.* 2004 Bollgard II cotton: compositional analysis and feeding studies of cottonseed from insect-protected cotton (*Gossypiumhirsutum* L.) producing the Cry 1Ac and Cry 2Ab2 proteins. J. Agric. Food Chem.52, 6969–6976.
74. Harijan N. 2009. Genetics and stability of cotton seed oil, seed cotton yield, component characters and expression pattern of cry1ac protein, fatty acid profile in Bt and non-Bt cotton (g. hirsutum l.) hybrids. Ph.D Thesis, Genetics and Plant Breeding Department University of Agricultural Sciences, Dharwad, India.
75. Harris HC, McWilliam JR, Mason WK. 1978. Influence of temperature on oil content and composition of sunflower seed. Aust. J. Agri. Res. 29: 1203-1212.
76. Hasan F, Ahmad RA. 2003. Effects of seasonal variations on oil and fatty acid profile of sunflower. Elia. 26(38)159-166.
77. Hassan FU, Ali H, Cheema MA, Manaf A. 2005. Effects of environmental variation on oil content and fatty acid composition of canola cultivars. Journal of Research (Science), Bahauddin Zakariya University, Multan, Pakistan.16 (2): 65-72.
78. Hassan FU, Manaf A, Qadir G, Basra SMA. 2007. Effects of Sulphur on Seed Yield, Oil, Protein and Glucosinolates of Canola Cultivars. Int. J. of Agri. & Biol. 09(3):504-508.
79. Henry JL, Macdonald KB. 1978. The effects of soil and fertilizer nitrogen and moisture stress on yield, Oil and protein concentration of rape. Canadian Journal of Soil Sciences 58: 303-310.
80. Hilditch TP, Williams PN. 1964. Chemical Constitution of Natural Fats, p.207, Chapman and Hall, London.
81. Ichihara KI, Noda M. 1980. Fatty acid composition and lipid synthesis in developing safflower seeds. Phtochem. 19:49-54.
82. Irving D, Shannon M, Breda V, Mackey B. 1988. Salinity effects on yield and oil quality of high-linoleate and higholeate cultivars of safflower. J. Agric. Food. Chem. 36:37–42.

83. Ishikawa G, Hasegawa H, Takagi Y, Taniska T. 2001. The accumulation pattern in developing seeds and its relation to fatty acid variation in soybean. Plant Breeding. 120:417-423.
84. Izquierdo NG, Aguirrezábal, LAN, Andrade FH, Cantarero MG. 2006. Modeling the response of fatty acid composition to temperature in a traditional *sunflower* hybrid. Agron. J. 98:451–461.
85. Izquierdo NG, Dosio GAA, Cantarero M, Lujan J, Aguirrezabal LAN. 2008. Weight per grain, oil concentration, and solar radiation intercepted during grain fi lling in black hull and striped hull *sunflower* hybrids. Crop Sci. 48:688–699.
86. Izquierdo NG, Mascioli S, Aguirrezábal LAN, Nolasco SM. 2007. Temperature influence during seed filling on tocopherol concentration in a traditional *sunflower* hybrid. Grasas y Aceites. 58:170–178.
87. Izquierdo N, Aguirrezábal L, Andrade F, Pereyra V. 2002. Night temperature affects fatty acid composition in *sunflower* oil depending on the hybrid and the phenological stage. Field Crops Res. 77:115-126.
88. Jan A, Khan N, Khan N, Khan I A, Khattak B. 2002. Chemical composition of canola as affected by nitrogen and sulphur. Asian J. Pl. Sci. 1: 519-21.
89. Jasso de Rodriguez, D, Phillips BS, Rodriguez-Garcia R, Angulo-Sanchez JL. 2002. Grain yield and fatty acid composition of sunflower seed for cultivar developed under dry land conditions. P. 139-142. In: J. Janick and A. Whipkey (eds.). Trends in New Crops and New Uses. ASHS Press, Alexandria, VA, USA.
90. Kabbaj A, Vervoort V, Abbott A, Tersac M, Berville A. 1996. Expression of stearate oleate and linoleatedesaturase genes in *sunflower* with normal and high oleic contents. Helia 19:1–17.
91. Kaleem S, Hassan FU. 2010. Seed and oil distribution in different circles of mature sunflower head. Pak J Bot, 42(5): 3005-3014.
92. Kandil A, Ibrahim A, Marquard R, Taha R. 1990. Response of some quality traits of *sunflower* seeds and oil to different environments. J. Agron. Crop Sci. 164:224–230.
93. Khan NU, Hassan G, Kumbhar MB, ParveenA, Ume A, Ahmad W. *et al.* 2007 Gene action of seed traits and oil content in upland cotton (*Gossypiumhirsutum* L.). J. Breed. Genet.39, 17–29.
94. Knowles PF. 1988. Recent advances in oil crops breeding. Applewhite TH. Proceeding of the World Conference on Biotechnology for the Fats and Oil Industry. Ed. American Oil Chemists Society: 35 – 38.
95. Kohel RJ, Cherry JP. 1983. Variation of cottonseed quality with stratified harvests. Crop Sci. 23:1119–1124.
96. Kohel RJ. 1980 Genetic studies of seed oil in cotton. Crop Sci. 20: 784–787.
97. Lajara JR, Diaz U, Quidiello RD. 1990. Definite influence of location and climatic conditions on the fatty acid composition of sunflower seed oil. J. Amer. Oil Chem. 67: 618-623.
98. Lawhon JT, Cater CM, Mattil KF. 1977. Evaluation of the food potential of sixteen varieties of cottonseed. J. Am. Oil Chem. Soc. 54:75–80.
99. León A, Lee M, Rufener G, Berry S, Mowers R. 1996. Genetic mapping of a locus (hyp) affecting seed hypodermis color in *sunflower*. Crop Sci. 36:1666–1668.
100. Li Y, Beisson F, Pollard M, Ohlrogge J. 2006. Oil content of Arabidopsis seeds: the influence of seed anatomy, light and plant-to-plant variation. Phytochem. 67:904–15.
101. Lukonge E, Labuschagne MT, Hugo A. 2007. The evaluation of oil and fatty acid composition in seed of cotton accessions from various countries. J. Sci. Food Agric. 87:340–347
102. Mailer RJ, Cornish PS. 1987. Effects of water stress on glucosinolate and oil concentrations in the seeds of rape (Brassica napus L.) and turnip rape (*Brassica rapa* L. var. silvestris [Lam.] Briggs). Australian J. of Experi. Agri. 27: 707 – 711.
103. Mailer RJ, Pratley JE. 1990. Field studies of moisture availability effects on glucosinolate and oil concentration in the seed of rape (*Brassica napus* L.) and turnip rape (*B. rapa* L. var. *silvestris* (Lam. Briggs). Canadian J. of Plant Sci. 70 (2), 399 - 407.
104. Manaf A, Fayyaz UH. 2006. Effects of sulphur on fatty acid accumulation in *brassica* cultivars. Int. J. Agri. Biol. 8(5): 588–592.
105. Mantese AI, Medan D, Hall AJ. 2006. Achene Structure, Development and Lipid Accumulation in Sunflower Cultivars Differingin Oil Contentat Maturity. Annals Bot. 97(6): 999-1010
106. Marinković R, DozetB, Vasic D. 2003. Sunflower breeding. Monograph,29. Cheesbrough, T.M. (1989). Changes in enzymes for fatty acid synthesis and desaturation during acclimation of developing soybean seeds altered growth temperature. Plant Physiol. 90, 760-764.
107. Marquard R. 1990. Untersuchungentiberdem Einfluss von Sorte und Standort auf den Tocopherogehaltver schiedener Pflanzanole. Fat Sci. Technol. 92:452–455.
108. Matsuzaki T, Iwai S, Koiwai A. 1988. Effects of temperature on seed fatty acid composition in

ovary culture of tobacco. Agric. Biol. Chem. 52: 1283-1285.
109. Mauney JR. 1966.Floral initiation of upland cotton Gossypiumhirsutum L. in response to temperatures. J. Exp. Bot. 17, 452–459.
110. McCartney CA, Scarth R, McVetty PBE, Daun JK. 2004. Genotypic and environmental effects on saturated fatty acid concentration of canola grown in Manitoba. Can. J. Plant Sci. 84: 749—756.
111. Miralles OM, Valero JA, Olalla FM. 1997. Growth, development and yield of five sunflower hybrids. Eur. J. Agron. 6: 47-59.
112. Mirleau-Thebaud V, Scheiner JD, Dayde J.2011. Influence of soil tillage and *Phomamacdonaldii* on sunflower (*Helianthus annuus* L.) yield and oil quality. Pyton. 80: 203-210.
113. Moghadam HRT, Hossein Z, Farshad G. 2011. Oil quality of canola cultivars in response to water stress and super absorbent polymer application. Pesq.Agropec. Trop. Goiânia, 41(4): 579-586.
114. Monotti M. 2003. Growing non-food sunflower in dryland conditions. Italian J. of Agro. 8: 3-8.
115. Morrison MJ. 1993. Heat stress during reproduction in summer rape. Can. J. Bot.**71:** 303–308.
116. Munro JM, Farbrother HG. 1969. Composite plant diagrams in cotton. Cotton. Gr. Rev. 48, 261–282.
117. Munshi SK, Kochhar A. 2008. Carbohydrate metabolism in the sliqua relating to oil-filling in Mustard deeds.J Agron Crop Sci. 172(2).126-136.
118. Munshi SK, Kumari A. 2006. Physical characteristics of siliqua and lipid composition of seeds located at different positions in mature mustard inflorescence. J Sci Food Agric. 64(3): 289-293.
119. Munshi SK, Kaushal B, Bajaj RK. 2003. Compositional changes in seeds influenced by their positions in different whorls of mature sunflower head. J. Sci. Food Agric., 83: 1622-1626.
120. Mustafa HSB, Ahsan M., Aslam M., Ali Q., Hasan E., Bibi T. and Mehmood T. 2013. Genetic variability and traits association in maize (*Zea mays* L.) accessions underdrought stress. J. Agric. Res., 2013, 51(3)
121. Nagao A, Yamazaki M. 1984. Effect of Temperature During Maturation on Fatty Acid Composition of Sunflower Seed, Agric. Biol. Chem. 48:553-555.
122. Norton G, Harris JF. 1975. Compositional changes in developing rapeseed. Planta. 123: 163-174.
123. Nuttal WF, Moulin AP, Townley-Smith LJ. 1992. Yield response of canola to nitrogen, phosphorus, precipitation and temperature. Agron. J., 84: 765–768.
124. Nykter M, Kymalainen HR, Gates F, Sjoberg A-M. 2006. Quality characteristics of edible linseed oil. Review article Agri. Food Sci. 15:402-413.
125. O'Brien RD, Wakelyn PJ. 2005. Cottonseed oil: an oil for *trans*-free options. Food Tech. 16:677–679.
126. Okporie EO,Oselebe HO.2007. Correlation of Protein and Oil Contents with Five Agronomic Characters of Maize (*Zea mays*L.) After Three Cycles of Reciprocal Recurrent Selection. W. J. Agri. Sci.3 (5): 639-641.
127. Onemli F. 2012. Impact of climate changes and correlations on oil fatty acids in sunflower. Pak. J. Agri. Sci. 49(4):455-458.
128. Pahlavni MH, Miri AA, Kazemi G. 2008 Response of oil and protein content to seed size in cotton. *Int* J. Agric. Biol.10, 643–647
129. Pandey SN, Thejappa N. 1975. Study on relationship between oil, protein, and gossypol in cottonseed kernels. J. Am. Oil Chem. Soc. 52:312–315.
130. Petcu E, Arsintescu A, Stanciu D.2001. The effect of drought stress on fatty acid composition in some romanian sunflower hybrids. Romanian Agric. Res. 15:39-43.
131. Pettigrew WT, Dowd MK.2011. Varying planting dates and irrigation regimes alters cottonseed composition. Crop Sci. 51:2155–2164.
132. Pettigrew WT, Dowd MK. 2012. Molecular biology and physiology, interactions between irrigation regimes and varieties result in altered cottonseed composition. The J. of Cotton Sci. 16:42–52.
133. Pleite R, Marilyn JP, Garces R, Martinez-Force E, Rawsthorne S. 2005. The sources of carbonand reducing power for fatty acid synthesis in the heterotrophic plastids of developing sunflower (*Helianthus annuus* L.) embryos**.** J. Exp. Bot., 56 (415): 1297-1303.
134. Ploschuk E, Hall A. 1995. Capitulum position in *sunflower* affects grain temperature and duration of grain filling. Field Crops Res. 44:111–117.
135. Pons WA, Jr, Hoffpauir CL, Hopper TH. 1953. Gossypol in cottonseed: influence of variety of cottonseed and environment. J. Agric. Food Chem. 1:1115–1118.
136. Pospišil M, Škevin D, Mustapic Z, Nakic SN, Butorac J, Matijevic D. 2007. Fatty Acid Composition in Oil of Recent Rapeseed Hybrids and 00-Cultivars. Agriculturae Conspectus Scientificus. 72(3)187-193.

137. Pritchard FM, Norton RM, Eagles HA, Salisbury PA, Nicolas M.1999. The effect of environment on victorian canola quality. 10th International rapeseed congress, Caneberra, Australia.
138. Pritchard FM, Eagles HA, Norton RM, Salisbury PA, Nicolas M. 2000. Environmental effects on seed composition of Victorian canola. Australian J. of Exp. Agric., 40(5): 679 – 685.
139. Pritchard FM, Green A, Norton RM, Salisbury PA, Nicolas M.2013. Effect of high temperatures during seed development on oil composition of mid oleic canola and high erucic acid rapeseed. http://www.australianoilseeds.com/__data/assets/pdf_file/0020/4655/Temperature_effect_on_specialties.pdf.
140. Qadir G, Ahmad S, Fayyaz UH, Cheema MA. 2006. Oil and fatty acid accumulation in sunflower as influenced by temperature variation. Pak. J. Bot., 38(4): 1137-1147.
141. Rahamatalla AB, Babiker EE, Krishna AG, El Tinay AH. 2001. Changes in fatty acids composition during seed growth and physicochemical characteristics of oil extracted from four safflower cultivars. Plant Foods for Human Nutrition J 56:385–395.
142. Ramos LCDS. 1985 A genetic study of cottonseed oil content associated with glanded and glandless strains. Ph.D. thesis, Texas A & M University, College Station, Texas, USA.
143. Reddy KR, Kakani VG, Zhao D, Koti S, Gao W. 2004. Interactive eVects of ultraviolet-B radiation and temperature on cotton growth, development, physiology and hyperspectral reflectance. Photochem. Photobiol. 79, 416–427.
144. Reddy KR, Hodges HF, McKinion, JM. 1997a. A comparison of scenarios for the eVect of global climate change on cotton growth and yield. Aust. J. Plant Physiol. 24, 707–713.
145. Reddy KR, Hodges HF,McKinion, JM. 1997b. Crop modeling and applications: A cotton example. Adv. Agron. 59, 225–290.
146. Reddy KR, Prasad PV, Kakani VG. 2005. Crop responses to elevated carbon dioxide and interactions with temperature. In ''Ecological Responses and Adaptations of Crops to Rising Atmospheric Carbon Dioxide'' (Z. Tuba, Ed.), pp. 157–191.Food Products Press, Binghamton, NY.
147. Reddy KR, Reddy VR, Hodges HF. 1992. Efects of temperature on early season cotton growth and development. Agron. J. 84, 229–337.
148. Reddy VR, Baker DN, Hodges HF. 1991a. Temperature eVects on cotton canopy growth, photosynthesis and respiration. Agron. J. 83, 699–704.
149. Reddy VR, Reddy KR, Baker, DN. 1991b. Temperature eVects on growth and development of cotton during the fruiting period. Agron. J. 83, 211–217.
150. Roche J, Bouniols A, Mouloungui Z, Barranco T, Cerny M. 2006. Management of environmental crop conditions to produce useful *sunflower* oil components. Eur. J. Lipid Sci. Technol. 108:287–297.
151. Rondanini D, Mantese A, Savin R, Hall AJ. 2006. Responses of *sunflower* yield and grain quality to alternating day/ night high temperature regimes during grain fi lling: Effects of timing, duration and intensity of exposure to stress. Field Crops Res. 96:48–62.
152. Rondanini D, Savin R, Hall A. 2003. Dynamics of fruit growth and oil quality of *sunflower* (Helianthus*annuus* L.) exposed to brief intervals of high temperature during grain filling. Field Crops Res. 83:79–90.
153. Santalla EM, Dosio GAA, Nolasco SM, Aguirrezábal LAN. 2002. The effects of intercepted solar radiation on *sunflower* (*Helianthusannuus* L.). Seed composition from different head positions. J. Am. Oil Chem. Soc. 79:69-74.
154. Santalla G, Riccobene I, Aguirrezábal L, Nolasco S. 1995. Influencia de la radiación solar interceptadadurante el llenado de los frutos. 3. Variaciones de la composiciónacídicadentrodel cap ítulo. 1° Congreso Nacional de Sojay 2° CongresoNacional de Oleaginosos, Pergamino, Argentina 2: 15 –22.
155. Saoussem H, Sadok B, Habib K, Mayer P. M. 2009.Fatty acid accumulation in the different fractions of the developing corn kernel. Food Chem., 117(3): 432-437.
156. Sawan ZM, Hafez SA, Basyony AE. 2001 Effect of phosphorus fertilization and foliar application of chelated zinc and calcium on seed, protein and oil yields and oil properties of cotton. Journal of Agricultural Science, 136:2 191-198.
157. Schwartzbeck JL,Jung S, Abbott AG, Mosley E,Lewis S, Pries GL, Powell GL, 2001. Endoplasmic oleoyl-PC desaturase references the second double bond, Phytochemi., 57 (643–652.
158. Schwartze, E. W., and ALSBERG, C. L. 1923. Quantitative variation of gossypol and its relation to the oil content of cottonseed. J. Agri. Res. 25: 285-295, illus.
159. Seiler, G.J. 1983. Effect of genotype, flowering date and environment on oil content and oil quality of wild sunflower seed. Crop Sci. 23: 1063-1068.
160. Sexton PJ, Batchelor WD, Shibles R. 1997. Sulfur availability, rubisco content and

photosynthetic rate of soybean. Crop Sci., 37: 1801–6.
161. Shafii B, Mahler KA, Price WJ, Auld DL. 1992. Genotype x environment interaction effects on winter rapeseed yield and oil content. Crop Science, 32: 922-927.
162. Si P, Mailer RJ, Galwey N, Turner DW. 2003. Influence of genotype and environment on oil and protein concentrations of canola (*Brassica napus* L.) grown across southern Australia. Australian J. Agric. Res. 54: 397–407.
163. Simolenka G, Kuiper PJC. 1977. Effect of low temperature upon lipid and fatty acid composition of roots and leaves of winter rape plants. Plant Physiol. 41: 29-35.
164. Singh M, Singh TH, Chalal GS.1985 Genetic analysis of some seed quality characters in upland cotton. Theor. Appl. Genet.71: 126–128.
165. Singh RP, Giri SN, Prasad PVV, Reddy KR. 2007. Influence of high temperature and breeding for heat tolerance in cotton: A review. Advances in Agronomy. 93:313-385.
166. Skoric D. 1992.Achievements and future directions of sunflower breeding. Field Crops Res. 30: 231-270.
167. Solangy MM, TunioSD, Chutto AB.1999. Studies on sunflower plantation under ridge and flatbed methods.Pak. J. Agric. Engg. & Vet. Sci. 15: 19-22.
168. Soleimanzadeh H, Habibi D, Ardakani MR, Paknejad F, Rejali F. 2010. Response of sunflower (*Helianthusannuus* L.) to drought stress under different potassium levels. World Applied Sci. J. 8: 443-448.
169. Stansbury MF, Hoffpauir CL, Hopper TH. 1953. Influence of variety and environment on the iodine value of cottonseed oil. J. Am. Oil Chem. Soc. 30:120–123.
170. Stansbury MF, Cucullu AF, Den Hartog GT. 1954. Cottonseed contents variation: Influence of variety and environment on oil content of cottonseed kernels. J. Agric. Food Chem. 2:692–696.
171. Steer B, Hocking P, Kortt A, Roxburgh C. 1984. Nitrogen nutrition of *sunflower* (Helianthus*annuus* L.): Yield components, the timing of their establishment and seed characteristics in response to nitrogen supply. Field Crops Res. 9, 219-236.
172. Steer B, Seiler G. 1990. Changes in fatty acid composition of *sunflower* (Helianthus*annuus*) seeds in response to time of nitrogen application, supply rates and defoliation. J. Sci. Food Agric. 51, 11–26.
173. Strecker L, Bieber M, Maza A, Grossberger T, Doskoczynski W. 1997. Aceite de maíz. Antecedentes, composición, procesamiento, refinación, utilización yaspectosnutricionales. Aceites y Grasas, 507–527.
174. Tahmasebi-enferadi S, Rabiei Z, Turi M, Baldini M, Vannozzi GP. 2004. Half-seed analysis for comparing linolenic acıd synthesis between high and low oleic acid sunflower inbred lines. Helia 27:63-72.
175. Tharp WH. 1948. Cottonseed composition-relation to variety, maturity, and environment of the plant. p. 117–156. *In* A. E. Bailey (ed.) Cottonseed and Cottonseed Products. Interscience, New York, NY.
176. Tremolieres A, Dubacq JP, Drapier D. 1982. Unsaturated fatty acids in maturing seeds of sunflower and rape: regulation by temperature and light intensity. Phytochemistry 21: 41 – 45.
177. Tremolieres, H., A. Tremolieres and P. Mazliak. 1978. Effects of light and temperature on fatty acid desaturation during the maturation of rapeseed. Phytochem. 17: 685-687.
178. Troncoso-Ponce, M.A., J. N. Kruger, G. Ratcliffe, R. Garces and E. Martínez-Force. 2009. Characterization of glycolytic initial metabolites and enzyme activities in developing sunflower (*Helianthus annuus* L.) seeds. Phytochem.
179. Turner, J.H., H.H. Ramey, Jr., and S. Worley, Jr. 1976. Influence of environment on seed quality of four cotton cultivars. Crop Sci. 16:407–409.
180. USDA National Cotton Variety Trials. 2009. Available at http://www.ars.usda.gov/SP2UserFiles/ Place/64021500/2009NCVT.pdf (verified 2011).
181. Velasco L, Fernandez-Martínez JM, GarciaRuiz R, Dominguez J. 2002. Genetic and environmental variation for tocopherol content and composition in *sunflower* commercial hybrids. J. Agric. Sci. 139:425-429.
182. Villalobos F, Hall A, Ritchie J, Orgaz F. 1996. OILCROP-SUN: A development, growth, and yield model of the *sunflower* crop. Agron. J. 88:403–415.
183. Walton G, Mendham M, Roberston M, Potter T. 1999. Phenology, physiology and agronomy. In: Canola in Australia: the first thirty years, P. Salisbury, T. Potter, G. McDonald, AG. Green (Eds.). pp. 9-14.
184. Williams JP, Khen MU, Mitchell K, Johnson G. 1988. The Effect of Temperature on the Level and Biosynthesis of Unsaturated Fatty Acid in Diacylglycerols of Brassica napus Leaves, Plant Physiol. 87:904–910.
185. Wilson JM, Crawford RMM. 1974. Leaf fatty acid content in relation to hardening and chilling injury. J. Exp. Bot. 25: 121-131.

186. Wolswinkel P. 1992. Transport of nutrients into developing seeds: a review of physiological mechanisms. Seed Sci. Rese.2: 59-73.
187. Wu J, McCarty JC, Jenkins JN. 2010. Cotton chromosome substitution lines crossed with cultivars: Genetic model evaluation and seed trait analyses. Theor. Appl. Genet.120, 1473–1483. www.naturland.de/fileadmin/MDB/documents/Publication/English/sesame.pdf.
188. Yaniv Z, Schafferman D, ZurIndustrial M. 1995. The effect of temperature on oil quality and yield parameters of high- and low-erucic acid Cruciferae seeds (rape and mustard). Crops and Prod., 3(4): 247-25.
189. Young W, Ron W, Wilen, Peta C. 2004. Bonham-Smith High temperature stress of *Brassica napus* during flowering reduces micro- and megagametophyte fertility, induces fruit abortion, and disrupts seed production. J. Exp. Bot. 55(396): 485-495.
190. Yu J, Yu S, Fan S, Song M, Zhai H, Li X, Zhang J. 2012 Mapping quantitative trait loci for cottonseed oil, protein and gossypol content in a *Gossypium hirsutum* × *Gossypium barbadense* backcross inbred line population. Euphytica.187: 191–201.
191. Zeiher C, Matumba N, Brown P, Silvertooth J. 1995. Response of upland cotton to elevated night temperatures. II. Results of controlled environmental studies. In ‘‘Proceeding of the Beltwide Cotton Conferences’’ (C. P. Dugger and D. A. Richter, Eds.), 1129. National Cotton Council of America, Memphis, TN.
192. Zheljazkov, V.D., Vick, B.A., Baldwin, B.S., Buehring, N., Astatkie, T., Johnson, B., 2009.Oil content and saturated fatty acids in *sunflower* as a function of planting date, nitrogen, and hybrid. Agron. J. 101, 1003–1011.
193. Zimmer, D., Zimmerman, D., 1972. Influence of some diseases on achene and oil quality of *sunflower*. Crop Sci. 12:859.

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