▼ Journal of Research (Science), Bahauddin Zakariya University, Multan, Pakistan.
Vol.16, No.2, October 2005, pp. 65-72 ISSN 1021-1012

EFFECTS OF ENVIRONMENTAL VARIATION ON OIL CONTENT AND FATTY ACID COMPOSITION OF CANOLA CULTIVARS

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Abstract: Oil contents of canola are largely influenced by temperature fluctuations. Longer reproductive phase and cooler temperature at the time of seed development stage of crop is favorable for good quality oil. Three field experiments were conducted one each at the University of Arid Agriculture, Rawalpindi (UAAR), Groundnut Research Station (GRS), Attock and Barani Agricultural Research Institute (BARI), Chakwal, to ascertain the effects of environmental variation on oil content and fatty acid of Canola cultivars. Eight canola cultivars were sown in a randomized complete block design in a net plot size of 5 x 2.7 m. At maturity two central rows were harvested to obtain seeds for chemical analysis. Seeds were analyzed for oil contents (%), fatty acid profile and glucosinolate content (µg g^{-1}) by NMR and colorimetric methods. Results revealed significant differences amongst cultivars, locations and their interaction for oil content and fatty acid profile. The seeds produced at Attock accumulated the maximum oil content (42.15%), oleic acid (59.76%) and least of erucic acid (32.65%). Among cultivars, Shiralee accumulated the maximum oil content (41.81%) and Zafar-2000 the minimum (38.86%), however, Zafar-2000 accumulated the highest percentage of Oleic acid (63.77) and the lowest of erucic acid (21.78).

Keywords: Accumulation, environment, fatty acid, location, oil contents.

INTRODUCTION

Edible oil is a major constituent of our routine daily diet. Pakistan has been facing chronic shortage of it and a large quantity of edible oil is being imported annually from other countries to bridge the gap existing between local production and the consumption. At present, edible oil requirement of the country is around two million tones annually and only about 30 % of it is met by local production [GOP 2004].

Although per capita consumption of oil has increased in the past, it is yet considerably low in Pakistan as compared to that utilized in other countries of the world. Non-true oilseed crops are contributing up to 70 % towards the national edible oil production in the country whereas the non conventional oil seed crops share only 6 % [GOP 2003].

Rapeseed and mustard play an important role in oil seed production, as they are the major group of winter oilseed crops and contribute about 16 % of the domestic edible oil production. Due to the presence of higher erucic acid and glucosinolates, rapeseed and mustard oil is not regular cooking oil. Glucosinolates are sulphur containing compounds that occur predominantly in Brassica spp. [Schung and Haneklaus 1988]. These substances can lower rapeseed cake palatability and thus produce a range of nutritional disorders in farm livestock [Vermorel *et al*. 1986].

Because of the health concerns, with the high erucic acid content only small quantities of the oil were being utilized as edible oil in 1950's. These concerns prompted an intensive breeding program by Canadian scientists to develop cultivars with low erucic acid content. This intensive breeding programme resulted to produce rapeseed cultivars with low erucic acid in the oil and low glucosinolates in the meal.

Erratic and low rainfall, mismanagement of soil moisture and improper utilization of soil moisture are the major factors limiting the crop production under rainfed conditions in Pakistan. The genotypic environment interaction is the key factor in the assessment of crop variety performance in term of quantity and quality of produce. Pritchard *et al*. [2000] determined the effect of environment on the quality of canola. They reported correlation of oil contents were correlated with cooler spring temperatures and higher spring rainfall. Oil contents were lowest in canola grown in hotter regions during dry years and were highest from cooler and wetter regions. Similarly, Deng and Scarth [1998] reported that the contents of saturated and monounsaturated fatty acids in seed oil increased when seed produced under high temperature. Linolenic levels were higher in seed harvested with lower daily temperature. Both temperature and duration of exposure to the temperature during seed development affected the fatty acid composition of the seed in controlled environment study. Plants subjected to high temperature treatment (30/25 ^{0}C day/night) for 40 days produced seed with lowest Linolenic contents and the highest levels of saturated and monounsaturated fatty acids.

Canola type species presently under cultivation respond differently in different agro-ecological zones as these have been bred under low temperature conditions where temperature rises smoothly during period of flowering to maturity. In contrast under our situation sharp increase in temperature from flowering to maturity not only hasten maturity but also causes flower abortion, shattering of siliqua, less quantity of oil accumulation with poor quality oil. The variation in day and night temperatures at which crops are grown, play a decisive role towards quality of produce. It influences the production and utilization of biochemical compounds. Oil contents of canola are largely influenced by temperature fluctuations. Longer reproductive phase and cooler temperature at the time of seed development stage of crop is favorable for high seed yield and good quality oil. Hocking *et al* [1997] observed higher oil concentration in cultivar Junee than Condobolin, due to differences in ambient temperature as there was 2.7 % decrease in oil concentration for each 1 ^{0}C rise in mean temperature during seed filling.

The present study was undertaken to establish the effects of varying environment effects on oil content and fatty acid composition of canola cultivars.

MATERIALS AND METHODS

Three experiments were conducted one each at University of Arid Agriculture, Rawalpindi (UAAR), Groundnut Research Station (GRS), Attock and Barani Agricultural Research Institute (BARI), Chakwal to establish the effect of environmental variations on oil content and fatty acid composition of canola cultivars.

The seed of eight canola varieties viz. Shiralee, Westar, Dunkeld, Zafar-2000, Bulbul-98, Con-II, 19-H and Abaseen were sown in a randomized complete block design with four replications. The crop was sown at Chakwal on 06-10-2003, at Attock on 13-10-2003 and at Rawalpindi on 14-10-2004 in a net plot size 5 m x 2.7 m. Recommended dozes of fertilizer at the rate of 80-40-0 NPK per hectare were applied at the time of last plowing. Crop was sown with hand drill using five kg seed per hectare keeping 45 cm distance between rows. After complete emergence, crop was thinned manually to maintain plant to plant distance of 5-6 cm. At maturity two central rows were harvested to obtain seeds for oil and fatty acid analysis. After drying and cleaning seeds were analyzed for oil contents (%), fatty acid profile and Glucosinolate content ($\mu g\ g^{-1}$) by the methods of NMR and colorimetric methods as described by Madsen [1976] and Smith *et al* [1985] respectively. Data thus collected were statistically analyzed using standard analysis of variance technique and means were compared with LSD at 5% probability [Steel and Torrie 1986].

RESULTS AND DISCUSSION

Cultivars differed significantly from one another for oil content (Table 1). The cultivar Shiralee accumulated the highest oil content (41.81 %) which was statistically at par with Westar, Bulbul-98 and 19-H. The lowest oil content (38.86 %) accumulated by Zafar -2000.

Significant differences were observed among location means (Table 1). The highest oil content (42.15 %) was recorded at Attock that differed significantly from other locations. At Rawalpindi 41.11 % oil content were recorded and the lowest oil content (39.03 %) were obtained at Chakwal.

The interaction between cultivars and locations were also found statistically significant. Data revealed that significantly higher (43.12 %) oil content was accumulated by cultivar Westar at Attock, which was at par with Shiralee, Dunkeld, Bulbul-98 and Abaseen at same location. The lowest oil content (37.51 %) was accumulated by cultivar Zafar-2000 at Chakwal that remained at par with Dunkeld, Bulbul-98 and Abaseen at the same location.

There are three factors during the crop reproductive stage with major impact on the level of oil in canola crop. These are: varieties, soil moisture, and temperature. These factors can be controlled to a large extent by selecting the variety and suitable time of sowing in any region. The impact of temperature on the oil content of canola seed is very simple [Walton 1998].

Table 1: Effect of varying environments on oil and fatty acid composition of canola cultivars.

Treatments	Oil contents (%)	Oleic acid (%)	Linolenic acid (%)	Erucic acid (%)	Glucosinolate content (μg g^{-1})
Cultivars					
Shiralee	41.81	57.30	7.542	38.40	72.10
Westar	40.10	57.64	7.682	35.12	76.88
Dunkeld	40.44	59.20	8.234	32.63	58.67
Zafar-2000	38.86	63.77	8.048	21.78	31.82
Bulbul-98	41.35	59.49	7.468	32.56	63.13
Con-II	40.83	55.81	7.572	41.38	78.14
19-H	41.04	61.73	7.517	28.23	53.97
Abaseen	40.69	53.81	7.500	44.18	72.12
Locations					
Rawalpindi	41.11	57.55	8.026	33.89	66.30
Attock	42.15	59.76	7.142	32.65	58.88
Chakwal	39.03	58.47	7.921	36.31	64.92
Interaction					
Rwp x Shiralee	41.03	57.73	7.792	35.93	49.69
Rwp x Westar	40.53	57.06	8.115	34.67	86.44
Rwp x Dunkeld	40.87	56.20	8.465	35.20	68.82
Rwp x Zafar-2000	40.19	62.20	8.365	20.90	39.87
Rwp x Bulbul-98	42.07	59.63	7.633	29.00	78.14
Rwp x Con-II	42.08	55.60	7.800	40.57	89.46
Rwp x 19-H	42.00	58.71	7.738	30.93	71.34
Rwp x Abaseen	40.15	53.23	8.300	43.93	46.67
Atk x Shiralee	43.02	59.07	7.000	37.01	76.68
Atk x Westar	43.42	58.00	6.865	34.87	60.26
Atk x Dunkeld	42.56	61.87	7.565	28.40	57.75
Atk x Zafar-2000	38.89	64.70	7.713	20.70	28.05
Atk x Bulbul-98	43.16	58.40	6.733	35.16	59.56
Atk x Con-II	40.95	56.05	7.150	40.43	66.06
Atk x 19-H	42.04	64.50	6.913	23.88	39.12
Atk x Abaseen	43.21	55.53	7.200	40.80	83.85
Chk x Shiralee	41.38	55.10	7.832	42.26	90.22
Chk x Westar	39.35	57.86	8.065	35.83	83.93
Chk x Dunkeld	37.90	59.53	8.700	34.30	49.44
Chk x Zafar-2000	37.51	64.40	8.065	23.73	27.54
Chk x Bulbul-98	38.82	60.43	8.040	33.53	51.71
Chk x Con-II	39.47	55.76	7.765	43.15	78.89
Chk x 19-H	39.08	61.97	7.900	29.90	51.46
Chk x Abaseen	38.72	52.67	7.000	47.80	86.00
LSD					
Interaction	1.363	2.900	0.5634	0.5634	17.62
Location	0.9212	1.169	0.3848	0.3848	NS
Cultivars	0.7867	1.675	0.3253	0.3253	10.18

Significant variation for oil content among cultivars, locations and their interactions in present study confirms the earlier finding of Pritchard *et al.* [2000] who determined the effects of environment on the quality of canola. They found that oil contents are correlated with cooler spring temperature and higher spring rainfall. Oil contents were lowest, on average, in canola grown in hotter regions during dry years and were highest in canola from cooler and wetter regions.

Data revealed highly significant differences among cultivar means for oleic acid (Table 1). The maximum oleic acid (63.77 %) was recorded in cultivar Zafar-2000 and it significantly differed from all other cultivars whereas the minimum oleic acid (55.81 %) was recorded in Con-II. Significant differences were observed among locations for oleic acid (Table1). The maximum oleic acid (59.76 %) was recorded at Attock, which also differed significantly from other two locations while the minimum oleic acid (57.55) percentage was recorded at Rawalpindi that was at par with Chakwal.

The interaction between cultivars and locations was also found statistically significant. Data showed that maximum oleic acid percentage (64.70) was recorded in Zafar-2000 at Attock location which was statistically at par with Zafar-2000 at Chakwal and 19-H at Attock while the minimum oleic acid (52.67 %) was recorded in Abaseen at Chakwal.

Data revealed significant differences among cultivars for linolenic acid (Table 1). The maximum linolenic acid (8.243 %) was recorded in Dunkeld, which was at par with Zafar-2000, and these two cultivars differed significant from all other cultivars, the minimum linolenic acid (7.468 %) was recorded in cultivar Bulbul-98. Cultivars Abaseen, 19-H, Con-II, Bulbul-98, Westar and Shiralee were statistically at par to each other for this parameter.

Average linolenic acid percentage for location means differed significantly. The maximum linolenic acid (8.026 %) was recorded at Rawalpindi followed by Chakwal. The minimum linolenic acid (7.142 %) was recorded at Attock, which differed significantly from other two locations.

The interaction between cultivars and locations were also found statistically significant for linolenic acid. The maximum linolenic acid was recorded in cultivar Dunkeld at Chakwal while the minimum linolenic acid (6.732 %) was recorded in Bulbul-98 at Attock. Quality of oil based on fatty acid profile i.e. oleic acid, linolenic acid and erucic acid is considered to be affected by the temperature during flowering to maturity. In present study, similar trend has been noticed. Location, which recorded less average maximum temperature during flowering to maturity, accumulated higher percentage of oleic acid and less of linolenic acid and erucic acid. Significant positive and negative relationship between average maximum temperature and linolenic acid, and oleic acid (Fig. 1 and 2) confirms that these two fatty acids are temperature responsive to a considerable extent but in opposite direction.

Mean values of Cultivar differed significantly from each other for erucic acid (Table 1). The maximum (44.18 %) erucic acid was recorded in cultivar Abaseen which differed significantly from all other cultivars for erucic acid, the minimum (21.78 %) erucic acid was recorded in cultivar Zafar-2000. Average erucic acid percentage for location differed significantly from each other. The maximum erucic acid (36.31 %) was recorded at Chakwal, which differed significantly from Rawalpindi and Attock whereas the minimum erucic acid (32.65 %) was recorded at Attock, which was statistically at par with Rawalpindi.

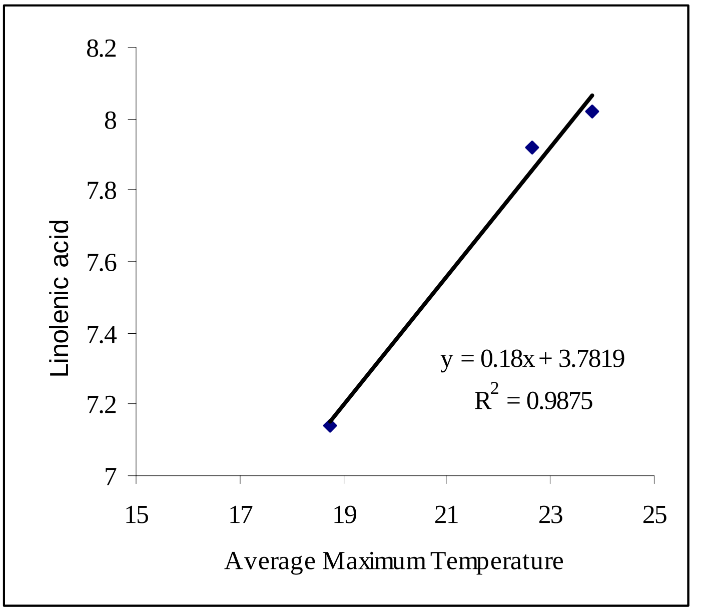

Fig. 1: Relationship between temperature and linolenic acid.

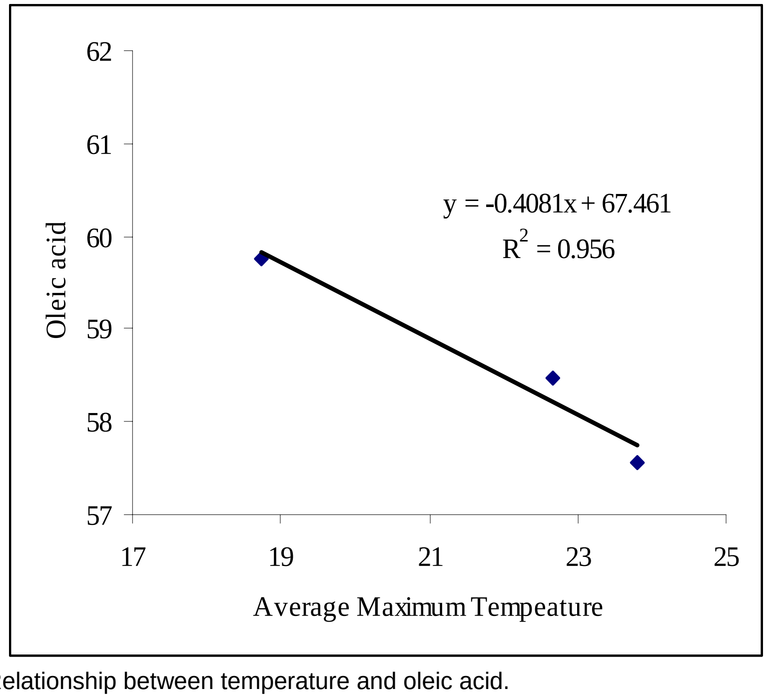

Fig. 2: Relationship between temperature and oleic acid.

The interaction among cultivars and locations was found statistically non significant for mean values of erucic acid. Data revealed significant differences for glucosinolates among cultivars (Table 1). The minimum glucosinolate contents (31.82 µg g^{-1}) were recorded in Zafar-2000. The maximum glucosinolate content (79.86 µg g^{-1}) was recorded in Abaseen and this cultivar was statistically at par with Con-II and Shiralee. Influence of locations towards glucosinolates were found to be non significant.

Performance of locally bred cultivars has been found better than those of exotic. The highest oleic acid and the lowest erucic acid content have been recorded in Zafar-2000. Lower is the erucic acid better is the cultivar. The interaction between cultivars and locations was found statistically significant. The maximum glucosinolate contents (109.10 µg g^{-1}) were recorded in cultivar Abaseen at Chakwal. Where as the minimum glucosinolate content (27.54 µg g^{-1}) were recorded in Zafar-2000 at Chakwal, which is also at par for same cultivar at Attock.

Glucosinolates accumulations have been reported to be affected by water /moisture availability particularly at seed development and maturation stage. [Champolivier and Merrien 1996]. The significant differences among cultivars in present study could by attributed to the over all environmental conditions where experiments were conducted. As canola is considered to be a crop of wetter and cooler regions so the statistically significant differences among cultivars and locations may be the effect of total availability of moisture and temperature throughout crop life cycle. Unusual dryness during seed maturation period might have enhanced the glucosinolates accumulation.

Acknowledgment

Authors thank Pakistan Science Foundation Islamabad for financial assistance to undertake this study.

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