World Journal of Agricultural Sciences 3 (3): 263-268, 2007
ISSN 1817-3047

Agronomic and Economic Performance of Winter Canola in Southeastern US

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Abstract: In the southeast US, winter canola in addition to winter wheat can become another commercial crop with benefits such as breaking of disease and insect cycles caused by continuous wheat cropping. Information on agronomic production practices and comparative profitability of canola and wheat for the southeastern US is lacking. Therefore, from 1998, a series of field experiments were conducted on canola to determine optimum planting date, seeding, nitrogen and sulfur rates, rotation suitability with summer crops and comparative economic value to winter wheat. Results from three planting dates, three seeding rates and four nitrogen rates experiments showed that canola planted in early October produced significantly higher seed yield (3204 kg ha^{-1}) than from mid to late October 10-15 (2362 & 2058 kg ha^{-1}) plantings. The seeding rate of 6.0 kg ha^{-1} and 180 kg Nitrogen ha^{-1} gave the highest (3779 kg ha^{-1}) seed yield. Canola response to sulfur application was significant and highest seed yield (3259 kg ha^{-1}) was obtained with 30 kg S ha^{-1} along with 228 kg N ha^{-1}. As a rotation crop after soybean and corn, canola gave significantly higher yields of 3129 and 2938 kg ha^{-1}, respectively than when planted after cotton (2521 kg ha^{-1}) or grain sorghum (2650 kg ha^{-1}). Both winter canola and wheat produced similar yields of 2.6 and 2.9 t ha^{-1}, respectively. As grain crop, canola with its higher price fetched \$220 ha^{-1} compared to \$109 ha^{-1} from wheat, however, this profitability is almost equal when income from wheat straw was added to that from grain.

Key words: *Brassica* · oil seed crop · rotation · summer crops · winter crops

INTRODUCTION

During the past two decades, production of canola as an oil seed crop has exceeded that of peanut, sunflower, cottonseed and is now second only to soybean [1]. In Alabama and the southeast US, winter wheat is perhaps the only major grain crop grown as a monocrop or in rotation with summer crops. Continuous monocropping of wheat accelerates the build up of insects, disease, weeds and gives low yield. To overcome these limitations and to break disease and insect cycle or build up, there is need to introduce winter canola. Harris *et al.* [2] studied rotational effects of canola on wheat and reported that wheat grown after canola yielded 11% more grain than wheat grown after wheat. In Australia and the UK, winter canola has been successfully used as an alternative crop to winter cereals, particularly to minimize take-all disease (*Ganoderma* spp.) due to continuous monocropping of wheat or wheat grown with other cereals. For southeast US, Raymer *et al.* [3] suggested that winter canola may not only be used to break insect, disease and weed build-up in wheat, but it also may be a more profitable crop than wheat. Canola and wheat need similar machinery and land management practices, which could enable farmers to accept canola as a companion or an alternative crop to wheat. However, introduction and acceptance of a new crop require available agronomic production practices, providing economic benefit in cropping system and more profit to farmers [4]. Due to these reasons, field experiments were carried out with the following objectives to: i) establish agronomic production practices for winter canola, ii) determine canola's performance after rotation with summer crops and iii) evaluate comparative yield and profitability of canola with winter wheat.

MATERIALS AND METHODS

From 1998 through 2005, the following four field experiments were conducted to establish production practices for canola and its comparative production economics with winter wheat.

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Expt. 1: Planting Date, Nitrogen and Seeding Rates Experiment: This two-year study was conducted during 1998 and 1999 growing seasons using canola (cv. Jetton). The land for experimental site was disc harrowed and weeds were controlled by applying Treflan (trifluralin) @ 2.0 l ha^{-1} prior to seeding. Based on soil tests, the recommended rates of P and K were applied before planting. The experiment design was split - plot using a factorial arrangement with four replications, where planting dates as main plots and three seeding and four nitrogen rates were randomized in sub-plots. Individual plots were 6 m long and 1 m wide and consisted of six rows each 20 cm apart. Dependency on rain necessitated using only two planting dates (24 September and 10 October) in 1998, but with use of irrigation, three planting dates (20 September, 1 October and 10 October) were used in 1999. Canola seeds were planted using a four-row planter. Seeding rates were 1.5, 3.0 and 6.0 kg ha^{-1} and nitrogen rates were 0, 60, 120 and 180 kg ha^{-1}. Nitrogen was split applied, half at two weeks after emergence and half at the time of bolting in mid–February. Seeds was combined from whole plots and the seed yield adjusted at 8.5% moisture content was expressed in kg ha^{-1}. The General Linear Model (GLM) procedures of the Statistical Analysis System [5] were used and the means were separated by using Tukey's test.

Expt. 2: Canola and Summer Crops Rotation Experiment: To evaluate the performance of canola as a rotation crop, canola cultivar Jetton was planted after harvest of four summer crops (soybean, corn, sorghum and cotton) for two years from 2002-03 and 2003-04. The rotation experiment consisted of five treatments: (1) Soybean--Canola--Soybean--Canola (Sy-C), (2) Corn--Canola--Corn--Canola (M-C), (3) Sorghum--Canola--Sorghum--Canola (S-C), (4) Cotton--Canola--Cotton--Canola (G-C) and (5) Fallow--Canola--Fallow--Canola (F-C). All treatments were replicated four times and each rotation treatment was in the same fixed place for each year. In 2002, summer crops were planted on May 1 and after harvest of summer crops, canola was planted on September 28. During 2003, summer crops were planted on May 3 and after their harvest, canola was planted on October 2. Based on the soil test recommendations for each crop, lime, N, P and K were applied. Canola (cv. Jetton) was planted on a tilled seedbed with a grain drill at a seeding rate of 6.0 kg ha^{-1}. Soybean (cv. Hutchinson), corn (cv. Pioneer 3160), sorghum (cv. Martin) and RoundupReady® cotton seeds were planted at recommended seeding rate of 68, 9, 9 and 9 kg ha^{-1}, respectively. The plot size for canola and summer crops was 1.06 m × 12.16 m adjusted to fit 4 rows for each summer crop and 6-rows of canola crop. Recommended pre-(Trifluralin) and post-emergence (Sethoxydim) herbicides, each @2.1 l ha^{-1} were used to control weeds.

Soybean were harvested by combining the two middle rows from each plot and seed yield has been reported with moisture level adjusted to 13.0%. Similarly, each of corn and sorghum were combined from the two middle rows and the grain yield was expressed in kg ha^{-1} with adjusted 15.5% moisture content for corn and 12% for grain sorghum. Yield of hand picked cotton (lint + seed) from the two middle rows was recorded in kg ha^{-1}. The yield data of all the crops were analyzed for analysis of variance using SAS program [5] and means were separated by Tukey's test.

Expt. 3: Effects of Nitrogen and Sulfur Rates on Canola: In 2003, 2004 and 2005, the effects of four N (57.0, 114.0, 171.0 and 228.0 kg ha^{-1}) and S (0.0, 11.0, 22.0 and 33.0 kg ha^{-1}) rates were evaluated on canola in a split-plot design with four replications. Sulfur was applied by using ammonium sulfate fertilizer and rates of N requirement were balanced with application of ammonium nitrate. Nitrogen rates were randomized in the main plots and S rates as sub-plots. Half of the N and S were applied at planting time in the fall and the remainder in spring. In well prepared field, P and K were applied according to soil test recommendation. Weeds were controlled by applying recommended pre-(Trifluralin) and post-emergence (Sethoxydim) herbicide. Canola was planted @ 6.0 kg seed ha^{-1} on September 28, October 2 and September 27 in 2002, 2003 and 2004, respectively. Effects of N and S on canola seed yield were recorded and analyzed using SAS program and means were separated by Tukey's test.

Expt. 4: Comparative Yield and Profitability of Winter Canola and Wheat: Two canola cultivars, Flint and Jetton and two wheat cultivars Jackson and Roberts were planted on October 3 and 10 in 2003 and 2004, respectively in plots 21 m x 2.1 m arranged in a Randomized Complete Block Design. Each year, the field was disked twice and harrowed once to make the final seed bed for planting. Each plot comprised of 12 rows spaced 18 cm apart. All treatments were replicated four times. Weed control was achieved by applying preemergence herbicide, Trifluralin @ 1.2 l ha^{-1} in canola plots and Hoelon @ 250 ml ha^{-1} to the wheat plots. Each year, herbicide 3-Way (2, 4-D+ MCPA+ Dicamba) was applied in wheat plots @ 185 ml ha^{-1} to control spring and summer broadleaf weeds. To both crops, Nitrogen @180 kg ha^{-1} was applied in two split applications of 60 kg ha^{-1} at fall and the remaining in early spring. Plants from 1.05 m x 6 m area were combine harvested in 2004 and 2005 to obtain seed yield (adjusted to 8.5% moisture) per hectare.

Cost of production: The itemized cost of production was estimated from published literature for both crops. The cost of production of canola was estimated at $5.00 per 27.3 kg [6] and wheat at the rate of $2.27 per 27.3 kg [7].

Profits: The net profits in US$ ha^{-1} were calculated as the difference between gross returns and cost of production. Gross returns for the two crops were calculated by multiplying seed yield by the price of the commodity in the month of July for the year the crop was harvested. Thus, gross returns for wheat were calculated @ $12.53 and $11.73 per 100 kg in July 2004 and 2005, respectively [8]. Similarly, gross returns from canola for 2004 and 2005 were calculated @ $29.45 and $ 23.62 per 100 kg, respectively [9].

The yield data were subjected to statistical analyses using the GLM procedures of SAS software application [5]. Means were separated by use of Tukey's test at 0.05 level of probability.

RESULTS AND DISCUSSION

Effect of Planting Dates, Seeding and N Rates on Canola: The highest average seed yields of 2362 and 3204 kg ha^{-1} were obtained from early October plantings in 1998 and 1999, respectively. The seed yield differences among years were because the 1998 experiments were rainfed whereas the experiments in 1999 were irrigated. In both years, seed yield was increased as the seeding rates increased (Table 1). The seeding @ 6 kg ha^{-1} and N @ 180 kg ha^{-1} gave the highest seed yield. Such increase in yield with increasing seeding rates has been reported by Potter *et al.* [10]. Early planting beginning September 15 resulted in excessive vegetative growth before winter dormancy, while plantings in late October did not produce sufficient growth for winter dormancy causing severe winter kill, poor stand establishment and final yield in winter canola. The study showed that for maximum yield from winter canola the optimum planting date is between September 30 and October 10.

Table 1: Effect of planting date, seeding and nitrogen rates on canola seed yield

	Year and Planting dates				
	1998		1999		
	Sept. 24	Oct. 10	Sept. 20	Oct. 1	Oct. 15
Treatment†	kg ha^{-1}				
N0 S1	1578h*	1628g2	027h	2230g	1838e
N60 S1	1812fg	2415d	2157g	2746e	1924de
N120 S1	1816fg	1903f	2338f	2516f	2058bc
N180 S1	1906fe	2108e	2356f	2728e	1970dc
Mean	1778	2013	2220	2555	1948
N0 S2	1580h	1909f	3031e	3142d	1958dc
N60 S2	1767g	2472dc	3411dc	3254d	1996c
N120 S2	2309a	2519dc	2962e	3571bc	2194a
N180 S2	2270ab	2462dc	3484bc	3631bc	2219a
Mean	1981	2340	3222	3400	2092
N0 S3	1832fg	2584c	3485bc	3522c	2058bc
N60 S3	1997de	2723b	3336d	3639b	2111ab
N120 S3	2108dc	2462d	3572ab	3685ab	2175a
N180 S3	2190bc	3165a	3632a	3779a	2197a
Mean	2032	2733	3506	3656	2135
Grand mean	1930	2362	2983	3204	2058

* Means within a column followed by the same letter are not significantly different,

† N-Nitrogen rate, S-Seed rate

Table 2: Effect of summer crops rotation on canola yield

	Year			
	2003		2004	
Treatment†	Yield (kg ha^{-1})	Variation from F-C (%)	Yield (kg ha^{-1})	Variation from F-C (%)
Sy-C	2739a*	7.1	3129a	8.8
M-C	2570ab	0.5	2938ab	2.1
S-C	2440b	-4.6	2650bc	-7.9
G-C	2445b	-4.4	2521c	-12.4
F-C	2557ab	–	2876bc	–

*Means within a column followed by the same letter are not significantly different.

†Sy-C, soybean-canola; M-C, corn-canola; S-C, sorghum-canola; G-C, cotton-canola; F-C, fallow-canola.

Influence of Summer Crop Rotation on Canola Yield: Seed yield of winter canola was significantly influenced when planted in rotation with summer crops in comparison to fallow planting in both 2003 and 2004 crop growing years seasons (Table 2). During 2003, the rotational effects on canola seed yield were significantly

Table 3: Effect of nitrogen and sulfur rates on seed yield in canola

	Year			
	2003	2004	2005	Average of years
Treatments	(kg ha^{-1})			
Nitrogen				
N57†	1474d*	2619d	1541d	1878d
N114	2046c	2850c	2074c	2323c
N171	2802b	3027b	2566b	2799b
N228	2969a	3205a	2744a	2973a
Sulfur				
S0††	2158c	2462c	1924d	2181c
S11	2195c	2809b	2056c	2354b
S22	2413b	3171a	2375b	2653a
S33	2525a	3259a	2571a	2785a

*Means within a column followed by the same letter are not significantly different,

†Nitrogen@ 57, 114, 171 and 228 kg ha^{-1}; †† Sulfur @ 0,11,22 and 33 kg ha^{-1}

greater when planted after soybean (2739 kg ha^{-1}) than when planted after cotton (2445 kg ha^{-1}) or sorghum (2440 kg ha^{-1}). The yield differences in canola when planted in rotation after soybean (2739 kg ha^{-1}), corn (2570 kg ha^{-1}), or fallow (2557 kg ha^{-1}) were statistically not significant. During 2004, canola planted after soybean gave the highest seed yield of 3129 kg ha^{-1} and it was significantly higher than the yield of canola planted after sorghum or cotton or fallow. Seed yield of canola planted after corn was significantly higher than canola planted after cotton. In 2003, the canola yield was 7.1% and 0.5% higher when planted after soybean and corn, respectively in comparison to the yield after fallow. The canola seed yield decreased when planted after cotton and sorghum by 4.4 and 4.6% respectively, compared to yield of canola after fallow. Similar decrease in seed yield was observed in canola planted after cotton (-12.4%) and sorghum (-7.9%) in comparison to canola planted after fallow in 2004 as well. Canola planted after soybean and corn produced 8.8 % and 2.1 % more seed yield, respectively, than canola planted after fallow. Guy [11] reported that wheat yields were at least 25% less following wheat than after canola, mustard, crambe, or pea. He who concluded that *Brassica* crops such as mustard, canola and crambe are excellent rotation crops and provide large amount of crop residue that control soil erosion.

Effects of Nitrogen and Sulfur Rates on Canola Yield: The influence of four N and three S rates were studied during three 2002, 2003 and 2005 growing seasons. Results showed that N and S rates significantly influenced canola seed yields (Table 3). Nitrogen at 228 kg ha^{-1} produced 2969, 3206 and 2744 kg ha^{-1} seed yield in 2003, 2004 and 2005, respectively which was significantly higher than at N rates of 57, 114 and 171 kg ha^{-1}. Application of Sulfur at 33 kg ha^{-1} produced 2525, 3259 and 2570 kg ha^{-1} seed yield in 2003, 2004 and 2005, respectively, which was significantly higher than control, 11 or 22 kg of S ha^{-1}. Similar results due to increase in N rates have been reported by Hopkinson [12]. Increased yield with increasing N rate for three out of four years has been reported by Kutcher *et al.* [13]. The authors also concluded that like biomass yield, the seed yield increased with an increase in N rate. Jackson [14] reported that in spring-type canola optimal seed yield occurred with 180 to 220 kg N ha^{-1} range, which was consistent with results reported by Popove [15]. Jackson [14] also reported a linear relationship between total plant yield and N rates, indicating profuse growth of spring-type canola when Nnitrogen supply is unlimited.

Comparative Yield and Profitability of Canola and Wheat: Among canola cultivars, Jetton with a longer vegetative phase produced a seed yield of 3.1 t ha^{-1} in 2003 and 2.3 t ha^{-1} in 2004 (Table 4), whereas Flint produced a seed yield of 2.7 t ha^{-1} in 2003 and 2.1 t ha^{-1} in 2004. Thus, Jetton outyielded Flint by 14.8 % in 2003 and by 9.5% in 2004. Oilseed rape varieties with a longer vegetative phase have been reported to produce greater biomass and outyield early maturing varieties [16]. In this study, Flint had fewer pods and lower seed weight than Jetton (data not shown) which may have been another reason for lower seed yields compared to Jetton. Number of pods, seeds per pod and pod weight determine seed yield of oilseed rape [17]. Among wheat cultivars, Roberts produced a seed yield of 3.1 in 2003 and 3.0 t ha^{-1} in 2004 compared to 2.6 and 2.8 t ha^{-1} by Jackson in 2003 and 2004, respectively. Roberts outyielded Jackson by 19.2% and 7.1% in 2003 and 2004 growing seasons, respectively. Roberts produced greater number of heads m^{-2} (data not shown) than Jackson which may have been the reason for higher grain yields by this cultivar.

The estimated cost of production of canola cultivar Jetton was \$568 and \$421 ha^{-1} in 2003 and 2004, respectively compared to \$495 and \$385 ha^{-1} for Flint in

Table 4: Comparative seed yield, cost and profit from canola and wheat crop

	Seed yield	Production Cost*	Net Profit**
	-------------	----------------------------	----------------------------
Cultivar-Year	ha^{-1}	(US $/ha)	
Canola*t*			
year -2004			
Jetton	3.1a	568	345
Flint	2.7a	495	300
Year -2005			
Jetton	2.3a	421	122
Flint	2.1a	385	111
Wheat			
Year-2004			
Jackson	2.6a	216	110
Roberts	3.1a	258	130
Year-2005			
Jackson	2.8a	233	95
Roberts	3.0a	250	102

*The production cost of canola and wheat were estimated from published work of Waller [9] and Lee *et al.* [7], respectively,

**The net profit for canola and wheat were calculated by following, www.afsc.ca/rdonlyers, 2005 and USDA/NASS, 2005, respectivey

2003 and 2004, respectively (Table 4). Thus, the cost of canola production was commensurate with seed yield, therefore, higher seed yield resulted in higher total production costs. Similarly in wheat, Roberts with higher seed yield also had a higher cost of production than the lower yielding cultivar Jackson. The cost of production for Roberts was $258 and $250 ha^{-1} in 2003 and 2004, respectively, whereas for Jackson the cost of production was $216 and $233 ha^{-1} in 2003 and 2004, respectively. The cost of production of wheat is about two times lower than canola. The production costs of wheat vary from $190 ha^{-1} in western Kansas to about $ 225 ha^{-1}in the southeastern Kansas [18]. Canola production costs are higher than wheat [9] and although the mean seed yield of canola (2.6 Mg ha^{-1}) and wheat (2.9 Mg ha^{-1}) were similar, the cost of canola production in both years was higher than for wheat. The canola production costs based on yields are similar to the estimated cost of production for canola in Georgia [9]. The total cost of production of canola in Mid-Columbia Area was an estimated $581 ha^{-1} [19], which is similar to the estimated production costs in the present study.

The net profits from canola cultivar Jetton was $345 ha^{-1} in 2003 and $122 ha^{-1} in 2004, whereas for Flint, the net profits were $300 ha^{-1} in 2003 and $111 ha^{-1} in 2004 (Table 4). Jetton with higher seed yield fetched higher net profits than Flint in both years. Wheat cultivar Roberts with consistently higher grain yield also fetched higher net returns than cv. Jackson. In 2003 and 2004 growing seasons, the net returns from Roberts were $130 ha^{-1} and $102 ha^{-1}, compared to $110 ha^{-1} and $95 ha^{-1} for Jackson, respectively.

Canola with higher seed yield combined with higher price showed a greater net profit compared to wheat. The mean net return ($220 ha^{-1}) from canola was double the mean net returns from wheat ($109 ha^{-1}). Rife *et al.* [20] reported a 8.76% return on investment for canola crop that yields approximately 2.0 Mg ha^{-1}. In Canada, spring canola yields a little less than wheat, but has a higher price and usually has a greater net profit, depending on transportation costs [1]. For rainfed wheat, the net returns over total production costs ranged from a -$26 ha^{-1} in southeastern Kansas to about $64 ha^{-1} in Western Kansas [18].

Calibrating Profits from Wheat as a Dual Purpose (Grain and Straw) Crop: Wheat could be a dual purpose crop as its straw besides grain is often sold as animal feed, bedding, landscaping, or for mulch [21]. Cultivar Jackson is known to yield about 5.2 t ha^{-1} of straw which if baled (20.5 kg per bale) would make about 254 bales ha^{-1} [7]. The total labor costs in making and handling of straw bales does not exceed $1.00 [21, 22]. At the current off-farm market price of $2.27 per square bale [6], the straw bales could, after deducting labor cost, fetch a net $323 ha^{-1} [2]. Thus, profits from wheat crop grown for grain ($102-135 ha^{-1}) and with grain plus straw ($323 ha^{-1}) could be equal to or higher than the net profits from canola.

CONCLUSIONS

Early October planted canola with seed rate at 6.0 kg and N @180 kg ha^{-1} produced higher yield than seed rate of 1.5 and 3.0 kg with 180 kg N ha^{-1}. Inclusion of winter canola in rotation with traditional summer crops is feasible and more productive after soybean than corn, sorghum and cotton. Differences in seed yield of canola among 180 kg and 228 kg ha^{-1} N rates indicated that the lower nitrogen rate is economical and more profitable than the higher application rate. Canola yield increased significantly with increasing rate of sulfur application. The comparative grain yield of winter canola and wheat were equal but returns from canola are more profitable than wheat however, this profitability from both crops was almost equal when income from straw was added to wheat grain.

REFERENCES

1. Anonymous, 2005. Canola: An emerging oilseed alternative. http://www.jeffersoninstitute.org/pubs/canola.shtml (August 27, 2006).
2. Harris, R.H., G.J. Scammell, W.J. Müller and J.F. Angus, 2002. Crop production in relation to species of previous cropsand management of previous pasture. Australian Journal of Agricultural Research, 53: 1271-1283.
3. Raymer, P.L., D.L. Auld and K.A. Mahler, 1990. Agronomy of canola in the United States. In: F. Shahidi (ed.), Canola and rapeseed: Production, chemistry, nutrition and processing technology. Van Nostrand Rhienhold, New York, pp: 25-35.
4. Johnston, A.M., Donald L. Tanaka, Perry R. Miller, Stewart A. Brandt, David C. Nielsen, Guy P. Lafond and Neil R. Riveland, 2002. Oilseed Crops for Semiarid Cropping Systems in the Northern Great Plains. Agronomy J., 94: 231-240.
5. SAS Institute, 2003. The SAS system for windows. Version 8.2. SAS Inst., Cary, NC.
6. Alford, R., 2007. Southeast Weekly Hay Report. Alabama Department of Agriculture USDA Market News Service, Montgomery, AL. http://www.ams.usda.gov/mnreport/MG_GR310.txt.February 12,2007.
7. Lee, D., T. Johnson, P. Raymer and R. Barnett, 2000. Small grains for non-grain uses. In: Buntin, D.G. and B.M Cunfer (Eds.) Southern Small Grains Resource Management Handbook. UGA-CAES publication B1190. http://pubs.caes.uga.edu/caespubs/pubed/B1190.htm. 2/12/07.
8. USDA/NASS, 2005. http://www.usda.gov/nass/pubs/agstats.htm (August 27, 2006).
9. Waller, B., 2001. Why Should I Participate in the Georgia Oilseed Initiative. Oilseed Reporter, 1: 2-3.
10. Potter, T., D. Kay and I. R. Ludwig, 2000. Effect of row spacing and sowing rate on canola cultivars with varying early vigor. Pro. of the 10th International Research Congress, Australia.
11. Guy, S.O., 1999. Crop residue and durability effects of brassicas and other crops on winter wheat. Proceedings of the 10th International rapeseed Congress, Canberra, Australia.
12. Hopkinson, S., 2001.The effect of planting dates, seeding, and nitrogen rates on yield and quality in canola. Ph.D thesis , Alabama A&M University, Normal, Alabama, USA., pp: 99.
13. Kutcher, H.R., S.S. Malhi and K.S. Gill, 2005. Topography and management of nitrogen and fungicide affects on disease and productivity of canola. Agron. J., 97: 533-541.
14. Jackson, G.D., 2000. Effect of nitrogen and sulfur on canola yield and nutrient uptake. Agronomy J., 92: 644-649.
15. Popove, G.B., 1994. Effects of nitrogen, phosphorus and sulfur on the yield, growth and quality of canola (*Brassica napus* L.). Bozeman: Montana State Univ, 1994 M.S. thesis Thesis.
16. Rao, M.S.S. and N.J. Mendham, 1991. A comparison of Chinoli (*Brassica campestris* ssp. *oleifera* x ssp. *chinensis*) and *B. napus* oilseed rape using different growth regulators, plant densities and irrigation treatments. J. Agric. Sci., Camb., 117: 177-187.
17. Rao, M.S.S. and N.J. Mendham, 1991. Soil-plant-water relations of oilseed rape (*Brassica napus* and *B. campestris*). J. Agric. Sci., Camb., 117: 197-205.
18. Langemeier, L.G., 1997. Profit prospects. In: Wheat Production Handbook. pp. 38-40. C529. Kansas State University Agricultural experiment Station and Cooperative Extension Service. www.oznet.ksu.edu (August 25, 2006).
19. Corp, M. and B. Eleveld, 1999. Enterprise Budget. Canola, Winter (Conventional) Mid-Columbia Area. Bulletin No. 8747. Oregon State University extension Service., Oregon State University, Portland.
20. Rife, C., G. Warmann and W. Heer, 2000. Great Plains Canola Research. Report of Progress 862. Kansas State University Agricultural Experiment Station and Cooperative Extension Service. www.oznet.ksu.edu (August 25, 2006)
21. Trimble, R.L., 1997. Economics of the wheat enterprise in Kentucky. http://www.ca.uky.edu/agc/pubs/id/id125/09.htm. 2/12/07.
22. Economic Research Service, 2005. Oil Crops Yearbook. http://usda.mannlib.cornell.edu/MannUsda/viewDocumentInfo.do?documented=1290.