



Effects of residue management and N-splitting methods on yield and biological and chemical characters of canola ecosystem

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Abstract

Burning or complete removal of crop residues is not a recommended practice for dry area. This action not only reduces soil quality, it can cause ceasing of crop growth and promote weed infestation in the current crop. Experimental researches were conducted in 2006-07 through 2007-08 to evaluate burning, incorporation and removal effects of cereal residues on canola (*Brassica napus* L.) ecological growth, yield productivity and N utilization on clay loam soil. Crop residue management (CRM) was examined at three N levels, in form of N-splitting application (NSA). Burning did not increase yield of canola plants but was able to stimulate growth of certain weed plants. Dry matter of unwanted plants, collected from burning treated plots, was significantly increased when checked over that of other CRM. Weed density was promoted when NSA was added into the system. The results also indicated that wheat stubble, incorporated within the soil, provided an ideal condition for canola growth. The improvement of plant characters with high-yielding efficiency appears to be developed on the plants which grown on incorporated plots. N utilization has been shown to have varied effects on growth development associated with CRM. A significant increase in agronomic performance was detected in conjunction with NSA when a small fraction of crop residues properly remained on the soil. Protein content and the quality of canola oil at the harvested seeds increased when cereal stubbles were incorporated into the soil rather than removed from the soil. In general, the findings showed that returning of right amount of wheat stubbles to the soil in conjunction with N not only exhibited a positive impact on yield and yield components but also increased contents of mineral elements (N, P, K, Zn and Mg) and soil organic matter. The continuity of such process would further improve structure and quality of soil characteristics.

Key words: Canola, crop residue, nitrogen splitting, crop yield, soil nutrient, weed.

Introduction

The choice of appropriate method in order to deal with the crop residues can play a significant effect on the soil properties and thus, may influence the growth and yield of the current crop. In south west of Iran, agricultural soils contain a very poor structure due to texture, lack or inappropriate crop rotation, use of heavy agricultural techniques, low annual precipitation, and high temperature. Removal or burning crop residues, in particular cereal residues, may intensify these problems on the soil in this area. Crop residues are reportedly benefiting the soil quality if it can be used in right way. Short-term growth benefit from burning and removal of wheat stubbles may offset by long-term effect on soil quality. Crop residues are source of organic C and mineral elements that can sustain plant growth and support the activities of soil microorganisms. Crop residue management and N-splitting can play an important role in minimizing soil degradation and improving soil quality in the region. High and sustainable crop production is linked to improved soil physical, chemical and biological properties of soil organic matter²⁹. Shaver *et al.*²⁴ reported that each ton/ha crop residue addition over a 12-year period reduced bulk density by 0.01 Mg/m³ and increased effective porosity by 0.3% and each g/kg of organic C in macro aggregates increased the proportion of macro aggregates by 4.4% in soil layer of 0-25 mm. The fertilizer N equivalent credit from crop residues was suggested as 8-10 kg/

ha for oilseed rape in Denmark²⁸, while Beckie⁴ estimated a 28 kg/ha credit to crops that follow peas.

Moreover, Gangwar *et al.*⁹ reported that crop residue management practices affected organic carbon, available P and K. Higher organic carbon (0.55%) and available P (38.8 kg ha⁻¹) were recorded under residue incorporation while available K (160.6 kg ha⁻¹) was highest by straw burning during the third year. In another study, on average, grain yield was increased by 23.7% and stover yield by 26.7% due to residue incorporation. Residue retention also enhanced N uptake by 28.3% in grain and 45.1% in stover of maize. Furthermore, the soil N fertility was improved by 29.2% due to residue retention²³.

Bahrani *et al.*³ reported that the highest grain yield of corn (15.73 t ha⁻¹) and grains per ear of corn (709.3) were obtained when 25-50% of wheat residues were soil incorporated in the field. Kharub *et al.*¹⁴ reported improvements in wheat yield when straw was incorporated in continuous rice-wheat system on a sandy clay loam. Permanent beds combined with retaining all crop residues in the soil as stubbles have the potential to increase both wheat and maize yields in the Yaqui Valley¹⁷.

Kushvaha *et al.*¹⁶ and Thomison *et al.*²⁷ pointed that retention of a small fraction of above-ground biomass and its incorporation in the soil enhances crop productivity and soil fertility in a cereal-

based tropical dryland agroecosystem. When nitrogen was applied at 4-5 leaf stage or at the beginning of flowering the yield of seed and protein was higher compared to nitrogen application at sowing²⁵. Ayub *et al.*² reported maximum grain yield of 84.31q ha⁻¹ was obtained where nitrogen was applied in three equal splittings (1/3 at sowing, 1/3 at tillering and 1/3 flowering), followed by total application at tillering and at sowing which yielded 80.47 q ha⁻¹ and 80.07 q ha⁻¹, respectively. Open spaces and bare parts of the field-trial are ideal places for weed emergence and weed refuge when mineral and moisture become available to the sites⁵. Kumar *et al.*¹⁵ reported that suppression of growth of Powell amaranth (*Amaranthus powellii* L.) appears to be associated primarily with lower N availability in buckwheat-grown soils. Moreover, Powell amaranth emergence was suppressed by buckwheat residues which might be due to allelopathic compounds concentrated in the shoot tissues. Also, weed communities and dominant species can be changed in response to various N splitting methods when studied under amaranth cultivars. Total weed density and biomass were greatest in amaranth cultivars with semi-equal N treatment (25-50-25%)¹.

Therefore, successful integration of crop residue management strategies into cropping systems requires understanding of the crop residue effects on both soil properties and crop production. This study aimed to evaluate the influence of crop residue management and N-splitting methods on canola early establishment, crop yield, soil nutrients and weed density and dry matter.

Materials and Methods

Site characteristics: A field experiment was conducted for 2 years (2006-2007 to 2007-2008) at the experimental farm of Collage of Agriculture, Shahid Chamran University, Ahvaz, Iran (31°N latitude and 48°E longitude) at an elevation of 20 m above mean sea level. Mean air temperature was 16.99°C and the average annual rainfall is 20.76 mm from November to May. The soil texture of the experimental site was clay loam.

Treatments: Wheat crop was planted in the first year and followed by planting of canola in the second year. Wheat (cv. Chamran) was planted during November and harvested during May. After harvest of wheat, the land was prepared for canola. The experimental design was a randomized complete block with 3 replications as a split plot. The crop residue management treatments (CRM) were on main plots, each 9 × 1.5 m² and different nitrogen splitting application (NSA) treatments were on sub plots, each 3 × 1.5 m².

CRM treatments:

R₁: Incorporated about 30% of the total wheat straw at three months before canola was planted (in site incorporated). Wheat stubble was treated accordingly on designated plots and then all plots were plowed 0.33 m deep.

R₂: Totally eliminated wheat straw residue

R₃: Burnt, about 30% of the total wheat straw at three months before canola planted (in site burning).

NSA treatments:

S₁: 50% pre planted + 50% at 12-leaf stage (50+50)

S₂: 25% pre planted + 75% at 12-leaf stage (25+75)

S₃: 25% pre planted + 50% at 12-leaf stage + 25% pre steam elongation (25+50+50).

The source of nitrogen was urea which applied in form of base and top-dress applications of N 150 kg/ha. The wheat crop seeded at 150 kg/ha⁻¹ and received 110-75-50, N-P-K. Crop yield was 5 Mg/ha. Wheat straw was incorporated into soil at 160 g/m² (about 30% of the total wheat straw yield) or burnt.

In the second year, canola (cv. Hayola 401) was planted during November and harvested during May. The canola population was 600,000 plants/ha and received 95-65-50, N-P-K.

Sampling and analyses: Plant measurements were taken from canola seedling dry matter, seed yield and yield components including quality and quantity parameters, soil nutrients, weed density and dry matter. Canola seedlings were harvested at 14, 28 and 42 days after emergence or based on 1,02; 1,05; 1,08 canola phenological stages²⁶. Then, leaf area and seedling dry weight were calculated for each treatment. Weeds, sampled in 1 m² quadrat per plot, were removed by hand, and then total weed density and dry matter were determined. Soil samples were collected at the end of each crop harvested from the 0 to 30 cm soil layer. Soil organic matter, nitrogen, phosphorus, potassium, zinc and magnesium were measured. Canola plants were harvested manually at the ripening stage. Samples were dried before weighing. Oil and protein percent and oil and protein yield were determined for each plot. Data were proceeded by the analysis of variance using SAS program and treatment means were separated with Duncan test at 5% and 1% level of probability.

Results and Discussion

Growth initiation of canola seedlings: Statistical analysis revealed information in which mean separation procedures indicated a significant difference between CRM treatments with regard to N. N-fertilizer which was applied as NSA contributed a positive impact on the early growth of plant development. The highest (164 g/m²) and the lowest (124 g/m²) foliage dry weight accumulated in the canola plants when the plants were grown on the soil with no stubbles or stubbles were incorporated into the soil, respectively. The usage of 50+50 NSA was able to stimulate growth of canola when the stubbles were either removed from the soil or incorporated into the soil as compared to other NSA treatments (Fig. 1). No significant differences were found on growth at the burning treated plots associated with NSA.

Measurements taken from individual leaf area of the plants in conjunction with various CRM were shown to be promoted by time and during plant's vegetative phase (Fig. 2). However, these growth phenomena happened to be significantly different at the 5%. Larger leaf area (0.3 m²) was observed on the plants when the stubbles were removed completely from the plots, while the least leaf area (0.2 m²) was achieved on the plants when the stubbles were incorporated into the soil.

The results showed that 50+50 NSA was more applicable to stimulate the plant growth development than two other NSA treatments regardless of CRM. In the present study, the dry matter and leaf areas alteration were performed differently in relation to NSA under CRM. The plants which received 50+50 NSA have shown to optimize dry matter which indicated additively growth with a linear response under removal and burning treated plots. Dry yield production was additively affected with non-linear

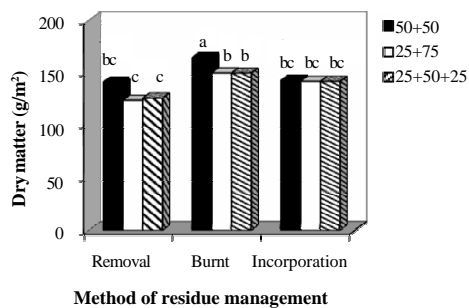


Figure 1. Interaction effect of residue management and N-splitting on dry matter.

Values with the same letter are not significantly different ($p < 0.05$, Duncan).

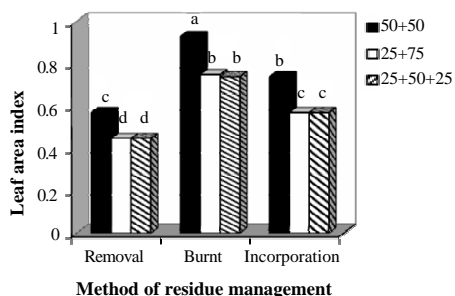


Figure 2. Interaction effect of residue management and N-splitting on leaf area index.

Values with the same letter are not significantly different ($p < 0.05$, Duncan).

response under incorporation-treated plot with same amount of N (Fig. 3a-b). The leaf area alteration had additive effects with a linear response under incorporated and burning treated plots, while the leaf area alterations were additively affected with a non-linear response under removal-treated plots (Fig. 4a-b). In general the results indicated that the healthy leaf areas with maximum dry matter were exhibited at plants grown on the soil with or without crop residues when compared to other treatments under all cases of NSA (Fig. 5a-b).

Soil mineral elements: Identifying an appropriate method to handle the stubbles of previous crops on the soil is a great challenge for the producers who like to minimize negative aspects of remaining crops on the soil and at the same time provide desirable growth condition for current crops. Data presented indicated that the crop residues may increase the average values of soil organic matter and minerals when one is able to use them in an appropriate way (Table 1). Soil organic matter, N, P, K and Zn were significantly improved under CRM at the 1% level, while soil Mg remained unchanged and NSA treatment didn't cause any significant change on the availability of this element.

The results of this study demonstrated that when the stubbles were incorporated into the soil, a positive effect can be achieved for plant growth (Table 2). The information which is generated in regard to incorporation procedure indicated that this method caused to lowering of soil bulk density¹⁰, which force the soil to release organic matter and minerals. The finding in this study is confirmed with the results by other workers^{9, 18, 19}. Although, burning the crop residues is controversial, it has been shown to have a beneficial influence in term of releasing certain minerals

into the soil. In our study the tissue analysis indicated that the plants grown at the burning treated had higher K contents in their leaf tissues than in other treatments (Table 2). The mechanism which is involved in releasing such mineral is not known, but some investigators believe that K might generate from ash of crop stubbles via mineralization under soil base conditions. This result was supported by same finding by DuePreez *et al.*⁶, who documented that in field study of cotton plant the amount of K was higher in burning than not burning treated plots.

N-fertilizer not only promoted mineral elements in the soil, but is usually essential for growth enhancement and maximizes yield production in crops. Nitrogen was added into system, because most of crop residues remained on soils are deficit in available soil nitrogen. The N availability under the presence of soil moisture caused decomposition of crop residues and release certain minerals within the soil. Information provided in this study showed that NSA enhanced organic matter, N, P and K that have direct influence on crop performance (Table 2).

Canola yield and its components: The ANOVA results in Table 3 show that CRM, NSA and CRM×NSA interaction significantly affected the plant biological performance, harvest index and protein and oil performances. The mean separation procedures indicated that there were significantly differences between treatments and these plant characters (Table 4).

Grain yield production was affected by CRM, NSA and their interaction. Yield performance was significant at the 1% level. Although, CRM in conjunction with NSA had positive impact on grain yield, these increases were not consistent for all treatments. When the stubbles were incorporated into the soil with addition of 25+50+25 NSA the highest grain yield was produced, while those plants sown in the soil having no crop residues and receiving 50+50 NSA had the lowest (1964.7 kg/ha) grain yield (Table 4). These results also support the works by other researchers who documented that crop residue incorporation have a positive growth effect on grain yield in short term^{3, 14}. Also, Limon-Ortega *et al.*¹⁷ showed that incorporation of all crop residues into the soil increased the potential of grain yields of wheat and maize. When the data were analyzed to evaluate biological gain in association with CRM the interpretation of the results indicated that the highest and lowest biological gains were accumulated in the plants grown at the incorporated and removal-treated plots (Table 4). Also, Hartkamp and White¹² stated that stubble incorporation increased biomass of maize plants significantly. The interaction of these treatments revealed information that the highest and lowest biological yield were predominantly affected by incorporation of stubble plus 25+50+25 NSA and removal of stubble plus 50+50 NSA, respectively. The actual reason for biological gain increases at 25+50+25 NSA was associated with time and the amount of N (Table 4). Nitrogen added at three consecutive periods to the soil during plant growth phases allowed the plants to uptake N for further growth and extension of secondary branches with more pod production per square metre. The benefits of different levels of N-fertilizer were also documented in an experiment which indicated that N availability within the soil has a direct influence on plant growth. Our findings showed that the positive impact of biological yield concerning the different levels of N-fertilizer was related to N-availability during growing season which causes to delay of senescence and increases carbon fixation in the plants²¹.

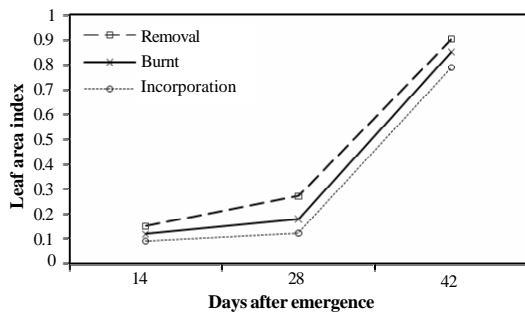


Figure 3a. Effect of residue management on increasing trend of leaf area index in method 50%+50%.

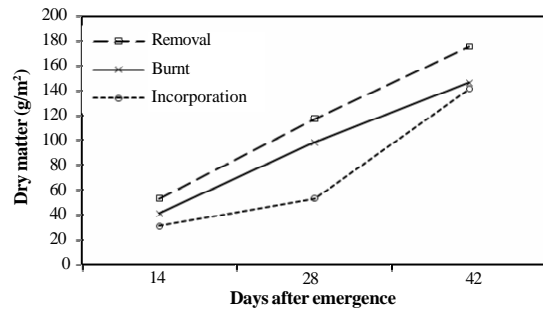


Figure 3b. Effect of residue management on increasing trend of dry matter in method 50%+50%.

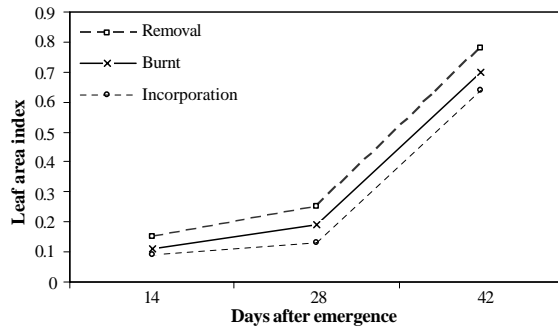


Figure 4a. Effect of residue management on increasing trend of leaf area index in method 25%+75%.

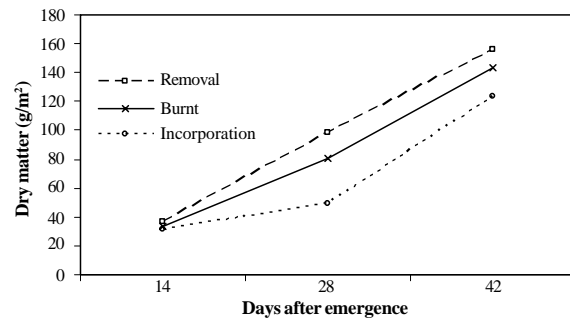


Figure 4b. Effect of residue management on increasing trend of dry matter in method 25%+75%.

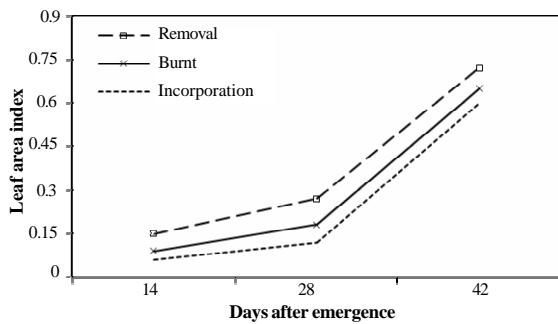


Figure 5a. Effect of residue management on increasing trend of leaf area index in method 25%+50%+25%.

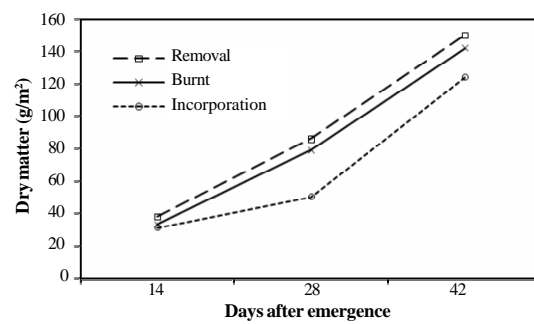


Figure 5b. Effect of residue management on increasing trend of dry matter in method 25%+50%+25%.

Table 1. Analysis of variance and mean for organic matter, N, P, K, Zn and Mg.

S.O.V	DF	Organic matter	Nitrogen	Phosphorus	Potassium	Zinc	Magnesium
Replication (Rep)	2	0.00001 ^{ns}	0.00004 ^{ns}	0.0008 ^{ns}	0.0002 ^{ns}	0.0002 ^{ns}	0.0004 ^{ns}
Crop residue management (CRM)	2	0.1298 ^{**}	0.1644 ^{**}	22.2084 ^{**}	844.84 ^{**}	0.2266 [*]	0.0008 ^{ns}
Error 1	4	0.00013	0.00001	0.0002	0.0048	0.000009	0.00004
Nitrogen Splitting Application (NSA)	2	0.00044 ^{ns}	0.000159 ^{ns}	0.0125 ^{ns}	0.6176 ^{ns}	0.0009 ^{ns}	0.0003 ^{ns}
CRM×NSA	4	0.00051 [*]	0.0006 [*]	0.0061 [*]	0.4228 [*]	0.0001 [*]	0.0001 ^{ns}
Error 2	12	0.000098	0.000023	0.0025	0.0010	0.00001	0.00002

** Significant at the 0.01 level; * Significant at the 0.05 level; ^{ns} Non-significant.

Table 2. Mean comparison of organic matter, N, P, K, Zn and Mg.

	CRM	NSA	CRM×NSA	Organic matter (%)	Nitrogen (%)	Phosphorus (ppm)	Potassium (ppm)	Zinc (meq/lit)	Magnesium (meq/lit)
Control				0.51	0.048	9.60	176.00	1.42	2.1600
	r1			0.72 a	0.063 a	12.61 a	178.23 b	1.73 a	2.1600 a
	r2			0.51 b	0.049 b	9.60 b	176.01 b	1.42 b	2.1600 a
	r3			0.53 b	0.039 c	9.84 b	194.09 a	1.43 b	2.1500 a
		s1		0.58 a	0.051 a	10.79 a	183.99 a	1.59 a	2.1600 a
		s2		0.58 a	0.051 a	10.84 a	183.68 a	1.59 a	2.1600 a
		s3		0.59 a	0.052 a	10.86 a	183.47 a	1.59 a	2.1500 a
			r1s1	0.72 a	0.063 a	12.61 a	177.20 b	1.73 a	2.6113 a
			r1s2	0.71 a	0.062 a	12.61 a	177.30 b	1.72 a	2.6113 a
			r1s3	0.75 a	0.064 a	12.62 a	177.50 b	1.74 a	2.6114 a
			r2s1	0.51 b	0.049 b	9.75 b	176.07 b	1.41 b	2.6113 a
			r2s2	0.52 b	0.050 b	9.70 b	175.80 b	1.42 b	2.6113 a
			r2s3	0.53 b	0.051 b	9.76 b	176.10 b	1.43 b	2.6113 a
			r3s1	0.53 b	0.039 c	9.92 b	194.70 a	1.43 b	2.6113 a
			r3s2	0.52 b	0.039 c	9.93 b	194.90 a	1.42 b	2.6113 a
			r3s3	0.53 b	0.040 c	9.93 b	195.02 a	1.44 b	2.6114 a

Control: Soil sampling before planting.

r1: Incorporated about 30% of the total wheat straw at three months before canola planted (in site incorporated).

r2: Totally eliminated wheat straw residue.

r3: Burnt, about 30% of the total wheat straw at three months before canola planted (in site burning).

s1: 50% pre planted + 50% at 12-leaf stage (50+50).

s2: 25% pre planted + 75% at 12-leaf stage (25+75).

s3: 25% pre planted + 50% at 12-leaf stage + 25% pre steam elongation (25+50+50).

Values with the same letter are not significantly different ($p < 0.01$, Duncan).

Table 3. Analysis of variance and mean for grain yield, biological yield, harvest index, oil percent and oil yield, protein percent and protein yield.

S.O.V	DF	Grain yield	Biological yield	Harvest index	Oil percent	Oil yield	Protein percent	Protein yield
Rep (R)	2	56.68 ^{ns}	56.29 ^{ns}	0.127 ^{ns}	0.007 ^{ns}	0.002 ^{ns}	0.013 ^{ns}	18.145 ^{ns}
Crop residue management (CRM)	2	6392336.29**	30606637.51**	23.761**	30.005**	724892.297**	14.332**	299165.612**
Error 1	4	130.59	392.62	0.130	0.047	74.220	0.013**	81.693
Nitrogen Splitting Application (NSA)	2	1668484.29**	3064960.01**	46.040**	17.923**	149441.160**	18.452**	189044.242**
CRM×NSA	4	230747.95**	111002.01*	16.467**	1.053**	26543.053**	0.325**	13472.288**
Error 2	12	79.87	219.34	0.068	0.050	22.455	0.001	11.686

** Significant at the 0.01 level; * Significant at the 0.05 level; ^{ns} Non-significant.

Although some researchers believe that harvest index may not be considered as a goal, it can be used as a biological tool to estimate crop management, in particular yield potential within crop population⁷. The present research showed that the highest (43.58%) and lowest (40.7%) harvest index were predicted in plant population when canola crop was grown on incorporated and burned treated plots, respectively (Table 4). The levels of NSA also acted differently on the values of harvest index. The use of 25+50+25 NSA had the highest and 50+50 NSA the lowest harvest index (Table 4). The use of N at three consecutive periods during growing season appeared to be an ideal method which plays as an essential source of nutrients for a part of the plant, in particular seed, which is economically important for canola production. Miller *et al.*²⁰ also showed similar results concerning the effect of N on crop growth performance in relation to crop stubbles managements.

In our study we found that protein contents of canola seeds increased drastically when the soil was treated via incorporating the stubbles with addition of 50+50 or 25+50+25 NSA (Table 4). Janzen and Kucey¹³ also documented that seed protein increased when the crop residues were properly incorporated into the soil along with essential plant nutrients. The incorporation of stubbles with adequate moisture caused decomposition of plant materials through mineralization process and tended to release N in the soil. This element becomes an essential source of nutrient for plant growth at the end of vegetative growth and initiation of reproductive cycle that has direct effect on grain protein yield. The highest protein was concentrated in the seeds of the plants which grown at the incorporation when compared to removal and burned treatments (Table 4). The reason for having seeds with high level of protein is maybe associated with excess of the plant available N at the vicinity of roots, which allows the plants to take

Table 4. Mean comparison of grain yield, biological yield, harvest index, oil percent and oil yield, protein percent and protein yield.

CRM	SA	N	CRM×NSA	Grain yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Oil percent (%)	Oil yield (kg/ha)	Protein percent (%)	Protein yield (kg/ha)
r1				3901.1a	8195.16a	47.6a	41.81a	1486.67a	26.2a	937.84a
r2				2618.7b	5890.11c	44.5b	38.26c	966.16c	23.9c	609.05c
r3				2312.6c	6410.44b	36.07c	39.3b	1030.37b	24.15b	636.9b
	s1			2544.3c	6345.44c	40.34c	41.01a	1037.91c	24.01b	608.33c
	s2			2888.2b	6755.66b	42.51b	40.11b	1150.33b	23.83c	686.37b
	s3			3400a	7494.61a	45.36a	38.25c	1294.96a	26.4a	889.11a
		r1s1		3150c	8156a	38.4g	43.15a	1245.82c	25.15c	735.52d
		r1s2		3923b	8976a	43.66c	42.75b	1498.58b	25.2c	908.82b
		r1s3		4630.5a	9553a	48.23a	39.55d	1715.6a	28.25a	1169.2a
		r2s1		2108.5cd	4906b	42.93d	39.65d	909.81i	23.35e	530.28g
		r2s2		2211cd	5142.5b	43.66c	38.2e	945.2h	23.1f	557.17f
		r2s3		2618.5cd	5726.3b	44.90b	37.02f	1043.46e	25.2c	739.72d
		r3s1		1964.7d	5973.8b	39.7h	40.35c	958.1g	23.55d	559.19f
		r3s2		2374.5cd	6148.5b	40.94f	39.4d	1007.2f	23.2f	593.13e
		r3s3		2530.8cd	5726.3b	41.46e	38.15e	1125.8d	25.7b	758.41c

r1: Incorporated about 30 % of the total wheat straw at three months before canola planted (in site incorporated).

r2: Totally eliminated wheat straw residue.

r3: Burnt, about 30 % of the total wheat straw at three months before canola planted (in site burning).

s1: 50% pre planted + 50% at 12-leaf stage (50+50).

s2: 25% pre planted + 75% at 12-leaf stage (25+75).

s3: 25% pre planted + 50% at 12-leaf stage + 25% pre steam elongation (25+50+50).

Values with the same letter are not significantly different (p<0.01, Duncan).

up N during seed formation process. The results of this study were similar to findings by other researchers who documented that there is a strong interdependence of the soil N and later plants growth in determining seed protein²⁷.

In general crop management procedures not only increased seed protein but it also was able to boost oil content with the highest rate in canola seeds at the incorporation treatment (Table 4). Low level of oil tended to be accumulated in the seeds of the plants that grown on the soil with no plant residues. The quantity of canola oil at the harvested seeds increased at two-three folds more when the cereal residues were incorporated into the soil rather than removed from the soil. On the other hand, it has been shown that the inverse relationship of protein and oil may be due to N availability at the later plant growth. When data was analyzed to evaluate these parameters, oil yield depression was observed at the NSA while grain protein yield was considerably increased (Table 4). The cause of imbalance in production for these traits is related to the existence of negative correlation between protein and oil content in grain^{11,28}.

Weed density and dry matter: Based on the values of mean comparisons procedure Table 5 shows that the highest and lowest weed densities per square metre were emerged at the burned and incorporated treated plots, respectively. Maximum and minimum weed populations appeared to be concentrated in the plots which received either 25+50+25 or 50+50 NAS (Table 6). The interaction of these treatments was significant which indicated that the present of weed stand was not same at each crop residue treatment. Burning-treated plot in conjunction with 25+50+50 NSA had the highest weed density compared to other CRM (Table 6). The reasons for weed occupation are related to mineral and

moisture availability, and the heat that generated via burning, causes to break seed-dormancy in some weed species^{8,30}. Under ideal conditions, moisture and soil minerals, in particular N, become available and these seeds are germinated^{1,22}.

Weed dry matter was high in those areas where seedbed was desirable for the plant growth under CRM treatments (Table 6). Accumulation of dry matter was not only affected by CRM but the portion of the weed development was related to N effect, due to N supplied by N-fertilizer. So it was observed that plant-available soil N was the major growth stimulus that given a guarantee for survival of weed species in main crop at the end of growing season^{5,22}. The results of this investigation revealed information concerning N-fertilizer. When the last portion of N was applied to the soil, the plants were in the reproductive phase, that enhanced seed development under CRM treatments. On the other hand it has been observed that the increase of the soil N also helps to improve the quality of seed formation in some of weed plants.

Table 5. Analysis of variance and mean for total weed density and total dry matter.

S.O.V	DF	Total of density	Total of dry matter
Replication (Rep)	2	0.00044 ^{ns}	43.16 ^{ns}
Crop residue management (CRM)	2	74.944 ^{**}	4.728 ^{**}
Error 1	4	2.620	0.845
Nitrogen Splitting Application (NSA)	2	95.765 ^{**}	17.745 ^{**}
CRM×NSA	4	13.300 ^{**}	1.345 ^{**}
Error 2	12	2.120	0.387

** Significant at the 0.01 level; * Significant at the 0.05 level; ^{ns} Non-significant.

Table 6. Mean comparison of total weed density and total dry matter.

CRM	NSA	CRM×NSA	Total of density (Plant/m ²)	Total of dry matter (g/m ²)
r1			6.2 c	64.03 c
r2			7.86 b	73.77 b
r3			13.3 a	181.56 a
	s1		6.5 c	26.77 c
	s2		8.83 b	84.93 b
	s3		12.03 a	108.66 a
		r1s1	4.3 f	40.1 f
		r1s2	6.2 e	59.2 e
		r1s3	8.1 d	92.8 c
		r2s1	6.3 e	56.01 e
		r2s2	8.2 d	72.2 d
		r2s3	9.1 c	93.1 c
		r3s1	9.8 c	92.2 c
		r3s2	12.1 b	123.4 b
		r3s3	18.9 a	140.1 a

r1: Incorporated about 30% of the total wheat straw at three months before canola planted (in site incorporated).

r2: Totally eliminated wheat straw residue.

r3: Burnt, about 30% of the total wheat straw at three months before canola planted (in site burning).

s1: 50% pre planted + 50% at 12-leaf stage (50+50).

s2: 25% pre planted + 75% at 12-leaf stage (25+75).

s3: 25% pre planted + 50% at 12-leaf stage + 25% pre steam elongation (25+50+50).

Values with the same letter are not significantly different (p<0.01, Duncan).

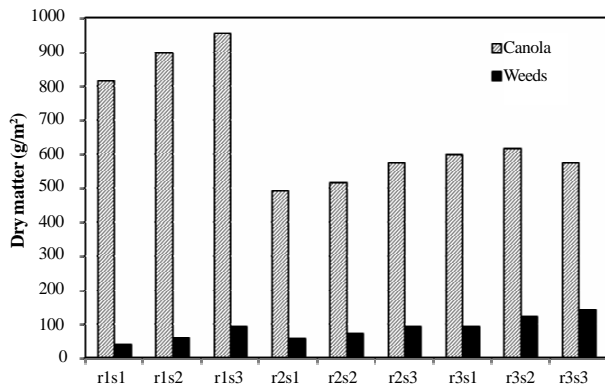


Figure 6. Interaction effect of residue management and N-splitting on dry matter of canola and weeds.

r1: Incorporated about 30 % of the total wheat straw at three monthly before canola planted (in site incorporated).

r2: Totally eliminated wheat straw residue.

r3: Burnt, about 30 % of the total wheat straw at three monthly before canola planted (in site burning).

s1: 50% pre planted + 50% at 12-leaf stage (50+50).

s2: 25% pre planted + 75% at 12-leaf stage (25+75).

s3: 25% pre planted + 50% at 12-leaf stage + 25% pre steam elongation (25+50+50).

Although the measurement of plant characters indicated that such event didn't have a negative impact on the end product of canola crop, it showed from weed ecological standpoints that these weed seeds can either remain in the soil or can be dissipated to other parts of the land. When environmental factors and soil status are in right condition the seeds then would re-emerge and contaminate the next following crops on these soils (Fig. 6).

Conclusions

This study showed that crop residue treatments in conjunction with N utilization have different growth effects on canola plant from seedlings stand up to a mature plant. The results indicated that neither burning nor eliminating of wheat stubbles can be a reliable alternative in south west region of Iran where soil moisture

limits crop production; short-term growth benefits can be offset by long-term negative influence in removing a large amount of carbonaceous residue and depleting soil organic matter. Incorporation or residue returned to the soil can optimize soil moisture and on the other hand tend to increase immobilization of N applied, enhancement of soil minerals and organic matter.

References

- Ayneband, A. 2008. Cultivar and nitrogen effects on amaranth forage yield and weed community. *Pakistan J. Biol. Sci.* **11**:80-85.
- Ayub, M., Sharar, M. S., Tanveer, A. and Khaliq, M. 2001. Growth and yield response of wheat (*Triticum aestivum* L.) to nitrogen application at different growth stages. *J. Biol. Syst.* **1**:92-94.
- Bahrani, M. J., Raufat, M. H. and Ghadiri, H. 2007. Influence of wheat residue management on irrigated corn grain production in a reduced tillage system. *Soil Till. Res.* **94**:305-309.
- Beckie, H. 1997. Field pea magic. Research Letter #97-01. Agriculture and Ari-Food Canada, Research Center, Saskatoon, Saskatchewan, Canada.
- Dhima, K. and Eleftherohorinos, L. 2001. Influence of nitrogen on competition between winter cereal and sterile oat. *Weed Sci.* **49**:77-82.
- DuePreez, C. C., Kotze, E. and Steyn, J. T. 2001. Long-term effects of wheat residue management on some fertility indicators of a semi-arid plinthosol. *Soil Till. Res.* **63**:25-33.
- Eagle, A. J., Brid, J. A., Horwath, W. R., Linqvist, B. A., Broder, S. M., Hiil, J. E. and Kessel, C. V. 2002. Rice yield and nitrogen utilization efficiency under alternative straw management practices. *Agron. J.* **92**: 1096-1103.
- Fernandez, R., Quiroga, A., Noellemeyer, E., Funaro, D., Montoya, J., Hitzmann, B. and Peinemann, N. 2006. A study of effect of the interaction between site-specific conditions-residue cover and weed control on water storage during fallow. *Agric. Water Management.* **95**: 1028-1040.
- Gangwar, K. S., Singh, K. K., Sharma, S. K. and Tomar, O. K. 2006. Alternative tillage and crop residue management in wheat after rice in sandy loam soils of Indo-Gangetic plains. *Soil Till. Res.* **88**:242-252.
- Ghuman, B. S. and Sur, H. S. 2001. Tillage and residue management effects on soil properties and yields of rainfed maize and wheat in a Subhumid subtropical climate. *Soil Till. Res.* **58**:1-10.
- Grant, C. A., Brrown, K., Racz, G. J. L. and Bailey, D. 2002. Influence of source, timing and placement of nitrogen fertilization on seed yield and nitrogen management. *Can. J. Plant Sci.* **82**:629-638.
- Hartkamp, A. and White, J. 2004. Crop residue retention in maize production system. *Agr. Syst.* **82**:117-138.
- Janzen, H. and Kucey, R. 1988. Carbon, nitrogen, and sulfur mineralization of crop residue as influenced by crop species and nutrient regime. *Plant Soil* **106**:34-41.
- Kharub, A. S., Sharma, R. K., Mongia, A. D., Chhokar, R. S., Tripathi, S. C. and Sharma, V. K. 2004. Effect of rice (*Oryza sativa*) straw removal, burning and incorporation on soil properties and crop productivity under rice-wheat (*Triticum aestivum*) system. *Indian J. Agric. Sci.* **74**:295-299.
- Kumar, V., Brainard, D. C. and Bellinder, R. R. 2009. Suppression of powell amaranth (*Amaranthus powellii*) by buckwheat residues: Role of allelopathy. *Weed Sci.* **57**:66-73.
- Kushvaha, C. P., Tripathi, S. K. and Singh, K. P. 2000. Variations in soil microbial biomass and N availability due to residue and tillage management in a dry land rice agroecosystem. *Soil Till. Res.* **56**:153-166
- Limon-Ortega, A., Sayre K. D., and Francis, C. A. 2000. Wheat and maize yields in response to straw management and nitrogen under a bed planting system. *Agron. J.* **92**:295-302.
- Malhi, S. S. and Kutcher, H. R. 2007. Small grains stubble burning and tillage effects on soil organic C and N and aggregation in northeastern Saskatchewan. *Soil Till. Res.* **94**:353-361.

- ¹⁹Mc Ghie, W. J. and Jacobs, B. 2000. The impact of contribution of bacterial and fungal microbial biomass. *Can. J. Microbiology* **21**:314-322.
- ²⁰Miller, P., McConkey, B. and Clayton, G. 2002. Pulse crop adaptation in the Northern Great Plains. *Agron. J.* **94**:261-272.
- ²¹Sahadeva, S. and Saran, G. 1993. Effect of irrigation, nitrogen and sulfur level on the growth, yield attributes, yield quality and water use of trial (*Brassica compestris*). *Indian J. Agron.* **38**:414-421.
- ²²Scursioni, J. and Arnold, R. 2002. Effect of nitrogen fertilization timing on the demographic processes of wild oat in barely. *Weed Sci.* **50**:616-621.
- ²³Shafi, M., Bakht, J., Jan, M. T. and Shah, Z. 2007. Soil C and N dynamic and maize (*Zea mays* L.) yield as affected by cropping systems and residue management in North-Western Pakistan. *Soil Till. Res.* **94**: 520-529.
- ²⁴Shaver, T. M., Peterson, G. A. and Sherrod, L. A. 2003. Cropping intensification in dryland systems improves soil physical properties: Regression relations. *Geoderma* **116**:149-164.
- ²⁵Sidlauskas, G. 2000. The influence of stand population density, nitrogen rates and timing of spring oil rapeseed (*Brassica napus*) seed, protein and fat yield. CAB Abst. 2000/08-2001/04.
- ²⁶Sylvester, R. B., Makepeace, R. J. and Broad, I. 1987. A code stages of development in oil seed rape. *Asp. Appl. Biol.* **6**:399-420.
- ²⁷Thomison, P. R., Geyer, A. B., Bishop, B., Young, J. and Lents, E. 2004. Nitrogen fertility on grain yield, protein, and oil of corn hybrids with enhanced grain quality traits. *Crop Management* doi:10.1094/CM-2004-1124-02-RS.
- ²⁸Thomsen, I. K. and Christensen, B. T. 1998. Cropping system and residue management effects on nitrate leaching and crop yields. *Agric. Ecosystem Environ.* **68**:73-84.
- ²⁹Tripathi, R. P., Sharma, P. and Singh, S. 2007. Influence of tillage and crop residue on soil physical properties and yields of rice and wheat under. *Soil Till. Res.* **92**:221-226.
- ³⁰Whybrew, J. E. 1964. The survival of wild oats (*Avena fatua*) under continuous spring barely growing. *Proceeding of the 7th British Weed Control Conference*, pp. 614-620.