**International Journal of Agricultural Sciences and Natural Resources**
2015; 2(3): 46-51
Published online April 20, 2015 (http://www.aascit.org/journal/ijasnr)
ISSN: 2375-3773

American Association for Science and Technology


**Keywords**
Canola,
Tillage Practices,
Yield,
Rice Harvest

Received: February 14, 2014
Revised: March 7, 2015
Accepted: March 8, 2015

# Canola Yield and Yield Components as Affected by Different Tillage Practices in Paddy Fields

**Mohammad Reza Alizadeh*, Alireza Allameh**

Department of Agricultural Engineering, Rice Research Institute of Iran (RRII), Rasht, Iran

## Email address

alizadeh_mohammadreza@yahoo.com (M. R. Alizadeh)

## Citation

Mohammad Reza Alizadeh, Alireza Allameh. Canola Yield and Yield Components as Affected by Different Tillage Practices in Paddy Fields. *International Journal of Agricultural Sciences and Natural Resources*. Vol. 2, No. 3, 2015, pp. 46-51.

## Abstract

The effects of different seedbed preparation practices in canola planting as a second crop after rice harvest was scrutinized. Experimental treatments included (i) rotivator, once to 10-15 cm deep ($T_1$), (ii) rotivator, twice to 10-15 cm deep ($T_2$), (iii) mouldboard plow to 25 cm deep + rotivator, once to 10-15 cm deep ($T_3$), (iv) no-till planting through removing rice stubbles from plots ($T_4$), and (v) no-till planting without removing rice stubbles from plots ($T_5$). The experiments were laid out in randomized complete block design (RCBD) with five treatments and in three replications. The results revealed that grain yield and yield components (except number of grain per pod and number of branch per plant) were significantly influenced by different tillage practices. The biennial means comparison showed that the maximum and minimum grain yield were associated to $T_3$ (1571 kg ha$^{-1}$), $T_2$ (1537 kg ha$^{-1}$) and $T_4$ (1389 kg ha$^{-1}$) and $T_5$ (1339 kg ha$^{-1}$), respectively. The average grain yield for $T_1$ was 1432 kg ha$^{-1}$. In primary tillage through moldboard plow, soil sticking to plow and tractor rear wheel slippage made a great deal of rugged surface across the field so that it took much time for land leveling. Therefore, rotivator application (once or twice) had acceptable outcomes in such soil moisture contents.

## 1. Introduction

Seedbed preparation is considered as one of the restricting factors in raising canola cultivation as a second crop after rice harvesting. Unlike other crops, using conventional implements for plowing and seedbed preparation (primary and secondary tillage) in paddy fields encounter difficulty. Soil texture and moisture content conditions, heavy seasonal rainfalls, and rice stubbles residues are bounding elements in applying conventional tillage implements. Introducing appropriate tillage practices for canola planting as a second crop after rice craves more attention in order to develop cultivation area, make soil proper conditions for plant growth, and reduce production expenditure per area.

There have been some studies regarding the influence of land preparation methods on canola yield and production costs which would be stated here. Yusuf and Bullock (1993) investigated the effect of two land preparation methods on canola yield. They used harrow and chisel plow for plowing. Their results indicated that tillage method had negligible effect on crop lodging, grain nitrogen, oil, and moisture content percentage at harvest time but grain yields were 3.0 and 2.8 ton ha$^{-1}$ by using harrow and chisel plow, respectively. Kosutic et al., (1995) examined three tillage methods including (i) chisel plow + PTO driven harrow, (ii) chisel plow + rotivator, (iii) rotivator with drill planter in cultivation of wheat, corn, and canola in a silt-loam soil in western part of Slovenia on the view of energy consumption, labor requirement, and grain yield. Their results showed that in cultivation of wheat and canola, using rotivator once with drill planter had the least energy consumption and labor requirement while there was the highest grain yield for canola.

The effect of tillage on plant growth and agricultural crops yield depends not only on crop type but also soil physical condition and each region climate condition. Applying an individual tillage method even for a given crop might be non-applicable for the same crop in other region. There have been different reports concerning the effects of tillage methods on agricultural crops yield. Bonari et al., (1995) compared conventional tillage (CT) with minimum tillage (MT) on a very sandy soil where dedicated to oilseed rape cultivation. They pointed out that the bulk density and penetration resistance of the plowed soil in CT plots was less than that of MT plots. Grain and biomass yields under CT and MT did not differ significantly but root system mass and tap-root length decreased under MT.

The effect of different tillage systems, cultivars, and planting dates were examined by Torabi et al., (2008) on canola yield, oil, soil moisture content, microbial carbon, and nitrogen. They concluded that planting canola under no-tillage and minimum tillage earlier during the fall cropping season might be agronomically more sustainable even if the highest yield derived under conventional tillage.

Fooladi Vand et al., (2009) investigated the impacts of different tillage systems (conventional and conservation tillage), seed rate and spraying time on the grain yield and yield components of rapeseed in dry land conditions. They reported that planting with conventional-till seed drilling; applying 7 kg ha$^{-1}$ seed rate and spraying before stem elongation were optimal choice for arid and semiarid conditions.

In a research, crop yield potential was assessed in accordance with conservation agriculture (CA) and conventional tillage (CT) in rainfed systems (Farooq et al., 2011). The results revealed that there was a slight increase in CA crop yield relative to CT. nevertheless, there are limitations in adopting CA so that more studies is required to determine optimal level of the main components of CA in the different regions. Investigation conducted to assess the effects of three different tillage systems (moldboard plow (MT), chisel (CT), and disc-harrow (DT)) and 50 rapeseed cultivars on rapeseed yield and economic costs (Chiriac et al., 2012; Chiriac et al., 2013). It was found out that MT, in spite of the highest operation cost, was the most efficient tillage method since it resulted in the highest mean yield.

Although, introducing canola varieties with desirable yield and precocity is quite important to gain the highest income from paddy fields but providing soil conditions for planting of these varieties will not be possible unless appropriate tillage methods are applied. Within recent years, on the other hand, attentions have been paid to canola farming after rice harvesting whereas no study has been conducted regarding the effect of tillage method on yield and growth of canola. Therefore, this study aimed to investigate the effect of various tillage practices on yield and yield components of canola as a second crop in paddy field conditions.

## 2. Materials and Methods

The experiments were conducted at paddy fields of Rice Research Institute of Iran, Rasht, Iran, during farming seasons of 2009-2010 and 2010- 2011. Rice harvesting was performed in the late August like past years and rice stubbles residues having roughly 45 cm height were left over across the field by the late September (beginning tillage operations). The experiments were laid out in randomized complete block design (RCBD) with five treatments and three replications. The tested treatments consisted of (i) tillage by rotivator, once in depth of 10-15 cm ($T_1$), (ii) tillage by rotivator, twice in depth of 10-15 cm ($T_2$), (iii) tillage by mouldboard plow in depth of 25 cm + rotivator, once in depth of 10-15 cm ($T_3$), (iv) no till-planting through removing rice stubbles from plots ($T_4$), and (v) no till-planting without removing rice stubbles from plots ($T_5$). In treatment $T_4$, rice stems residues were cut off by labors and transferred to outside of the field. In treatment $T_5$, rice stubbles residues were left over intact across the field.

Agronomic crop management accomplished as instructions for canola cultivation in the region. Before seed planting, in order to compensate soil nutrition deficit, urea and triple super phosphate fertilizers were added to soil as 150 and 150 kg ha$^{-1}$, respectively. Urea fertilizer was applied by 100 kg ha$^{-1}$ in two stages which rated as 50 kg in the beginning of stem longitudinal growth and the other 50 kg at the flowering stage in the form of top dressing. Due to heavy soil texture and moisture content conditions of paddy field, 12 kg ha$^{-1}$ of PF variety was broadcasted manually.

In grain ripening stage, ten plants were selected randomly in each plot and traits such as plant height, the height of the lowest podded branch from soil surface, the number of pods per plant, and the number of branch were determined. In order to determine the number of grains per pod, 30 pods were randomly selected from 10 plants and the number of grains per pods was counted. To measure the weight of 1000 grains, after crop harvesting, eight samples of 100 kernels were selected randomly from each experimental plot. Then, it was obtained by multiplying average of measurements by 10. To specify grain yield, an area of 12 m$^2$ (3 m × 4 m) was harvested from each plot and grains weighted after threshing and cleaning and grain yield was computed on 12 % moisture content and in kgha$^{-1}$. Data analysis of variance and means comparison were carried out in Duncan's multiple range tests at 5 % level by SAS software.

## 3. Results and Discussion

### 3.1. Plant Height

The effect of tillage method on plant height was significant at 1 % level during test years (Tables 1 and 3). Means comparison showed that, for two test years, the maximum plant height was associated to $T_3$ while $T_5$ and T4 had the minimum (Table 2 and 4). $T_2$ and $T_3$ had no significant difference in terms of plant height. Also, $T_4$ and $T_5$ ranked the same. The results of compound analysis indicated that the effect of tillage method on plant height was significant ($p < 0.01$) but the effect of year and interaction of tillage method × year were not significant (Table 5). Biennial means comparison showed that the maximum plant height concerned to $T_3$ (107.5 cm) while the minimum related to $T_4$ (88.2 cm) and $T_5$ (88.7 cm) (Table 6).

Height rising in canola is accompanied by taller raceme and more flower and pod in number. In grain fill up stage, due to leaves shattering, photosynthesis in plant takes place by pods and stems. Hence, having longer stems results in higher photosynthesis in plant and grain yield consequently (Rabiee et al., 2004). Several parameters affect plant height. Among them, the relationship between root penetration and growth and plant height has attracted scientists' attention. Investigations indicated that when root penetrated deeper in soil, vegetative growth developed considerably as well (Jamshidian and Khaje Poor, 1998; Heikkin and Auld, 1991).

## 3.2. The Number of Branch

From ANOVA, the effect of tillage methods on the number of branch was not significant for two years of test (Tables 1 and 3). Means comparison showed the same trend for test years (Table 2 and 4). Although, there was no significant difference between means of the number of branch for all treatments but, no tillage treatments ($T_4$ and $T_5$) had less branch than $T_1$ and/or $T_2$ and $T_3$. In $T_3$, the maximum number of branch was observed for crop seasons of 2009-2010 and 2010-2011 with 4.8 and 5.4, respectively. In the compound analysis of variance, the effect of year, tillage method, and interaction of year × tillage method was not significant (Table 5). In no tillage treatments, plant height reduction can be considered as the main reason for the lower number of branch. Similar results have been reported by Jamshidian and KhajePoor (1998) and Rabiee et al., (2004).

## 3.3. The Height of the Lowest Podded Branch from Soil Surface

The simple data analysis of variance indicated that the effect of tillage method on the height of the lowest podded branch from soil surface was significant at 1 % level (Tables 1 and 3). In both test years, this trait was greater in $T_2$ and $T_3$ than that of other treatments (Tables 2 and 4). From the compound analysis, it was observed that the effect of tillage method on this trait was significant however the effect of year and interaction of year × tillage method were not significant (Table 5). In $T_2$ and $T_3$, the lowest podded branch had the longest height from soil surface with 33.4 and 33.9 cm, respectively but $T_1$, $T_4$, and $T_5$ had the shortest height with 28.7, 26.9, and 26.8 cm, respectively. Hence, they were statistically in a same group.

Increasing the height of the lowest podded branch from soil surface in $T_2$ and $T_3$ could be attributed to plant height rise. Rabiee et al., (2004) have reported the same results. When the lowest podded branch has longest space from soil surface, harvesting machines (in both direct and indirect harvesting methods) can be easily adjusted and this helps to higher efficiency and lower harvesting losses.

## 3.4. The Number of Pods Per Plant

The simple data analysis of variance showed that the tillage method significantly affected the number of pods per plant (Tables 1 and 3). In both test years, the number of pods per plant had a similar trend for all treatments so that the greatest number of pods per plant was associated to $T_3$ with 98.0 and 108.2 for 2009-2010 and 2010-2011, respectively and the smallest one was related to $T_5$ with 87.5 (2009-2010) and $T_4$ with 91.0 (2010-2011) (Tables 2 and 4). By the compound analysis of variance, tillage method had significant effect on the number of pods per plant but the effect of year and the interaction of year × tillage method were not significant (Table 5). The maximum number of pods per plant was observed in $T_3$ with 103.1 (average of two years) but $T_4$ and $T_5$ had the minimum pods per plant with the mean of 90.2. Biennial means comparison indicated that there was no significant difference between $T_1$, $T_2$, and $T_3$ for this trait and all were statistically located in a same group, whereas $T_4$ and $T_5$ ranked lower (Table 6).

The number of pods per plant is considered as one of the most important grain yield components because they enclose grains and provide them with photosynthesis substances and also it is an index for weight of grain to some extent (Chay and Thurling, 1989). Increasing the number of pods per plant can be attributed to an increase in branch (Ilkaee and Imam, 2003; Tayo and Morgan, 1979).

## 3.5. The Number of Grain Per Pod and Weight of 1000 Grains

The effect of tillage method on the number of grain per pod was not significant for tested years (Tables 1 and 3) so that all treatments were set statistically in a same group (Tables 2 and 4). Investigations by others represented such a similar results (Rabiee et al., 2004). Basically, environmental and agronomic factors have negligible effect on this trait. As a result, genetic discrepancies between varieties govern this yield component (Barzali et al., 2003). The compound analysis of variance (Table 5) and two-year means comparison (Table 6) have shown similar trend. The effect of tillage method on the weight of 1000 grains was significant at 5 % level during test years (Tables 1 and 3). Biennial means comparison indicated that the weight of 1000 grains for $T_1$, $T_2$, and $T_3$ was more than no tillage treatments ($T_4$ and $T_5$).

## 3.6. Grain Yield and Yield Components

The simple data analysis of variance showed that the effect of tillage methods on grain yield was significant (Table 1 and 3). $T_2$ and $T_3$ have had the maximum grain yield but the minimum obtained for $T_4$ and $T_5$ (Table 2 and 4). The compound data analysis of variance also was an indicative of significant effect of tillage methods on grain yield (Table 5). The effect of year was significant on this trait as well. Some researchers believe in grain yield increase as a result of enhanced plant establishment while others suggest that reducing soil compaction, development and growth of roots inside soil, attracting more nutritious, and aerial organs development are influential in raising grain yield (Majnoun Hosseini et al., 2006; Yazdifar and Ramea, 2009; Sarkees, 2013; Hansen et al., 2011; Maltas et al., 2013; Kuotsu et al., 2014).

It is necessary to underline that the effect of tillage methods on grain yield and yield components of canola in a common condition is different from what is observed in paddy fields. In an investigation, it was revealed that the highest grain yield was associated to conventional tillage treatment whereas the lowest one was related to no tillage treatment due to small size of seeds and high sensitivity of canola plant to proper seedbed establishment.

***Table 1.*** *ANOVA for different tillage methods in canola planting after rice (2009-2010)*

| Sources of variance (SV) | Degree of freedom (df) | Mean Squares (M.S.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Grain yield (kg ha$^{-1}$) | Plant height (cm) | No. of branch | No. of pods per plant | Height of the lowest podded branch from soil surface (cm) | No. of grain per pod | 1000 grains weight (g) |
| Replication (R) | 2 | 126213.067$^{*}$ | 20.669$^{ns}$ | 0.469$^{ns}$ | 368.435$^{*}$ | 17.569$^{ns}$ | 0.269$^{ns}$ | 0.002$^{ns}$ |
| Treatment (T) | 4 | 31576.167$^{*}$ | 144.858$^{**}$ | 0.439$^{ns}$ | 51.823$^{*}$ | 35.434$^{*}$ | 0.455$^{ns}$ | 0.020$^{*}$ |
| Error (E) | 8 | 21011.817 | 9.564 | 0.197 | 10.629 | 5.400 | 0.392 | 0.004 |

$^{ns}$ non-significant; $^{*}$ significant at 5%; $^{**}$ significant at 1%

***Table 2.*** *Means comparison for different tillage methods in canola planting after rice (2009-2010)*

| Treatment | Grain yield (kg ha$^{-1}$) | Plant height (cm) | No. of branch | No. of pods per plant | Height of the lowest podded branch from soil surface (cm) | No. of grain per pod | 1000 grain weight (g) |
|---|---|---|---|---|---|---|---|
| T1 | 1249$^{a}$ | 94.0$^{b}$ | 4.2$^{a}$ | 92.2$^{abc}$ | 27.2$^{b}$ | 20.7$^{a}$ | 3.370$^{a}$ |
| T2 | 1307$^{a}$ | 98.2$^{ab}$ | 4.8$^{a}$ | 94.6$^{ab}$ | 32.8$^{a}$ | 21.7$^{a}$ | 3.213$^{bc}$ |
| T3 | 1352$^{a}$ | 102.3$^{a}$ | 4.7$^{a}$ | 98.0$^{a}$ | 32.0$^{a}$ | 20.9$^{a}$ | 3.283$^{ab}$ |
| T4 | 1204$^{a}$ | 87.5$^{c}$ | 4.0$^{a}$ | 89.5$^{bc}$ | 25.4$^{b}$ | 21.3$^{a}$ | 3.153$^{c}$ |
| T5 | 1086$^{a}$ | 86.0$^{c}$ | 4.1$^{a}$ | 87.4$^{c}$ | 26.2$^{b}$ | 21.0$^{a}$ | 3.220$^{bc}$ |

In each column, figures having common letter are not significant at 5% level.

***Table 3.*** *ANOVA for different tillage methods in canola planting after rice (2010-2011)*

| Sources of variance (SV) | Degree of freedom (df) | Mean Squares (M.S.) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Grain yield (kg ha$^{-1}$) | Plant height (cm) | No. of branch | No. of pods per plant | Height of the lowest podded branch from soil surface (cm) | No. of grain per pod | 1000 grains weight (g) |
| Replication (R) | 2 | 50021.267$^{*}$ | 54.905$^{ns}$ | 0.065$^{ns}$ | 472.418$^{*}$ | 18.989$^{ns}$ | 0.243$^{ns}$ | 0.014$^{ns}$ |
| Treatment (T) | 4 | 31731.900$^{*}$ | 281.389$^{**}$ | 0.595$^{ns}$ | 154.771$^{*}$ | 38.416$^{*}$ | 0.154$^{ns}$ | 0.013$^{*}$ |
| Error (E) | 8 | 2609.100 | 16.625 | 0.158 | 18.893 | 4.289 | 1.034 | 0.002 |

$^{ns}$ non-significant; $^{*}$ significant at 5%; $^{**}$ significant at 1%

***Table 4.*** *Means comparison for different tillage methods in canola planting after rice (2010-2011)*

| Treatment | Grain yield (kg ha$^{-1}$) | Plant height (cm) | No. of branch | No. of pods per plant | Height of the lowest podded branch from soil surface (cm) | No. of grain per pod | 1000 grain weight (g) |
|---|---|---|---|---|---|---|---|
| T1 | 1616$^{a}$ | 97.5$^{b}$ | 4.8$^{a}$ | 97.4$^{abc}$ | 30.2$^{b}$ | 21.3$^{a}$ | 3.410$^{a}$ |
| T2 | 1767$^{a}$ | 104.3$^{ab}$ | 5.4$^{a}$ | 103.7$^{ab}$ | 34.0$^{a}$ | 21.0$^{a}$ | 3.533$^{bc}$ |
| T3 | 1791$^{a}$ | 112.7$^{a}$ | 5.1$^{a}$ | 108.2$^{a}$ | 35.8$^{a}$ | 20.9$^{a}$ | 3.483$^{ab}$ |
| T4 | 1574$^{a}$ | 89.0$^{c}$ | 4.5$^{a}$ | 91.0$^{bc}$ | 27.5$^{b}$ | 21.0$^{a}$ | 3.430$^{c}$ |
| T5 | 1592$^{a}$ | 91.4$^{c}$ | 4.3$^{a}$ | 93.2$^{c}$ | 28.4$^{b}$ | 20.7$^{a}$ | 3.360$^{bc}$ |

In each column, figures having common letter are not significant at 5 % level.

***Table 5.*** *Compound ANOVA for different tillage methods in canola planting after rice*

| Sources of variance (SV) | Degree of freedom (df) | Mean Squares (MS) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Grain yield (kg ha$^{-1}$) | Plant height (cm) | No. of branch | No. of pods per plant | Height of the lowest podded branch from soil surface (cm) | No. of grain per pod | 1000 grains weight (g) |
| Year | 1 | 1377734.7$^{*}$ | 217.083$^{ns}$ | 1.587$^{ns}$ | 302.736$^{ns}$ | 45.387$^{ns}$ | 0.147$^{ns}$ | 0.286$^{**}$ |
| Replication × year | 4 | 88117.167 | 32.287 | 0.267 | 420.426 | 18.279 | 0.256 | 0.008 |
| Tillage | 4 | 57940.617$^{**}$ | 409.926$^{**}$ | 0.996$^{**}$ | 188.550$^{**}$ | 71.812$^{**}$ | 0.198$^{ns}$ | 0.026$^{**}$ |
| Tillage × year | 4 | 5367.450$^{ns}$ | 16.321$^{ns}$ | 0.038$^{ns}$ | 18.045$^{ns}$ | 2.038$^{ns}$ | 0.411$^{ns}$ | 0.007$^{ns}$ |
| Total error | 16 | 11810.458 | 13.095 | 0.177 | 14.761 | 4.845 | 0.713 | 0.003 |

$^{ns}$ non-significant; $^{*}$ significant at 5 %; $^{**}$ significant at 1 %

***Table 6.*** *Biennial means comparison for tillage methods in canola planting after rice*

| Treatment | Grain yield (kg ha$^{-1}$) | Plant height (cm) | No. of branch | No. of pods per plant | Height of the lowest podded branch from soil surface (cm) | No. of grain per pod | 1000 grain weight (g) |
|---|---|---|---|---|---|---|---|
| Year | | | | | | | |
| Year 1 | 1239$^{b}$ | 93.60$^{a}$ | 4.4$^{a}$ | 92.3$^{a}$ | 28.7$^{a}$ | 21.1$^{a}$ | 3.248$^{b}$ |
| Year 2 | 1668$^{a}$ | 98.99$^{a}$ | 4.8$^{a}$ | 98.7$^{a}$ | 31.2$^{a}$ | 21.0$^{a}$ | 3.443$^{a}$ |
| Tillage | | | | | | | |
| T1 | 1432$^{ab}$ | 95.8$^{c}$ | 4.5$^{bc}$ | 94.8$^{bc}$ | 28.7$^{b}$ | 21.0$^{a}$ | 3.311$^{b}$ |
| T2 | 1537$^{a}$ | 102.2$^{b}$ | 5.1$^{a}$ | 99.1$^{ab}$ | 33.4$^{a}$ | 21.3$^{a}$ | 3.427$^{a}$ |
| T3 | 1571$^{a}$ | 107.5$^{a}$ | 4.9$^{ab}$ | 103.1$^{a}$ | 33.9$^{a}$ | 20.9$^{a}$ | 3.408$^{a}$ |
| T4 | 1389$^{a}$ | 88.2$^{d}$ | 4.2$^{c}$ | 90.2$^{c}$ | 26.9$^{b}$ | 21.1$^{a}$ | 3.291$^{b}$ |
| T5 | 1339$^{a}$ | 88.7$^{d}$ | 4.2$^{c}$ | 90.3$^{c}$ | 26.8$^{b}$ | 20.8$^{a}$ | 3.290$^{b}$ |

In each column, figures having common letter are not significant at 5 % level.

## 4. Conclusion

Tillage practices had significant impacts on yield and yield components of canola. Treatments of $T_3$ and $T_2$ have affected plant growth through plant height rise, the number of pods per plant, and grain yield per area unit compared to no tillage treatments of $T_4$ and $T_5$. Observations indicated that using mouldboard plow as a primary tillage implement (as used in treatment $T_3$) in moist paddy fields would encounter difficulties such as soil sticking to plow bottom and that led to increased draft and tractor rear wheel slippage in consequent. In these circumstances, applying rotivator (once or twice) as a tillage implement for canola planting after rice would have higher efficiency in paddy fields.

## Acknowledgement

This study was supported financially by Agricultural Engineering Research Institute (AERI) and Rice Research Institute of Iran (RRII). The authors would appreciate their assistances.

## References

[1] Barzali, M., Javanshir, A., Shakiba, M., Moghadam, M., Nourinia, A., 2003. The effect of different tillage methods on yield and yield components of soybean in Gorgan. Seed and Scion. 19(2): 173-189 (in Persian).

[2] Bonari, E., Mazzoncini, M., Peruzzi, A., 1995. Effects of conventional and minimum tillage on winter oilseed rape (Brassica napus L.) in a sandy soil. Soil and Tillage Research. 33(2): 91-108.

[3] Chay, P., Thurling N., 1989. Variation in pod length in spring rape (*Brassica napus* L.) and its effects on seed yield and yield components. The Journal of Agricultural Science. 113(2): 139-147.

[4] Chiriac, G., Raus, L., Coroi, I.G., Gales, D.C., Jitareanu, G., 2013. Effect of tillage and cultivar on winter oilseed rape (Brassica napus L.) yield and economic efficiency in Suceava plateau. ProEnvironment. 6: 130-135.

[5] Chiriac, G., Raus, L., Jitareanu, G., 2012. Effect of tillage and cultivar on oilseed rape (Brassica napus L.) yield in the northern area of Moldavian plateau. Lucrari Stiintifice (Seria Agronomie). 55(2): 159-163.

[6] Farooq, M., Flower, K.C., Jabran, K., Wahid, A., Siddique, K.H.M., 2011. Crop yield and weed management in rainfed conservation agriculture. Soil and Tillage Research. 117: 172-183.

[7] Fooladi Vand, S., Aynehband, A., Naraki, F., 2009. Effects of tillage method, seed rate and microelement spraying time on grain yield and yield components of rapeseed (Brassica napus L.) in warm dryland condition. Journal of Food, Agriculture and Environment. 7(3-4): 627-633.

[8] Heikkinen, M.K., Auld, D.L. 1991. Harvest index and yield of winter rapeseed grown at different plant populations. Proceedings of International Canola Conference, Saskatoon, Canada, p: 1229-1231.

[9] Ilkaee, M.N., Imam, Y., 2003. The effect of plant intensity on yield and yield components of two winter varieties of canola. Iranian Journal of Agricultural Sciences. 34(3): 509-515 (in Persian).

[10] Jamshidian, R., Khajepoor, M., 1998. The effect of different seedbed preparation methods on vegetative growth, yield and yield components of mung bean. Journal of Agricultural and Environmental Sciences and Technology. 3(1): 9-20 (in Persian).

[11] Kosutic, S., Filipovic, D., Ivancon, S., Aktualniu, Z., 1995. Experience with different tillage methods in wheat, oilseed rape and maize production. Current problem in Agricultural Engineering. 115-121.

[12] Majnoun Hosseini, N., Alizadeh, H.M., Malek Ahmadi, H., 2006. Effects of plant density and nitrogen rates on the competitive ability of canola (Brassica napus L.) against weeds. Journal of Agricultural Sciences and Technology. 8: 281-291.

[13] Rabiee, M., Karimi, M., Safa, F., 2004. The effect of planting date on yield and agronomic traits of canola as a second crop after rice in Kouchesfahan region. Iranian Journal of Agricultural Sciences. 35(1): 177-187 (in Persian).

[14] Sarkees, N.A. 2013. Response of growth, yield and oil of rapeseed to sowing method and seeding rate. IOSR Journal of Agriculture and Veterinary Science. 3(1): 1-6.

[15] Tayo, T.O., Morgan, D.G., 1979. Factors influencing flower and pod development in oilseed rape (*Brassica napus* L.). The Journal of Agricultural Science. 92(2): 363-373.

[16] Torabi, H., Naghdibadi, H.A., Omidi, H., Amirshekari, H., Miransari, M., 2008. Effects of soil tillage, canola (Brassica napus L.) cultivars and planting date on canola yield, and oil and some biological and physical properties of soil. Archives of Agronomy and Soil Science. 54:175-188.

[17] Yazdifar, S., Ramea, V., 2009. Effects of row spacing and seeding rates on some agronomical traits of spring canola (Brassica napus L.) cultivars. Journal of Central European Agriculture. 10(1): 115-122.

[18] Yusuf, R.I., Bullock, D.G., 1993. Effect of several production factors on two varieties of rapeseed in the central of United States. Journal of Plant Nutrition. 16(7): 1279-1288.