Characters and grain yield of *Brassica napus*. L as affected by tillage systems and sowing date

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Abstract

In order to study the effect of tillage systems and sowing dates on yield and soil characters of rapeseed genotypes (*Brassica napus* L.), two field experiments were carried out at the Sari Agricultural Experimental Station, 25 km of Eastern Sari, Iran in 2001–2002 and 2002–2003. The experimental design was split plot factorial with three replications. Three tillage system levels were allocated to main plots, and combination of rapeseed genotypes (Hyola 401, PF) and sowing dates (including. 8, 23 Sep and 7 Oct) were randomized to sub-plots. The tillage levels were consisting of: no- tillage, minimum tillage (residue return with two disks) and conventional tillage (residue return with plow and one disk). Results of ANOVA using SAS Procedures showed that tillage systems and rapeseed genotypes had significant differences at the 1% probability level on soil moisture content. Conventional tillage produced less soil moisture content in two years and there is no difference between minimum and no tillage. Hyola 401 genotype was better than PF variety in soil moisture content in two years. Combined analysis showed that sowing date and tillage system had significant differences on earthworm, enzymatic activity of dehydrogenase (0-10 cm), dehydrogenase (10-20 cm), alkaline phosphates, acid phosphates, grain yield, oil content and oil yield ($P<0.05$). Microbial biomass nitrogen was the most at 8 Sep and no tillage system with 23 Oct and no tillage. PF variety also had the most grain yield at first sowing date and conventional tillage whereas Hyola variety with first sowing date and no tillage was located in the next rank. Varieties were differences ($p<0.01$) for 1000-grain weight, grain yield, oil content and oil yield. Result showed that in spit of production more grain yield in plants with conventional tillage, the varieties also could be used with no or minimum tillage and first sowing date for sustainable agriculture. Hyola variety is early maturity therefore it can be used in short season environment. Overall the result of this research showed that minimum and no tillage have advantages in comparison with conventional tillage. Soil water content is advantage of no and minimum tillage in related conventional tillage.

Key words: Tillage systems, *Brassica napus* L., Yield and Oil Content, Sowing date and Microbial activity.

Introduction

Iran is the main country in the world to import plant oil. At present 100 to 120 thousand tons of Soya meal was produced in Iran and more them % 90 of it import from other countries. On the other hand yearly consume increment of plant oil has been reached from 570 g in 30 decay to about 18 kg in past year. Therefore we need to stay on inner power and move to self-sufficiency in this matter, in the event that Jihad Keshavarzi Ministry also emphasizes on development of canola cultivation and olive as own strategy. Canola is the first selection of crop oilseed in Iran and in base of research development of canola cultivation is emphasize because of different climate in the country and having high quality. Crop residues in N.T. systems help reduce soil erosion (Bolinder et al., 1999). No tillage system, however, can affect soil temperature (Garcia et al., 1997). N.T. and M.T. systems are an effective step in efficiently saving more precipitation for crop production (Ahmad et al., 2000). Canola is an excellent break crop for wheat, and its effectiveness is thought to be due in part to the suppression of soil-borne cereal pathogens by biocide compounds released by decaying root tissues, which reduce disease infection in following crops (Aoyama et al. 2001). The beneficial effects of retained crop residues for erosion control has been well documented (Baum et al., 2003) however the yields of crops can be reduced. Retained wheat residues have been shown to reduce yield in several studies (Baum et al., 2003). More recently, there has been mounting circumstantial evidence for reduced yield of canola crops sown into retained wheat residues. Several factors may contribute to the poor growth of canola sown into wheat residues including (1) poor soil-seed contact, (2) ineffective pre-sowing herbicide incorporation resulting in increased weed competition, (3) nitrogen immobilisation and (4) increased incidence of root disease. Recent investigations into poor growth under crop residues have demonstrated that phytotoxins may be contributing to the decline (Calderon et al., 2000). These toxins may be a result of leaching, through processes of decomposition or synthesised by microbes (Calderon et al., 2000). The toxins identified include more than 300 secondary plant and microbial compounds. Many factors may contribute to the production and detrimental action of these chemicals including the state of decomposition of crop residues, the quantity of stubble, the species and variety of the stubble and the environmental conditions during the growth of the next crop (Chen et al., 2003). With the move toward stubble retention in cropping systems, identifying stubble and crop combinations in which the risk of phytotoxicity is high is necessary to avoid yield reduction. For example found that wheat yield was significantly higher under canola stubble than under peas and attribituted this to the greater phototoxic of pea stubble. As the area of canola and the desire to retain stubble in wheat-canola rotations increases, it is important to assess the risks of allelopathy. Farming systems in Iran have been characterised by two main patterns of land use. Firstly, legume pastures grown in rotation with cereal crops such as wheat and secondly, periods of fallow (primarily for moisture conservation but also weed and disease control) followed by a cereal crop. In the drier areas and central, a common rotation is pasture-fallow-wheat. Since the early 1970's there has been an intensification of cereal cropping in response to improvement in relative profitability as well as the development of conservation farming' systems. The expansion of cereal cropping occurred due to opening up of new land and at the expense of pasture and fallow periods (Dodor and Tabatabai, 2003). Canola has become a commonly grown rotation crop with cereals and pastures. It has the advantages of reducing cereal root diseases, improving soil structure (due to a different root structure to cereals), preventing build up of herbicide resistant weeds and diversifying income. Crop yields are determined from growing season rainfall, growing season losses, transpiration, and various weed and disease penalties which vary according to preceding crop history. In this paper we assess the place of canola in the tillage system in the Bay-Cola region of northern Iran in terms of the effects of tillage changes and relative yield to other crops on the inclusion of canola. In addition, we address the effect of tillage systems on soil enzyme activity, soil characters and microbial biomass canola and its effect on yield. The objective of these experiments is to evaluate of soil quality characters and grain yield of Brassica napus. L as affected by tillage systems and sowing date.

Materials and Methods

In order to study the effect of tillage systems and sowing dates on yield and soil characters of rapeseed genotypes (Brassica napus L.), field experiment was carried out at Bayea-cala, the Sari Agricultural Experimental Station, 25 km of Eastern Sari, Iran in 2001–2002 and 2002–2003. The experimental design was split plot factorial with three replications. Three tillage system levels were allocated to main plots, and combination of rapeseed genotypes (Hyola 401, PF) and sowing dates (including 8, 23 Sep and 7 Oct) were randomised to sub-plots. The tillage levels were consisting of: no- tillage, minimum tillage (residue return with two disks) and conventional tillage (residue return with plow and one disk). The distance between plots and plants on rows were 3 M and 5 Cm respectively. Soil practice was performed at early September. Plots received enough fertilizer and application of 2.5litter/ha trephlan before planting for weed control. Fertilizer was applied in basis of soil analysis (all plots and phosphors fertilizer and one third nitrogen fertilizer requirement in basis of canola production directions in country different climate at planting stage). The maximum fertilizer requirement was 50kg/ha net nitrogen, 59-kg/ha P2O2 and 100 kg/ha K2O.One third nitrogen fertilizer was applied at bolting time and final amount of fertilizer was used at the beginning of flowering. All protection stages were performed as traditional method. Soil samples were collected during the 2003 season, in late April. Soil samples from each plot consisted of five composite sub samples that were taken with a probe (6.0-cm diameter core) and divided into segments of 0–5 and 10–15 cm. Field-moist soil samples were divided into two sub samples. One sub sample was sieved at 2 mm and stored at 2 °C for biochemical analysis and the other sub sample was air-dried at room temperature and sieved at 2 mm for physical–chemical and chemical analysis or at 0.2–4 mm for aggregate stability. Visible pieces of crop residues and roots were removed. Surface crop residues were collected after primary tillage from two midrow to midrow 1 m2 areas that were representative of each tillage treatment, dried (60 °C, 48 h) and weighed then converted to kg ha−1 (Steiner et al., 1994). Surface percentage of cover was determined using a line-transect measurement, by stretching a 10-m string with 100 marks (10 cm apart) across the field at a 45° angle to the rows. The number of times residue was found under a mark indicated the percentage of cover (Steiner et al., 1994). Total organic C was determined by oxidation with potassium dichromate in a sulphuric medium and excess dichromate evaluated using Mohr's salt (Yeomans and Bremner, 1988). Water-soluble carbon in soil aqueous extracts (1:5, w/v) was determined by wet oxidation with K2Cr2O7 and measurement of the absorbance at 590 nm (Kristensen et al., 2000). Dehydrogenase activity was determined according to Garcia et al. (1997). For this, 1 g of soil at 60% of its field capacity was exposed to 0.2 ml of 0.4% 2-p-iodophenyl-3-p-nitrophenyl-5-phenyltetrazolium chloride (INT) in distilled water for 20 h at 22 °C in darkness. The iodo-nitrotetrazolium Formosan (INTF) formed was extracted with 10 ml of methanol by shaking vigorously for 1 min and filtration through a Whatman No. 5 filter paper. The INTF was measured spectrophotometrically at 490 nm. Acid phosphatase activity was determined using p-nitro phenyl phosphate disodium (PNPP, 0.115 M) as substrate. Two millilitres 0.5 M sodium acetate buffer at pH 5.5 (Nannipieri et al., 1994) and 0.5 ml of substrate were added to 0.5 g of soil and incubated at 37 °C for 90 min. The reaction was stopped by cooling at 2 °C for 15 min. Then, 0.5 ml 0.5 M CaCl2 and 2 ml 0.5 M NaOH were added, and the mixture were centrifuged at 2287 × g for 5 min. The p-nitro phenol (PNP) formed was determined by spectrophotometer at 398 nm. Controls were made in the same way, although the substrate was added before the CaCl2 and Noah. Plants were harvested when % 40- 50 of seed on main and branch pods became bright brown or black. Grain yield was determined on middle row of plot after omitting the margin effect (half meter from beginning and end of each row). The data were analysed using the general linear model (GLM) procedure of the statistical analysis system, SAS (SAS Inst., Cary, Nc) to perform analysis of variance and selected correlation when analysis of variance showed significant treatment effects, Duncan's multiple range test was applied to compare the means at p= 0.05. Bartlet test determined the homogeneity of variance in all traits. Soil water content had not error variance homogeneity in two consecutive years therefore means was compared separately in each year. Mix analysis was applied to the rest of trait.

Result and Discussion

Tillage system and variety had significant differences on soil water content (Table 1).Simple and interaction effects among variety, sowing date and tillage systems on water content were significant ($p<0.01$) (Table1). Hyola variety and conventional tillage system had less soil water content. The same result was obtained in second year ($p< 0.01$). Increasing soil water contenting short sowing date has been previously reported (Hamrouni *et al*., 2001). Conventional tillage system had less soil water content than minimum and no tillage system. There were significant differences between minimum and no tillage system for former trait. Interaction effect on tillage system and sowing date was significant on soil water content ($p<0.05$) (Table 5).tillage system with 7 Oct sowing date had more soil water content. It seems that more soil water content is suitable for no tillage system. Soil water contents very important in protection plant and depends to genotype and environmental condition. Soil water content reduces demand for irrigation order to establish crop covering and after in above plant canopy quickly for achieving maximum radiation. SMBC and SMBN were affected by tillage systems and sowing date ($p<0.01$). (Table6). Conventional tillage systems were less than minimum and no tillage systems. There was not difference between minimum and no tillage systems in case SMBC (Table 7). SMC was increased by establishment suitable growth background and better utilization of climatic parameters. Bell and Van Rees (2003) also reported the same result. Interaction effect among variety, sowing date and tillage system on SMBN was significantly differences (Table 9). The most SMBN was obtained by Hyola variety with 16 row distances and conventional tillage system. The lowest SMBC was for PF variety with 8 Sep sowing date and no tillage system. Henriksen *et al*. 2002 reported increasing height in conventional tillage system. Height alteration is ordinary manifest of genetically condition and environmental condition in the most plant. Sometimes height increasing is benefit in a plant canopy in aspect of competition with other plants. In this experiment tillage system and sowing date treatments affect on Earth Worm ($p<0.01$). Conventional tillage system had less EW than other tillage systems, but there was not difference between minimum and no tillage system (Table 8). Interaction effects among variety and sowing date on EW were significant ($p<0.01$). Tillage system, sowing date and variety have significantly effect on grain yield (Table 6). No tillage system had lower grain yield than normal and Min tillage system. There were not significantly differences between normal and min tillage system for grain yield (Table 7). Hyola variety had lower grain yield than PF variety (Table 9). Grain yield is resulted of plant canopy activity during a growth season and utilization manner of radiation and other environmental sources. In this case, leaf photosynthetic activity has been affected by radiation, its distribution and respiration (Hamrouni *et al*. 2001). Varieties were different in former mentioned characteristic varieties that germinate early, growth rapidly in winter and produce leaf area in early rapid growth, can utilize more radiation and increase radiation efficiency in leaves and as a result produce more yields. Since PF variety has more rapid growth than Hyola variety therefore it has the most grain yield, since it utilize from environmental source as suitable manner in comparison with Hyola variety. This result is in agreement with other studies. There is significant difference for interaction effects among variety, tillage system and sowing date in grain yield and SMBC ($p<0.01$) (Table 6). There is relation among yield component, so that increasing one component decreases the other components. Result showed that in spit of more grain yield in conventional tillage system, In general, result in this experiment showed that minimum and no tillage system have many benefits in comparison with conventional tillage system. Climatic trend during the two-year trial, even though reflecting the average climatic trend of the area, presented some particular aspects. During the first year, in fact, high soil moisture content was determined by continuous and plentiful rain fall since October, limiting seeding possibilities in the opportune period. Nevertheless both rain after rapeseed seeding and temperatures, in both years, allow to a regular development of crop germination and emergence. Sowing date was effect on Dehydrogenase in this experiment. Interaction effect among sowing date and tillage system on Dehydrogenase enzyme significantly difference ($p<0.01$). The activity of dehydrogenase is considered an indicator of the oxidative metabolism in soils and thus of the microbiological activity (Garcia et al., 1997), because it is exclusively intracellular and, theoretically, can function only within viable cells. Phosphatases catalyse the hydrolysis of both organic phosphate (P) esters and anhydrides of phosphoric acid into inorganic P. Phosphatase activity may originate from the plant roots (and associated mycorrhiza and other fungi), or from bacteria (Tarafdar and Marschner, 1994).Dehydrogenase activity was decreased significantly by intensive tillage. The interaction between the tillage treatments and soil depth affected dehydrogenase activity to a very significant degree ($P = 0.001$). Thus, the differences in dehydrogenase activity between no-tilled and tilled soils decreased with soil depth. The water regime did not affect dehydrogenase activity. The quality and quantity of soil organic matter normally changes very slowly and many years (5–10 years) are required to detect changes resulting from disturbance. The extent of soil organic matter turnover is mainly controlled by the size and activity of the microbial biomass, which may respond to disturbance over shorter time scales (months). For this reason, soil biological and biochemical parameters may have a role as early and sensitive indicators of soil ecological stress and restoration (Roldán et al., 2003 and Izquierdo et al., 2003). Bolinder et al. (1999) indicated that the soil microbial biomass is more sensitive to changes in soil quality than total organic carbon or nitrogen. Soil enzyme activities are especially significant because they control nutrient release for plant and microbial growth. Likewise, the labile pool of soil organic matter, which is closely related to soil microbial biomass, could be used as a sensitive indicator of short-term changes in soil management. Tillage system had significant effects on soil acid phosphates activities. Tillage reduced the acid phosphates activities at all soil depths, particularly with the adoption of Till. The irrigation increased the phosphates activity and decreased activity. Likewise, the irrigation of maize plants significantly increased the positive effect of the no-tillage treatment on phosphates activity. Only phosphates activity was influenced by soil depth. The content of organic matter in soil under no-tillage with irrigation was greater compared with the average of the other tillage treatments. Below the surface 0–5 cm, organic matter decreased and there were no significant differences due to treatments or irrigation. The interaction between the tillage treatments and soil depth affected dehydrogenate activity to a very significant degree ($P = 0.001$). Thus, the differences in dehydrogenate activity between no-tilled and tilled soils decreased with soil depth. Tillage system had significant effects on soil acid phosphates activities. Tillage reduced the and acid phosphates activities at all soil depths, particularly with the adoption of mouldboard. In conclusion, dehydrogenase activity indicated that Variety had no effect on total microbial activity. However, tillage systems were effective with respect to increasing crop residue levels on the soil surface. The no-tillage system, which promotes surface accumulation of crop residues, was the most effective for improvement of soil physical and biochemical quality and for increasing the storage of organic matter in the soil, which may contribute greatly to the long-term sustainability of agricultural ecosystems under subtropical conditions. The beneficial effects of this conservation tillage system on soil quality were more noticeable in the surface 0–5 cm. More search in this case required.

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Table1: Analysis of variance for Soil water content in 2001-2002 and 2002-2003

		Mean of Squares	
		2001-2002	2002-2003
S.O.V	DF	Soil water content %	Soil water content %
R	2	59797/21	297/21
Tillage systems	2	**93352/20	**7118/31
R*Ts	4	7782/1	5086/2
Sowing date	2	9802/0	5168/1
variety	1	**5067/4	667/0
T*SD	4	929/1	*4344/2
Ts*V	2	9872/0	*4489/3
V*SD	2	1915/0	4017/0
V*SD*T	4	2078/1	6164/0
…. Error	30	8551/0	7602/0

Ns, * and **: not significant, significant at the 5 and 1 % levels of probability respectively.

Table2: Means comparison of for Soil water content in tillage systems

	2001-2002	2002-2003
Tillage System	Soil water content %	Soil water content %
No Tillage (N.T)	03/18 a	09/23 a
Minimum Tillage(M T)	58/17 a	43/22 a
Conventional Tillage(CT)	98/15 b	53/20 b

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table3: Means comparison of Soil water content in rapeseeds.

2002-2003	2001-2002	
Soil water content%	Soil water content %	Variety
20/20b	49/17 a	yola401
91/21 a	91/16 b	PF

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table4: Means comparison of combined analysis for soil water content in tillage systems

Soil water content %	Variety	Tillage System
41/18 a	yola401	No Tillage (N.T)
64/17 ab	PF	
04/18 ab	yola401	Minimum T.
12/17 b	PF	
16 c	yola401	Conventional T.
96/15 c	PF	

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table5: Means comparison of combined analysis for soil water content in tillage systems

sowing date	Soil water content %	Tillage System
8 Sep	23/23 ab	No Tillage (N.T)
23 Sep	38/22 bc	
7 Oct	65/23 a	
8 Sep	23/22 bc	
23 Sep	03/22 cd	Minimum T.
7 Oct	03/23 abc	
8 Sep	08/21 de	
23 Sep	63/20 ef	Conventional T.
7 Oct	88/19 f	

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table6: combined analysis for soil and agronomic characters in tillage systems

Mean of Squares									
acid phosphates	Alkaline phosphates	Dehydrogenate		Ew	SMBN	SMC	Oil yield	df	S.O.V
		(20-10)	(10-0)						
67/32	676/35606	00724	7008/2189	6759/194	563/378	52/42067	9/347754	1	Year
02352/0	87/496	997/1	7617/21	5925/4	3607/32	143/585	46/38841	4	Y))R
**0226/8	**009/6346	**433/253	**3353/2984	**1759/68	**0359/92	**99/29546	**24/208461	2	Tillage systems
0001/0	3981/90	1378/0	00028/0	**4537/26	**083333/0	**66/1271	**18/469757	2	Y* T
01410/0	328/244	4017/3	2328/4	5648/32	6646/3	6145/12	17/13856	8	R*T(Y)
**20481/0	**788/6512	745/2	**2953/11	**7314/4	**4445/6	**64/5124	**54/425301	2	sowing date(D)
02373/0	787/7	021/1	**7408/3	12037/1	1348/3	8934/10	**69/380770	1	Variety
010/0	*287/569	6103/0	00028/0	23148/1	0869/0	9136/4	**2/72818	2	Y*SD
020/0	565/83	3445/0	00083/0	7500/0	05333/0	2889/5	**79/32398	1	Y*V
**11925/0	**523/2642	**7940/6	**9664/1	0648/3	**8044/3	**075/1392	**95/133760	4	T*SD
03370/0	843/277	4444/0	5586/1	0092/1	**9515/17	*6084/63	5/14389	2	T*V
**05148/0	898/459	2336/3	4519/0	**0093/5	**3389/7	4417/46	**8/25887	2	SD*V
00010/0	5648/214	6504/0	00028/0	6944/0	42111/0	6423/0	79/18079	2	Y*T*V
00010/0	843/347	2089/0	00028/0	3611/0	26695/0	8389/3	*6/21747	2	Y*SD*V
00010/0	134/275	3005/0	00056/0	9259/0	08902/0	8423/1	**88/227902	4	Y*SD*T
00010/0	8842/64	4223/0	00056/0	5556/1	2393/0	4019/1	4/12214	4	Y*T*SD*V
02148/0	828/226	987/1	1314/1	8981/2	16522/0	**8338/105	**24/17646	4	V*SD*T
01522/0	698/186	8343/1	6146/0	3963/1	87189/0	5168/21	9/7323	60	Error

Ns, * and **: not significant, significant at the 5 and 1 % levels of probability, respectively.

Table7: Means comparison of combined analysis for soil and agronomic characters in tillage systems

Dehydrogenate Milligram	microgram	DH microgram		EW ($n.m^2$)	SMBN (mg/kg)	SMC (mg/kg)	Grain yield (kg/ha)	Tillage systems
AKP	ACP	20-10(cm)	10-0 (cm)					
47/3020 a	83/3 a	83/49 a	26/58 a	8a	94/26 a	07/317 a	b2/2612	No Tillage (N.T)
6/3000 b	44/3 b	42/45 b	38/54 b	72/6 a	45/24 b	16/273 b	b9/2661	Minimum T.
3/2995 b	89/2 c	95/44 b	91/40 c	25/5 a	96/23 b	24/263 c	a8/2906	Conventional T.

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %.)

Table8: Means comparison of soil and agronomic characters in sowing date

AKP microgram	ACP milligram	DH10-0 cm microgram	EW ($n.m^2$)	SMBC (mg/kg)	SMBN (mg/kg)	Grain yield (kg/ha)	sowing date(D)
47/3015 a	47/3 a	67/51 a	25/6 b	17/297 a	56/25 a	a41/2887	8 Sep
72/3010 a	38/3 b	29/51 b	78/6 ab	84/282 b	09/25 b	a16/2835	23 Sep
17/2990 b	32/3 c	57/50 c	94/6 a	48/273 b	72/24 c	b38/2458	7 Oct

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table9: Means comparison of soil and agronomic characters in combined analysis

DH 10-0 (cm) microgram	Oil yield(kg/ha)	Oil content(%)	Grain yield(kg/ha)	Variety
37/51 a	64/1093 b	b96/41	04/2603 b	Hyola401
09/50 b	40/1212 a	a61/42	92/2850 a	PF

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table10: Means comparison of interactions among brassica sowing date and tillage systems

AKP microgram	ACP Milligram	DH 20-10 (cm) microgram	DH 10-0 (cm) microgram	SMBN (mg/kg)	SMC (mg/kg)	Combination treatment Tillage system * Sowing date	
67/3041 a	4 a	12/45 b	87/58 a	03/28 a	20/341 a	8 Sep	No Tillage (N.T)
33/3033 a	8/3 b	77/45 b	45/58 a	33/26b	70/316 b		
42/2986 d	68/3 c	98/45 c	45/57 b	47/26 b	32/293 c		
3010 b	40/3 d	99/48 a	03/55 c	38/24 cd	47/282 d	23 Sep	Minimum T.
50/2998 bcd	48/3 d	15/50 a	67/54 c	86/24 c	79/270 e		
33/2993 cd	45/3 d	15/50 a	43/53 d	13/24 cd	83/267 ef		
75/2994 cd	3 e	36/45 b	13/41 e	27/24 cd	22/266 f	7 Oct	Conventional T.
33/3000 bc	85/3 f	15/45 b	83/40 e	08/24 cd	02/261 g		
75/2990 cd	82/2 f	98/43 c	77/40 e	54/23 d	89/260g		

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table11: Means comparison of interactions among brassica varieties, tillage systems and sowing date on agronomic characterr

SMC (%)	Grain yield(kg/ha)	Variety	Sowing date	Tillage System
22/340 a	7/3164 b	Hyola401	8 Sep	No Tillage (N.T)
18/342a	9/2912 bcd	PF		
47/317 b	8/2754 cde	Hyola401	23 Sep	
93/315b	3/2463 fg	PF		
57/295 c	7/2697 def	Hyola401	7 Oct	
08/291 c	8/2986 bc	PF		
85/280 d	2675 def	Hyola401	8 Sep	Minimum T.
08/284 d	3/3012 b	PF		
18/273 e	6/2693 def	Hyola401	23 Sep	
40/268 e	9/1958 i	PF		
97/259 f	4/3148 b	Hyola401	7 Oct	
48/272 e	4/2197 h	PF		
28/268 e	1/3162 b	Hyola401	8 Sep	Conventional T.
38/267 e	2/3689 a	PF		
75/260 f	2306 gh	Hyola401	23 Sep	
28/261 f	7/2523 efg	PF		
30/261 f	7/2554 efg	Hyola401	7 Oct	
46/260 f	2709 def	PF		

Mean followed by the same letters in each column are not significantly different (Duncan multiple rang test 5 %).

Table12: Correlation coefficients of among soil characters

AKP	ACP	DH 10-20 cm	DH 0-10 cm	EW	SMBN	SMBC	SMC	
							1	SMC
						1	679/0 **	SMBC
					1	798/0**	811/0**	SMBN
				1	405/0**	528/0**	517/0**	EW
			1	565/0**	687/0**	789/0**	729/0**	DH 0-10 cm
		1	489/0**	407/0**	367/0**	290/0**	657/0**	DH 10-20 cm
	1	619/0**	881/0**	603/0**	777/0**	855/0**	834/0**	ACP
1	733/0**	425/0**	598/0**	351/0**	657/0**	783/0**	627/0**	AKP

* And **: significant at the 5 and 1 % levels of probability respectively.

SMC: soil moisture content SMBC : soil microbial biomass carbon

SMBN: soil microbial biomass nitrogen EW: earth worm DH: dehydrogenate in 0-10 centimeter depth

DH: dehydrogenate in 10-20 centimeter depth ACP: acid phosphates AKP: alkaline phosphates