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Plant Emergence, Potato Yield and Yield Components as Affected by Timing of Tillage Systems

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Abstract: Plant emergence, potato yield and yield components as affected by timing of tillage systems were investigated in Mid-Anatolia Climate Belt of Turkey. Timing of tillage systems were mouldboard plough in autumn+disc harrow in spring+planting (AMPD); chisel in autumn+ disc harrow in spring+planting (ACD); mouldboard plough+disc harrow in spring+planting (SMPD); chisel+disc harrow in spring+planting (SCD); rotovator in spring+planting (SR) respectively. Plant emergence as mean emerged dates (MED), emerged rate index (ERI), percentage of emerged seedling (PE) were calculated for Hermes and Marfona potato cultivars, respectively. Potato yield and yield components as total tuber yield (TTY), plant yield (PY), tuber number (TN), mean tuber weigth (MTW) were determined for each cultivar, respectively. MED, ERI and PE were determined as 29.60 days, 0.100 seedling/m day and 86.0% for Marfona cultivar, respectively. Total tuber yield varied from 38.03 and 48.74 t ha-1 for Hermes and Marfona potato cultivars, respectively. ACD system was yielded higher total tuber yield than that of the other tillage systems. For Hermes and Marfona potato cultivars were evaluated with the Principal Component Analysis (PCA) to most appropriate indices the best indices for the plant emergence, yield and yield components. The differences in each of the plant emergence and yield components among the cultivars studied were significant. In particular, the cultivars demonstrated different reactions to the studied parameters. The results indicated that MED, TNPP and ST were the most appropriate indices to emergence, yield and yield components for Hermes cultivar, whereas the other indices were the best indices for Marfona cultivar.
Key words: Potato, timing of tillage systems, plant emergence, yield and yield components

INTRODUCTION

The tillage systems for soil conservation have been extended on a large acreage all over the world. The conventional practices reduced cost of production and contribution to the environment (Cociu, 2010). Emergence is influenced by seedling tuber quality (age and sprouting stage), soil temperature and soil moisture. The method of soil preparation affects the soil temperature and moisture conditions around the planted seedling potato tuber (Massah and Noorolahi, 2008). Yield components have been affected with thereduction of the number and depth of the soil tillage operations (Yankov, 2010). Potato has a weak root system, and that impermeable layers in soil greatly reduce yield. Soil compaction and erosion are the key factors limiting potato yield and quality (Moorthy and Henderson, 2002). Compaction increases bulk density and penetrometer resistance while reduces penetrability of root to soil and crop yield (Husnjak et al., 2002). Conventional tillage system is widely used in potato production in Mid-Anatolia Climate of Turkey. Tillage systems consisting of mouldboard plough have the detrimental effect on soil quality due to the excessive tillage and production of low levels of crop residue. Conservation tillage systems having chisel and disc harrow are being experimented by farmers, and is widespread in Turkey.

Ekeberg and Riley (1996) obtained lower tuber yield with conventional tillage in early harvesting. Mundy et al., (1999) compared soil physical properties, potato growth and yield in conventional-tillage (CT), no-tillage (NT), and subsurface-tillage (SST) systems at two sites in eastern North Carolina. Potatoes in the NT and SST systems emerged slowly as compared to potatoes planted with CT. Essah and Honeycutt (2004) evaluated the yield and quality of the potato cultivar 'Russet Burbank' as affected by soil tillage and seed-sprouting treatments in dry soil during early spring. The tillage treatments were raised bed in autumn, ridge till in autumn and chisel plow in spring, respectively. Plants from green-sprouted seed emerged earlier than those from non-sprouted seed tubers. The objectives of this study were to investigate the effects of timing of tillage systems on potato emergence, yield and yield components and to obtain information on supporting the development of potato production systems in the region.

MATERIALS and METHODS

The experiment was conducted in a research field in 2009 at Urgup Plain located in 15 km Southeast of Nevşehir Province (38°37'59"N latitude; 34°54'46"E longitude), Mid-Anatolian Climateof Turkey. The altitude of region was 1433 m and slope was ranged 0-5%. The soil texture is sandy clay loam (61.5% sand, 16.7% silt and 21.8% clay). The organic matter content was 1.04% EC was 96.67 μS/cm, 16.67 kg/da P2O5, 148.33 kg/da K2O, respectively. The annual average of precipitation, temperature and relative humidity are 495.8 mm, 12.9°C, and 63.4%, respectively. (Anonymous, 2009). The experiment was conducted in the third week of October (tillage in autumn) and May (tillage in spring) following the oat harvest. The values of precipitation, temperature and relative humidity during tillage in spring in May were as 46.8 mm, 13.4°C, and 58.5%, respectively

The experiment was designed as a randomized complete block design with three replicates with a main factor of potato cultivars and a sub-factor of tillage systems. Plots sizes were 10 m wide and 10 m long. The experimental area comprised of two adjacent sites which were used as wheat and potato rotation for several years. Potato was planted in rows spaced 70 cm apart at a rate of 4.76x 104 tubers/ha. Weights of standard tractor and semi automatic potato planter were 2.21 Mg and 0.47 Mg, respectively. A potato planter consisting of planting unit, furrow opener and covering disc and 2 rows was used. Planting depth was 0.06 m, and working speed was 6 km/h. The mouldboard plough, chisel and rotovator were used for primary tillage. The planting preparation operations followed the normal practices for the conventional and conservational tillage systems. In all treatments, it was necessary to harrow in spring to ensure a sufficiently loose soil for the potato crop. All management practices for potato production were the same as those used by local farmers. Weeds were-controlled by harrowing and ridging. The list of tillage equipments, planter and harvester used in the experiments and their specifications were given in Table 1. Marfona and Hermes potato cultivars were used in the experiment. In this study, timings of tillage systems were as AMPD (mouldboard plough in autumn + disc harrow in spring +planting), SMPD (mouldboard plough+spring disc harrow in spring +planting, ACD (chisel in autumn + disc harrow in spring +planting), SCD (chisel+disc harrow in spring+planting), SR (rotovator in spring+planting), respectively.

Bulk density and gravimetric water content were determined using 100 cm3 cylinders, after oven drying for 24 h at 105°C. Soil penetration resistance was measured with a manual penetrometer (Eijkelkamp Co.) with maximum measurement range of 5000 kPa and 80 cm depth. Soil bulk density and penetration resistance were determined before tillage and after the planting operation. Six samples were taken for soil bulk density and penetration resistance per plot. Emerged potato tubers were counted several times during the emergence period in the rows with 6 m length for each treatment to determine mean emergence dates (MED), emerged rate index (ERI) and percentage of emerged tubers (PE). MED, ERI and PE were calculated as (Bilbro and Wanjura, 1982).

The number of tubers per plant (TN), plant yield (PY), and mean tuber weight (MTW, g) were determined from 10 randomly selected plants in each subplot prior to harvest. Potatoes was harvested by a harvester on October 12, 2009. Total tuber yield (TTY, t ha-1) was determined by harvesting the net sampling plot (4 row sections of 5 m) in each plot. After harvesting, tubers of each plot were graded into three size categories (>50 mm, 30–50 mm and <30 mm unmarketable) and weighed. Marketable potato tuber yield (big tuber and mid-size tuber, BT; MT) was determined as yield of potato in the size range >50 mm and 35-50mm, respectively (Henriksen et al., 2006). Collected data were analyzed to the analysis of variance (ANOVA) using SPSS software. Principal Component Analysis (PCA) was performed to obtain more reliable plant emergence parameters and yield components for potato cultivars in potato production.

RESULTS and DISCUSSION

Soil moisture content, bulk density and penetration resistance

Results of soil moisture content, bulk density and penetration resistance measurements in tillage systems before tillage and after planting were presented in Table 2. There were no significant differences in soil moisture content and penetration resistance of each tillage system for all soil depths studied. However, the effect of tillage systems on bulk density was statistically significant (P<0.05) at 0-10 cm soil depth. The values of soil parameters measured in 0-10 cm depth after planting were lower than those measureed at 10-20 and 20-30 cm depths in all tillage systems. Before tillage, soil moisture contents at 10-20 cm and 20-30 cm depths were lower than that of tillage in spring with AMPD and SMPD treatments in autumn, respectively. Tillage in spring, the moisture content was higher than that of tillage with chisel in autumn for ACD and SCD at before tillage, respectively. SR tillage system yielded the lowest moisture content among the tillage systems at prior to tillage (Table 2).

Table 1. Characteristics of the tillage equipment and planter.

Tool type	Unit number	Weight (Mg)	Working width (mm)	Working depth (mm)	Hitch type
Mouldboard plough	3	0.33	900	300	Mounted
Disc harrow	10	0.22	2250	100-150	Mounted
Chisel	7	0.42	1800	300-400	Mounted
Rotovator	48	0.54	2100	150	Mounted
Potato planter	2	0.47	1400	50-130	Mounted
Potato harvester	2	0.65	1400	20-25	Mounted

Table 2. Soil moisture content, soil bulk density, and soil penetration resistance affected by tillage systems before tillage and after planting.

Soil properties	Soil depth (cm)	Measurement time	AMPD	SMPD	ACD	SCD	SR	Mean
Soil moisture content (%)	0-10	BT	20.68	18.48	19.75	17.03	15.25	18.24
		AP	18.29	24.91	20.51	19.26	19.85	20.56
		Mean	19.49	21.70	20.13	18.15	17.55	
	10-20	BT	23.13	25.25	25.08	23.54	21.00	23.60
		AP	23.22	25.20	25.92	19.59	20.84	22.95
		Mean	23.17	25.23	25.50	21.57	20.92	
	20-30	BT	24.54	25.11	26.44	25.16	23.49	24.95
		AP	23.17	22.66	25.96	22.41	25.50	23.94
		Mean	23.85	23.89	26.20	23.78	24.49	
	Tillage system mean		22.17	23.60	23.94	21.17	20.99	24.44
Soil bulk density (g cm^{-3})	0-10	BT	1.35	1.21	1.24	1.20	1.18	1.40
		AP	1.21	0.96	1.06	0.98	0.93	1.03
		Mean	1.28 a‡	1.09 b	1.15 ab	1.09 b	1.06 b	
	10-20	BT	1.41	1.31	1.34	1.31	1.25	1.33
		AP	1.16	1.13	1.38	1.19	1.11	1.20
		Mean	1.29 ab†	1.22 bc	1.36 a	1.25 bc	1.18 c	
	20-30	BT	1.39	1.35	1.29	1.42	1.28	1.35
		AP	1.43	1.16	1.43	1.35	1.28	1.33
		Mean	1.41 a†	1.25 c	1.36 ab	1.38 a	1.28 bc	
	Tillage system mean		1.33	1.18	1.29	1.24	1.17	1.29
Soil penetration resistance (MPa)	0-10	BT	0.99	1.28	0.92	1.26	0.95	1.08
		AP	0.34	0.20	0.57	0.51	0.36	0.40
		Mean	0.67	0.74	0.75	0.89	0.66	
	10-20	BT	1.37	1.52	1.36	1.59	1.44	1.46
		AP	0.98	0.61	1.06	0.89	0.95	0.90
		Mean	1.18	1.07	1.21	1.24	1.20	
	20-30	BT	1.94	2.16	2.14	2.30	2.65	2.24
		AP	1.82	1.21	2.04	1.73	1.71	1.70
		Mean	1.88	1.69	2.09	2.02	2.18	
	Tillage system mean		1.24	1.16	1.35	1.38	1.34	1.30

‡: The tillage system means in the same group not followed by the same letter (within same line) are not significantly different according to Fisher protected LSD test (P = 0.01).
†: The tillage system means in the same group not followed by the same letter (within same line) are not significantly different according to Fisher protected LSD test (P = 0.05).
BT: Before tillage; AP: After planting; AMPD: mouldboard plough in autumn + disc harrow in spring +planting; SMPD: mouldboard plough+spring disc harrow in spring +planting; ACD: chisel in autumn + disc harrow in spring +planting; SCD: chisel+disc harrow in spring +planting; SR: rotovator in spring+planting

Soil bulk density significantly increased in all tillage treatments after planting for each soil depth, and greater in ACD (1.24 g cm^{-3}) than that of SCD (1.20 g cm^{-3}). Soil bulk density in SR was lower compared to the other tillage systems before and after tillage at all depths, respectively. Soil bulk density in spring was lower than those obtained in autumn at 0-10 cm depth (Table 2). The values of soil parameters were higher in ACD consisting of chisel than that of AMPD with mouldboard plough after planting at 10-20 cm and 20-30 cm depths. Differences in penetration resistance were greater in the subsoil depth (20-30 cm) before tillage and after planting. Soil parameters measured with chisel in autumn and tillage in spring were higher than those of mouldboard plough after planting. SR resulted in lower soil bulk density and penetration resistance at 0-10 cm than the other tillage systems in both tillage in autumn and in spring after planting. In this study, mouldboard plough appears to be capable of reducing bulk density and soil compaction, however chisel application conserved the moisture content in soil layers. Carter et al. (1998) reported that, soil penetration resistance values of mouldboard plough and chisel in autumn and tillage in spring were ranged between 0.5 to 2.0 MPa in pre-planting and harvesting of potato. Husnjak et al. (2002) reported that, soil moisture content and bulk density values were higher in conservational tillage system having chisel and harrowing as 20.95 % and 1.51 g cm^{-3} compared to the conventional tillage system consisting of mouldboard plough and disc harrow as 19.35% and 1.48 g cm^{-3}. Pabin et al. (2003) reported that, conservational and no tillage systems given greater soil bulk densities compared to conventional tillage system. The lower water content in soil and the higher bulk density resulted in increased mechanical impedance for root growth. Essah and Honeycutt (2004) reported that, potato yield and quality of the potato cultivar 'Russet Burbank' were affected by different soil tillage systems (raised bed in autumn, ridge till in autumn and chisel plow in spring).

Mean emergence date, emerged rate index and percentage of emerged seedling

The variance analysis with effects of potato cultivar and tillage systems on plant emergence, yield and yield componenets was shown in Table 3. The effects of tillage systems on mean emergence date (MED) and emerged seedling rate (ERI) were statistically significant (P<0.01).

Table 3. Effects of tillage systems and potato cultivar on plant emergence, yield and yield components.

Source	D.F.	MED	ERI	PE	TTY	TN	PY	MTW	BT	MT	ST
Potato cultivar (PC)	1	‡	‡	‡	‡	‡	‡	‡	‡	‡	‡
Tillage systems (TS)	4	‡	‡	†	†	ns	ns	‡	‡	ns	‡
PC x TS	4	†	ns	ns	ns	ns	ns	ns	ns	ns	ns

MED: mean emergence dates; ERI: emerged seedling rate; PE: percentage of emerged seedling; TTY: total tuber yield; PY: plant yield; TN: tuber number; MTW: mean tuber weigth; BT: big tuber; MT: mid-size tuber; ST: small tuber ‡: P< 0.01 †: P < 0.05 ns: non-significant

Table 4. Plant emergence parameters as affected by timing of tillage systems for Hermes and Marfona potato cultivars.

Plant emergence parameters	Potato cultivar	AMPD	SMPD	ACD	SCD	SR	Mean
Mean emergence dates (MED, day)	Marfona	29.60	29.51	29.67	29.70	29.52	29.60
	Hermes	30.02	30.08	30.22	30.07	29.82	30.04
	Mean	29.81 ab†	29.79 b	29.94 a	29.88 ab	29.67 c	
Emerged seedling rate (ERI, seedling/m day)	Marfona	0.112	0.100	0.098	0.092	0.099	0.100
	Hermes	0.109	0.086	0.085	0.081	0.090	0.089
	Mean	0.110 a†	0.093 ab	0.089 c	0.086 c	0.095 b	
Percentage of emerged seedling (PE, %)	Marfona	87.08	88.25	86.92	82.08	88.00	86.47
	Hermes	76.50	77.25	72.08	72.92	80.33	75.82
	Mean	81.79 abc‡	82.75 ab	79.50 bc	77.50 c	84.17 a	

‡: The tillage system means in the same group not followed by the same letter (within same line) are not significantly different according to Fisher protected LSD test (P = 0.01). †: The tillage system means in the same group not followed by the same letter (within same line) are not significantly different according to Fisher protected LSD test (P = 0.05).
AMPD: mouldboard plough in autumn + disc harrow in spring +planting; SMPD: mouldboard plough+spring disc harrow in spring +planting; ACD: chisel in autumn + disc harrow in spring +planting; SCD: chisel+disc harrow in spring +planting; SR: rotovator in spring+planting

The effects of potato cultivar on MED, ERI and PE were statistically significant (P<0.01) (Table 3). The lowest and highest MED were recorded as 29.51 and 30.22 days in ACD and SMPD for Hermes and Marfona potato cultivars, respectively (Table 4). Mean emerged dates obtained from AMPD and SMPD were lower than those of the ACD, SCD and SR. The seedling emergence rates were slightly lower for both and tillage in autumn and in spring (ACD and AMPD) than those of the tillage systems in spring (SCD and SMPD). The higher seedling emergence rates were obtained as 0.109 and 0.112 seedling/m days for Hermes and Marfona cultivars, respectively. The lowest and highest PE were obtained as 72.1 % and 88.3% in SCD for Hermes and Marfona cultivars, respectively. PE was higher in AMPD and SMPD having mouldboard plough than those of ACD and SCD having chisel. PE was slightly higher in spring tillage (SMPD) than that of AMPD tillage system. PE was positively affected by timing tillage sytems in ACD. Marfona yielded higher PE (86.5%) as compared to Hermes potato cultivar (75.8%), (Table 4). Mundy et al. (1999) reported that, reduced tillage systems (no-till and subsurface-tillage) resulted in slower potato development early in the season and emerged more slowly compared to potatoes planted with conventional tillage system. Essah and Honeycutt (2004) reported that, potato yield and quality affected by soil tillage and seed-sprouting treatments in the spring. Altuntas and Dede (2009) reported that, the percentage of emerged seedlings was positively affected by ridge planting and conservational tillage systems. Seedling emergence percentage was greater in the CT system which may be attributable to more suitable soil conditions for seedbed preparation. Holmstrom et al. (2006) reported that, tillage treatments were not significantly different with respect to potato plant emergence. Differing emergence was reported as a result of tillage effects.

Total tuber yield, plant yield, tuber number, mean tuber weigth and tuber size distribution

The effects of tillage systems and potato cultivar on yield and yield components were presented in Table 5**.** The effects of tillage systems on yield and yield components as mean tuber weigth (MTW), tuber size distribution; big, mid-size and small tuber (BT, MT, ST) were statistically significant (P<0.01). The effects of potato cultivar on TTY, TN, and tuber size distribution were statistically significant (P<0.01). The lowest and highest total tuber yield for potato cultivars were obtained as 37.36 t ha^{-1} (SR) and 50.34 t ha^{-1} (SCD), respectively (Table 5). TTY obtained in SCD tillage system was higher than the other tillage systems for both Hermes and Marfona cultivars. TTY was higher in Marfona than Hermes cultivar for each tillage system. The tuber number (TN) was recorded as 10.16 and 9.39 for Marfona and Hermes potato cultivars, respectively. The highest TN was obtained as 9.53 and 10.27 in SR tillage system for Marfona and Hermes, respectively. Tuber yield and TNPP were negatively correlated for each potato cultivar (Table 5). Plant yield (PY) was higher in SCD than the other tillage systems, whereas, SR system was the lowest in PY. Total tuber yield was positively affected by PY component.

In autumn tillage system (AMPD) was yielded higher PY than that of tillage system in spring (SMPD) for Marfona cultivar, respectively. Mean tuber weigth (MTW) was higher in SCD than the other tillage systems, whereas MTW was lower in SR system for each cultivar, respectively. Marfona yielded higher potato yield and yield components as compared to Hermes cultivar (Table 5). Marketable tuber yield (30-50 mm and >50 mm) was higher in SCD than the other tillage systems, whereas small tuber yield (ST) was higher in SR system for both cultivars, respectively. Henriksen et al. (2006) reported that, with total and marketable yield of 27.9 and 14.2 t ha^{-1} in winter resulted in higher tuber yields than both ridging in autumn and ridging in autumn+tilting and re-establishment of ridges in winter.

Principal component analysis (PCA) was performed to obtain more reliable plant emergence parameters and yield components for potato cultivar for potato production. In the first principal component; MT, TTY, MTW, PY, MED, TN and PE were the most important components contributing to variation that obtained about 82.3%. (Table 6). MED, TN and ST could be more descriptive to introduce the differences among emergence and yield components for Hermes, whereas, the other emergence and yield components were effective to define Marfona cultivar.

In the second principal component, ST was the most important component contributing to variation that obtained about 13.6% (Table 6). Tuber yield is a complex component and a function of several other components (Fufa et al., 2005). Figure 1 showed a positive relationship between plant emergence and yield components such as TTY and PE; whereas TTY and TN; PE and MED were negatively correlated. ACD and AMPD tillage systems had higher ST and TN for Hermes; whereas SCD and SMPD had higher MT and ERI parameters for Marfona cultivar, respectively (Fig. 1).

Table 5. Yield and yield components of Hermes and Marfona potato cultivars as affected by timing of tillage systems.

Yield and yield components	Potato cultivar	AMPD	SMPD	ACD	SCD	SR	Mean
Total tuber yield (TTY, t ha^{-1})	Marfona	48.68	49.02	48.01	50.34	47.63	48.74
	Hermes	37.75	38.50	37.77	38.88	37.36	38.03
	Mean	43.16 b‡	43.76ab	42.89 b	44.61a	42.50 b	
Tuber number (TN, number)	Marfona	9.50	9.30	9.30	9.30	9.53	9.39
	Hermes	10.07	10.27	10.07	10.13	10.27	10.16
	Mean	9.78	9.78	9.68	9.72	9.90	
Plant yield (PY, g)	Marfona	1104.5	1098.8	1079.1	1126.9	1095.2	1100.9
	Hermes	828.6	869.9	830.4	875.0	840.7	848.9
	Mean	966.5	984.3	954.7	1001.0	967.9	
Mean tuber weigth (MTW, g)	Marfona	116.3	118.1	116.1	121.2	114.9	117.3
	Hermes	82.3	84.7	82.5	86.3	81.9	83.5
	Mean	99.3 bc‡	101.4 b	99.3 bc	103.8 a	98.4 c	
Big tuber (BT, t ha^{-1})	Marfona	30.12	30.88	29.45	32.14	29.32	20.28
	Hermes	19.74	20.48	19.70	21.90	19.57	30.38
	Mean	24.93 b‡	25.68 b	24.57 b	27.02 a	24.45 b	
Mid-size tuber (MT, t ha^{-1})	Marfona	15.91	15.79	16.16	16.14	15.47	15.16
	Hermes	15.26	15.48	14.53	15.54	14.99	15.89
	Mean	1558.7	1563.4	1534.5	1584.0	1523.0	
Small tuber (ST, t ha^{-1})	Marfona	2.54	2.39	2.39	2.03	2.84	2.80
	Hermes	2.77	2.57	3.41	2.21	3.04	2.44
	Mean	2.65 ab‡	2.48 b	2.90 a	2.12 c	2.94 d	

‡: The tillage system means in the same group not followed by the same letter (within same line) are not significantly different according to Fisher protected LSD test (P = 0.01).
AMPD: mouldboard plough in autumn + disc harrow in spring +planting; SMPD: mouldboard plough+spring disc harrow in spring +planting; ACD: chisel in autumn + disc harrow in spring +planting; SCD: chisel+disc harrow in spring +planting; SR: rotovator in spring+planting

Table 6. Results of principal component analysis in regard to plant emergence, yield and yield components for Marfona and Hermes potato cultivars.

	PC1	PC2	PC3	PC4
MED (mean emerged dates)	**-0.8607**	0.2153	0.4019	-0.0768
ERI (emerged rate index)	0.4623	0.2153	-0.5107	0.1604
PE (percentage of emerged seedling)	**0.8288**	-0.1524	-0.5850	0.1415
TTY (total tuber yield)	**0.9935**	-0.2106	0.0533	0.0727
PY (plant yield)	**0.9801**	-0.1181	0.0192	-0.0446
TN (tuber number)	**-08060**	-0.1697	-0.2175	-0.4062
MTW (mean tuber weigth)	**0.9622**	0.1139	-0.0527	-0.2007
BT(big tuber)	-0.6208	-0.1758	0.0178	0.0117
MT (mid-size tuber)	**0.9918**	**-0.7832**	0.0631	0.0565
ST (small tuber)	0.6299	-0.0755	-0.1704	0.0141
Proportion of total variance %	82.3	13.6	1.9	1.0
% cumulative variance	82.3	95.9	97.78	98.8

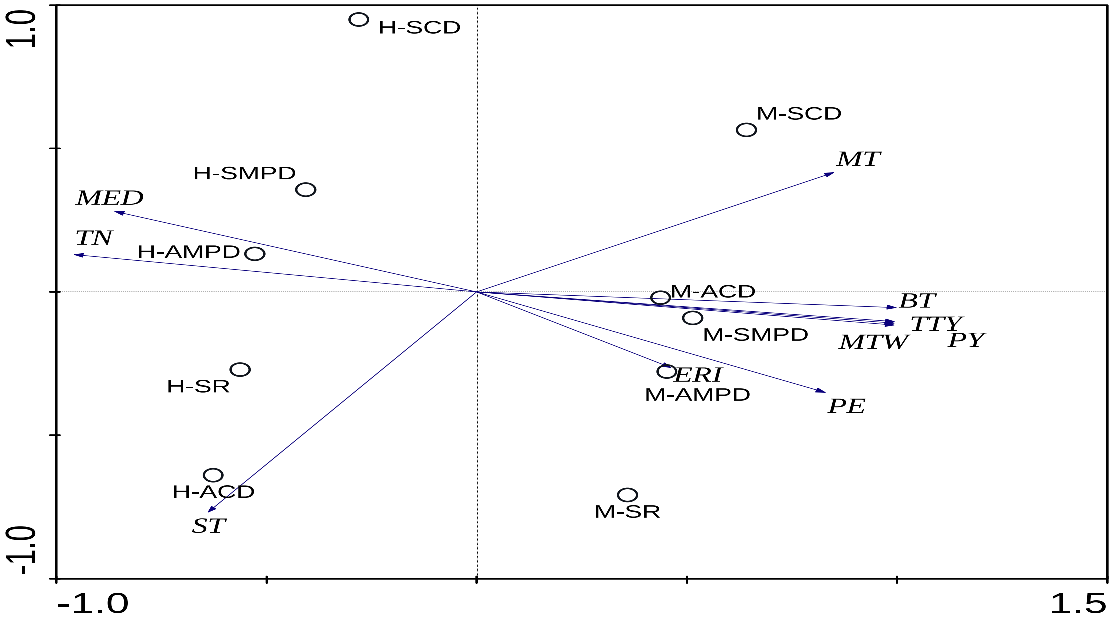

Figure 1. Varimax rotated principal component loadings in regard to plant parameters and yield components.

H-AMPD (Hermes, mouldboard plough in autumn + disc harrow in spring +planting), H-SMPD (Hermes, mouldboard plough+spring disc harrow in spring +planting), H-ACD (Hermes, chisel in autumn + disc harrow in spring +planting); H-SCD (Hermes, chisel+disc harrow in spring +planting), H-SR (Hermes, rotovator in spring+planting), M-AMPD (Marfona, mouldboard plough in autumn + disc harrow in spring +planting), M-SMPD (Marfona, mouldboard plough+spring disc harrow in spring +planting), M-ACD (Marfona, chisel in autumn + disc harrow in spring +planting), M-SCD (Marfona, chisel+disc harrow in spring +planting), M-SR (Marfona, rotovator in spring+planting), MED (mean emerged dates, days), ERI (emerged rate index, seedling/m day), PE (percentage of emerged seedling, %), TTY (total tuber yield, t ha^{-1}), PY (plant yield, g), TN (tuber number), MTW (mean tuber weigth, g), BT (big tuber, t ha^{-1}), MT (mid-size tuber, t ha^{-1}), ST (small tuber, t ha^{-1}).

CONCLUSION

In this study, the effects of timing of tillage systems on plant emergence, yield and yield components were investigated. Soil bulk density and plant emergence parameters (MED, ERI and PE) were influenced by tillage systems. Soil bulk density and penetration resistance in spring tillage were lower than those obtained in autumn tillage systems after planting. The higher penetration resistance in subsoil was obtained rotovator in spring (SR) tillage system. The favorable soil characterisitcs (the lowest bulk density and soil compaction) were obtained in spring tillage with SMPD. In spring tillage, MED were slightly lower compared to those obtained with the other tillage systems for Marfona cultivar. The percentage emerged seedling was slightly higher in SR and SMPD tillage systems than the other tillage systems. Potato yield and yield components specially TTY, BY, PY and MTW were positively affected by PE and ERI. For Hermes, the best indices were MED, TN, ST, whereas ERI, PE and the other yield components were the best indices for Marfona cultivar. PCA allowed comparative evaluation of plant emergence parameters and yield components for Hermes and Marfona cultivars, and helped identify desirable plant emergence and yield components in potato production.

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