Effect of tillage methods on sowing uniformity of maize

D. Karayel and A. Özmerzi

Department of Farm Machinery, Faculty of Agriculture, University of Akdeniz, 07070 Antalya, Turkey.

Karayel, D. and Özmerzi, A. 2002. **Effect of tillage methods on sowing uniformity of maize**. Canadian Biosystems Engineering/Le génie des biosystèmes au Canada **44**: 2.23-2.26. A comparative study was conducted in the years 2000 and 2001 with four conventional tillage methods to determine the effect of tillage methods on precision maize sowing. The tillage methods were: Method I - chisel plow, disc harrow, and roller; Method II - moldboard plow, disc harrow, and roller; Method III - moldboard plow, powered rotary tiller, and roller; and Method IV - chisel plow, powered rotary tiller, and roller. Maize was sown in silty-loam soil at a tractor speed of 6 km/h and nominal sowing depth of 40 mm. A precision vacuum seeder was used in the field tests. Multiple index, miss index, and quality of feed index of horizontal distribution pattern and emergence rate index, and mean emergence time were not affected by tillage methods and years of experiment. The most uniform sowing depth and the maximum percentage of emergence were obtained with Method II. **Keywords:** precision sowing, tillage.

Une étude comparative a été réalisée en 2000 et 2001 pour déterminer les effets de quatre méthodes de travail du sol sur le semis de precision du maïs. Les méthodes de travail du sol sont: Méthode I - chisel, pulvériseur à disques et rouleau; Méthode II - charrue à versoirs, pulvériseur à disques et rouleau; Méthode III - charrue à versoirs, rotoculteur et rouleau et, Méthode IV - chisel, rotoculteur et rouleau. Le maïs a été semé dans un loam limoneux à une vitesse de 6 km/h et à une profondeur nominale de semis de 40 mm. Un semoir de précision pneumatique à pression négative a été utilisé pour les essais aux champs. Les indices multiple, de graine manquante, de taux d'émergence et de qualité d'alimentation de même que le temps moyen d'émergence n'ont pas été affectés par la méthode de préparation du sol et les périodes d'expérimentation. L'uniformité de la profondeur de semis et le pourcentage le plus élevé d'émergence ont été obtenus avec la Méthode II. **Mots clés**: semis de précision, travail du sol.

INTRODUCTION

A seeder should place a seed in an environment in which the seed will reliably germinate and emerge. Seed quality, soil conditions, seeder design, and the skill of the operator all play a part in determining the final plant stand.

Precision seeders theoretically place seeds at a required spacing and provide a good growing area per seed. Previous literature on precision sowing deals with the effects of various factors on sowing uniformity of precision seeders. Bracy et al. (1998) demonstrated that variability in seed spacing with a precision vacuum seeder decreased with increased nominal seed spacing but with a belt seeder, seed spacing uniformity was not affected by nominal seed spacing. Wanjura and Hudspeth (1969) found that a 8 mm seed drop height consistently produced a better seed pattern than a 15 mm drop height with a precision vacuum seeder. They recommended that the metering device on a seeder should be located as low as feasible and that seed should fall freely to the bottom of the soil trench. Karayel and Özmerzi (2001) stated that the variability in seed spacing with a precision vacuum seeder increased with increasing forward speed. They found that a forward speed of 1 m/s consistently produced a better seed pattern than 1.5 and 2.0 m/s for precision sowing of melon and cucumber seeds.

The aim of soil tillage is to prepare a suitable seedbed for the seed. The choices relating to tillage methods strongly affected the other components of the cropping system (Toderi and Bonari 1986). Kushwaha and Foster (1993) evaluated six different seeder furrow openers on three soil types in relation to spring wheat emergence, sowing depth, and final grain yield under conventional and conservation tillage. They found that treatments with conventional tillage performed significantly better than the conservation tillage plots.

The objective of this research was to measure the effect of conventional tillage methods on the sowing uniformity of maize when a precision seeder is used. For this purpose four conventional tillage methods were compared. These were:

Method I: chisel plow, disc harrow, and roller
Method II: moldboard plow, disc harrow, and roller
Method III: moldboard plow, powered rotary tiller, and roller
Method IV: chisel plow, powered rotary tiller, and roller

MATERIALS and METHODS

The study was conducted at the Research and Application Land, Faculty of Agriculture, University of Akdeniz, Antalya, Turkey. The soil, composed of 38.1% sand, 26.0% silt, and 35.9% clay, was classified as silty-loam. The soil tillage equipment used in the research is commonly used in the Antalya Region of Turkey. In Methods II and III, plowing depth was 200 mm. In Methods I and IV, chisel depth was 300 mm, in Methods I and II the disc harrow was passed twice. In all methods, the roller was passed twice to consolidate the soil, to crush clods, and smooth the surface. Table 1 shows the general specification of tillage equipment used in this research.

The soil had no rocks or hard clay clods and was without crop residue. Table 2 shows the penetration resistance (PR), moisture content (MC), and bulk density (BD) of the soil for the top 45 mm before sowing. Measurements of soil moisture status and bulk density were carried out using a thin-walled cylinder (50 mm diameter by 150 mm long) to a depth of 45 mm. A plunger was used to remove the soil samples from the cylinders. In addition, penetrometer readings were made between 0-45 mm depth to determine the penetration resistance of the soils. The

Table 1. Specification of tillage equipment used for the seedbed preparation for maize.

Equipment	Width (mm)	Specification
Moldboard plow	1150	general purpose type, 3 bodies in the frame each of width 360 mm
Chisel plow	2200	8 straight shanks, 62 mm wide tines at a depth of 410 mm
Disc harrow	1800	36 discs each of 520 mm diameter, 35° inclined to the direction of travel with 200 mm between discs in each row
Powered rotary tiller	2080	horizontal rotary axis type, 24 L-shaped blades mounted with 3 right-hand and 3 left-hand blades per flange
Roller	2200	flat type, 500 mm in diameter

values were then transformed to cone-index values by dividing the readings by the cone base area. Soil moisture status, BD, and PR were measured at six places for each treatment. Maize seed (Pioneer 3162) of 239 g/1000 seeds was used for all treatments.

A Hassia model UNM (Hassia, Butzbach, Germany) precision vacuum seeder was operated in all tests. The seeder was a general purpose seeder designed for row crops such as maize and soybeans. A seed plate was used in the metering mechanism. The seed plate operated in a vertical plane and required a vacuum of 500 to 850 mm of water to select a seed. Air suction from the holes of the seed plate caused the seed to stick to the holes. Each of the holes was 4 mm in diameter. The stuck seed was released from the rotating plate by blocking the air suction over the opener. It had no seed tube and the seed fall height (12 mm) was kept low to maintain a uniform spacing by avoiding bouncing of the seed that is more likely to occur when dropping from higher up. Each sowing unit was independently mounted on a parallelogram by joint springs and was composed of a shoe opener followed by a presswheel which closed and compacted the seed furrow and also maintained a constant sowing depth. The seed metering system was adjusted for a nominal seed spacing of 210 mm on the row and a nominal depth of 40 mm. The seeder was operated at a speed of 6 km/h.

After sowing, horizontal distribution patterns, sowing depth uniformities, mean emergence times (MET), emergence rate indexes (ERI), and percentage of emergence (PE) were compared. The distance between the nearest neighbouring plants and the distances in the transverse direction of plants to a straight line parallel to the row were measured in the horizontal plane. Plant spacings were measured in the field 17 days after sowing between about 30 maize plants along a 7 m length of crop row for all treatments. The depths of the seeds to the soil surface were measured in the vertical plane. Mean sowing depth and coefficient of variation were determined by measuring the mesocotyl length of 30 maize plants to the nearest 1.0 mm along a 7 m length of crop row for all treatments and replications.

The sowing uniformity of the horizontal distribution pattern was analysed using the methods described in Kachman and Smith (1995). The multiple index is the percentage of plant spacings that were less than or equal to half of the nominal spacing and indicates the percentage of multiple seed drops. Miss index is the percentage of plant spacings greater than 1.5 times the nominal seed spacing and was interpreted as the percentage of missed seed locations or skips. Quality-of-feed index (QFI) is the percentage of plant spacings that were more than half but no more than 1.5 times the nominal spacing. QFI is 100% minus miss and multiple indexes and is a measure of the percentages of single seed drops. Preciseness (PREC) is the coefficient of variation of the spacings (length) between the nearest plants in a row that are classified as singles after omitting the outliers consisting of misses and multiples.

Seedling counts were made in 25 m of row per treatment every day during the emergence period. From these counts, mean emergence time, emergence rate index, and percentage of emergence were calculated as:

$$MET = \frac{N_1 T_1 + N_2 T_2 + \ldots\ldots N_n T_n}{N_1 + N_2 + \ldots\ldots N_n} \quad (1)$$

$$ERI = \frac{S_{te}}{MET} \quad (2)$$

$$PE = \frac{S_{te}}{n} \quad (3)$$

where:

$N_{1...n}$ = number of seedlings emerging since the time of previous count,
$T_{1...n}$ = number of days after sowing,
MET = mean emergence time (d),
S_{te} = number of total emerged seedlings per meter,
ERI = emergence rate index,
PE = percentage of emergence, and
n = number of seeds sown per meter.

Table 2. Penetration resistance (PR), moisture content (MC), and bulk density (BD) of the soil depth 0-45 mm before sowing in years 2000 and 2001.

Tillage Method	2000			2001		
	Maximum PR (MPa)	Mean MC (%)	BD (Mg/m^3)	Maximum PR (MPa)	Mean MC (%)	BD (Mg/m^3)
I	1.6	16.6	1.10	1.5	17.1	1.12
II	1.4	17.2	1.08	1.3	17.4	1.13
III	1.7	17.5	1.02	1.8	17.9	1.04
IV	1.7	17.0	1.01	1.7	16.7	1.05

Table 3. Test parameters.

Class	Level	Values
Tillage Methods	4	Methods I, II, III, IV
Years	2	2000, 2001

Table 4. Analysis of variance (F values) for selected factors.

Source	Multiple index (%)	Miss index (%)	QFI (%)	Mean sowing depth (mm)	PE (%)	MET (days)	Maximum ERI (seedlings d^{-1} m^{-1})
Tillage Method (TM)	2.22	2.74	2.99	11.77*	86.09*	1.41	0.86
Year (Y)	0.09	2.21	0.79	0.69	0.95	4.09	0.74
TM x Y	0.27	1.48	1.97	1.39	0.83	0.20	0.99

* significant at the 0.001 probability level.

Table 5. The sowing uniformity of horizontal distribution patterns for different tillage methods in years 2000 and 2001.

Tillage Method	2000				2001			
	QFI (%)	Multiple index (%)	Miss index (%)	PREC (%)	QFI (%)	Multiple index (%)	Miss index (%)	PREC (%)
I	89.6	4.0	6.4	23.4	90.3	3.7	6.0	19.3
II	92.0	3.6	4.4	14.0	91.3	3.5	5.2	12.7
III	90.4	5.4	4.2	14.6	88.5	5.8	5.5	15.3
IV	89.4	4.5	5.1	21.7	89.8	4.8	5.4	23.1

Each experiment included four treatments arranged as a randomised complete block (Neter et al. 1990) replicated three times. The average area of the plots was aproximately 0.5 ha and their lengths ranged from 200 to 250 m. The plots were completely randomized and placed side by side. Following a normality test of the variable it was not necessary to employ any transformation. An analysis of variance method was then applied to analyse data sets using the GLM procedure of the SAS package (SAS 1995). Table 3 lists the levels of each parameter in the experiment. Tillage method treatments were the main plot with year being the subplots. Duncan's multiple-range tests were used to identify significantly different means within dependent variables.

Table 6. Uniformity of sowing depth in years 2000 and 2001.

Tillage Method	2000		2001	
	Mean sowing depth (mm)	CV of depth (%)	Mean sowing depth (mm)	CV of depth (%)
I	38.1b*	7.0	37.1b	6.8
II	39.8a	3.7	39.5a	3.9
III	38.2b	6.4	38.1b	6.9
IV	38.7b	6.3	37.4b	7.2

* Means within a group followed by the same letter are not significantly different at probability P=0.05 by Duncan's multiple range test.

RESULTS and DISCUSSION

Effect of tillage methods on sowing uniformity of maize was analyzed related to the sowing uniformity of horizontal distribution pattern, uniformity of sowing depth, MET, ERI, and PE. All data from the two-year study were combined for the factorial analysis of variance to determine the significant difference in the variability among the parameters. The results of this analysis are given in Table 4.

The results of the analysis show that the multiple index, miss index, and QFI of horizontal distribution pattern were not significantly influenced by tillage methods and years of experiment. Few skips (≤ 6.4%) or multiple seed drops (≤ 5.8%) occurred at any treatment. Horizontal sowing uniformity of Methods II and III were considered acceptable for field conditions. As indicated, all values of PREC were under 15.3%, and all values of QFI were over 88.5%. Best PREC was obtained for tillage Method II for both years (Table 5).

Analysis of combined data (Table 4) showed significant differences in mean sowing depth occurring among tillage methods. Years did not result in significant differences. Table 6 shows the influence of the tillage methods on uniformity of

Table 7. Mean emergence time (MET), emergence rate index (ERI), and percentage of emergence (PE) in years 2000 and 2001.

Tillage Method	2000 PE (%)	2000 MET (days)	2000 Maximum ERI (seedlings d^{-1} m^{-1})	2001 PE (%)	2001 MET (days)	2001 Maximum ERI (seedlings d^{-1} m^{-1})
I	77c*	11.8	0.30	80b	10.9	0.33
II	92a	11.6	0.36	91a	11.1	0.39
III	86b	11.7	0.34	85b	10.8	0.36
IV	79c	12.2	0.30	81b	11.8	0.34

* Means within a group followed by same letter are not significantly different at probability P=0.05 by Duncan's multiple range test.

sowing depth. The mean sowing depth and the CV of depth are given for each tillage method. The most uniform sowing depth was obtained with Method II. CV of depth was 3.7 and 3.9% for the study years of 2000 and 2001, respectively.

The seeder had a shoe type furrow opener. Chaudhuri (2001) reported that the PR of the soil was a critical factor affecting uniformity of sowing depth of the furrow openers and shoe type furrow openers did not perform well when PR increased. In this research the CV of the depth of Method II (Table 2) was less for both years due to the lower PR of the soil.

Tillage methods and years did not have a significant effect on MET and maximum ERI. It should be noted that the results refer to MET of maize seeds ranging from 10.8 to 12.2 days for all treatments (Table 7).

The analysis of combined data (Table 4) showed a significant difference in PE due to tillage methods. Years created no significant differences. Tillage Method II had significantly higher plant emergence counts for both years. Due to the uniform sowing depth, PE of Method II was higher. Our results support reports from Heege (1993) who found the negative effect of high variation in sowing depth on PE.

CONCLUSION

On the basis of this research we reached the following conclusions. Multiple index, miss index, and quality of feed index of the horizontal distribution pattern were not affected by tillage methods and years of experiment. Best precision was obtained by Method II for both years. The most uniform sowing depth and maximum percentage of emergence were obtained with Method II. Emergence rate index and mean emergence time were not affected by tillage methods and years. According to precision of the horizontal distribution pattern, percentage of emergence, and uniformity of sowing depth, Method II can be recommended for more precise maize sowing.

ACKNOWLEDGMENTS

This paper was made possible by funding from the Research Fund of Akdeniz University.

REFERENCES

Bracy, R.P., R.L. Parish and J.E. McCoy. 1998. Precision seeder uniformity varies with theoretical spacing. ASAE Paper No. 981095. St. Joseph, MI: ASAE.

Chaudhuri, D. 2001. Performance evaluation of various types of furrow openers on seed drills. *Journal of Agricultural Engineering Research* 79(2): 125-137.

Heege, H.J. 1993. Seeding methods performance for cereals, rape, and beans. *Transaction of the ASAE* 36(3): 653-661.

Kachman, S.D. and J.A. Smith. 1995. Alternative measures of accuracy in plant spacing for planters using single seed metering. *Transaction of the ASAE* 38(2): 379-387.

Karayel, D. and A. Özmerzi. 2001. Effect of forward speed and seed spacing on seeding uniformity of a precision vacuum metering unit for melon and cucumber seeds. *Journal of University of Akdeniz, Faculty of Agriculture* 14(2): 63-67.

Kushwaha, R.L. and R.K. Foster. 1993. Field evaluation of grain drill furrow openers under conservation and conventional tillage systems. *Canadian Agricultural Engineering* 35(4): 253-260.

Neter J., W. Wasserman and M.H. Kuther. 1990. *Applied Linear Statistical Model*, 3rd edition. Boston, MA: Richard D. Irwin.

SAS. 1995. *SAS System for Windows*, Release 6.11. Cary, NC: SAS Institute.

Toderi G. and E. Bonari. 1986. Soil tillage: Crop management aspects. II. Tillage and crops. *Rivista di Agronomia* 20(2-3)106-133.

Wanjura, D.F. and E.B. Hudspeth, Jr. 1969. Performance of vacuum wheels metering individual cottonseed. *Transaction of ASAE* 12(6): 775-777.