TILLAGE PRACTICES AND EFFECT OF SOWING METHODS ON GROWTH AND YIELD OF MAIZE CROP

MEMON S.Q., MIRZA B. BAIG, MARI G.R.

Abstract

An experiment was carried out at Latif Experimental Farm, Sindh Agriculture University, Tando Jam during 2004, in order to assess the effect of tillage on soil physical properties growth and yield of maize under different sowing methods. The maize variety Akbar was planted on clay loam soil under three different methods ridge, drilling and broadcasting using RCBD. It was found that soil moisture content was higher in ridge sowing method as compared to other sowing methods. While bulk density and soil strength were relatively lower in ridge sowing plots as compared to seed drill and seed broadcasting plots. The results of agronomic observations revealed that plant height, number of leaves/plant, number of cobs/plant, dry cob weight, seed index, root length and total grain yield/ha were superior in ridge sowing, the second best was seed drilling, while seed broadcasting was found to be less effective. Maize sown on ridges resulted in greater seed emergence 89%, plant height 155.1 cm, weight of hulled dry cob 177.67 g, de-hulled dry cob 127.53 g and seed index 198.26 g, which in turn caused greater grain yield 6.35 t/ha, the next best was seed drilling, while seed broadcasting was not effective as other two methods.

Key words: tillage practices, sowing methods, emergence, growth, yield, maize

INTRODUCTION

Many developing countries strive for an increase of their agriculture production in order to feed the rapidly growing population. Contrary to many other countries, Pakistan still has the possibility to expand the cultivated area since there is no lack of suitable land. Maize is most important cereal crop of the world, it is used for three main purposes as human food, feed for poultry and livestock. Maize being the highest yielding cereal crop in the world is of significant importance, where rapidly increasing population has already out stripped the available food supplies to use for direct human consumption, the other major outlets are the wet-milling industry and livestock feed. The maize crop categorized as cereal having starch in the grain, production of starch is the major objective of wet-milling industry, the production of maize oil is then very dependent on the demand for the starch component. Thousands of years recorded history, groups of human being have been tilling in order to increase the production of food, tillage includes any physical manipulation of soil, usually done in preparation for same aspect of crops production. The most favorable crop production requires a suitable soil condition, while the suitable soil condition can be obtained by best tillage practices. Kapner (1982) defined the tillage as the mechanical manipulation of soil, the goal of proper tillage is to provide a suitable environment for seed germination, weed control, excess moisture removed and reduction of surface runoff by increasing infiltration. The degree of soil compaction, soil bulk density and soil moisture condition are important factors that influence seedling emergence and crop yield.

The tillage equipment may cause soil compaction and upset the balance between the air and water components of soil, the compaction cause due to tillage implements may increase the soil strength and restrict root growth. However, a slight compaction is needed to gain good contact between seed and soil particles. This can be achieved by well planed tillage practices that can provide means for creating congenial soil environment, which is particularly necessary for seed germination and effective plant growth. Frequent traffic of machinery and equipment, in irrigated field cause a breakdown of soil structure in the topsoil layer, and considerable compaction of the lower layers. As a result, it is difficult to prepare a good seedbed, germination is affected, and irregular stands are obtained.

MATERIAL AND METHODS

The study was conducted at Latif Experimental Farm, Sindh Agriculture University, Tando Jam, during 2004. The experimental area is located at distance of about ½ km in north of Sindh Agriculture University, Tando Jam. The soil at the site was medium textured clay loam, it has an average bulk density of 1.21 g/cm^3, retains 19.45% moisture. The experiment was laid out in a Randomized Complete Block Design with three treatments, each replicated three times for the study, the treatment consisted of T-1 (Ridge sowing method), T-2 (drilling sowing method), T-3 (Broadcasting method). Seedbed was prepared according to the treatments. Ridges were prepared by ridger, keeping 75 cm distance between ridge to ridge, while for seed drilling the plots were leveled by using leveler, for broadcasting the plots

were remained ploughed. Homogenous seeds of a maize variety Akbar were dibbled into ridges at a 5 cm depth, while for drilling row to row distance was 75 cm, however, broadcasting was done manually seed rate was 50 kg/ha, the recommended doze of fertilizer was applied (Khoso, 1998). In each treatment the agronomic observations were recorded, plants were selected randomly from each plot and tagged.

Physical Properties of Soil

Soil samples were taken at the depths of 0-15 cm, 15-30 cm and 30-45 cm, respectively. The soil samples were collected in polyethylene bags and soil moisture content, bulk density and soil texture were analyzed.

Soil moisture content

Soil moisture content on dry weight basis was determined randomly, the soil samples were taken from the test plots, at a depth of (0–15, 15–30, 30–45,) cm, the electrical balance was used for measuring the soil samples. The samples were placed in oven at 105^0C for 24 hours. The dried soil samples were re-weighed in an electrical balance and the weight was recorded. The soil moisture percent (% dry weight basis) was calculated using the following formula, RNAM, (1995).

$$MC \quad \frac{Ww \quad Ww}{Wd} \upsilon 100$$

Where

MC =	Moisture content	(%)
Ww =	Weight of wet soil	(g)
Wd =	Weight of dry soil	(g)

Soil texture (by hydrometer methods)

Soil samples were collected and dried into open air, the dispersion cups were filled 1/3 with water and 10 ml of $1N.Na_2Co_3$ were added to the cup. The material was dispersed for 5–10 minutes with the help of dispersion machine. Reading with hydrometer was taken after two hours and 40 seconds, then the percent clay, silt and sand were calculated as follows, RNAM (1995).

$$\% \text{ Clay} \quad \text{Silt} \quad \frac{1^{st} \text{ correct reading}}{\text{Wt of soil sample}} \upsilon 100$$

$$\% \text{ Clay} \quad \frac{2^{st} \text{ correct reading}}{\text{Wt of soil sample}} \upsilon 100$$

% Silt = (% Clay + % Silt) – % Clay

% Sand = 100 – (% Clay + % Silt)

Bulk density of the soil

The measurement of soil bulk density (g/cm^3), soil sample were randomly taken at a depth of (0–15, 15–30, 30–45,) cm, from the main test plot. The diameter of core sampler was measured with venire caliper. The samples were dried in a hot air oven at 105^0C and dry weight of soil sample was recorded. The bulk density of soil was determined by using the following formula, RNAM (1995).

$$' = M/V$$

$$V \quad \frac{\Sigma}{4} D^2 L$$

$$\Phi \quad \frac{4M}{3.142\ D^2 L}$$

Where

' =	soil bulk density	(g/cm^3)
M =	Dry soil mass in a core sampler	(g)
V =	volume of cylindrical core sampler	(cm^3)
D =	diameter of cylindrical core sampler	(cm)
L =	length of cylindrical core sampler	(cm)

Soil aggregation

Soil aggregation was evaluated by using a set of sieves. This methods is called the sieve analysis, the set of six sieves were selected for determining the degree of soil aggregates with mesh of 75 mm, 50 mm, 37.5 mm, 25 mm, 12.5 mm, 8 mm. The soil aggregations were determined randomly placing half square meter frame over ploughed area. The soil samples were gently passed through a set of above sieves, passed through the smallest aperture sieve and were retained on the next sieve and were passed through the smallest aperture sieve, following formula was used to determine the soil aggregation, RNAM (1995).

$$\text{Mean Soil Clod Diameter} \quad \frac{f^{WD}}{f^{W}}$$

Where

W = sum of weight of soil clods or weight of soil held by a particular sieve kg.

D = Equivalent diameter of clods or size of sieve (mm).

Soil compaction

Soil strength is the ability or capacity of a particular condition to resist or endure an applied force. Penetration resistance is a composite parameter that involves several independent properties of a soil but it is generally considered to reflect the strength of the soil. To measure penetration resistance, a simple instrumented probe known as a pentrometer was used to observe the relation to penetration depth Kapner (1982).

Tillage implements

The implement used in the present research study was moldboard plough, Tandem disc harrow, seed driller and Ridger. All the implements were standard field machines powered by MF-375 diesel tractor. The instruments and other materials used in the research study were steel tape, stop watch, meter scale, soil sampler, soil containers, electric oven, electric balance,

soil cone penetrometer, graduated cylinder, jericon, range poles, camera and chalks. The specifications of the tillage implements used in research study were as follows.

Specification s of tillage machines

Implements	Specifications
Mould board Plough	3 bottom mounted, general purpose mould board, extension of mould board 21.5 cm, width of plow 120 cm and vertical clearance 68 cm.
Tandem disc harrow	Tandem disc harrow having 2 gangue, each gangue contain 8 disc, dia of rear gangue 60 cm, front gangue 42 cm, vertical clearance 43 cm.
Seed drill	A tractor driven manual operated corn planter five seed planting tubes, depth of sowing 10 cm, tine to tine spacing 75 cm.
Ridger	The ridger was used for earthen up the crop sown in rows. 3-ridge mounted, maximum row spacing 71.1 cm, overall width 117.8 cm, depth 105.0 cm, clearance (under frame) 55.0 cm.

Emergence percentage
For seed emergence/ square meter was used to calculate the emergence percentage and number of plants were counted, and emergence %age was calculated from each replication according to the formula,

$$\text{Emergence \% age} \quad \frac{\text{No. of seed emergence}}{\text{No. of seed sowing}} \upsilon 100$$

Number of leaves/Plant
Square meter was used to count the number of leaves per plant in each replication. The plants were randomly selected in each replication and number of leaves per plant was counted and their average was workout.

Plant height
Plant height was recorded from randomly selected plants in each treatment with measuring scale from soil surface to the tip of the plant in cm and their average was workout.

Number of cob/plant
Square meter was used to count the number of cob per plant in each replication. Number of cob per plant produced by each replication was selected and counted their mean values were calculated.

Cob length (cm)
Square meter was used to measure the length of cob per plant in each replication. At harvest cob length was recorded from each replication-selected plant with the help of measuring tap and their average was tabulated in centimeters.

Cob weight (g)
Maize cob from each selected plant at harvest was air-dried and their weight was obtained by using electrical balance in grams.

1000 maize grain weight (g)
A harvest maize cob collected from each plots was air dried and threshed separately then a samples 1000 grains from each treatments was obtained and their weight was recorded by using electrical balance.

Maize grain yield (t/ha)
After threshing of cobs from each plot was weight through electrical balance and tabulated as grain yield/ha by using the following formula

$$\text{Grain yield/ha} \quad \frac{\text{Grain yield/treatment}}{\text{Area/treatment}} \upsilon \text{ Area/ha}$$

Root length
Root length reading were taken at harvest of maize crop, it was measured in centimeters from the base of the stem to the tip of the root. Soil was dugged to proper depth and cut deep block of the soil from five different locations in each plot. The block with plant was soaked in water for 24 hours, root was separated carefully from adhering organic matter and soil particles, and five plants were selected from each plot to determine root length.

RESULTS

Soil Texture

The analysis of experimental soil at various depths 0–15, 15–30 and 30–45 cm recoded. It was observed that the soil was clay-to-clay loam. At 0–15 cm, the textural class was clay with 30.5% sand, 24.1% silt and 45.8% clay. While at 15–30 cm the textural class was the same, while at 30–45 cm soil depth the texture was changed clay to clay loam with 32.6% sand, 31.6% silt and 35.8% clay, shown in Table 1.

Soil moisture content, under different sowing methods

Soil moisture content at 0–15 cm depth as shown in the Table 2. The mean soil moisture content before tillage operation was 19.44 percent. The average soil moisture content after each irrigation all treatments was recorded (19.23, –20.68 percent. There was significant difference in all treatments. The average soil moisture content at 15–30 cm depth and 30–45 cm depth are shown in Table 2, and Table 2 there was significant difference in all treatments.

Tab.1: Soil texture at 0–45 cm depth

Soil depth (cm)	Sand (%)	***Silt*** (%)	Clay (%)	Textural class
0–15	30.5	24.1	45.8	Clay
15–30	22.6	36.6	40.8	Clay
30–45	32.6	31.6	35.8	Clay loam

Tab. 2: Soil moisture content 0-15 cm depth after each irrigation

Treatments	Before Till lager	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean (%)
T-1	19.44	20.59	20.65	20.73	20.74	20.68
T-2	19.43	19.61	19.62	19.66	19.68	19.64
T-3	19.44	19.13	19.21	19.27	19.30	19.23
Mean (%)	19.44					

Soil moisture contents 15–30 cm depth after each irrigation.

Treatments	Before Tillage	Number of irrigation				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean (%)
T-1	19.45	19.40	19.35	19.28	20.47	19.869
T-2	19.46	19.73	19.60	19.51	20.10	19.70
T-3	19.45	19.83	19.74	19.66	19.90	19.59
Mean (%)	19.45					

Soil moisture content 30–45 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean (%)
T-1	19.48	20.02	19.90	19.85	20.47	20.21
T-2	19.49	20.15	19.98	19.89	20.23	20.04
T-3	19.48	20.21	20.05	20.10	20.10	19.93
Mean (%)	19.48					

Ir = irrigation

	Treatments	Intervals
S.E	0.0298	0.0344
Cd1	0.0730	0.0843
Cd2	0.111	0.1276

Bulk density of the soil, under different sowing methods

The bulk density of the soil at 0–15 cm depth was shown in the Table 3. The average mean bulk density before tillage operation recorded that 1.21 g/cm^3, there was significant difference in all treatments. While the bulk density of the soil after tillage operation in all the treatments it was ranged from 1.13, 1.14 and 1.15 g/cm^3. There was highly significant difference in all treatments. The bulk density of the soil at 15–30 cm depth was shown in the Table 3. The average mean bulk density

before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in all the treatments it was varied from 1.15, 1.19 g/cm^3. There was highly significant difference in treatments. The bulk density of the soil at 30–45 cm depth was shown in the Table 3.The average mean bulk density before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in treatments were from 1.22–1.22 g/cm^3. There was no-significant difference in all treatments.

Soil compaction, under different sowing methods

The soil compaction at 0–45 cm depth was shown in the Table 4. The mean soil compaction before tillage operation was recorded, there was significant difference in all treatments. While soil compaction after tillage operation in all treatments was recorded. There was highly significant difference in all treatments.

Plant Analysis

Emergence of maize seedling

The emergence of maize seedling shown in Table 5. The results revealed that the differences in the emergence of seedlings between three methods of sowing were highly significant. Maize sown on ridges resulted in greater emergence of seedling (89%), followed by drilling the seed (85%) , while seed broadcasting resulted in a lower emergence of seedlings (83%). The greater emergence of seedlings on ridge sowing was due to well pulverization of soil resulting easier appearance of the seedling than drilling or broadcast of seed.

Plant height

The average plant height of maize crop recorded at various intervals under different method of planting as shown in Table 6, it reveal that after 15 days of sowing it was greater under ridge sowing (20.4 cm/plant) followed by seed drilling (20.2 cm/plant) while it was lowest incase of seed broadcasting (18.5 cm/plant). After 30 days 40.2, 39.6 and 34.1 cm/plant, after 45 days of sowing 89.8, 89.4 and 90.3 cm/plant, after 60 days 124.7, 118.5 and 119.10 cm/plant, after 75 days 138.5, 137.8 and 135.2 cm/plant, while after 97 days (at harvest time) it was 155.1, 152.3 and 151.1 cm/plant in ridge, drilling and seed broadcasting methods. The above results demonstrate that ridge sowing displayed greater plant height as compared to drilling and broadcasting methods.

Root length (cm)

The results on root length of maize recorded at harvest shown in Table 7. It may be seen from the results that varied significantly between the treatments. Maize sown on ridges resulted in greater of root length (33.1 cm/plant), followed by seed drilling (29.5 cm/plant), while seed broadcasting resulted in lower length of root (27.20 cm/plant). The statistical analysis of the data showed a significant (P ” 0.01) change in the length of root between the treatments.

Number of leaves/plant

The results on number of leaves/plant of maize planted under three different methods of sowing shown in the Table 8. The results revealed that number of leaves recorded after 15 days of sowing remained same in all three treatments, while they change after 30 days of sowing up to harvest. Maize sown on ridges produced greater number of leaves 7, 10, 14, 15.3 and 17/plant after 30, 45, 60, 75 and 97 days of sowing respectively, while seed drilling or seed broadcasting resulted in more or less similar number of leaves/plant. The results further demonstrate that the differences between drilling and broadcasting are non significant.

Tab. 3: Bulk density 0–15 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean g/cm^3
T-1	1.20	1.08	1.10	1.16	1.17	1.13
T-2	1.21	1.09	1.11	1.16	1.16	1.14
T-3	1.21	1.09	1.12	1.17	1.17	1.15
Mean g/cm^3	1.21					

Bulk density 15–30 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean g/cm^3
T-1	1.21	1.11	1.14	1.16	1.20	1.15
T-2	1.21	1.14	1.19	1.21	1.22	1.19
T-3	1.22	1.13	1.18	1.21	1.22	1.19
Mean g/cm^3	1.22					

Bulk density 30-45 cm depth after each irrigation

Treatments	Before Tillage	Number of irrigations				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean g/cm^3
T-1	1.22	1.22	1.22	1.22	1.22	1.22
T-2	1.22	1.22	1.22	1.22	1.22	1.22
T-3	1.22	1.22	1.22	1.22	1.22	1.22
Mean g/cm^3	1.22					

Ir = irrigation

	Treatments	Intervals
S.E	5.2526	6.0653
Cd1	12.8689	14.8599
Cd2	-	22.5023

Tab. 4: Soil compaction 0–15cm depth

Treatments	Before Tillage	After Tillage				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean KN/m^2
T-1	962	506	655	820	960	735
T-2	967	530	690	860	955	761
T-3	967	532	687	859	964	761
Mean KN/m^2	965					

Soil compaction 15–30cm depth

Treatments	Before Tillage	After Tillage				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean KN/m^2
T-1	1036	635	855	1020	1145	914
T-2	1037	640	860	1023	1146	917
T-3	1040	641	861	1024	1146	918
Mean KN/m^2	1038					

Soil compaction 30–45cm depth

Treatments	Before Tillage	After Tillage				
		1st Ir 01-08-04	2nd Ir 25-08-04	3rd ir 15-09-04	4th Ir 30-09-04	Mean KN/m^2
T-1	1142	1142	1142	1142	1142	1142
T-2	1142	1142	1142	1142	1142	1142
T-3	1142	1142	1142	1142	1142	1142
Mean KN/m^2	1142					

Ir = irrigation

	Treatments	Intervals
S.E	0.6293	0.7765
Cd1	1.5419	1.9024
Cd2	2.335	2.881

Tab. 5: Average emergence of maize under different sowing methods

Sowing methods	R-I	R-II	R-III	Mean (%)
Ridge	87	89	91	89 a
Seed drill	84	86	85	85 b
Broadcast	84	83	82	83 b

S.E. = 0.913
Cd1 = 2.920
Cd2 = 4.196

Tab. 6: Average plant height of maize under different sowing methods

Replication	Plant height (cm) days after sowing.					
	15	30	45	60	75	97 (at harvest)
Ridge						
I	20.9	40	90.3	120.8	137.9	156.2
II	20.4	39	89.6	125.9	138.2	154.3
II	19.9	41.6	89.7	127.6	139.6	154.8
Average	20.4	40.2	89.8	124.7	138.5	155.1 a
Seed drill						
I	20.1	36.7	89.3	119.2	136.2	152.2
II	19.8	41.3	89.3	119.6	140.1	152.2
II	20.7	41.0	89.6	116.7	137.2	153.1
Average	20.2	39.6	89.4	118.5	137.8	152.5 b
Broadcast						
I	19.1	33.0	90.0	119.3	135.3	151.2
II	18.5	34.4	90.1	118.3	134.2	150.0
II	17.9	35.0	91.0	119.8	136.1	152.3
Average	18.5	34.1	90.3	119.1	135.2	151.1 c

S.E = 0.456
Cd1 = 1.459
Cd2 = 2.096

Tab. 7: Average root length under different sowing methods

Sowing methods	R-I	R-II	R-III	Mean (cm)
Ridge	34.6	32.2	32.6	33.1 a
Seed drill	30.1	29.6	28.8	29.5 b
Broadcast	29.2	24.8	27.7	27.2 b

S.E. = 0.645
Cd1 = 2.064
Cd2 = 2.965

Tab. 8: Average number of leaves/plant, under different sowing methods

Replication	Number of leaves days after sowing.					
	15	30	45	60	75	97 (at harvest)
Ridge						
I	4	7	10	14	15	18
II	4	7	10	14	16	16
II	4	7	10	14	15	17
Average	4	7	10	14	15.3	17
Seed drill						
I	4	6	9	13	14	15
II	4	6	9	13	14	16
II	4	6	9	14	13	15
Average	4	6	9	13.3	13.6	15.3
Broadcast						
I	4	6	9	13	14	16
II	4	6	10	13	13	16
II	4	6	9	13	14	15
Average	4	6	9.3	13	13.6	15.6

S.E. = 0.471

Length of cob hulled and de-hulled

Table 9 shows the results on average length of cobs hulled of maize planted under three different sowing methods recorded, the results showed that length of cobs did not differ significantly between the treatments. Maize sown on ridge produced maximum length of cob (24.40 cm), followed by seed drilling (20.5 cm), while seed broadcasting resulted in minimum length of cob (19.40 cm/plant). The results on average length of cob de-hulled shown in Table 9. It can be seen from the results that length of cob de-hulled also did not differ significantly between the treatments. It was found that ridge sown crop produced greater cob length de-hulled (21.5 cm), followed by drilling (17.8 cm), while seed broadcasting resulted in lesser cob length (16.6 cm/plant).

Tab. 9: Average cob length hulled, after 97 days (at harvesting)

Sowing methods	R-I	R-II	R-III	Mean (cm)
Ridge	23.2	26.0	24.0	24.4
Seed drill	22.4	18.9	20.3	20.5
Broadcast	20.1	23.0	15.3	19.4

Average cob length de-hulled

Sowing methods	R-I	R-II	R-III	Mean (cm)
Ridge	20.2	23.1	21.2	21.5
Seed drill	19.8	16.2	17.5	17.8
Broadcast	18.3	19.3	12.4	16.6

S.E. = 1.494

Dry weight of cob (hulled / de-hulled)

The results on mean dry weight of cob hulled / de-hulled shown in the Table 10. It may be seen from the results that dry weight of cob both hulled and de-hulled varied significantly between the treatments. In hulled ridge sowing produced maximum weight of dry cob (177.67 g/cob), followed by seed drilling (172.77 g/cob), while seed broadcasting produced minimum dry weight of cob (167.12 g/cob). In case of de-hulled ridge sowing produced maximum weight of dry cob (127.53 g/cob), followed by drilling (123.43 g/cob), while broadcasting showed lowest weight of dry cob (122.32 g/cob) on de-hulled basis.

Tab. 10: Average hulled dry cob

Sowing methods	R-I	R-II	R-III	Mean (g)
Ridge	178.06	176.16	178.79	177.67 a
Seed drill	171.21	172.11	174.91	172.77 ab
Broadcast	166.64	169.65	165.09	167.12 b

Average de-hulled dry cob weight

Sowing methods	R-I	R-II	R-III	Mean (g)
Ridge	127.06	126.16	129.39	127.53 a
Seed drill	125.21	123.11	121.99	123.43 ab
Broadcast	123.64	122.22	121.10	122.32 b

S.E. = 0.938
Cd1 = 3.001 Cd2 = 4.311

Seed index (1000 grain weight) gram

Table 11 shows the results of mean seed index it may be seen from the results that seed index differed significantly between the treatments. Maize sown on ridges produced greater seed index value (198.26 g), followed by seed drilling (193.04 g), where as; seed broadcasting produced lower seed index value (183.26 g).

Maize grain yield

The results on average maize grain yield/ha tabulated on the basis of grain yield/treatments shown in Table 12. It revealed that grain yield differed significantly between the treatments at one percent level of probability. Maize sown on ridges gave maximum grain yield 6357 kg/ha (6.3 t/ha), followed by seed drilling 5834 kg/ha (5.8 t/ha), while seed broadcasting gave minimum grain yield 4887 kg/ha (4.8 t/ha).

Economic analysis

The results on economic analysis of various methods in maize planting shown in Table 13, reveal that maize sown on ridges, seed drilling and seed broadcasting incurred Rs. 15 817.29/ha, Rs. 15 779.79/ha and Rs. 15 416.54/ha on total cost of production, respectively. Where as total gross return was Rs. 81 051.75/ha, from

production of 6357 kg/ha, Rs. 74 383.50/ha from production of 5834 kg/ha and Rs. 62 309.25/ha from production of 4887 kg/ha at the rate of Rs.12.75/kg in case of ridges, drilling and broadcasting, respectively. Thus, ridge planting gave a healthy net return of Rs. 65 234.46/ha, followed by seed drilling Rs. 58 603.71/ha and seed broadcasting Rs. 46 892.71/ha. These results clearly demonstrate that maize sown on ridge gave an additional income of Rs. 6630.75 against seed drilling and Rs. 11 711.00 against seed broadcasting on per hectare basis.

Tab. 11: Average 1000 dry maize grain weight

Sowing methods	R-I	R-II	R-III	Mean (g)
Ridge	196.30	200.15	198.35	198.26
Seed drill	193.34	190.80	195.00	193.04
Broadcast	183.48	178.90	187.40	183.26

S.E. = 1.626
Cd1 = 5.204
Cd2 = 7.476

Tab. 12: Average grain yield t/ha, under different sowing methods

Sowing methods	R-I	R-II	R-III	Mean (kg/ha)	(t/ha)
Ridge	6361	6429	6283	6357	6.35
Seed drill	5859	5816	5829	5834	5.83
Broadcast	4978	4811	4873	4887	4.88

S.E. = 38.793
Cd1 = 124.100
Cd2 = 178.300

Tab. 13: Economic analysis of different methods of sowing

Cost	Sowing methods		
	Ridge	Drilling	Broadcasting
1. Fuel consumption (Rs.)	1719.363	1685.27	1355.04
2. Lubricant at 10% of diesel cost (Rs.)	171.93	168.52	135.50
3. Labour cost			
Skilled 3 No. @Rs.200/hrX4-hr Watch man 1No. @ Rs. 1800/M x 3	2400.00	2400.00	2400.00
4. Inputs	5400.00	5400.00	5400.00
Seed at 50kg/ha (Rs.)			
DAP 2.5 bags (60kg/ha) @Rs.1000/bag	687.00	687.00	687.00
Urea 125 kN/ha (4.5bags) @Rs.480/bag	2139.00	2139.00	2139.00
5. Tractor hired @ Rs.200/hr for 4-hrs	800.00	800.00	800.00
6. Total cost of production (a) (Rs.)	15 817.29	15 779.79	15 416.54
Return			
1. Yield t/ha	6.357	5.834	4.887
2. Gross income/h (b) sell @ Rs.12.75/kg	81 051.75	74 383.50	62 309.25
3. Net income/h (b – a) (Rs.)	65 234.46	58 603.71	46 892.71

DISCUSSION

Appropriate method of sowing has several advantages like better inter-culturing, weeding, uniform irrigation, management of insect, pest and disease and mechanical harvesting. Ridge sowing is considered to be the method which have the above advantages, against the other methods of sowing like drilling and broadcasting of seed, although seed drilling is also an appropriate method of sowing to have some less advantages in contrast to ridge sowing in the modern agriculture farming.

Ridge cultivation is originally developed for preparing seed bed in field that were to be irrigated by furrow irrigation, it was found however, that the method has merits which are quite independent of the irrigation system. The furrow between the ridge provides efficient drainage during the rainy periods, in early spring the ridge dried more rapidly and the soil warmed up sooner, than in land cultivated on the flat in the conventional manner. All the unfavorable effects of the compaction following tillage operations remained confined to the furrow between the ridge as a result, only one quarter, approximately of the field was adversely affected, whilst roots found favorable conditions in the remaining three quarters, in which soil structure was well preserved and ensured favorable conditions of aeration and moisture. The results of the present study revealed that the experimental soil was clay-to-clay loam, soil moisture content at 0–15 cm depth the mean soil moisture content before tillage operation was 19.44 percent. The soil moisture content after tillage operation in all treatments ranged from 19.23–20.68 percent. There was highly significant difference in all treatments. Soil moisture content at 15–30 cm depth, the mean soil moisture content before tillage operation was found to be 19.45 percent. The soil moisture content after tillage operation in all treatments varied from 19.59–19.86 percent. There was non- significant difference in all treatments. Soil moisture content at 30–45 cm depth, the mean soil moisture content before tillage operation was observed 19.48 percent. The soil moisture content after tillage operation in all treatments ranged from 19.93–20.21 percent. There was highly significant difference in all treatments. The result of moisture content shows that soil moisture content was conserved more in ridge plot as compared to other treatments, it is conducted that soil inverted by moldboard plough plus disc harrow plus ridger is more suitable for the conservation of high soil moisture content. The reason may be that in ridge plot more water holding capacity due to high looseness of soil particles. The present result is supported by Gyurioza *et al.* (1999), that ridge tillage the moisture content greater than in the ploughed treatment.

The bulk density of the soil at 0–15 cm depth the mean bulk density before tillage operation recorded that 1.21 g/cm^3, there was significant difference in all treatments while the bulk density of the soil after tillage operation in all the treatments it was ranged from 1.13–1.15 g/cm^3. There was highly significant difference in all treatments. The bulk density of the soil at 15–30 cm depth, the mean bulk density before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in all the treatments it was varied from 1.15–1.19 g/cm^3. There was highly significant difference in all treatments. The bulk density of the soil at 30–45 cm depth the mean bulk density before tillage operation recorded that 1.22 g/cm^3, while the bulk density of the soil after tillage operation in all the treatments it was ranged from 1.22–1.22 g/cm^3. There was non- significant difference in all treatments.

However, with moldboard operation the soil aggre-gation was 24.30, 24.29 and 24.74 mm in all plots. Si-milarly, incase of disc harrow operation the soil aggregation was 19.50, 19.62 and 19.37 mm, in all three treatment plots were prepared, however, when ridger was operated the soil aggregation was 17.76, while seed driller displayed 17.94 mm. Results further indicated that the soil compaction at 0–15 cm depth the mean soil compaction before tillage operation recorded that 965 KN/m^2, there was significant difference in all treatments. While soil compaction after tillage operation in all treatments was ranged 735–761 KN/m^2. There was highly significant difference in all treatments. The soil compaction at 15–30 cm depth, the mean soil compaction before tillage operation recorded that 1038 KN/m^2 while soil com-paction after tillage operation in all treatments was varied from 914–918 KN/m^2. There was significant difference in all treatments. The soil compaction at 30–45 cm depth the mean soil compaction before tillage operation recorded that 1142 KN/m^2 while soil compaction after tillage operation in all treatments was ranged 1142–1142 KN/m^2. There was non- significant difference in all treatments.

The results on plant analysis revealed that maize sown on ridges produced greater emergence of seedlings (89%), similarly plant height recorded after 15, 30, 45, 60, 75 and 97 days after sowing was greater incase of ridge sowing. Number of leaves/ plant recorded after 15, 30, 45, 60, 75 and 97 days of sowing was more in ridge sowing. Ridge sowing also produced greater number of cobs/plant, after 55 and 97 days length of hulled and de-hulled cob, hulled and de-hulled dry cob weight, 1000 maize grain weight, grain yield/ha and root length at maturity 33.1, 29.5 and 27.2 cm, ridge, seed drilling and seed broadcasting methods, respectively.

The results on economic analysis depicted that maize sown on ridge gave a net return Rs. 65 234.46/ha, which further displayed an additional income of Rs. 6630.75 /ha, against drill sowing and Rs. 11 711.00/ha against seed broadcasting, respectively.

The present results are supported by the findings of Vogal *et al.* (1994) found that grain yield of maize was higher with tied ridging plots. While Vedove *et al.* (1996) found that grain yield of maize was greater with ridging which was attributed to the greater amount of available N under this system.

Gyurioza *et al.* (1999) evaluated ridge tillage cultivation system for maize soybean and sugar beet, they found significant differences in the moisture content in direct sowing and ridge tillage the moisture content of 0–10

cm layer in the inter rows was 3.5–5.6% greater than in the ploughed treatment and in other parts of the ridge (sides and top of the ridge). A similar and inverse trend was observed for the temperatures. There were no substantial differences in the yield in the first year with over 11 t/ha in all treatments.

Musambasi *et al*. (2003) reported that maize planting on ridges gave the highest grain yield (5197kg/ha) during the 1995–96 season.

CONCLUSION

Appropriate method of sowing has several advantages like better inter-culturing, uniform irrigation, management of insect, pest and disease and mechanical harvesting, ridge sowing is considered to be the method which have the above advantages, against the other methods of sowing like drilling and broadcasting of seed, although seed drilling is also a appropriate method of sowing to have some less advantages in contrast to ridge sowing in the modern agriculture farming. On the basis of present study, it may be concluded that planting maize on ridge found to be more profitable as compared to seed drilling and seed broadcasting respectively.

Recommendations

Maize variety no doubt, has assured increased production yet this is being grown on limited scale in the province of Sindh. This is because of the fact that any systematic income and resulting net profit gain has never been placed before the farmers, so as to attract them to bring more area under maize. In order to give an insight in to the profitability of maize production, the present study was under taken. It is suggested that for getting healthy return from maize farming, sowing should be made on ridges as this method has several advantages.

REFERENCES

Khoso A.W. (1998): Crop of Sindh. 5th Edition, Pub. Allied printing corporation, Hyderabad.

Buhler D.D. (1998): Effect of ridge truncation on weed populations and control in ridge-tillage corn. Weed Sciences (USA), 46 (2):. 225–230.

Belay A., Gebrekidan H., Uloro Y. (1998): Effect of tied ridges on grain yield response of maize to application of crop residue and residual N and P on two soil types at Alemaya,Ethiopia.south. African Journal of Plant and soil (Ethiopia), 15 (4):.123–129.

Birkas M., Gyricza C., Percze A. (1998): Experiments with ridge tillage for maize in a brown forest soil. Novenytermeles (Hungary), 47 (5): 559–571.

Mckyes E. (1985): .Soil cutting and Tillage. Elsevier-Newyork-Tokyo, Science publishers B.V. Nether lands, pp. 1–3.

Giardini A.,Cinti F.,Stefanelli G. (1996): Effect of ridging on agronomic factors and yields of maize and soybeans in the absence of weeds. Rivista di Agronomic (Italy), 30 (3): 236–240.

Ginting D., Moncrief J.F., Gupta S.C., Evans S.D. (1998): Corn yield, runoff, and tillage system. Journal of Environmental Quality (USA), 27 (6): 1396–1402.

Gyuricza C.,Peter L.,Laszlo P.,Birkas M. (1999): Effect of ridge on the physical status of the soil and on the maize yield. Novenytermeles (Hungary), 48 (6): 631–645.

Hatfield J.L., Allmaras R.R., Rehm G.W. (1998): Ridge tillage for corn and soybean production: environmental quality impacts. Soil and tillage Research (USA), 48 (3): 145–154.

Kepner R.A., Bainer R., Barger E.L. (1982): Principles of Farm Machinery. III ed., AVI Publishing, INC. Westport, Connecticut, USA.

Lal R. (1997): Long-term tillage and maize monoculture effects on a tropical Alfisol Nigeria. Soil and tillage research (USA), 42 (3): 161–174.

Kersten M., Hack AMA F. (1991): Effect of four tillage methods on growth of maize in Zambia, 22 (3), summer.

Mahal S.S., Dejenu D.G., Gill M.S. (2000): Growth and yield of maize as influenced by flood under different planting methods and nitrogen levels. Environmental and Ecology (India), 18 (4): 789–792.

Materechera S.A. (1998). A note on tillage practice effects on yield of maize under smallholder cropping in Malawi, Zimbabwe. Journal of Agricultural Research (Malawi), 34 (2): 125–130.

Mercado A.R., Garrity,D.P. Jr. (1999): Ridge tillage system enhances corn productivity, profitability and sustainability. An international workshop held in Mindanao, Philippines, from 12–15 October, pp. 191–194.

Musambasi D., Chivinge O.A., Mariga I.K. (2003): Effect of ridging treatment and two early maturing maize cultivars on witch weed [strigaasiatica (L) kuntze] density and maize yield under dry land maize based cropping system in Zambabwe. Crop Research (Hisar), Zambabwe, 25 (1): 37–45.

Peruzzi A., Raffaelli m., Ciolo S. (1998): Evaluation of two no-till drills for maize and sunflower cultivation in central Italy. Agricoltura Mediterranea (Italy), 128 (4): 321–329.

RANM (1995): Test codes and procedure for farm machinery. Technical series, No:12.

Rehm G.W., Lamb J.A. (2004): Impact of banded potassium on crop yield and soil potassium in ridge-till planting. Soil society of America Journal (USA), 68 (2): 629–636.

Thomas A.L., Kaspar T.C. (1997): Maize nodal root response to time of soil ridging. Agronomy Journal (USA), 89 (2): 195–200.

Vogal H., Nyagumbo I., Olsen K. (1994): Effect of tied

ridging and mulch ripping on water conservation in maize production on sandveld soils. Tropen-landwrit (Germany), 95, April, pp. 33–44.Vedove G. delle Giovanardi R., Ceccon P. (1996): Soil physical properties, growth and yield of maize grown on ridges. Rivista di Agronomia (Italy), 30 (4): 571–579.

Zugec I., Juric I. (1997): Effects of reduced soil tillage on ferralsol rhodic on maize grain yield in the Horro Alleltu area, Ethiopia, Poljoprivreda (Croatia), 3 (2): 6.

Received for publication on August 30, 2007
Accepted for publication on October 15, 2007

Corresponding authors

Prof. Dr. Mirza B. Baig
Department of Agricultural Sciences
Allama Iqbal Open University
H- 8, ISLAMABAD, PAKISTAN
mbaig95@yahoo.ca