Biological Sciences Section

Pak. j. sci. ind. res., vol. 36, no. 9, September 1993

PLANTING TECHNIQUES OF MAIZE ON THREE DIFFERENT SOIL FAMILIES

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(Received December 18, 1991; revised May 20, 1993)

Planting techniques for maize are presently recommended without taking into consideration soil characteristics and landscape positions. Secondly, there is no scientific base to transfer soil management practices from one place to another place. An experiment was conducted to find out most suitable planting technique for the soil families under test and a base for transfer of soil management technology. The soil families were: (i) Fine-silty, mixed, hyperthermic, udic Haplustalfs convex phase, (ii) Coarse-silty, mixed, hyperthermic, typic Ustochrepts sloping and terraced phase and (iii) Fine-loamy, mixed, hyperthermic, udic Haplustalfs sandy loam surface phase. The benchmark soil series were Guliana convex phase, Missa sloping and terraced phase and Balkassar sandy loam surface phase respectively. Suitable planting techniques for maize on the three benchmark soils of the three soil families were found to be different. Planting on: ridges for Guliana soil series, braodbeds for Missa soil series and flat parts of Balkasssar soil series were suitable. The planting techniques depended upon soil physical characteristics and attributes of landform. The site and planting technique interaction for a particular benchmark soil was non-significant which support the view that planting technique for a soil family can be transferred to the same family provided other production factors remain the same.

Key words: Planting techniques, Soil family, Maize.

Introduction

Maize is the third important cereal in Pakistan after wheat and rice. Besides its use in supplementing the food and feed supplies, it has wide industrial uses. However, its average yield is dismally low (1271 kg/ha) whereas its potential yield is over 6 tonnes/ha. Thus there exists a very high yield gap, Zia *et al.* [1].

A special requirement of maize crop is good drainage, as it is very sensitive to water logging or excessive wetness in the root zone during the seedling stage and flowering. Water stagnation during tasselling, silking and pollination can cause upto 50% yield reduction [2]. As most of the rainfall in Pothwar occurs during the maize growing season and is highly torrential, temporary water stagnation is a common feature, especially in terraced and lowlying fields. Secondly, some soils of maize growing areas are highly susceptible to crust formation becuase of having fine silt and fine sand fraction in their parent material [3].

The planting method under rainfed conditions greatly effect the crop production. Chatha and Aslam [4] reported that ridge planting of maize significantly produced higher yield (2517 kg/ha) than that of flat sowing (1649 kg/ha) with an increase of 53 %. On the other hand, the scientists of Barani Agricultural Research and Development (BARD) project planted maize on ridges which were bunded (tide) every five meters and on flat parts in Kharif 1984. The yield of maize planted on flat parts was higher than planted on ridges, as the water could not escape (BARI) [5] Majid *et al.* [6] conducted study to find the effect of tillage practices combined with planting techniques i.e.flat, ridge and tide ridge, on maize production. Chiselling + tine cultivator alongwith ridge sowing of maize proved to be the best. Khokar *et al.* [7] studied the effect of different tillage depth/spacing with four planting patterns i.e. flat, ridge, tide ridge and broad bed. Maximum grain yield (1984 kg/ha) was obtained from tide ridge, while the sowing on flat gave the least yield (1710 kg/ha).

Literature review indicates that recommendation for planting techniques of maize crop are generally not based on soil and landscape conditions Therefore, these do not produce the desired results. It was, therefore felt to conduct experiments to develop site specific planting techniques based not only on the climate parameters but also on soil and land characteristics. Secondly, as there is no scientific base for transfer of soil management technology from one place to another, the experiment was conducted to test whether soil-based management practices are applicable to other locations within the same climate zone and the soil family.

Material and Methods

There benchmark soils namely Guliana, Missa and Balkassar belonging to following soil families respectively were selected in subhumid subtropical climate in Pothwar plateau:

Name of soil family. (1) Fine-silty, mixed, hyperthermic, udic Haplustalfs, convex phase. (2) Coarse-silty mixed, hyperthermic, typic Ustochrepts, sloping and terraced phase. (3) Fine-loamy, mixed, hyperthermic, udic Haplustalfs, sandy loam surface phase.

Three sites at least 15 km apart were selected for each of the benchmark soils. At each site, soil profile pit (1.5 x 1 sq meter) was dug to approx. 150 cm depth. The soil profiles were described according to Soil Survey Manual [8] and classified according to Soil Taxonomy [9] The soil samples of the 0-15 cm and 15-30 cm depth were taken for physiochemical analyses (Table 1).

Split-plot design was adopted with planting methods in the main plots and fertilizer doses in the sub-plots. The three planting methods tested were: sowing on (a): flat (b), ridge and (c) broad bed. The ridges and broad bed were tide at end so that no runoff could accumulate in furrows between the ridge or broad bed. There were 25 treatments of fertilizer doses comprising different combinations of N and P @ 0,50,100,150 and 200 kg/ha. Source of nitrogen (N) was urea while of phosphorus (P_2O_5) single super phosphate. Three ploughing and planking operations were carried out in the experimental field to remove weeds and to prepare suitable seedbed for germination.

TABLE 1. PHYSIO-CHEMICAL CHARACTERISTICS OF THREE BENCHMARK SOILS.

Site	Clay %	Silt %	Sand %	Textural class	pH	$CaCO_3$ %	Organic carbon %	N mg/kg (ppm)	P mg/kg (ppm)	K mg/kg (ppm)	Moist. capacity %	Wilting point %	B.D. oven dry g/cm³
GULIANA SOIL													
Site 1													
0–15cm	19.3	73.9	6.8	Silty loam	7.9	0.8	0.55	10.9	6.3	125	20.5	8.6	1.59
15–30cm	29.6	67.3	3.1	Silty clay loam	7.5	0.4	0.50	8.2	5.9	121	21.8	11.2	1.49
Site 2													
0–15cm	17.5	75.7	6.8	Silty loam	8.0	0.5	0.61	11.7	7.2	112	19.7	8.7	1.57
15–30cm	30.3	68.2	1.5	Silty clay loam	7.8	0.3	0.57	9.5	6.2	103	20.9	10.8	1.55
Site 3													
0–15cm	20.2	77.2	2.6	Silty loam	8.1	0.2	0.50	9.5	5.8	103	20.9	8.5	1.55
15–30cm	29.8	63.7	6.5	Silty clay loam	7.8	0.1	0.49	8.6	5.7	101	22.3	11.1	1.54
MISSA SOIL													
Site 1													
0–15cm	11.6	75.8	12.6	Silt loam	8.2	18	0.38	6.8	4.7	86	17.6	7.0	1.31
15–30cm	14.2	81.7	4.1	Silt loam	8.1	21	0.29	5.4	3.5	72	18.6	7.4	1.48
Site 2													
0–15cm	11.2	73.2	15.6	Silt loam	8.3	19	0.42	7.1	5.2	95	17.4	6.9	1.32
15–30cm	13.9	79.8	6.3	Silt loam	8.2	20	0.34	6.7	4.1	78	18.8	7.5	1.50
Site 3													
0–15cm	10.5	72.1	17.4	Silt loam	8.2	17	0.48	7.5	5.5	94	17.5	7.1	1.33
15–30cm	12.8	80.3	6.9	Silt loam	8.0	22	0.36	6.8	3.9	80	18.0	7.4	1.50
BALKASSAR SOIL													
Site 1													
0–15cm	12.1	18.2	69.7	Fine sandy loam	8.2	3	0.30	4.3	2.9	56	14.6	8.7	1.51
15–30cm	13.3	20.4	66.3	Fine sandy loam	8.3	4	0.20	3.8	3.1	47	13.5	8.8	1.52
Site 2													
0–15cm	11.9	17.6	70.5	Fine sandy loam	8.3	2	0.38	4.8	3.2	67	14.2	8.5	1.52
15–30cm	12.5	20.7	66.8	Fine sandy loam	8.4	5	0.27	4.2	3.6	51	13.3	8.7	1.52
Site 3													
0–15cm	10.5	18.5	71.0	Fine sandy loam	8.4	3	0.41	5.1	4.3	79	14.5	8.4	1.50
15–30cm	12.1	19.8	68.1	Fine sandy	8.3	4	0.25	4.3	3.5	54	13.9	8.6	1.53

1–Moisture at field capacity (0.3 bar) and wilting point (15 bar) were determined with the help of pressure membrane apparatus for the estimation of available moisture.

2–Organic matter was determined by chromic acid oxidation method (organic carbon (%)=% organic matter/1.742.

3–Total nitrogen was determined by Kjeldhal method, by sodium bicarbonate extractable method as described by Winkelman and Rouhal Amin (1986) in mannual of laboratory methods, NARC.

4–Soil texture, $CaCO_3$ and pH (1:1) were determined as per Black *et al.*, (1965).

All fertilizers were applied by broadcast method at the time of sowing. Maize variety 'Gohar' was sown on flat parts, ridges and broad bed by man driven drill @ 40 kg/ha. All other recommended cultural practices were carried out. The crop was harvested at maturity and grain yield was estimated on the basis fo 3 crop cuts of 1 m^2 each from all the plots. Rainfall for each of the three areas of experimentation was recorded (Fig.1) Moisture sampling was done for the three planting methods at all the three sites in check plots at an increment of 30 cm upto depth of 120 cm at forthnight intervals by gravimetric method (Table 2). Analysis of variance of maize grain yield data was carried out according to split plot arrangement combined over locations. Regression analysis was also run to determine yield response to N and P fertilizers with various planting methods.

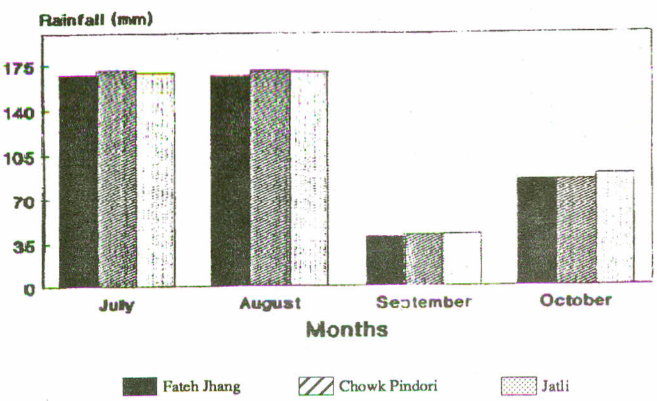

Fig. 1. Monthly rainfall during Kharif season (1986) on three locations representing three soil families.

Results and Discussion

Planting techniques and moisture status. Moisture status in three soils during the crop growing period is presented in Table 2. The data show that the effect of planting method on the moisture contents of three soils is different. In Guliana soil, 4.3 and 3.7 % more moisture was conserved by ridge-furrow and broad bed-furrow systems respectively with respect to sowing on flat parts. This is because Guliana soil occurs on flat to slightly convex position and is highly susceptible to crust formation because of having more fine silt and fine sand particles in the surface soil [3]. Thus, there was more runoff on flat parts than on ridges or broad beds which are comparatively less susceptible to crust formation [10]. Secondly, the ridge-furrow and broad bed-furrow systems were tide at end, so no runoff could occure. This findings is in agreement with the findings of Clark and Jones [11] who reported that ridge-furrow system increases moisture in soil profile. Missa soil occurs on terraced gently sloping to sloping land. Runoff accumulates during high intensity rain therefore, lesser moisture of the order of 4.5 and 6.8% respectively is present on ridges and broadbed as compared to flat parts. This is because, the runoff from higher adjacent land accumulated for short period on flat parts but as the ridge-furrow and broad bed-furrow system were tide at ends, no additional rain water as runoff accumulated in between furrows. Balkassar soil has fine sandy loam surface texture. There is no hindrance in rain, water penetration and conservation in soil profile. The ridges and broad beds made with loose fine sandy loam texture of the surface soil, because of high temperature during the growth period were more susceptible to evaporation resulting in depletion of moisture in soil

TABLE 2. SOIL MOISTURE (mm/m) STATUS DURING KHARIF SEASON (JULY-OCTOBER) ON THREE SOIL FAMILIES.

Date of	Guliana soil			Missa soil			Balkassar soil		
observation	Flat	Ridges	Broadbed	Flat	Ridges	Broadbed	Flat	Ridges	Broadbed
July, 1	14.8	15.4	15.3	11.6	11.2	10.9	10.3	9.7	9.5
July, 15	14.3	14.7	14.8	11.9	11.4	11.1	10.5	9.8	10.1
July, 30	18.1	18.9	18.6	14.4	13.8	13.2	13.9	12.5	11.8
August, 15	15.1	15.6	15.9	12.1	11.7	11.5	11.7	11.2	10.7
August, 30	19.8	21.5	20.3	16.6	15.9	15.7	13.9	13.3	12.6
September, 15	14.3	14.9	15.1	10.6	10.1	9.8	9.3	8.5	8.4
September, 30	15.4	15.6	15.5	13.0	12.5	12.3	11.8	11.3	10.9
October, 15	17.8	18.8	19.4	14.4	13.7	13.4	12.1	11.7	11.2
October, 30	15.3	15.5	15.7	14.1	13.4	12.9	9.2	8.9	8.5
Range	5.5	6.8	5.5	6.0	5.8	5.9	4.7	4.8	4.2
Mean	16.1	16.8	16.7	13.2	12.6	12.3	11.4	10.8	10.4
S. D.	1.9	2.2	2.0	1.7	1.6	1.6	1.7	1.5	1.3
Change over Flat (%)	–	4.3	3.7	–	– 4.5	-6.8	–	– 5.2	- 8.8

profile especially in surface layer (Table 2). These results are in agreement with the findings of Bury [12] and Chih [13] who, reported that soils with coarse surface possessed highest evaporation potential which increased in ridge-furrow system. The results in also supported by Hedge *et al.* [14] who reported that planting technique (ridge-furrow system) did not improve water retention in Alfisoils having fine-loamy particles in the control section of soil family as compared to flat system.

Planting techniques-soil family. Analysis of the yield data pooled across sites for each soil family is presented in (Table 3). The site effect was significant for Guliana soil but non-significant for Balkassar soil and Missa soil. This reflects that site to site variability was not-significant except for Guliana soil which was mainly due to the heterogenity of error variance. Effect of three maize planting methods was significant on all three soil families. Significant yield differences were observed due to planting methods on each soil. Interestingly, planting methods and site interaction were non-significant on Balkassar and Guliana soils but significant on Missa soil. This is because one of the sites of Missa was on nearly level to gently sloping without terraced land. This implied that there were no significant differences in the yield response of any of the planting methods studied acrosss three sites within a soil family. Mean yields differences among fertilizer treatments were highly significant on all the three soils. Similar to planting method x site interaction, the treatments x site interaction was also non-siginificant. This implied that response of a particular dose of NP did not vary significantly among the three sites within a soil family. However, treatment x planting method interaction was highly significant for Missa and Guliana soil but non-significant for Balkassar soil being not much responsive to ridge-furrow and broad bed furrows systems. Interaction for treatment x planting mehtod x site was non-significant for the three soils which is not an un-common phenomenon. The coefficient of variation (C.V.) for Balkassar, Missa and Guliana soils were estimated to be 11.1, 9.8 and 8.7% respectively. This indicates that C.V's were within tolerance limits and yielded precise results of the data.

Planting techniques and fertilizer. Regression analysis for different planting methods and fertilizer doses on three soils is given in Table 4. While planting maize on flat parts, the highest response of nitrogen is given in Balkassar soil, followed by Guliana soil and least in Missa soil. The response of P_2O_5 is highest on Guliana, followed by Balkassar and least in Missa soil. The available nitrogen in Balkassar is least (Table 1) hence its response to nitrogen is highest. Missa soil occur on sloping terraced land, there is possibility of nitrogen leaching as well as N loss specially from flat parts, due to runoff. Major quantity of N is also lost due to denitrification and some minor quantity due to NH_3 volatilization [15,16]. Therefore, the response of nitrogen is lesser on Missa soil as compared to Guliana soil although it has lesser N available than in Guliana soil. Missa soil is strongly calcareous and 18-22% free lime is present in soil which fixed the applied P_2O_5 and hence the response of P_2O_5 is least on this soil among the three soils under test. Guliana soil has almost no free lime, hence the response of P_2O_5 is highest on this soil. In ridge planting, the response of nitrogen is highest in Guliana soil, followed by Balkassar and least in Missa soil. The response of nitrogen in Guliana soil is better in this planting technique than on flat parts becuase of more moisture. The response of P_2O_5 is highest in Guliana, followed by Balkassar soil and

TABLE 3. MEAN SQUARES FOR DIFFERENT PLANTING METHODS AND FERTILIZER DOSES ON THREE SOIL SERIES.

Source of variation	d.f.	Mean squares		
		Balkassar soil	Missa soil	Guliana soil
Sites	2	368354.3ns	36781.9ns	609130.6*
Rep. (Sites)	6	183054.8	60745.5	187670.9
Planting methods	2	711323.2*	54538824.9**	27525249.3**
Planting methods x sites	4	139423.9ns	129598.5*	79639.9ns
Error (a)	12	119507.8	28703.5	108941.7
Treatments	24	9993546.6**	12529139.8**	13032288.7**
Treatments x sites	48	39367.8ns	25794.6ns	18854.4ns
Treatments x planting methods	48	73289.3ns	277008.4**	237288.4**
Treatments x planting methods x sites	96	27248.8ns	22186.4ns	16736.4ns
Error (b)	432	67056.4	83527.9	94284.5
C.V. (%)	--	11.1	9.8	8.7

TABLE 4. REGRESSION ANALYSIS FOR DIFFERENT PLANTING METHODS AND FERTILIZER DOSES ON THREE SOIL SERIES.

Soil series/ planting methods	Constant	Regression coefficients					R^{-2}
		N	P	NP	N^2	P^2	
GULIANA SOIL							
(a) Flat	1764.07	15.76**	11.46**	-27.20*	-.05**	-.04**	0.96
(b) Ridges	1801.54	22.56**	14.54*	-37.10	-.07**	-.05**	0.95
(c) Broadbed	1929.94	23.01**	14.91**	-37.92	-.07**	-05**	0.95
MISSA SOIL							
(a) Flat	1259.91	12.82**	8.06**	20.88	-.04**	-.03ns	0.91
(b) Ridges	1549.12	17.41**	6.92**	24.33	-.06**	-.02**	0.97
(c) Broadbed	1710.77	20.62**	7.82*	28.44	-.07**	-.02**	0.94
BALKASSAR SOIL							
(a) Flat	1073.15	18.80**	9.53**	28.98	-.05**	-.04**	0.92
(b) Ridges	960.08	19.16**	7.82**	26.98	-.05**	-.03**	0.95
(c) Broadbed	881.16	19.14**	8.75**	27.89	-.05**	-.03**	0.91

* Significant at 5% prob. level, ** Significant at 1% prob. level.

least on Missa soil for the same reasons as already mentioned. In broad bed planting techniques, the response of nitrogen is in decending order in Guliana, Missa and Balkassar soils. The P_2O_5 response is highest in Guliana, followed by Balkassar and least in Missa soil. Statistically, all the regression equations were good fit. The coefficients for N and P had positive signs and highly significant for three plantings methods within a soil family. The adjusted R^{-2} values for all the nine equations were very high and ranged from 0 .91 to 0.97 indicating high explanatory power of the equations.

Planting techniques and grain yield. The grain yield of maize in Guliana soil was least on flat parts while there was significant difference in yield when sown on ridges and broad beds (Fig.2). As the cost of making broad bed is higher than making ridges, ridge-furrow system is recommended for Guliana soil. Broad bed-furrow system gave significantly higher yield than ridge-furrow and flat system in Missa soil on the other hand, there was no significant difference in grain yield among the three planting methods in Balkassar soil. Hence it is obvious that ridge-furrow system, broad bed-furrow system and flat system are useful for planting maize on Guliana, Missa and Balkassar soils respectively.

Transfer of soil management practices on the basis of soil family. The response of three planting methods in each of the three soils is significantly different (Table 3). The interaction of plantings methods and sites is non-significant in Balkassar and Guliana soil but significant at 5% level in Missa soil. The fertilizer treatment effect is highly significant in all the three soils. The treatment x sites interaction and treatment x planting methods x site interactions are non-significant for the three soils. We conclude that transfer of planting methods and treatments (fertilizer) is possible to the same soil provided other production factors remain the same.

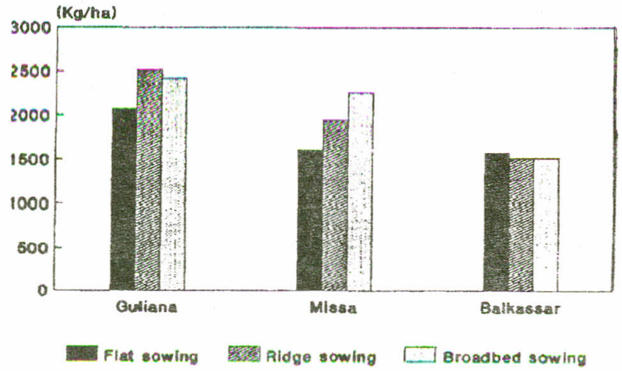

Fig. 2. Average maize grain yield for different planting methods on three soil families.

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