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YIELD, WATER USE EFFICIENCY AND ROOT DEVELOPMENT OF RAINFED MAIZE CULTIVARS IN RELATION TO MOISTURE CONSERVATION PRACTICES IN ERODED SOIL OF CENTRAL UTTAR PRADESH

S.K. Uttam, P.N. Yadav, U.D. Awasthi, Sarvesh Kumar, R.P. Singh and Hemant Solanki
Department of Soil Conservation and Water Management,
C.S. Azad University of Agriculture and Technology, Kanpur-208 002 (U.P.)

ABSTRACT

A field experiment was conducted during kharif seasons of 2011 and 2012 on light textured soil at Kanpur to find out the effect of moisture conservation practices and row spacings on growth behaviour, yield, water use efficiency (WUE) and root development of rainfed maize cultivars. Results revealed that the cultivar 'Azad Uttam' considered to be the most promising in terms of grain yield, WUE, root development and net return as compared to 'Azad Kamal'. Row spacings did not cause significant variation for yields. However, pooled 2 years data, closer row spacing of 45 cm exhibited higher crop canopy, yield, WUE and net return than the wider row spacing of 60 cm. Ridging and furrowing in between the crop rows at 20 DAS gave significantly higher growth and grain yield of maize. Highest number of roots/plant, dry weight of roots /plant, WUE, net return and cost : benefit ratio were also recorded when ridging and furrowing practice was adopted.

Key Words : *Crop canopy development, splash loss, soil moisture, water use, water use efficiency, net return, root development*

Eroded lands constitute a major part of problematic soils in Uttar Pradesh occupying an area of about 1.4 m ha. The problem of soil fertility assumes serious dimensions in those areas where the fertile top soil has either been washed away by water or blown away by wind, such soils can not be expected to support normal plant growth unless adequate fertilizers and moisture are applied. Fertilizer has not only shown remarkable increase in crop yield on these lands but has also proved to be the key factor in success or failure of crops in many cases. Rainfed farming contributes a predominant share in Indian agriculture and entails specialized techniques such as moisture conservation and plant geometry including suitable variety for an efficient and economical response to fertilizers. Nutrient absorption is affected directly by the level of moisture and indirectly by the effect of water on the metabolic activities of plant, soil aeration and the concentrations of the soil solution. Crop geometry plays an improvement role in intercepting sunlight for photosynthesis besides influencing the uptake of plant nutrients and thus influences the crop yield. The present investigation was carried out to find out the influences row spacings and moisture conservation practices on growth, yield, water use efficiency and root development of rainfed maize cultivars.

MATERIALS AND METHODS

A field experiment was conducted during kharif seasons of 2011 and 2012 at Soil Conservation and Water Management Farm of the Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. The experimental site had a slope of 1.5 per cent with the top soil washed out by water erosion. However, the area was made cultivable by bunding. 12 treatment combinations comprising 2 cultivars, i.e. Azad Kamal and Azad Uttam, 3 moisture conservation practices, i.e. one weeding and hoeing by 'khurpi' after 20 days of sowing, ridging and furrowing with the help of spade at 20 DAS in between the crop rows and atrazine (pre-emergence) @ 1.0 kg a.i /ha and 2 row spacings, i.e. 45 and 60 cm was tested in factorial randomized block design with three replications. The gross plot size was 5.0 x 3.6 m and the net plot size was 4.0 x 2.7 m and 4.5 x 2.4 m in case of 45 and 60 cm row spacing, respectively. The experimental soil was moderately deep, sandy loam, well drained having pH 7.9, organic carbon 0.34%, low in total -N (0.03%), medium in P_2O_5 (15.3 kg/ha) and medium in K_2O (138.4 kg/ha), field capacity 18.8% and bulk density 1.38 Mg/m^3. An uniform dose of 80 kg N + 40 kg P_2O_5 + 40 kg K_2O/ha was applied through Urea, Di-ammonium phosphate (DAP) and Muriate of potash, respectively. The sowing of maize crop was done on July 12 and 18

Table-1 : Growth, splash loss and yield attributes of maize as affecte by cultivars, moisture conservation practices and row spacings (pooled 2 years).

Treatment	Plant height (cm)	Stem girth (cm)	Crop canopy development (%)			Splash loss (t/ha)	Cobs / plant	Length of main cob (cm)	Grains / main cob
			30 DAS	45 DAS	60 DAS				
Cultivars									
Azad Kamal	141.8	5.4	22.6	41.0	60.4	3.90	1.2	13.1	171.8
Azad Uttam	186.1	6.8	24.4	45.8	70.9	3.23	1.4	15.6	223.0
C.D. (P = 0.05)	11.3	0.5	NS	1.9	3.9	-	0.1	0.8	11.3
Moisture conservation practices									
One weeding & hoeing by khurpi	156.4	5.5	22.9	41.8	61.6	4.53	1.2	14.3	194.2
Ridging & furrowing by spade	184.1	6.9	25.0	47.2	73.5	2.97	1.5	15.6	212.0
Atrazine (pre-emergence)	151.4	6.0	22.7	41.0	61.8	3.61	1.2	13.3	186.0
C.D. (P = 0.05)	12.3	0.5	1.6	2.9	3.7	-	0.12	0.7	10.7
Row spacings-cm									
45	179.1	5.6	25.0	44.7	70.0	3.22	1.2	13.7	189.7
60	148.8	6.7	22.5	42.5	61.3	3.91	1.4	15.1	205.1
C.D. (P=0.05)	11.3	0.5	1.9	1.9	3.9	-	0.1	0.8	11.3

in two respective years. Recommended package of cultural practices was followed. The available soil moisture in 100 cm soil profile at sowing time was 178.5 and 240 mm during 2011 and 2012, respectively. Rainfall during crop growing season was 805 and 645 mm during first and second year, respectively. The crop was harvested on October 10 and 11 during 2011 and 2012, respectively.

Root studies were made at harvest by selecting 2 plants at random from each plot. The roots were freed with a fine jet of water spray so that the delicate rootlets were not broken. The soil moisture was determined thermogravimetrically using the samples collected from 0-25, 25-50, 50-75 and 75-100 cm depths at different growth stages. The moisture use by the crop was computed by summing up the value to soil moisture depletion from the profile during the entire crop period. WUE of the crop was calculated by the formula (WUE=Y/ET) as expressed by (1). Observations on soil loss by splash were recorded by cylindrical splash cup of 10 cm diameter placed at 15 cm depth. Canopy development in each treatment was measured at fortnightly intervals with the help of 60 cm x 60 cm quadrate having 2304 small square apertures. Studies on water use, splash loss and root development were made in one replication only where the plant stand was most uniform. Net return was computed by difference method when cost of cultivation of a given treatment plot was subtracted from gross return of respective plot. The balance was recorded as net return (Rs/ha). The gross return value of a treatment plot was divided by cost of cultivation of respective treatment and figure so obtained was recorded as cost: benefit ratio for different treatment plots.

RESULTS AND DISCUSSION

Growth and yield

Grain and stover yields of maize were recorded significantly higher in cultivar 'Azad Uttam' than 'Azad Kamal' (Table-2). These might be attributed to higher growth parameters viz. plant height, stem girth and yield attributes viz. cobs/plant, length of main cob, grains / main cob in cultivar 'Azad Uttam' (Table-1). Yield variations between maize genotypes have already been reported by (2). Row spacing of 45 cm and 60 cm did not differ significantly from each other in grain or stover yield. Though, yield attributes were higher under 60 cm row spacing but it could not increase the yield / unit area perhaps because of lesser plant stand/ unit area. On the other hand, in 45 cm row spacing, growth and yield attributes were lower than 60 cm row spacing but because of higher plant stand/ unit area, it could complete with 60 cm row spacing by producing grain and stover yields / unit area at par with wider row spacing of 60 cm. Moreover, higher plant population under 45 cm row spacing could take full advantage of available soil moisture because of wide spread sufficient rains in crop period. These results

Table-2 : Root development, yield, total WU, WUE and economics of maize as affected by cultivars, moisture conservation practices and row spacings (pooled 2 years).

Treatment	Root depth (cm)	Number of root/plant	Dry weight of roots/ plant	Grain yield (q/ha)	Stover yield (q/ha)	Total WU (mm)	WUE (kg grain/ ha/ mm)	Cost of cultivation (Rs/ha)	Gross return (Rs /ha)	Net return (Rs/ha)	Cost: benefit ratio
Cultivars											
Azad Kamal	18.6	45.3	13.4	20.48	61.3	481.7	4.27	19078	27401	8323	1:1.44
Azad Uttam	22.0	54.7	15.4	23.68	70.0	505.1	4.70	19078	31571	12493	1:1.65
C.D. (P = 0.05)	-	-	-	1.85	4.1	-	-	-	-	-	-
Moisture conservation practices											
One weeding & hoeing by khurpi	22.1	45.8	12.8	21.25	63.5	506.9	4.20	19505	28412	8907	1:1.46
Ridging & furrowing by spade	18.0	54.5	16.2	24.81	72.8	491.1	5.07	20015	33045	13030	1:1.65
Atrazine (pre-emergence)	20.9	49.6	14.3	20.18	60.5	500.7	4.02	17715	26995	9280	1:1.52
C.D. (P = 0.05)	-	-	-	2.01	5.1	-	-	-	-	-	-
Row spacings-cm											
45	21.8	48.0	14.0	22.93	67.6	506.1	4.54	19413	30567	11154	1:1.57
60	18.9	52.0	14.8	21.37	63.7	492.9	4.35	18743	28557	9814	1:1.52

may be supported by the findings of (3). Out of three moisture conservation practices, ridging and furrowing practice recorded significantly highest grain and stover yields, while other two practices remained at par with each other. These yields might be attributed to yield attributes and growth parameters which also observed to be the highest under redging and furrowing. These results are in accordance with the findings of (4, 5, 6).

Crop canopy development and splash loss

Soil splash loss was estimated comparatively lesser in cultivar 'Azad Uttam' than 'Azad Kamal' (Table-1). It might be attributed more canopy development of cultivar 'Azad Uttam'. In case of row spacing, splash loss of soil was recorded lesser in 45 cm row spacing than wider row spacing of 60 cm. The higher crop canopy being observed under 45 cm row spacing might has responsible to reduce beating action of rain drops which recorded in lesser soil loss. Among moisture conservation practices, ridging and furrowing practice recorded minimum splash loss of soil while maximum in one weeding and hoeing treatment. It might be attributed to more canopy development under ridging and furrowing treatment at all stages of crop growth. Besides, soil particles disturbed due to rain drops were collected in furrows which also reduced the soil loss in ridging and furrowing practice. On the other hand, in one weeding and hoeing treatment, soil in upper layer was smooth which subjected to erosion with rain water, therefore, soil loss was maximized in this treatment. Those results support the findings of (7).

Root development

Cultivar 'Azad Uttam' registered higher root depth, number of roots and dry weight of roots/ plant than the cultivar 'Azad Kamal' (Table-2). The row spacing of 45 cm recorded 21.8 cm root depth against 18.9 cm under 60 cm row spacing with great margin. However, number of roots and dry weight of roots/plant were observed higher under 60 cm than 45 cm row spacing. More number and dry weight of roots/ plant recorded under 60 cm row spacing might be due to more land space available/plant resulting more air, moisture, nutrients and sun energy as compared to 45 cm row spacing. Root depth was recorded more under 45 cm due to plant roots do not find sufficient space for horizontal growth, therefore they penetrated the soil to deeper depth in search of moisture and nutrients. It supports the findings of (8).

Total WU and WUE

The cultivar 'Azad Uttam' was found more efficient over 'Azad Kamal' in respect of total WU and WUE (Table-2). 45 cm row spacing recorded higher total WU than wider row spacing of 60 cm. It might be due to greater plant density in 45 cm row spacing leading to

greater transpirational surface linked directly with water loss from cropped area. 45 cm row spacing also recorded higher WUE than 60 cm spacing. It might be ascribed due to optimum plant stand for growth and yield of rainfed maize under 45 cm row spacing. Increase in grain yield under closer spacing was much higher (7.30%) than the increase in total WU (2.68%), thus WUE was higher under 45 cm than 60 cm row spacing. Ridging and furrowing treatment recorded lower total WU (491.1 mm) and higher WUE (5.07 kg grain/ ha mm) as compared to other moisture conservation practices. The higher WUE recorded by the crop grown under ridging and furrowing treatment might have been due to eradication of weeds and more collection of water in furrows as a result sufficient moisture conserved in the soil which in turn made it possible to utilize moisture by the crop more efficiently over other moisture conservation practices. Similar were the findings of (5).

Economics

It is clear from the data presented in Table-2 that net return (Rs 12493/ha) and cost : benefit ratio (1:1.65) of maize were found higher in cultivar 'Azad Uttam' over 'Azad Kamal'. Highest net return of Rs 13030/ ha and cost : benefit ratio of 1:1.65 were obtained with ridging and furrowing in between the crop rows at 20 DAS. The row spacing of 45 cm recorded higher net return of Rs 11154/ha against Rs 9814/ ha under 60 cm row spacing.

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