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Effect of Tillage and Mulching on Yield of Corn in the Submontaneous Rainfed Region of Punjab, India

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ABSTRACT

A field study to evaluate the effect of tillage and different modes of straw mulch application on corn yield was carried out in a submontaneous rainfed tract of Punjab, India. Dry matter yield in M_w plots was 138% higher as compared to in the M_o plots whereas minimum tilled plots had 22% higher values of dry matter yield as compared to the conventionally tilled plots. Grain and straw yield was observed to be 4 and 3% higher in minimum tilled plots as compared to the conventionally tilled plots. Minimum tillage was more effective in conserving soil moisture than the conventional tillage. Mulch spread on the whole plot increased the grain yield by 60.5% as compared to unmulched control.

Key Words: Tillage; Mulching; Corn; Yield

INTRODUCTION

In India, rainfed area constitutes about 68% of arable land (144 million ha) contributing about 45% of food grain production. In Punjab, the rainfed area amounts to about 5 million ha stretching towards lower Shivaliks. This area is characterized by a higher frequency of uneven distribution of rainfall in time and space often causing dry spells of two weeks or more resulting in moisture stress conditions. If these occur at the critical growth period of crops, the yields are seriously impaired. Thus, the major problem of establishing a crop in the dry season is the lack of adequate moisture in the seed zone in the area. Another hindrance in the successful cultivation of rainfed crops is the problem of soil erosion. It has been reported that during the last 40 years, about one-third of the total arable land of the world is being lost by soil erosion and it is being continuously lost @ 10 million hectare per year (Pimental *et al*., 1995). In India, the problem of soil erosion is quite serious as about 18.5% of the total soil erosion occurs here and about 5334 million tonnes of soil is being lost annually (Dhruvanarayana & Ram Babu, 1983) along with 10 million tonnes of fertilizer (Kanwar, 1973) and other essential elements. In the submontaenous tract of Punjab, about 0.47 million hectare of the area is suffering from the problem of soil erosion mainly by water due to uneven topography, high soil erodibility, low fertility of soil and high erosivity of rains (Khera & Singh, 1995). The soils of the area are generally coarse in texture (sandy loam) and poor in fertility. The area receives an average annual rainfall of 1000 $\pm$ 304 mm, 80% of which is received in two and half months of the whole year during the monsoon season. However, rains are highly erratic in nature and are of high intensity which normally prevails for a shorter period of time. Generally, the monsoon rains are received in 20 to 30 rainstorms, out of which 8 to 12 produce runoff (Hadda & Sur, 1987). Flowing runoff water carries soil particles along with the fertile nutrients. Type of tillage operations and use of crop residues/ straw to improve the physico-chemical properties and microbial activity of soil are salient features of efficient rainfed farming (Reddy *et al*., 2002). Although the positive effect of straw mulching on the plant growth and yield is well established, only a limited number of studies have been conducted to study the effect of different modes of straw mulch application on the plant growth under different tillage treatments in the rainfed region. Farmers of the area are resource poor and generally practice maize-wheat cropping sequence. Keeping this in view, the present investigation was undertaken to study the combined effect of tillage and different modes of straw mulch application on the yield of corn (*Zea mays* var. Parkash) in the rainfed submontaneous tract of Punjab.

MATERIALS AND METHODS

The field experiment was conducted at the Zonal Research Station for Kandi area (ZRSKA) Ballowal-Saunkhri, district Nawanshahr, Punjab, India to evaluate the effect of tillage and cover management techniques on the yield of maize crop. The area is situated at a latitude of 30°-41' to 32°-30' N and longitude of 75° 30' to 76° 48' E and is 355 m above mean sea level. The surface soil samples were collected from the experimental site and different physical and chemical properties were determined using standard procedures.

The field experiment was laid out in a split plot design with two tillage treatments (T_m = Minimum tillage and T_c = Conventional tillage) in the main plots and five modes of straw mulch application viz. straw mulch spread on whole plot (M_w), straw mulch applied on lower 1/3rd of the plot ($M_{1/3rd}$), straw mulch applied in strips (M_s), vertical mulching (M_v) and no mulching (M_o) in the sub-plots of

size 5 x 1.5 m^2 in three replications. Minimum tillage comprised of one disking and one/cultivation; whereas, conventional tillage comprised of disking twice followed by three cultivations. In the strip application, rice straw mulch was applied in 15×5 cm strips constructed in alternative rows and vertical mulching straw mulch was applied in vertical holes (10 cm diameter and 15 cm deep) made with auger. Thus, there were 6 strips and 17 vertical holes per plot in the (M_s) and (M_v) treatments, respectively. Corn (*Zea mays* cv. Parkash) was planted on 6th July 2002 with 45 cm row-to-row and 22.5 cm plant-to-plant spacing. Fertilizers were applied at the recommended rates. Straw mulch @ 6 t ha^{-1} was applied as per treatment. The results were analyzed statistically using split plot design (Cochran & Cox, 1957). A total of 547 mm rain was received during the monsoon season which was much below the normal rainfall of the area. This rainfall was received in 31 rainstorms out of which 12 were erosive. Dry matter yield was recorded by taking five plants randomly from each plot and then air dried followed by oven dry at 65±1^{0}C to a constant weight. The harvested crop was separated in grain and straw, and yield was recorded. The grain yield was adjusted at 15% grain moisture content.

RESULTS AND DISCUSSION

Soils of the experimental site. The soil of the experimental site was coarse textured and low in organic matter. The soils are deficient to low in available N and P while medium in K. DTPA-extractable Zn was found to be low in the soils (Table I).

Dry matter yield. Dry matter per plant recorded 92 days after sowing was observed to be 294, 193, 185, 115 and 110 g, respectively in M_w, $M_{1/3rd}$, M_s, M_v and M_o treatments under minimum tilled treatments; whereas, the respective values of dry matter decreased to 213, 202, 117, 101 and 96 g $plant^{-1}$ in conventionally tilled plots (Table II). It was also observed that M_w plots had 137.8% higher dry matter yield as compared to the M_o plots; whereas, minimum tilled plots produced 22.1% higher dry matter as compared to the conventionally tilled plots. When averaged over tillage treatments, dry matter yield under different modes of straw mulch application viz. M_w, $M_{1/3rd}$, M_s and M_v was observed to be 156, 99, 53 and 8% higher than the unmulched control plots (M_o). The interaction between tillage and straw mulching was also observed to be significant. The average dry matter yield of corn in the mulched plots were significantly higher than the unmulched plots which is because of more favourable influence of mulching on the soil (Weeraratna & Asghur, 1990; Gajera *et al.*, 1998).

Grain yield. Minimum tilled and fully covered straw mulched plots (T_mM_w) provided the best growth conditions. As compared to control, mulch spread on the whole plot increased the grain yield by 60.5%. Grain yield was observed to be 4.0% higher under minimum tillage treatments as compared to conventional tillage treatments. These differences in grain yield under two different tillage treatments could not reach the level of significance. The grain yield was, however, significantly higher by 30, 28.6 and 0.7% in $M_{1/3rd}$, M_s and M_v plots, respectively over unmulched control (M_o) plots (Table III). The increase in grain yield of corn under mulching conditions may be due to increased soil moisture storage and suppressing weed growth (Mastana, 1988; Bhardwaj & Sindwal, 1998). Also application of straw mulch helps in providing optimum soil temperature resulting in better growth and yield (Mastana, 1988). In a study by Khera and Singh (1998), there was more than 50% increase in grain yield of maize in presence of straw mulch. The beneficial effects of straw mulch in reducing soil loss and increasing crop yields were also reported by Hadda and Sur (1989), and Khera and Singh (1995). The similar results were also reported by Gill *et al.* (1992) in a field experiment where corn yield increased significantly with residue mulch application along with minimum tillage.

Straw yield. Straw yield of corn was observed to be 3.1% higher under minimum tillage as compared to conventional tillage treatment and these differences could not reach the level of significance. However, the different modes of straw mulch application significantly affected the straw yield of corn. Straw yield in M_w, $M_{1/3rd}$ and M_s plots was observed to be significantly higher than unmulched control plots (Table IV). The straw yield under vertical mulching treatment was observed to be higher than the control but it could not reach

Table I. Physical and chemical characteristics of soils of the experimental site

Soil characteristics	Values
pH	8.0
EC (d S m^{-1})	0.3
Organic carbon (g kg^{-1})	21
Bulk density (Mg m^{-3})	1.40
Texture	Sandy loam
Available N (kg ha^{-1})	132
Available P (kg ha^{-1})	16.4
Available K (kg ha^{-1})	198
Available Zn (mg kg^{-1})	0.44

Table II. Effect of tillage and mode of mulch application on dry matter yield of corn (g $plant^{-1}$)

Mode of Mulch Application	Tillage		Mean
	T_m	T_c	
M_w	294.2	212.8	253.5
$M_{1/3rd}$	201.5	193.0	197.2
M_s	185.4	117.0	151.2
M_v	114.8	100.1	107.1
M_o	109.9	96.1	99.0
Mean	177.8	145.5	
CD (5%)	Tillage (T) = 23.1; Mulching (M)= 10.7; T x M = 15.2		

T_m = Minimum tillage, T_c = Conventional tillage, M_w= Mulch on the whole plot, $M_{1/3rd}$= Mulch on the lower 1/3rd of the plot, M_s= Strip mulching, M_v= Vertical mulching, M_o= Control bare plots

Table III. Effect of tillage and mode of mulch application on grain yield of corn (q ha^{-1})

Mode of Mulch Application	Tillage		Mean
	T_m	T_c	
M_w	41.4	39.1	40.3
$M_{1/3rd}$	33.1	32.0	32.6
M_s	33.0	31.6	32.3
M_v	25.6	25.0	25.3
M_o	25.5	24.6	25.1
Mean	31.7	30.5	
	Tillage (T) = NS		
CD (5%)	Mulching (M) = 1.04		
	T x M = NS		

T_m = Minimum tillage, T_c = Conventional tillage, M_w= Mulch on the whole plot, $M_{1/3rd}$= Mulch on the lower 1/3rd of the plot, M_s= Strip mulching, M_v= Vertical mulching, M_o= Control bare plots

Table IV. Effect of tillage and mode of mulch application on straw yield of corn (q ha^{-1})

Mode of Mulch Application	Tillage		Mean
	T_m	T_c	
M_w	56.9	55.0	55.9
$M_{1/3rd}$	52.4	53.5	53.0
M_s	51.9	51.0	51.5
M_v	45.7	43.5	44.6
M_o	44.1	40.7	42.4
Mean	50.2	48.7	
	Tillage (T) = NS		
CD (5%)	Mulching (M) = 2.56		
	T x M = NS		

T_m = Minimum tillage, T_c = Conventional tillage, M_w= Mulch on the whole plot, $M_{1/3rd}$= Mulch on the lower 1/3rd of the plot, M_s= Strip mulching, M_v= Vertical mulching, M_o= Control bare plots

the level of significance. Like in the grain yield, the interaction between tillage and mulching was observed to be non-significant for straw yield also. Mulch material induced soil water potential, increased the emergence, plant dry matter, grain and straw yields (Dubey *et al.*, 1995). Similar increase in maize fodder yields with mulch application in rainfed area was observed by Khera and Singh (1998).

CONCLUSION

Among five different modes of mulching imposed, mulch applied on whole plot proved to be most effective followed by mulching on lower 1/3rd plot, strip and vertical in promoting the corn yield. Among tillage treatments, minimum tillage was found to be better over the conventional tillage in promoting crop yields. However, as far as interactive effect of tillage and different modes of straw mulch application is concerned, minimum tilled plots with fully covered plots were found to be the most effective and conventionally tilled with bare plots was found to be the least effective in promoting corn yield in the rainfed area of Punjab.

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