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Research Paper

Effect of tillage practices, mulching and intercropping on rainfed maize (*Zea mays*) in foothill of Shivaliks, Jammu, Jammu and Kashmir

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2017 and 2018 at Advanced Centre for Rainfed Agriculture, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Dhianasr, Jammu and Kashmir to evaluate the effect of tillage, residue mulching and intercropping on nutrients, growth and yield of rainfed maize (*Zea mays* L.). The experiment was laid out in a randomized block design with 3 replications. The treatments included conventional tillage (CT), CT+ mulching (CTm), CT + intercropping with mash [*Vigna mungo* (L.) Hepper] (CTi), minimum tillage (MT), MT + mulching (MTm), MT + intercropping with mash (MTi), MT + residue (MTr), zero tillage (ZT), ZT + mulching (ZTm) and ZT + residue (ZTr). The highest grain yield (3.01 t/ha) and yield attributes were recorded with minimum tillage + residue incorporation (MTr). However, the grain yield recorded in all the treatments were at par when equivalent yield of intercrop was taken. The intercropping of mash in maize sown by conventional tillage resulted in 34.3% reduction in grain yield of maize as compared to conventional tillage. The stover yield ranged from 5.65 to 7.93 t/ha and harvest index ranged from 23.8 to 32.5% in all the treatments was at par.

Key words: Intercropping, Mulch, Nutrients, Rainfed maize, Tillage

Maize (*Zea mays* L.) is an important crop for food and nutritional security and is grown in diverse agroclimatic conditions. It is the world's third largest cereal crop which contributes significantly to the national food basket and serves as a source of primary raw material for a number of industrial products for food, animal feed, poultry feed, starch and brewery (Owla *et al.,* 2015). Though maize also contributes a significant portion of the food consumed by poor communities in developing countries, its production is insufficient to meet the requirement of the people. Rainfed agriculture is the most important sector for providing food security in India and rainfed area constitutes about 68% of arable land and contributes about 45% of foodgrain production of the country. The rainfed foothill Shivaliks of Jammu, commonly known as the *Kandi* belt is one such region of Northern India that has all the ingredients of impending agricultural disaster because of the erratic local weather conditions. About 1.0 million ha of land is already degraded in the Jammu and land degradation here is largely due to water erosion.

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 system (Reddy *et al*., 2002). Khan (2001) also reported that mulching is a desirable management practice which regulates farm environment and thereby enhances crop production through regulating soil temperature, and by reducing leaching and evapotranspiration (Liu *et al*., 2000). Although the positive effect of straw mulching on the plant growth and yield is well established, limited numbers 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. Soil tillage and mulch in the form of residue strongly influence crop productivity (Keshavarzpour and Rashidi, 2007; Moriaque *et al*., 2019). Intercropping also increases the crop-equivalent yield of the crop and helps in proper utilization of the natural resources and increases productivity of crop (Sekhon *et al*., 2018a). Keeping this in view, the present investigation was undertaken to study the

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combined effect of tillage and different modes of straw mulch/intercropping on the yield of corn (*Zea mays* var. 'Kanchan') in the rainfed sub-mountainous tract of Jammu.

MATERIALS AND METHODS

The experiment was conducted during the rainy (*kharif*) season of 2017 and 2018 at Advanced Centre for Rainfed Agriculture (ACRA) of the Sher-e-Kashmir University of Agricultural Sciences and Technology-Jammu, Dhiansar, Jammu and Kashmir. The experimental site is located in the *Kandi* region (32° 39′ N, 74° 58′ E, 332 m above the mean sea level) and has sub-tropical climate. The mean annual rainfall varies from 1,050 to 1,115 mm.

The experiment was laid out in a randomized block design. The experiment consist of 10 treatments, viz. conventional tillage (CT); CT + mulching (CTm); CT + intercropping with mash or blackgram (CTi); minimum tillage (MT); MT + mulching (MTm); MT + intercropping with mash or blackgram (MTi); MT + residue, 30% residue of previous wheat (*Triticum aestivum* L.) crop (MTr); zero tillage (ZT), ZT + mulching (ZTm); and ZT + residue, 30% residue of previous wheat (*Triticum aestivum* L.) crop (ZTr), replicated 3 times. The nutrient requirement of the crop was met by the addition of well-rotten FYM @ 15 t/ha and N: P: K was applied as per the recommended dose in the ratio of 60: 40: 20 kg/ha. The two-thirds dose of the nitrogen and full dose of phosphorus and potassium were applied basal at the time of sowing and the remaining one-third dose of nitrogen was top-dressed at 1 month after sowing of the maize crop. Two ploughings and planking were done before sowing of the crop in conventional tillage and in minimum tillage, 1 ploughing followed by planking was done at the time of sowing of the crop. In zero tillage, no ploughing or planking was done. In residue treatments, 30% biomass of the previous sown wheat crop was used as residue. *Adhatoda vasica* (a freely available weed) was used @ 6 t/ha for mulching and it was spread in mulch plots after sowing of maize crop. The maize variety sown was Kanchan (KH 517) and variety of mash or blackgram [*Vigna mungo* (L.) Hepper] was PU 31. The soil was free from salinity but slightly acidic in nature, medium in phosphorus and low in nitrogen and potassium content. The organic matter content of the soil was low and textural class varying between sandy loam to loamy sand. The soils had lower cation-exchange capacity due to coarse texture and low in organic carbon content.

RESULTS AND DISCUSSION

Days to tasseling and silking

The data pertaining to days to tasseling and silking revealed that, the different treatments did not cause significant variation in the days to tasseling and silking (Table 1). The slight variation recorded in different phenological stages might be due to variation in weather parameters during both the years. Ghosh *et al*., (2014) also reported that, the phenological traits, i.e. days to 50% tasseling, silking and maturity, are genetically controlled and can be influenced only little with different agronomic manipulations.

Yield attributes

Conley and John (2013) reported that, test weight is an important factor for a promising variety. The effect of tillage, mulch and intercropping treatments on yield attributes like cob length, stover length, number of cobs/plant, number of rows/cob and test weight were found to be non-significant (Table 1). This might be due to short duration of the experiment, as the duration of the experiment was only

Table 1. Effect of different tillage, mulch and intercropping practices on yield attributes of maize (pooled data of 2 years)

Treatment	Days to tasseling	Days to silking	Cob length (cm)	Stover length (cm)	Test weight (g)	Cobs/ plant	Rows/ cob
CT	47.0	64.0	11.9	172.3	193.8	1.07	15.3
CTm	47.3	64.7	11.5	166.4	188.4	1.07	14.7
CTi	47.8	65.2	11.0	157.7	180.4	1.00	14.3
MT	47.5	66.5	11.2	154.0	179.5	1.13	14.7
MTm	47.7	66.0	11.4	149.6	183.2	1.00	15.3
MTi	48.2	66.8	10.9	140.7	178.0	1.07	15.0
MTr	47.3	66.5	11.5	173.1	178.8	1.13	15.7
ZT	47.7	65.5	11.0	155.2	188.6	1.07	14.7
ZTm	48.0	66.2	11.6	166.1	181.5	1.00	15.3
ZTr	47.7	67.0	11.2	164.3	189.1	1.07	14.3
SEm±	0.80	0.76	0.40	8.94	4.02	0.06	0.4
CD (P=0.05)	N.S	N.S	N.S	N.S	N.S	N.S	N.S

CT, conventional tillage; CTm, CT+ mulching; CTi, CT + intercropping with mash or blackgram; MT, minimum tillage; MTm, MT + mulching; MTi, MT + intercropping with mash or blackgram; MTr, MT + residue (30% residue of previous wheat crop); ZT, zero tillage; ZTm, ZT + mulching and ZTr, ZT + residue (30% residue of previous wheat crop).

for 2 years. Ghosh *et al*., (2014) also reported that, the number of grains/cob, cob length, stover length and test weight of maize was genetically controlled and hence influenced only little with different agronomic manipulations.

Nutrient content in soil and plant

The effect of different practices on available nutrients (N, P, K) content in plant (Table 2) revealed that, uptake of N, P and K in grains varied significantly with treatments. Intercropping of mash in maize resulted in significant reduction in N uptake by maize grains in conventional tillage intercropping (CTi), i.e. 33.15 kg/ha as compared to conventional tillage i.e. 50.0 kg/ha. This might be due to competition for nutrients between main and intercrop. Similar trend was observed in other nutrients also. However, N content in intercropping treatment was more in soil than the other treatments (Table 3), which might be attributed to fixation of atmospheric nitrogen by intercrop (mash) that increased the N content in the soil profile. Sekhon *et al*., (2018b) also reported increase in the availability of nutrient content particularly nitrogen in soils having intercropping system. However, the differences in N and P uptake by plants were found to be non-significant.

Grain yield, stover yield, harvest index and economics

The highest grain yield (Table 4) was recorded in MTr (3.01 t/ha) and the lowest in CTi (1.97 t/ha). The grain yield recorded in all the treatments were statistically at par when equivalent yield of intercrop was taken. However, an intercropping of mash in maize resulted in significant reduction in grain yield of maize crop in conventional tillage

Table 2. Effect of different tillage, mulch and intercropping on uptake of nutrients (kg/ha) by grain (pooled data of 2 years)

Treatment	N (kg/ha)	P (kg/ha)	K (kg/ha)
CT	50.0	10.1	15.7
CTm	47.2	9.6	14.3
CTi	33.2	7.0	10.1
MT	47.1	9.8	14.3
MTm	49.4	10.3	15.0
MTi	38.7	7.9	12.0
MTr	50.6	10.8	15.2
ZT	44.6	9.0	13.2
ZTm	44.8	9.6	14.1
ZTr	44.5	9.4	13.8
SEm±	5.05	0.79	0.64
CD (P=0.05)	N.S	N.S	1.94

CT, conventional tillage; CTm, CT+ mulching; CTi, CT + intercropping with mash or blackgram; MT, minimum tillage; MTm, MT + mulching; MTi, MT + intercropping with mash or blackgram; MTr, MT + residue (30% residue of previous wheat crop); ZT, zero tillage; ZTm, ZT + mulching and ZTr, ZT + residue (30% residue of previous wheat crop).

Table 3. Effect of different tillage, mulch and intercropping on available nutrients (kg/ha) in soil (pooled data of 2 years)

Treatment	N (kg/ha)	P (kg/ha)	K (kg/ha)
CT	103.5	17.6	98.9
CTm	102.3	17.6	101.6
CTi	106.0	16.5	105.4
MT	107.5	16.6	106.3
MTm	108.3	17.6	104.3
MTi	115.8	16.2	97.4
MTr	112.7	18.6	98.8
ZT	107.9	18.0	103.7
ZTm	102.4	17.3	101.9
ZTr	111.0	19.4	105.5
SEm±	2.77	0.91	2.28
CD (P=0.05)	8.29	N.S	N.S

CT, conventional tillage; CTm, CT+ mulching; CTi, CT + intercropping with mash or blackgram; MT, minimum tillage; MTm, MT + mulching; MTi, MT + intercropping with mash or blackgram; MTr, MT + residue (30% residue of previous wheat crop); ZT, zero tillage; ZTm, ZT + mulching and ZTr, ZT + residue (30% residue of previous wheat crop).

(CTi) as compared to all the other treatments. The intercropping of mash in minimum tillage (MTi) significantly reduced the grain yield as compared to CT, MTm, MT, MTm and MTR. However, it was statistically at par with CTi, ZT, ZTm and ZTr. The stover yield obtained in all the treatments was also statistically at par. Similarly, the harvest index recorded in all the treatments was at par with each other. Khan (2001) also reported that mulching is a desirable management practice which regulates farm environment and thereby enhances crop production through regulating soil temperature, and by reducing leaching and evapotranspiration (Liu *et al*., 2000). The highest grain yield (3.01 t/ha) was recorded in MTr which indicated the necessity of using residue mulch in conjunction with minimum tillage in order to improve crop production. Reddy *et al*., (2002) also reported that, use of crop residues/straw improved the physico-chemical properties and microbial activity of soil. The lowest grain yield recorded in intercropping treatments might be due to the competition between the 2 crops. Similarly, Gidnavar *et al*., (1991) obtained lower yields of maize when intercropped with 1 or 2 rows of legumes. Rafey and Prasad (1992) and Gangwar and Sharma (1994) also reported decrease in maize yield due to intercrop. Sekhon *et al*., (2019) also revealed that crop equivalent yield was higher than the sole cropping of main crop in different cropping systems. In zero-tillage treatments, the rainfall water could not penetrate into the soil profile and hence the crop suffered due to scarcity of water and nutrients and ultimately resulted in lower productivity. Mu *et al*., (2016) also reported that in China, tillage practices in wheat-maize cropping system improved the soil water absorption and water utilization by crop and there by improved yield. The highest mean stover yield was recorded in minimum tillage with residue (MTr) and minimum stover yield was recorded in zero tillage with mulching (ZTm). Kahlon *et al*., (2013) and Singh *et al*., (2014) also reported that, the effect of tillage and mulching on soil physio-chemical properties appears over a longer period of time and not over a shorter period of time. The highest harvest index was recorded in conventional tillage (CT). The highest mean benefit: cost ratio (Table 4) was recorded in conventional tillage (1.37), followed by minimum tillage + residue (1.35), and the lowest benefit: cost (B:C) ratio was recorded in intercropping treatment (0.92). The highest benefit: cost ratio was recorded in conventional method might be owing to the potential yield obtained compared to all the other tillage methods. Singh *et al.,* (2009) also observed that the operational energy and benefit: cost ratio obtained were higher in conventional tillage than in reduced tillage in maize crop.

The intercropping of mash in maize sown by conventional tillage resulted in significant reduction in grain yield of maize crop as compared to all the treatments. However, grain yield recorded in all the treatments were statistically at par when equivalent yield of intercrop was taken. The stover yield obtained in all the treatments was statistically at par in all the tillage, intercrop, mulch and residue treatments. The results showed that the effects of different tillage and mulch application on yield, yield attributes of maize crop and soil properties appear over a longer period of time and not over a shorter period of time.

Table 4. Effect of different tillage, mulch and intercropping on grain yield, stover yield, harvest index and benefit: cost ratio of maize (pooled data of 2 years)

Treatment	Grain yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Benefit: cost ratio
CT	3.0	6.53	32.3	1.37
CTm	2.8	7.32	28.4	1.18
CTi	1.97 (2.69)	6.27	23.8	0.92
MT	2.82	6.98	29.3	1.32
MTm	2.95	7.64	28.3	1.27
MTi	2.27 (2.94)	5.65	28.5	1.02
MTr	3.01	7.93	27.8	1.35
ZT	2.61	5.84	31.2	1.27
ZTm	2.68	5.65	32.5	1.20
ZTr	2.64	5.84	31.2	1.13
SEm±	0.16	0.55	0.40	0.11
CD (P=0.05)	0.50	N.S	–	N.S

Values in parentheses is maize equivalent yield
CT, conventional tillage; CTm, CT+ mulching; CTi, CT + intercropping with mash or blackgram; MT, minimum tillage; MTm, MT + mulching; MTi, MT + intercropping with mash or blackgram; MTr, MT + residue (30% residue of previous wheat crop); ZT, zero tillage; ZTm, ZT + mulching and ZTr, ZT + residue (30% residue of previous wheat crop).

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