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Effect of management practices on moisture conservation, nutrient availability, soil loss, runoff and growth parameters of rainfed grown capsicum under mid-hills of Himachal Pradesh

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Abstract

Conservation tillage increased soil moisture over unmulched conventional tillage treatments (T_2 & T_3) by 0.85 to 1.34% at flowering and 0.55 to 1.15% at harvesting stage during first and second year. Mulch based treatments (T_4-T_9) on an average increased moisture content by 3.62 and 5.18% over the unmulched treatments (T_2 & T_3) at flowering and 1.38 and 4.07% at harvesting stage during the year 2001 and 2002, respectively. Conservation tillage increased the availability of N and K in the soil. Grass and plastic mulches also increased available NPK contents in the soil over un-mulched treatments under low level of applied nutrients. Un-mulched conventional tillage treatment resulted in highest run-off (250.8 and 218.2 mm) and soil loss (12.3 and 11.2 t ha^{-1}) during first and second year. Amongst all the treatments, lowest run-off of 99.7 and 88.5 mm was under plastic mulch (T_8), whereas, lowest soil loss of 0.83 and 0.70 t ha^{-1} was under plastic mulch treatment (T_9) during first and second year. Mulch based treatments increased the root mass density over their corresponding un-mulched treatments. Higher dose of NPK (150%) along with grass mulch proved superior in respect of capsicum yield (30 q ha^{-1}). Conservation tillage produced 33% higher yield as compared to un-mulched conventional tillage treatment.

Key words: Conservation tillage, conventional tillage, plastic mulch, grass mulch, root mass density.

Introduction

. Soil moisture conservation practices are reported to increase the profile water storage, nutrient availability and decrease the runoff and soil loss. Optimum soil moisture regime plays a significant role in the development of root system, vegetative growth as well as fruit production (Verma *et al.* 2005). In mid-hills of Himachal Pradesh uneven distribution of rains, occurrence of runoff and soil loss during rains, frequent dry spells, and poor water retentivity of soils and large area under rainfed cultivation are the major constraints in vegetable crop production. The success of crop production in these areas, therefore, depends on the practices, which ensure sustained supply of moisture. In mid-hills of Himachal Pradesh capsicum is the main cash crop. However, due to lack of assured irrigation in the region the productivity of this crop is very low. Under such situations moderation of hydrothermal regimes of the soil by tillage and mulching has also been reported to influence the root growth, nutrient uptake, plant growth and yield of crops (Chia, 1982; Acharya and Bhagat, 1984; Verma and Acharya, 1996). Therefore, it is logical to study the response of different management practices on moisture conservation, nutrient availability, root growth, soil loss, runoff, and yield of capsicum under rainfed conditions.

Material and Methods

Field experiments were conducted on commercial capsicum crop during the year 2001 and 2002 on gravely loam soil, having bulk density 1.19 Mg m^{-3}, porosity 48.60%, pH 6.9, organic carbon 9.8 g kg^{-1}, maximum water holding capacity 32.17%, hydraulic conductivity 2.36 cm hr^{-1}, infiltration rate 1.10 cm hr^{-1} and available NPK content of 327, 39.2 & 253 kg ha^{-1}. The rainfall distribution in the region is erratic. The annual rainfall is between 1000 to 1250 mm and major amount of which is received during July to August months. However, during the study period, April and May months remained dry and after that rainfall increased during June and July months and again it followed a decreasing trend from August to September (Fig.1).

The experiment was started in May 2001 with capsicum var. California Wonder in a plot of 4x3 m. Recommended N, P_2O_5 and K_2O were applied @ 100, 75 and 55 kg ha^{-1}. All the quantity of P and K was applied at the time of field preparation while N was applied in two splits. Top dressing of N was done by removing the mulch strip placed between the rows.

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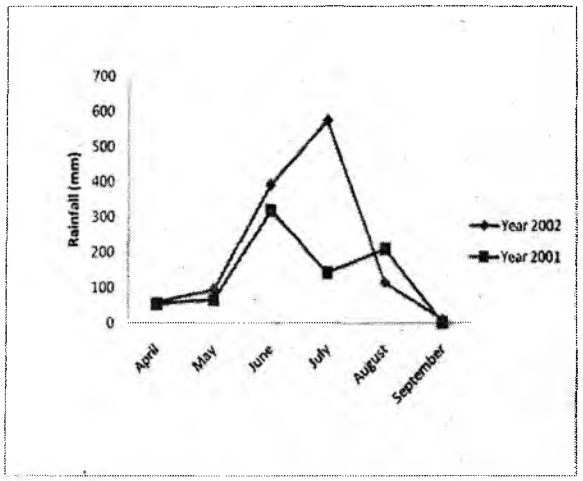


Fig.1 Rainfall during growing season of capsicum crop

In each year transplanting was done during May and harvesting was completed during first week of September. There were two tillage treatments (conservation and conventional) and two types of mulch materials (grass and black polyethylene). In conservation tillage narrow slit was prepared to transplant the capsicum seedlings. In conventional tillage whole plot was cultivated upto plough depth of 15 cm. The locally available grass @ 10 t ha^{-1} on dry weight basis was used as mulch material. The black polyethylene sheet (25 micron) was spread as strips in between the rows immediately after transplanting. For better establishment of plants half litre of water was given to each seedling per day upto fifteen days. There were nine treatments, replicated thrice under randomized block design. The treatments were T_1 (conservation tillage + 100% NPK); T_2 (conventional tillage + 100% NPK); T_3 (conventional tillage +50% NPK); T_4 {conventional tillage +50% NPK + grass mulch (GM)}; T_5 (conventional tillage +100% NPK +GM); T_6 (conventional tillage + 150% NPK + GM); T_7 {conventional tillage + 50% NPK + plastic mulch (PM)}; T_8 (conventional tillage + 100% NPK + PM); T_9 (conventional tillage + 150 % NPK + PM). To study the runoff and soil losses, the bunds of the experimental plots were raised to 15 cm height during preparation of plots for transplanting to prevent the entry of water from outside and neighbouring plots. Ramser Samplers were installed in each plot and iron drums of 220 litres capacity as run-off collectors were installed just below the plot surface in 1.10 m buffer zone. The run-off from each plot was drained to the respective collectors through the outlet of samplers.

After every rainstorm, the data on run-off were recorded. Runoff samples were collected after thorough stirring the contents of the drum. To estimate soil loss a known volume of the run-off sample was centrifuged and filtered through Whatman No. 1 filter paper and sediment on the filter paper was dried and weighed. Soil moisture content of surface layer (0-15 cm) was determined by standard gravimetric method. The per cent loss in moisture content was estimated by subtracting moisture content at transplanting time from that present at the time of harvesting of the capsicum crop. Moisture content remained in the soil during transplanting (15 days after harvesting of first crop) of new crop under different treatments over unmulched conventional treatment (T_2) was estimated by:

$$\frac{\text{Moisture content under conservation practices- Moisture content under unmulched treatment } (T_2)}{\text{Moisture content under unmulched treatment } (T_2)} \times 100$$

Soil samples from the surface layer (0-15) were collected at the end of field experiments and were analysed for available NPK content using standard procedures. Root mass density (RMD) was determined at flowering and maturity stage of the crops. Metallic cores (10.3 cm internal diameter, 16.4 cm height) were used for taking samples for root studies from each replication. The sample cores were kept in water overnight and then soil was removed from the roots by washing with fine jet of water. The roots were collected on fine sieves for final washing with a microjet tap. The roots were transferred to filter paper and pressed gently in folds to remove imbibed water. The roots were then dried in an oven at 60 ± 5^0C to a constant weight and finally the dried weight was taken. The root mass density (RMD) was computed by dividing the dry weight of roots by the volume of the core and expressed as g per m^3.

Results and Discussion

Soil moisture conservation

Moisture content under different treatments ranged between 22.50 to 26.68% and 19.25 to 24.72% and 21.85 to 23.75% and 18.35 to 22.85% at the flowering and harvesting stages of capsicum crop during first and second year, respectively (Table 1). Mulch based treatments (T_4-T_9) on an average increased moisture content by 3.62 and 5.18% over the unmulched treatments (T_2 & T_3) at flowering stage and 1.38 and 4.07% at harvesting stage during 2001 and 2002, respectively. On the other hand conservation treatment (T_1) increased soil moisture by 0.85 and

1.34% at flowering and 0.55 and 1.15% at harvesting stage over unmulched conventional tillage treatments (T_2 & T_3). Whereas, at the time of transplanting of next crop, moisture content under various treatments was found to be ranged from 18.30 to 21.25 and 14.25 to 20.75% only. Unmulched conservation tillage (T_2) resulted in the maximum loss of moisture (3.85% and 4.50%) from the time of harvest to the transplanting of next crop during the year 2001 and 2002. The application of grass and plastic mulch under different conventional tillage treatments (T_4-T_9) relatively reduced the moisture loss to the range of 2.40 to 2.70% and 1.65 to 2.75% in first and second year, respectively. Conservation tillage on the other hand resulted in soil moisture loss of 2.80 and 3.20% during first and second year which was relatively less than unmulched treatments.

Different treatments were found to increase moisture in the soil for next crop over unmulched conventional treatment (T_2) in both the years. Various conservation practices (T_1 & T_4-T_9) increased moisture content to the tune of 7.6 to 15.5% and 15.8 to 45.6% over unmulched treatment (T_2 & T_3) during first and second year. (Table 1). The increased soil moisture content under these treatments is apparently related to the reduced evaporation and more downward movement of water into deeper parts of the profile where it remained conserved for longer period (Hillel, 1968; Verma, 2005). Conservation tillage (T_1) by retaining previous season crop residue on the surface was found to increase moisture content by 7.6 to 15.8 % over unmulched treatment (T_2) in both the years. Application of grass mulch under T_4 to T_6 treatments on an average increased moisture content by 11.86 and 42.69% during first and second year over unmulched conventional tillage practice.

Plastic mulch application under T_7 to T_9 treatments was found to register 14.86 and 40.58 % increase in first and second year. Higher soil moisture content in the second year of study was due to occurrence of rains during harvesting to transplanting stages of the crop.

Nutrient availability

The availability of NPK was found to increase with the increasing levels of nutrient application in the soil. Amongst all the treatments application of 150% of the recommended dose of N P and K along with grass mulch resulted in the highest availability of N (397.5 kg ha^{-1}), P (37 kg ha^{-1}) and K (173.3 kg ha^{-1}) in the soil

Table 1. Effect of different practices on *in-situ* soil moisture conservation at different stages of capsicum crop

Treatment	Average soil moisture (%)						Per cent loss (-)		Per cent gain at transplanting time over (T_2)	
	At Flowering		At harvest		At transplanting of succeeding crop					
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
T_1	23.60	20.75	22.60	19.70	19.80	16.50	2.80	3.20	7.60	15.79
T_2	23.00	19.50	22.25	18.75	18.40	14.25	3.85	4.50	-	-
T_3	22.50	19.25	21.85	18.35	18.30	14.75	3.55	3.60	-	-
T_4	26.40	24.70	23.45	22.75	20.75	20.50	2.70	2.25	12.75	43.86
T_5	26.20	24.30	23.25	22.40	20.65	20.75	2.60	1.65	12.23	45.61
T_6	25.70	24.30	22.75	22.40	20.35	19.75	2.40	2.65	10.60	38.60
T_7	26.65	24.65	23.75	22.55	21.25	19.90	2.50	2.65	15.50	39.65
T_8	26.60	24.72	23.65	22.75	21.10	20.00	2.55	2.75	14.67	40.35
T_9	26.68	24.71	23.70	22.85	21.05	20.20	2.65	2.65	14.40	41.75

(Table 2). This effect was statistically at par with the application of same level of NPK under plastic mulch treatment (T_9). Grass mulching + 100% NPK (T_5) increased available N in the soil over its corresponding unmulched treatment (T_2). Conservation tillage treatment significantly increased available N (391.70 kg ha^{-1}) and K (170.87 kg ha^{-1}) content in soil over the unmulched conventional tillage (T_2). Application of 50% of the recommended dose of P under grass mulch (T_4) registered significantly higher availability of P (33.07 kg ha^{-1}) in soil as compared to the unmulched treatment which was found statistically at par with its corresponding application with plastic mulch. Similarly, grass mulch + 100% NPK under conventional tillage (T_5) also resulted in a significant increase in the availability of K (170.76 kg ha^{-1}) in the soil over its corresponding unmulched treatment (T_2). The increased availability of NPK under conservation tillage and mulch based treatments might be ascribed to better hydrothermal regimes under these practices (Singh, 1992).

Table 2. Effect of different practices on nutrient availability under capsicum crop

Treatment	Available Nutrients (kg ha^{-1})		
	N	P	K
T_1	391.70	34.17	170.87
T_2	388.00	34.03	169.50
T_3	372.30	31.57	167.30
T_4	373.00	33.07	167.80
T_5	392.50	34.67	170.76
T_6	397.50	37.00	173.30
T_7	372.20	33.00	167.20
T_8	391.30	34.33	169.80
T_9	396.30	36.50	172.50
CD (P=0.05)	3.29	0.93	1.25

Root growth

The root growth of capsicum at flowering and at harvest stage was significantly influenced by different management practices (Table 3). During both the years, significantly highest root mass density 2.02, 2.20 and 2.42. 2.55 gm^{-3}x10^3 at flowering and at maturity stages were recorded under T_6 (conventional tillage + 150% NPK+ grass mulch) treatment during 2001 and 2002, respectively. This combination was found statistically at par with treatment T_9 where plastic mulch was applied in place of grass mulch at both the stages. The better root mass density may be ascribed to favourable hydrothermal regimes and increased availability of nutrients under mulch based practices. Verma and Acharya (1996) and Moreno *et al.* (1997) also highlighted the beneficial effects of straw mulch and available nutrients on root growth. At both the stages significantly higher root mass density was recorded under conservation tillage as compared to un-mulched conventional treatments (T_1 & T_2). Lowest root mass density was noticed under unmulched conventional tillage treatment T_3 where 50% of recommended dose of NPK was applied. With the increase in fertilizer doses the root mass density was found to increase. The poor root growth under unmulched treatments may be due to unfavourable moisture levels in the soil and sub-optimal thermal regimes. Many research workers reported that root growth is affected by inadequate soil moisture (Chaudhary and Sandhu, 1983) and sub-optimal thermal regimes (Bhagat and Acharya, 1987).

Table 3. Effect of different practices on root mass density of capsicum at flowering (FS) and at maturity stage (MS)

Treatment	Root mass density (gm^{-3}x10^3)			
	2001		2002	
	FS	MS	FS	MS
T_1	1.42	1.51	1.62	1.60
T_2	0.93	1.03	1.38	1.38
T_3	0.83	1.00	1.30	1.25
T_4	1.60	1.95	1.65	1.44
T_5	1.92	2.05	2.15	2.25
T_6	2.02	2.20	2.42	2.55
T_7	1.58	1.75	1.61	1.37
T_8	1.73	1.92	2.08	2.15
T_9	1.82	1.98	2.30	2.50
CD (P=0.05)	0.24	0.24	0.16	0.08

Runoff

Data in table 4 indicated that lowest runoff of 99.7 and 88.5 mm in 2001 and 2002 was recorded under plastic mulch treatment (T_8). The application of plastic mulch under conventional tillage, on an average, reduced the runoff by 59.7% and 59.2% over unmulched treatment (T_2 and T_3) during first and second year. The application of grass mulch under conventional tillage treatments (T_4, T_5 and T_6) reduced the runoff to 58.7 and 58.0% over unmulched conventional tillage treatments (T_2 and T_3) during first and second year.

Table 4. Effect of different practices on run off, soil loss and yield of capsicum crop

Treatment	Run off (mm)		Soil loss (t ha^{-1})		Yield (q ha^{-1})	
	2001	2002	2001	2002	2001	2002
T_1	205.0	149.7	10.27	8.20	6.3 (18.9)	13.3 (33.0)
T_2	245.0	217.6	12.07	11.10	5.3 (-)	10.0 (-)
T_3	250.8	218.2	12.30	11.20	5.6 (-)	7.2 (-)
T_4	103.5	91.5	0.88	0.74	6.7 (26.4)	11.7 (17.0)
T_5	102.2	91.7	0.87	0.72	9.2 (73.6)	22.8 (128.0)
T_6	101.7	90.7	0.89	0.72	8.0 (50.9)	30.0 (200.0)
T_7	100.2	89.4	0.86	0.71	7.7 (45.3)	11.9 (19.0)
T_8	99.7	88.5	0.84	0.71	8.5 (60.4)	20.4 (104.0)
T_9	99.8	88.5	0.83	0.70	8.5 (60.4)	28.9 (189.0)
CD (P=0.05)	5.11	3.29	0.191	2.76	NS	3.74

*Values mentioned in parentheses are per cent yield increase values over unmulched conventional tillage treatment T_2

The conservational tillage (T_1) was also found to reduce the runoff to the tune of 17 and 31% during first and second years, respectively. During both the years maximum runoff (250.8 and 218.2 mm) was recorded under unmulched conventional tillage treatment (T_3). Both the mulch types were found statistically at par in respect of runoff reduction under capsicum crop.

Soil loss

Different practices resulted in a significant influence on soil loss under rainfed grown capsicum crop (Table 4). The highest soil losses (12.3 & 11.2 t ha^{-1}) were recorded under unmulched conventional tillage treatment T_3, whereas, lowest (0.83 and 0.70 t ha^{-1}) was noticed under plastic mulched plot (T_9) during 2001 and 2002, respectively. The maximum reduction in soil loss was recorded with the application of plastic mulch and the average reduction over unmulched conventional treatment (T_2) was to the tune of 93.0 and 93.7% during first and second year. The application of grass mulch under conventional tillage also reduced the soil loss and the average reduction was to the tune of 92.8 and 93.5% during the year 2001 and 2002. The reduction in soil loss under grass and plastic mulched plots was found to be statistically at par with each other during both the years. The conservation tillage on the other hand found to reduce soil loss to the tune of 15.8% (2001) and 26.8% (2002) over unmulched conventional tillage treatments (T_2 and T_3). The reduction in run-off and soil loss under plastic mulched plots might be due to reduction in raindrop impact on the soil surface. Whereas, increased infiltration and residence time for rainwater as well as reduced over land flow velocity might have decreased run off and soil loss under grass mulched plots (Hillel, 1968 ; Verma, 2005).

Crop yield

During first year various practices were found non significant with respect to yield of capsicum crop (Table 4). However, in the second year application of 50% higher the recommended dose of NPK along with grass mulch under conventional tillage (T_6) produced highest (30 q ha^{-1}) yield which was statistically at par with plastic mulch treatment (T_9). Application of recommended dose of NPK under conventional tillage treatment along with grass mulch (T_5) produced 128% higher yield over unmulched conventional tillage (T_2), whereas, application of plastic mulch under this tillage treatment produced 104% higher yield with the same level of NPK. Conservational tillage treatment resulted in an increase of 33% over unmulched conventional tillage treatment (T_2). This may be attributed to higher moisture status, nutrient availability and consequently to better water balance in plant system under grass and plastic mulch plots. Similar, results have also been reported by Abdul-Baki *et al.* (1999) in capsicum crop.

Conclusion

The present study indicated that grass mulch @ 10 t ha^{-1} or black polyethylene sheet by increasing soil moisture content tended to increase NPK availability in the soil and proved effective in controlling soil loss, runoff, and ultimately in improving growth parameters of capsicum crop. Grass and / or black polyethylene sheet may therefore, be used for growing capsicum crop under rainfed condition. In mid hills of Himachal Pradesh the dry grass is used for stall feeding as a result its availability as mulch material is very limited and hence black polythene sheet may be used for mulching the capsicum crop.

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References

Abdul-Baki AA, Morse RD and Teasdate JR 1999. Tillage and mulch effects on yield and fruit fresh mass of bell pepper (*Capsicum annum* L.). J. Veg. Crop Prod. **5 (1)**:43-58.

Acharya CL and Bhagat RM 1984. Infiltration behavior, root development and yield of rainfed maize under different soil management practices. Proc. Indian National Sci. Acad. B **50**: 441-48.

Bhagat RM and Acharya CL 1987. Effect of soil management on rainfed wheat in northern India. I. Hydrothermal regime and root growth. Soil and Tillage Res. **9**:65-77.

Chaudhary TN and Sandhu KS 1983. Soil physical environment and root growth. Adv. Soil Sci. **1**:1-43.

Chia AJ 1982. Yield and yield components of four spring wheat cultivars grown under three tillage systems. Agron. J. **74**: 317-20.

Gupta DK and Bhan Suraj 1992. Effect of *in-situ* moisture conservation practices and

fertilization on yield and its attributes for rainfed mustard of Central Uttar Pradesh. Indian J. Soil Conserv. **20**:28-31.

Hillel D 1968. Soil water evaporation and means of minimizing it. Rep. Hebrew Univ. of Jerusalem, Israel.

Moreno F, Pelegrin F, Fernandez JE and Murillo JM 1997. Soil physical properties, water depletion and crop development under traditional and conservation tillage in southern Spain. Soil and Tillage Res. **41**:25-41.

Verma ML and Acharya, CL 1996. Root development, leaf area index, water use and yield of rainfed wheat under different soil water conservation practices and levels of nitrogen. J. Indian Soc. Soil Sci. **44**:625-32.

Verma ML, Sharma RK and Bhandari AR 2005. Effect of soil water conservation practices on root growth, yield, nutrient removal and quality of pea and tomato crops. J. Indian Soc. Soil Sci. **53**: 602-07.

Singh SP 1992. Studies on mulching of vegetable crops-a review, p 115-43. In: SP Singh (ed.) Advances in Horticulture and Forestry 2. Scientific Publication, Jodhpur, India.

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