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Effect of tillage and nitrogen on growth and yield of pearl millet under rainfed conditions

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ABSTRACT

A field experiment was conducted during the rainy season *(kharif)* of 2005 and 2006 to study the effect of tillage and supply of nitrogen through different sources on the performance of pearl millet *(Pennisetum glaucum)* in respect of growth and yield. Pearl millet yield varied significantly due to tillage practices during both the years. The highest average grain yield (2124 kg ha^{-1}) was obtained with deep tillage + two interculture and lowest (1601 kg ha^{-1}) with minimum tillage + one interculture. Application of 100% nitrogen through inorganic source gave significantly higher yield of grain and stover. Seasonal water use was highest with minimum tillage + one interculture in both the years. Maximum water use efficiency was recorded under deep tillage both for grain (7.54 kg ha^{-1} mm^{-1}) and stover (18.30 kg ha^{-1} mm^{-1}). Among the different tillage practices deep tillage + two interculture gave superior results in respect of growth characters like plant height, number of tillers $plant^{-1}$ and number of ears $plant^{-1}$. Yield attributing characters like length, weight of ear, grain weight ear^{-1}, grain weight $plant^{-1}$ and 1000 grain weight were also significantly higher under same treatments. Application of 100% nitrogen through inorganic source not only recorded significantly higher values of all the growth and yield attributing characters but also gave significantly higher yield of grain and stover. Application of nitrogen though different sources did not influence the water use efficiency during both the seasons. However, water use efficiency of grain and stover under application of 100% nitrogen through inorganic source was higher.

1. INTRODUCTION

Pearl millet is important staple food and feed in semi arid and arid regions of the country. It is the most drought tolerant crop among cereals and millets. The grain of pearl millet is superior in nutritive value than sorghum grain, but inferior in feeding value. Pearl millet grain contains about 12.4, 12.6, 5.0, 67.3 and 2.7 %; moisture, protein, fat, carbohydrates and minerals, respectively (Rai, 2002). There has been no sustainable rise in productivity of rainfed pearl millet, mainly because of soil-moisture deficiency, usually at critical stages of growth. The soils of the pearl millet growing regions being mostly light in texture embody low moisture holding capacity (Lal *et al*., 2007). Efforts have been made to augment the soil-moisture retentivity by adopting various tillage and nutrient management practices. Optimum soil tillage is a prerequisite for good crop stands, growth and yield. Tillage practice is the one of the several useful measures of in-situ moisture conservation. Use of organic sources along with chemical fertilizers not only conserves moisture and reduces erosion but also increases the use efficiency of fertilizers, thereby improving the overall productivity of soil. Proper tillage operation coupled with organic manure has positive impact on dry land crops. Optimum tillage prevents soil erosion in high rainfall regions and incorporation of stubbles further reduces erosivity. Weeds are the major problems to dry land crop and the yield is greatly affected if weeds are not removed in time. So the effect of optimum tillage with the control of weeds either by use of herbicides or manually need to be qualitatively assessed in relation to the yield as well as soil health. Little or no information is available on the performance of pearl millet in relation to different tillage practices and various sources of nitrogen under rainfed conditions of South West Uttar Pradesh. Therefore, present investigation was undertaken on light textured alluvial soil.

2. MATERIALS AND METHODS

The experiment was carried out during the two consecutive *kharif* seasons of 2005 and 2006 at Research Farm of All India Coordinated Research Project for Dryland Agriculture, Raja Balwant Singh College, Bichpuri, Agra. The soil of the experimental plot was sandy loam having pH 7.9, 0.30 % organic carbon, available nitrogen, phosphorus and potassium was 191.50, 21.50 and 304.56 kg ha^{-1}, respectively. Moisture content at field capacity and permanent wilting point was 17.75 and 6.60 %, respectively. The experiment was laid out in split plot design replicated four times. The main plot treatments were consisted of four tillage practices *viz*., (i) deep tillage + two interculture - T_1, (ii) minimum tillage + one interculture - T_2, (iii) minimum tillage + two interculture - T_3 and (iv) minimum tillage + one interculture + weedicide application- T_4. Sub-plot treatments were comprised of three sources of nitrogen supply *viz*., (i) application of 100% nitrogen through organic source - N_1 (ii) application of 50% nitrogen through organic source + 50% nitrogen through inorganic source - N_2 and (iii) application of 100% nitrogen through inorganic source - N_3.

For the purpose of study, deep tillage operation was performed by one ploughing the field with disc plough followed by one ploughing with disc harrow + one ploughing with cultivator to develop seed bed for sowing. Minimum tillage operation was done by one ploughing the field with disc harrow + one ploughing with cultivator. Interculture operation was done manually as per treatment at 20 and 40 Days After Sowing (DAS), respectively. The pearl millet variety *"Pro Agro-9330"* was sown on 3 August, in 2005 and 15 July, in 2006, respectively at a spacing of 45 cm x 15 cm. Uniform dose of 40 kg P_2O_5 was applied at sowing (as basal). As per treatment requirement full quantity of farmyard manure and half of the nitrogen were applied at the time of sowing (as basal) and the remaining half was broadcasted at 30 DAS. During *kharif* 2005, a total 628.2 mm rainfall was received, while it was 330 mm during 2006 (Table 1). During 2005, well distributed rainfall was received whereas during 2006, there was early withdrawal of monsoon and highly erratic and below the normal rainfall. Relative humidity was higher during both the seasons and ambient temperature as well as atmospheric evaporation was higher during second season

Table : 1
Meteorological data during experimental period (July to October) for the year 2005 and 2006

SMW	Sunshine (hrs day^{-1})		Rainfall (mm)		Pan evaporation (mm day^{-1})		Temperature (°C) Maximum		Temperature (°C) Minimum		Relative humidity (%)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
27	3.9	8.1	164	-	4.7	6.5	33.7	39.1	24.9	28.9	87	86
28	3.4	2.4	196.4	145.5	3.4	4.0	32.4	32.0	25.1	25.2	92	94
29	4.6	3.1	51.6	-	4.2	3.5	32.7	33.9	27.3	26.0	89	92
30	4.6	3.8	56.4	148.1	4.9	3.6	34.4	32.0	25.7	25.1	92	88
31	6.6	7.0	21.0	26.3	4.5	4.0	35.4	32.5	26.8	25.1	94	88
32	6.3	6.6	-	1.3	5.6	3.5	35.4	32.4	25.9	24.5	85	84
33	4.3	8.3	28.0	8.8	6.1	4.7	35.8	36.1	26.0	26.4	79	82
34	7.1	5.7	65.6	-	6.3	4.7	34.8	34.5	24.3	25.2	90	81
35	10.7	4.5	-	-	7.8	4.5	37.6	32.8	24.6	23.8	72	89
36	7.5	8.3	-	-	7.0	3.4	36.7	33.4	25.1	23.8	85	84
37	6.9	9.1	21.9	-	6.1	4.6	33.7	36.4	24.1	24.4	85	79
38	6.5	8.7	21.6	-	5.0	5.4	32.6	36.8	23.4	24.2	92	80
39	7.4	9.7	2.3	-	3.9	6.2	32.4	36.4	22.6	24.0	91	79
40	9.6	8.9	-	-	5.0	6.2	35.5	38.1	19.1	21.3	85	79
41	9.4	9.5	-	-	6.0	6.0	35.7	27.1	17.4	19.6	88	69
42	9.6	8.3	-	-	4.3	5.2	34.0	34.2	15.8	18.5	89	84
43	8.1	8.8	-	-	2.8	3.5	32.6	29.6	13.4	15.4	89	91

Note: Y_1 = 2005, Y_2 = 2006

as compared to first season. In general, weather conditions were more favourable for growth and development of crop during 2005, which have been reflected very clearly on growth and yield of crop.

Soil moisture content up to 90 cm depth was determined with gravimetric method from soil layers of 0-15, 15-30, 30-60 and 60-90 cm depth. Soil moisture measurements were taken prior to sowing and thereafter 20 days interval throughout the growing season. After drying, the moisture content was calculated on dry weight basis and the data so obtained were utilized for the determination of water use and water use efficiency.

3. RESULTS AND DISCUSSION

Growth Characters

Growth characters were influenced significantly by tillage practices and nitrogen supply from different sources (Table 2). Among the tillage treatments, deep tillage recorded maximum and significantly higher values in respect of all these growth characters except crop stand meter-1 row length during both the seasons. The favourable effect of conservation practice on crop growth might be due to conservation of adequate soil moisture which in turn enhanced plant physiological activities and growth (Singh and Verma, 2002 and Nema *et al*., 2008).

It was interesting to note that these growth characters except crop stand meter^{-1} row length were significantly higher in application of 100% nitrogen through inorganic source during both the years. It can be safely stated that increase in height of plant is a function of metabolic activity and is directly related to balanced nitrogen nutrition. In conformity to the present findings, Meena *et al* (2003) reported that application 60 kg N ha^{-1} through fertilizer (inorganic sources) was best in terms of plant height, number of tillers plant^{-1}, grain weight and ear length.

Yield Attributes

The data (Table 3) on yield attributes of pearl millet as influenced by various tillage treatments showed that length, weight of ear, grain weight ear^{-1}, grain weight plant^{-1} and 1000 grain weight during both the years differed significantly. Deep tillage resulted in maximum and significantly higher values of all these yield attributing characters than minimum tillage. The increase in yield might be due to conservation of rain water and its adequate supply to plant for its development and growth which in turn reflected favourably on yield attributing characters (Nema *et al*., 2008).

Application of 100% nitrogen through inorganic source significantly increased all these yield attributing characters during both the seasons. In another study, application of nitrogen @ 60 kg ha^{-1} through inorganic fertilizer significantly increased the length, girth and weight of ear, 1000 grain weight and grain yield per plant^{-1} (Singh and Verma, 2002).

Grain and Stover Yield

The grain and stover yield of pearl millet (Table 5) was influenced by tillage practices and nitrogen supply from different sources. The maximum grain and stover yield was obtained under deep tillage treatment whereas

Table : 2
Growth characters of pearl millet as influenced by various tillage practices and sources of nitrogen

Treatment	Plant height(cm)		Number of ears plant^{-1}		Effective tillers plant^{-1}	
	2005	2006	2005	2006	2005	2006
Tillage						
T_1	165.7	164.3	1.68	1.57	2.52	2.10
T_2	152.3	152.1	1.26	1.21	1.65	1.62
T_3	158.2	156.8	1.44	1.36	2.12	1.67
T_4	160.6	159.9	1.49	1.38	2.31	1.78
SE_m ±	2.27	1.83	0.08	0.08	0.05	0.08
CD (0.05)	7.25	5.85	0.27	0.25	0.16	0.26
Nitrogen						
N_1	153.6	152.7	1.32	1.25	1.82	1.58
N_2	159.8	157.8	1.46	1.39	2.16	1.73
N_3	166.0	164.1	1.62	1.49	2.47	2.06
SE_m ±	1.95	1.28	0.07	0.06	0.04	0.07
CD (0.05)	5.68	4.61	0.20	0.17	0.11	0.21

Table : 3
Effect of different tillage practices and source of nitrogen on yield attributes of pearl millet

Treatment	Length of ear (cm)		Weight of ear (g)		Grain weight ear^{-1}(g)		Grain weight $plant^{-1}$ (g)		1000 Grain weight (g)	
	2005	2006	2005	2006	2005	2006	2005	2006	2005	2006
Tillage										
T_1	24.02	22.10	19.76	18.08	10.87	9.74	14.98	13.30	5.86	5.31
T_2	19.71	17.84	16.59	15.46	8.77	7.76	11.01	10.02	4.42	4.03
T_3	21.21	19.01	18.41	16.35	9.78	8.35	11.51	10.90	4.61	4.27
T_4	21.98	20.19	18.48	16.98	9.84	8.72	12.59	11.16	4.62	4.39
SE_m ±	0.57	0.42	0.56	0.54	0.23	0.14	0.31	0.28	0.07	0.06
CD (0.05)	1.82	1.34	1.79	1.72	0.74	0.45	0.99	0.89	0.22	0.19
Nitrogen										
N_1	19.01	17.19	16.66	15.84	8.94	8.01	11.34	10.18	4.53	4.09
N_2	22.21	20.29	18.57	16.43	9.98	8.49	12.26	11.14	4.72	4.31
N_3	23.97	21.88	19.70	17.88	10.72	9.44	13.66	12.76	5.48	5.11
SE_m ±	0.46	0.36	0.46	0.45	0.19	0.11	0.26	0.24	0.06	0.05
CD (0.05)	1.36	1.05	1.36	1.31	0.55	0.32	0.75	0.71	0.18	0.15

Table : 4
Water use (mm) at various crop growth stages as influenced by various treatments

Treatment	Crop growth stages (DAS)									
	2005					2006				
	0-20	20-40	40-60	60-80	Total	0-20	20-40	40-60	60-80	Total
Tillage										
T_1	66.9	84.5	86.3	50.4	288.1	69.9	86.0	87.2	31.7	274.5
T_2	70.0	93.5	101.6	58.6	323.7	68.4	97.8	100.2	42.4	308.8
T_3	66.6	87.6	93.5	54.7	302.4	65.2	87.4	94.6	41.3	288.5
T_4	66.0	86.6	92.1	52.6	297.3	64.6	89.0	93.7	36.7	283.6
SE_m±	2.57	0.93	0.63	1.43	3.78	2.71	0.79	1.12	1.42	3.22
CD (0.05)	8.21	2.97	2.01	4.57	12.08	8.66	2.52	3.57	4.53	10.29
Nitrogen										
N_1	66.2	84.8	84.9	48.2	283.9	64.1	85.9	88.2	35.2	273.4
N_2	68.0	86.7	90.5	57.1	302.3	67.5	88.3	94.0	41.4	291.2
N_3	68.2	94.5	99.9	59.4	322.4	71.6	88.0	100.4	41.5	302.5
SE_m±	2.69	0.94	1.21	0.77	3.86	2.44	1.48	1.18	0.68	3.47
CD (0.05)	7.83	2.74	3.52	2.24	11.24	7.11	4.31	3.43	1.98	10.11

the minimum was under minimum tillage. The deep tillage gave 33.29 and 31.93 % increase in yield during 2005 and 2006, respectively over minimum tillage with one interculture. Similar trend was also noticed in respect of stover yield. The higher yield obtained with deep tillage may be ascribed due to favourable influence of plant growth and yield attributes. Similar trend was also noticed in respect of stover yield. The similar results were observed by Singh and Verma (2002) and reported that mean grain yield under deep tillage increased by 20.6 and 6.1 % over shallow and medium tillage treatments, respectively. In another study, deep tillage by disc plough gave 19.2 % higher yield of pearl millet than shallow tillage (Nema *et al.*, 2008)

Table 5 reveals that the grain yield of pearl millet was 1791, 1839 and 1959 kg ha^{-1} in 2005 and 1644, 1721 and

Table : 5
Grain yield, stover yield and water use efficiency as influenced by different tillage practices and source of nitrogen

Treatment	Yield (kg ha^{-1})						Water use efficiency (kg ha^{-1} mm^{-1})			
	Grain			Stover			Grain		Stover	
	2005	2006	Mean	2005	2006	Mean	2005	2006	2005	2006
Tillage										
T_1	2202	2045	2124	5306	4999	5153	7.6	7.4	18.4	18.2
T_2	1652	1550	1601	4181	3970	4076	5.1	5.0	12.9	12.8
T_3	1777	1685	1731	4408	4209	4309	5.9	5.8	14.6	14.5
T_4	1821	1696	1745	4482	4214	4348	6.1	6.0	15.0	14.8
SE_m ±	60.10	52.50	44.10	131.30	114.60	133.0	0.20	0.18	0.51	0.47
CD (0.05)	191.50	167.30	198.30	419.80	366.20	601.70	0.64	0.57	1.63	1.50
Nitrogen										
N_1	1791	1644	1639	4291	3898	4095	6.30	6.01	15.1	14.2
N_2	1839	1721	1780	4522	4269	4396	6.0	5.9	14.5	14.7
N_3	1959	1850	1994	4980	4747	4864	6.38	6.11	15.4	15.6
SE_m ±	45.40	43.75	44.60	104.50	9.66	104.80	0.17	0.15	0.48	0.45
CD (0.05)	132.20	127.46	145.70	304.60	281.40	342.40	0.49	0.43	1.40	1.31

1850 kg ha^{-1} in 2006 under application of 100% nitrogen through organic source, application of 50% nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through inorganic source, respectively. This shows that application of 100% nitrogen through inorganic source resulted in higher yield in both the seasons. To support the findings of the present study, Nema *et al*. (2008) obtained a maximum yield 2082 kg ha-1 of pearl millet under 100 % application of nitrogen through urea. Other workers (Meena *et al*., 2003 and Hadda *et al*., 2005), also reported that pearl millet yield responded linearly to 100 % nitrogen application through inorganic sources up to 60 kg ha^{-1}.

Water Use and Water Use Efficiency

It is evident from the data (Table 4) that during both the seasons of investigation, minimum tillage recorded maximum consumptive use of water whereas the minimum was observed under deep tillage. Because deep tillage checked weed growth and reduced moisture losses from soil surface. During early stages of crop growth, the rate of water use was very low in both the years. It may be due to incomplete coverage by the crop plants resulting in lesser transpiration losses. With advance in age and crop growth, the rate of water use progressively increased and it was more during 60 80 DAS. Significant difference in consumptive water use between deep tillage and minimum tillage plots can be reasonably attributed to suppression of weeds (weed control) during early period of crop growth, by deep tilling of the soil (Dogra *et al*., 2002). Deep tillage gave better moisture conservation for rainfed crops especially under erratic rainfall distribution during crop period (Aggrawal and Sharma, 2002). Water use efficiency (Table 5) was in reverse order to that of consumptive use. Maximum water use efficiency was observed in deep tillage which may be attributed to the greater yield advantage through deep tillage. Nema *et al* (2008) also reported higher water use efficiency under deep tillage than shallow tillage.

Application of 100% nitrogen through inorganic source showed higher consumptive use than all other nitrogen source treatments (Table 4). This can be attributed to the better root development and crop growth with application of nitrogen through inorganic source. Application of 100% nitrogen through organic source recorded minimum consumptive use at all the growth stages during both the seasons. The water use efficiency for grain was higher under application of 100% nitrogen through inorganic source and lowest under application of 100% nitrogen through organic source (Table 5). Similar results for stover were obtained during both the seasons. This may be attributed to increased dry matter production due to the better nutrients uptake and enhanced growth of the crop. Many researchers (Patel *et al*., 2001 and Nema *et al*., 2008) reported similar results of nitrogen application through fertilizer increased water use by improving root development.

4. CONCLUSIONS

Based on this study it can be concluded that, deep tillage with one interculture treatment was superior to minimum tillage treatments in improving physical conditions of soil, which in turn resulted in deeper rooting system for efficient use of water from lower soil depth during dry spell and better supply of nutrients to crop. Deep tillage was very effective in conserving soil moisture during the cropping season and increased yield attributes and grain yield of pearl millet. Hence, deep tillage is especially desirable for enhancing downward movement of water in the profile for higher crop yields under dry land condition.

Appreciable higher grain yield of pearl millet with application of 100 % nitrogen through inorganic source was because of fertilizer increased water use by improving root development and better crop growth, which ultimately led to higher grain yield.

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