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Effect of different tillage practices and nutrient sources on qualitative performance of pearl millet under dry land

Dr. BL Sinha

Abstract
A field experiment was conducted during the two consecutive rainy season (*kharif*) to study the effect of tillage and nutrient sources (supply of nitrogen through different sources) on the performance of pearl millet (Pennisetum glaucum) at Raja Balwant Singh College, Bichpuri, Agra (U.P.). 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. The maximum protein production was obtained under conventional tillage whereas the minimum was under low tillage with one interculture during both the seasons. Application of 100% nitrogen through inorganic source recorded maximum protein production whereas the minimum was under than application of 100% nitrogen through organic source. Conventional tillage had appreciable higher total uptake of nitrogen than low tillage treatments. Application of nitrogen through inorganic source resulted appreciable higher total uptake of nitrogen than application of nitrogen through organic source.

Keywords: Tillage, protein nitrogen, pearl millet, dryland

Introduction
Pearl millet [*Pennisetum glaucum* (L.)R.Br] commonly known as bajra, is an important drought hardy coarse grain crop that provides staple food for the poor in a short period. It flourishes satisfactorily and can be cultivated under rainfall as low as 200 to 250 mm, which makes it one of the most reliable cereals in the rainfed regions of arid and semi-arid region. The realized productivity of pearl millet is below its potential. The main reasons of poor crop yield are low moisture availability to crop during growing season and lack of proper nutrient management (Choudhary *et al*., 2016). As the moisture is the most limiting factor in the rainfed farming and the rainfall is the only source of water for these lands, *in-situ* rain water conservation in the root zone is perhaps the most cost-effective means of increasing moisture availability to the plants. Water conservation is considered a key element of conservation agriculture, especially in dryland areas exposed to erratic and unreliable rainfall (Serraj and Siddique, 2012) [7]. In recent years, interest of farmers in conservation tillage has also increased because of escalation of fuel prices and production costs. 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) [3]. 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 (Sinha, 2015) [8]. 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.

Materials and Methods

A field experiment was conducted during the two consecutive *kharif* seasons of 2005(Y_1) and 2006 (Y_2) 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 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 first year of experimentation, well distributed rainfall was received whereas during second consecutive year, 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 as compared to first season. In general, weather conditions were more favourable for growth and development of crop during first year, which have been reflected very clearly on growth and yield of crop.

Results and Discussion

Effect of tillage and nutrient management on yield of pearl millet and soil health in semi arid tropics of Agra region (U.P.) was reported by Sinha (2015) [8]. The qualitative performance of pearl millet was judged in terms production of protein, nitrogen uptake in grain as well as in Stover and total produce.

Production of protein through grain

Effect of tillage

A critical examination of the data displayed in Table 1 under reference would reveal that tillage treatments significantly influenced protein production during both the seasons. The maximum protein production of was obtained under conventional tillage whereas the minimum was under low tillage with one interculture during both the seasons. Higher protein production in conventional tillage is attributed to the yield and nitrogen content in grain as it has direct relationship with both these characters. During first season, low tillage + one intercultur with weedicide application gave significantly superior results on protein production by grain than other low tillage treatments. Low tillage + two interculture and low tillage + one interculture were statistically at par, but low tillage + two interculture gave better results on production of protein. During second season both low tillage + one intercultur with weedicide application and low tillage + two interculture recorded significantly higher protein production than low tillage + one intercultur. However both low tillage + one intercultur with weedicide application and low tillage + two interculture treatments failed to establish significant variation in protein production.

Table 1: Effect of tillage and nutrient management on production of Protein

Treatments	Production of protein (kg ha^{-1})			
	Grain		Stover	
	Y_1	Y_2	Y_1	Y_2
Tillage				
T_1	207.87	190.39	152.81	140.47
T_2	151.82	141.51	109.96	101.63
T_3	165.44	155.86	118.57	112.80
T_4	169.72	157.05	123.25	113.36
SE ±	5.33	3.77	3.33	2.60
CD (0.05)	17.03	12.05	10.64	8.32
Source of Nutrient				
N_1	162.89	150.09	113.28	102.51
N_2	171.21	159.19	124.36	114.84
N_3	183.75	172.43	139.94	130.54
SE ±	3.84	3.22	2.83	2.12
CD (0.05)	11.21	9.39	8.26	6.18

Effect of nutrient

Results presented in Table 1 reveal that different sources of nitrogen influenced the production of protein through grain during both the seasons. Application of 100% nitrogen through inorganic source recorded maximum protein production whereas the minimum was under than application of 100% nitrogen through organic source. Both application of 100% nitrogen through inorganic source and application of 50% nitrogen through organic source + 50% nitrogen through inorganic source were found significantly better than application of 100% nitrogen through organic source. The protein production was 162.89, 1717.21 and 183.75 kg ha^{-1} during first season and 150.09, 159.19 and 172.43 kg ha^{-1} during second season under application of 100% nitrogen through organic source, 50% of nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through inorganic source respectively. Similar trends have been found in case of production of protein though stover during both seasons under investigation.

Combined Effect of Tillage and Nutrient Sources on Production of Protein in Grain

The protein production through grain was found to be influenced significantly by interactions tillage practices and nitrogen sources during both the season shown in Fig 1and 2.

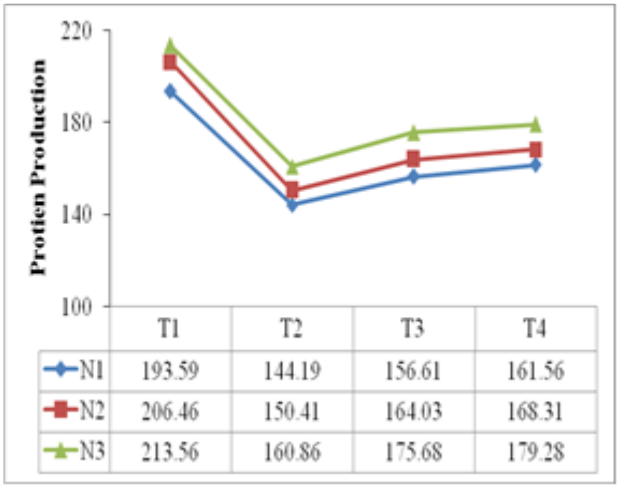

Fig. 1: Combined effect of tillage and source of nutrient on production of protein in grain for first season

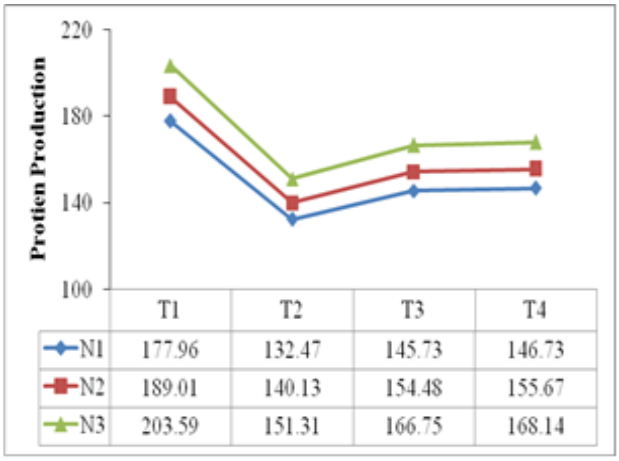

Fig. 2: Combined effect of tillage and source of nutrient on production of protein in grain for second season

Table 2 indicates that combination conventional tillage + two interculture (T_1) with application of 100% nitrogen through inorganic source (N_3) recorded maximum and significantly higher quantity of protein during both of the seasons, while the minimum was under low tillage treatment + one inter culture (T_2) with application 100% nitrogen through organic source (N_1) combination. All combinations between low tillage treatments with all sources of nitrogen were statistically at par; however interaction of low tillage + one interculture + weedicide application (T_4) with application 100% nitrogen through inorganic source (N_3) gave superior results on production protein through grain than other combinations.

Product of protein through stover

Effect of tillage

It is obvious from the data presented in Table 1 that tillage treatments significantly influenced protein production through stover during both the seasons. The maximum protein production was obtained under conventional tillage whereas the minimum was under low tillage with one interculture during both the seasons. During first season, low tillage + one intercultur with weedicide application gave significantly superior results on protein production by stover than other low tillage treatments. Low tillage + two interculture and low tillage + one interculture were statistically at par, but low tillage + two interculture gave better results on production of protein. During second season, both low tillage + one intercultur with weedicide application and low tillage + two interculture recorded significantly higher protein production than low tillage + one intercultur. However both low tillage + one intercultur with weedicide application and low tillage + two interculture treatments failed to establish significant variation in protein production. Similar results were reported by (Nema *et al.*, 2008, Singh and Verma, 2002) [5, 9].

Effect of nutrient

Data computed in Table 1 would indicate that different sources of nitrogen influenced the production of protein through stover during both the seasons. Application of 100% nitrogen through inorganic source recorded maximum protein production whereas the minimum was under than application of 100% nitrogen through organic source. Both application of 100% nitrogen through inorganic source and application of 50% nitrogen through organic source + 50% nitrogen through inorganic source were found significantly better than application of 100% nitrogen through organic source. The protein production was 113.28, 124.36, and 139.94 kg ha $^{-1}$ during first season and 102.51, 114.84 and 130.54 kg ha $^{-1}$ during second season under application of 100% nitrogen through organic source, 50% of nitrogen 100% nitrogen through inorganic source respectively.

Combined Effect of Tillage and Nutrient sources on Production of Protein in Stover

The protein production through stover and was found to be influenced significantly by interactions tillage practices and nitrogen sources during first and second season, respectively. Table 2 indicates that combination conventional tillage + two interculture (T_1) with application of 100% nitrogen through inorganic source (N_3) recorded maximum and significantly higher quantity of protein during both of the seasons, while the minimum was under low tillage treatment + one inter culture (T_2) with application 100% nitrogen through organic source (N_1) combination. All combinations between low tillage treatments with all sources of nitrogen were statistically at par; however interaction of low tillage + one interculture + weedicide application (T_4) with application 100% nitrogen through inorganic source (N_3) gave superior results on production protein through stover than other combinations.

Table 2: Combined effect of different tillage practices and source of nutrient on production of protein in grain and stover for both the season

Tillage	Nutrient application					
	Y_1			Y_2		
	N_1	N_2	N_3	N_1	N_2	N_3
	Grain					
T_1	193.59	206.46	213.56	177.96	189.01	203.59
T_2	144.19	150.41	160.86	132.47	140.13	151.31
T_3	156.61	164.03	175.68	145.73	154.48	166.75
T_4	161.56	168.31	179.28	146.73	155.67	168.14
SE ±			9.14			6.43
CD (0.05)			28.63			18.76
	Stover					
T_1	139.28	151.03	168.11	125.16	139.35	156.90
T_2	98.62	108.17	123.07	88.03	100.51	116.35
T_3	105.54	116.78	133.38	100.50	111.68	126.22
T_4	109.68	121.46	138.60	100.76	112.23	127.08
SE ±			5.66			4.23
CD (0.05)			16.49			12.35

Nitrogen Uptake through Grain

Effect of tillage

A glance on the Table 3 reveal that significant differences in respect of nitrogen uptake were observed under different tillage treatments during both the seasons. Conventional tillage recorded maximum and significantly higher nitrogen uptake as compared to low tillage treatments during both the seasons. Among low tillage treatments, low tillage + one interculture with weedicide application treatment recorded significantly higher nitrogen uptake than other low tillage treatments. Similar trend was observed during both the seasons. The values of nitrogen uptake as influenced by different tillage practices were 33.25, 24.28, 26.48 and 27.13 kg N ha^{-1} in first season and 30.47, 22.63, 24.94 and 25.10 kg N ha^{-1} in second season under conventional tillage + two interculture, low tillage + one interculture, low tillage + two interculture and low tillage + one interculture + weedicide application. Many researchers (Patel *et al.*, 2001, Meena *et al* 2003,Nema *et al.*, 2008, Kaushik *et al*, 2018) [6, 4, 5, 2] reported similar results.

Table 3: Nitrogen uptake (kg ha^{-1}) through grain, stover and total produce as influenced by various treatments

Treatments	Nitrogen uptake (kg ha^{-1})					
	Grain		Stover		Total Produce	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
Tillage						
T_1	33.25	30.47	24.40	22.50	57.65	52.97
T_2	24.28	22.63	17.56	16.28	41.38	38.39
T_3	26.48	24.94	19.12	18.09	45.60	43.03
T_4	27.13	25.10	19.72	18.12	46.85	43.22
SE ±	0.44	0.43	0.41	0.38	0.46	0.45
CD (0.05)	1.42	1.39	1.33	1.21	1.49	1.43
Source of Nutrient						
N_1	26.52	24.10	18.02	16.37	44.52	40.37
N_2	27.42	25.57	19.89	18.36	47.29	43.83
N_3	29.41	27.67	22.69	21.51	51.80	49.00
SE ±	0.32	0.31	0.33	0.30	0.52	0.51
CD (0.05)	0.94	0.92	0.95	0.89	1.53	1.50

Effect of nutrient

An examination of the data summarized in Table 3 reveals that nitrogen uptake by grain responded to sources of nitrogen during both the seasons. Application of 100% nitrogen through inorganic source recorded maximum and significantly higher nitrogen uptake as compared to application of 50% nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through organic source. Application of 100% nitrogen through organic source recorded minimum nitrogen uptake during both the seasons. Significant variations in nitrogen uptake were also observed among the different nitrogen sources Similar, trend was observed during both the seasons. The nitrogen uptake through grain was 26.52, 27.42 and 29.41 kg N ha^{-1} in 2005 and 24.10, 25.57 and 27.67 kg N ha^{-1} in 2006 under application of 100% nitrogen through organic source, 50% of nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through inorganic source respectively.

Combined Effect of Tillage and Nutrient Interaction on Nitrogen Uptake in Grain

The data presented in Table 4 reveal that nitrogen uptake by grain was found to be influenced by tillage and nutrient interaction in both the seasons. Significant higher uptake was observed under conventional tillage + two interculture (T_1) with application of 100% nitrogen through inorganic source (N_3) combination, minimum being under low tillage treatment + one inter culture (T_2) with application 100% nitrogen through organic source (N_1) combination during both seasons shown in Fig. 3and 4. Interactions of low tillage + one interculture with weedicide application(T_4) and low tillage + two interculture(T_3) with all nitrogen sources recorded significantly higher nitrogen uptake than the combinations of low tillage + one interculture (T_2) with corresponding sources of nitrogen during both the seasons.

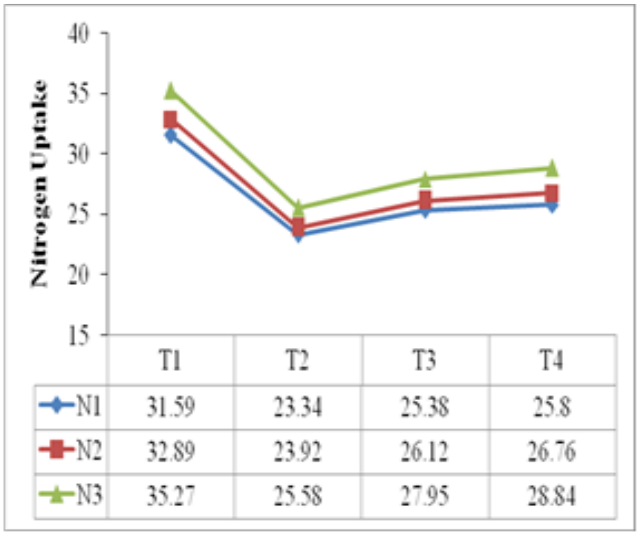

Fig 3: Combined effect of tillage and source of nutrient on nitrogen uptake in grain for first season

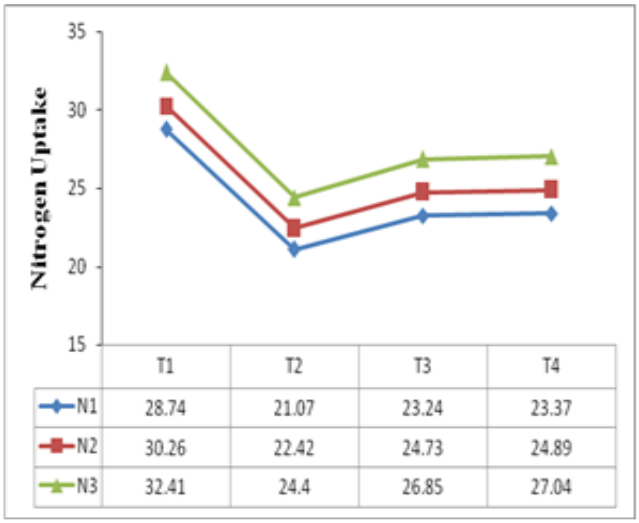

Fig 4: Combined effect of tillage and source of nutrient on nitrogen uptake in grain for second season

Table 4: Combined effect of different tillage practices and source of nutrient on N- uptake through grain and stover

Tillage	Source of nutrient					
	Y_1			Y_2		
	N_1	N_2	N_3	N_1	N_2	N_3
	Grain					
T_1	31.59	32.89	35.27	28.74	30.26	32.41
T_2	23.34	23.92	25.58	21.07	22.42	24.40
T_3	25.38	26.12	27.95	23.24	24.73	26.85
T_4	25.80	26.76	28.84	23.37	24.89	27.04
SE +			0.64			0.62
CD (0.05)			1.86			1.80
	Stover					
T_1	21.93	24.09	27.18	19.55	22.12	25.84
T_2	15.58	17.25	17.67	13.96	15.89	18.98
T_3	17.01	18.81	19.36	15.96	17.70	20.61
T_4	17.56	19.41	20.01	16.01	17.73	20.62
SE +			0.66			0.60
CD (0.05)			1.92			1.75

Nitrogen uptake through stover

Effect of tillage

It is clear from Table 3 that different tillage treatments influenced nitrogen uptake through stover. Conventional tillage recorded maximum and significantly higher nitrogen uptake as compared to low tillage treatments. Both low tillage + one interculture with weedicide application and low tillage + two interculture treatments were also found significantly better than low tillage + one interculture treatment in this regard. However, low tillage + one interculture with weedicide application and low tillage + two interculture treatments failed to establish significant variations in nitrogen uptake during both the seasons. Similar, trend was observed during both the seasons. The values of nitrogen uptake were 24.40, 17.56, 19.12 and 19.72 kg N ha^{-1} in 2005 and 22.50,16.28, 18.09 and 18.12 kg N ha^{-1} in 2006 under conventional tillage + two interculture, low tillage + one interculture, low tillage + two interculture and low tillage + one interculture + weedicide application.

Effect of nutrient

It is evident from Table 3 that nitrogen application influenced the nitrogen uptake through stover significantly during both the seasons. Application of 100% nitrogen through inorganic source recorded maximum and significantly higher nitrogen uptake through stover as compared to application of 50% nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through organic source. Application of 100% nitrogen through organic source recorded minimum nitrogen uptake during both the seasons. Significant variations in nitrogen uptake were also observed among the different nitrogen sources Similar, trend was observed during both the seasons.

Combined Effect of Tillage and Nutrient sources on Nitrogen Uptake in Stover

Table 4 reveals that tillage and nutrient interaction, influenced the nitrogen uptake through stover significantly in both the seasons. Combination conventional tillage + two interculture (T_1) with application of 100% nitrogen through inorganic source (N_3) recorded significantly higher nitrogen uptake through stover during both the seasons. Minimum nitrogen uptake was observed under low tillage treatment + one inter culture (T_2) with application 100% nitrogen through organic source (N_1) combination during both the seasons. Interactions of low tillage + one interculture with weedicide application (T_4) and low tillage + two interculture (T_3) with all nitrogen sources recorded significantly higher nitrogen uptake than the combinations of low tillage + one interculture (T_2) with corresponding sources of nitrogen during both the seasons, but both low tillage treatments (T_3 & T_4) with all nitrogen sources failed to establish significant variations between them.

Total nitrogen uptake

Effect of tillage

Table 3 reveals that different tillage treatments influenced the nitrogen uptake significantly during both the seasons. Conventional tillage recorded maximum total nitrogen uptake, minimum being under low tillage with one interculure. Both low tillage + one interculture with weedicide application and low tillage + two interculture treatments were also found significantly better than low tillage + one interculture treatment in this regard. However, low tillage + one interculture with weedicide application and low tillage + two interculture treatments failed to establish significant variations in nitrogen uptake during both the seasons. Similar, trend was observed during both the seasons.

Effect of nutrient

The data presented in table reveal 4 that total nitrogen uptake was found to be influenced due to nitrogen sources during both the seasons. Application of 100% nitrogen through inorganic source recorded maximum total nitrogen uptake minimum being under application of 100% nitrogen through organic source. Significant variation in nitrogen uptake were also observed among the three nitrogen sources i.e. application of 100% nitrogen through organic source, 50% of nitrogen through organic source + 50% nitrogen through inorganic source and application of 100% nitrogen through inorganic source.

Combined Effect of Tillage and Nutrient Interaction on Nitrogen Uptake

Table 5 indicates that the combination of tillage practices and nitrogen sources influenced the total nitrogen uptake significantly during both the seasons. Maximum and significantly higher nitrogen uptake was recorded under conventional tillage + two interculture (T_1) with application of 100% nitrogen through inorganic source (N_3), minimum being under low tillage treatment + one inter culture (T_2) with application 100% nitrogen through organic source (N_1) during both the seasons. The table under reference further indicates that both low tillage + one interculture with weedicide

application (T_4) and low tillage + two interculture (T_3) with all nitrogen sources failed to establish significant variations between them but recorded significantly higher nitrogen uptake than the combinations of low tillage + one interculture (T_2) with corresponding sources of nitrogen during both the seasons.

Table 5: Interaction effect of different tillage practices and source of nutrient on Nitrogen uptake through total produce

Tillage	Source of nutrient					
	2005			2006		
	N_1	N_2	N_3	N_1	N_2	N_3
T_1	54.45	55.33	63.17	48.03	52.40	58.48
T_2	38.07	41.38	44.69	34.61	37.82	42.74
T_3	41.98	45.60	49.22	39.34	42.45	47.29
T_4	43.58	46.85	50.12	39.50	42.64	47.52
SE +			1.04			1.02
CD (0.05)			3.03			2.97

Conclusion

On the basis of two year experimentation, it may be concluded that tillage system plays important role in the availability of the nutrients. The maximum protein production was obtained under conventional tillage whereas the minimum was under low tillage with one interculture during both the seasons. Application of 100% nitrogen through inorganic source recorded maximum protein production whereas the minimum was under than application of 100% nitrogen through organic source. Conventional tillage had appreciable higher total uptake of nitrogen than low tillage treatments. Application of nitrogen through inorganic source resulted appreciable higher total uptake of nitrogen than application of nitrogen through organic source.

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