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Effect of tillage, organics, nitrogen and their interactions on yield attributes and yield of foxtail millet (*Setaria italica*) under shallow Alfisols during rainy season

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ABSTRACT

A field experiment was conducted during 1997–98 and 1998–99 at Agricultural Research Station, Hanumanamatti, Dharwad, to know the effect of tillage practices, organics, nitrogen levels and their interactions on growth components and dry-matter accumulation in foxtail millet *(Setaria italica)* during the rainy season. Medium tillage and ridging recorded significantly higher yield attributes at harvest. Ear length, mean panicle weight, yield/plant, grains/panicle, 1,000-seed weight, threshing (%) and grain yield were significantly superior in medium tillage and ridging treatment. Among organics, enriched FYM + *Azospirillum* recorded significantly higher yield parameters, followed by *Gliricidia* green manuring. Application of 60 kg N/ha enhanced the yield parameters over 30 and 0 kg N/ha. Medium tillage and ridging with enriched FYM + *Azospirillum* + 60 kg N/ha recorded significantly higher yield components. Next best was medium tillage and ridging with *Gliricidia* green manuring + 60 kg N/ha .

Key words : Tillage practices, Organics, Dry-matter accumulation, Grain yield

Low productivity of foxtail millet is mainly due to its cultivation on marginal and submarginal lands with low fertility under low input management. Tillage is very much essential to incorporate the organic sources as well as to mix the fertilizers in the soil. In doing so the losses of nutrients are prevented by removing the weeds particularly the deep-rooted ones. In recent years, much emphasis has been given for use of organics to produce adequate amount of high-quality food. Such integrated nutrient supply system helps for maintenance and possibly improvement of soil fertility for sustaining crop productivity on long-term basis (Babalad, 1999). Good-quality farmyard manure (FYM) is perhaps the most valuable organic manure. Green-

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manuring has been recognized an efficient agronomic practice for stimulation of various biological transformations in the soil leading to improved soil fertility and health (Pali, 2000). Biofertilizers improve the yield and other soil parameters.

The low yield of cereals in the Alfisols under rainfed conditions mainly attributed to poor nutrient status of soil, limited use of nitrogenous fertilizers either through organic or chemical sources coupled with insufficient moisture during crop growth period. Keeping in view these facts, an experiment was conducted to study effect of tillage, organics, nitrogen and their interactions on foxtail millet in Alfisols.

MATERIALS AND METHODS

The field experiment was conducted on shallow alfisols (pH 7.0) at Agricultural Research Station, Hanumanamatti, of UAS, Dharwad.

There were 4 main plots (tillage practices), viz. M_1, shallow tillage (5 mm) with flat bed sowing; M_2, shallow tillage (5 cm) and ridging; M_3, medium tillage (15 cm) with flat bed sowing; and M_4, medium tillage (15 cm) and ridging; 4 subplots (organics), viz. S_1, enriched FYM @ 2.5 tonnes/ha; S_2, enriched FYM @ 2.tonnes/ha + *Azospirillum* @ 10 kg/ha; S_3, *Gliricidia* green manuring @ 5 tonnes/ha; and S_4 control (without organics); and 3 sub-subplots (nitrogen levels), viz . 0, 30 and 60 kg N/ha, making 48 treatment combinations. Immediately after receipt of rains during April-May, tillage treatment, viz. medium tillage to a depth of 15 cm by bullock-drawn mouldboard plough and shallow tillage to a depth of 5 cm were imposed by bullock-drawn harrow. The *in-situ* moisture conservation treatments, viz. ridges and furrows at 30 cm were formed by bullock-drawn harrow. The *in-situ* moisture-conservation treatments, viz. ridges and furrows at 30 cm, were formed by bullock-drawn ridger. *Gliricidia* incorporation was made manually during first week of June and first week of May during 1997-98 and 1998-99, respectively, and covered manually. Enriched FYM and nitrogen fertilizers were applied at the time of sowing along the rows. The enriched FYM was prepared by taking FYM in polyethylene bags and 50 % of recommended single superphosphate was added and packed tightly in them. The bags were kept for incubation or enrichment for a month. *Azospirillum* @ 10 kg/ha was added to this before sowing the crop.

After treatment, 1 week before sowing the land was harrowed and soil was brought to fine filth. Nitrogen was applied as per the treatment and recommended dose of phosphorus (15 kg/ha) and potassium (15 kg/ha) was applied common to all the treatments at the time of sowing. Fertilizer was applied in furrows opened manually at 30 cm rows and covered. 'SIA 2642' foxtail millet genotype was used. Required plant population was maintained by thinning the plants 20 days after sowing (DAS). The intercultivation operations were carried out, first at 20-25 days and second at 30-35 days. Ridging as made as per treatment in the main plots. Hand-weeding was carried out once for complete removal of weeds. The data were analysed statistically (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Tillage practices

Significantly higher grain yield was obtained under medium tillage and ridging over medium tillage with flat sowing and shallow tillage and ridging (Table 1), because of better crop growth, increased dry-matter production and its distribution among leaves, stem and ear. Higher uptake of nutrients and improved yield components were also observed, mainly owing to favourable physical condition with greater moisture provided to the crop with this tillage practice (Sharma *et al.*, 1988). Straw yield followed the same trend of grain yield, while harvest index was not influenced significantly with tillage practices.

Medium tillage and ridging recorded significantly higher total dry-matter production compared with rest of the tillage practices (Table 2). Significantly higher ear length at harvest was recorded in medium tillage with ridging treatment, followed by medium tillage with flat bed sowing, shallow tillage with ridging and shallow tillage with flat bed sowing treatments (Table 2). This might be because of the medium tillage that would have created a favourable physical environment for the increased mineralisation and mobility of fertilizer, as noticed in improvement in available N, resulting in higher nutrient uptake and crop growth, thus leading to higher ear length and grain yield. This might have accommodated more number of grains with a provision of sufficient space for development of grains, leading to higher seed index. This finding is in the line with the findings of Yoram Kapulnik *et al.* (1981).

Organics

Enriched FYM + *Azospirillum* recorded significantly higher grain yield over *Gliricidia* green-manuring or enriched FYM alone, which were significantly superior to the control. The increase in economic yield was 82, 76 and 50 % with enriched FYM + *Azospirillum*, *Gliricidia* and only enriched FYM over the control respectively (Table1). Enriched FYM + *Azospirillum* treatment recorded significantly higher yields/plant compared with *Gliricidia* green manuring and other treatments (Table 2). These results are in conformity with the findings of AICSMIP (1997, 2000) and Kushwaha and Chandel (1997).

The higher economic yield under enriched FYM + *Azospirillum* was mainly as a result of increased water-holding capacity and nutrient supply, which helped the crop to receive optimum level of soil moisture and nutrients besides fixation of atmospheric nitrogen with application of *Azospirillum*. It has resulted in the increased TDM, ear length, seed weight/ear, mean-panicle weight, yield/pant and 1,000-grain weight attributed for higher economic yield (Table2). All the organics were significantly superior to no organics. The increase in yield components due to enriched FYM + *Azospirillum* treatment might be due to the fact that the crop has not experienced nutrient stress at any growth stage.

Nitrogen

The grain yield was higher with 60 kg/ha, which was significantly superior to application of 30 kg N/ha and no nitrogen. The increase in grain yield was 38 and 60%

Table 1. Grain yield (kg/ha), straw yield (kg/ha) and harvest index of foxtail millet as influenced by tillage practices, organics and nitrogen levels during the rainy season (pooled)

Treatment	Grain yield (kg/ha) at				Straw yield (kg/ha) at				Harvest index at			
Tillage practices and Organics	N_0	N_{30}	N_{60}	Mean	N_0	N_{30}	N_{60}	Mean	N_0	N_{30}	N_{60}	Mean
ST-FS												
E FYM	810	1,077	1,208	1,032	1,717	2,406	2,787	2,302	0.322	0.309	0.303	0.311
E FYM + Azo	904	1,305	1,496	1,235	2,013	2,568	3,047	2,543	0.312	0.339	0.329	0.327
Gly	845	291	1,449	1,195	1,776	2,508	2,867	2,384	0.328	0.342	0.337	0.335
Control	529	652	742	641	1,178	1,481	1,701	1,453	0.317	0.307	0.306	0.310
Mean	772	1,081	1,223	1,026	1,671	2,241	2,600	2,171	0.320	0.324	0.319	0.321
ST-R												
E FYM	875	1,776	1,327	1,126	1,867	2,639	3,047	2,517	0.329	0.318	0.310	0.319
E FYM + Azo	1,007	1,381	1,579	1,322	2,327	2,747	3,292	2,788	0.302	0.333	0.325	0.320
Gly	926	1,391	1,553	1,290	1,967	2,768	3,009	2,581	0.327	0.331	0.344	0.334
Control	611	719	837	723	1,110	1,680	1,790	1,500	0.360	0.312	0.322	0.331
Mean	855	1,167	1,324	1,115	1,818	2,439	2,784	2,347	0.329	0.324	0.325	0.326
MT-FS												
E FYM	928	1,233	1,423	1,195	1,931	2,783	2,998	2,570	0.324	0.328	0.336	0.329
E FYM + Azo	1,060	1,490	1,776	1,442	2,316	2,986	3,303	2,868	0.339	0.333	0.348	0.340
Gly	955	1,473	1,748	1,392	2,137	2,884	3,229	2,750	0.315	0.340	0.352	0.336
Control	687	799	934	807	1,356	1,781	1,936	1,691	0.354	0.322	0.328	0.335
Mean	908	1,249	1,470	1,209	1,935	2,609	2,866	2,470	0.333	0.331	0.341	0.335
MT-R												
E FYM	981	1,294	1,498	1,257	2,101	2,871	3,213	2,728	0.323	0.311	0.308	0.314
E FYM + Azo	1,118	1,587	2,044	1,582	2,491	3,116	3,524	3,043	0.310	0.335	0.364	0.336
Gly	1,008	1,636	1,869	1,507	2,412	2,991	3,276	2,892	0.298	0.355	0.365	0.339
Control	758	865	1,024	883	1,576	1,916	2,184	1,875	0.335	0.321	0.347	0.334
Mean	966	1,345	1,609	1,307	2,133	2,723	3,049	2,635	0.316	0.331	0.346	0.331
Mean												

Table 1 *(continued)*

Treatment	Grain yield (kg/ha) at				Straw yield (kg/ha) at				Harvest index at			
Tillage practices and Organics	N_0	N_{30}	N_{60}	Mean	N_0	N_{30}	N_{60}	Mean	N_0	N_{30}	N_{60}	Mean
E FYM	898	1,195	1,364	1,152	1,904	2,675	3,010	2,530	0.325	0.317	0.314	0.318
E FYM + Azo	1,022	1,441	1,724	1,395	2,287	2,854	3,291	2,811	0.316	0.335	0.341	0.331
Gly	933	1,448	1,655	1,345	2,073	2,788	3,095	2,652	0.317	0.342	0.350	0.336
Control	647	759	884	763	1,293	1,694	1,903	1,630	0.342	0.315	0.326	0.328
Mean	875	1,211	1,407		1,889	2,503	2,825		0.325	0.327	0.333	
For comparison of means			CD (P=0.05)				CD (P=0.05)				CD (P=0.05)	
Tillage practice (TP)			37				91				NS	
Organics (O)			32				66				0.008	
Nitrogen levels (N)			27				57				NS	
Interactions												
TP × O			63				131				NS	
TP × N			53				114				NS	
O × N			53				114				0.019	
TP × O × N			106				228				NS	

ST-FS, Shallow tillage-flat sowing; MT-FS, medium tillage-flat sowing; E, FYM, enriched FYM @ 2.5 tonnes/ha, Gly-*Glyricidia* green manuring @ 5.0 tonnes/ha; ST-R, shallow tillage and ridging; MT-R, medium tillage and ridging; *Azo. Azospirillum* @ 10.0 kg/ha, Control, without organics

with application of 30 and 60 kg N/ha respectively, over no nitrogen. It was due to improved TDMP and yield components with nitrogen application (Table 2).

Interactions

Significantly higher grain yield (Table 1) was recorded in medium tillage and ridging with enriched FYM + *Azospirillum* + 60 kg N/ha over other treatment combinations. The next best treatment combination was medium tillage and ridging with *Gliricidia* green-manuring+60 kg N/ha. The same trend was also observed for straw yield. The improved tillage practices with integrated nutrient system favourably influenced the growth and development of foxtail millet. The greater dry-matter accumulation and superior yield attributes resulted in higher yield performances. These results are in line with those of Kumar *et al.* (1995).

Interaction effect of tillage practices, organics and nitrogen on yield components followed the same trend as that of grain and straw yields. Seth and Balyan (1989) observed conservation moisture through *in-situ* moisture-conservation practices including tillage, organics and addition of nutrients especially nitrogen through organic and inorganic sources on sustainable basis and help in maintaining or improving soil productivity in drylands. Also Patil (1998) at Bijapur observed that deep tillage with FYM @ 2.50 tonnes/ha subabul lopping @ 5 tonnes/ha + 50 kg N/ha recorded significantly higher winter sorghum grain and straw yields. Such findings were also made by Barber and Motocha (1992) and Aggarwal *et al.* (1997)

Nutrient uptake

Medium tillage and ridging recorded significantly higher N uptake followed by medium tillage and flat sowing and shallow tillage and ridging. Among organics, *Gliricidia* green-manuring recorded higher uptake, which was closely followed by enriched FYM + *Azospirillum*, whereas control (without organics) recorded significantly lower uptake. Among N levels, 670 kg N /ha recorded higher N uptake by foxtail millet which was significantly higher over 30 kg N/ha and 0 kg N/ha (Table 3).

Medium tillage and ridging recorded the maximum phosphorus uptake which was significantly superior to medium tillage flat sowing but found at par. Among organics, enriched FYM + *Azospirillum* recorded significantly higher uptake, followed by *Glyricidia* green-manuring compared with the control (without organics) which recorded lower uptake. Nitrogen levels showed non-significant differences.

Among tillage practices, medium tillage and ridging recorded significantly higher potassium uptake, which was closely followed by medium tillage with flat-bed sowing compared to shallow tillage flat bed sowing. Among organics *Glyricidia*, green manuring recorded higher potassium uptake followed by enriched FYM + *Azospirillum* and enriched FYM compared with the control (without organics) which was

Table 2. Total dry-matter production at harvest, ear length at harvest, panicle weight, grain yield, grain number/ panicle and 1,000-seed weight (g) of foxtail millet during rainy season as influenced by tillage, organic and nitrogen levels (pooled data for 1997–98 and 1998–99)

Treatment	TDMP (g/plant)	Ear length at harvest (cm/ear)	Panicle weight (g/panicle)	Grain yield (g/plant)	Grains/ panicle	1,000-grain weight (g)
Tillage practices						
ST-FS	6.674	12.32	4.127	1.506	1,196	3.408
ST -R	6.987	13.32	4.556	1.904	1,332	3.210
MT-FS	7.050	14.00	4.009	1.667	1,411	3.403
MT-R	8.783	15.81	4.690	1.963	1,360	3.543
CD (P=0.05)	0.097	0.25	0.062	0.038	92	0.016
Organics						
E. FYM	6.991	13.60	4.396	1.693	1,332	3.347
E FYM+*Azospirillum*	8.945	15.84	4.840	2.235	1,342	3.450
Gliricidia	7.059	14.12	4.004	1.787	1,356	3.422
Control	6.234	11.89	3.352	1.324	1,283	3.348
CD (P=0.05)	0.106	0.16	0.40	0.022	NS	0.027
N (kg/ha)						
0	5.116	12.33	2.104	1.277	1,199	3.018
30	5.576	13.75	4.926	1.790	1,337	3.331
60	9.228	15.72	5.926	2.212	1,469	3.827
CD (P=0.05)	0.092	0.14	0.034	0.019	NS	0.046

ST-FS, Shallow tillage-flat sowing; MT-FS, medium tillage-flat sowing; E, FYM, enriched FYM @ 2.5 tonnes/ha, Gly-*Gliricidia* green manuring @ 5.0 tonnes/ha; ST-R, shallow tillage and ridging; MT-R, medium tillage and ridging; *Azospirillum* @ 10.0 kg/ha, Control, without organics

recorded lower uptake. Among N levels, 60 kg/ha registered higher N uptake, followed by 30 kg N/ha and 0 kg/Nha.

Soil-fertility status

The available nitrogen in the soil was found non-significant due to tillage practices. Among organics, *Gliricidia* green-manuring recorded significantly higher available N, followed by enriched FYM + *Azospirillum* compared with the control (without organics). Among N levels, 60 kg/ha recorded significantly higher available N than other treatments. This was followed by 30 kg N/ha.

Medium tillage and ridging recorded significantly higher available phosphorus in soil followed by medium tillage flat sowing and were found at par. Among organics *Gliricidia* green-manuring recorded significantly higher available phosphorus followed by enriched FYM + *Azospirillum* and were found at par. However control (without organics) recorded significantly lower soil-available phosphorus. Among N levels, 60 kg /ha recorded significantly higher available phosphorus but in foxtail millet–castor sequence showed non-significant differences.

Significantly higher available potassium in soil was observed in the case of medium tillage and ridging, followed by medium tillage flat sowing but both were found at par. *Gliricidia* green manuring recorded significantly higher available potassium, which was closely followed by enriched FYM + *Azospirillum* and were significantly superior to the control. Among N levels, 60

Table 3. Nutrient uptake and available nutrient status of foxtail millet during *kharif* as influenced by tillage practices, organics and nitrogen levels under shallow alfisols (pooled data for 1997–98 and 1998–99)

Treatment	Nutrient uptake (kg/ha)			Available nutrient status (kg/ha)		
	Nitrogen	Phosphorus	Potassium	Nitrogen	Phosphorus	Potassium
Tillage practices						
ST-FS	33.03	6.00	50.43	220.94	20.89	224.83
ST -R	34.51	6.16	52.68	221.86	21.14	245.13
MT-FS	35.56	6.46	52.22	222.67	21.42	246.02
MT-R	36.39	6.67	53.69	222.46	21.61	246.35
CD (P=0.05)	2.56	1.73	0.36	NS	0.23	0.57
Organics						
E FYM	35.76	6.47	52.79	226.43	21.31	247.54
E FYM+*Azospirillum*	38.48	6.72	54.58	227.88	21.56	248.33
Gliricidia	39.71	6.63	56.16	228.24	21.99	249.34
Control	26.69	5.47	45.50	205.38	20.21	237.11
CD (P=0.05)	0.39	0.35	0.31	1.83	0.16	1.03
N (kg/ha)						
0	28.41	5.89	49.99	219.53	20.67	244.97
30	34.63	6.08	53.00	222.15	21.37	245.48
60	41.63	7.01	56.78	224.23	21.77	246.30
CD (P=0.05)	0.34	NS	0.27	1.70	0.25	0.96

ST-FS, Shallow tillage-flat sowing; MT-FS, medium tillage-flat sowing; E FYM, enriched FYM @ 2.5 tonnes/ha, *Gly-Gliricidia* green manuring @ 5.0 tonnes/ha; ST-R, shallow tillage and ridging; MT-R, medium tillage and ridging; *Azo. Azospirillum* @ 10.0 kg/ha, Control, without organics

kg/ha showed significantly higher available potassium and next best was found to be 30 kg N/ha.

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