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Residue management and levels of fertilizer on growth, yield, quality and soil fertility status of summer pearl millet [*Pennisetum glaucum* (L.) R. Br.]

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Abstract
A field study was conducted during the summer seasons of 2017 and 2018 on loamy sand soils of Agronomy Instructional Farm, Chimanbhai Patel College of Agriculture, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar, Gujarat to assess the residue management and fertilizer levels on growth, yield, protein content and soil fertility status of summer pearl millet [*Pennisetum glaucum* (L.) R. Br.]. The pooled results indicated that among the wheat residue management treatments, harvesting through combine harvester and straw incorporate in soil + decomposer fungal consortia (1 lit/t) + 25 kg N/ha enhanced the dry matter production, grain yield of pearl millet and protein content with the soil chemical and biological properties over burning of crop residues. Among wheat residue management treatments, harvesting through combine harvester and burning the straw recorded significantly lower weed density and dry weight of weeds at 20 DAS in pearl millet. Application of 120: 60: 00 kg N: P_2O_5: K_2O/ha (100 per cent RDF) to pearl millet significantly improved growth parameters, seed yield, highest protein content with the soil chemical and biological properties than 50 per cent RDF (60: 30: 00 kg N: P_2O_5: K_2O/ha), while, significantly lower weed density and dry weight of weeds recorded under 50 per cent RDF.

Keywords: Residue management, fertilizer levels, T. *viride*, Madhya, decomposer fungal consortia and decomposer bacterial consortia

Introduction

Crop residue incorporation is an environmental friendly strategy which is becoming a common soil management practice for sustainability of soil health. Crop residues are certainly an asset in these countries and seldom left in the field. In India, 516 million tonnes (mt) crop residues were produced, among that 122 and 110 mt dry rice and wheat straw were generated (MOSPI, 2013-14) [7]. Total crop residue burned 129.07 mt, out of that 30.65 rice straw and 27.58 mt wheat straws may end up in field burning. In Gujarat, total crop residue production was about 22.9 mt, among that 5.73 mt was burned out in the field (Devi *et al.*, 2017) [3]. Farmers of Saurashtra region of the Gujarat, usually practice the burning of crop residues such as wheat residues for fast land preparation for the next crop. This burning of crop residues leads to emission of greenhouse gases *viz.*, carbon dioxide, methane, nitrous oxide etc. causing global warming apart from causing numerous human and animal health related problems due to release of soot particles and smoke. It also causes considerable nutrient losses, about 25 percent of N and P, 50 percent of S and 75 percent of K which otherwise are valuable nutrient sources. The burning of crop residues is wastage of valuable resources which could be a source of carbon, bio-active compounds, feed and energy for rural households and small industries. One tons of rice straw on burning will release about 3 kg particulate matter, 60 kg CO, 1460 kg CO_2, 199 kg ash and 2 kg SO_2 (Gadi *et al.*, 2003) [4]. Pearl millet commonly known as [*Pennisetum glaucum* (L.) R. Br.]. Bajra or Bajri is the staple food for millions of people in the arid and semi-arid tropics of the world. Pearl millet is one of the major millet crops and is considered as a poor man's food. It is also rich in vitamins 'A' and 'B.' In addition to grains, it also supplies larger amount of good quality green and dry fodder for animals.

For summer pearl millet, Banaskantha is the leading district with more than 40 percent of the area and production followed by Anand and Kheda. Pearl millet is an exhaustive crop which needs to be supplied with high doses of inorganic fertilizers to meet the nutritional requirements of the crop. Among three major plant nutrients, nitrogen is one of the most important nutrients, which plays a vital role in all living plant tissues and constitutes about 1-4 percent of the dry weight.

It imparts green colour to leaves and stem and enable them for efficient photosynthesis. It is an integral part of chlorophyll and enzymes essential for plant growth. Phosphorus plays a key role in various physiological processes like root growth and dry matter production.

Materials and Methods

The soil of the experimental plot was loamy sand in texture having pH (7.43 and 7.38 during 2017 and 2018 respectively) and EC (0.14 and 0.12 dS/m during 2017 and 2018 respectively). Analysis showed that the experimental soil was low in organic carbon (0.176 and 0.191 percent during 2017 and 2018 respectively) and available nitrogen (155.20 and 156.11 kg/ha during 2017 and 2018 respectively) and medium in phosphorus (37.76 and 38.43 during 2017 and 2018 respectively) and potassium status (255.19 and 253.23 kg/ha during 2017 and 2018). There were twenty-one treatment combinations comprising of seven residue management practices like no residue incorporation (manual harvesting) (R_1), Wheat harvesting through combine harvester and burning the straw (R_2), Wheat harvesting through combine harvester and straw incorporation in soil (R_3), Wheat harvesting through combine harvester and straw incorporation in soil + 5 kg T. viride + 25 kg N/ha (R_4), Wheat harvesting through combine harvester and straw incorporation in soil + 5 kg madhyam + 25 kg N/ha (R_5), Wheat harvesting through combine harvester and straw incorporate in soil + decomposer fungal consortia (1 lit/t) + 25 kg N/ha (R_6) and Wheat harvesting through combine harvester and straw incorporate in soil + decomposer bacterial consortia (1 lit/t) + 25 kg N/ha (R_7) as a main plot treatment along with three fertilizer levels as a sub-plot treatment *viz*., 50 percent RDF (F_1), 75 percent RDF (F_2) and 100 percent RDF (F_3). The experiment was laid out in split plot design with three replications. The required quantity of nitrogen and phosphorus were calculated as per the treatments (F_1, F_2 and F_3) in form of urea and DAP, respectively. The entire quantity of phosphorus (RDF) in the form of DAP and half quantity of nitrogen in the form of urea were applied prior to sowing in the opened furrows and furrows were lightly covered with soil after fertilizer application in all plots. The remaining dose of nitrogen was applied as top dressing in two equal splits at 30 and 45 DAS. Pearl millet hybrid "GHB 732" was sown on 21st March and 13th March during 2017 and 2018, respectively using recommended seed rate of 3.75 kg/ha keeping 45 cm distance between two rows.

Results and Discussion

Effect of residue management

At 30 DAS, wheat harvesting through combine harvester and straw incorporation in soil + decomposer fungal consortia (1 lit/t) + 25 kg N/ha (R_6) recorded significantly maximum dry matter (5.07, 5.48 and 5.27 g/plant in 2017, 2018 and pooled results, respectively). Significant improvement in dry matter/plant at different stages of summer pearl millet on account of decomposed residues which have improved soil physical, chemical and biological properties and provided congenial environment for growth of crop. Similar findings were reported by Choudhary *et al*. (2016) [2] and Soleymani *et al*. (2016) [10]. Wheat harvesting through combine harvester and burning the straw (R_2) recorded significantly lower weed density and dry weight of weeds during 2017, 2018 and in pooled results. The weed density values were 9.27, 7.40 and 8.34 numbers/m^2 during both the years as well as in pooled results, respectively in treatment R_2. The dry weights of weed values were 7.88, 8.88 and 8.38 g/m^2 during both the years respectively in treatment R_2. The effectiveness of wheat residue burning in retarding weed growth more than wheat straw incorporation was presumably due to the loss of viable weed seeds lying on the soil surface due to burning. These results are in close conformity with those of reported by Khaliq *et al.* (2015) [5] who noticed that residue burning treatment reduce the weed growth. Significantly higher grain yield of 4242, 4321 and 4281 kg/ha were recorded under treatment when wheat harvesting through combine harvester and straw incorporation in soil + decomposer fungal consortia (1 lit/t) + 25 kg N/ha (R_6) during 2017, 2018 and in pooled results, respectively. A significant increase in grain yield observed under these treatments because, straw incorporation with microbial inoculants leads to faster decomposition of straw, improved the status of soil organic matter, leading to higher uptake of available nutrients from soil and ultimately increased the growth and yield components. The present findings are in close agreement with the results obtained by Shafi *et al*. (2007) [9] and Rajkhowa and Borah (2008) [8], Mbah and Nneji (2011) [6] and Amgain *et al*. (2013) [1]. Wheat harvesting through combine harvester and straw incorporation in soil + decomposer fungal consortia (1 lit/t) + 25 kg N/ha (R_6) estimated significantly higher protein content in grain 11.12, 11.26 and 11.19 per cent during 2017, 2018 and on pooled basis, respectively. Wheat harvesting through combine harvester and straw incorporation in soil + decomposer fungal consortia (1 lit/t) + 25 kg N/ha (R_6) recorded significantly higher percentage of organic carbon (0.305, 0.310 and 0.307% during 2017, 2018 and in pooled results, respectively), significantly higher available nitrogen (185.09, 183.94 and 184.52 kg/ha during 2017, 2018 and in pooled results, respectively), significantly higher available phosphorus (50.18, 50.35 and 50.26 kg/ha during 2017, 2018 and in pooled results). An assessment of data (Table 2) revealed that wheat harvesting through combine harvester and burning the straw (R_2) recorded significantly higher available potassium (270.07, 275.03 and 272.55 kg/ha during 2017, 2018 and in pooled results, respectively), which was followed by treatments R_6 and R_5. The findings are in conformity with those of Lal *et al*. (2000) [11], Kachroo and Dixit (2005) [12], Surekha *et al*. (2003) [13], Yadav *et al*. (2009) [14] and Ogbodo (2011) [15].

Effect of fertilizer levels

Data indicated that supply of 100 per cent RDF produced maximum dry matter (4.90, 5.13 and 5.02 g/plant in 2017, 2018 and pooled results at 30 DAS, respectively, which was significantly superior over to 50 per cent RDF at all the growth stages (Table 1). Improved dry matter production at higher levels of fertilizer (100% RDF) was attributed to the fact that nutrients being important constituent of nucleotides, proteins, chlorophyll and enzymes, involves in various metabolic processes which have direct impact on vegetative and reproductive phase of pearl millet plants. Though, application of fertilizers did not affect the germination status of weeds. The 50 percent RDF (F_1) treatment had relatively lower dry weight of weeds. The dry weights of weed value were 16.07, 16.13 and 16.10 g/m^2 during both the years as well as in pooled results respectively, in treatment F_1. Significantly higher dry weight of weeds was observed in 100 per cent (F_3). Weeds differ substantially in their response to fertilization.

Higher level of fertilizer (100% RDF) significantly improved the grain yield (3851 kg/ha, 3992 kg/ha and 3921 kg/ha) over its lower level (50% RDF) in 2017, 2018 and on pooled basis, respectively. Significantly the highest protein content to the tune of 11.16, 11.24 and 11.20 per cent was obtained with treatment F_3 (100% RDF) during 2017, 2018 and in pooled data severally. Significantly lowest protein content in grain (10.43, 10.60 and 10.51 per cent during 2017, 2018 and in pooled data, respectively) was registered with the treatment F_1 (50% RDF). The application of 100 per cent RDF proved its superiority by registering the highest organic carbon (0.273, 0.281 and 0.277%) after harvest of the pearl millet crop during both the years of experimentation as well as in pooled data. Treatment F_3 (100% RDF) recorded significantly highest available nitrogen (180.42, 178.67 and 179.54 kg/ha), highest available phosphorus (46.41, 47.45 and 46.93 kg/ha), highest available potassium (265.98, 269.61 and 267.79 kg/ha) during 2017, 2018 and in pooled results, respectively. The findings are in conformity with those of Sharma and Jain (2014) [16] and Sravan *et al.* (2014) [17].

Interaction effect

Treatment combination R_6F_3 (wheat harvesting through combine harvester and straw incorporation in soil + decomposer fungal consortia (1 lit/t) + 25 kg N/ha + 100% RDF) recorded significantly higher grain yield (4771 kg/ha), which was at par with treatment combination R_5F_3 only (Table 3). Whereas, treatment combination R_2F_1 (wheat harvesting through combine harvester and burning the straw + 50% RDF) recorded lower grain yield of 2315 kg/ha.

Table 1: Effect of wheat residue management and fertilizer levels on growth and yield of summer pearl millet

Treatments	Dry matter accumulation (g/plant) at 30 DAS			Weed density at 20 DAS (Numbers/m^2)			Dry weight of weeds (g/m^2) at 20 DAS			Grain yield (kg/ha)		
	2017	2018	pooled	2017	2018	pooled	2017	2018	pooled	2017	2018	pooled
Wheat residue management (R)												
R_1	4.26	4.07	4.16	12.82	12.28	12.55	13.78	13.15	13.47	3127	3164	3145
R_2	4.02	4.05	4.04	9.27	7.40	8.34	7.88	8.88	8.38	2813	2847	2830
R_3	4.57	4.44	4.51	13.64	13.57	13.60	15.49	16.05	15.77	3141	3267	3204
R_4	4.65	4.53	4.59	16.07	15.96	16.02	18.82	16.97	17.90	3434	3597	3516
R_5	4.71	4.98	4.85	16.62	17.78	17.20	24.31	25.59	24.95	4051	4218	4134
R_6	5.07	5.48	5.27	16.23	17.13	16.68	22.10	22.81	22.45	4242	4321	4281
R_7	4.67	4.57	4.62	15.00	16.22	15.61	19.55	20.54	20.04	3743	3832	3788
S.Em.±	0.11	0.15	0.10	0.67	0.54	0.43	0.58	0.48	0.38	88	92	63
C.D. at 5%	0.35	0.49	0.29	2.08	1.68	1.27	1.79	1.48	1.10	271	284	186
C.V.%	7.50	11.39	9.07	14.22	11.38	12.87	10.01	8.15	9.11	7.54	7.67	7.61
Fertilizer levels (F)												
F_1	4.23	4.16	4.20	14.06	13.91	13.98	16.07	16.13	16.10	3142	3195	3169
F_2	4.56	4.48	4.52	14.16	14.45	14.31	17.40	17.77	17.59	3528	3633	3580
F_3	4.90	5.13	5.02	14.49	14.65	14.57	18.79	19.25	19.02	3851	3992	3921
S.Em.±	0.06	0.08	0.05	0.32	0.28	0.21	0.18	0.23	0.14	48	50	34
C.D. at 5%	0.16	0.24	0.14	NS	NS	NS	0.52	0.66	0.41	141	145	99
Interaction (R × F)												
S.Em.±	0.15	0.22	0.13	0.83	0.74	0.56	0.47	0.60	0.38	128	132	92
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	373	384	261
C.V.%	5.71	8.41	7.20	10.16	9.00	9.59	4.69	5.91	5.34	6.36	6.37	6.37

Table 2: Effect of wheat residue management and fertilizer levels on quality and soil fertility of summer pearl millet

Treatments	Protein (%)			Organic carbon (%)			Available N (kg/ha)			Available P_2O_5 (kg/ha)			Available K_2O (kg/ha)		
	2017	2018	pooled	2017	2018	pooled	2017	2018	pooled	2017	2018	pooled	2017	2018	pooled
Wheat residue management (R)															
R_1	10.60	10.73	10.67	0.201	0.209	0.205	165.81	161.57	163.69	41.35	41.67	41.51	254.17	255.27	254.72
R_2	10.49	10.64	10.56	0.162	0.172	0.167	160.61	157.80	159.21	38.47	39.06	38.77	270.07	275.03	272.55
R_3	10.69	10.73	10.71	0.234	0.237	0.235	170.87	165.72	168.30	42.96	43.13	43.05	256.09	258.28	257.18
R_4	10.68	10.82	10.75	0.273	0.285	0.279	174.05	171.11	172.58	46.31	46.34	46.33	257.09	260.88	258.98
R_5	10.99	11.13	11.06	0.296	0.308	0.302	180.98	179.12	180.05	48.29	49.60	48.94	264.05	269.41	266.73
R_6	11.12	11.26	11.19	0.305	0.310	0.307	185.09	183.94	184.52	50.18	50.35	50.26	264.87	270.24	267.56
R_7	10.72	10.87	10.79	0.288	0.295	0.291	175.04	173.33	174.18	46.65	46.99	46.82	258.44	262.14	260.29
S.Em.±	0.12	0.10	0.08	0.005	0.004	0.003	2.33	2.27	1.63	0.69	0.72	0.50	3.31	3.50	2.41
C.D. at 5%	0.39	0.32	0.24	0.014	0.012	0.005	7.20	7.00	4.76	2.14	2.23	1.46	10.22	10.80	7.04
C.V.%	3.55	2.83	3.20	5.53	4.34	4.96	4.05	4.00	4.03	4.64	4.80	4.72	3.82	3.98	3.90
Fertilizer levels (F)															
F_1	10.43	10.60	10.51	0.232	0.240	0.236	166.48	162.73	164.60	43.11	43.10	43.10	256.66	259.58	258.12
F_2	10.68	10.81	10.74	0.248	0.257	0.253	172.73	169.72	171.23	45.16	45.37	45.26	259.41	264.20	261.81
F_3	11.16	11.24	11.20	0.273	0.281	0.277	180.42	178.67	179.54	46.41	47.45	46.93	265.98	269.61	267.79
S.Em.±	0.05	0.05	0.04	0.002	0.002	0.001	1.38	0.89	0.82	0.27	0.32	0.21	1.47	1.63	1.10
C.D. at 5%	0.14	0.15	0.10	0.005	0.005	0.003	4.00	2.58	2.33	0.79	0.93	0.60	4.27	4.71	3.11
Interaction (R × F)															
S.Em.±	0.12	0.14	0.09	0.004	0.005	0.003	3.66	2.36	2.18	0.72	0.85	0.56	3.90	4.30	2.90

C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V.%	2.00	2.25	2.13	3.08	3.17	3.13	3.66	2.40	3.10	2.79	3.23	3.02	2.59	2.82	2.71
Initial	-	-	-	0.176	0.191	-	155.20	156.11	-	37.76	38.43	-	255.19	253.23	-

Table 3: Interaction effect of wheat residue management and fertilizer levels on grain yield of summer pearl millet

Fertilizer levels	Wheat residue management						
	R_1	**R_2**	**R_3**	**R_4**	**R_5**	**R_6**	**R_7**
2017							
F_1	2760	2294	2900	2840	3745	3827	3631
F_2	3214	3051	3144	3564	3674	4275	3673
F_3	3406	3094	3378	3899	4623	4633	3927
S.Em.±	128						
C.D. at 5%	373						
2018							
F_1	2767	2337	2931	3077	3939	3948	3368
F_2	3299	3056	3389	3593	3951	4097	4046
F_3	3427	3150	3480	4120	4764	4918	4082
S.Em.±	132						
C.D. at 5%	384						
Pooled							
F_1	2764	2315	2915	2959	3842	3888	3500
F_2	3257	3053	3266	3579	3862	4186	3859
F_3	3416	3122	3429	4009	4698	4771	4004
S.Em.±	92						
C.D. at 5%	261						

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