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STUDIES ON BIOLOGICAL DECOMPOSITION OF WHEAT STRAW

IV. INCORPORATION OF WHEAT STRAW AND ITS MICROBIAL DECOMPOSERS ON YIELDS OF GROUNDNUT FOLLOWED BY WHEAT*

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KEY WORDS

Decomposition Groundnut Soil properties Wheat Wheat straw Yield

SUMMARY

The incorporation of undecomposed wheat straw in the soil along-with the micro-organisms favourably increased the yield of groundnut crop. An increase of 37 per cent in yield was recorded when wheat straw was inoculated with *Penicillium digitatum* and the C.P ratio was adjusted to 65. Inoculated treatments of narrower C:P ratio gave a higher yield than wider C:P ratio treatments inoculated with the same cultures. An increase in nitrogen uptake by groundnut plants was recorded due to incorporation of straw alongwith the micro-organisms in soil The organic carbon and nitrogen content of the soil increased with all the treatments except control. The highest increase in organic carbon and nitrogen of the soil was observed with a treatment of wheat straw of 65 C:P ratio inoculated with *S. coccosporum*. The yield of wheat crop after groundnut was significantly more with several treatments than control plots. The highest increase of 79 per cent in grain yield of wheat was observed in the plots previouslq received with wheat straw of 200 C:P ratio.

INTRODUCTION

An addition of organic matter as crop or animal residues influences physico-chemical and biological properties of soil. Maintenance of soil organic matter level is a practical problem of tropical countries like India. The application of organic residues is a must for maintenance of fertility level of these soils as it leads to the formation of humus which affects growth and development of plants

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and micro-organisms[2,7,13,14,24]. A large surplus of wheat straw has been the result of the increased production of wheat by intensive cultivation and mechanization. The wheat straw yield for India alone was 8.72 million tons during 1974. Decomposition of organic matter is essentially a microbiological process[17,18,23,24]. The way to solve the problem of maintaining soil organic matter level is to recycle the agricultural wastes either by composting or direct soil incorporation, but the composting process is very laborious and time consuming. It has been reported earlier that direct incorporation of crop residues adversely affected the crop growth[1,8]. This communication deals with the effect of direct incorporation of wheat straw inoculated with different micro-organisms on yields of groundnut followed by wheat and also its effect on soil nitrogen and organic carbon content.

MATERIALS AND METHODS

The experiment, consisting of thirteen treatments three times replicated was conducted during the rain fed (Kharif) and irrigated summer (Rabi) seasons of 1974, at the Central Campus of Mahatma Phule Krishi Vidyapeeth, Rahuri, India The soil was light – sandy and had 0.043% nitrogen, 0 369% organic carbon and pH of 8 65 The straw used for incorporation contained 9 90% moisture, 36% organic carbon, 0 45% total nitrogen, 0.025% total phosphorus and 0.30% potash The fungal cultures, *Alternaria tenuis*, *Staphylotrichum coccosporum*, and *Penicillium digitatum* and a bacterial isolate *Bacillus* sp with good decomposing ability were used.

The beds of 2 7 m by 2 7 m were prepared and 12 kg of chopped undecomposed wheat straw was spread uniformly in each bed A solution of urea was sprinkled to adjust the C·N ratio of straw to 36. Two C P ratios of 200 and 65 for the straw were used The phosphorus content was adjusted with super phosphate solution. The inoculated treatments received 150 ml of culture suspension (10^4 spores/cells per ml) and the straw was thoroughly mixed with soil The plots were lightly irrigated before sowing

Groundnut seeds of S.B XI variety treated with agroson and Rhizobium culture were dibbled at a spacing of 30 × 15 cm and the plots were lightly irrigated. Other interculture operations and irrigations were given as and when required Ten plants were selected from each bed at random and harvested separately for observations, such as shelling percentage, thousand kernel weight, dry matter, nitrogen and phosphorus uptake by plants. The total pod yield from each bed was also recorded The plants were analysed for total nitrogen and phosphorus by microkjeldahl and vanodomolybdophosphoric yellow color methods, respectively[11] Soil samples taken after the groundnut crop were analysed for total nitrogen (macrokjeldahl method)[11], and organic carbon[12]. The beds were cleaned off the crop residues without disturbing the layout. Soil in each bed was loosened and irrigated prior to sowing of wheat Wheat seeds of Sonalika variety were sown at the rate of 125 kg/ha with a row to row spacing of 22 5 cm Ten wheat plants selected at random were harvested for dry matter and thousand grain weight. The total yield of grain and husk from each plot was recorded

RESULTS

The yield data of groundnut (Table 1) indicate that direct pulverization of straw alongwith different micro-organisms resulted in favourable increase in yield.

Table 1. Effect of direct incorporation of wheat straw on dry matter weight, nitrogen and phosphorus uptake and yield of groundnut plants

Sl. No.	Name of treatment	Dry matter weight (g per plant)		Uptake of nutrients (mg/100 g based on dry weight basis)		Yield of ground nut (g/plot)	Per cent increase over control
		At flowering	At harvest	N	P		
1.	Wheat straw alone	6.64*	22.86*	100.00*	166.66*	1319.95*	32 79
2.	Wheat straw with nitrogen	3.94	23.61	73.33	191.66	950.25	— 4.40
3.	Wheat straw (I)	5 20	21.72	93.33	275.00	1266.48	27.41
4.	Wheat straw (II)	6.52	18.99	96.66	241.66	1034.09	4.03
5.	W.S. (I + *P. digitatum*)	5.96	24.34	98.33	141.66	1152.58	15.95
6.	W.S. (II + *P. digitatum*)	5.51	22.11	120.00	158.33	1369.86	37.81
7.	W.S. (I + *A. tenuis*)	5.00	22.44	88.33	150.00	924.41	— 7.00
8	W.S. (II + *A. tenuis*)	6.27	20.88	90.00	100.00	1352.13	36 02
9.	W.S. (I + *S. coccosporum*)	5.32	19.96	46.66	158.33	844.57	—15.03
10.	W.S. (II + *S. coccosporum*)	5.08	22.36	75.00	158.33	1269.54	27.71
11.	W.S. (I + *Bacillus* sp.)	5.33	22.34	70.00	158.33	1154.70	16.16
12.	W.S. (II + *Bacillus* sp.)	3.73	25.26	71.66	658.33	1142.21	14.90
13.	Control (without straw, inoculation and fertilizer)	5.95	17.75	60.00	133.33	994.01	—
	C.D. at 5%	NS	NS	26.69	224.11	267.82	—

C.N ratio of treatments 2 to 12 was adjusted to 36.1

* Average of three replications

I – 200 C:P ratio

II – 65 C:P ratio

NS – Non Significant

The treatments *viz*, wheat straw of 65 C:P ratio + *P. digitatum*, wheat straw of 65 C:P ratio + *S. coccosporum* and wheat straw of 200 C:P ratio alone gave a significant increase in yield over an uninoculated control receiving no wheat straw. Three of the treatments had lower yields than the control but the reduction was not significant. The treatments with narrower C:P ratio and inoculation with cultures gave higher yields than the treatments of a wider C:P ratio inoculated with the same cultures. A maximum increase in the yield of 37.18 per cent over the control was recorded when wheat straw of 65 C:P ratio inoculated with *P. digitatum* was incorporated.

The data on shelling percentage and thousand kernel weight of groundnut were statistically in-significant and are not discussed here.

The data in Table 1 also show that direct incorporation of wheat straw alongwith different micro-organisms did not affect the dry matter of groundnut plants at flowering as well as at harvesting stage. However, nitrogen uptake by groundnut plants was significantly higher in the case of the treatments 1 and 3 to 8. The treatments with narrower C:P ratio showed higher nitrogen uptake than their respective treatments with wider C:P ratio. Wheat straw addition alone did significantly increase the nitrogen uptake by groundnut plants but wheat straw enriched with nitrogen failed to show a significant increase. A significant increase in phosphorus uptake was observed with wheat straw of 65 C:P ratio inoculated with *Bacillus* sp. Unlike overall other treatments of nitrogen, phosphorus uptake was not related with C:P ratio. On the contrary, in two cases the uptake was lower with a narrow C:P ratio than that of wider C:P ratio.

The data on soil analysis after groundnut (Table 2) indicate a significant increase of total nitrogen and organic carbon with all the treatments except control. A maximum increase in nitrogen content of soil was observed with wheat straw of 65 C:P ratio + *S. coccosporum* and wheat straw of 65 C:P ratio + *Bacillus* sp. Organic carbon content of all the treatments showed a positive increase over control. The increase in organic carbon ranged from 75 to 109 per cent over control. It is interesting to note that more nitrogen and organic carbon contents were observed in inoculated treatments with narrower C:P ratio than the treatments inoculated with same cultures but a wider C:P ratio. Though non-significant, a slight reduction in pH towards neutrality was observed in all the treatments.

Data on dry matter, grain yield, thousand grain weight and grain to husk ratio of wheat indicated that only wheat straw of 65 C:P ratio + *P. digitatum* had given significant increase in dry matter at harvest stage. Though in-significant, a slight increase in dry matter was observed with all other treatments except Nos. 1, 8 and 12.

Table 2. Effect of direct incorporation of wheat straw on nitrogen, organic carbon content and pH of soil after harvesting of groundnut crop

Sl. No.	Name of treatment	Nitrogen mg/100 g	Organic carbon mg/100 g	Per cent increase over control	pH
1.	Wheat straw alone	45.46*	527.66*	103.72	8.56*
2.	Wheat straw (with nitrogen)	42.58	494.00	90.73	8.63
3.	Wheat straw (I)	43.41	503.66	94.46	8.50
4.	W.S. (II)	40.94	475.00	83.39	8.55
5.	W.S. (I + *P. digitatum*)	43.81	508.33	96.26	8.46
6.	W.S. (II + *P. digitatum*)	45.88	523.33	102.05	8.51
7.	W.S. (I + *A. tenuis*)	40.94	475.00	83.39	8.56
8.	W.S (II + *A. tenuis*)	44.20	513.00	98.06	8.55
9.	W.S. (I + *S. coccosporum*)	40.10	465.33	79.66	8.50
10.	W.S. (II + *S. coccosporum*)	46.74	542.33	109.39	8.48
11.	W.S. (I + *Bacillus* sp.)	39.27	455.66	75.93	8.51
12.	W.S. (II + *Bacillus* sp.)	46.71	542.00	109.26	8.46
13.	Control (without straw, inoculation and fertilizer)	22.32	259.00	–	8.60
	C.D. at 5%	9.87	84.64	–	NS

C:N ratio of treatments 2 to 12 was adjusted to 36:1
* Average of three replications
I – 200 C:P ratio
II – 65 C.P ratio
NS – Non significant

Table 3 also indicates that all treatments except wheat straw of 65 C:P ratio and wheat straw of 200 C:P ratio + *P. digitatum* gave significantly increased wheat yields over control. A maximum increase of 79 per cent in grain yield was observed with wheat straw of 200 C:P ratio followed by treatments of wheat straw with nitrogen. No significant differences in thousand grain weight of wheat and grain to husk ratio were observed.

DISCUSSION

Our experiments indicate that direct pulverization of straw alongwith different micro-organisms had a favourable effect on groundnut yield. The higher yields observed with inoculated treatments of narrower C:P ratio than their respective treatments with wider C:P ratio indicate that higher doses of phosphatic fertilizers enhanced the activities of added strawdecomposing organisms resulting in a direct or indirect favourable effect on groundnut yields. Besides, a reverse trend in yield was noted with uninoculated treatments of wheat straw with either C:P

Table 3 Effect of direct incorporation of wheat straw on dry matter weight, yield and grain to husk ratio of wheat

Sl. No	Name of treatment	Dry matter weight (g/plant)	Yield of wheat grains (g/plot)	Per cent increase over control	Grain to husk ratio
1	Wheat straw alone	3.56*	904 26*	39.61	2.60*
2.	Wheat straw with nitrogen	4.31	1088 39	68.03	3.01
3.	Wheat straw (I)	4.86	1161 68	79.35	2.74
4.	Wheat straw (II)	5.21	891 24	37.60	2.82
5	W S (I + *P digitatum*)	5 05	863 00	33 24	2.70
6.	W.S (II + *P digitatum*)	5.71	940.40	45 19	2 63
7	W.S (I + *A tenuis*)	4.80	995 80	53 74	2 71
8	W S (II + *A tenuis*)	2.47	989.29	52 73	2 78
9.	W.S. (I + *S coccosporum*)	3.98	912 44	40 87	2 42
10.	W.S (II + *S coccosporum*)	5.04	1049 79	62 07	2 32
11.	W.S (I + *Bacillus* sp)	4.43	935.64	44 45	2 53
12.	W.S. (II + *Bacillus* sp.)	3.53	767 80	18 54	2 49
13	Control (without straw, inoculation and fertiliser)	3.73	647.70	—	2.29
	C.D. at 5%	1.71	243 29	—	NS

C N Ratio of treatments 2 to 12 was adjusted to 36 1
* Average of three replications
I – 200 C P ratio
II – 65 C P ratio
NS – Non-significant

ratios. An increase in yield due to incorporation of organic matter with adequate nitrogen was reported earlier[10]. The direct incorporation of straw alongwith different micro-organisms and with adequate amounts of nitrogen and phosphorus may possibly eliminate the laborious and also the time consuming process of composting. The increase in crop yields due to direct incorporation of organic materials and not the compost addition, was observed by several workers[4,6,13,15]. The slight reduction in yield with two of the treatments over the control observed in this experiment may be due to phytotoxic substances in the straw or produced by micro-organisms from the straw. These treatments also had surprisingly a wider C:P ratio. The reduction in crop yields was also observed by various workers[3,9,16,19] when crop residues of wheat, corn, sorghum and oat were left on the soil surface. They have attributed this reduction in yield to the presence of phytotoxic substances.

Incorporation of straw with different cultures had an additive effect on the organic carbon and nitrogen contents of the soil. Similar results were recorded by

earlier investigators[10 12] The current experiments indicate that higher doses of phosphatic fertilizers added with straw had a beneficial effect on residual nitrogen and organic carbon content of soil The present investigation also shows that the incorporation of straw with different cultures slightly reduces the pH of soil towards neutrality The use of wheat straw was proposed for reclamation of saline-alkaline soils [5]

Residual trial with wheat shows that incorporation of straw with different micro-organisms not only favours the growth of groundnut but also gives higher yields of wheat as a second crop The increase in wheat yield was due to the increase in nitrogen and organic carbon content of soil It was stated that application of straw produced higher cereal yield than mineral fertilizers[12] the next two years after application.

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REFERENCES

1 Agarwal, R P , Batra, M L , Jaganath and Khanna, P K 1974 Effect of nitrogen levels and depths of mixing of wheat residues on crop yields and soil nitrogen J Indian Soc Soil Sci **22,** 77–79
2 Bhardwaj, K K R and Gaur, A C 1970 The effect of humic and fulvic acids on the growth and efficiency of nitrogen fixation of *Azotobacter chroococcum* Fol Microbiol **15,** 364–367
3 Borner, H 1960 Liberation of organic substances from higher plants and their role in soil sickness problems Bot rev **26,** 393–425
4 Dhar, N R and Pande, R K 1968 Effect of different organic materials and phosphate on the yield of paddy grain and paddy straw, wheat grain and wheat straw in field trials Proc Natl Acad Sci India Sec A **38,** 427–432
5 Dhar, N R and Chauhan, R P S 1971 Value of organic matter and phosphate in the reclamation of saline and alkaline soils Proc Natl Acad Sci India Sec A 41–46
6 Ferguson, W S 1966 Effect of repeated application of straw on grain yields and on some soil properties Can J Soil Sci **47,** 117–121
7 Gaur, A C , Subba Rao, R V and Sadasivam, K V 1972 Soil structure as influenced by organic matter and inorganic fertilizers Labdev J Sci Technol **10–B 1,** 55–56
8 Guenzi, W D and McCalla, T M 1964 Residue substances affected crop growth Crops Soils 16–25
9 Guenzi, W D , McCalla, T M and Norstadt, F A 1967 Presence and persistance of Phytotoxic substances in wheat, oat, corn, and sorghum residues Agron J **59,** 163–165
10 Gupta, R C and Idnani, M A 1970 Utilization of organic materials by enrichment with nitrogen Indian J Agric Sci **40,** 211
11 Jackson, M L 1967 Soil chemical analysis Prentice-Hall, Private Limited New Delhi, India

12 Kick, H. and Dorr, R. 1956 Investigation of the organic matter supplied to agriculture soil by straw and F.Y.M. Soils and Fertilizers. **19,** 90.
13 Kononva, M. M. and Aleksandrova, I. V. 1959 The biochemistry of humus formation and some problems of plant nutrition. Soils and fertilizers. **22,** 77–83.
14 Kutzner, H. 1968 The role of streptomycetes in the formation of humic substances. Landwirtsch. Forsch. **21,** 48–61.
15 McCalla, T. M. 1968 Crop residues agricultural wastes plowing them under increase crop yields. J. Farm, Ranch and Home quarterly
16 Nielsen, K. F , Cuddy, T. F. and Woods, W. B 1960 The influence of the extracts of some crops and soil residues on germination and growth. Can. J. Plant Sci. **40,** 188–197
17 Norman, A. G 1930 The biological decomposition of plant materials. Ann. Appl. Biol **17,** 575–613.
18 Norman, A. G. 1934 The biological decomposition of plant materials. IX. The aerobic decomposition of hemicelluloses. Ann. Appl Biol **21,** 425–475.
19 Patrick, Z. A. and Koch, L. W. 1963 The adverse effect of phytotoxic substances from decomposing plant residues on resistance of tobacco to black root rot. Can. J. Bot. **41,** 447–458.
20 Shaw, W. M. and Brooks, R. 1960 Organic matter decomposition and plant nutrient release from incorporations of Soybean hay and wheat straw in Holston Sandy loam in out door lysimeters. Soil Sci. Soc. Am. Proc. **24,** 54–57.
21 Walkley, A. and Black I. A. 1934 An examination of the Degtiareff method for determination of soil organic matter and a proposed modification of the chromic acid titration method. Soil Sci. **37,** 29–38.
22 Wani, Suhas P. and Shinde, P. A. 1976 Mineralization of nutrients during biological degradation of wheat straw. Indian J. Microbiol. **16,** 61–64.
23 Wani, Suhas P. and Shinde, P. A. 1977 Studies on biological decomposition of wheat straw. I. Screening of wheat straw decomposing micro-organisms in *vitro*. Plant and Soil **47,** 13–16.
24 Wani, Suhas P. and Shinde, P. A. 1978 Studies on biological decomposition of wheat straw. II. Screening of wheat straw decomposing micro-organisms under field condition. Mysore J. Agric. Sci. **42,** 388–391.