

Changes in the Physicochemical Properties of Soil on the Decomposition of *Aeschynomene Americana*

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(Received March, 1969)

THE process of green manuring has been followed for a long time for restoring the fertility of soil both in temperate and tropical countries. For this purpose mostly leguminous plants with leafy growth are preferred. It is generally believed that the turning down of plants into the soil contributes organic matter which is of edaphic importance in at least three ways. By its slow breakdown it provides mineral nitrogen for nutrition of the plants, it acts as a base exchange material and it helps to cement the small soil particles into crumbs, thereby "conferring" structure and water holding capacity on the soil (7). Despite these facts certain workers are also of the view that green manuring did not improve soil fertility up to a significant level (16, 17, 20).

On the decomposition of organic matter probably a substantial amount of nitrogen and other nutrients are released, trapped by the soil particles and later are made available for the growing plants. Dhar (3) emphasized that organic matter such as straw, plant residues, grasses, when incorporated into the soil or composted not only improves the physical properties of soil but also fixes atmospheric nitrogen and protects the soil nitrogen. He further suggested that calcium phosphates can largely add to these effects of organic matter.

In India although *Crotalaria*, *Cyamopsis* and *Sesbania* are most commonly used for green manuring purposes, we are quite ignorant about the green manuring value of a large number of other leguminous plants. In this regard the author (19) conducted a series of experiments with as many as forty-four species of legumes, mostly uncultivated types, and found certain species which presented possibilities for utilization as soil renovator. For example, *Aeschynomene americana* having prolific growth of foliage showed remarkably high nodulation and nitrogen fixing ability. These results, hence suggested a further study of this weed legume as to how far its decomposition

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may bring about changes in the physical and chemical properties of soil. With this end in view the present experiment was conducted at the Research Farm, College of Agriculture, Banaras Hindu University, Varanasi in 1967.

MATERIALS AND METHODS

Aeschynomene americana pods were collected at the appropriate time directly from the healthy and fully matured plants growing wildy at different places in the locality. To avoid the germination problem, seeds were stored in earthen dishes kept in the open atmosphere. In this way, these seeds were subjected to normal environmental conditions for acclimatization.

The experiment with five treatments as detailed below and four replications was laid down in a simple randomized block design having individual plots of 3m X 2m size.

F₀—Control (without fertilizer mixture)

F₁—68 kg P₂ O₅ per hectare

F₂—68 kg P₂ O₅ + 685 g Mo per hectare

F₃—68 kg P₂ O₅ + 850 g B per hectare

F₄—68 kg P₂ O₅ + 685 g Mo + 850 g B per hectare

Phosphate was given in the form of superphosphate (single), whereas molybdenum and boron were applied as sodium molybdate and borax respectively. Seeds were sown broadcast at the rate of 11.35 kg/ha.

A week or ten days before flowering the plants were examined for growth in terms of height, branches and foliage fresh weight and then ploughed under the soil. To ascertain their decomposition, the plots were duly irrigated as and when required to maintain adequate moisture. With the development of proper tilth, repeated ploughings were given in order to ensure proper aeration and suitable temperature conditions for the decomposition process. Changes in the physical and chemical properties of surface and sub-surface soils on the decomposition of plants were studied after six weeks of burial.

Maximum amount of water held by the saturated soil when the excess of water has drained away is known as water holding capacity. It was determined by placing soil in a brass cup with a perforated bottom. The cup was placed in a tray containing water so as its one-fourth part dipped into it. After 10 to 12 hours when the soils were

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completely saturated the cup was removed and kept on a blotting sheet in order to remove the adhering water. By determining wet and dry weights, the amount of water held by the soil was calculated and expressed as percent of dry soil.

Field capacity was determined by tapping air-dried soils into a 18" tall glass cylinder. A small quantity of water was then poured on top of the soil and the cylinder was capped to prevent evaporation. When downward movement of water ceased, the moist part of the soil column was carefully taken out and its water content was determined by usual method of oven drying. This was calculated on dry weight basis and expressed as field capacity.

Organic carbon in soil was determined following the Walkley and Black's method, while ammonia and nitrate contents were determined by Richardson's modification of Olsen's method as detailed by Piper (10). For the determination of total nitrogen modified Kjeldahl's procedure was followed (1).

RESULTS

Growth and Foliage Yield

An examination of the data presented in Table 1 shows that the growth of plants in terms of height increased on fertilization with phosphate. There was greater stimulation when phosphorus was supplied with molybdenum and still more so when administered in conjunction with boron. The effect of these fertilizers was almost identical on the branching behaviour and foliage fresh weight. The response of plants was observed to be maximum when phosphorus, molybdenum and boron were applied together in the form of a mixture. The differences among different treatments were found to be fairly significant.

Physicochemical Properties of Soil

In order to judge the initial physicochemical status of the plots, soil samples from 0-6, 6-12 and 12-18 inch depths were taken at the

Table 1.—Effects of phosphorus, molybdenum and boron on growth and foliage yield of *Aeschynomene americana*

Treatment		Stem height (cm)		No. of branches per plant		Foliage fresh wt. g ¹ /ha
F ₀	..	65.0	..	35.0	..	136.025
F ₁	..	84.5	..	51.3	..	183.725
F ₂	..	94.6	..	58.3	..	192.625
F ₃	..	98.5	..	55.3	..	196.475
F ₄	..	103.7	..	59.5	..	206.600
C.D. at 1%	..	13.02	..	10.68	..	42.532
C.D. at 5%	..	9.30	..	7.63	..	30.380

time of sowing and determined for water holding capacity, field capacity, organic carbon, ammonia, nitrate and total nitrogen contents. The values were observed to be highest in the top 6 inch layer of soil followed by 6-12 and 12-18 inch layers (Table 2). It is obvious, since the cultural practices are confined mostly to the surface soil.

Table 2.—Physicochemical status of surface and sub-surface soils

Character		Before the commencement of experiment		
		0"-6"	6"-12"	12"-18"
Water holding capacity (%)	..	40.5	38.7	31.2
Field capacity (%)	..	18.1	16.9	13.2
Organic carbon (%)	..	0.173	0.092	0.024
Ammoniacal nitrogen (ppm)	..	6.4	4.2	1.2
Nitrate nitrogen (ppm)	..	41.8	36.2	7.5
Total nitrogen (%)	..	0.045	0.020	0.010

Physical Properties

Water holding capacity, field capacity and carbon contents of surface and sub-surface soils were determined prior to the incorporation of plant materials into the soil and again after six weeks of the decomposition. It may be noted that the sub-surface soil had lower water retaining capacity and contained lesser organic carbon than the surface soil. Green manuring with *Aeschynomene americana* improved the physical conditions of soil even in plots which were not subjected to any fertilizer treatment. There was, however, a marked improvement in the case of fertilized plots (Table 3).

Table 3.—Changes in the physical properties of soil on the decomposition of *Aeschynomene americana*

Treatment		Water holding capacity (%)		Field capacity (%)		Organic carbon (%)	
		6 weeks		6 weeks		6 weeks	
		at burial	after burial	at burial	after burial	at burial	after burial
F ₀ : 0-6"	..	43.2..	47.3..	20.7..	24.6..	0.214..	0.308
6"-12"	..	41.6..	46.7..	19.1..	22.8..	0.125..	0.225
12"-18"	..	31.8..	33.5..	12.0..	14.5..	0.025..	0.044
F ₁ : 0-6"	..	45.5..	53.2..	21.2..	26.5..	0.235..	0.468
6"-12"	..	42.5..	50.0..	20.0..	23.5..	0.163..	0.236
12"-18"	..	32.2..	33.8..	12.8..	15.5..	0.037..	0.730
F ₂ : 0-6"	..	45.4..	52.8..	21.0..	27.5..	0.230..	0.472
6"-12"	..	43.0..	51.5..	20.6..	25.0..	0.165..	0.266
12"-18"	..	31.6..	33.5..	13.5..	15.3..	0.035..	0.120
F ₃ : 0-6"	..	45.8..	53.5..	20.8..	28.2..	0.233..	0.433
6"-12"	..	42.8..	51.8..	20.8..	26.1..	0.164..	0.287
12"-18"	..	32.0..	34.6..	12.9..	15.5..	0.035..	0.125
F ₄ : 0-6"	..	45.7..	54.1..	21.3..	29.3..	0.240..	0.550
6"-12"	..	41.9..	52.0..	21.5..	27.3..	0.164..	0.300
12"-18"	..	33.0..	34.8..	13.6..	16.0..	0.036..	0.135

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Of the three fertilizers, namely phosphorus, molybdenum and boron, the effect of phosphorus was observed to be very conspicuous. Application of molybdenum or boron along with phosphorus though resulting in some additional effects, the maximum response was obtained in the case where all the three nutrients, viz., phosphorus-molybdenum-boron were added together. It, thus, seems obvious that fertilization of field plots not only increased the foliage growth but also enhanced the decomposition ability and enriched the physical properties of soil.

Chemical Properties

Table 4 lists the values of ammoniacal nitrogen, nitrate nitrogen and total nitrogen contents in the 0-6, 6-12 and 12-18 inch layers of soil determined just before and six weeks after the incorporation of plant materials into the soil.

Table 4.—Changes in the chemical properties of soil on the decomposition of *Aeschynomene americana*

Treatment		Ammoniacal N (ppm)		Nitrate N (ppm)		Total N (ppm)	
			6 weeks after burial		6 weeks after burial		6 weeks after burial
		at burial		at burial		at burial	
F ⁰ : 0 - 6"	..	7.0..	10.2..	68.5..	125.4..	0.063..	0.083
6"-12"	..	4.5..	8.5..	49.2..	101.5..	0.028..	0.047
12"-18"	..	1.3..	4.8..	9.8..	13.8..	0.013..	0.018
F ¹ : 0 - 6"	..	8.8..	14.7..	80.3..	187.7..	0.068..	0.123
6"-12"	..	5.1..	13.1..	61.5..	125.5..	0.032..	0.062
12"-18"	..	2.0..	6.3..	12.2..	15.8..	0.015..	0.021
F ² : 0 - 6"	..	8.9	14.5..	76.2..	180.5..	0.068..	0.129
6"-12"	..	5.4..	13.0..	70.4..	120.0..	0.035..	0.065
12"-18"	..	2.0..	7.6..	12.5..	16.3..	0.014..	0.022
F ³ : 0 - 6"	..	8.8..	14.1..	83.2..	180.5..	0.065..	0.126
6"-12"	..	5.5..	12.8..	66.5..	130.0..	0.036..	0.060
12"-18"	..	2.1..	6.8..	12.0..	16.5..	0.015..	0.020
F ⁴ : 0 - 6"	..	8.7..	15.5..	85.5..	188.0..	0.069..	0.133
6"-12"	..	5.5..	14.6..	65.5..	147.5..	0.035..	0.070
12"-18"	..	2.0..	6.8..	13.3..	17.2..	0.016..	0.025

A comparative study of the values obtained at the above mentioned two stages reveals that both available and total nitrogen contents are appreciably increased, particularly in the surface soil after six weeks of decomposition. These increases were further marked in the soils of plots where phosphorus alone or coupled with molybdenum and boron was also added at the time of sowing. These results may lead to suggest that phosphate fertilization preferably in conjunction with molybdenum and boron is of immense importance for legumes.

It may further be pointed out that the added fertilizers simultaneously increased the green foliage of plants and on its decomposition also improved the physicochemical properties of the soil (cf Table 2, 3, 4). However, the increases brought about in the soil conditions were greater as compared with increases in the growth of foliage. It, thus, seems reasonable to conclude that fertilizers aid significantly the process of decomposition of green manuring substances.

DISCUSSION

Significant increase in the height, number of branches and foliage fresh weight of *Aeschynomene americana* was noticed on the application of phosphate alone or in conjunction with molybdenum and boron. Beneficial effects of phosphatic fertilizers on leguminous plants have been reported by a number of workers (2, 14, 15, 19). Similarly molybdenum and boron are also known to have well marked stimulatory effects on the foliage growth of legumes (19). Since the growth of this class of plants involves an association between a micro-organism and a higher plant, the effects of added nutrients, viz., phosphorus, molybdenum and boron may be either directly on the host plant itself, or it may be exerted indirectly through the nodule organism and the fixation process.

Prior to the commencement of flowering when the plants of *Aeschynomene americana* grown under different conditions of added fertilizers were ploughed under the soil, there was marked change in the physical and chemical properties of surface and sub-surface soils. After six weeks of decomposition the water retaining capacity, organic carbon and nitrogen contents were observed to be fairly high as compared to their initial values at the time of burial. In this regard mention might be made to the earlier experiments of a number of workers who also noted considerable increase in the water retaining capacity (4, 7, 12), organic carbon (9, 11) and nitrogen contents (6, 9, 11, 12, 18) of soil on the decomposition of plant materials.

The benefit of green manuring depends to a large extent on the decomposition process, which is more or less affected by the nature and constituents of the incorporated material. Jensen (5) pointed out that the rotting of nitrogen poor plants in a soil will lower its content of mineral nitrogen, i.e. ammonia and nitrate ions, whilst the rotting of nitrogen rich material, as is true with *Aeschynomene americana* (19), will increase it.

The data of the present experiment (see Table 3, 4) also revealed that the physicochemical properties of soil were further improved when the green manuring plants were fertilized with phosphate,

molybdenum and boron at the time of sowing. Similar results have been reported by Sen and his associates (13, 14, 15) in *Cyamopsis tetragonoloba* and by Khanna and Mahaian (6) in *Sesbania aculeata*. These effects of fertilizers were partly because there was greater quantity of plant materials available for turning under the soil (Table 1), and partly because the decomposition was more effective due presumably to the effects of fertilizers on the soil microbes. Strong support to this contention may be had from the work of Mamchenkov (8) who reported that increasing the phosphate supply of material well supplied with nitrogen, such as clover residues, increases the proportion of carbonaceous material converted to humic substances by reducing the proportion respired as carbondioxide.

SUMMARY AND CONCLUSION

In a simple randomized block design, the changes in the physico-chemical properties of surface and sub-surface soils on the decomposition of *Aeschynomene americana* grown under different conditions of fertilizer treatments were studied.

Application of fertilizers, viz., phosphorus, molybdenum and boron at the time of sowing seemed to play a very important role on green manuring benefits of plants. It not only adds to the bulk of foliage but also seemed to stimulate the decomposition process thereby enhancing the fertility status of the soil.

Conclusively, *Aeschynomene americana* is a wild legume possessing tremendous capacity of nodulation and nitrogen fixation, and thus presents possibilities of its utilization as a soil renovator or green manuring plant.

ACKNOWLEDGEMENTS

The author is highly indebted to Dr. R. S. Choudhri, M.Sc., Ph.D. (Cornell, U. S. A.), D.Sc., F. N. A. Sc., Principal and Dean, Faculty of Agriculture, Banaras Hindu University, for suggesting the problem and rendering all facilities throughout the progress of this work. Financial assistance provided by the State Department of Agriculture, U. P. and I. C. A. R. is acknowledged with thanks.

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