Influence of superphosphate on the formation of water stable aggregates

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Abstract

Wet sieve analysis of soil under two ragi varieties *viz.*, 9–2–7 and *Purna* fertilized with 40, 80, 160 and 320 Kg P_2O_5 superphosphate/hectare showed that water stable aggregates, as determined by the methods of Kasi Viswanath and Pillai *and* Kemper and Chepil, were more with increasing quantities of superphosphate and were highest with 320 Kg P_2O_5 superphosphate/hectare.

Key words : Superphosphate, water stable aggregates, soil.

1. Introduction

The production and use of superphosphate have been a very important development in agriculture throughout the world, and the continuous and permanent plot experiments with superphosphate and other artificial fertilizers as well as organic manures since 1843 at the Rothamsted Experimental Station, England, are indeed significant contributions to the science and practice of agriculture.

Lutz *et al.*[1] studied the effect of phosphate fertilizers on some physical properties of soils. Biswas and his co-workers[2–5] recorded the beneficial effect of superphosphate on soil structure, particularly under legume cultivation. More recently, Samra and Biswas[6] studied the role of different forms of phosphate in the mechanism of soil aggregation.

We had an occasion to examine the soil on which an experiment under field conditions has been in progress since 1968 at the University of Agricultural Sciences, Bangalore, designed to study the "build-up" of fertilizer phosphate, applied as superphosphate in relation to crop production. We examined that soil for protozoa and water stable aggregates. We reported earlier the influence of superphosphate on soil protozoa[7] and in this paper we report the influence of superphosphate on the formation of water stable aggregates in the soil.

2. Material and methods

Material

Soil samples (0–6") were collected in January 1969.

Methods

Two methods were employed for wet sieve analysis. The first method was standardised in our laboratory[8] and the second method was described by Kemper and Chepil[9]. Wet sieve analysis of soil for the determination of its water stable aggregates was originally conceived by Tiulin[10] and his method was later developed by Yoder[11] using a mechanical device for raising and lowering sieves in water. There have been several modifications of the method described by Yoder and, among them, the method of Kemper and Chepil has been widely used. At the same time it should be pointed out that, in the method described by Kasi Viswanath and Pillai[8], the soil is subjected to a more drastic treatment with water than in any of the other methods. Such drastic treatment of the soil occurs during heavy rains or during irrigations with large quantities of water.

3. Results and discussion

Water stable aggregates in the soil under 9–2–7 variety of ragi (Eleusine coracana)

The results given in Table I show (i) that aggregates of 0·25 mm size, which are generally more, increased in the soil with increasing quantities of superphosphate; and (ii) that the method of Kemper and Chepil gave much higher values for water stable aggregates compared to the method of Kasi Viswanath and Pillai.

Table I

Water stable aggregates in the soil under 9–2–7 Variety of ragi fertilized with superphosphate

Superphosphate P_2O_5 Kg/hectare	Aggregate size (mm)				Total percentage	
	0·25		0·50			
	I	II	I	II	I	II
0 (control)	24·1	35·3	15·5	19·0	39·6	54·3
40	24·5	39·3	16·1	23·0	40·6	62·3
80	22·3	46·0	18·3	23·6	40·6	69·6
160	26·8	48·0	18·0	22·1	44·8	70·1
320	25·5	46·3	20·0	24·8	45·5	71·1

I: According to the method of Kasi Viswanath and Pillai.
II: According to the method of Kemper and Chepil.

The percentage increase (Fig. 1) in the total water stable aggregates over the control (that is, soil which did not receive superphosphate) was strikingly more with increasing quantities of superphosphate (40, 80, 160 and 320 Kg P_2O_5 superphosphate/hectare) which was particularly higher by the method of Kemper and Chepil.

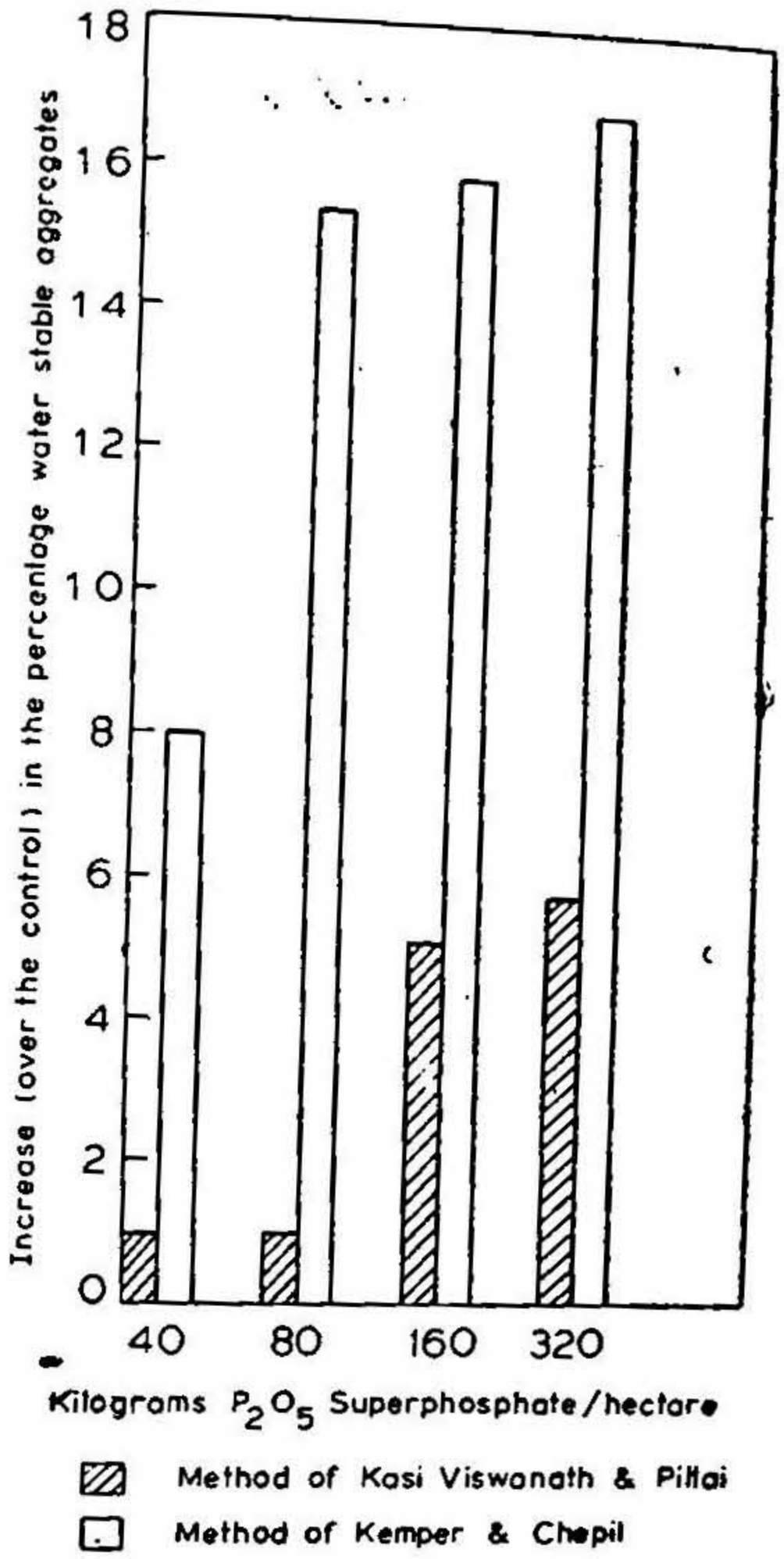

FIG. 1. Influence of superphosphate on water stable aggretgaes in the soil under 9–2–7 variety of ragi.

Water stable aggregates in the soil under **Purna** *variety of ragi*

The results given in Table II like those presented in Table I confirm that the soil that received superphosphate gave more water stable aggregates particularly those of 0·25 mm size.

Further, the percentage increase in water stable aggregates over the control, as represented in Fig. 2, also confirm that by both the methods there was increase in water stable aggregates due to the addition of superphosphate.

In 1971, Badanur and Venkata Rao[11] studied phosphorus build up and its influence on physical and chemical properties of Hebbal red soils and also analysed the soil under discussion for water stable aggregates. Jowar (*Andropogan sorghum*), wheat (*Triticum sestium*), sannhemp (*Crotalaria juntia*) and ragi (9–2–7 and *Purna* varieties) were

Table II

Water stable aggregates in soil under Purna *variety of ragi fertilized with superphosphate*

Superphosphate P_2O_5 Kg/hectare	Aggregate size (mm)				Total percentage	
	0·25		0·50			
	I	II	I	II	I	II
0 (control)	22·6	39·5	15·1	20·0	37·7	59·5
40	23·1	45·0	15·6	23·3	38·8	68·3
80	20·3	50·5	18·5	22·6	38·8	73·1
160	24·5	50·5	15·3	25·3	39·8	75·8
320	23·0	50·6	17·6	26·8	40·6	77·4

I : According to the method of Kasi Viswanath and Pillai.
II : According to the method of Kemper and Chepil.

cultivated on that soil between January 1969 and December 1971. According to Badanur and Venkata Rao, water stable aggregates larger than 0·25 mm size increased from 17.2 in the control to 21·0 in the soil that received 320 Kg P_2O_5 superphosphate/ hectare and that the increase was significant statistically at 5% level.

In the examination carried out on the soil in 1969, we also observed that water stable aggregates increased uniformly and more strikingly as determined by the method of Kemper and Chepil. The values are, no doubt, attractive to implicate superphosphate as a direct factor in the definite improvement in soil structure. In this connection it may be useful to refer to the observations of Allison[13] who stated that "Our understanding of soil aggregate formation and stabilization is as unsatisfactory at the present time as that of any other phase of soil science", and, referring to the wet sieve analysis (as carried out by the modifications of Yoder's method), stated that the method "gives consistent, reproducible results from which beautiful curves can be drawn, but can we apply such data to the field with any confidence ? In my opinion the answer is often no." The observations now made and those by others[1–5, 12] under field conditions suggest that the views of Allison are not convincing.

Relationship between superphosphate, protozoa, water stable aggregates and the yield of 9–2–7 variety of ragi

To study this relationship, the values for the yield of grain and those of straw recorded by Venkata Rao and Sadasivaiah[14] in 1968–69 on the soil are included in Table III. It may be seen from Table III that every increment of superphosphate given to the soil yielded higher numbers of protozoa, percentage of water stable aggregates and

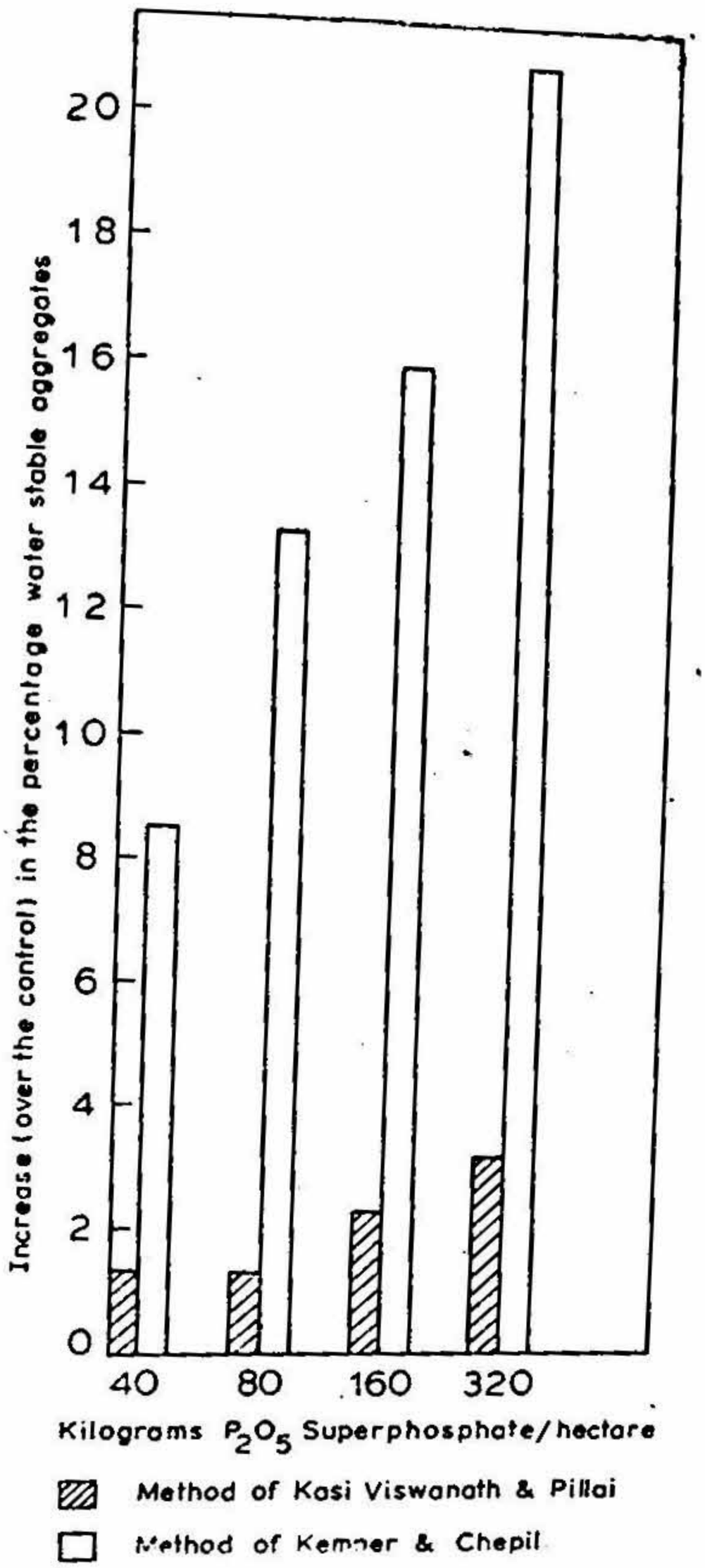

FIG. 2. Influence of superphosphate on water stable aggregates in the soil under *Purna* variety of ragi.

yield of grain and straw, with the exception of application of 320 Kg P_2O_5 superphosphate/hectare where the yield of straw was less than that obtained under 160 Kg P_2O_5 superphosphate/hectare.

It may also be relevant to recall that among all the microorganisms examined in the soil, only the protozoa were selectively stimulated by superphosphate[7].

Relationship between superphosphate, protozoa, water stable aggregates and yield of* Purna *variety of ragi

Similar to the results, obtained for 9–2–7 variety of ragi, the results given in Table IV for *Purna* variety, clearly confirm that addition of increasing quantities of superphosphate influenced protozoan development, enhanced percentage of water stable aggregates and gave higher yields of grain and straw concomitantly.

Table III

Influence of superphosphate on the protozoa, water stable aggregates and yield of grains and straw of 9–2–7 variety of ragi

Superphosphate P_2O_5 Kg/hectare	Protozoa* ($\times 10^2$/g soil)		Percentage water stable aggregates		Yield (g/sq. yd.) of ragi	
	Autoclaved sewage	"Agricultural medium"	I	II	Grain	Straw
0 (control)	240	460	39·6	54·3	554	952
40	300	580	40·6	62·3	717	1292
80	580	620	40·6	69·6	726	1383
160	620	680	44·8	70·1	863	2208
320	860	900	44·5	71·2	1019	2142

* For details on the influence of superphosphate on soil protozoa see reference 7.

I : According to the method of Kasi Viswanath and Pillai.

II : According to the method of Kemper and Chepil.

In view of the broad and striking similarity of the influence of superphosphate on water stable aggregates under both the varieties of ragi, it was found necessary to subject the results to statistical analysis.

Statistical analysis

An analysis of variance as presented in Table V indicates that the statistical relationship between superphosphate dosage and the formation of water stable aggregates was very highly significant.

The results presented here thus give some fresh evidence on the favourable influence of superphosphate on water stable aggregates in the soil. The mechanism of formation of water stable aggregates in soil under the influence of inorganic fertilizers will not only be of importance to practical agriculture but may also prove to be of fundamental importance, and this will be the subject of another communication.

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Table IV

Influence of superphosphate on protozoa, water stable aggregates and yield of grain and straw of Purna *variety of ragi*

Superphosphate P_2O_5 Kg/hectare	Protozoa* (× 10^2/g soil)		Percentage water stable aggregates		Yield (g/sq. yd.) of ragi	
	Auto-claved sewage	"Agri-cultural medium"	I	II	Grain	Straw
0 (control)	110	200	37·7	59·5	460	713
40	170	380	38·8	68·3	577	846
80	200	550	38·8	73·1	666	1082
160	250	580	39·8	75·8	726	1190
320	900	1850	40·7	77·4	926	1878

* For details on the influence of superphosphate on soil protozoa see reference 7.
I : According to the method of Kasi Viswanath and Pillai.
II : According to the method of Kemper and Chepil.

Table V

Analysis of variance of total percentage of water stable aggregates in the soil under 9–2–7 *variety of ragi and* Purna *variety of ragi*

Source	Degrees of freedom	Sum of squares	Variance	'F'
Variety	1	19·2	19·2	
Method	1	11316·2	11316·2	291·0**
Phosphorus level	4	926·2	231·8	6·0**
Error	53	2028·4	38·2	
Total	59	14290·0		

** Very highly significant at 1 per cent level (minimum difference required for significance is 13·8 of total percentage of water stable aggregates).
Variety × phosphorus level interaction was not significant.

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