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Review Article:

Phosphate Fertilization of Crops
Part I. Paddy and Wheat*

by
U. S. SREE RAMULU[1]

Out of the three fertilizers, nitrogenous, phosphatic and potassic fertilizers, use of phosphatic fertilizers has been a problem in our country due to varied responses of crops for the same. The areas under each crop and also the amount of nutrients removed by each crop are presented in table 1. Since almost all crops remove fairly large amounts of phosphorus, it is proposed to review the work done in our country and also elsewhere in the following pages.

1. **Paddy** *(Oryza sativa* Linn.*)*: Increased yields of paddy due to the application of phosphatic fertilizers have been reported by Borasio (1951), Cassidy and Singh (1956) and Coulter and Lockard (1955). In India, significant increases in the yield of the crop were reported by Krishna Rao (1959) in Andhra, Seshagiri Rao and Krishna Rao (1960) in Telengana, Verma (1960) in Gwalior, Tiwari (1960) in Madya Pradesh, Ghose *et al.* (1960) in Bihar. I. C. A. R. (1956) has reported that superphosphate when applied with ammonium sulphate to paddy had resulted in far higher yields than individual applications in the States of Bombay, Madras, Bengal and Madya Pradesh.

But workers like Bal (1950), Chang and Tsong (1953) and Lindt jr. (1953) reported from insignificant response to practically no response to phosphate fertilization of paddy. In India, in majority of the places the application of phosphates had either not increased the yields of paddy or had resulted in very uneconomical yields. A few workers like Nakagawa *et al.* (1955) have reported even depression of yields due to application of superphosphate. Aiyer (1948) reported that application of phosphates with potash resulted in depressing the beneficial effect of potash. Basak (1956) reported that no beneficial effect was obtained due to the phosphatic fertilizers even when it was combined with organic matter.

Contrary to the negative results obtained in the field experiments, work in nutrient solutions by Takashi *et al.* (1950) has clearly shown that deficiency of P resulted in retardation of N and Mg. absorption, decreased

[1] Assistant in Chemistry, Agricultural College & Research Institute, Coimbatore-3. Present address: 3446, Avocado St., Riverside, California.

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TABLE I

Area, Annual Production of important Crops in the world, India and Madras State, Optimum pH and Uptake of Nutrients by various Crops

S. No.	Name of crops	World		India		Madras State		Optimum pH	Uptake of Nutrients in lb.				Yield of crops
		Area	Production	Area	Production	Area	Production		N	P_2O_5	K_2O	CaO	
CD. CROPS:													
1.	Rice *(Oryza sativa)* ...	2,89,200	2,49,700	83,335	33,700	5,913	3,550	5·0 — 6·5	58	20	67	28	35 cwt. grain and 24 cwt. straw
2.	*Jowar (Sorghum vulgare)* ...	67,950	27,160	42,108	9,085	1,780	554	5·5 — 7·5	*	...	...	...	
3.	Maize *(Zea mays)* ...	2,26,700	1,85,700	10,758	3,915	15	7	5·5 — 7·5	114	43	125	20	35 cwt. grain + 60 cwt. straw
4.	*Bajra* or *Cumbu (Pennisetum typhoides)* ...	*	...	28,063	3,134	1,237	314	5·5 — 7·5	*	...	...	...	
5.	*Ragi (Eleusine coracana)* ...	*	...	5,760	1,640	884	345	6·0 — 7·5	*	...	...	...	
6.	Wheat *(Triticum vulgare)* ...	3,48,300	1,77,300	31,751	10,648	4	1	6·0 — 7·5	63	32	54	*	24 cwt. grain + 40 cwt. straw
COMMERCIAL CROPS:													
1.	Sugarcane *(Saccharum officinarum)* ...	...	3,67,400	5,734	8,690	150	2,918	6·0 — 8·0	76	54	170	130	36 tons
2.	Cotton *(Gossypium hirsutum)* ...	83,950	9,840	18,971	5,394	1,134	419	5·0 — 6·0	75	30	78	79	350 lb. lint + 800 seed
3.	Potato *(Solanum tuberosum)* ...	37,570	1,81,800	884	2,656	27	79	4·8 — 6·5	95	42	188	62	10 ton tubers
4.	Tobacco *(Nicotiana tabacum)* ...	8,428	3,443	968	294	43	25	5·5 — 7·5	116	36	214	98	16 cwt.
5.	Groundnut *(Arachis hypogaea)* ...	38,060	13,770	15,455	4,354	2,039	988	5·3 — 6·6	80	22	54	24	14 cwt.

Area in Acres (Thousands); Production in tons (Thousands); * Figures not available.

tiller production, and also N percentage at tillering with poor stunted growth, poor ear formation and low grain yield. Similarly, De Geus (1954) has also stated while reviewing the work in all parts of the world, that irrespective of the influence of phosphatic fertilizers on the yields of paddy, phosphorus application was essential for the growth, tillering and root development of paddy and also for counteracting the adverse effects of excess applications of nitrogenous fertilizers. A few other workers have reported that the application of P increased the number and length of roots which in turn resulted in increased feeding zone and also increased uptake of nutrients.

In addition to conflicting results from the above workers Beacher (1952) and Scharpensel *et al.* (1956) have reported that application of phosphatic fertilizers even in areas where available P was low, had not given any increase in yields.

The fundamental basis for the differential behaviour seems to be due to the flooded conditions of the paddy soils during the growth of the crop. Gasser (1956) reported losses of P from the applied phosphatic fertilizers down the profile due to the flooded conditions of paddy soils. Possibly this might have been one of the reasons for workers like Chandraratna (1961), Goorg (1951) and DeGeus (1954) advocating moderate dressings of phosphatic fertilizers instead of heavy applications because in the former case the amount lost in the ground water will be less than in the latter condition. But the use of insoluble forms of phosphatic fertilizers to overcome the above loss is practically not possible since paddy crops absorb almost the whole of its phosphorus requirement in its early growth period and its productive efficiency is greatest in the initial growth period on grain phosphorus (Hayashi *et al.* 1951) and also as most of the root growth is in the first 70 days of its life period (Hong 1957). Placement of fertilizers of the root zone has been reported to reduce leaching and this can be given still a wider trial though in the calcareous soils of Pusa and sandy soils of Andhra broadcasting of phospatic fertilizers was found to be better than placement.

Other possible ways of increasing the yields of paddy seem to be to find out ways and means of reducing the production of H_2S in paddy fields wherever they are produced as it has been reported that P uptake was reduced when the concentration of H_2S increased (Mitsui *et al.* 1951) and also use of amendments like lime which have been reported to increase the availability of phosphorus (Chang and Pul 1951). Another interesting possibility seem to be in the soaking of seeds in phosphate solutions of various concentrations since the above method has been

reported to increase the yields of paddy (Narayanan and Gopalakrishnan 1949; Rhind *et al.* 1959). Foliar application of phosphorus has been reported to be beneficial at higher concentrations of 1000 ppm. and 5000 ppm. in Bombay (I. C. A. R., 1958).

Use of soil test for assessing the nutrient status of paddy soils has not been very encouraging. Though by the usual conventional methods of analysis, many soils have been classified as phosphorus deficient soils, still when phosphate fertilizers were applied to the paddy crop, there was no response while other crops like barley when grown in the same soil as winter crop responded to phosphatic fertilizers (Aoki 1941, Scharpensal *et al.* 1956). Moreover, Gasser (1956) and Felix (1955 and 1960) have reported that under flooded conditions reduction of insoluble ferric phosphate to more soluble ferrous phosphate takes place and this also has to be considered as available P. Further, Felix (1955) has stated that there is an increase in water soluble phosphate due to (a) reduction of ferric phosphate to ferrous phosphate, (b) hydrolysis of ferric and aluminium phosphate due to increased alkalinity, (c) displacement of phosphate from ferric and aluminium phosphates by complexing agents produced by the anaerobic decomposition of organic matter, (d) anionic exchange between phosphate adsorbed on the clay and organic anions and (e) hydration of ferric and aluminium phosphates. He has further shown that the increase in solubility in acetic acid to be due to the above reactions plus the greater accessibility of calcium phosphates brought about by the removal of protective coatings of ferric oxides. So, the usual methods of soil analysis used for estimating available nutrient status in paddy soils have to be perfected before classifying the soils as deficient, medium or high in available P status and also before making any recommendations.

The question of determining the balanced nutrient requirement of paddy crop throughout the growth period has not yet been fully studied. Ashby (1953) advocated a N : P : K ratio of 47:40:50, 1:1:1·7 and 1:2:2 respectively while Dave (1947) reported N:P = 1:1 ratio to be the best when P_2O_5 was the limiting factor. Workers in Bombay state (1956–57) have reported that a N: P_2O_5 ratio of 1 : 0·25 to be the best and a depression of yield was recorded by them when ratio of N: P_2O_5 was 1 : 1. The yields of crop could be increased if an optimum ratio of N : P : K could be fixed for paddy for each type of soil

Quality: Much emphasis is being laid on the yield of grain alone and not on the uptake of nutrients as criterion in the studies on application of fertilizers. Phosphorus content of grain has been reported to have

been increased by the application of phosphatic fertilizers by Coulter and Lockard (1955) and Sree Ramulu *et al.* (1960). Since increase in P content also improves the quality of grain, attention should be focussed in future at least on the uptake and composition of grain and straw while assessing the efficacy of phosphatic fertilizers to the paddy crop.

So, in conclusion, it can be said that yields of paddy could be increased through the application of phosphatic fertilizers if, (1) methods are evloved to reduce lossess of available phosphorus under water-logged conditions and also making all the applied phosphorus available to the crop during early stages of growth, (2) methods are standardised for classifying and studying the nutrient status and availability under water-logged conditions, (3) proper balanced nutrient requirements of paddy for each type of soil is found out and also (4) attention is paid to quality also while assessing the efficiency of phosphate fertilizers.

B. Wheat *(Triticum vulgare)*: Next to paddy, wheat is the most important food crop in India and this removes on an average 63 lb. N, 32 lb. P_2O_5 and 54 lb. K_2O for a crop of 24 cwt. grain and 40 cwt. of straw. Application of phosphatic fertilizers has generally been accepted to increase the yields of wheat in almost all types of soils like sandy loam (Acharya *et al.* 1958), grantic volcanic or red clay soils (Letelier 1957), wooded steppe and steppe Zones (Antropov 1953), calcareous soils (Chaves and Gonzalez-Garcia 1955; Jekic 1958) and other soils (Bains 1949; Filiporski and Jekic 1951; Jain *et al.* 1959 and Srivatsava *et al.* 1955). Lynch (1956) has also reported that he could not find any definite response to phosphate fertilization among the soil types. Though it was generally accepted that this crop responds to phosphate fertilizers, on the question of quantitative response for each type of fertilizers, Letelier Almeyda (1954) reported that organic forms of phosphatic fertilizers were not as effective as inorganic fertilizers while Kalekmann and Pereria (1949) and Lyzin (1952) reported that combination of both forms were better than individual applications. Application of organo super or super after inoculation with azotobacter was reported to increase the yields more than the application of super phosphate (Kudashov 1956; Kudzin and Arshvich 1958; Kulikova and Maiboroden (1953). Application of granular forms of super was reported to be better than ordinary super and also better response to phosphate fertilization was obtained when the fertilizers were drilled or applied in rows than when broadcast (Reith 1952; *Eire Dept. of Agric.*, 1953; I.C.A.R., 1958; Arthyukov and Turchin 1953 and Volochkova 1953). Cook *et al.* (1958) advocate the use of water soluble forms of phosphates for better response while application of phosphatic fertilizer either with ammonium sulphate or with farm yard manure was reported to increase the

yields better than individual applications. Gorski *et al.* (1954) have stressed the importance of P application in the early stages of growth. Except for the above few reports not much of systematic work seem to have been done in the past two decades to study the best form and nature of fertilizer, time and method of application of phosphatic fertilizers in different soils to wheat crop.

The best utilization of any fertilizer could be achieved only if the availability of nutrient is increased to the maximum. Eck and Stewart (1959) reviewing the data of 53 experiments states that the soil tests for P alone will be of little value in predicting yield response to phosphorus under dry conditions. Sevostyanova (1956) reported that irrigation increased the utilization of top dressed P and soil P, thus resulting in increased yields. So, if the time of maximum requirement of the crop is known, then the possibility of increasing the availability by irrigation could be explored.

Quality: Regarding the influence of phosphatic fertilization on the quality of wheat, Chandrasekharan *et al.* (1953), Williams and Smith (1954), Srivastsava *et al.* (1955) and Grosse-Brauck and Mann (1956) have reported increase in P_2O_5 content but decrease in protein content of grain due to application of phosphatic fertilizers. Rahea and Misra (1956) reported that dressings of P either increased or decreased the nitrogen content of grain depending upon the presence or absence of Nitrogen. Hunt *et al.* (1950), Bains (1953) and Gupta and Das (1956) reported increase of thiamine and nicotinic acid content of wheat due to application of phosphatic fertilizers. Johnson (1953), Avidoni and Kuzina (1954), Zekhavehuko and Panchenko (1955) and Fedorov *et al.* (1955) have reported the improvement in winter hardiness of wheat due to application of phosphates. But not much work has been done to study the effect of application of phosphatic fertilizers on the baking quality of wheat. In view of the above reports, it seems adviceable to maintain an optimum ratio between nitrogenous and phosphatic fertilizers and also worthwhile to make further studies on the interaction of quality and yields under the conditions prevailing in our country, so that yields may be pushed up without sacrificing the quality.

Summing up the previous work on wheat, the yields of wheat could further be increased with maximum benefit to the ryot if,

1. the optimum ratio of organic and inorganic forms of phosphatic fertilizers in the combination of fertilizers is fixed up;
2. the best form and type of fertilizer, time and method of application of phosphatic fertilizers in different soils are found out;

3. methods are found out for increasing the availability of nutrients and also for assessing the correct nutrient status of the soil for wheat crop using soil tests, and

4. the optimum ratio of phosphatic and nitrogeneous fertilizers are fixed up for each type of soil, so that the quality of crop may be improved simultaneously with the yields.

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B. WHEAT

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