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Effects of Continuous Use of Nitrogen Alone and In Combination with Phosphorus and Potassium Fertilizers on Plant Available Major and Secondary Nutrients in Soil under Wheat-Rice Intensive Crop Rotation

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Abstract – Available phosphorus of the soil, decreased with nitrogen application as compared to control. Addition of phosphorus over nitrogen significantly increased phosphorus content. It was increased by 68-80 per cent with combine application of NPK and decreased 13 per cent under the plots receiving N-alone as compared to control. The potassium fertilization over NP further improved phosphorus content. The nitrogen fertilizer alone and phosphorus lowered potassium availability by 3 and 5 per cent, respectively, over no fertilizer. The availability of Potassium declined by about 2 per cent after Wheat and Rice harvest in each year. Sulphur availability improved by 27 and 22 per cent under N,P and NPK treatments, respectively, whereas its availability decreased 6 percent under nitrogen alone over control.

The continuous application of fertilizers N, P and K could help to improve such nutrients deficiencies due to imbalanced application of fertilizers under intensive farming systems.

With high yielding varieties in an intensive cropping system. The depletion of sulphur and micronutrients not being added through fertilizers become more rapid. As the demand for higher yield goes up and the plant requirements for N,P and K are more efficiently met through fertilizers, sulphur and micronutrients in the soil are likely to become limited. According to Williams and Steinbergs (1959) the soil should contain at least 10 ppm of sulphate-sulphur for normal plant growth. Anand Svarup and Ghose (1980) found a rapid decrease in water extractable sulphate in soil where diammonium phosphate was applied continuously as phosphorus source in a long term field experiment.

In the interest of sustained crop productivity at high levels of fertilization, it is necessary to look farward into the effect of continuous manuring fertilization and cropping practices both on the yield as well as on the fertility status of the soil. By considering these views, Laws and Gilbert started the world's oldest classical manurial experiment in 1843 at Broadbalk field in Rothamsted (England). India also started a few long term manurial experiments on Rothamsted model at Kanpur in 1885, Pusa (Bihar) in 1908 and Coimbatore (Madras now TamilNadu) in 1909. However, these experiments were initiated under dryland condition and did not meet the requirements of the modern intensive farming production system.

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MATERIALS & METHODS

The experiment was initiated in rabi with wheat as the first crop followed by rice. The mildly alkaline soil pH (8.03) of the experimental field, which have sandy loam soil in texture. These soil have a little free calcium carbonate at the surface but the lower layers are rich in this constituents and small calcium incrustation. The soluble salt contents are average to high but the exchange complex is saturated with calcium to the extent of eighty percent. Sand, Silt, Clay were 52.0, 27.5 & 20.0 % respectively. The Organic Carbon was 0.36 % and Ec 0.35%. The Available Plant Nutrients (ppm) were Phosphoru-8, Potash 97.5, Sulphur 10, Zinc 0.65, Iron 2.60, Manganese 7.35, and Copper 1.77 ppm, respectively.

The experiment was laid out in a randomized block design with four treatments viz.,

(1) $N_0P_0K_0$ (2) $N_{120}P_0K_0$ (3) $N_{120}P_{60}K_0$

(4) $N_{120}P_{60}K_{60}$ with four replications. Wheat variety HD 2204 and rice variety Saket 4 was grown in a

sequence. Nitrogen, phosphorus and potash were applied through urea, single super phosphate and muriate of potash, respectively. Nitrogen was applied in two splits, half the quantity at sowing time and the remaining half after first irrigation in wheat. In rice, one-third quantity of N was applied at transplanting and remaining N in two equal splits at tillering and panicle initiation stages. The entire quantities of P and K were applied at the time of sowing/transplanting.

The soil samples were air dried, powdered and passed through a 2 mm sieve. Various soil chemical analysis were done by the standard methods (Piper,1966 and Jackson, 1967).

Mechanical analysis was done by International Pipette method. pH was determined by Elico digital pH meter in 1:2:5 soil water suspension.

Electrical conductivity was determined by Philips conductivity meter in 1:2.5 soil-water suspension. Organic carbon was determined by Walkley and Black's rapid titration method.

Available nutrients in the soil were determined by standard methods (Jackson, 1967 and Black, 1965). Available phosphorus Olsen-P was determined by sulphomolybdi.c blue colour method.

Available Potassium was extracted with neutral IN NH_4OAC solution and estimated Flame photometrically. Available Sulphur was estimatedby turbidimetric method of Chesnin and Yien (1950).

RESULT & DISCUSSION

Effect on Available Phosphorus

Available phosphorus of the soil, in general, decreased with nitrogen application as compared to control but the magnitude of decrease was not significant. Addition of phosphorus over nitrogen significantly increased phosphorus content after harvest of each crop. The potassium fertilization over NP further improved phosphorus content and significant increases were recorded during rabi. Average value over the year indicated that phosphorus content was increased to the extent of 68- 80 per cent with combine application of NPK and decreased to the order of 13 per cent under the plots receiving N-alone as compared to control.

On an average with continuous cropping for a period of 4 years the phosphorus fertility of the soil improved by 8 per cent over initial fertility status of the soil.

Continuous cropping without phosphorus application caused marked decreased in available phosphorus content of soil, the magnitude of decrease being larger under continuous use of nitrogen alone as compared to no fertilizer-control. Which may be due to greater removal of phosphorus from the soil because of enhanced plant growth due to nitrogen application. Maurya and Ghosh (1972) in alluvial soil and Bajwa and Paul (1978) in tropical and arid brown soil had reported similar effect of nitrogenous fertilizer.

However, available phosphorus status increased markedly with phosphorus application. These observations are int accord with earlier workers (Havangi and Mann, 1970, Mokrievich et al. 1978; Bajwa and Paul, 1978, Prasad and Singh, 1980 Yaduvansi st al. 1984).

Effect on available potassium

A perusal of soil analysis data indicated that application of nitrogen alone or combined with phosphorus in a regular fashion caused decreased in available K content of the soil as compared to control. The highest reduction in available K was observed under combined application of nitrogen and phosphorus The availability of soil K enhanced significantly with Potassium application. Considering average K content of soil over 7 crop seasons, it is observed that nitrogen fertilizer alone and phosphorus lowered potassium availability by 3 and 5 per cent, respectively, over no fertilizer-control, whereas under NPK treatments available potassium increased by 19 per cent over control. The availability of potassium declined by about 2 per cent after wheat and rice harvest in each year. The reductions of potassium content over a period ending of wheat crop was 9 and 10 per cent under unfertilized and fertilized plot, respectively, as a result of cropping, as compared to that of value obtained in unfertilized (98.33 ppm and in fertilized plot (64.87 ppm) in after wheat. ChangYen et al 2012 reported increasing trend in k content in soil after application of NPK fertilizer. The highest availability of potassium in soil was recorded in plot receiving highest level of NPK which is ascribed to the supply of this nutrient through fertilizer. The improvement in a status of soil under permanent manurial trials was also reported by Mathan (1979), singh at al. (1983), Nambiar and Ghosh (1984) and Verma at al. (1987). These workers concluded that fertilizers directly contribute towards the available potassium. Decrease in available potassium content in control plots was less than that which received nitrogen alone or combined with phosphorus fertilizer. Verma (1987) also made similar observation under continuous cropping of rice-wheat rotations. The availability of potassium in soil declined with the application of nitrogen alone or combined with phosphorus and maximum reduction was recorded under nitrogen and phosphorus treatment which may be related with comparatively more uptake of potassium under NP treatment due to higher yield level. This observation is in accord withi Tiwari (1982) and Nambiar and Ghosh (1984).

Effect on available sulphur

Table 1: Effect on available Phosphorus, Potash and Sulphur (in ppm) in Soil after harvest of wheat and rice

Treatments			Wheat			Rice			Wheat			Rice			Wheat			Rice			Wheat			Mean			% increase over control		
N	P	K	P	K	S	P	K	S	P	K	S	P	K	S	P	K	S	P	K	S	P	K	S	P	K	S	P	K	S
0	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
120	0	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
120	60	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
120	60	60	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Mean			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
CD %			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						
Relative value Over initial assuming as 100			[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]						

A perusal of the data clearly reveals that treatment receiving nitrogen alone generally lowered available sulphur content of soil.

Addition of potassium over nitrogen and phosphate fertilizer again decreased sulphur content. On the basis of an average for 4 years, it is inferred that sulphur availability improved by 27 and 22 per cent under NP and NPK treatments, respectively, whereas its availability decreased 6 per cent under nitrogen alone over control (9 ppm). The availability of sulphur irrespective of fertilization over a period of 4 years was slightly lowered due to continuous cropping as compared to that obtained during period of experiment start. While considering values of available sulphur under control (9.7 ppm), nitrogen (10.0 ppm). NP (11.0 ppm) and NPK (10.5 ppm) the relative values of available sulphur were 93, 95, 115, and 108 per cent, respectively after rabi.

The sulphur status of the plots which received sulphur containing fertilizer (SSP) was generally higher than those receiving no fertilizer and nitrogen alone through urea. Singh and Singh (1975) and Anand Swarup and Ghosh (1979) also reported significant improvement in fertility status of sulphur with the addition of single superphosphate. Application of sulphur free fertilizer like urea declined status of sulphur even from control. These observations are in accord with Kanwar and Takkar (1963) and Kanwar (1967) who reported that unless sulphur containing fertilizer are added to the soil at regular intervals, the sulphur deficiency may occur with sulphur free fertilizers under intensive cropping system.

Application of P (SSP) alongwith N (urea) showed highest available sulphur content. Addition of potassium over nitrogen and phosphorus decreased available sulphur content of soil. This may be due to higher uptake of sulphur under NFK treatment. Graded doses of NPK, however, increased sulphur availability up to the highest dose in the second experiment. Ghosh (1980) also reported that NPK fertilizer improved sulphur status of soil than single application of nitrogen, phosphorus and potassium in long term fertility experiment in an alluvial soil of Delhi.

Application of nitrogen alone or combined with phosphorus in a regular fashion caused decreased in available K content of the soil, as compared to control receiving no. such fertilizers. The highest reduction in available K was observed under combined application of nitrogen and phosphorus, but with application of potassium over combined application of NP, the availability of soil K enhanced significantly. Application of nitrogen alone and nitrogen combined with phosphorus lowered potassium availability by 3 and 5 percent, whereas under NPK treatments available potassium increased by 19 per cent over control.

The treatment receiving nitrogen alone generally lowered available sulphur content of soil. Application of phosphorus in each year has significantly increased available sulphur content over treated or untreated plot with nitrogen fertilizer.

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