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## EFFECT OF PREMIXING OF COPPER SULPHATE WITH FARMYARD MANURE ON THE AVAILABILITY OF COPPER TO WHEAT PLANTS

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**Abstract.** A pot trial was conducted on an alkaline calcareous loam-soil of Lyallpur to determine the effect of premixing of copper sulphate with farmyard manure before their application to soils on the yield and uptake of copper by wheat plants. Copper sulphate was applied at 18, 36 and 72 mg and farmyard manure at 2.2 g/pot.

Premixing of copper sulphate with farmyard manure, about 12 hr before their incorporation into soil, had no effect on the yield of 35 days old plants. Straw and grain yields at maturity were also not affected. Premixed treatment, however, markedly increased both the concentration and the total uptake of copper in 35 days old plants. These preliminary investigations indicate that application of copper fertilizer to soil after its premixing with farmyard manure may have important practical implications in copper nutrition of plants.

Copper fertilizers have recently been found to increase the yield of crops in Pakistan.<sup>2</sup> Since a majority of soils in Pakistan are alkaline and calcareous, fixation of copper in these soils<sup>14</sup> is a major problem in its availability to plants.

A number of factors have been found to increase its availability to plants. Organic compounds such as chelating agents are of special interest in this respect.<sup>6</sup> In addition, many organic compounds may temporarily bind copper by various mechanisms<sup>13</sup> and thus reduce its fixation in soil. The copper thus bound may become slowly available to plants as the organic matter is mineralized by the soil organisms. The farmyard manure contains a number of chelating agents<sup>11,15</sup> and other organic compounds which are capable of complexing copper. The manure is quite cheap but is available only in limited quantities in Pakistan.

The small quantity of farmyard manure, if added direct to soil, could be expected to have limited effect on fixation of copper in soil and thus on the availability of applied copper. The effect may be enhanced if both farmyard manure and copper are mixed together before their addition to soil. The present investigation is undertaken to test this hypothesis.

### Materials and Methods

A bulk sample from the surface (0-23 cm) of an alkaline (pH 7.9) calcareous (CaCO<sub>3</sub> 3%) loam soil, having 0.8% organic matter, was collected from the experimental farm of the Institute. The soil was air-dried, sieved through a 4.0-mm plastic sieve and thoroughly mixed. Sub samples of about 6.4 kg soil were weighed into polythene bags placed inside the undrained plastic pots with 20 cm surface dia. Basal fertilizer dressings of ammonium sulphate at 360 mg N/pot (180 mg at sowing and 180 mg after one month) and superphosphate at 220 mg/pot were applied to all the pots. Copper sulphate was applied at 18, 36 and

72 mg/pot and farmyard manure at 2.2 g/pot. The treatments in quadruplicate were imposed in three ways (a) copper sulphate alone, (b) copper sulphate and farmyard manure (air-dried and pulverised) mixed with the soil separately and (c) copper sulphate and farmyard manure mixed together about 12 hr before their incorporation into soil. Farmyard manure contained 10% moisture at the time of its mixing with copper sulphate and the mixture was air-dried and pulverised just before their mixing into the soil.

Twenty seeds of wheat (*Triticum aestivum* L. cv. Chenab 70) were sown in each pot on December 6, 1971, and 10 days later were thinned to 10 seeds/pot. The pots were irrigated to field capacity with deionised water each day throughout the growth period. On the 35th day of their growth, six plants were harvested from each pot. They were dried overnight at 70°C, digested in a nitric acid-perchloric acid mixture<sup>10</sup> and analysed for copper contents.<sup>9</sup> The remaining four plants were harvested at maturity and their grain and straw yields were recorded.

### Results

*Effect of CuSO<sub>4</sub>-Treatments on the Yields of Plants.* Application of copper sulphate at 18 mg/pot increased the dry-matter yield of 35-day old plants ( $P < 0.01$ , Table 1). Higher doses of 36 and 72 mg/pot of copper sulphate had no further effect. By maturity the plants receiving no CuSO<sub>4</sub> remained stunted. They remained green while the plants with added copper were maturing. They produced secondary tillers from the base of the old shoots. Such a secondary growth increased the straw yield to such an extent that the difference in dry-matter yield observed at 35th day of plant growth from addition of CuSO<sub>4</sub> disappeared. Such growth has been ascribed to copper deficiency in wheat.<sup>3</sup> Surprisingly addition of copper had no effect on grain

TABLE 1. THE EFFECT OF PREMIXING COPPER SULPHATE AND FARMYARD MANURE ON THE DRY-MATTER YIELD OF WHEAT PLANTS.

CuSO <sub>4</sub> -treatments		Dry-matter yield (g/pot)		
Rate of application (mg CuSO <sub>4</sub> /pot)	Method of application	35-Day* old plants	Straw at maturity	Grain at maturity
0	—	0.51	13.5	10.0
	FYM added	0.60	11.4	9.5
18	CuSO <sub>4</sub> alone	1.11	12.0	7.4
	Unmixed	1.12	13.9	8.6
	Premixed	1.15	14.4	8.6
36	CuSO <sub>4</sub> alone	0.97	15.8	10.9
	Unmixed	0.89	13.9	9.8
	Premixed	0.89	15.2	10.0
72	CuSO <sub>4</sub> alone	0.85	11.9	8.6
	Unmixed	1.20	11.3	8.3
	Premixed	0.92	12.0	8.6
	P = 0.05	0.097	2.5	N.S.
	P = 0.01	0.13	3.4	N.S.

\* Statistical analysis was done on square root transformed data.

yield (Table 1). This might have occurred due to some artifacts since copper deficiency in vegetative growth of plants invariably reduces their grain yield.<sup>2,3</sup>

Premixed or unmixed treatments at any of the dose level of copper sulphate had no effect on the dry-matter yield of 35-day old plants (except the unmixed treatment at 72 mg/pot of CuSO<sub>4</sub> which slightly increased their yield) or straw and grain yield at maturity (Table 1).

*Effect of CuSO<sub>4</sub>-Treatments on Concentration and Total Uptake of Copper in Plants.* Increasing doses of copper sulphate at 18, 36 and 72 mg/pot progressively increased both the concentration and the total uptake of copper in 35-day old plants ( $P < 0.01$  or  $0.05$ , Table 2). In the absence of applied copper the plants contained deficient concentration of the element (3.7–3.9 p.p.m.).

At all the levels of copper sulphate application, premixed treatment gave concentration and total uptake of copper in 35-day old plants appreciably higher than the treatments where either copper sulphate alone was added or copper sulphate and farmyard manure were added separately ( $P < 0.01$ , Table 2). Since the dry-matter yield of plants in premixed treatment was generally the same as in the other treatments (Table 1), the premixed treatment seems to have direct effect on the copper availability from soil to plants (not through increase in yield). The additional uptake of copper by plants in the premixed treatment appears to arise entirely from the fertilizer copper and not from the native copper of soil or farmyard manure (Cu 5 p.p.m.) since farmyard manure added in the absence of applied copper has no effect on copper uptake. This was expected since extremely small amounts of farmyard manure were added. When added without premixing, such a small quantity of farmyard manure had no effect on copper uptake even in the presence of applied copper (unmixed treatment) except at the highest dose of copper sulphate (72 mg) application where it increased both the concentration and the total uptake of copper in plants to a small extent ( $P < 0.05$ ).

TABLE 2. THE EFFECT OF PREMIXING COPPER SULPHATE WITH FARMYARD MANURE ON CONCENTRATION AND TOTAL UPTAKE OF COPPER IN 35-DAY OLD WHEAT PLANTS.

CuSO <sub>4</sub> -treatments		Copper concn in dry matter (p.p.m.)	Total copper uptake in dry-matter (μg/pot)
Rate of application (mg CuSO <sub>4</sub> /pot)	Method of application		
0	—	3.9	2.0
	FYM added	3.7	2.2
18	CuSO <sub>4</sub> alone	11.8	13.3
	Unmixed	12.2	14.0
	Premixed	16.3	18.3
36	CuSO <sub>4</sub> alone	19.1	18.1
	Unmixed	19.5	17.5
	Premixed	25.9	22.5
72	CuSO <sub>4</sub> alone	31.5	28.4
	Unmixed	36.3	33.4
	Premixed	40.6	48.3
	P = 0.05	0.40	0.44
	P = 0.01	0.54	0.59

LSD ( $\sqrt{\text{trans-}}$  formed data)

### Discussion

The present studies have indicated that premixing copper sulphate with farmyard manure appreciably increased the availability of fertilizer copper to wheat plants from a calcareous alkaline loam-soil of Pakistan. Such studies have never been reported before.

Premixing copper sulphate with farmyard manure may make copper sulphate more effective due to close association of the two fertilizers attained during the premixing process. Application of this mixture to soil would be expected to reduce the direct exposure of copper sulphate to the fixing agents of the soil. During the mixing process, organic manure may form a protective cover on the CuSO<sub>4</sub> granules or bind copper on its exchange sites.<sup>4,5</sup> When applied to soil such a mixture may be expected to release copper continuously to plants by gradual mineralization.

Farmyard manure also contains a number of organic compounds such as aliphatic acids, amino acids and carbohydrates<sup>15</sup> which are capable of forming chelates with trace elements.<sup>6,15</sup> The small amounts of farmyard manure used in these experiments may exhibit chelating properties only to a limited extent<sup>7,16</sup> when added to soil without premixing with copper sulphate. It may, however, be quite effective in chelating copper when mixed with copper sulphate before its incorporation into the soil. The chelated metals indeed are less likely to be fixed by soil.<sup>8</sup> Although the rates of absorption of chelated trace metals by plants are far less than those of their ionic forms,<sup>12</sup> the chelated metals remain more available to plants due to their higher solubility in soil solution and their rapid transport to plant roots.<sup>7</sup> Chelated metals are also translocated more easily from roots to shoots.<sup>18</sup> The effect of chelating agents on the uptake of trace metals may differ markedly under various soil conditions<sup>17</sup> but this affect appears quite important in calcareous soils.<sup>1,8</sup>

Whatever the mechanism may be, the present studies seem to have important practical implications in plant nutrition. Copper sulphate is an imported commodity and is quite expensive. A saving on its use is, therefore,

warranted. The present results (Table 2) clearly indicate that a substantial saving in the use of copper sulphate fertilizer is possible if applied with the premixed technique. For example, the application of 18 mg/pot of copper sulphate with this technique gave copper uptake in plants as high as with the application of 36 mg/pot of copper sulphate when added without premixing (Table 2). The process requires only 600 lb/acre of farmyard manure. Such a small amount of farmyard manure is easily available, is quite cheap and easy to handle.

The importance of premixing technique on the availability of other trace elements such as iron, zinc and manganese should also be studied since they also exhibit strong chelating properties with organic compounds.<sup>1,13</sup>

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