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# Effect of Nitrogen and Phosphorus in Conjunction with Organic and Micronutrients on Yield and Nutrient Uptake by Maize-Wheat Cropping Sequences and Soil Fertility

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**Abstract**

A pot experiment was undertaken to study the effect of N and P in conjunction with organic manure and micronutrients on yield and nutrient uptake by maize-wheat cropping sequences. The application of either FYM or pressmud (PM) to maize in *kharif* was found beneficial in increasing yields of both maize and wheat in *rabi.* The highest grain yield of wheat was recorded with the application of 100% NP plus foliar spray of multi-micronutrients, whereas dry matter yield was highest with the application of 100% NP only. The highest N, S and Zn uptake by wheat was also recorded with the application of 100% NP plus foliar spray of multi-micronutrients, whereas the highest N and P uptake by maize was recorded with treatment of 100% NP only. Generally, PM enhanced the availability of most of the nutrients except P after maize, whereas the residual effect of FYM was superior over PM after wheat.
**Key words : FYM, Nitrogen, Phosphorus, Maize-wheat, Yield.**

The depleting soil fertility owing to intensive cropping necessitates judicious use of renewable (organic) and non-renewable (inorganic) sources of input for sustainable agricultural production. Integrated nutrient management minimizes the dependence of crop production on chemical fertilizers. In addition, organic sources such as farm yard manure (FYM) and pressmud (PM) have cumulative and residual effects in improving physical, chemical and biological environment of soil which not only reduces the need of chemical fertilizers but also sustains the crop productivity of soil. The present investigation was conducted to generate information on integrated nutrient management in maize-wheat cropping system using locally available organics viz. FYM and PM application to first crop at different fertility levels including supplementation of sulfur and micronutrients under pot studies.

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## Methods

The bulk soil sample was collected from the Golagamdi site of Sankheda district, Gujarat for the pot experiment as the soil was found to be deficient in sulfur and marginal in micronutrients viz. Zn and Fe and S based on critical limits (1). The air-dried soil samples were ground and pass through 2 mm sieve. The physico-chemical analysis of the sample was carried out by using standard soil analytical procedures as described by Piper (2). The initial status of soil used in pot experiment is given in Table 1. Air dried 6 kg 8 mm sieved soil was filled in polythene lined earthen pots (7 kg capacity). Eighteen treatments were formed comprising of two organics besides control and within inorganic treatments, six different fertility levels were kept (Table 2). The 18 different treatment combinations were replicated thrice in factorial complete randomized design (FCRD). The organics used in the experiment were locally available FYM (0.5% N) and PM (1% N) from sulfitation process. The maize var GM-4 was grown up to 60 days while wheat var GW-496 (*Triticum aestivum* L.) was grown up to maturity in subsequent season. The organics were applied in *kharif* maize only and their effect was studied in *rabi* wheat.

**Table 1.** The initial soil status of Golagamdi.

| | Characters and methods | Value |
|---|---|---|
| | Mechanical analysis (International pipette method) | |
| 1 | Clay (%) | 40 |
| 2 | Silt (%) | 22 |
| 3 | Fine sand (%) | 30.2 |
| 4 | Coarse sand (%) | 7.8 |
| | Texture and classification | Clay loam soil (typic chromustert) |
| 5 | pH (2.5) | 8.23 |
| 6 | EC 2.5 (dS/m) | 0.18 |
| 7 | Organic carbon (g/kg) | 3.8 |
| 8 | Available N kg/ha | 132 |
| 9 | Available $P_2O_5$ (0.5 M $NaHCO_3$ extractable P) kg/ha | 27.3 |
| 10 | Available $K_2O$ (Neutral N $NH_4OAc$ extractable K) kg/ha | 307 |
| 11 | Available S (0.15% $CaCl_{12}$ extractable S) mg/kg | 8.6 |
| 12 | Micronutrients (0.005 M DTPA extractable) mg/kg | |
| | Fe (mg/kg) | 7.51 |
| | Zn (mg/kg) | 0.96 |
| | Mn (mg/kg) | 5.68 |
| | Cu (mg/kg) | 1.03 |

**Table 2.** Treatment details.

| **Treatments** | |
|---|---|
| Organics (Three) : | |
| No organic | ($M_0$) |
| FYM 10 t/ha | ($M_1$) |
| Pressmud 5 t/ha | ($M_2$) |
| **Fertility Levels** | |
| No fertilizer | ($F_0$) |
| 75% of recommended NP | ($F_1$) |
| 100% of recommended NP | ($F_2$) |
| 75% of recommended Np + Soil application of S, Zn (20 and 5 kg/ha through gypsum and $ZnSO_4$, respectively) and Fe (as foliar spray 0.25% neutralized $FeSO_4$) | ($F_3$) |
| 100% of recommended NP + Soil application of S, Zn 20 and 5 kg/ha through gypsum and $ZnSO_4$, respectively) and Fe (as foliar spray 0.25% neutralized $FeSO_4$) | ($F_4$) |
| 100% of recommended NP + Foliar spray of multi-micronutrients formulation (grade I : containing Fe 2%, Mn 0.5%, Zn 4%, Cu 0.3% and B 0.5%) 1% | ($F_5$) |

The plant samples were taken at the harvest of maize for determination of total contents of macro- and micronutrients. The oven dried plant samples were finely ground in a SS Willey mill and were digested with $HNO_3$ : $HClO_4$ (4 : 1) di-acid mixture following the procedure outlined by Jackson (3). The plant samples were analyzed for nitrogen by modified Kjeldahl's digestion method, phosphorus by vanadomolybdo-phosphoric yellow color method in nitric acid system (3) and sulfur by turbidimetric method (4).

The soil samples were also collected from each plot to assess the nutrient status of the soil after harvest of maize. The samples were air dried, ground and passed through 2 mm sieve and were analyzed for pH, EC in ratio 1 : 2.5 (soil : water), organic carbon (5), available nitrogen (6), phosphorus (7) and sulfur by $CaCl_2$ extractable solution (8). The soil samples were analyzed for available micronutrients by extracting with 0.005 M DTPA (9) and the contents were determined on atomic absorption spectrophotometer (PE 3110).

## Results and Discussion

### *Yield*

Application of organic matter viz. FYM and PM either alone or in combination with inorganic fertilizers increased biomass of maize and wheat over control (Table 3). The data revealed that PM ($M_2$) (13.41 g/pot) could produce significantly higher biomass of maize over FYM ($M_1$) (10.87 g/pot). This might be due to favorable influence of PM on soil properties to increase the availability of native nutrients in the soil. Similar results were also reported and Khanda et al. (10) and Bajpai et al. (11). Besides, the PM ($M_2$) itself contained appreciable quantities of major and micronutrients and sulfur. The beneficial effect of PM application on maize yield has been reported by Dang and Verma (12).

The results in general suggested that use of FYM and PM in conjunction with either 75% or (100%) recommended dose of NP application to the first crop derived the benefits of organics application on maize yield in the first season and the residual effect on wheat yield in subsequent season. In the second season, only fertilizer application of 100% NP along with

**Table 3.** Dry matter yield of maize and wheat grain yield as influenced by integrated nutrient manage-ment.

| Treatments | Maize yield (g/pot) Dry matter | Wheat yield (g/pot) Grain | Dry matter |
|---|---|---|---|
| $M_0$ | 8.21 | 1.00 | 1.88 |
| $M_1$ | 10.87 | 1.89 | 2.39 |
| $M_2$ | 13.41 | 1.46 | 2.13 |
| CD ($P$ = 0.05) | 0.92 | 0.15 | 0.09 |
| $F_0$ | 8.77 | 0.89 | 2.05 |
| $F_1$ | 11.63 | 1.30 | 2.10 |
| $F_2$ | 11.80 | 1.50 | 2.08 |
| $F_3$ | 11.66 | 1.46 | 2.03 |
| $F_4$ | 11.63 | 1.59 | 2.28 |
| $F_5$ | 9.48 | 1.98 | 2.26 |
| CD ($P$ = 0.05) | 1.31 | 0.21 | 0.13 |

**Table 4.** Effect of integrated nutrient management on nutrients uptake by maize.

| Treatments | Nutrient uptake (mg/pot) N | P | S | Zn | Fe |
|---|---|---|---|---|---|
| $M_0$ | 149.48 | 5.71 | 14.80 | 2.21 | 6.17 |
| $M_1$ | 201.10 | 12.45 | 16.13 | 2.27 | 8.53 |
| $M_2$ | 191.40 | 11.05 | 19.75 | 2.11 | 8.64 |
| CD ($P$= 0.05) | 18.82 | 1.20 | 1.49 | NS | 0.78 |
| $F_0$ | 113.42 | 7.11 | 9.71 | 1.03 | 3.82 |
| $F_1$ | 189.18 | 11.47 | 16.71 | 1.23 | 4.45 |
| $F_2$ | 220.65 | 12.23 | 18.25 | 1.12 | 4.70 |
| $F_3$ | 187.42 | 9.81 | 20.10 | 2.00 | 13.61 |
| $F_4$ | 219.57 | 11.90 | 22.88 | 2.77 | 14.87 |
| $F_5$ | 153.73 | 5.90 | 13.71 | 5.03 | 5.24 |
| CD ($P$= 0.05) | 26.61 | 1.70 | 2.11 | 0.37 | 1.10 |

supplementation of micronutrient through foliar spray would be sufficient to harvest maximum wheat yield (13). The beneficial effect of micronutrient application alone and in combination with organic on wheat yield have been reported by Sharma and Singh (14).

### *Nutrient Uptake*

*NPS Uptake.* The nitrogen uptake by maize and wheat grain and total has been shown in Tables 4 and 5, respectively. The over all results indicated the superiority of PM over FYM in increasing N uptake over no organics as has also been reported by Lal and Mathur (15). The results indicated the better performance of PM as a direct application to the first crop of maize. In wheat, the residual effect carried over by FYM proved to be better in increasing utilization of N compared to PM (Table 5). It is clear from the N uptake that FYM residual effect was found to be long lasting in providing N nutrition higher compared to PM. The application of fertilizer further helped to increase crop growth and accordingly N uptake was also found higher with increasing level of fertilizer application. Only organics either through FYM or PM in the absence of inorganic fertilizer application did not utilize the N as high as utilized by integrated treatment combination. The results of Lal and Mathur (15) are in the line of similar findings. It has been noticed that the balance fertilization practices was found to

**Table 5.** Effect of integrated nutrient management on nutrients uptake by wheat.

| Treat-ments | N Grain | N Total | P Grain | P Total | S Grain | S Total | Zn Grain | Zn Total | Fe Grain | Fe Total |
|---|---|---|---|---|---|---|---|---|---|---|
| | Nutrient uptake (mg/pot) | | | | | | | | | |
| $M_0$ | 25.01 | 43.77 | 1.06 | 2.13 | 1.81 | 7.42 | 0.032 | 0.23 | 0.10 | 1.27 |
| $M_1$ | 43.85 | 61.44 | 1.86 | 3.06 | 2.54 | 8.19 | 0.050 | 0.22 | 0.10 | 1.27 |
| $M_2$ | 34.86 | 51.88 | 1.48 | 2.47 | 2.30 | 8.10 | 0.048 | 0.21 | 0.08 | 1.20 |
| CD ($P$= 0.05) | 4.16 | 4.21 | 0.15 | 0.19 | 0.40 | NS | 0.006 | NS | 0.01 | NS |
| $F_0$ | 22.50 | 39.54 | 1.08 | 2.55 | 1.79 | 7.78 | 0.027 | 0.16 | 0.05 | 0.66 |
| $F_1$ | 32.16 | 50.48 | 1.33 | 2.70 | 1.89 | 7.01 | 0.036 | 0.16 | 0.08 | 0.67 |
| $F_2$ | 34.50 | 51.09 | 1.63 | 2.65 | 2.48 | 7.77 | 0.043 | 0.15 | 0.09 | 0.70 |
| $F_3$ | 35.28 | 52.95 | 1.72 | 2.88 | 2.30 | 8.25 | 0.043 | 0.17 | 0.11 | 1.83 |
| $F_4$ | 36.72 | 54.35 | 1.42 | 2.48 | 2.09 | 8.01 | 0.042 | 0.18 | 0.11 | 2.06 |
| $F_5$ | 46.26 | 65.75 | 1.62 | 2.60 | 2.77 | 8.61 | 0.067 | 0.49 | 0.12 | 1.55 |
| CD ($P$= 0.05) | 5.88 | 5.96 | 0.22 | NS | 0.57 | NS | 0.008 | 0.02 | 0.02 | 0.23 |

**Table 6.** Effect of integrated nutrient management on soil properties after maize.

| Treat-ments | pH (1 : 2.5) | EC (dS/m) | Available nutrients N | $P_2O_5$ (kg/ha) | S | Zn (mg/kg) | Fe |
|---|---|---|---|---|---|---|---|
| $M_0$ | 7.95 | 0.27 | 98.0 | 37.70 | 13.98 | 1.29 | 8.02 |
| $M_1$ | 7.94 | 0.28 | 174.8 | 69.44 | 15.86 | 1.41 | 7.77 |
| $M_2$ | 7.86 | 0.37 | 207.8 | 57.15 | 27.99 | 1.67 | 8.20 |
| CD ($P$=0.05) | 0.05 | 0.01 | 9.1 | 3.48 | 1.27 | 0.15 | 0.27 |
| $F_0$ | 7.99 | 0.25 | 123.9 | 55.41 | 12.40 | 1.06 | 7.70 |
| $F_1$ | 7.91 | 0.25 | 133.3 | 57.15 | 13.79 | 0.95 | 8.13 |
| $F_2$ | 7.92 | 0.27 | 150.5 | 50.71 | 16.39 | 1.15 | 8.05 |
| $F_3$ | 7.88 | 0.32 | 166.2 | 55.40 | 27.65 | 2.22 | 8.14 |
| $F_4$ | 7.87 | 0.37 | 197.6 | 53.88 | 29.95 | 2.11 | 7.95 |
| $F_5$ | 7.91 | 0.38 | 189.7 | 56.02 | 15.49 | 1.24 | 8.02 |
| CD ($P$=0.05) | 0.07 | 0.02 | 12.9 | NS | 1.80 | 0.21 | NS |

be more helpful in better utilization of N due to improvement in crop growth as a result of application of major and other limiting nutrients like Zn and S.

The P uptake has shown an increase under the respective treatments of P application. The increase in P uptake was in accordance with the results reported by Sharma et al. (16). The P uptake was influenced by both FYM and PM application more favorable over no organics in maize. Dang and Verma (12) also noticed improvement in P uptake by maize and wheat with PM application. The organic acids released during decomposition of FYM might have exerted beneficial effect in mobilizing soil native P utilization by maize. The favorable effect was found even in subsequent wheat. The PM was brought from sulfitation process ; therefore, its direct and residual effects were likely to be acidic enough to mobilize the native P in soil.

The S uptake by maize was quite higher under $F_3$ and $F_4$ treatments because of S addition through $ZnSO_4$ and gypsum besides foliar application of micronutrient. The residual effect of FYM showed slightly higher S uptake by subsequent wheat compared to PM. The results are in accordance with those of Sinha and Sakal (17). The results revealed that higher S uptake by maize was observed under PM than FYM. The inclusion of S in the treatments of $F_3$ and $F_4$ as balanced fertilization showed better effect in improving S utilization by both the crops.

*Zn and Fe.* The utilization of Zn and Fe in the presence of both organic treatments viz. FYM and PM was found higher as a direct effect in maize (Table 4). The uptake was higher under recommended level of NP fertilizer application along with supplementation of sulfur and micronutrient which was equally effective with 75% of recommended dose of NP fertilization and micronutrient supplementation. In Zn utilization was also higher under these treatments. It was noticed that in the absence of any fertilizer application, FYM and PM both improved Zn uptake over control. The findings reported by Kumar et al. (18) are in the line of present results. This was because native Zn might have been utilized due to release of organic acids in soil, whereas in the presence of NP application higher Zn utilization is attributed to the priming effect causing higher crop growth and thereby higher removal of Zn particularly on soils marginal to deficient in Zn.

The depressing effect on Zn uptake in the presence of organics might be due to chelating or immobilization of Zn with organic legends causing reduction in its availability to plant roots during growing of the crop. However, the overall effect of organics and Zn application revealed that Zn uptake was higher irrespective of organics or inorganic over absolute control. Addition of $ZnSO_4$ increased the concentration gradient of Zn to roots and hence, increased uptake of Zn leading to enhanced biomass production.

The effect of fertilizer application on micronutrients removal under residual effect of organics in wheat revealed that $F_3$, $F_4$ and $F_5$ were superior over other treatments with respect to utilization of these nutrients (Table 5). There was some depressing effect on total uptake of micronutrient by wheat under the influence of residual effect of organics for the possible reasons of immobilization or chelating effect to

**Table 7.** Residual effect of integrated nutrient management on soil properties after wheat.

| Treat-ments | pH (1 : 2.5) | EC (dS/m) | Available nutrients N (kg/ha) | $P_2O_5$ | S | Zn (mg/kg) | Fe |
|---|---|---|---|---|---|---|---|
| $M_0$ | 8.16 | 0.25 | 57.8 | 33.88 | 14.42 | 1.26 | 7.30 |
| $M_1$ | 8.21 | 0.29 | 196.9 | 71.49 | 15.78 | 1.38 | 7.13 |
| $M_2$ | 8.24 | 0.37 | 210.9 | 49.25 | 18.56 | 1.31 | 7.47 |
| CD (*P*=0.05) | 0.020 | 0.015 | 8.69 | 3.04 | 0.95 | 0.09 | NS |
| $F_0$ | 8.26 | 0.23 | 98.8 | 51.32 | 10.56 | 1.07 | 7.22 |
| $F_1$ | 8.21 | 0.26 | 155.2 | 59.57 | 12.91 | 1.23 | 7.22 |
| $F_2$ | 8.21 | 0.28 | 166.2 | 49.12 | 15.43 | 1.13 | 7.43 |
| $F_3$ | 8.18 | 0.30 | 161.3 | 47.52 | 20.79 | 1.82 | 7.53 |
| $F_4$ | 8.19 | 0.38 | 177.3 | 49.02 | 20.86 | 1.57 | 6.95 |
| $F_5$ | 8.17 | 0.37 | 172.3 | 52.68 | 16.98 | 1.08 | 7.45 |
| CD (*P*=0.05) | 0.028 | 0.021 | 12.29 | 4.30 | 1.35 | 0.12 | NS |

reduce the availability and thereby total Zn uptake. Such effect was somewhat higher due to residual effect of PM. Thus, the results indicated that the residual effect of FYM was more effective and beneficial causing higher utilization of micronutrients compared to PM application. The fertilizer application at 75% and 100% NP were found to be equally effective in utilization of these nutrients under the residual influence of soil application of limiting nutrients viz. Zn and S to maize. Patel et al. (1) also mentioned the reduction in crop productivity of soil due to use of inorganic fertilizers only and scarce use of organics. The foliar spray of multi micronutrient (grade-I) was found to be more beneficial in wheat compared to that of maize.

### *pH and EC*

The results emphasized that PM application as direct effect proved to be beneficial in lowering down the soil pH from its initial value of 8.23 (Tables 6 and 7). The FYM also affected in the similar way. The reduction in soil pH was mainly due to release of organic acids in the soil system upon decomposition of organics ; at the same time, more of the salts are included into the soil resulting in higher value of EC over other treatments with no organics. The higher reduction in soil pH with PM treatment is because of the presence of salts of acidic nature in its composition as the product was taken from the sugar mill using sulfitation process (19).

The results further revealed that the soil pH as a result of residual effect of organics again tried to shift towards alkaline reaction at wheat harvest (Table 7). This might be attributed to the buffering action of soil and also conversion of some organic acids into bicarbonate and carbonates with time. Thus, the results established the superiority of PM as direct effect in reducing soil pH. The increase in nutrients availability is mainly a function of soil pH and therefore, the higher utilization of nutrients by the crops showed better response in term of producing higher dry matter yields. The role of organic matter in improving soil fertility status was therefore, established to enhance or maintain crop productivity of the soil to harvest higher crop yields under maize-wheat sequence.

### *Available Nitrogen*

The results revealed that organics and inorganic treatments significantly affected on available N content of soil. It was noticed that both FYM ($M_1$) and PM ($M_2$) influenced favorable in increasing available N in soil. The increase in available N under these treatments was expected due to direct addition of N and indirect effects resulted from the decomposition of organic matter to cause mineralization of organically bound nitrogen and thereby improvement in available N status. The soil pH tried to shift toward the zone of neutrality to enhance the availability of nutrients in the soil. The beneficial effect of organics to improve soil properties and thus increase in N availability as reported by Bajpai et al. (11). The over all effect of PM ($M_2$) was higher than FYM ($M_1$), whereas the residual effect of FYM was more in increasing available N content as compared to PM. The combination of organic and inorganic treatments proved to be better in improving soil available N status due to significant nature of M × F interaction. The presence of inorganic source of N enhanced the microbial activities to accelerate the rate of organic matter decomposition. The phenomenon favors the addition of N and other nutrients in the system due to biochemical changes.

### *Available Phosphorus*

Available phosphorus status of soil after maize and wheat harvest indicated that organics were superior in improving available P. It might be due to the mineralization of organic phosphorus under the influence of organic acids. The production of organic acids which has a solubilizing effect on soil phosphorus and organic anions retard the fixation of P in soil (20). The results indicated that both direct and residual effect of FYM on available P was more pronounced than that of PM. The FYM maintained higher level of available P as compared to PM after maize and wheat harvest. The integration of inorganic fertilizer P in combination with organic (FYM) proved to be better in maintaining higher level of available P at harvest of both the crops is in conformity with findings of Tolanur and Badanur (21).

### *Available Sulfur*

Available S content in soil after maize and wheat harvest indicated that both organics and inorganic treatments significantly influenced on available S status of soil. The direct effect of PM ( $M_2$ ) increased available-S more than FYM. Among the inorganic treatments $F_3$ and $F_4$ increased available-S due to supplementation of $ZnSO_4$ and gypsum as soil application. The available S after maize harvest under $M_2F_3$ and $M_2F_4$ was found to be higher ; and also the residual effect of $M_2$ in conjunction with $F_3$ and $F_4$ recorded maximum available S. The higher available S status under PM was due to obvious reasons as it contributed its own S into soil through microbiological oxidation. The improvement in available S due to PM application was found in accordance with the results reported by Sinha and Sakal (17).

### *DTPA-Extractable Zn and Fe Status of Soil*

The content of DTPA-Fe after maize harvest was significantly affected by both the manures ; however, the residual effect of manures after wheat harvest was found to be non-significant. The results revealed that DTPA-Fe content in soil after wheat harvest decreased more than that of DTPA-Fe content after maize harvest. The decrease in DTPA-Fe might be a result of removal of Fe by the crops ; and also it might be attributed to the complication with organic legends besides effect of alkaline pH during wheat (22). It is, therefore, necessary to check the soil Fe status after maize harvest in order to its supplementation for sustainable crops productivity. The initial DTPA-Fe content in soil was marginal, therefore, the supplementation of iron was made through foliar spray and hence, not much variation of DTPA-Fe after maize and wheat harvest was noticed.

The DTPA-Zn content in soil after maize and wheat harvest was significantly affected by organics, inorganic treatments and interaction. The results revealed that PM ( $M_2$ ) application increased DTPA-Zn after maize harvest. The positive influence of PM on soil DTPA-Zn has also been reported by Dang and Verma (12). The PM itself also contained 130.5 mg/kg of Zn and the effect of organic acids might have helped in increasing available Zn status under organic treatments. The residual effect of $M_1$ (FYM) was better in improving available Zn (DTPA-Zn) status more than that of observed under PM. Among the inorganic treatments, $F_3$ and $F_4$ increased DTPA-Zn due to direct addition of Zn through $ZnSO_4$ application to soil. Similar observations were made by Singh and Nambiar (23). Further integration of organic with inorganic treatment was found to be superior in this respect under direct and indirect effect of FYM ($M_1$) and PM ( $M_2$ ) especially in conjunction with $F_3$ and $F_4$.

The Zn and S along with 100% NP application in association with either FYM or PM for better maintenance of fertility and crop productivity of the soil was found to be advantageous to harvest higher yields of maize and wheat as direct and residual effects, respectively. The multi-micronutrient spray was not found to be advantageous in maize, but its inclusion in nutrient management was found quite beneficial in wheat. The utilization of the major and micronutrients was higher by the crops due to FYM and PM application in association with 100% NP along with supplementation of deficient nutrients viz. S, Zn and Fe. Also, these treatments either maintained or improved the soil fertility status in the soil as a result of balanced fertilization.

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