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# Integrated nutrient management in green gram (*Phaseolus radiatus*) – Indian mustard (*Brassica juncea*) - summer groundnut (*Arachis hypogaea*) cropping system

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## ABSTRACT

A field experiment was carried out for two consecutive years during 1998-99 and 1999-2000 at Zonal Agriculture Research Station, Mainpuri, C.S.Azad University of Agriculture and Technology, Kanpur. The main objective was to popularize the summer groundnut cultivation in multiple cropping of green gram-mustard-summer groundnut on nutrient deficient soil. Results display that the application of 20 kg N + 50 kg $P_2O_5$ in combination of FYM @ 10 t $ha^{-1}$ registered significantly higher growth, yield components and grain yield of green gram (5.29 q $ha^{-1}$) over control and conventional system of R.D.F. Likewise, the integration of residue of FYM @ 10 t $ha^{-1}$ with 120 kg N + 40 kg $P_2O_5$ + 40 kg $K_2O$ $ha^{-1}$ pushed up significantly to growth and yield traits of mustard which culminated into significant increase in seed yield of mustard (24.48 q $ha^{-1}$). Application of 15 kg N + 30 kg $P_2O_5$ + 45 kg $K_2O$ $ha^{-1}$ in conjunction with remaining residue of 10 t FYM $ha^{-1}$ gave significantly higher pod yield of summer groundnut by 22.21 q $ha^{-1}$ over control and conventional system of RDF. The growth and yield contributing characters noted in groundnut were concordant to the pod yield of groundnut. The uptake of NPK was increased under different crops of cropping system, when fertilized with RDF in association of FYM. Analysis of soil after harvesting of different crops of the sequence showed a significant build up of NPK with the application of FYM. The population of earthworms was higher in the soil receiving plenty of FYM, inoculated with vermi compost.

**Key words :** Soil biodiversity, Multiple cropping, Inoculation, Nutrient biocycle and Vermi compost.

## INTRODUCTION

Application of FYM in multiple cropping is a holistic nutrients management system, which promotes and improves the health of the agro system related to biodiversity, nutrient bio cycles and soil microbial and biochemical activities. The conventional agriculture is heavily dependent on non-renewable resources viz., chemical fertilizers and pesticides. The excessive and imbalanced use of agro-chemicals on soil and plant is not only damaging the soil biodiversity i.e. bacteria, fungi, actinomycetes etc. but also reduces the productivity potential of the farmland. Conventional intensive agriculture causes several problems as depletion of soil organic matter and plant nutrients besides occurrences of pest and diseases. The nutrients present in the FYM are dissolved easily in water and quickly find their way in soil, water bodies and food chains. The soil is a living dynamic system and biodiversity is adversely affected if soil is not amended with organic manure at regular intervals to feed the soil biota.

Multiple cropping system is the most common and widely adopted system throughout the Indo-Gangetic plains of Uttar Pradesh. This cropping system is the major consumer of chemical fertilizers and pesticides but the trend of fertilizer use efficiency is not encouraging. The balanced use of plant nutrients is needed for normal optimum growth of plants in multiple cropping. The requirements and the balanced use of plant nutrients cannot be only met by use of chemical fertilizers alone but more advantageously by different methods of organic recycling and large-scale use of renewable organic resources.

With the view to increase the productivity of green gram during rainy season, mustard during winter season and groundnut during summer season under multiple cropping, popularized the groundnut cultivation during summer season and to enrich the nutrients deficient soil, the present experiment was planned and executed under integrated nutrient management.

## MATERIALS AND METHODS

The experiment was carried out for two consecutive years during 1998-99 and 1999-2000 at Zonal Agriculture Research Station, Mainpuri, C. S. Azad University of Agriculture & Technology, Kanpur. The soil of the experimental site was sandy loam in texture having pH

8.5, organic carbon 0.45 %, and low in fertility (total nitrogen 0.04 %, available phosphorus 10 kg $ha^{-1}$ and available potash 278 kg $ha^{-1}$). The treatments consisted a control, conventional system of RDF, RDF + FYM @ 2 t $ha^{-1}$, RDF + FYM @ 4 t $ha^{-1}$, RDF + FYM @ 6 t $ha^{-1}$, RDF + FYM @ 8 t $ha^{-1}$, RDF + FYM @ 10 t $ha^{-1}$ & RDF + FYM @ 12 t $ha^{-1}$ for green gram, FYM was not applied to the succeeding crop of mustard and summer groundnut, which were raised on residue of different levels of FYM and RDF. A recommended dose of 20 kg N + 50 kg $P_2O_5$ $ha^{-1}$ to green gram, 120 kg N + 40 kg $P_2O_5$ + 40 kg $K_2O$ $ha^{-1}$ to mustard and 15 kg N + 30 kg $P_2O_5$ + 45 kg $K_2O$ $ha^{-1}$ to summer groundnut were given. The different doses of FYM applied to first year green gram were inoculated with vermi compost @ 0.5 t/10 t FYM just to prepare the vermi compost *in situ* and increase the demography of earthworms in the experimental field. The experiment was laid out in RBD with three replications. FYM applied in the experimental field was contained 0.30% N, 0.15% $P_2O_5$ and 0.30% $K_2O$. Similarly, vermi compost used as a inoculants was comprised organic matter 16.98%, total nitrogen 1.50%, phosphorus 0.30%, potassium 0.46%, sodium 0.15%, calcium 0.10%, copper 8.5 ppm, iron 7.3 ppm, zinc 10.5 ppm and sulphur 448 ppm. FYM was applied before the field preparation as per treatment while NPK doses recommended to green gram and summer groundnut were applied at sowing. In mustard half dose of N and full dose of $P_2O_5$ and $K_2O$ was applied at sowing and remaining half dose of N was top dressed after final thinning and first irrigation. The green gram (Cv. T 44) planted in rows 30 cm a part using 15 kg seed $ha^{-1}$ in the second fortnight of July harvested after 70 days in the first week of October during both experimental seasons. The succeeding crop of mustard (Cv. Alankar) was planted in rows at 45 cm apart using 5 kg seed $ha^{-1}$ on 20 October and harvested after 125 day on 23 February during two experimental seasons. After harvesting of mustard, field was prepared for sowing of summer groundnut. The groundnut (Cv. Dh-86) planted in rows 30 cm apart using 100 kg kernel $ha^{-1}$ on 15 March and harvested after 85 days on 10 June during both experimental years. No irrigation was given to green gram while three irrigations to mustard and four irrigations to summer groundnut were given.

Chemical analysis of soil and plants was carried out from each plot at harvest.Modified Kjendahl, vandomolybdo-phosphate yellow colour and flame photometer method, determined nitrogen, phosphorus and potash contents respectively. The earthworms population in soil was counted up to the depth of 0.5 meter after offset of rains. The variances for error were found homogeneous. Hence, the pooling of the data for each character was done for the two years by the standard method suggested by Cochran and Cox (1957).

## RESULTS AND DISCUSSION

### *Effect on growth, yield traits and grain yield of rainy season green gram*

The main shoot height, branches $plant^{-1}$ and pods $plant^{-1}$ positively influenced due to integration of FYM with RDF (Table 1). Similarly, seeds $pod^{-1}$ and 1000-seed weight also increased linearly due to combination of FYM with RDF. Growth and yield traits values were recorded highest at integration of FYM @ 12 t $ha^{-1}$ with RDF but this integration stagnated the values of all these growth and yield traits as compared to FYM @ 10 t $ha^{-1}$.

Seed yield was influenced significantly due to combination of FYM with RDF. The highest seed yield of green gram was recorded under integration of FYM @ 12 t $ha^{-1}$ with RDF, which was statistically at par with 4,6,8 and 10 t FYM $ha^{-1}$. The availability of plant nutrients through FYM has most pronounced effect on seed yield of green gram. Therefore, the application of FYM in the integration of RDF improved the growth and yield traits, which culminated in to significantly increase in seed yield of green gram.

### *Effect on growth, yield traits and seed yield of mustard:*

The branches $plant^{-1}$, pods $plant^{-1}$ and 1000-seed weight were significantly influenced due to integration of residue of FYM with RDF. These attributes were higher under combination of residue of FYM @ 10 t $ha^{-1}$ with 120 kg N + 40 kg $P_2O_5$ + 40 kg $K_2O$ $ha^{-1}$ compared with control and conventional system of RDF (Table 2). It was observed that better growth and yield attributes were recorded when residue of FYM was combined with NPK. Thus, it was an indicative of their role in various physiological functions.

Seed yield was influenced due to residual effect of different doses of FYM. The highest seed yield of Indian mustard was weighed at integration of residue of FYM @ 10 t $ha^{-1}$ with 120 kg N + 40 kg $P_2O_5$ + 40 kg $K_2O$ $ha^{-1}$. The further installment of FYM residue confined the seed yield of mustard in comparison to residue of FYM @ 10 t $ha^{-1}$.

As yield is the resultant out comes of the effect of various growth factors and yield parameters, its expression was observed with their integration influence. With the increment in supply of essential elements through FYM to Indian mustard, their availability, acquisition, mobilization and influx into the plant tissues increased and thus improved growth and yield components and finally

Table 1 : Growth attributes, yield components and seed yield of green gram under different treatments (pooled data of 1998 & 1999).

| Treatment | Pooled growth, yield attributes and seed yield | | | | | |
|---|---|---|---|---|---|---|
| | Main shoot height (cm) | Branches plant$^{-1}$ | Pods plant$^{-1}$ | Seeds pod$^{-1}$ | 1000-seeds weight (g) | Seed yield q/ha$^{-1}$ |
| Control | 54.88 | 9.44 | 18.11 | 7.11 | 20.44 | 3.54 |
| Conventional system of RDF | 60.77 | 9.99 | 18.88 | 7.66 | 21.66 | 4.11 |
| RDF + FYM @ 2 t ha$^{-1}$ | 62.66 | 10.11 | 19.11 | 7.77 | 23.44 | 4.55 |
| RDF + FYM @ 4 t ha$^{-1}$ | 64.77 | 10.22 | 20.00 | 8.00 | 24.55 | 4.79 |
| RDF + FYM @ 6 t ha$^{-1}$ | 66.55 | 10.55 | 20.44 | 8.44 | 25.44 | 5.07 |
| RDF + FYM @ 8 t ha$^{-1}$ | 67.55 | 10.66 | 20.55 | 8.66 | 26.00 | 5.11 |
| RDF + FYM @ 10 t ha$^{-1}$ | 68.22 | 10.88 | 20.77 | 9.33 | 28.00 | 5.29 |
| RDF + FYM @ 12 t ha$^{-1}$ | 68.44 | 11.00 | 20.88 | 9.44 | 28.33 | 5.62 |
| C.D. 5% | 3.36 | 0.72 | 1.42 | 0.97 | 1.27 | 0.94 |

Nutrients status of applied FYM - 0.30% N, 0.15% $P_2O_5$ and 0.30% $K_2O$.

Nutrients status of vermicompost used as a inoculant – 16.98% organic matter, 1.50% total nitrogen, 0.30% phosphorus, 0.46% potassium, 0.15% sodium, 0.10% calcium, 8.5 ppm copper, 7.3 ppm iron, 10.5 ppm zinc and 448 ppm sulphur.

Table 2 : Growth, yield attributes and seed yield of Indian mustard as influenced by different treatments (pooled data of 1998 & 1999).

| Treatment | Pooled growth and yield attributes | | | |
|---|---|---|---|---|
| | Branches plant$^{-1}$ | Pods plant$^{-1}$ | 1000- seed weight (g) | Seed yield q ha$^{-1}$ |
| Control | 45.77 | 450.77 | 4.28 | 16.48 |
| Conventional system of RDF | 58.55 | 624.88 | 4.45 | 20.39 |
| RDF + residue of FYM @ 2 t ha$^{-1}$ | 60.44 | 638.33 | 4.60 | 20.73 |
| RDF + residue of FYM @ 4 t ha$^{-1}$ | 62.00 | 645.11 | 4.68 | 21.62 |
| RDF + residue of FYM @ 6 t ha$^{-1}$ | 65.11 | 654.88 | 4.73 | 22.62 |
| RDF + residue of FYM @ 8 t ha$^{-1}$ | 68.00 | 670.11 | 4.85 | 23.01 |
| RDF + residue of FYM @ 10 t ha$^{-1}$ | 70.22 | 685.44 | 4.91 | 24.48 |
| RDF + residue of FYM @ 12 t ha$^{-1}$ | 72.00 | 694.88 | 4.86 | 23.87 |
| C.D. 5% | 2.63 | 3.36 | 0.15 | 3.09 |

the seed yield. These results corroborated the findings of Mandal and Sinha (2002).

***Effect on growth, yield traits and pod yield of summer groundnut :***

The remaining residue of FYM @ 10 t ha$^{-1}$ in the integration of 15 kg N + 30 kg $P_2O_5$ + 45 kg $K_2O$ ha$^{-1}$ significantly increased pod yield of summer groundnut compared with control and conventional system of RDF. The conjunction of residue of FYM with recommended dose of fertilizer brought about an all round significant improvement in growth and yield attributes, which resulted in additional improvement in pod yield (Table 3). Such a conducive effect of organic manure could be attributed to the supply of nutrients through mineralization and improvement of physico-chemical properties of soil. These results are in line with those of Kachot *et al.* (2001).

Since the FYM was applied to every year in multiple cropping, the crop yield has gone on increasing due to direct plus residual effect on every succeeding crop. This

Table 3: Growth, yield traits and yield of summer groundnut under residual effect of FYM (pooled data of 1999 & 2000).

| Treatment | Pooled growth, yield traits and pod yield | | | | |
|---|---|---|---|---|---|
| | Main shoot height (cm) | Pods plant$^{-1}$ | Kernel pod$^{-1}$ | 100 – kernel weight (g) | Pod yield q ha$^{-1}$ |
| Control | 17.22 | 18.88 | 1.22 | 24.66 | 13.66 |
| Conventional system of RDF | 17.44 | 24.11 | 1.44 | 29.00 | 15.86 |
| RDF + residue of FYM @ 2 t ha$^{-1}$ | 17.55 | 31.22 | 1.77 | 32.66 | 17.95 |
| RDF + residue of FYM @ 4 t ha$^{-1}$ | 17.77 | 33.11 | 1.88 | 35.33 | 18.72 |
| RDF + residue of FYM @ 6 t ha$^{-1}$ | 17.88 | 34.22 | 2.00 | 38.33 | 19.15 |
| RDF + residue of FYM @ 8 t ha$^{-1}$ | 18.00 | 35.22 | 2.00 | 42.66 | 21.54 |
| RDF + residue of FYM @ 10 t ha$^{-1}$ | 18.00 | 36.44 | 2.00 | 45.33 | 22.21 |
| RDF + residue of FYM @ 12 t ha$^{-1}$ | 18.22 | 36.66 | 2.00 | 45.33 | 23.09 |
| C.D. 5% | N.S. | 1.82 | 0.30 | 1.18 | 3.39 |

Table 4 : Effect of organic and inorganic sources of nutrients on the uptake of nutrients (kg ha$^{-1}$) in green gram-mustard-summer groundnut sequence (pooled data of 1999 & 2000).

| Treatment | Pooled data of nutrient uptake (kg ha$^{-1}$) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Green gram | | Mustard | | | Summer groundnut | | | | | |
| | N | P | N | P | K | N | | P | | K | |
| | | | | | | P | H | P | H | P | H |
| Control | 12.8 | 1.7 | 100.3 | 22.6 | 65.9 | 46.2 | 50.8 | 7.8 | 7.4 | 10.0 | 34.2 |
| Conventional system of RDF | 14.9 | 2.0 | 125.8 | 27.2 | 72.7 | 58.6 | 55.6 | 8.7 | 7.5 | 10.2 | 36.4 |
| RDF + FYM @ 2 t ha$^{-1}$ | 16.5 | 2.2 | 127.9 | 27.6 | 74.0 | 66.4 | 59.7 | 9.8 | 8.5 | 11.6 | 41.4 |
| RDF + FYM @ 4 t ha$^{-1}$ | 17.3 | 2.3 | 133.3 | 28.7 | 77.1 | 69.2 | 65.7 | 10.2 | 8.8 | 12.1 | 43.1 |
| RDF + FYM @ 6 t ha$^{-1}$ | 18.4 | 2.4 | 139.5 | 29.9 | 80.7 | 70.8 | 67.2 | 10.5 | 9.1 | 12.4 | 44.2 |
| RDF + FYM @ 8 t ha$^{-1}$ | 18.5 | 2.5 | 141.9 | 30.3 | 82.1 | 75.6 | 71.8 | 11.8 | 10.2 | 14.0 | 49.9 |
| RDF + FYM @ 10 t ha$^{-1}$ | 19.2 | 2.6 | 151.0 | 32.1 | 85.7 | 78.1 | 74.1 | 12.2 | 10.6 | 14.4 | 51.4 |
| RDF + FYM @ 12 t ha$^{-1}$ | 20.4 | 2.7 | 147.2 | 31.4 | 85.2 | 79.4 | 75.4 | 12.8 | 11.1 | 14.9 | 52.1 |
| C.D. 5% | 0.9 | 0.4 | 2.7 | 0.9 | 1.5 | 1.9 | 2.6 | 0.7 | 0.9 | 1.6 | 1.2 |

P = Pod; H= Haulms

was due to cumulative effect of FYM.

***Effect on nutrient uptake :***

The integration of different doses of FYM with RDF significantly improved the N uptake of green gram compared with control and conventional system of RDF and it was the maximum with highest tested dose of FYM. The combination of FYM also significantly enhanced the P uptake of green gram over the control. Further, the effect of 2 and 4 t ha$^{-1}$ FYM on P uptake of green gram was not statistically different from conventional system of RDF that showed marginal benefit in P uptake. The variation in N P uptake of green gram was due to variation in yield levels (Table 4). Similar results on nutrients uptake were also reported by Yadav *et al*. (2003).

The uptake of NPK by the mustard was considerably higher when integration of residue of FYM was done. In such case the higher uptake of NPK nutrients could be due to proper and timely release of nutrients for uptake. The uptake of NPK was less when fertilizers were applied through inorganic source and control. The plant uptake of NPK in mustard followed the pattern of seed yield (Table 4). Similar results have also been reported by Sharma *et al.* (1999).

The uptake of N by pod of groundnut varied phenomenally with in the treatments and indicated

statistical significance. The poor uptake of N (46.2 kg $ha^{-1}$) was associated with control. The integration of remaining residue of FYM accounted for significantly higher N uptake. The highest N uptake was associated with the 12 t remaining residue of FYM $ha^{-1}$, this however was at par with 10 t remaining residue of FYM $ha^{-1}$. The haulms N uptake varied between 50.8 and 75.4 kg $ha^{-1}$ due to the inherent capability of summer groundnut in fulfilling its N requirement. The more beneficial nature of FYM was obvious and it ensured a better nutritional environment. The uptake of P by summer groundnut pod was 7.8 to 12.8 kg $ha^{-1}$ and relatively higher uptake by pod could be well visualized with residue of FYM. The haulms P uptake values varied from 7.4 to 11.1 kg $ha^{-1}$. The uptake of K by pod and haulms of summer groundnut was influenced significantly. With the increasing FYM levels, uptake of K increased and this effect was more pronounced at higher levels of FYM. The cause for such a phenomenon may be attributed to enhanced root growth and N & K content of FYM (Table 4). These observations are in accordance with findings of Parasuraman and Mani (2003).

***Soil fertility :***

In general, improvement in available soil NPK was observed over their initial levels in continuous green gram-mustard-summer groundnut cropping system followed for two years and fertilized with inorganic fertilizers in

Table 5 : Effect of organic and inorganic management on the soil fertility status after two years green gram-mustard-summer groundnut system (pooled data of 1999 & 2000).

| Treatment | Post harvest status | | | | Net change (net gain/loss) | | | |
|---|---|---|---|---|---|---|---|---|
| | O.C. (%) | Available soil N (kg $ha^{-1}$) | Available soil P (kg $ha^{-1}$) | Available soil K (kg $ha^{-1}$) | O.C. (%) | Available soil N (kg $ha^{-1}$) | Available soil P (kg $ha^{-1}$) | Available soil K (kg $ha^{-1}$) |
| Control | 0.46 | 226.6 | 10.2 | 290.3 | +0.01 | +8.4 | +0.2 | +12.3 |
| Conventional system of RDF | 0.47 | 228.9 | 11.2 | 298.3 | +0.02 | +10.7 | +1.2 | +20.3 |
| RDF + FYM @ 2 t $ha^{-1}$ | 0.48 | 233.6 | 11.7 | 303.6 | +0.03 | +15.4 | +1.7 | +25.6 |
| RDF + FYM @ 4 t $ha^{-1}$ | 0.50 | 242.5 | 11.9 | 307.9 | +0.05 | +24.3 | +1.9 | +29.9 |
| RDF + FYM @ 6 t $ha^{-1}$ | 0.52 | 252.3 | 12.3 | 310.2 | +0.07 | +34.1 | +2.3 | +32.2 |
| RDF + FYM @ 8 t $ha^{-1}$ | 0.54 | 261.9 | 12.9 | 313.9 | +0.09 | +43.7 | +2.9 | +35.9 |
| RDF + FYM @ 10 t $ha^{-1}$ | 0.54 | 263.0 | 13.4 | 316.2 | +0.09 | +44.8 | +3.4 | +38.2 |
| RDF + FYM @ 12 t $ha^{-1}$ | 0.55 | 266.7 | 13.8 | 320.7 | +0.10 | +48.5 | +3.8 | +42.7 |
| C.D. 5% | 0.01 | 2.7 | 2.0 | 3.0 | - | - | - | - |

Initial fertility status- O.C. 0.45%, Total N 0.04%, Available soil N 218.2 kg $ha^{-1}$, Available soil P 10 kg $ha^{-1}$ and Available soil K 278.0 kg $ha^{-1}$.

Table 6 : Population of earthworms in the soil after harvesting of green gram.

| Treatment | 1999 | | 2000 | |
|---|---|---|---|---|
| | $Sqm^{-1}$ | $Ha^{-1}$ (Estimated) | $Sqm^{-1}$ | $Ha^{-1}$ (Estimated) |
| Control | 13 | 1,30,000 | 34 | 3,40,000 |
| Conventional system of RDF | 21 | 2,10,000 | 51 | 5,10,000 |
| RDF + FYM @ 2 t $ha^{-1}$ | 57 | 5,70,000 | 81 | 8,10,000 |
| RDF + FYM @ 4 t $ha^{-1}$ | 66 | 6,60,000 | 89 | 8,90,000 |
| RDF + FYM @ 6 t $ha^{-1}$ | 73 | 7,30,000 | 114 | 11,40,000 |
| RDF + FYM @ 8 t $ha^{-1}$ | 91 | 9,10,000 | 117 | 11,70,000 |
| RDF + FYM @ 10 t $ha^{-1}$ | 96 | 9,60,000 | 126 | 12,60,000 |
| RDF + FYM @ 12 t $ha^{-1}$ | 98 | 9,80,000 | 131 | 13,10,000 |

Earthworms demography at initial stage was 2 $Sqm^{-1}$ or 20,000 ha-1 counted after on set of rain.

conjunction with different levels of FYM. The effect of amended FYM was more pronounced than that of conventional system of RDF on the build up of NPK. With regard to NPK balance in the soil, it is evident from data that increase in FYM levels has resulted in substantial increase in soil NPK status (Table 5). Available soil N increased due to integrated nutrient supply with FYM and $N_2$ fixation by green gram and summer groundnut. A considerable build up of available soil P was noticed. This increased availability of nutrients may be assigned usual residual effect of applied P fertilizer. Beside, legume crops i.e. green gram and summer groundnut roots secret certain acidic substances which dissolve insoluble P converting in to easily assimilable form. Available soil K was found to increase over its initial level. This may be due to release of non-exchangeable K on account of addition of organic manure for utilization of green gram-mustard-summer groundnut.

***Earthworms count in soil :***

The population of earthworm was higher in the soil receiving plenty of FYM, inoculated with vermi compost compared with control and conventional system of RDF. With the increasing levels of FYM, population of earthworms increased, it was maximum at RDF + FYM @ 12 t $ha^{-1}$ closely followed by RDF + FYM @ 10 t $ha^{-1}$, while minimum counted at RDF + FYM @ 2 t $ha^{-1}$. The earthworms counted in control and conventional system of RDF plots was less even than to the population counted at lower level of FYM (RDF+FYM @ 2 t $ha^{-1}$). The demography of earthworms was more pronounced to the second year (Table 6). The difference in the earthworms population was due to the variation in the levels of FYM. These results are in line with those of Agasimani *et al.* (1994).

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