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# Effects of sheep manure, plant population and nitrogen levels on growth and fresh fruit yield of chilli pepper (*Capsicum frutescence* l.) at Samaru, Zaria, Nigeria

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## ABSTRACT

Field experiments were conducted between 2004 and 2006 at the Institute for Agricultural Research Farm, Samaru Zaria in the Northern guinea savannah ecological zone of Nigeria, to study the response of chilli pepper (Capsicum frutescence L.) to sheep manure, plant population and nitrogen levels. Treatments evaluated consisted of four levels of sheep manure rates (0 t, 5 t, 10 t, and15 t $ha^{-1}$), three plant populations (22,222; 44,444; and 66,666 plants $ha^{1}$) and four rates of Nitrogen (0kg,60kg 120kg and 180 kg N $ha^{1}$). The treatments were laid out in a split plot design and replicated three times. Result showed that application of sheep manure produced about significant increase in number of branches by 80%, similarly number of fruits increased by more than 600% and fresh fruit yields (Kg $ha^{-1}$) recorded 57% increase over the control. Plant population was observed to significantly increase in the number of fruits per plant with 22,222 and 44,444plant/ha recording similar values, but higher number of fruits produced per plant than 66,666 plants $ha^{-1}$ However, fresh fruit yield of Chilli pepper was not significantly influenced by plant population. The use of 120kgN $ha^{1}$ resulted in increased number of branches, fruit per plant and fresh fruit yields by 57 and 60% respectively over non fertilized plants. Application of sheep manure at 10 t $ha^{1}$, +44,444plants ha and 120kgN ha could be recommended for the production of chilli pepper under rain fed condition in Northern Guinea savannah.

**Keywords**: Chilli pepper; manure; plant population; nitrogen; yield

## INTRODUCTION

Chilli pepper (*Capsicum frutescence* L.) belongs to the family Solanaceae. Chillipepper grown mostly in the tropics as the chief spice for their pungency and widely used in many cuisines to add "heat" to dishes (Purse glove, 1969; Aliyu 2000). Successful pepper production in Nigeria; most especially in the savannah is challenged and limited by low soil nutrient. Supply of soil nutrients had been reported as the most important factor aside moisture, influencing pepper production in Nigeria savannah where most of pepper production takes place, as reported by (Jones, 1977; Mohammed, 1989; Aliyu, 2002, 2003). In Nigeria the traditional bush fallowing had shortened or was abandoned completely in many locations due to scarcity of farmlands further aggravating the issue of low soil fertility.

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Therefore, external sources of nutrients to maintain soil productive capacities are necessary as observed by Chude (1993). However, farmers' access to external sources of nutrients are constrained by low rural income and high cost of inorganic fertilizers among others. Most farmers rely on nutrient recycling (addition of manure and crop residues) for the maintenance of soil fertility. The use of manure in sustaining soil fertility had been linked to its ability to improve the physical and chemical properties of the soils. Manure was reported to gradually release nutrients that closely coincided with plant nutrient demand (Rutunga and Neel, 2006; Odion *et al.,* 2007). The application of manure alone does not compensate for the amount of nutrients removed by crops, this observation was further supported by Powell and Williams (1993), they reported that manure from animals, together with any household refuse were used to fertilize farms. It was widely believed that a much elaborate use of inorganic fertilizer is crucial for achieving the necessary sustainable increase in food supply and its quality. High cost, scarcity, adulteration and general inefficiency characterized the use of inorganic fertilizer in Nigeria and most other African countries. Bationo *et al.* (2000) observed that the efficiency of fertilizer increased dramatically when combined judiciously with organic nutrients sources. Aliyu (2000a) reported higher yields of pepper with the application of manure supplemented with inorganic fertilizer. Similarly, Iwuafor *et al.* (2002) reported enhanced efficiency of inorganic fertilizer with improved soil fertility as a result of manure application, leading to an indirect effect on nitrogen availability to the crop. One of the problems faced in an attempt to increase crop productivity was how to manipulate plant population for optimum efficiency. Farmers space crops too widely apart resulting in poor ground cover for much of the growing season. It was reported that the manipulation of plant population had greatly improved crop productivity per unit area (Singh and Ajeigbe,2000). In Northern Nigeria, farmers generally practice mixed faming, thus every farming household keep small ruminants and these produce manure on daily basis. During the Eid-el-Kabir festival tens of thousands of sheep are also brought into the country and these produce large quantities of manure which sometimes constitutes environmental problem. Adequate information on the benefit of and the use of sheep manure would allow it to be better disposed of, which would also enrich the soil and improve crop production. Hitherto, chilli pepper is grown in small plots intercropped with cereals and legumes. Thus, there is the tendency to use low plant population with subsequent resulting in low productivity. However due to the rising price of pepper, more land is now being devoted to the production of the crop and is being grown as sole hence the need to determine the appropriate plant population for higher yields. The research was conceived to address the gap of information on the effect of sheep manure on pepper and to update information on the response of pepper yields to nitrogen and plant population and also to determine the appropriate combination rate of the nutrient sources (organic & inorganic) to adopt for production under sole crop of chilli pepper.

## MATERIALS AND METHODS

### Study Area

Field experiments were conducted during the wet seasons (July to November) of 2004, 2005 and 2006 respectively, at the Institute for Agricultural Research Farm (IAR) Ahmadu Bello University Samaru, Zaria ($11^{0}11^{i}$\`N; $07^{0}$ $38^{i}$\`E) 686 m above sea level located in the Northern Guinea Savannah zone of Nigeria. The climate of the savannah has a mean annual rainfall of about 1000mm to1500mm, while the monthly mean temperature ranges from 22°C during nighttime to 33°C in the daytime. The savannas have several months of dryness, followed by a rainy season that lasts 6-8 months. The Northern guinea savanna (or savanna woodland/wooded savanna) is the most extensive vegetation in Nigeria ecosystem and consist of a mixture of trees and grass. As described by Sarumi *et al*. (1996), is situated in the humid tropical savanna zone, characterised by the trees being sufficiently widely spaced that the canopy does not close. The open canopy allows sufficient light to reach the ground to support an unbroken herbaceous layer consisting primarily of grasses. The major soils found in the ecological zones have coarse-textured surface soil and are low in organic matter and chemical fertility. Although, yields can be improved by addition of inorganic and organic fertilizer, Vanlauwe *et al*. (2002) and Chude (1993).

**Treatments, Experimental Design and Field layout**

The experiment consisted of forty-eight (48) treatment combinations made up of four rates of sheep manure (0, 5, 10 and 15 tons ha$^{-1}$), three plant populations (22,222; 44,444; 66,666 plants ha$^{-1}$); and four levels of nitrogen (0, 60, 120 and 180 kg N ha$^{-1}$). The experimental design used was a split-plot design (main and sub plot). Combination of plant population and nitrogen levels allocated to the main plot; while sheep manure was assigned to the sub-plot and replicated three times. Plots were separated by a path one meter wide, and a 2 m path was maintained between blocks. Inter-row spacing of 75cm was used, while Plants were spaced 60, 30 and 20cm to achieve the plant population treatments 22,222; 44,444; 66,666 plantsha$^{-1}$. Gross-plot size was 9m$^{2}$, and the net plot size was 4.5 m$^{2}$ Chilli pepper (*Capsicum frutescens* L) variety 'DANTSIGA' an improved local variety was used. Chilli pepper seedlings were raised for transplanting by sowing the seeds on a prepared seedbed of 1 x 2m. Seedlings were properly taken care of until the fifth week after emergence before being transplanted to the field.

The field was ploughed and harrowed twice each year to a fine tilt after which the field was ridged 75cm between rows. Field was laid out into plots. Sheep manure was applied to the designated plots as per treatments, two weeks before transplanting to allow for equilibration. Healthy and uniform sized seedlings were removed from the nursery to the field on 8$^{th}$, 9$^{th}$ and 12$^{th}$ July in 2004, 2005 and 2006, respectively. Transplanting was done after a good heavy rainfall. Seedlings were transplanted on ridges 75cm apart at a spacing of 20, 30 and 60cm within row to achieve the desired population of 66,000; 44,000 and 22,000 plants ha$^{-1}$ respectively. Nitrogen fertilizer was applied using urea in two split doses at two and six weeks after transplanting. by side dressing as per the treatments. Weeds were controlled by hoe weeding. at 2, 4, 6 and 8 weeks after transplanting (WAT). Re-moulding was also done at 12 WAT. Farm sanitation through weeding, roughing plants with signs or symptoms of diseases and/or pests as well as constant monitoring prevented outbreaks in the field during the crop growth cycle. Harvesting was carried out at weekly intervals. It started at the 18$^{th}$ week after transplanting (WAT). At each harvest, fully ripe fruits were hand-picked manually.

**Data Collection and Analysis**

Data on growth characters on per plant basis were taken from five tagged plants at two weeks interval beginning from the (6$^{th}$) sixth week after transplanting. The leaf area index was measured using handheld leaf area meter and CGR Crop growth rate which is dry matter accumulation per unit of land area per unit of time, was determined using the procedure described by (Watson, 1958).and expressed in $g/cm^2/wk$. Yield and yield components values measured were recorded at harvest on a per plant and net plot basis.

Data collected were subjected to analysis of variance for split plot design to test the significance of treatment means as described by Snedecor and Cochran (1967). Significant means ($p<0.05$) were compared using Duncan Multiple Range Test (DMRT) Duncan (1955).

## RESULTS AND DISCUSSION

### Soil and Manure

The physical and chemical properties of the soils collected at different depths of 0-15 and 15-30cm from the experimental sites before cropping as well as chemical composition of samples of sheep manure used is presented in Tables 1 and 2 respectively.

Table 1: Physico– chemical properties of soils of the experimental site during 2004, 2005 and 2006 rainy seasons at Samaru.

| Soil Depth (cm) | 2004 | | 2005 | | 2006 | |
|---|---|---|---|---|---|---|
| | 0 – 15 | 15 – 30 | 0 – 15 | 15 – 30 | 0 – 15 | 15 – 30 |
| Physical composition (%) | | | | | | |
| Sand | 46 | 40 | 36 | 28 | 34 | 30 |
| Silt | 34 | 40 | 50 | 50 | 44 | 42 |
| Clay | 20 | 20 | 14 | 22 | 22 | 28 |
| Textural class | Loamy | | Silt Loam | | Loamy | |
| Chemical composition | | | | | | |
| pH in water | 4.80 | | 6.31 | | 6.70 | |
| pH in 0.01ml $Cacl_2$ | 4.30 | | 5.80 | | 6.05 | |
| Organic Carbon $gkg^1$ | 0.024 | | 0.034 | | 0.036 | |
| Total Nitrogen ($gkg^1$ | 0.007 | | 0.011 | | 0.012 | |
| Available Phosphorus $mgkg^1$ | 2..05 | | 2..11 | | 2.92 | |
| Exchangeable Bases ($Cmol/kg^1$) | | | | | | |
| Ca | 4.10 | | 5.6 | | 4.8 | |
| Mg | 2.20 | | 0.37 | | 1.8 | |
| Na | 0.16 | | 0.13 | | 0.18 | |
| K | 0.41 | | 0.41 | | 0.46 | |
| CEC | 8.6 | | 7.4 | | 6.8 | |

Table 2: Chemical content of sheep manure analysis during the experimental period of 2004, 2005 and 2006 wet season at Samaru

| Chemical Properties (%) | Seasons (Year) | | |
|---|---|---|---|
| | 2004 | 2005 | 2006 |
| Total Nitrogen | 3.02 | 3.30 | 3.20 |
| Phosphorus | 0.21 | 0.22 | 0.22 |
| Potassium | 2.22 | 2.70 | 2.60 |
| Calcium | 0.21 | 0.24 | 0.24 |
| Magnesium | 0.30 | 0.32 | 0.31 |
| Organic carbon | 34.91 | 38.91 | 36.81 |

Result indicated that the total soil N is low, similarly the available phosphorus $g/kg^1$ soil, exchangeable potassium, $cmol/kg^1$ were low. The exchangeable bases were also low. The soil textural class was loamy. Silt loam and loamy in 2004,2005 and 2006 respectively. Chude (1993) asserted that most soils in Nigeria are potentially low in natural fertility and therefore cannot sustain high crop yields under continuous cultivation hence the need to supplement available nutrients from external sources, for improved crop productivity.

**Effect of Sheep Manure on Growth and Yield of Chilli Pepper**

From this study it was observed that application of sheep manure influenced most growth and yield parameters of chilli pepper (*Capsium fritescens* L.) over the control during the sampling periods (Table 3). Plant height and number of branches showed a highly significant increase with sheep manure rate compared with the control in all the weeks sampled. The response had been associated with an increase in mineralized nutrients improved soil physical and chemical conditions. This was in agreement with the report of Anon (2007b), who postulated that manure contained both micro and macro nutrients that were gradually released to crops as they mineralized. Sheep manure applied at 10t $ha^1$ increased LAI (p0.05) at 12WAT and CGR of 2.40 and 5.37 at 10 and 12 WAT (Table 4.) The improved availability of plant nutrients that necessitated an efficient rooting system, and the formation of chlorophyll, lead to production of biomass that eventually translated into higher final fruit yields. Highly significant response shown by yield characters such as fruits per plant, and fresh fruits yield $kgha^{-1}$ (Table 5) when the rate of applied sheep manure was raised to 10 t $ha^{-1}$. This could be attributed to the ability of manure to supply N, K and carbon, available P and other essential nutrients needed by chilli pepper plant. These nutrients were moderately released leading to longer periods of supply. The slow release of nutrients induced sustained appropriate growth but not excessive vegetatively. Efficient partitioning of large reserve of assimilate produced enhanced dry matter accumulation, hence the high fruit yields recorded. This observation agrees with the findings of Aliyu and Kuchinda (2002), Aliyu (2002) Dauda et. al, (2005), and Anon (2007a) Yahaya *et al*. (.2013) who reported that nutrients in manures most especially nitrogen and other elements become available more slowly extending to the latter part of the growing season benefitting chilles being an indeterminate crop ensuring more yield.

**Effect of Plant Population on Growth and Yield of Chilli Pepper**

The number of branches in chilli pepper was influenced by plant population (Table 3). It was observed that the use of a population of44,444 plants $ha^{-1}$ was similar with 22,222 plants $ha^{-1}$ but higher than that of 66,666 $ha^{-1}$ in terms of number of branches. The increase in height and reduction in number of branches at 66,666 plants $ha^{-1}$ could be ascribed to the reduction in growth factors and moisture available to the individual plant as a result of stiffer competition between stands in dense canopies. The quest for solar radiation leads to etiolating; hence taller plants emerged with fewer branches. The competition between and within stands for water, mineral salts, and environmental factors (i.e. solar radiation and $C0_2$) resulted in decreased assimilates production and partitioning thereby leading to decrease growth. LAI and CGR at 10 WAT were increased ($p< 0.05$) with corresponding increase in plant population (Table 4). This could be attributed to interception of more solar radiation by plant per unit area which implied higher efficiency in converting the available light to photo assimilate. The highest population in this study 66,666 plants ha$^{-1}$ produced statistically comparable yields with 44,444 plants ha$^{1}$. This is an indication that potentials of higher population yielding more was contestable under this study. Even though the population was higher by one third (1/3), this implied that under good management a farmer could save the cost of using more seedlings to achieve higher yields. The non-significant difference in fresh fruit yield could be due to competition for growth factors at the higher population levels which was not compensated by the increase in plants per area, this agrees with the report o of Mohammad and Yahaya (2018). Peppers grown at the lower population were able to utilize more of the growth resources (moisture, nutrients, light and space) more efficiently than those grown under stressed conditions of high population. The fewer but heavier fruits produced at low plant population were able to neutralize the advantages due to higher harvestable fruit at higher plant population, thereby leading to statistical similarity in fruit yieldha$^{-1}$ among the various plant population used.

Table 3: Effect of treatments on plant height (cm) and number of branches of pepper during 2004, 2005 and 2006 wet seasons at Samaru (combined mean of the 3 years)

| Treatments | Plant Height (cm) | | | Branches | | |
|---|---|---|---|---|---|---|
| | 6WAT | 8WAT | 10WAT | 6WAT | 8WAT | 10WAT |
| Manure rates t/ha | | | | | | |
| 0 | 26.48b | 40.53b | 50.63c | 16.44c | 43.94b | 63.31c |
| 5 | 28.84a | 43.86a | 59.39b | 19.34a | 52.57a | 77.85b |
| 10 | 29.49a | 45.15a | 69.60a | 20.57a | 51.46a | 86.28a |
| 15 | 28.17a | 48.98a | 68.29a | 18.86b | 50.94a | 78.05b |
| SE-+ | 0.57 | 0.71 | | 1.13 | 1.45 | 1.26 |
| Plant population pl/ha$^{1}$ | | | | | | |
| 22,222 | 27.53 | 43.82 | 58.96 | 18.67a | 49.81a | 97.11a |
| 44,444 | 28.06 | 44.03 | 59.24 | 19.04a | 51.21a | 95.61a |
| 66,666 | 29.29 | 46.77 | 63.19 | 12.41b | 26.67b | 44.15b |
| SE -+ | 1.79 | 2.30 | 2.85 | 1.20 | 2.50 | 4.8 |
| Nitrogen kgNha$^{-1}$ | | | | | | |
| 0 | 26.61 | 38.07c | 45.81d | 15.04c | 40.44c | 55.22c |
| 60 | 28.62 | 42.95b | 54.84c | 21.36b | 48.87b | 74.94b |
| 120 | 29.04 | 44.80b | 65.32b | 27.44a | 55.97a | 99.15a |
| 180 | 29.22 | 53.36a | 77.90a | 25.06a | 53.25a | 94.77a |
| SE+- | 1.55 | 1.99 | | 0.98 | 2.29 | 2.81 |
| Interactions | | | | | | |
| MXP | ns | ns | ns | ns | ns | ns |
| MXN | ns | ns | ns | ns | ns | ns |
| PXN | ns | ns | ns | ns | ns | ns |
| MXPXN | ns | ns | ns | ns | ns | ns |

Means followed by the same letter(s) within a column are not significantly different at 5%using DMRT

**Effect of Nitrogen on Growth and Yield of Chilli Pepper**

Nitrogen application to pepper resulted in an increase in plant height, number of branches (Table 3) in all the seasons, this could be due to the ability of nitrogen to promote aerial vegetative growth as an important constituent of chlorophyll, amino and Nucleic acids.

The role of N in enhancing photosynthetic processes resulted in the production of more assimilates, used in vegetative development through meristematic tissue differentiation. This corroborated the findings of Olson *et al*. (1991); Mohammad and Yahaya (2018), who reported significant response to N application by growth parameters of pepper. A highly significant response to nitrogen was observed on LAI and CGR (Table 4). This is an indication that chillies through nitrogen supplementation have enhanced the development of vegetative structures with larger surface area for light interception for more and assimilate synthesis leading to the production of more dry matter this enhanced dry matter accumulated led to improved final fruit yields. This finding agreed with the report of Aliyu (2002) and Watson (1952) concluded that differences existed between and within species, but productivity was much more related to leaf area components.

Table 4: Effect of treatments on LAI and CGR of Chilli pepper during 2004, 2005 and 2006 wet seasons at Samaru (combined mean of the 3 years)

| Treatments | LAI | | | Crop Growth Rate | |
|---|---|---|---|---|---|
| | 8WAT | 10WAT | 12WAT | 10WAT | 12WAT |
| Manure rates t/ha | | | | | |
| 0 | 0.272 | 0.591 | 0.563 | 2.03b | 4.20b |
| 5 | 0.289 | 0.636 | 1.226b | 2.23b | 4.80b |
| 10 | 0.311 | 0.652 | 1.328a | 2.40a | 5.37a |
| 15 | 0.286 | 0.633 | 1.180b | 2.34a | 4.96a |
| SE-+ | 0.046 | 0.233 | 0.032 | 0.11 | 0.23 |
| Plant Population pl/ha1 | | | | | |
| 22,222 | 0.148 | 0.321c | 0.557c | 2.20b | 4.91 |
| 44,444 | 0.301 | 0.646b | 1.167b | 2.35a | 5.40 |
| 66,666 | 0.421 | 0.918a | 1.885a | 2.37a | 4.10 |
| SE -+ | 0.017 | 0.020 | 0.058 | 0.11 | 0.29 |
| Nitrogen kgNha1 | | | | | |
| 0 | 0.260b | 0.491c | 0.871c | 0.97b | 3.59b |
| 60 | 0.311a | 0.603b | 1.162b | 2.40a | 5.40a |
| 120 | 0.329a | 0.706a | 1.418a | 2.80a | 5.18a |
| 180 | 0.295a | 0.725a | 1.404a | 2.48a | 4.98a |
| Interactions | | | | | |
| MXP | ns | ns | Ns | ns | ns |
| MXN | ns | ns | Ns | ns | ns |
| PXN | ns | ns | ns | ns | ns |
| MXPXN | ns | ns | ns | ns | ns |

Means followed by the same letter(s) within a column are not significantly different at 5%using DMRT

Nitrogen increased the performance of yield characters as well as the final yield (Table 5). This could be due to the cumulative effect of N assimilated which stimulates vegetative growth, resulting in more assimilated produced and partitioned to the sink after satisfying the physiologic and metabolic requirement of the vegetative robust plant. Generally, an increase in pepper fruits per plant and fruit yields per $ha^1$ due to N application was observed, and highest values produced at $120kgNha^{-1}$application level since N is a component of chlorophyll an increase in N application level is believed to positively enhance its content thereby enhancing the photosynthetic activity leading to higher assimilate production. This will translate to an increment in the final fruit yield. The reduction in fruit yields when the highest N rate was applied, could be due to the fact that the requirements for these parameters were mostly satisfied at 120kgNha$^{-1}$ and above it resulted in extensive vegetative growth in terms of taller height and a greater number of branches at the expense o fruit production. This is could also be attributed to the negative effect of luxury consumption that is characterized by higher biomass production at the expense of fruiting and yields. Aliyu *et al*. (1996) and Aliyu (2000b) reported that too much nitrogen reduces fruit number and yield.

Table 5: Effect of treatments on number of fruits per plant and fresh fruit yield of chilli pepper combined data during 2004-2006 wet season at Samaru (combine mean of 3years)

| Treatments | Number of fruits/plant | Fresh fruit yield t/ha |
|---|---|---|
| Manure rate t/ha | | |
| 0 | 87.39c | 1317.73b |
| 5 | 225.47b | 2970.42a |
| 10 | 284.61a | 3003.63a |
| 15 | 222.98a | 2835.42a |
| SE+ - | 3.40 | 68.40 |
| Plant population p/ha | | |
| 22,222 | 294.17a | 2867,63 |
| 44,444 | 284.65a | 2973.23 |
| 66,666 | 170.62b | 2804.63 |
| SE+- | 14.20 | 90.10 |
| Nitrogen levels kg N/ ha | | |
| 0 | I26.74d | 1952.33c |
| 60 | 190.71c | 2974.82b |
| 120 | 302.25a | 3505.14a |
| 180 | 250.64b | 3083.94a |
| SE+- | 4.04 | 31.01 |
| Interaction I | | |
| SXP | ns | ns |
| SXN | ** | ns |
| PXN | ns | ns |
| SXPXN | ns | ns |

Means followed by the same letter(s) within a column are not significantly different at 5%using DMRT

Table 6: Interaction between sheep manure and nitrogen on number of fruits per plant at samara during 2004,2005 and 2006 wet seasons (combined mean of 3years)

| Treatments | Nitrogen Levels (Kg N ha$^{1}$) | | | |
|---|---|---|---|---|
| | 0 | 60 | 120 | 180 |
| Sheep manure | | | | |
| 0 | 108 k | 229h | 354b | 289e |
| 5 | 163 j | 246gh | 399a | 305d |
| 10 | 198 i | 275f | 410a | 334c |
| 15 | 190i | 276f | 413a | 321cd |
| SE+-- | | 5.97 | | |

Interaction means followed by unlike letter(s) are significantly different at 5 and 1 percent level of significance using DMRT

## CONCLUSION

From the findings of this study, chilli pepper growth parameters and fruit yields significantly increased by application of sheep manure. Fruits per plant and fresh fruits yield were both maximized at lower plant population. LAI, branching fruits per plant and fresh fruit yields were enhanced by N rates. Higher values for most of the parameters measured were attained at 120kgNha$^{-1}$ + 5t ha$^{-1}$ sheep manure signifying that the crop's requirement for these important factors was met at these rates. In the light of this study the use of 120kgN ha$^{1}$ + 5t ha$^{1}$ and 44,444 plant ha$^{1}$ could be recommended chilli pepper growers.

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