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Effect of integrated nutrient management on growth and yield attributes of cluster bean under South Gujarat conditions

Upma Gamit, DR Bhanderi, RV Tank and KS Vaghela

Abstract
The field trial was conducted to find out the effect of integrated nutrient management on cluster bean at Navsari Agricultural University during year 2021 and 2022. The experiment comprised of 12 treatment combinations having three level of chemical source of nutrient (C_1: 100% RDF, C_2: 75% RDF and C_3: 50% RDF) and four levels of organic source of nutrient (O_1: control (No organics), O_2: PSB, O_3: *Rhizobium*, and O_4: NOVEL prime organic liquid nutrient) in randomized block design (factorial concept) with three replications. Among three levels of chemical source of nutrient application of 100% RDF (C_1) helped in obtaining maximum values for growth parameters *viz*., plant height, number of leaves at 60 and 90 DAS, fresh biomass of plant at harvest and stem diameter, yield parameters i.e., pod length, pod width, number of clusters plant^{-1}, number of pods cluster^{-1}, number of pods plant^{-1}, dry matter yield, fresh pod yield and harvest index. Whereas, maximum values for growth parameters and yield attributes were noted when plants were treated with NOVEL prime organic liquid nutrient (O_4). Interaction of 100% RDF and NOVEL prime organic liquid nutrient found superior over all the treatment combination for yield parameters i.e., number of pods plant^{-1}, dry matter yield and fresh pod yield.

Keywords: Cluster bean, integrated nutrient management, chemical source of nutrient, organic source of nutrient, growth parameters and yield attributes

Introduction
Cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] popularly known as "*Guar*" is an important vegetable crop mainly grown as a summer crop in South Gujarat region. In Gujarat, horticultural crops occupy 19,77,405 ha area with production of 2,50,51,540 MT. Among that, vegetable crops occupy 7,99,532 ha with production of 15,41,157 MT. While, cluster bean occupies area of 44,022 ha with production of 4, 31, 045 MT. In South Gujarat, cluster bean is mainly cultivated in Surat, Narmada, Bharuch, The Dangs, Navsari, Valsad and Tapi districts. Cluster bean occupies 5544 ha area under south Gujarat region with production of 47,645 MT (Anon., 2020) [1]. Pods of cluster bean are rich in food value and each 100 g contains 10.8 g carbohydrate, 3.2 g protein, 1.4 g minerals, 316 IU vitamin-A, 47 mg Vitamin-C and Vitamin K. It contains approximately 75 per cent dietary fiber; allows fiber to be added to a food with a minimal effect on taste and texture. Among vegetable crops, guar occupies an important place in the national economy because of its industrial importance mainly due to the presence of gum in its endosperm (35 to 40%). Cluster bean is grown for different purposes *viz*., vegetable, green fodder, manure and feed from very ancient times.
In the modern cultivation of horticultural crops, heavy amount of fertilizer is consumed. The fertilizers are not only short in supply but, costly also and produced at the cost of irreparable loss of non- renewable energy. In view of escalating cost, it will be major limiting factor for increasing agricultural production in days to come. Therefore, it has been essential to evolve and adopt a suitable strategy for integrated nutrient supply by using a judicious combination of chemical fertilizers, organic manures and biofertilizers and other organic inputs etc. It will be useful in curtailing over dependence on fertilizer for nutrient supply to plant (Singh, 2018) [23].
Nitrogen fixing, phosphate solubilizing bacteria and potassium solubilizing bacteria are main biofertilizers for horticultural crops. These micro- organisms are either free living or symbiotic with plant and contribute directly or indirectly towards major nutrients required by the plant. They also produce hormones, vitamins and other growth factors required for the growth and development of plant (Singh, 2018) [23]. NOVEL Prime organic liquid nutrient is a new generation crop protector which is used as organic fungicide.

It is an upgraded product of Navsari Agricultural University similar to Novel organic liquid nutrient but it has additional fungicidal properties which is due to incorporation of formulation made from different botanical species.

The nutrient management thus, assumes importance to sustain productivity. Low-cost nutrient supplementation through bio fertilizers as integrated nutrient management (INM) supply system may be a better option to fulfil nutrient requirement of the crop. FYM is rich in nutrients required by plant and helps to buffer soils against rapid chemical changes. It also acts as a source of energy for the growth of soil microbes and improvement in organic carbon, available nitrogen, phosphorus, potassium etc.

Materials and Methods

The present investigation was laid out at Vegetable Research Farm, Regional Horticultural Research Station, ASPEE College of Horticulture and Forestry, Navsari Agricultural University, Navsari during summer season of 2021 and 2022. According to agro-climatic conditions of Gujarat state, Navsari falls under 'South Gujarat Heavy Rainfall Zone, AES-III'. The climate of this zone is typically tropical and monsoonic. An average rainfall of the tract is about 1500 mm and is normally receive by second fortnight of June and cease by September end.

The soil is black cotton soil with a pH of 7.78, available nitrogen (300 kg ha^{-1}), available phosphorus (45.67 kg ha^{-1}) and available potash (538.272 kg ha^{-1}), respectively. The experiment is conducted in randomized block design (factorial concept) with three chemical source of nutrient (100% RDF, 75% RDF and 50% RDF) and four level of organic source of nutrient (control (no organics), PSB, Rhizobium and NOVEL prime organic liquid nutrient). All treatments were replicated three times. The seeds were directly sown in the experimental plot at a distance of 45 cm between row and 30 cm within the row on 24th February, 2021 in first year and on 21st February, 2022 in second year. The chemical fertilizers were applied at the rate of 20:40:00 NPK kg ha^{-1}, respectively. Nitrogen was applied in two splits. First half quantity of nitrogen was given at the time of sowing along with entire dose of phosphorus and potash. Remaining half quantity of nitrogen was given at flowering stage. For the establishment of the crop, the first irrigation was given immediately after sowing. The subsequent irrigation was given as required, depending upon soil moisture and weather conditions. For effective control of weeds pre- emergence herbicide pendimethalin was applied after a day of sowing. Hand weeding was also carried out as and when required throughout the period of experimental field to keep the field weeds free.

The observation was recorded growth parameters *i.e.*, plant height (cm), number of leaves $plant^{-1}$, fresh biomass (t ha^{-1}) and stem diameter (cm); and yield parameters *viz.*, pod length, pod diameter, number of cluster $plant^{-1}$, number of pods $cluster^{-1}$, number of pods $plant^{-1}$, dry matter yield (kg ha^{-1}), fresh pod yield (kg ha^{-1}) harvest index (%). Statistical analysis of data obtained in different set of experiments was calculated following the standard procedure as stated by Panse and Sukhatme (1985) [14].

Results and Discussion

Effect of chemical source of nutrient on growth and yield attributes of cluster bean

The data enumerated in (Table 1 and 2) shows that chemical source of nutrient had significant effect on growth parameters *i.e.*, cluster appears, plant height, number of leaves $plant^{-1}$, fresh biomass (t ha^{-1}) and stem diameter (cm) and yield attributes *viz*., pod length, pod diameter, number of cluster $plant^{-1}$, number of pods $cluster^{-1}$, number of pods $plant^{-1}$, dry matter yield (kg ha^{-1}), fresh pod yield (kg ha^{-1}) harvest index (%) (Table 3, 4 and 5). Among different levels of chemical source of nutrient, plants applied with 100% RDF (C_1) recorded maximum values for plant height (137.42 cm), number of leaves at 60 and 90 DAS (16.01 and 29.07, respectively), fresh biomass of plant at harvest (16.38 t ha^{-1}) and stem diameter (1.14 cm). Increase in growth parameter with 100% RDF (C_1) might be due to increased availability of nutrients to plant initially through chemical fertilizers which increases photosynthetic activity and more production of photosynthates led to increase in plant height, number of leaves $plant^{-1}$ and stem diameter and this ultimately increased fresh biomass of plant. This result is in line with findings of Sammauria *et.al* (2009) [19], Ayub *et al.* (2012) [4], Usha *et al.* (2018) [25] in cluster bean and Samapika *et al.* (2019) [17] in Dolichos bean. Whereas, in case of yield attributes *viz*., maximum pod length (10.57 cm) and pod width (0.75 cm), number of clusters $plant^{-1}$ (24.81), number of pods $cluster^{-1}$ (4.14), number of pods $plant^{-1}$ (103.11), dry matter yield (1706.19 kg ha^{-1}), fresh pod yield (10526.63 kg ha^{-1}) and harvest index (38.95%) were also reported with 100% RDF (C_1). Increased supply of N and P and their higher uptake by plants might have stimulated the rate of various physiological processes in plant and resulted in higher biomass synthesis and amount of food material which was later translocated into developing plant parts resulting in increased number of clusters $plant^{-1}$, pods $cluster^{-1}$, number of pods $plant^{-1}$, pod length and pod diameter which led to increase in fresh pod yield (kg ha^{-1}). The higher dry matter (kg ha^{-1}) accumulation $plant^{-1}$ might be due to higher availability of nutrient which resulted in higher growth and development of the plant. Harvest index is mainly on account of increase in the growth parameters and yield attributes of cluster bean which resulted in higher production of photosynthates were utilized by the plant for development of sink under adequate supply of nutrients due to increasing in rate of inorganic fertilizer. Sammauria *et al*. (2009) [19], Kumhar *et al*. (2012) [12], Bathal and Kumar (2016) [5], Anuradha *et al*. (2017) [3], Usha *et al*. (2018) [25] and Seerangan *et al*. (2019) [21] in cluster bean, Anupma *et al*. (2014) [2] in dwarf pea, Kamble *et al*. (2016) [9] in French bean, Singh *et al*. (2017) [3] in chick pea, and Pargi *et al*. (2018) [15] in cowpea.

Table 1: Effect of integrated nutrient management on plant height, number of leaves plant^{-1} of cluster bean

Treatment	Plant height (cm)			Number of leaves plant^{-1} at 60 DAS			Number of leaves plant $^{-1}$ at 90 DAS		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Factor 1: Chemical source of nutrient									
C_1: 100% RDF	138.37	136.47	137.42	17.93	14.09	16.01	31.33	26.80	29.07
C_2: 75% RDF	136.85	134.76	135.81	17.44	13.80	15.62	30.63	26.17	28.40
C_3: 50% RDF	130.21	128.13	129.17	15.00	12.00	13.50	26.90	23.44	25.17
S.Em±	0.78	1.01	0.64	0.30	0.31	0.21	0.40	0.43	0.29
CD at 5%	2.30	2.96	1.82	0.87	0.90	0.61	1.19	1.25	0.84
Factor 2: Organic source of nutrient									
O_1: Control (No organics)	130.62	128.44	129.53	15.72	12.27	14.00	28.11	23.88	25.99
O_2: PSB	134.94	132.32	133.63	16.64	12.61	14.63	28.98	25.18	27.08
O_3: *Rhizobium*	136.89	135.09	135.99	17.06	13.42	15.24	29.73	25.98	27.86
O_4: NOVEL prime	138.12	136.63	137.38	17.73	14.89	16.31	31.67	26.84	29.26
S.Em±	0.90	1.17	0.74	0.34	0.35	0.25	0.47	0.49	0.34
CD at 5%	2.65	3.42	2.10	1.01	1.04	0.70	1.37	1.44	0.97
Interaction (C×O)									
S.Em±	1.56	2.02	1.27	0.59	0.61	0.43	0.81	0.85	0.59
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	2.00	2.62	2.33	6.12	8.00	6.95	4.73	5.80	5.23
Interaction pooled									
Source	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O
S.Em±	0.90	1.04	1.81	0.30	0.35	0.60	0.42	0.48	0.83
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 2: Effect of integrated nutrient management on fresh biomass of plant and stem diameter of cluster bean

Treatment	Fresh biomass of plant at harvest (t ha^{-1})			Stem diameter (cm)		
	2021	2022	Pooled	2021	2022	Pooled
Factor 1: Chemical source of nutrient						
C_1: 100% RDF	16.47	16.28	16.38	1.14	1.13	1.14
C_2: 75% RDF	16.37	16.15	16.26	1.14	1.12	1.13
C_3: 50% RDF	14.60	14.10	14.35	1.01	1.03	1.02
S.Em±	0.27	0.24	0.18	0.01	0.02	0.01
CD at 5%	0.80	0.70	0.52	0.03	0.07	0.04
Factor 2: Organic source of nutrient						
O_1: Control (No organics)	15.11	14.65	14.88	1.03	1.04	1.03
O_2: PSB	15.49	15.24	15.37	1.09	1.07	1.08
O_3: *Rhizobium*	16.28	16.07	16.17	1.11	1.10	1.11
O_4: NOVEL prime	16.38	16.07	16.22	1.16	1.15	1.16
S.Em±	0.32	0.28	0.21	0.01	0.03	0.01
CD at 5%	0.93	0.81	0.60	0.04	0.08	0.04
Interaction (C×O)						
S.Em±	0.55	0.48	0.36	0.02	0.05	0.03
CD at 5%	NS	NS	NS	NS	NS	NS
CV (%)	6.01	5.37	5.71	3.69	7.23	5.73
Interaction pooled						
Source	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O
S.Em±	0.26	0.30	0.52	0.02	0.02	0.04
CD at 5%	NS	NS	NS	NS	NS	NS

Effect of organic source of nutrient on growth and yield attributes of cluster bean

Data described in (Table 1, 2, 3, 4 and 5) shows that Organic source of nutrient had significant effect on growth as well as on yield attributes of cluster bean. Maximum plant height (137.38 cm), number of leaves at 60 and 90 DAS (16.31 and 29.26, respectively), fresh biomass of plant at harvest (16.22 t ha^{-1}) and stem diameter (1.16 cm) was obtained with NOVEL prime organic liquid nutrient (O4), Increase in growth parameters with application of NOVEL prime organic liquid nutrient (O4) might be due to fostered meristematic activities which was catalyzed by growth regulator in novel prime organic liquid nutrient *viz*., gibberellic acid, naphthalic acetic acid and cytokinin which leads to enhance cell division and cell elongation because they act on all developmental plant processes, ultimately enhanced photosynthesis this led to increases plant height (cm), number of leaves plant^{-1}, fresh biomass of plant (t ha^{-1}) and stem diameter (cm). These results are in conformity with results of Himani, (2018) [8] in cluster bean, Savaliya (2020) [20] in cowpea, Champaneri, (2020) [6] in Indian bean, Salunkhe *et al.* (2013) [18] in onion and Desai *et al.* (2018) [7] in tuberose.

NOVEL prime organic liquid nutrient had positive effect on yield attributes with maximum values of pod length (10.51 cm) and pod width (0.74 cm), number of cluster plant^{-1} (25.01), number of pods clusters^{-1} (4.10), number of pods plant^{-1} (104.64), dry matter yield (1821.09 kg ha^{-1}), fresh pod yield (10558.90 kg ha^{-1}) and harvest index (39.17%). There is higher amount of macro and micro nutrients as well as growth promoting substances present in Novel prime organic liquid nutrients. This treatment produces higher leaf area, which might be associated with higher production of clusters plant^{-1}.

The increased leaf area naturally produced more photosynthates and the movement of these photosynthates from source to sink might help in increasing number of clusters plant^{-1}. Moreover, NOVEL prime contains Zn that helps in increasing pollen producing capacity, size and viability of the pollen grains that leads to better pollination and also have positive effect on the synthesis and activity of chlorophylls; thereby it increases the Photosynthesis. Ability to photosynthesize and produce more food increases the generative power; whereby the plant can hold more fruits. The augmentation in yield is closely associated with components like number of clusters plant^{-1}, number of pods cluster^{-1}, pods plant^{-1}, pod length and pod width recorded the highest values in this treatment. Additionally, this effect might be contributed to easy assimilation of nutrients and balance in NPK ratio, leads to improved crop production. The application of water-soluble nutrients accelerates an uptake of water and nutrients, commanding higher photosynthesis and enhanced food accumulation in edible parts. This accumulation of food in edible part *i.e.*, number of clusters plant^{-1} and pods cluster^{-1}, ultimately leads to increase pod yield. The efficient partitioning of photosynthates towards the sink might be the cause for enhanced biomass which may have led to increased dry matter yield. Growth regulator and micronutrient present in NOVEL prime which increase plant biomass, total dry matter of plant that might have led to highest harvest index. These findings are in conformity with Himani (2018) [8] in cluster bean, Kazemi (2013) [10] in tomato, Salunkhe *et al*. (2013) [18] in onion, Krishna, *et al*. (2018) [11] in okra, Patel *et al.* (2018) [16] in cabbage, Shah (2019) [2] in sweet potato, Singhal *et al*. (2015) [24], Savaliya (2020) [20] and Mandaliya (2021) [13] in cowpea and Champaneri (2020) [6] in Indian bean.

Interaction effect of chemical and organic source of nutrient on growth and yield attributes of cluster bean

Interaction effect of chemical source of nutrient on growth parameters found non-significant in pooled analysis. Whereas, interaction of both factors was found significant for yield parameters, interaction of chemical and organic source of nutrient significantly affected yield attributes *viz.*, number of pods plant^{-1} (117.70), dry matter yield (2236.87 kg ha^{-1}) and fresh pod yield (11861.19 kg ha^{-1}) except number of cluster plant^{-1}, number of pods cluster^{-1}. Treatment combination C_1O_4 (100% RDF with NOVEL prime organic liquid nutrients) found best among all treatment combinations.

Table 3: Effect of integrated nutrient management on pod length, pod width and number of cluster plant $^{-1}$ of cluster bean

Treatment	Pod length (cm)			Pod width (cm)			Number of clusters plant^{-1}		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Factor 1: Chemical source of nutrient									
C_1: 100% RDF	10.90	10.25	10.57	0.78	0.72	0.75	24.97	24.65	24.81
C_2: 75% RDF	10.64	10.12	10.38	0.75	0.69	0.72	24.19	23.91	24.05
C_3: 50% RDF	9.61	9.44	9.52	0.67	0.61	0.64	21.36	21.15	21.25
S.Em±	0.13	0.10	0.08	0.01	0.01	0.01	0.59	0.55	0.41
CD at 5%	0.39	0.29	0.24	0.04	0.03	0.03	1.74	1.62	1.16
Factor 2: Organic source of nutrient									
O_1: Control (No organics)	9.77	9.62	9.69	0.69	0.64	0.66	22.06	21.95	22.01
O_2: PSB	10.35	9.85	10.10	0.71	0.66	0.69	23.17	22.81	22.99
O_3: *Rhizobium*	10.57	10.09	10.33	0.75	0.69	0.72	23.64	23.32	23.48
O_4: NOVEL prime	10.84	10.18	10.51	0.78	0.70	0.74	25.16	24.87	25.01
S.Em±	0.15	0.12	0.10	0.02	0.01	0.01	0.68	0.64	0.47
CD at 5%	0.45	0.34	0.27	0.05	0.03	0.03	2.01	1.87	1.33
Interaction (C×O)									
S.Em±	0.27	0.20	0.17	0.03	0.02	0.02	1.18	1.11	0.81
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS
CV (%)	4.45	3.49	4.02	6.88	5.07	6.12	8.73	8.25	8.50
Interaction pooled									
Source	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O
S.Em±	0.12	0.14	0.24	0.01	0.01	0.02	0.57	0.66	1.15
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4: Effect of integrated nutrient management on number of pods cluster^{-1}, number of pods plant^{-1} and dry matter yield of cluster bean

Treatment	Number of pods cluster^{-1}			Number of pods plant^{-1}			Dry matter yield (kg ha^{-1})		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
Factor 1: Chemical source of nutrient									
C_1: 100% RDF	4.15	4.13	4.14	104.36	101.85	103.11	1735.28	1677.11	1706.19
C_2: 75% RDF	4.13	4.11	4.12	99.18	97.76	98.47	1616.63	1603.59	1610.11
C_3: 50% RDF	3.68	3.65	3.66	78.47	83.33	80.90	1142.24	1012.68	1077.46
S.Em±	0.05	0.04	0.03	1.99	1.45	1.23	60.70	56.76	41.55
CD at 5%	0.14	0.11	0.09	5.83	4.24	3.50	178.03	166.47	118.43
Factor 2: Organic source of nutrient									
O_1: Control (No organics)	3.81	3.84	3.83	84.14	85.36	84.75	1231.52	1097.24	1164.38
O_2: PSB	3.94	3.93	3.94	90.98	90.93	90.95	1402.30	1371.90	1387.10
O_3: *Rhizobium*	4.06	3.99	4.03	96.22	96.38	96.30	1507.16	1464.39	1485.78
O_4: NOVEL prime	4.12	4.08	4.10	104.68	104.60	104.64	1851.21	1790.97	1821.09
S.Em±	0.05	0.04	0.03	2.30	1.67	1.42	70.09	65.54	47.98
CD at 5%	0.16	0.13	0.10	6.73	4.90	4.05	205.57	192.22	136.75
Interaction (C×O)									

S.Em±	0.09	0.08	0.06	3.98	2.89	2.46	121.40	113.52	83.10
CD at 5%	NS	NS	NS	NS	NS	7.01	356.05	332.94	236.86
CV (%)	4.06	3.31	3.71	7.33	5.32	6.40	14.04	13.74	13.90
Interaction pooled									
Source	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O
S.Em±	0.04	0.05	0.09	1.74	2.01	3.48	58.76	67.85	117.53
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 5: Effect of Integrated nutrient management on fresh pod yield and harvest index of cluster bean

Treatment	Fresh pod yield (kg ha^{-1})			Harvest index (%)		
	2021	2022	Pooled	2021	2022	Pooled
Factor 1: Chemical source of nutrient						
C_1: 100% RDF	10628.75	10424.51	10526.63	39.15	38.76	38.95
C_2: 75% RDF	10197.15	10071.44	10134.29	38.33	38.29	38.31
C_3: 50% RDF	8697.69	8104.54	8401.12	37.41	36.49	36.95
S.Em±	158.92	141.84	106.50	0.53	0.66	0.42
CD at 5%	466.08	416.00	303.55	NS	NS	1.21
Factor 2: Organic source of nutrient						
O_1: Control (No organics)	8991.44	8551.56	8771.50	37.34	36.82	37.08
O_2: PSB	9599.55	9217.55	9408.55	38.28	37.64	37.96
O_3: *Rhizobium*	10044.78	9976.09	10010.44	38.16	37.99	38.07
O_4: NOVEL prime	10729.02	10388.78	10558.90	39.40	38.94	39.17
S.Em±	183.50	163.78	122.98	0.61	0.77	0.49
CD at 5%	538.19	480.36	350.51	NS	NS	1.40
Interaction (C×O)						
S.Em±	314.15	280.68	206.15	1.06	1.33	0.85
CD at 5%	932.16	832.00	607.11	NS	NS	NS
CV (%)	5.59	5.15	5.39	4.78	6.07	5.46
Interaction pooled						
Source	Y*C	Y*O	Y*C*O	Y*C	Y*O	Y*C*O
S.Em±	150.62	173.92	301.24	0.60	0.69	1.20
CD at 5%	NS	NS	NS	NS	NS	NS

Conclusion

Among all treatment combinations, application of 100% RDF with NOVEL prime organic liquid nutrient found superior in terms of obtaining maximum number of pods plant^{-1}, dry matter yield and fresh pod yield. From two years study, it can be concluded that 100% RDF as chemical source of nutrient accomplished superior growth parameters (plant height, number of leaves plant^{-1}, fresh biomass of plant and stem diameter) and yield parameters (pod length, pod width, number of cluster plant^{-1}, number of pods cluster^{-1}, number of pods plant^{-1}, dry matter yield, fresh pod yield and harvest index). Whereas, positive effect of NOVEL prime organic liquid could have invigorated cluster bean for premium performance in terms of all growth and yield attributes.

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