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Influence of manure application on soil chemical properties and crop yield under cotton cultivation

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Abstract
A field experiment was conducted during *Kharif* 2013-14 and 2014-15 at experimental fields of Cotton Research Unit CRU), Central Research Station (CRS), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, to assess the effect of organic manures on chemical properties of soil in arborium cotton (AKA-8) with eight sole organic treatments. Significantly highest organic carbon (5.93 g $kg^{-}1$) was reported by the treatment FYM @ 10 t ha^{-1} and same dose of FYM application reported significantly lowest values of pH (7.90) and lowest EC (0.116 dSm^{-1}). Significantly highest total nitrogen (0.066 per cent), available potassium (382.92 kg ha^{-1}) and available Sulphur (16.81 ppm) were also recorded with the application of FYM @ 10 t ha^{-1}. However significantly highest available phosphorus (34.37 kg ha^{-1}) was recorded by the treatment VC @ 5 t ha^{-1}. Significantly highest productivity of cotton i.e. 15.38 q ha^{-1} seed cotton and 85.36 q ha^{-1} dry matter was observed under the treatment of FYM @ 10 t ha^{-1} and which was statistically equal with the application of castor cake @ 500 kg ha^{-1}. The overall performance of absolute control treatment was lowest regarding all soil properties under study as well as yields of the cotton crop.

Keywords: Chemical properties, FYM, organic manure, yield

Introduction
Organic cotton production is expected to expand in response to increased demand for organic fiber. Organic cotton is the production system, which can bring back the cotton cultivation on sustainable basis without affecting environment. Organic cotton production system involves integrated nutrient management practices through organics like, manures, oilcakes, green manures, liquid manures, bio-fertilizers etc. and integrated and biological plant protection *viz*., agronomic practices, crop rotation, bio-pesticides etc., apart from encouraging natural parasites, predators and parasitoids in the cotton ecosystem (Singh *et al*., 2013) [14]. Farmyard manure provides essential plant nutrients including micronutrients and it also improves soil physical, chemical and biological environment of soil for favourable crop growth and yield. It is also known to accelerate the respiratory process that increase cell permeability and hormonal growth action or by combination of all these processes (Ismail *et al*., 1998) [7]. Biofertiliser is one of natural and sustainable nutritional input. Mainly there are two types of biofertilizers which are used on mass scale. These are nitrogenous and phosphatic biofertilizers. The nitrogenous biofertiliser for cotton are *Azotobacter (A.chroococcum)* and *Azospirillum* (A. braazilense). These organisms with the help of nitrogenase enzyme fix atmospheric nitrogen. The phosphorus biofertilizers consist of several bacteria (*Bacillus megatherium*, *Pseudomonas striata*) and fungi (*Aspergillus awamori* and *Penicillium digitatum*). It has been estimated that 1 ton *Azotobacter/ Azospirillum* is equivalent to 40 ton Nitrogen @ 20 kg N fixed per year per crop at 500 g^{-1} dose and 1 ton PSM is equivalent to 24 ton Phosphorus (P_2O_5). Enhancement in the yield of cotton depending on variety and strain efficiency of biofertilizers. Organic matter has a very crucial significance for soil fertility improvement. It ensures a soft and loose soil with good porosity and thus good infiltration of water. The organic matter particles act like tiny sponges, thus keeping the soil moist for a longer time. Organic matter takes up and slow releases nutrients so that they are available to the crop. Organic material feeds and hosts a huge number of beneficial soil organisms, from earth worms to microbes, which continuously work toward improving soil fertility (Guled *et al*., 2002) [6]. So far, less attention has been given on fullfilment of nutritional requirement of the crops through organic resources under rainfed condition and this aspect needs prime attention through investigation of performance of organic manures along with use of biofertilizers to improve soil quality and yield of cotton.

Therefore, present investigation was undertaken at Cotton Research Station, Akola during *kharif* 2013-14 and 2014-15 to study the performance of organic manuring on soil quality and yield of cotton.

Material and Methods: The present investigation was carried out at experimental fields of Cotton Research Unit CRU), Central Research Station (CRS), Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola. The crop cotton was raised during *Kharif 2013 and 2014*. The experiment was laidout in simple randomized block design with three replications and comprised of 8 treatments *viz*., T1-Farm Yard Manure (FYM) 5 t ha^{-1}, T2- vermicompost 2.5 t ha^{-1}, T3- FYM 10 t ha^{-1}; T4- vermicompost 5 t ha^{-1}, T 5- in situ green manuring with Sunhemp, T6 - Castor cake @ 500 kg ha^{-1}, T7 - Sunhemp + FYM (source of 15 kg P_2O_5) and T8 – Control. The crop was arborium cotton variety AKA-8.

Result and Discussion

pH and EC: The data on soil reaction (pH) and electrical conductivity is presented in Table 1. The data showed that due to application of different organic treatments of nutrient management, the soil pH varied from 7.89 – 8.14 (2013-14) and 7.90 to 8.07 (2014-15) and EC varied from 0.117 dS m^{-1} to 0.120 dS m^{-1} and 0.116 dS m^{-1} to 0.122 dS m^{-1} in 2013-14 and 2014-15 respectively. The variations in pH and EC were statistically significant during both the years of experimentation.

From data, it was observed that the highest pH and EC values were found in the absolute control and it was decrease as the doses of organic nutrient sources increases. Significantly lowest values of pH were observed in the treatment received well decompose FYM @ 10 t ha^{-1} i.e. 7.89 (2013-14) and was at par with VC 5 t ha^{-1} (7.93), VC 2.5 t ha^{-1} (7.99), sunhemp + FYM (source of 15 kg P_2O_5) (7.93), and sunhemp in situ (8.01) in first trial while after second trial same treatment (T_3) was at par with all other organic treatment. Highest pH was found in absolute control i. e. 8.14 (2013-14) and 8.18 (2014-15). Application of FYM @ 10 t ha^{-1} (T_3) recorded 2.59 per cent and 2.46 per cent decreased in pH over initial absolute control treatment (T_8) in 2013-14 and 2014-15, respectively. However, decreased in pH with the application of FYM @ 10 t ha^{-1} over absolute control treatment was 3.07 per cent and 3.42 per cent in the year of 2013-14 and 2014-15, respectively. Significantly lowest 0.117 dSm^{-1} (2013-14) and 0.116 dSm^{-1} (2014-15) EC with the application of FYM @ 10 t ha^{-1} which was statistically equal with the application of all organic treatments after both the trial of experimentation. Highest EC was found in absolute control i. e. 0.120 dSm^{-1} (2013-14) and 0.122 dSm^{-1} (2014-15). It was noticed that pH and EC are significantly improved over the initial values of experiment. Application of FYM @ 10 t ha^{-1} (T_3) recorded 3.30 per cent and 4.13 per cent decreased in EC over initial absolute control treatment (T_8) in 2013-14 and 2014-15 respectively. However, decreased in EC with the application of FYM @ 10 t ha^{-1} over absolute control treatment was 2.50 per cent and 4.91 per cent in the year of 2013-14 and 2014-15 respectively. Similar results also reported by Gattani *et al.* (1976) [4], Badanur *et al*. (1990), Katkar *et al*. (2005) [8] and Kukal *et al*. (2012) [9].

Table 1: Effect of organic sources on chemical properties in Vertisols under cotton

Treatment Detail	pH		EC (dS m^{-1})		Organic carbon (g kg^{-1})	Total N (Percent)		Available P (kg ha^{-1})	Available K (kg ha^{-1})		
	2013-14	2014-15	2013-14	2014-15	2013-14	2013-14	2013-14	2014-15	2013-14	2014-15	2013-14	2014-15
T1 - FYM 5 t ha^{-1}	8.04	7.94	0.119	0.119	26.69	26.69	0.029	0.033	26.69	29.78	361.67	363.55
T2 - VC 2.5 t ha^{-1}	7.99	7.99	0.118	0.119	32.59	32.59	0.031	0.038	32.59	34.06	354.64	358.91
T3 - FYM 10 t ha^{-1}	7.89	7.90	0.117	0.116	31.12	31.12	0.061	0.066	31.12	32.23	381.41	382.92
T4 - VC 5 t ha^{-1}	7.93	7.92	0.117	0.117	34.20	34.20	0.051	0.052	34.20	34.37	373.67	379.40
T5 - Sunhemp in situ	8.01	7.90	0.118	0.117	28.57	28.57	0.040	0.052	28.57	29.78	368.87	371.56
T6 - Castor cake @500 kg ha^{-1}	8.02	8.04	0.118	0.118	30.98	30.98	0.058	0.066	30.98	29.14	356.00	359.99
T7 - Sunhemp + RD of nutrient on P basis	7.93	7.92	0.119	0.116	29.11	29.11	0.049	0.053	29.11	31.20	370.46	372.82
T8 – Control	8.14	8.18	0.120	0.122	24.95	24.95	0.019	0.016	24.95	22.17	336.63	333.17
SE (m)±	0.04	0.09	0.001	0.002	1.40	1.40	0.001	0.002	1.40	0.71	0.487	0.958
CD	0.12	0.27	0.002	0.005	4.15	4.15	0.004	0.005	4.15	2.11	1.446	2.846

Organic carbon

The results regarding organic carbon content in soil after harvest of cotton was presented in Table 1 and showed that impact of organic sources on organic carbon content was significant. Organic carbon values varied from 3.66 to 5.45 g kg^{-1} (2013-14) and 4.00 to 5.93 g kg^{-1} (2014-15).

Data (Table 1) showed significantly highest buildup of organic carbon content of soil after harvest of cotton with the addition of highest dose of well decomposed organic matter i.e. FYM @ 10 t ha^{-1} reported i. e. 5.45 g kg^{-1} (2013-14) and 5.93 g kg^{-1} (2014-15) which was at par with all other organic treatment in both the years of experimentation. Lowest organic carbon 3.66 g kg^{-1} and 4.00 g kg^{-1} was observed in absolute control plot in 2013-14 and 2014-15, respectively. Application of FYM @ 10 t ha^{-1} (T_3) recorded 42.29 per cent and 54.83 per cent increase in organic carbon over initial absolute control treatment (T_8) in 2013-14 and 2014-15 respectively. However, increased in organic carbon with the application of FYM @ 10 t ha^{-1} over absolute control treatment was 48.90 per cent and 48.25 per cent in the year of 2013-14 and 2014-15 respectively. The organic carbon content in the soil increased slightly after harvest of the second year of cotton than first year. This is might be due to the direct addition of organic matter through vermicompost, FYM, green manuring with sunhemp thereby increasing root biomass of plant (Stolyarenko *et al.* 1992) [16].

Similar results were also reported by Guled *et al.* (2002) [6], Ghuman *et al.* (2006) [17] and Badole *et al.* (2000) [2]. The increase in organic carbon content due to use of organic manures might had been due to direct incorporation of organic matter, better root growth and more plant residues addition. Similar results were reported by Gayatri and Mathur (2009) [5], Surekha and Rao (2009) [17], Vineela *et al.* (2008) [19], Mishra *et al.* (2008) [11], Masto *et al.* (2007) [10].

Macronutrients status: In this section the data on effect of different organic treatments of nutrient management of cotton on availability of macronutrients (i. e. Total N and available P, K) in addition to available sulphur in soil are presented in Table 1 and depicted in Fig. 1, 2, 3 respectively.

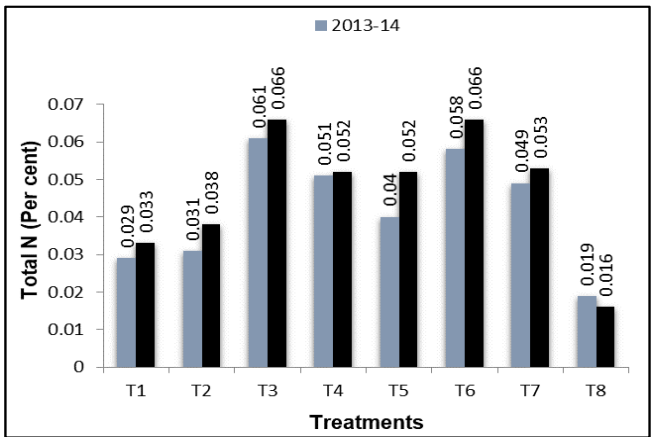

Fig 1: Total N as influenced by various organic treatments

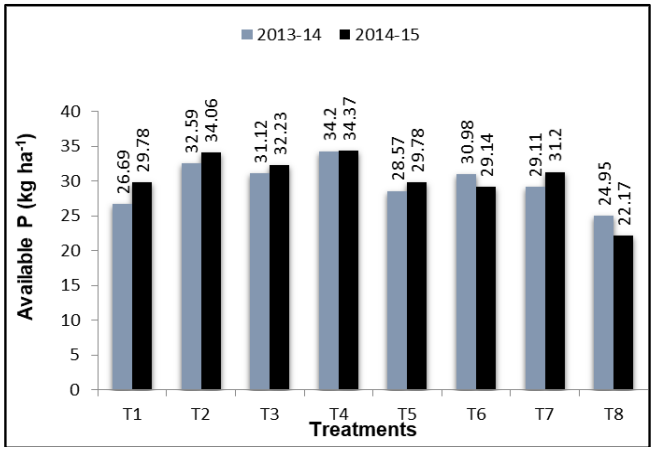

Fig 2: Available phosphorus as influenced by various organic treatments

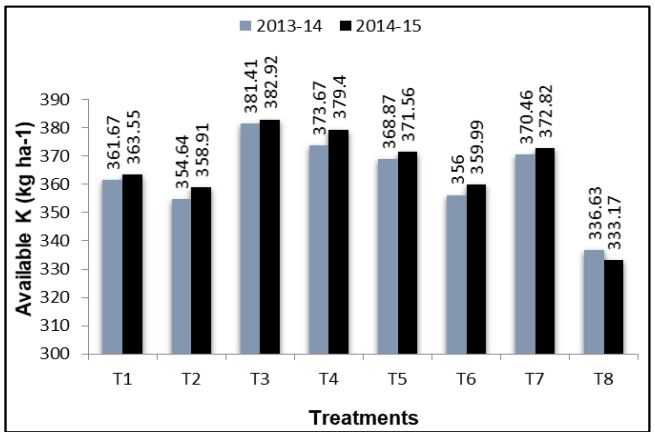

Fig. 3: Available potassium as influenced by various organic treatments

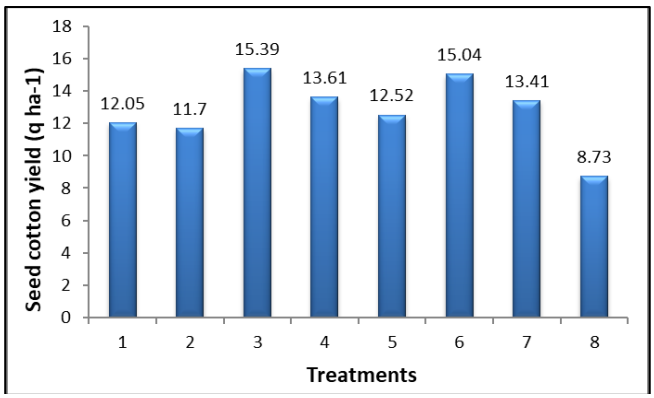

Fig. 4: Seed cotton yield as influenced by various organic treatments

Total Nitrogen: The data presented in Table 1 and Fig. 1 showed that, the effect of different organic treatments of nutrient management to cotton on total nitrogen content of soil was significant during both the years of study. The total nitrogen status as influenced by the treatment FYM 10 t ha^{-1} was significantly highest in both the years of experimentation. The data showed significantly highest 0.064 per cent total nitrogen content in soil was observed during due to addition of FYM @ 10 t ha^{-1} i.e. 0.061 per cent (2013-14) and 0.066 per cent (2014-15) and it was statistically equal with the application of castor cake @ 500 kg i.e. 0.058 per cent (2013-14) and 0.066 per cent (2014-15). Lowest total nitrogen content was observed in absolute control treatment i. e. 0.019 per cent and 0.016 per cent in 2013-14 and 2014-15, respectively which was lower than the initial total N content in soil i. e. 0.024 per cent. In all organic manure application total nitrogen content was recorded lowest with the application of FYM @ 5 t ha^{-1}. Amongst green manuring treatments, its combination with FYM recorded significantly higher total nitrogen over green manuring alone treatment. Application of FYM @ 10 t ha^{-1} (T_3) recorded 110.34 per cent and 127.58 per cent increase in total nitrogen over initial absolute control treatment (T_8) in 2013-14 and 2014-15, respectively. However, increment in total nitrogen with the application of FYM @ 10 t ha^{-1} over absolute control treatment was 221.05 per cent and 312.50 per cent in the year of 2013-14 and 2014-15 respectively. Similar results were also stated by Badole *et al.* (2000) [2], Ravankar *et al.* (2000) [13], Adeyemo and Agele (2010) [1], Bouajila and Sanaa (2011) [3] and Tadesse *et al.* (2013) [18].

Available Phosphorus: The data presented in Table 1 and Fig 2 showed that, available phosphorus content varied from 24.95 kg ha^{-1} – 34.20 kg ha^{-1} (2013-14) and 22.17 kg ha^{-1} - 34.37 kg ha^{-1} (2014-15) with the different organic treatments of nutrient management of cotton during both the years of experimentation.

Data revealed that, available phosphorus in soil increases with the increase in doses of well decomposed organic sources i.e. vermicompost and FYM. Available phosphorus content was estimated significant with the application of VC 5 t ha^{-1} in both the years of study whereas lowest content was noted in absolute control treatment.

Data (Table 1) showed that, in 2013-14 application of VC 5 t ha^{-1} (34.20 kg ha^{-1}) significantly increased the available phosphorus status of soil and it was statistically equal with the application of VC 2.5 t ha^{-1} (32.59 kg ha^{-1}), FYM 10 t ha^{-1} (31.12 kg ha^{-1}) and castor cake @ 500 kg ha^{-1} (30.98 kg ha^{-1}). In 2014-15 same treatment (T_4) was at par with the application of VC 2.5 t ha^{-1} (34.06 kg ha^{-1}) and FYM 10 t ha^{-1} (32.23 kg ha^{-1}). Lowest available phosphorus content was estimated in absolute control treatment i. e. 24.95 kg ha^{-1} and 22.17 kg ha^{-1} in 2013-14 and 2014-15, respectively. Application of VC 5 t ha^{-1} (T_3) recorded 25.27 per cent and 25.89 per cent increase in available phosphorus over initial absolute control treatment (T_8) in 2013-14 and 2014-15 respectively which was lower than initial available P content in soil i. e. 27.30. However, increased in available phosphorus with the application of VC 5 t ha^{-1} over absolute control treatment was 37.07 per cent and 55.02 per cent in the year of 2013-14 and 2014-15 respectively. This might be due to fact that, vermicompost contains higher phosphorus as compared to other organic sources used in the experimentation i. e. Incorporation of 5 t ha^{-1} of vermicompost leads to addition of 94.5 kg ha^{-1} phosphorus in soil. The results are in agreement

with Manjappa (1999), Bellakki and Badanur (1997), Borkar *et al*. (2002), Tiwari *et al*. (2002) and Katkar *et al*. (2005) [8]. Significantly lowest available P i. e. 22.95 kg ha^{-1} (2013-14) and 22.17 kg ha^{-1} (2014-15) was observed in the treatment absolute control (Without any organic treatment).

The CO_2 released during decomposition of organic matter forms carbonic acid, solubilising certain primary minerals. The appreciable build up in available phosphorus may be due to the influence of organic matter in increasing the labile phosphorus in soil through complexing of cation like Ca^{2+} which are mainly responsible for fixation of phosphorus (Kharche *et al*., 2011).

The larger built up in soil P on conjunctive use of fertilizer and organic manure was because of additional supply of P through FYM and reduction in fixation of applied P or mobilization of native P by organic acids produced during organic matter decomposition (Singh and Wanjari, 2007) [15].

Available Potassium: It is evident from the data presented in Table 1 and Fig. 3 that effect of different organic treatments of nutrient management on soil available potassium was significant during both the years of study. Further, available K status was varied from 334.90 kg ha^{-1} – 382.17 kg ha^{-1} (2013-14) and 333.17 kg ha^{-1} – 382.92 kg ha^{-1} (2014-15) under the various organic treatments.

From data (Table 1) it was observed that, available K in the soil increased with addition of higher doses of well decomposed organic manures i.e. FYM and vermicompost. Significantly highest 381.41 kg ha^{-1} and 382.92 kg ha^{-1} available K was recorded by the treatment received FYM 10 t ha^{-1} over all other treatments in 2013-14 and 2014-15 respectively. The lowest K was estimated in the absolute control treatment 336.63 kg ha^{-1} (2013-14) and 333.17 kg ha^{-1} (2014-15) and it was also less than initial status of soil available K i. e. 345.00 kg ha-1. Application of FYM @ 10 t ha^{-1} (T_3) recorded 10.55 per cent and 10.99 per cent increase in available potassium over initial absolute control treatment (T_8) in 2013-14 and 2014-15 respectively. However, increased in available potassium with the application of FYM @ 10 t ha^{-1} over absolute control treatment was 13.36 per cent and 14.95 per cent in the year of 2013-14 and 2014-15, respectively. Similar results was reported by Nalatwadmath *et al*. (2003) [] that, a built up of available K only in organic manure treatment which was maximum (33 per cent) as compared to control. Amongst green manuring treatments, its combination with FYM recorded significantly higher available K over green manuring alone treatment.

Effect of organic sources on yield performance of cotton in Vertisols

Seed cotton yield: The pooled yield data presented in Table 2 and Fig. 4 revealed that, significantly highest seed cotton yield was recorded in the treatment of bulky organic matter i.e. FYM @ 10 t ha^{-1} in both the years of study. It was in ranged 8.73 - 15.39 q ha^{-1}. Yield was more in second year as compared to first year of experimentation. Pooled data showed that, significantly highest seed cotton yield was recorded in the treatment of bulky organic matter i.e. FYM @ 10 t ha^{-1} (15.39 q ha^{-1}) which was at par with all other organic treatment. The significantly lowest performance of cotton crop in respect of seed cotton (8.73 q ha^{-1}) was observed in the absolute control treatment. Similar results were also reported by Wankhade *et al.* (2001) [20]. Nawlakhe *et al*. (2010) [21] reported that, number of bolls picked per plant, seed cotton yield per plant seed cotton yield (q ha^{-1}) and stalk yield (q ha^{-1}) were reported significantly superior by application of vermicompost at the rate of 2 t ha^{-1} over others except FYM at the rate of 5 t ha^{-1} which was at par with it. Bulky organic manure FYM @ 10 t ha^{-1} and concentrated organic manure castor cake @ 500 kg ha^{-1} showed numerically equal optimum yield i. e. 15 q ha^{-1} means nutritional supplying capacity of both the organic manures can meet out the nutritional requirement of deshi cotton AKA-8.

Dry matter yield: The data on dry matter yield mentioned in Table 2 shows significant influence on various organic sources i. e. FYM, vermicompost, castor cake and green manuring of sunhemp. Data revealed that, dry matter yield ranged from 63.44 to 85.36 q ha^{-1}. From data, it was noticed that dry matter yield increased with the increase in doses of well decomposed organic manures i. e. Vermicompost and FYM. Pooled data showed that, significantly highest dry matter yield was recorded in the treatment of bulky organic matter i.e. FYM @ 10 t ha^{-1} (85.36 q ha^{-1}) which at par with castor cake @ 500 kg^{-1}, VC @ 5 t ha^{-1} and FYM @ 5 t ha^{-1}. However, application of lower doses of organic material i.e. vermicompost @ 2.5 t ha^{-1} (65.40 q ha^{-1}) showed lower dry matter yield as compared to other manure treatment. The significantly lowest performance of cotton crop in respect of seed cotton (63.44 q ha^{-1}) was observed in the absolute control treatment over other all organic sources treatments under experimentation. Nawlakhe *et al*. (2010) [21] reported that, number of bolls picked per plant, seed cotton yield per plant seed cotton yield (q ha^{-1}) and stalk yield (q ha^{-1}) were reported significantly superior by application of vermicompost at the rate of 2 t ha^{-1} over others except FYM at the rate of 5 t ha^{-1} which was par with it. Similar results are reported by Prakash *et al*. (2002) and Katkar *et al*. (2002).

Conclusion

Hence, from the organic cotton experimentation, it can be concluded that, depending on availability FYM @ 10 t ha^{-1} or castor cake 500 kg ha^{-1} can be used to improve chemical properties of soil for getting optimum yield of *deshi* cotton under *rainfed* condition in Vertisol.

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