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RESEARCH ARTICLE

Field Efficacy of Certain Biorational Pesticides Against Aphid, *Aphis gossypii* Glover (Hemiptera: Aphididae) on Watermelon, *Citrullus lanatus* Thunb. Matsum and Nakai

Sankar C [1*], Jayaraj J [1] Shanthi M [1] Chinniah C [1], Vellaikumar S [2] and Rajamanickam C [3]

[1]Department of Agricultural Entomology, Agricultural College and Research Institute (AC&RI), Tamil Nadu Agricultural University, Madurai -625 104, Tamil Nadu, India and Department of Livestock Farm Complex, Veterinary College and Research Institute, Tamil Nadu Veterinary and Animal Sciences University, Mohanur Road, Namakkal - 637 002

[2]Department of Biotechnology, Agricultural College and Research Institute, Tamil Nadu Agricultural University, Madurai -625 104. Tamil Nadu, India

[3]Department of Horticulture, Citrus Research Station, Tamil Nadu Agricultural University , Vannikonenthal, Trinelveli District – 627 951, Tamil Nadu, India

ABSTRACT

Aphis gossypii Glover is the major sucking pest in watermelon in early stage of the crop resulting 45-75 % of seedling mortality. In the present study, a field experiment was conducted to evaluate certain biorational pesticides against *A. gossypii* in watermelon. It was found that a significant lower number of *A. gossypii* population (4.39 aphid/leaf) was recorded with the treatment of *Azadirachta indica* oil @ 3% followed by *Beauveria bassiana* ($1x10^8$ cfu spores @ 8 ($g.L^{-1}$)(6.01 aphid/leaf) and spinosad 45% SC @ 0.3($mL.L^{-1}$) (9.16 aphid/leaf), respectively resulting 92.89%, 90.27% and 85.17% reduction of *A. gossypii* population. Similarly, with the same trend the highest fruit yield (25.50 t ha^{-1}) was recorded in the treatment of *A. indica* followed *B. bassiana* (24.43 t ha-^{1}), spinosad (23.53 t ha-^{1}) and the lowest in the untreated check (16.30 t ha-^{1}). The increase in fruit yield (56.44%) was recorded in the treatment of *A. indica* followed *B. bassiana*, (49.87%) and spinosad (44.17%). A maximum incremental benefit-cost ratio of 1:2.84 was recorded in the treatment of *A. indica* followed by *B. bassiana* (1:2.74) and spinosad (1:2.68). From these findings it may be recommended that three rounds of application of *A. indica* oil @ 3% or *B. bassiana* ($1x10^8$cfu spores @8g /L) or spinosad 45% SC@ 0.3 ($mL.L^{-1}$)at 15 days interval for the management of *A. gossypii* in watermelon

Keywords: *Watermelon; Aphis gossypii; Leaf damage; Biorational pesticides*

INTRODUCTION

Watermelon is an important horticultural crop grown for consumption and export purpose. It is a staple food both in fresh and preserved form. It is cultivated throughout the tropical zones of the world (Anonymous, 1988), It is an annual vining plant belonging to the family Cucurbitaceae. The fruit is rich in vitamins A, B1, B2, C, and minerals (Moniruzzaman, 1988). More than 35 varieties/ hybrids like, Arka Manik, PKM 1, Arka Jyoti, Pusa Bedana, Durgapur Kesar, NS707, Namdhari-NS-34, Asahi Yamato and Ice box hybrids (Sugar Baby, Madhuri, Black Magic. Melody, Maxx, Sugar, Super queen, Kalash, Melody, Mahima, Sahana Queen) are grown in India. It is cultivated to the extent of 1.03 lakh ha with an annual production of 25.04 lakh mt ha^{-1} in India (Anonymous, 2019). It is cultivated in 6,420 ha in Tamil Nadu with annual production of 1.75 mt ha^{-1} with an average productivity 32 t ha^{-1} (Potnuru Santosh Kumar and Kulkarni 2018). It is also extensively cultivated in Tamil Nadu during kharif, Rabi and summer seasons and predominantly in the districts of Villupuram, Namakkal, Ariyalur, Coimbatore and Erode (Chadha, 2013).

Several insect pests attack watermelon at various stages that ravage its cultivation (Anonymous, 2012). The cotton aphid, *Aphis gossypii* was the most destructive pests of watermelon in the early stage of crop growth. They are minute pear-shaped, soft-bodied insects with high reproductive potential and ability to transmit viruses non-persistent manner. They suck sap from tender plants, leading to curling of leaves and distortion, especially when the population is high. They excrete lot of honeydews and sugar-rich substrates that promote the growth of sooty mold (*Capnodium* spp.) on plant parts and leaves lowering their photosynthetic efficiency. The

*Corresponding author's e-mail: csankarento@gmail.com

farmers resort to the application of several rounds of various unrecommended insecticides against *A. gossypii*, which are harmful to human beings and the environment (Anonymous, 1991). Hence, a study was under taken to find effective and eco friendly biorationals on watermelon.

MATERIALS AND METHODS

The field experiment was carried out in a farmer's field at Konur village (11° 12'30" N, 78° 4'41" E"), Namakkal district of Tamil Nadu during summer season 2020 to evaluate field efficacy of certain biorational pesticides against *A. gossypii* in comparison with farmers practice in Randomized Block Design (RBD) with fourteen treatments (Table.1)

Table1. List of biorational pesticides tested against *A.gossypii* in watermelon

Treatments details
T_1- *Vitex negundo* - leaf decoction 5%
T_2 - *Azadirachta indica* - oil 3%
T_3 - *Pongamia pinnata* -leaf decoction 3%
T_4 - *Ocimum sanctum*- leaf decoction 5%
T_5 - *Ricinus communis* -oil 3%
T_6 - *Eucalyptus globulus* - leaf decoction 3%
T_7 - *Beauveria bassiana* (1x10^8 cfu spores) -8g.L-1^{-1}
T_8 - *Metarhizium anisopliae*-(1x10^8 cfu spores) 8g.L^{-1}
T_9 - *Paecilomyces fumosoroseus* -(1x10^8 cfu spores) 8g.L^{-1}
T_{10} - *Lecanicillium lecanii* (1x10^8 cfu spores) 8g.L^{-1}
T_{11} - Emamectin benzoate 5% SG@0.4g.L^{-1}
T_{12} - Spinosad 45% SC@ 0.3mL.L^{-1}
T_{13} - Imidacloprid17.8%SL@0.3mL.L^{-1} (Treated check)
T_{14} - Untreated check

Three replications were maintained for each treatment. The popular hybrid F_1 (Melody) was sown in protray and 13 days old seedlings were transplanted in the main field at a spacing of 2.5 m x 0.5 m and other recommended package of practices were adopted to raise the crop successfully.

The first spray was given with the onset of pest incidence after recording the pretreatment count. The subsequent sprays were repeated after 15 days using a high volume sprayer with required concentrations. The posttreatment counts on pests were recorded on 1, 3, 7, 14 days after each application. Ten plants were selected randomly from each replication in a plant and *A. gossypii* populations were recorded from three leaves in infested branches (one from the top of the terminal twig) with the unopened leaves and two from opened leaves, and the mean number was calculated per leaf and expressed as number/leaf. The efficacy of the treatments was assessed based on the category by using a number of population-level of aphids as per Sikha Deka *et al.* (2016)

Aphid population /leaf	Category
<1. No. of aphid	Negligible
1-10. No. of aphid	Low
11-30. No. of aphid	Moderate
31-40. No. of aphid	Severe
>50. No. of aphid	Very Severe

Watermelon fruits were harvested from all three replications and pooled to arrive fruit yield. The yield data were also recorded in untreated plots and the increase in yield and income from each treatment over untreated checks were worked out. Accordingly, the incremental cost-benefit ratio was worked out for all the treatments by using the following formula ICBR = Gross income / (total cost of cultivation + cost of plant protection) as adopted by Akila and Sundara Babu (1994) where the cost of plant protection = cost of insecticide + labour charges for spraying.

Statistical analysis

The data generated from the field experiments were analyzed for ANOVA. The data on insect population were transformed into square root transformation and analyzed using SPSS (version 22) (IBM crop Released 2013) software to identify the most effective treatments and their means were compared by significant difference at $p<0.05$ ANOVA followed by Tukey's Honest Significant Difference test.

RESULTS AND DISCUSSION

The results revealed that all the biorational pesticides were effective in reducing *A. gossypii* infestation. The data on *A. gossypii* population per leaf percent reduction of the population over untreated check, increase in yield and ICBR due to biorationals are furnished in Table 1 and Fig 1.

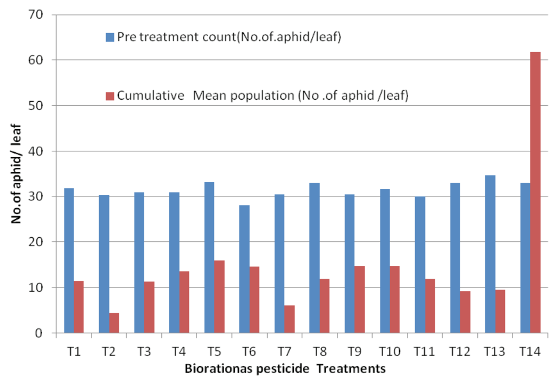

Fig 1. Mean number of *A. gossypii* against biorational pesticides

The lowest population of *A. gossypii* in the treatment of *A. indica (*4.39/leaf) was recorded followed by *B. bassiana* (6.01 /leaf), spinosad (9.16/leaf) and the highest number of *A. gossypii* was observed in the untreated check (61.79/leaf). Further, the order of efficacy of the treatments was imidacloprid (Treated check) (9.57 aphid/ leaf) < *P. pinnata* (11.36 aphid/leaf) < *V. negundo* (11.38 aphid/leaf) < emamectin benzoate (11.86 aphid/leaf) < *M. anisopliae* (11.95 aphid/leaf) < *O. sanctum* (13.59 aphid/leaf) < *E. globulus* (14.64 aphid/leaf) < *L. lecanii* (14.74 aphid/leaf) < *P. fumosoroseus* (14.75 aphid /leaf) < *R. communis* (15.93 aphid /leaf).

The observation on *A. gossypii* population density in the treatment of *A. indica* was recorded as the lowest category followed by *B. bassiana,* spinosad and imidacloprid. The moderate category was recorded in *P. pinnata*, *V. negundo*, emamectin benzoate, *M. anisopliae*, *O. sanctum*, *E. globulus*, *L. lecanii*, *P. fumosoroseus*, *R. communis* and the very severe category were in the untreated control respectively (Table 2).

Similarly, the reduction of *A. gossypii* population was high in *A. indica* (92.89%) followed by *B. bassiana* (90.27%) and spinosad (85.17%). Further, the order of the reduction over treated check (Imidacloprid) was 84.51%, followed *by P. pinnata* (81.61%) > *V. negundo* (81.58%) >emamectin benzoate (80.80%) > *M. anisopliae* (80.66%) > *O. sanctum* (78.05%) > *E. globulus* (76.30%) > *L. lecanii* (76.14%) > *P. fumosoroseus* (76.12%) > *R. communis* (74.21%).

Table 2. Biorational pesticides against *Aphis gossypii* on watermelon

	Treatments details	*** Cumulative Mean Number of aphid/ top three leaves (PTC)	***Cumulative Mean Number of aphids/ top three Leaves -(X±SE)***	Aphid population (Category)	Per cent reduction over untreated check	Fruit Yield (t.ha^{-1})***	Per cent increasing yield over untreated check	ICBR
T_1	Vitex negundo - leaf decoction 5%	31.88 (5.65)	11.38 (3.37)±1.40^{abc}	Moderate	81.58(9.03)	19.93(4.46)^{fe}	22.26(4.72)^{f}	1:2.40
T_2	Azadirachta indica - oil 3%	30.30 (5.50)	4.39 (2.09)±0.63 ^{a}	Low	92.89(9.64)	25.5(5.05)^{a}	56.44(7.51) ^{a}	1:2.84
T_3	Pongamia pinnata -leaf decoction 3%	30.95 (5.56)	11.3 (3.37)±1.11 ^{bc}	Moderate	81.61(9.03)	22.9(4.79)^{bc}	21.93(4.68)^{f}	1:2.31
T_4	Ocimum sanctum- leaf decoction 5%	30.88 (5.56)	13.5 (3.69)±1.23 ^{bc}	Moderate	78.00(8.83)	19.6(4.43) ^{gfe}	20.24(4.5) ^{fg}	1:2.48
T_5	Ricinus communis -oil 3%	33.16 (5.76)	15.93(3.99)±1.34 ^{c}	Moderate	74.21(8.61)	23.03(4.8) ^{bc}	41.28(6.42)^{c}	1:2.59
T_6	Eucalyptus globulus - leaf decoction 3%	28.04 (5.30)	14.64(3.83)±1.38 ^{c}	Moderate	76.30(8.73)	21.53(4.64)^{cd}	31.9(5.65)^{d}	1:2.46
T_7	Beauveria bassiana (1x10^{8}cfu spores) -8g.L^{-1}	30.53 (5.53)	6.01(2.45)±0.80 ^{bc}	Low	90.27(9.50)	24.43(4.94)^{ab}	49.87(7.06) ^{b}	1:2.74
T_8	Metarhizium anisopliae-(1x10^{8}cfu spores) 8g.L^{-1}	32.95 (5.74)	11.95(3.46)±1.26 ^{bc}	Moderate	80.66(8.98)	18.5(4.3) ^{gf}	13.49(3.67) ^{h}	1:2.17
T_9	Paecilomyces fumosoroseus -(1x10^{8}cfu spores) 8g.L^{-1}	30.54 (5.53)	14.75 (3.84)±0.95 ^{c}	Moderate	76.12(8.72)	18.17(4.26) ^{g}	11.41(3.38)^{l}	1:2.20
T_{10}	Lecanicillium lecanii (1x10^{8}cfu spores) 8g.L^{-1}	31.64 (5.62)	14.74 (3.84)±1.19 ^{c}	Moderate	76.14(8.73)	19.5(4.42) ^{gfe}	19.63(4.43) ^{g}	1:2.34
T_{11}	Emamectin benzoate 5% SG@0.4g.L^{-1}	30.09 (5.49)	11.86 (3.44)±1.28 ^{bc}	Moderate	80.80(8.99)	20.37(4.51)^{ed}	25.15(5.01)^{e}	1:2.40
T_{12}	Spinosad 45% SC@ 0.3m.L-1	32.96 (5.74)	9.16 (3.03)±0.87 ^{abc}	Low	85.17(9.23)	23.53(4.85) ^{b}	44.17(6.65) ^{c}	1:2.68
T_{13}	Imidacloprid17.8%SL@0.3ml.L^{-1} (Treated check)	34.72 (5.89)	9.57 (3.09)±1.11 ^{abc}	Low	84.51(9.19)	23.50 (4.85) ^{b}	44.04 (6.64) ^{c}	1:2.68
T_{14}	Untreated check	33.06 (5.71)	61.79 (7.86)±3.40 ^{d}	Sever	-	16.3(4.04)^{h}	-	-
F	-	-	28.80	-	-	80.44	1963.98	-
P	-	*-NS-	**<0.000	-	-	**< 0.000	**< 0.000	-
SD	-	-	13.85	-	-	2.69	16.33	-
SE	-	-	3.70	-	-	0.72	04.37	-

PTC- Pre treatment count DAS-Days after spraying, F= F value of Tukeys Test P=Statistical significant. *NS – Non significant
SE= Standard error **Highly significant SD= Standard deviation ICBR-Incremental cost benefit ratio **** Sale price of watermelon was Rs.5.00 per

*** Each value is the mean of three replications.
Figures in parentheses are square root transformed values.
In a column, means followed by common letter(s) is /are not significantly different by Tukey HSDs test at P=0.05%

A significantly highest fruit yield (25.50 t ha^{-1}) was recorded in the treatment of *A. indica* followed by in *B. bassiana*, (24.43 t ha^{-1}), spinosad (23.53 t ha^{-1}) and lowest in untreated check (16.30 t ha^{-1}). Further, the orders of fruit yields were in imidacloprid (23.50 t ha^{-1}) >*R. communis* (23.03 t ha^{-1}) > *P. pinnata* (22.90 t ha^{-1}) > *E. globulus* (21.53 t ha^{-1}) >emamectin benzoate (20.37 t ha^{-1}) > *V. negundo* (19.93 t ha^{-1}) > *O. sanctum* (19.60 t ha^{-1}) > *L. lecanii,* (19.50 t ha^{-1}) > *M. anisopliae* (18.50 t ha^{-1}) > *P. fumosoroseus* (18.17 t ha^{-1}) (treated check) and (untreated check) (16.30 t ha^{-1}) respectively.

The increase in fruit yield (56.44%) was recorded in the treatment of *A. indica* followed by *B. bassiana*, (49.87%) and spinosad (44.17%). Further, the order of increase in fruit yield over treated check was in imidacloprid (44.04%) >*R. communis* (41.28%)> *E. globulus* (31.90%) > emamectin benzoate (25.15%) > *V. negundo* (22.26%) > *P. pinnata* (21.93%) >*O. sanctum* (20.24 %)> *L. lecanii* (19.63 %) > *M. anisopliae* (13.49 %) > *P. fumosoroseus* (11.41%).

A maximum ICBR of 1:2.84 was recorded in the treatment of *A. indica* followed by in *B. bassiana*, (1:2.74) and spinosad (1:2.68) followed by imidacloprid (1:2.68) > *R. communis* (1:2.59). > *O. sanctum* (1:2.48) > *E. globulus* (1:2.46) > *V. negundo* (1:2.40) > emamectin benzoate (1:2.40) > *L. lecanii* (1:2.34) > *P. pinnata* (1:2.31), *P. fumosoroseus* (1:2.20) > *M. anisopliae* (1:2.17).

Nur *et al.* (2020) reported that biorational insecticides are found to have repellent, antifeedant and mortality effects on herbivore insects and affect their reproduction, growth and development thus reducing their population and infestation on *Lablab purpureus.* Our finding on the watermelon crop agrees with Sedlacek and Townsend (1990) that the heavy infestations by aphids are common on cucurbitaceous and solanaceous crops. In our study, the biorational insecticides tested were found to have significantly lowered the infestation of *A. gossypii.* These findings are in accordance with Amin *et al.* (2017) and Mohammad *et al*. (2018) who observed the reduction of *A. gossypii* population and infestation in bitter gourd with sequential application of bio-pesticide, botanical insecticides.

Lowery *et al* (1993) found that neem oil 3% found to be very effective against *A. gossypii* under laboratory condition. The present study is in accordance with the findings of Sardana *et al.* (2004). Khalequzzaman and Nahar (2008) found that *A. indica* was more toxic than imidacloprid, malathion, and carbosulfan to control four aphid species namely *Aphis craccivora*, *A. gossypii, Myzus persicae* and *Lipaphis erysimi* on bean, brinjal, potato and cauliflower plants respectively. Mandal *et al*. (2006) evaluated various neem based products and found that neem oil (3%) was effective against *A. gossypii* in okra which is supporting our findings. Dimetry *et al.* (2013) found that Nimbecidine @ 0.03% + microbial product of *L. lecanii* spores @1×10^9 were effective against aphid, *M. persicae* in cucumber which is (Mahesar *et.al.,*2011; Naeem *et.al.*,2012) supporting our findings.

Muhammad *et al*. (2013) confirmed the effectiveness of *B. bassiana* 1×10^6, 1×10^7 and 1×10^8 spores/mL on *A. gossypii* and found the uppermost concentration (1×10^8 spores/ mL) proved to give maximum control within short period of time. Similar observations were made by Arun *et al*. (2018) and they reported that the entomopathogenic fungi, *B. bassiana* were found to be effective against *L.erysimi*. These findings are in line with our observations. Khadija Javed *et al*. (2019) confirmed that maximum aphid mortality was observed with the treatment of *L. lecanii* and *B. bassiana* under lab conditions correlates with our results in watermelon even under field condition also.

Ahmed *et al.* (2016) found the role of *B.bassiana* against the adults of cabbage aphid, *Brevicoryne brassicae* under laboratory conditions at three tested concentrations (10^5, 10^6 and 10^7 spores/ mL). After 7 days of application, the resulting mortality percentages were 37.77%, 60.00% and 73.33% respectively under field conditions. This finding is supported by our observation. Ravi and Nakat (2017) found that the combination of Entomopathogenic fungi as *L lecanii* 1.15 % WP + *M. anisopliae* 1.15 % WP was the most effective treatment as compared to standard check dimethoate suppressing of *A.gossypii* population in Okra. Similar findings by Arun Janu *et al*., (2018) were found in *A. gossypii* which correlate with the present investigation.

Rosalind *et al*. (1995) showed that strain of *B. bassiana* (1×10^{15}spores/ mL) reduced pea aphid, *Acyrthosiphon pisum* population up to 97.9 % under field conditions. Khan *et al*. (2012) also proved the same results showing 80% mortality caused by the filtrate application of *B. bassiana* while 57% mortality caused by conidia on 6th day of application. The present findings are in close agreement with Singh *et al*. (2008) who reported that *L. lecanii* @ 10^8 spores(mL^{-1}) dose was effective in controlling the aphid population to 75.79 %. While, Kadam *et al.* (2008) showed that the *L. lecanii* @ 6×10^5 (cfu .$m.L^{-1}$) 0.3 % had reduced the initial population of *M.persicae* in mustard. Palande and Pokharkar (2005) reported that the biological activity of *V. lecanii* against *B brassicae* with mortality from 16.3 to 93.3 % by the concentrations of 1×10^3 to 1×10^9 cfu/ mL. are in line with our investigation.

Similarly, Poprawski *et al*. (1999) also reported that the *B. bassiana* based myco insecticide was effective against brown citrus aphid, *Toxoptera citricida* and observed rapid kill of 94.4% and 79.8% with 5×10^{13} and 2.5×10^{13} conidia ha^{-1} respectively. Neelam *et al.* (2003) tested the *L. lecanii* at the concentration of 10^6, 10^7,10^8 conidia mL^{-1} against *L. erysimi* and reported the highest mortality of 80% 96 hrs of treatment at the concentration of 10^8 conidia mL^{-1}. Nirmala *et al*. (2006) and Asi *et al*. (2009) found that the, *L. lecanii*, *M. anisopliae* and *P. fumosoroseus* can effectively control aphid. Furthermore, Vu *et al*. (2007) reported that among the fungi tested, *L. lecanii*, *P.fumosoroseus B. bassiana*, *M.anisopliae, Cordyceps scarabaeicola* and *Nomuraea rileyi,* performed as the best in controlling *A. gossypii.*

Suganthy and Sakthivel (2012) found that the maximum population reduction was observed in neem oil 3% treatment (2.6 aphid/ plant), followed by NSKE (2.8 aphid/ plant) and *V. negundo* (3.1 aphid/ plant) in *Solanum nigrum.* The results were following the findings of Uthamasamy and Gajendran (1992), Belmain *et al*. (2001) who confirmed that *V.negundo* @ 2% recorded the highest mortality of *A. gosspii* with strong repellence from (77.11%). Kulat *et al.* (1997) have also indicated that pongam leaf extract was highly toxic to the *A. gossypii* in okra. Das et *al.* (2008) found that spinosad -treated plants provided a higher yield of lab lab. Among the botanicals neem oil showed a significant reduction of aphid population and consequently gave better yield (1.22 kg/plot) which are in conformity with our investigation Patel *et al.* (2015) reported that emamectin benzoate @ 10 g.a.i ha^{-1} was found to be most effective as it recorded the lowest infestation of all the recorded sucking pest of brinjal. Nur *et al.* (2020) found that the treatments viz, spinosad, emamectin benzoate and neem oil have exerted the lowest aphid population and resulted in significantly higher marketable yield than that of the control on *Lablab purpureus*. These records are comparable with our investigation in watermelon. The effectiveness of *R. communis* oil in our experiment is also comparable with the results of Arya *et al.* (2014) in the mustard aphid.

CONCLUSION

It is inferred that among the thirteen bio rational pesticides evaluated for their efficacy against *A. gossypii* in watermelon three rounds of application of *A. indica* oil @ 3% or *B. bassiana* ($1x10^8$cfu spores @ 8g/Lit) or spinosad 45% SC @ 0.3mL/Lit at 15 days interval could be adopted for the management of *A. gossypii* in watermelon

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Ethics statement

No specific permits were required for the described field studies because no human or animal subjects were involved in this research.

Consent for publication

All the authors agreed to publish the content.

Competing interests

There were no conflict of interest in the publication of this content

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required. If anything is required from the MS, certainly, this will be extended by communicating with the corresponding author through corresponding official mail: csankarento@gmail.com

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