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FIELD EVALUATION OF VARIOUS TREATMENT-SCHEDULES FOR THE CONTROL OF EPILACHNA BEETLE, *Henosepilachna vigintioctopunctata* (Fab.), ON BRINJAL

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ABSTRACT

A field trial was conducted during *kharif* 2012 and 2013 to assess the efficacy of seven treatment-schedules against Epilachna beetle on brinjal. The application of neem cake @ 300 kg ha^{-1} before seedling transplantation and foliar sprays of chlorpyriphos 20 EC + cypermethrin 5 EC @ 0.15%, cartap hydrochloride 50 SP @ 0.1% and azadirachtin 1 EC @ 0.1% at 30, 50 and 70 days after transplantation (DAT), respectively [T_1], proved most effective in reducing Epilachna population (73.9-74.7%). This was followed by treatment-schedule of seedling treatment with carbosulfan 25 EC @ 0.2% and foliar sprays of thiamethoxam 25 WG @ 0.1%, endosulfan 35EC @ 0.2% and *Bacillus thuringiensis* var. *kurstaki* 5 WP @ 0.2% at 30, 60 and 80 DAT, respectively [T_4], which depicted 58.6-68.8% decrease in beetle population. Highest yield of 13.89 to 14.28 t ha^{-1} was obtained in T_1 and lowest of 10.74 to 10.87 t ha^{-1} in T_5 (seedling treatment with imidacloprid 17.8 SL @ 0.03% and foliar spray of imidacloprid 17.8 SL @ 0.02%, novaluron 10 EC @ 0.075%, *B. thuringiensis* var. *kurstaki* 5 WP @ 0.2% and novaluron 10 EC @ 0.075% at 30, 50, 70 and 90 DAT, respectively) succeeded by untreated control. The cost-benefit ratio was maximum in T_3 (spray fipronil, novaluron, deltamethrin and fenvalerate at 30, 50, 70 and 90 DAT, respectively) and minimum in T_6 (spray with thiamethoxam 25 WG @ 0.1%, spinosad 2.5 EC @ 0.03% and abamectin 1.9 EC @ 0.2% at 30, 50 and 70 DAT, respectively).

Key words: Brinjal, efficacy, *Epilachna*, treatment schedules, yield attributes

INTRODUCTION

Vegetables play a vital role in providing essential protective nutrients like vitamins and minerals and are used as selective diet (Sharma and Saxena, 2012). Eggplant, *Solanum melongena* L., is a common popular vegetable crop worldwide grown in subtropical and tropical areas (Sarker *et al*., 2006) including India. Being a succulent crop with high plant canopy, it is susceptible to many insect-pest attacks. Forty four species of insect pests reportedly damage this crop in India (Lal, 1975). Among these Epilachna beetle, *Henosepilachna vigintioctopunctata* (Coleoptera: Coccinellidae), locally known as Hadda beetle, is one of the most destructive insects (Sreedevi *et al*., 1993, Rahaman *et al*., 2008; Islam *et al*., 2011). It is a polyphagous pest which shows its presence on brinjal and other economically important solanaceous and cucurbitaceous crops. *Henosepilachna* beetle causes considerable economic losses to many crops including brinjal depending upon the location, season and variations in prevailing environmental conditions (Bhagat and Munshi, 2004). Due to its infestation during every crop season, both quality and quantity of crop output are adversely affected. Both grub and adult feed on leaves. The larvae confine their attack to the lower leaf surface while adult beetles usually feed on upper surface (Khan *et al*., 2000). The affected leaves become skeletonized, gradually dry and drop down which ultimately leads to plant growth retardation and adversely affects fruit production in epidemic situations (Konar *et al*., 2005). Fruit yield reduction upto 60% and leaf damage upto 80% have been reported ((Rajagopal and Trivedi, 1989; Mall *et al*., 1992). In grub-infested leaves of eggplant, fully damaged epidermis, parenchyma cells and phloem cells of vascular bundles are generally noticed (Mohanchander *et al*., 2013).

The management of *Henosepilachna* beetle is based on synthetic pesticides due to their quick and knock-down action (Liu *et al*., 2003). However, the frequent and indiscriminate use of these pesticides in vegetable fields has resulted in widespread development of resistance, undesirable effects on non-target organisms, presence of toxic residues in food and environmental/health hazards (Kranthi *et al*., 2002). These problems have highlighted the need for developing new, safe and eco-friendly pest control strategies. The use of natural plant products with microbial and less hazardous pesticides is considered to be an eco-friendly proposition. Therefore, a field study was undertaken to find out the bio-efficacy of different treatment-schedules including chemicals and non-chemicals against coccinellid attacking brinjal.

MATERIALS AND METHODS

A field trial was conducted at Adisaptagram Seed Farm, Hooghly, West Bengal (India) during *kharif* season (June to October) of years 2012 and 2013 to assess the bio-efficacy of seven treatment-schedules on population buildup of Epilachna beetle infesting brinjal. The brinjal seedlings cv. 'Muktakeshi' were transplanted in late June in plots of 3.75 x 4.50 m size at plant spacing of 75 x 75 cm. All the standard agronomic practices recommended for the region were followed for raising a good crop. The treatment-schedules followed consisted of both chemical and non-chemical insecticides. The treatment-schedules evaluated were as under:

T_1 = i) Soil application of neem cake @ 300 kg ha^{-1} before seedling transplantation, ii) foliar spray with chlorpyriphos 20 EC + cypermethrin 5 EC (Koranda from Rallis India) @ 1.5 mL L^{-1} water at 30 DAT (days after transplantation); iii) foliar spray with cartap hydrochloride 50 SP (Caldan from Dhanuka Agritech) @ 1.0 g L^{-1} water at 50 DAT, and iv) foliar spray with azadirachtin 1 EC (Neembaan from Pest Control India) @ 1 mL L^{-1} water at 70 DAT;

T_2 = i) Soil application of phorate 10 G (Umet from United Phosphorus Ltd.) @ 1.5 kg a.i. ha^{-1} before seedling transplantation; ii) foliar spray with acephate 75 SP (Asataf from Rallis India) @ 0.75 g L^{-1} water at 50 DAT; iii) foliar spray with thiodicarb 75 WP (Larvin from Bayer Crop Science) @ 0.75 g L^{-1} water at 70 DAT; and iv) foliar spray with *Bacillus thuringiensis* var. *kurstaki* 5 WP (Halt from Biostadt India) @ 2.0 g L^{-1} water at 90 DAT;

T_3 = i) Foliar spray with fipronil 5 EC (Regent from Bayer Crop Science) @ 0.5 mL L^{-1} water at 30 DAT; ii) Foliar spray with novaluron 10 EC (Rimon from Indofil Industries) @ 0.75 mL L^{-1} water at 50 DAT; iii) foliar spray with deltamethrin 2.8 EC (Decis from Bayer Crop Science) @ 0.5 mL L^{-1} water at 70 DAT; iv) foliar spray with fenvalerate 20 EC (Tatafen from Rallis India) @ 0.5 mL L^{-1} water at 90 DAT;

T_4 = i) Seedling treatment with carbosulfan 25 EC (Marshal from FMC India) @ 2 mL L^{-1} water before seedling transplantation; ii) foliar spray with thiamethoxam 25 WG (Actata from Syngenta) @ 0.33 g L^{-1} water at 30 DAT; iii) foliar spray with endosulfan 35 EC (Endocel from Exel India) @ 2 mL L^{-1} water at 60 DAT; iv) foliar spray with *B. thuringiensis* var. *kurstaki* 5 WP @ 2 g L^{-1} water at 80 DAT;

T_5 = i) Seedling treatment with imidacloprid 17.8 SL (Confidor from Bayer Crop Science) @ 0.3 mL L^{-1} water before seedling transplantation; ii) foliar spray with imidacloprid 17.8 SL @ 0.2 mL L^{-1} water at 30 DAT; iii) foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} water at 50 DAT; iv) foliar spray with *B. thuringiensis var kurstaki* 5 WP @ 2 g L^{-1} water at 70 DAT; vi) foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} water at 90 DAT

T_6 = i) Foliar spray with thiamethoxam 25 WG @ 0.33 g L^{-1} water at 30 DAT; ii) foliar spray with spinosad 2.5 EC (Tracer from Dow Agro Science) @ 1 mL 3 L^{-1} water at 50 DAT; iii) foliar spray with abamectin 1.9 EC (Vertimec from Syngenta) @ 2 mL L^{-1} water at 70 DAT;

T_7 = Water sprays (control)

The experiment was conducted in a randomized block design with each treatment replicated three times. The infestation pattern of Epilachna beetle was recorded from randomly selected 10 plants in each plot and counted from one upper, one middle and one lower leaf from each plant. The observation on Epilachna beetle was recorded at 10 days interval. The number and weight of marketable and unmarketable fruits were noted separately in each plot at the time of crop harvest. The data was subjected to appropriate transformation wherever necessary prior to statistical analysis using MSTAT-C software.

RESULTS AND DISCUSSION

Incidence of Epilachna beetle

All the treatment schedules proved significantly superior over control throughout the crop life during 2012 (Table 1). Among the various treatment schedules: T_1 (soil application of neem cake @ 300 kg ha^{-1} before seedling transplantation, foliar spray with chlorpyriphos 20 EC + cypermethrin 5 EC @ 1.5 mL L^{-1} water at 30 DAT, foliar spray with cartap hydrochloride 50 SP @ 1 g L^{-1} water at 50 DAT, foliar spray with azadirachtin 1 EC @ 1 mL L^{-1} water at 70 DAT), T_2 (soil application of phorate 10 G @ 1.5 kg a.i ha^{-1} before transplanting, foliar spray with acephate 75 SP @ 0.75 g L^{-1} water at 50 DAT, foliar spray with thiodicarb 75 WP @ 0.75 g L^{-1} water at 70 DAT, foliar spray with *B. thuringiensis* var. *kurstaki* 5 WP @ 2 g L^{-1} water at 90 DAT, T_4 (seedling treatment with carbosulfan 25 EC @ 2 mL L^{-1} water before transplanting, foliar spray with thiamethoxam 25 WG @ 0.33 g L^{-1} water at 30 DAT, foliar spray with endosulfan 35 EC @ 2 mL L^{-1} water at 60 DAT, foliar spray with *B. thuringiensis* 5 WP @ 2 g L^{-1} water at 80 DAT and T_5 (seedling treatment with imidacloprid 17.8 SL @ 0.3 mL L^{-1} water before transplanting, foliar spray with imidacloprid 17.8 SL @ 0.2 mL L^{-1} water at 30 DAT, foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} water at 50 DAT, foliar spray with *B. thuringiensis* @ 2 g L^{-1} water at 70 DAT, foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} water at 90 DAT) maintained lower population of coccinellid round the season. Among the seven treatment schedules tested, T_1 was most effective in decreasing (5.39 per three leaves) the coccinellid population per three leaves below its critical level than other treatment schedules as well as control. The next best treatments were T_2 (8.0) followed by T_5 (8.03), T_4 (8.84), T_6 (10.27), T_3 (12.33) and T_7 (21.33). Consequently, the per cent decrease of coccinellid population over control was maximum in T_1 (62.35), followed by T_2 (62.5), T_5 (62.3), T_4 (58.6), T_6 (51.8) and T_3 (42.2).

In 2^{nd} year (2013) all the treatment-schedules tested were effective in significantly reducing coccinellid population over control (Table 2). Treatment-schedule T_1 showed low mean beetle population (6.33) per 3 leaves; the others in deceasing order were T_4 (7.57), T_2 (8.63), T_5 (9.33), T_6 [foliar spray with thiamethoxam 25 WG @ 0.33 g L^{-1} water at 30 DAT, foliar spray with spinosad 2.5 EC @ 1 mL L^{-1} water at 50 DAT, foliar spray with abamectin 1.9 EC @ 2 mL L^{-1} water at 70 DAT] (12.18), T_3 [foliar spray with fipronil 5 EC @ 0.5 mL L^{-1} water at 30 DAT, foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} water at 50 DAT, foliar spray with deltamethrin 2.8 EC@ 0.5 mL L^{-1} water at 70 DAT, foliar spray with fenvalerate 20 EC @ 0.5 mL L^{-1} water at 90 DAT(13.04) and

Table 1: Incidence of Epilachna beetle on brinjal in various treatment schedules during 2012

Treat-ment schedule **	Population of Epilachna beetle on different dates after planting (means of three replications)										Mean population	Decrease over control (%)
	July		August			September			October			
	II	III	I	II	III	I	II	III	II	III		
T_1	0 (0)	4.33	2.66	6.66	4.66	8.33	4.33	10.00	12.38	6.00	5.39	74.73
		(11.51)	(9.27)	(14.33)	(12.13)	(16.12)	(11.51)	(17.85)	(20.24)	(13.78)		
T_2	0 (0)	0 (0)	6.33	14.33	7.66	15.33	6.66	12.66	15.66	9.33	8.00	62.49
			(14.04)	(21.95)	(15.66)	(22.74)	(14.72)	(20.53)	(23.06)	17.26)		
T_3	0 (0)	17.33	10.33	16.33	25.66	33.66	10.33	8.33	5.33	0 (0)	12.33	42.19
		(24.29)	(18.20)	(23.56)	(30.27)	(35.24)	(18.31)	(16.37)	(12.84)			
T_4	0 (0)	7.33	4.66	10.66	6.33	9.33	16.66	20.33	14.66	7.33	8.84	58.56
		(15.19)	(12.13)	(18.78)	(14.39)	(17.31)	(23.71)	(26.35)	(22.19)	(15.19)		
T_5	0 (0)	4.66	2.33	6.33	5.66	10.33	14.33	20.33	15.66	8.66	8.03	62.35
		(12.03)	(7.17)	(14.01)	(13.16)	(18.11)	(21.83)	(26.55)	(23.00)	(16.71)		
T_6	0 (0)	10.33	6.33	18.33	7.66	14.66	10.66	19.33	15.33	(10.33	10.27	51.85
		(18.31)	(13.97)	(24.91)	(15.48)	(22.16)	(18.62)	(25.69)	22.86	18.16		
T_7	6.33	15.33	28.33	36.66	44.33	38.33	27.66	17.66	11.33	8.66	21.33	-
	(13.89)	(22.70)	(31.95)	(37.12)	(41.61)	(38.08)	(31.58)	(24.45)	(19.18)	(16.51)		
SEM±	1.54	2.56	2.89	3.17	3.54	3.58	2.90	3.30	2.83	2.93	-	-
$CD_{0.05}$	3.88	6.45	7.28	7.99	8.92	9.02	7.32	8.32	7.14	7.39	-	-

*****Figures in parenthesis are angular transformed values; **T_1 = i) Soil application of neem cake @ 300 kg ha^{-1} before seedling transplantation, ii) foliar spray with chlorpyriphos 20 EC + cypermethrin 5 EC) @ 1.5 mL L^{-1} at 30 DAT; iii) foliar spray with cartap hydrochloride 50 SP @ 1.0 g L^{-1} at 50 DAT, and iv) foliar spray with azadirachtin 1 EC @ 1 mL L^{-1} at 70 DAT; T_2 = i) Soil application of phorate 10 G @ 1.5 kg a.i. ha^{-1} before transplantation; ii) foliar spray with acephate 75 SP @ 0.75 g L^{-1} at 50 DAT; iii) foliar spray with thiodicarb 75 WP @ 0.75 g L^{-1} at 70 DAT; and iv) foliar spray with *B. thuringiensis* 5 WP @ 2.0 g L^{-1} at 90 DAT; T_3 = i) Foliar spray with fipronil 5 EC @ 0.5 mL L^{-1} at 30 DAT; ii) Foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} at 50 DAT; iii) foliar spray with deltamethrin 2.8 EC @ 0.5 mL L^{-1} at 70 DAT; iv) foliar spray with fenvalerate 20 EC @ 0.5 mL L^{-1} at 90 DAT; T_4 = i) Seedling treatment with carbosulfan 25 EC @ 2 mL L^{-1} before transplantation; ii) foliar spray with thiamethoxam 25 WG @ 0.33 g L^{-1} at 30 DAT; iii) foliar spray with endosulfan 35 EC @ 2 mL L^{-1} at 60 DAT; iv) foliar spray with *B. thuringiensis* 5 WP @ 2 g L^{-1} at 80 DAT; T_5 = i) Seedling treatment with imidacloprid 17.8 SL @ 0.3 mL L^{-1} before transplantation; ii) foliar spray with imidacloprid 17.8 SL @ 0.2 mL L^{-1} at 30 DAT; iii) foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} at 50 DAT; iv) foliar spray with *B. thuringiensis* 5 WP @ 2 g L^{-1} at 70 DAT; vi) foliar spray with novaluron 10 EC @ 0.75 mL L^{-1} at 90 DAT; T_6 = i) Foliar spray with thiamethoxam 25 WG @ 0.33 g L^{-1} at 30 DAT; ii) foliar spray with spinosad 2.5 EC @ 1 mL 3 L^{-1} at 50 DAT; iii) foliar spray with abamectin 1.9 EC @ 2% at 70 DAT; T_7 = Water spray (control)

T_7 [control] (24.24). T_1 showed highest decrease in beetle population over control (73.9%), which was followed by T_4 (68.8%), T_2 (64.4%), T_5 (61.5%), T_6 (49.7%) and T_3 (46.0%).

Out of the seven treatment-schedules evaluated, T_1 proved most effective in lessening coccinellid population on brinjal. This may be attributed to the fact that at the time of beetle population development, the crop was sprayed with chemical insecticides including synthetic pyrethroid, which maintained low population of coccinellid. Our results are in agreement with Mala *et al.* (1992) who reported chlorpyriphos, cypermethrin and cartap hydrochloride as effective insecticides against the pest. Cartap hydrochloride followed by neem oil have been reported most effective treatments for the control of epilachna beetle (Ghosh and Chakrabarty, 2012). Synthetic pyrethroids were also used in T_3 but not as effective as in T_1. The treatment schedules T_2, T_4 and T_5 gave satisfactorily control of coccinellid in brinjal. The findings of Chitra *et al.* (1993), Sreedevi *et al.* (1993), Rajendran and Gopalan (1999), Mandal and Kumar (2001) and Konar *et al.* (2005) are in conformity to our results.

Yield of brinjal fruits and economics of treatment schedules

The marketable fruit yield of brinjal during 2012 was maximum in T_1 (13.89 t ha^{-1}) followed by T_6, T_3, T_2, T_4, T_5 and T_7 (Table 3). Treatment T_1 gave highest net profit (Rs. 48,306 ha^{-1}) over control and was succeeded by T_3, T_6, T_2, T_4 and T_5. However, the cost benefit ratio was highest in T_3 (1: 20.7)

Table 2: Incidence of Epilachna beetle on brinjal in various treatment-schedules during 2013

Treat-ment schedule **	Population of Epilachna beetle on different dates after planting (means of three replications)										Mean popu-lation	Decrease over control (%)
	July		August			September			October			
	II	III	I	II	III	I	II	III	II	III		
T_1	2.66 (9.27)	7.66 (15.56)	2.33 (7.17)	5.33 (12.91)	3.33 (10.34)	8.66 (16.71)	5.66 (13.16)	11.00 (18.99)	14.33 (21.93)	8.66 (16.65)	6.33	73.89
T_2	0 (0)	3.33 (10.15)	7.33 (15.19)	13.66 (21.18)	7.66 (15.78)	16.33 (23.56)	6.33 (14.09)	10.66 (18.73)	18.33 (25.12)	11.33 (19.21)	8.63	64.40
T_3	6.66 (14.33)	15.33 (22.79)	7.66 (15.78)	18.66 (25.22)	28.33 (31.99)	35.33 (36.33)	10.33 (18.31)	9.33 (17.31)	7.66 (15.56)	4.66 (12.13)	13.04	46.00
T_4	0 (0)	6.00 (13.87)	3.33 (10.34)	6.66 (14.33)	2.66 (9.08)	8.33 (16.22)	14.66 (22.16)	19.00 (25.59)	13.33 (21.17)	9.33 (17.31)	7.57	68.77
T_5	0 (0)	5.66 (13.16)	2.33 (8.47)	7.33 (15.19)	10.66 (18.62)	14.33 (21.83)	23.66 (28.80)	18.33 (25.01)	13.00 (20.70)	7.33 (15.19)	9.33	61.51
T_6	9.33 (17.26)	16.66 (23.76)	10.66 (18.62)	22.33 (27.90)	12.33 (20.10)	15.33 (22.74)	10.33 (18.24)	17.66 (24.74)	11.66 (19.49)	7.66 (15.78)	12.18	49.75
T_7	7.00 (14.68)	18.33 (25.00)	26.33 (30.58)	37.66 (37.68)	50.33 (45.20)	43.33 (41.11)	31.66 (34.07)	25.33 (29.91)	16.33 (23.58)	10.33 (18.31)	24.24	-
SEM±	1.70	2.13	2.46	2.88	2.68	2.85	2.60	2.53	2.27	2.32	-	-
$CD_{0.05}$	4.29	5.37	6.21	7.26	6.76	6.76	6.55	6.38	5.72	5.85	-	-

***Figures in parenthesis are angular transformed values; **For treatment details see footnote in Table 1

followed by T_4 (1:20.5) and T_2 (1:20.1). During 2013, the marketable fruit yield was highest in T_1 (14.29 t ha^{-1}), succeeded closely by T_6 (13.48 t ha^{-1}) and T_3 (13.22 t ha^{-1}). The maximum net profit over control was observed in T_1 (₹ 52,258 ha^{-1}) closely followed by T_3 and T_6. Treatment schedule T_3 gave maximum monetary return (1: 24.4) over control followed by T_4 (1:22.9) and T_2 (1:18.6). Among the different treatment schedules, T_1, T_3 and T_6 recorded higher marketable fruits of brinjal. T_2 and T_4 also showed quite better yield. However, CBR was maximum in T_3 (1:20.7-24.4) because in this schedule two synthetic pyrethroids were applied which were most cost effective against coccinellid. The net profit was highest (₹ 48306-52258) in T_1 costing ₹ 4590 for beetle management. Such high cost was due to integration of neem cake in this schedule. However, it was ₹ 39380-46412 in T_3 with costing of ₹ 1900 only against Epilachna. Less treatment cost for synthetic pyrethroids resulting effective and economical return was also reported earlier by Tripathi and Patnaik (2003) who got 8.09-40.40 times benefit over the cost in case of beetle management.

Conclusion: Considering the highest net monetary return and better soil health through neem cake, of the seven treatment-schedules evaluated, **s**oil application of neem cake @ 300 kg ha^{-1} before

Table 3: Cost effectiveness of various treatment-schedules in the management of Epilachna beetle in brinjal during 2012 and 2013

Treatment schedules*	Marketable yield (t ha^{-1})		Added benefit over control (₹ ha^{-1})		Cost of treatment (₹ ha^{-1})		Net profit (₹ ha^{-1})		CBR (Cost benefit ratio)	
	2012	2013	2012	2013	2012	2013	2012	2013	2012	2013
T_1	13.89	14.28	52,896	56,848	4,590	4,590	48,306	52,258	1:10.52	1:11.38
T_2	12.25	11.74	37,152	34,408	1,759	1,759	35,393	32,649	1:20.12	1:18.56
T_3	12.68	13.32	41,208	48,312	1,900	1,900	39,380	46,412	1:20.73	1:24.43
T_4	11.68	11.83	31,680	35,200	1,470	1,470	30,210	33,730	1:20.55	1:22.94
T_5	10.87	10.74	23,904	25,608	2,961	2961	20,943	22,647	1:7.07	1:7.65
T_6	13.28	13.48	47,040	49,720	8,812	8,861	38,228	40,859	1:4.34	1:4.61
T_7	8.38	7.83	-	-	-	-	-	-	-	-

The selling price of brinjal during 2012 and 2013 were ₹ 9600 and 8800 t^{-1}, respectively; *For treatment details see footnote in Table 1.

seedling transplantation followed by foliar spray with chlorpyriphos 20 EC + cypermethrin 5 EC @ 1.5 mL L^{-1} water at 30 DAT, foliar spray with cartap hydrochloride 50 SP @ 1 g L^{-1} water at 50 DAT and foliar spray with azadirachtin 1 EC @ 1 mL L^{-1} water at 70 DAT could be recommended for effective management of Epilachna beetle in brinjal.

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