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Evaluation of Synthetic Insecticides for the Management of Sweet Potato Weevil, *Cylas formicarius* (Fabricius) (Coleoptera: Brentidae)

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Abstract

Sweet potato weevil (SPW), *Cylas formicarius* (Fab.) is the most devastating pest of sweet potato in the field and tubers under storage. The infestation of weevil reduces the quality of the tubers; therefore, it affects marketability and economic value of the crop as well. Efficacy of six insecticides, namely Imidacloprid, Chlorpyrifos, Malathion, Dimethoate, Dichlorvos and Quinalphos at three concentrations (0.001, 0.01 and 0.05%) were evaluated against SPW by two different bioassay methods - foliar application and vine dipping- and compared their toxicity against control with water. In the case of foliar application, the mortality of SPW on 1, 3, 5, 7 and 9 days after treatment (DAT) was highest in the treatments with Imidacloprid and Chlorpyrifos. In contrast, it was least in Malathion and Dimethoate. Imidacloprid was found most effective for vine dipping, and its effect lasted upto 9 DAT. The present study revealed that foliar application of Imidacloprid at the concentrations of 0.01 and 0.05% was most effective against SPW.

Key words: *Cylas formicarius,* Malathion, Dimethoate, Dichlorvos, Chlorpyrifos, Quinalphos, Imidacloprid, sweet potato

Introduction

Sweet potato, an important food crop, is ranked as the seventh most significant crop of the world after wheat, rice, maize, potato, barley and cassava (Prakash et al., 2016; CIP, 2017; Prakash et al., 2017). Over 95% of its production is in developing countries; nevertheless, infestation by a broad spectrum of insects pests is the limiting factor in sweet potato production at global level, and these insect pests are more prevalent in the tropical regions (Jackai et al., 2006). Among the 300 insects and non-insect pests reported on sweet potato, the weevil, *Cylas formicarius* (Fab.) has been recognized as the most noxious pest (Chalfant et al., 1990; Korada et al., 2010). Kandori et al. (2006) reported that *C. formicarius* was the major pest of sweet potato in the tropical and subtropical zones from West and East Africa, Southern Africa, Madagascar, Mauritius, Seychelles, India, Bangladesh, Sri Lanka, South East Asia, China, Philippines, Indonesia, USA, West Indies, Mexico, northern South America, and several other locations around the world. *Cylas puncticollis* and *C. brunneus* are the major species of SPW reported on sweet potato in Uganda (Smit, 2003; Mwanga et al., 2009; Muyinza et al., 2012), Kenya (Smit and Matengo, 1995; Nderitu et al., 2009), Nigeria (Ehisianya, 2019) and from 20 other African countries (CAB International, 2005).

Sweet potato weevil damages all parts of the crop (Edison et al., 2009). Larval stages feed stem and tuber and causing extensive damage to the crop (Jackai et al., 2006). Cryptic and concealed feeding habits of larval stages and nocturnal activity of adults are the major impediments to detect the infestation and to develop an appropriate strategy for its management. Weevil infestation induces the production of terpenoids in tuber, causing bitter taste to the tuber (Stathers et al., 2003) and turns them unpalatable and unfit for allied uses. Though SPW is nocturnal in habit, it can respond to the pheromone source even at daylight (Reddy et al., 2012b). Synthetic insecticides are widely used for the management of SPW. Sutherland (1986a) studied the efficiency of 59 different chemical insecticides and botanicals against SPW, and researchers claimed adequate control of SPW by spraying insecticides either as a foliar application or as soil drenching (Palaniswami and Mohandas, 1996). Selection of quality planting material is the primary requirement in weevil management, as the infested sweet potato vine carries eggs and larval stages, those cause fast spread in the fields (Talekar, 1995; Nottingham, 2002). Weevil-free vine cuttings can be produced by dipping the vines in a suitable insecticide solution before planting. Talekar (1995) reported that dipping sweet potato vines in Carbofuran (0.05 %) before planting could considerably reduce the weevil infestation, even though the crop was very near to a weevil source. Korada (2010) opined that dipping sweet potato vines in Endosulfan, Fenthion and Fenitrothion @ 0.05% can control the weevil for four weeks. Although various control measures have been practiced to reduce the damage caused by SPW, insecticide application remains the main strategy for its control (Sutherland, 1986a).

Materials and Methods

Collection of sweet potato weevils

Pheromone trap with 100 μg of the compound, Z3-Dodecenyl-*E*2-butenoate in red standard rubber septa as the lure was kept in the sweet potato field of ICAR-Central Tuber Crops Research Institute, Thiruvananthapuram, Kerala, India, and the collected male weevils were transferred into a 500 ml capacity plastic jar. Cuttings of tender sweet potato vines of ~2 cm size was given for feeding, and the mouth of the jar was closed with muslin cloth.

Screening synthetic insecticides against sweet potato weevil

Six synthetic insecticides in three different groups namely. organophosphates (Chlorpyrifos 20 EC, Malathion 50 EC, Dimethoate 30 EC and Dichlorvos 76 EC), organothiophosphate (Quinalphos 25EC) and neonicotinoid (Imidacloprid 17.8 SL) at three concentrations (0.001, 0.01 and 0.05%) were evaluated against SPW during August to February of 2017 and 2018.

a. Foliar application

Sweet potato plants, variety, Sree Arun raised in pots (30cm dia) were sprayed with the prepared insecticides solutions by using a hand sprayer. Water sprayed plants were served as control. Leaves with petiole collected from sweet potato plants from 1, 3, 5, 7 and 9 DAT were transferred into clean Petri dishes (90 x 20 mm), and into which 20 male adult of SPW was released. The experiment was conducted with three replications at room temperature at 28-30^{o}C and 60-70% RH. Mortality of SPW was recorded 24 hours after treatment (HAT) for days.

b. Systemic action

Sweet potato vine cuttings of ~15 cm long were prepared, and the stem base was dipped in conical flasks containing 100 ml of the prepared concentrations of insecticides. Vine cuttings in water were kept as control. After 30 minutes, the cuttings were individually transferred into 250 ml tap water taken in plastic containers (500 ml) and kept at room temperature. Leaves collected from these treated plants at 1, 3, 5 7 and 9 DAT was used for feeding the weevil, and their mortality was observed.

Results and Discussion

a. Foliar application

Among the six insecticides with three different concentrations used for feeding, the mortality of SPW was found 100% on 1 DAT with 0.05% concentration of Imidacloprid, Chlorpyrifos, Dichlorvos and Quinalphos (Fig. 1). Complete mortality of SPW at 0.01% concentration was observed only in the Imidacloprid treated batches on 1DAT, but in the treatments with Chlorpyrifos, Dichlorvos and Quinalphos, out of 20 weevils per each replication, the average mortality of weevil recorded was 18.3 (91.0%), 15.7 (78.3%) and 13.7 (68.3%), respectively. Malathion and Dimethoate were found relatively less toxic to SPW, and this result was in corroboration with the findings of Leng and Reddy (2012). Singh et al. (2005) have reported the efficiency and versatility of neonicotinoid in controlling insect pests like borers, jassids and aphids in okra. On 5 DAT, of the 20 SPW per replication were treated with 0.05% conc., the mortality was highest in the batches treated with Imidacloprid (15.0) followed

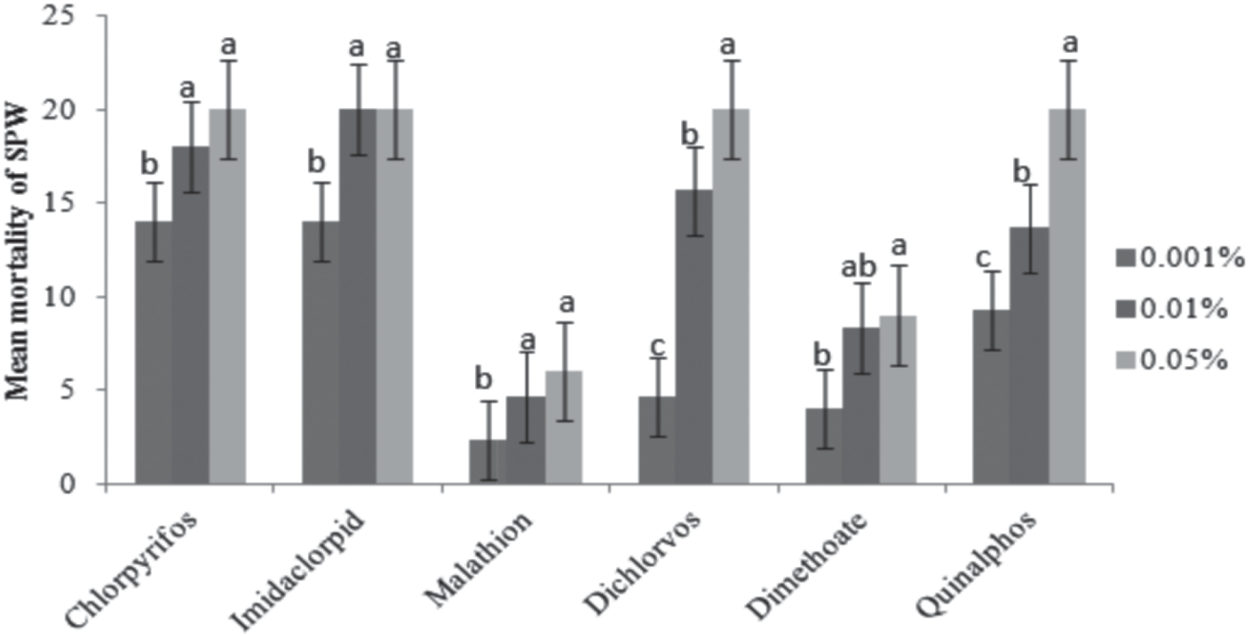

Fig. 1. Mortality of sweet potato weevil on the first day after feeding with sweet potato leaves treated with synthetic insecticides by foliar application

Duncan's Multiple range Test ($p < 0.05$); Letters of the same in each group is not significant. Replication 3, $n = 20$

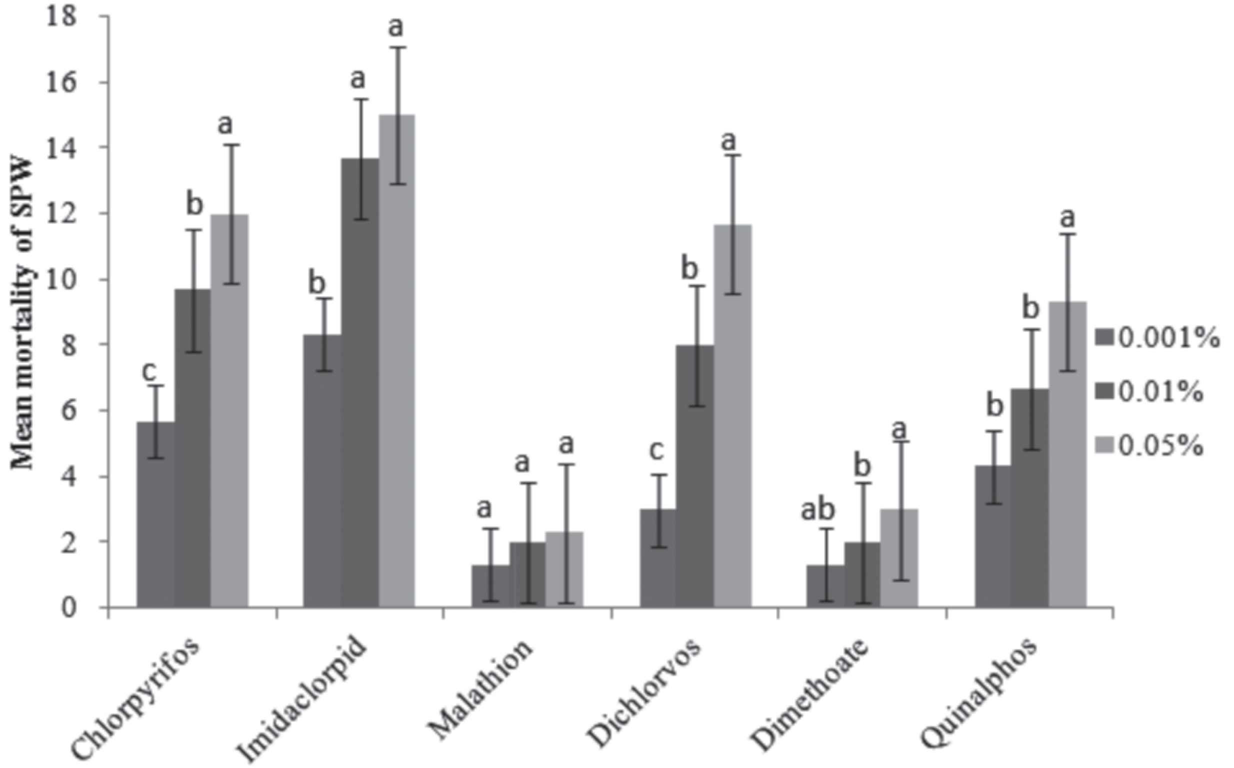

Fig. 2. Mortality of sweet potato weevil on the fifth day after feeding with sweet potato leaves treated with synthetic insecticides by foliar application

Duncan's Multiple range Test ($p < 0.05$); bars with the same letter in each group is not significant. Replication 3, $n = 20$

by Chlorpyrifos (12.0) and Dichlorvos (11.7) (Fig. 2). Weevil fed with leaves treated with Imidacloprid at 0.01% had a mortality of 13.7 (68.5%), but it was less than 50.0% in the rest of the treatments. Mortality of SPW was found less in lowest concentration (0.001%) and it was noticed as relatively less in Chlorpyrifos 5.7 (28.4%), followed by 4.3 (21.7%) in Quinalphos, 3.0 (15.0%) in Dichlorvos, and 1.3 (6.0%) each in Dimethoate and Malathion as against 8.3 (41.3%) in Imidacloprid. Toxicity of the insecticides declined considerably with respect to the DAT. On 9 DAT, except the treatment with Imidacloprid, none of the other treatments caused over 50% mortality of the target pest (Fig. 3).

Of the six insecticides evaluated, Imidacloprid was proved to have the highest toxicity to SPW and a positive correlation (r= 0.9) was found between mortality and DAT. Roberts and Hutson (1999) reported the effectiveness of Imidacloprid against sucking pests like aphids, whiteflies, thrips, leafhopper; and other pests like bugs, beetles, and borers in fruits and vegetables. Chlorpyrifos was found next to Imidacloprid in its efficacy to kill SPW. Hwang (2001) opined that Chlorpyrifos was more effective and persistent insecticide and use of this insecticide could reduce the tuber damage by weevil to an extend of 57-65%. Hwang and Hung (1992, 1994) also reported that Chlorpyrifos and Fensulfothion granules were more toxic to the adults SPW, and laboratory experiment proved their persistence in the soil for months. Sweet potato leaves treated with Malathion and Dimethoate caused very little mortality to SPW. Teli and Salunke (1993) observed that a single dusting of Malathion failed to reduce weevil population and extent of damage on vine and tubers.

b. Systemic action

The experiment proved that leaves collected from the vines, those dipped in insecticides were less toxic than those collected from foliar application. Weevils fed with leaves collected from vine cuttings dipped in all the three concentrations of Imidacloprid had the highest mortality than the other five insecticides, and Malathion had the least mortality (Table 1). Mortality of weevil due to the feeding of leaf collected from vine cuttings dipped in Imidacloprid at the concentration of 0.05% was complete on 1 DAT, but it declined to 88.4 and 51.7% at 0.01 and 0.001% concentration, respectively. Mortality of weevil due to its feeding with leaves collected from vine cuttings dipped in 0.05% con. of Chlorpyrifos, Quinalphos, Dichlorvos, Dimethoate and Malathion was

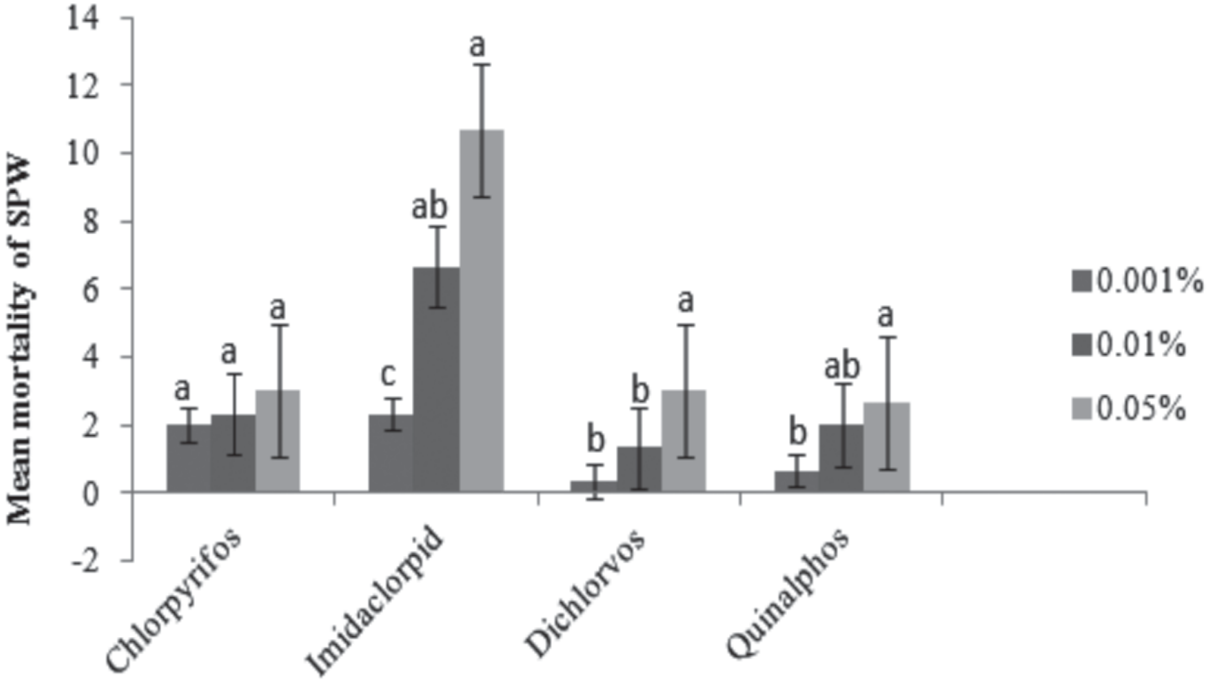

Fig. 3. Mortality of sweet potato weevil on the ninth day after feeding with sweet potato leaves treated with synthetic insecticides by foliar application

Duncan's Multiple range Test ($p < 0.05$); bars with the same letter in each group is not significant. Replication 3, n = 20

Table 1. Mortality of sweet potato weevil on the first day after feeding with leaves collected from sweet potato vines dipped in synthetic insecticides

Concen-tration (%)	Insecticides						
	Imidacloprid	Chlorpyrifos	Malathion	Dimethoate	Dichlorvos	Quinalphos	Control
0.001	10.3^{c}(51.6)	7.0^{c}(35.0)	1.7^{a}(8.2)	1.3^{b}(6.6)	3.7^{b}(18.3)	4.0^{c}(20.0)	0
0.01	17.7^{b}(88.3)	15.0^{b}(75.0)	2.3^{a}(11.6)	5.3^{ab}(26.6)	6.3^{ab}(31.6)	9.7^{b}(48.3)	0
0.05	20.0^{a}(100.0)	18.3^{a}(91.6)	3.0^{a}(15.0)	9.0^{a}(45.0)	11.0^{a}(55.0)	12.3^{a}(61.6)	0
General Mean	15.9	13.4	2.3	5.2	7.0	8.7	0
p-Value	<.0001	<.0001	0.04	0.0038	0.0066	<.0001	-
CV(%)	2.3	4.9	17.5	23.0	19.3	4.7	-

Duncan's Multiple range Test ($p < 0.05$), Parentheses show percentage mortality, n = 20, Replication = 3

91.7, 61.7, 55.0, 45.0 and 15.0% respectively, and it declined drastically to 35.0, 20.0, 18.3, 8.6 and 6.6% for Chlorpyrifos, Quinalphos, Dichlorvos, Malathion and Dimethoate respectively, at a concentration of 0.001%. Talekar (1991), and Smith and Odongo (1997) reported that dipping vine cuttings in systemic insecticide before planting eliminated the stages of SPW and protected the crop up to one month after planting. Tesfaye (2002) opined that treatment of planting material by dipping systemic insecticidal solution for 30 minutes can control SPW during the early stages of the plant growth.

On 5 DAT at 0.05%, the highest mortality of SPW was observed in the batches treated with Imidacloprid (71.7%), followed by Chlorpyrifos (60.0%). However, mortality was significantly lower in weevils those fed with leaves collected from vines dipped in Dichlorvos, Quinalphos and Dimethoate, and no weevil was killed in Malathion treated vines (Table 2). Tesfaye (2002) observed that vine cutting dipped in organophosphate decreased the damage by SPW. Current investigation ascertained that dipping sweet potato vines in Imidacloprid was significantly ($P < 0.05$) effective in managing SPW than all other treatments. Except Chlorpyrifos, all other selected organophosphate insecticides did not show promising effect to manage the weevil. Singh et al. (2005) reported that dipping sweet potato vine in 0.004% Imidacloprid overnight, and three sprayings at fortnightly interval can reduce the weevil infestation and increase the tuber yield.

Mortality of SPW fed with leaves treated with Imidacloprid at 0.05, 0.01 and 0.001% on 9 DAT was 53.3, 48.3 and 28.3%, respectively, but no death of SPW was noticed in all other treatments. Mortality of SPW due to feeding the leaves collected from sweet potato vines dipped in Imidacloprid (0.01%) had a positive correlation ($r = 0.9$) between mortality of weevil and DAT (Fig. 4).

The present study proved that among the selected six insecticides, Imidacloprid was found the most effective, followed by Chlorpyrifos for treating the sweet potato planting material to manage SPW.

Table 2. Mortality of sweet potato weevil on the fifth day after feeding with leaves collected from sweet potato vines dipped in synthetic insecticides

Concen-tration (%)	Insecticides						
	Imidacloprid	Chlorpyrifos	Malathion	Dimethoate	Dichlorvos	Quinalphos	Control
0.001	7.7^{b}(38.3)	5.7^{c}(28.3)	0	0.3^{b}(1.6)	0.3^{a}(1.6)	0.7^{c}(3.3)	0
0.01	13.3^{a}(66.6)	9.7^{b}(48.3)	0	3.0^{a}(15.0)	1.3^{a}(6.6)	2.7^{b}(13.3)	0
0.05	14.3^{a}(71.6)	12.0^{a}(60.0)	0	4.0^{a}(20.0)	1.6^{a}(8.3)	5.3^{a}(26.6)	0
General Mean	11.8	9.1	0	2.4	1.1	2.9	0
p-Value	0.0002	<.0001	-	0.0004	0.1451	0.0002	-
CV(%)	4.5	3.6	-	13.6	60.0	11.5	-

Duncan's Multiple range Test ($p < 0.05$), Parentheses show percentage mortality, n = 20, Replication = 3

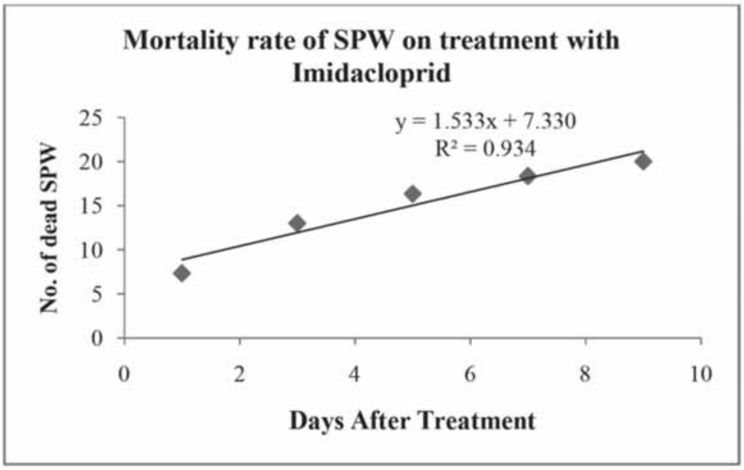

Fig. 4. Linear relationship between mortality of sweet potato weevil due to the treatment of Imidacloprid at 0.01% and days after treatment

Conclusion

Screening of six synthetic insecticides against SPW showed variation in their toxicity. The result proved that Imidacloprid is the most promising insecticide for the control of adult SPW, followed by Chlorpyrifos. While the toxicity was found moderately to SPW due to the treatment with Quinalphos and Dichlorvos, it was least in the treatments with Dimethoate and Malathion. Dipping vine cuttings and spraying Imidacloprid at regular intervals can be suggested to manage SPW.

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