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Role of Alternative Insecticides in Integrated Pest Management (IPM) to Certain Sugar Beet Insects

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ABSTRACT
Conventional insecticides led to numerous problems, environmental pollution, elimination of insect predators and incidence insect resistance to these insecticides. thus, this field experiment was done at the experimental farm of Sakha Agricultural Research Station, Kafr El-Sheikh Governorate during 2019/2020 and 2020/2021 seasons for evaluating the efficacy of some alternative insecticides against certain sugar beet insects and calculating their side effect on associated insect predators as compared to conventional ones. Alternative insecticides (Raner ® 24% SC, ferto® 5% SC and Methobiet® 24% SC) caused overall mean of reduction in *Spodoptera* spp. larvae populations with (78.51- 93.78), (80.4-93.29) and (77.97-92.04%), respectively during the two seasons. In such concern, these insecticides caused reductions in insect predators numbers with (26.55-11.57%), (23.16- 10.84) and (24.0-11.39%) respectively throughout the two seasons. As, the conventional insecticides (Dora ® 48% EC, Marshal® 20% EC, Diracomel® 90%SP and Pleo ® 5% EC) Caused reductions to these predators population with (98.66 - 96.72), (97.41 - 98.02), (99.38 - 98.68) and (95.59-97.95%) respectively in the two seasons. Concerning the beetfly, pegomyia mixta, alternative insecticide (Gold ® 1.8% EC) caused reductions to this insect larvae numbers with (72.40 and 67.29%), respectively during the two season. Whereas, the same previous insecticide incidence reductions with (34.77 - 40.60%) against insect predators in the two seasons, respectively. On the other hand, conventional insecticides (Ematrade ® 35% SC, Billy ® 25% wG, Flagetara ® 25% WP, Sumithion ® 50% EC, Basudin ® 60% Ec) caused reductions to these predators ranging between (88.13 to 94.877) over the two seasons. Lastly, these alternative insecticides are promising insecticides with high efficacy against sugar beet insects, at the same time less-toxic to predators compared with conventional ones. Consequently, it would be ideal agents for integrated pest management (IPM) to sugar beet insects, especially sugar beet is a food crop.

Keywords: Role, alternative insecticides, IPM, sugar beet.

1. Introduction

Several insect pest species attack sugar beet plants. beginning from seed germination up to maturity and harvest (Abdel-Moniem *et al.,* 2014; El-Fergani, 2019 and Bazazo and Hassan, 2021) these insect pests proved to reduce this crop quality (sugar percent) and quantity (roots weight) (Rashed, 2017 and El- Dessouki, 2019). The cotton Leaf worms, *Spodoptera* spp. and beet fly, Pegomyia mixta Vill. are destructive insects and causing high economic losses to sugar beet crop in Egypt (EL-Dessouki, 2019). Unfortunately, most of the farmers. spray the conventional insecticides for controlling these insects. The intensive use of conventional insecticides led to several important drastic problems; i.e. environmental pollution elimination of insect predators and incidence insect resistance to these insecticides (Awad *et al*., 2014). Currently, IPM aims to suppress pest populations below the economic injury level (EIL) (Anonymous, 2012). IPM allows for safer pest control (Clercq *et al.,* 2011).

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Therefore, this study aimed to evaluate the efficiency of some alternative insecticides against major sugar beet insects and their associated predators as compared to conventional ones.

2. Material and Methods

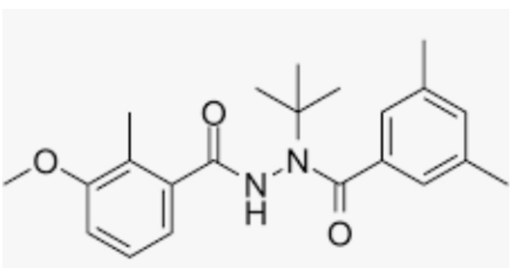
The current experiment was conducted in two sugar beet fields grown with Nader cultivar during 2019/2020and 2020/2021 seasons. The first field was sown on 15th August and 16th August, respectively for spraying *Spodoptera* spp. Seven insecticides in Table (1) were used.

Table 1: List of insecticides applied on sugar beet plants against *Spodoptera spp* larvae during 2019/2020 and 2020/2021 seasons.

Insecticide		**Category**	**Rate /feddan**
Common name	**Trade name**		
Mexthoxyfenozide*	Raner 24% Sc	Ecdysone agonists	75 cm^3
Chromafenozide*	Ferto 5% Sc	Ecdysone agonists	400 cm^3
Mexthoxyfenozide*	Methobiet 24% Sc	Ecdysone agonists	75 cm^3
Chlorpyrifos**	Dora 48% Ec	Conventional	1 Liter
Carbosulfan**	Marshal 20% Ec	Conventional	250 cm^3
Methomyl**	Diracomel 90% Sp	Conventional	300 gm
Pyridalyl**	Pelo 5% Ec	Conventional	100 cm^3

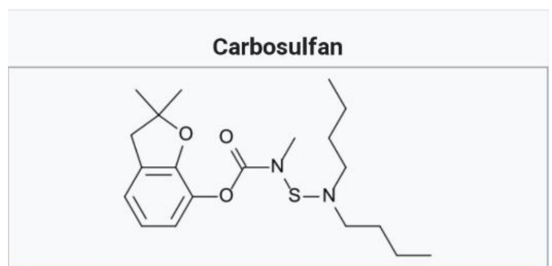
Alternative insecticide*
Conventional insecticides**

Methoxyfenozide



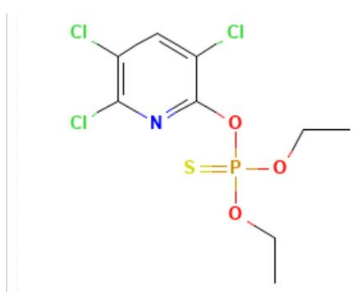
Formula: $C_{22}H_{28}N_2O_3$

Mode of action: accelerating the moulting process. It acts as an ecdysone agonist or moulting hormone, 20-hydroxyecdysone



Carbosulfan ($C_2OH_{32}N_2O_3S$)

Mode of action: Systemic with contact and stomach action. Acetylcholine esterase inhibitor.
Chlorpyrifos (Compound) $C_9H_{11}CI_3NO_3PS$)



Act as anerve agent and is classified as anerve agent and is classified as an acetylcholinestrase (AChE) inhibitor

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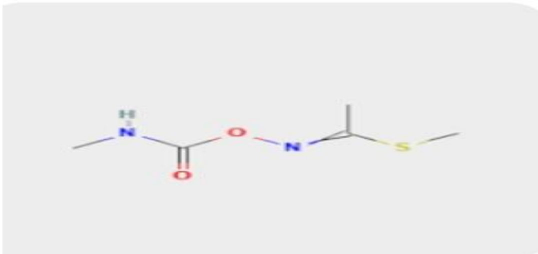
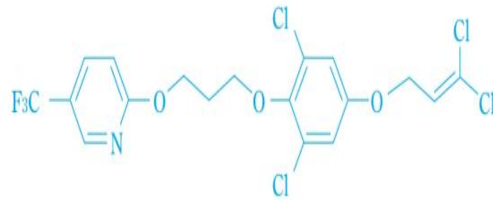


Methomyl ($C_5H_{10}N_2O_2S$)



$C_{18}H_{14}C_{14}F_3NO_3$

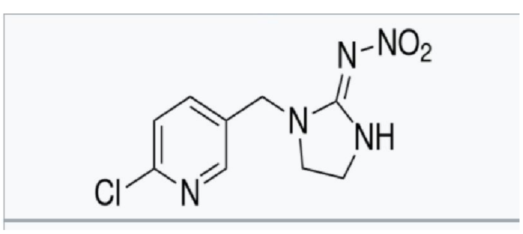
Methomyl is effective as a "contact insecticide," because it kills target insects upon direct contact, and also as a "systemic insecticide" because of its capability to cause overall "systemic" poisoning in target insects, after it is absorbed and transported throughout the pests that feed on treated plants. Pyridalyl.

Mode of action: pyridaiyi action requires cytochrome P450 activity for production of abioactive derivative pyridaiyi metabolism being prevented by general p450inhibitors Each insecticide was replicated four times (7x4=28 plots), each plot measure 42 m2 in addition to four plots as control. 40 plants were inspected before spraying and 40 plants after spraying for one, seven and 10 days for each treatment (conventional) and three, seven and 10 days for (alternatives)as well as control plots. Completely randomized block design was applied. Knap sac sprayer (20 L) was used in spraying of these insecticides. The date of spraying were 15th and 16th September during the two seasons, respectively.The larvae and insect predators (Chrysoperla. Carnea + Formicidae) were recorded by visual examination in the field. Regarding P. mixta, the experiment was sown on 15th and 16th September during the two seasons. Six insecticides were used in Table (2). The previous protocol was followed.

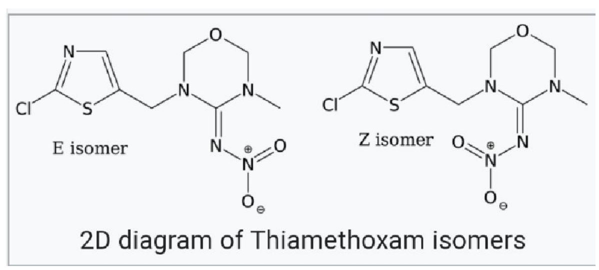
Table 2: List of insecticides applied on sugar beet plants against *P.mixita* larvae during 2019/2020 and 2020/2021 seasons.

Traded name	Chemical class	Common name	Rate /feddan
Ematrade 35% SC**	Neonicotinoids	Imidacloprid	300 ml
Billy 25% WG**	Neonicotinoids	Thiamethoxan	125 g
Flagetara 25% WP**	Neonicotinoids	Thiamethoxan	40 g
Sumithion 50% EC**	Organophosphate	Fenitrothion	1000 ml
Basudin 60% EC**	Organophosphate	Diazinon	1000 ml
Gold 1.8% EC*	Avermectin	Abamectin	1000 ml

Alternative insecticide*
Conventional insecticides**



Imidacloprid ($C_9H_{10}ClN_5O_2$)



Thiamethoxam ($C_8H_{10}Cl_5O_3S$)

The mode of action of imidaclopride is to block neurotransmissions by postsynaptic antagonism of nicotinic acetylcholine receptors

Thiamethoxam controls target pests by interfering with the nicotinic acetylcholine receptors in their nervous system.

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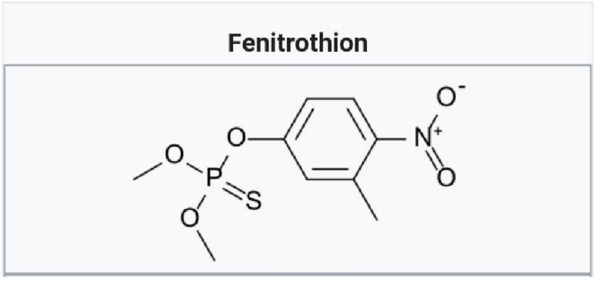
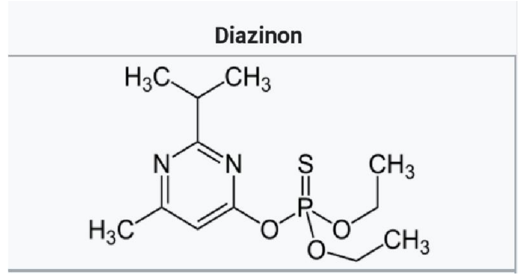
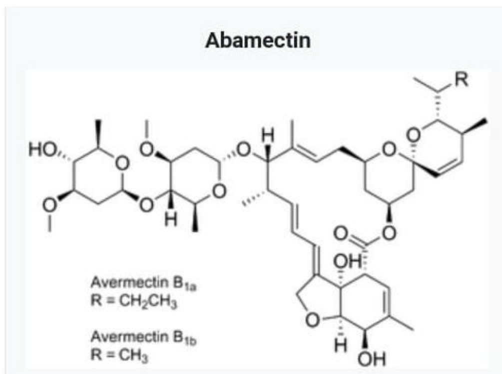


Chemical formula: $C_9H_{12}No_5PS$



Diazinon ($C_{12}H_{21}N_2O_3PS$)

Mode of action: non systemic with contact and stomach action. Cholenestrase inhibitor Diazinon inhibits the enzyme acetylcholinesterase (AChE), which hydrolyzes the neurotransmitter acetylcholine (ACh) in cholinergic synapses and neuromuscular junctions. This results in abnormal accumulation of ACh in the nervous system.



$C_{95}H1_{42}O_{28}$

Mode of Action: Stimulate the gamma aminobutyric acid (GABA) system, achemical transmitter produced at nerve endings which inhibits both nerve to nerve and nerve to muscle communication. The affected insect becomes paralyzed, stop feeding, and dies after a few days.

The reductions in larvae of these insects and insect predators were calculated by Henderson and Tilton formula (1955). Also, mean of reductions due to these insecticides were analyzed using Duncan test (1955).

3. Results and Discussion

Role of alternative insecticides in controlling *Spodoptera* spp. and P. mixta Controlling as well as insect predators maintining in comparison with conventional ones:

Data in tables (3 and 4) clarify that ecdysone agonists insecticides; Raner 24% SC, Ferto 5% SC, and Methobiet 24SC% were caused overall mean of reduction in *Spodoptera* spp numbers with 78.51, 80.41 and 77.97%, respectively, in 2019/2020 season. While, 93.78, 93.29 and 92.04%, respectively, in 2020/2021 season.

Concerning, the conventional ones; Dora, Marshal, Diracomel and Pleo were caused overall mean of reduction to the same insect with 85.21, 84.71, 83.91 and 89.11%, respectively, in 2019/2020 season. Whereas, 95.61, 95.30, 95.44 and 95.61%, respectively, in 2020/2021 season.

Concerning the insect predators, data in these tables show that ecodysome agonists caused reduction in insect predators with 26.55, 23.16 and 24.00%, respectively in 2019/2020. Also, 11.57, and 11.39%,10.84,11.39 respectively, in 2020/2021 season. While, the conventional ones induced reduction with 98.66, 97.41, 99.38 and 95.59 % in 2019/2020: Also, 96.72, 98.02, 98.68 and 97.95 % in 2020/2021 season.

Table 3: Overall mean of reduction in *Spodoptera* spp larvae numbers due to certain conventional and ecdysone agonist's insecticides in 2019/2020 season and 2020/2021 seasons.

Compounds	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction (%)
	M.	M.	Red. (%)	M.	Red. (%)	M.	Red.	M.	Red. (%)	
					2019/2020					
Raner	15.50	-	-	5.75	67.54	4.50	77.96	2.25	90.05[a]	78.51
Ferto	15.50	-	-	6.00	66.12	3.50	82.86	1.75	92.26[a]	80.41
Methobiet	15.75	-	-	6.25	65.27	4.25	79.51	2.50	89.13[b]	77.97
Dora	16.00	4.75	71.66	-	-	2.25	89.32	1.25	94.65[a]	85.21
Marshal	15.75	4.50	72.72	-	-	2.50	87.95	1.50	93.47[a]	84.71
Diracomel	15.50	4.75	70.74	-	-	2.75	86.53	1.25	94.47[a]	83.91
Pleo	15.50	3.75	96.90	-	-	1.50	92.65	0.50	97.79[a]	89.11
Check	15.75	16.50	-	18.00	-	20.75	-	23.00	-	-
					2020/2021					
Raner	26.00	-	-	1.75	49.66	2.75	93.18	3.25	93.50[a]	93.78
Ferto	26.25	-	-	2.25	93.20	3.00	92.63	3.00	94.06[a]	93.29
Methobiet	25.25	-	-	2.50	92.15	3.25	91.70	3.75	92.28[a]	92.04
Dora	25.25	0.75	97.23	-	-	1.25	96.80	3.50	92.80[a]	95.61
Marshal	25.00	0.75	97.20	-	-	1.75	95.48	3.25	93.24[a]	95.30
Diracomel	26.50	1.00	96.48	-	-	1.75	95.74	3.00	94.11[a]	95.44
Pleo	26.25	1.25	95.56	-	-	1.75	95.73	2.25	95.54[a]	95.61
Check	26.75	28.75	-	33.75	-	41.50	-	51.50	-	-

The Duncan test at level of 5% probability was applied, the mean followed by the same letter do not differ significantly.

Table 4: Overall mean of reduction in insect predator's population associated with *Spodoptera* spp. due to certain conventional and ecdysone agonist's insecticides in 2019/2020 and 2020/2021 seasons.

Compounds	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction (%)
	M.	M.	Red. (%)	M.	Red. (%)	M.	Red. (%)	M.	Red. (%)	
					2019/2020					
Raner	10.00	-	-	9.50	18.85	9.50	25.09	9.25	35.72[a]	26.55
Ferto	9.75	-	-	9.75	14.58	9.50	23.17	9.25	31.75[a]	23.16
Methobiet	9.25	-	-	9.00	16.89	9.00	23.28	8.75	31.95[a]	24.00
Dora	9.00	0.00	100	-	-	0.00	100	0.50	96.00[b]	98.66
Marshal	9.50	0.00	100	-	-	0.25	97.92	0.75	94.32[b]	97.41
Diracomel	9.75	0.00	100	-	-	0.00	100	0.25	98.15[b]	99.38
Pleo	10.25	0.00	100	-	-	0.50	96.15	0.75	90.64[b]	95.59
Check	10.25	11.25	-	12.00	-	13.00	-	14.25	-	-
					2020/2021					
Raner	11.50	-	-	11.00	9.97	11.00	11.70	11.25	13.04[a]	11.57
Ferto	11.75	-	-	11.50	7.88	11.25	11.62	11.25	13.04[a]	10.84
Methobiet	12.00	-	-	11.75	7.84	11.50	11.53	11.50	14.81[a]	11.39
Dora	11.50	0.00	100	-	-	0.50	95.98	0.75	94.20[b]	96.72
Marshal	12.00	0.00	100	-	-	0.00	100	0.75	94.07[b]	98.02
Diracomel	11.25	0.00	100	-	-	0.00	100	0.50	96.04[b]	98.68
Pleo	11.00	0.00	100	-	-	0.25	97.00	0.50	95.95[b]	97.95
Check	12.00	12.50	-	12.75	-	13.00	-	13.50	-	-

The Duncan test at level of 5% probability was applied, the mean followed by the same letter do not differ significantly.

These results concluded that ecdysore agonists (methoxyfenorzide and chromafenozide) are promising insecticides with high efficacy against various insect, at the same time almost non-toxic to pollinators, predators, parasitoids, mammals and has minimum impact on the environment; consequently, it would be an ideal agent for integrated pest management (IPM).

Schneider *et al.* (2008) reported that methoxyfenozide and chromafenozide are safer for natural enemies than conventional ones. Shahout *et al*., (2011) concluded that eadysome agonists are high efficacy against various insects. These insecticides induce premature molting and cause the death of insects by mimicking their hormone.

Also, Abou-Taleb (2016) noticed that selective insecticides with modes of action different from those conventional insecticides groups are highly desirable in IPM programs. Among these insecticides are methoxyfenzide + chromafenzide.

Concerning P. mixta *larvae* during the two seasons, data in Table (5) show that conventional insecticides (Ematrade, Billy, Flagetara, Sumithion and Basudin) induced reduction in P. mixta larvae with 81.47, 81.88, 81.16, 80.87 and 81.35% in first season, respectively. While, the values were 83.54, 82.47, 82.53, 83.03 and 85.84%during the second season. Whereas, the alternative insecticide (Gold) caused reductions with 72.40 and 67.29%in the two seasons, respectively.

Table 5: Reduction in P. mixta larva numbers, due to certain insecticides.

Compounds	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction (%)
	M.	M.	Red. (%)	M.	Red. (%)	M.	Red. (%)	M.	Red. (%)	
					2019/2020					
Ematrade	20.0	7.5	63.87	-	-	40	85.63	1.75	94.91	81.47[a]
Billy	19.75	7.25	64.63	-	-	4.0	85.45	1.5	95.58	81.88[a]
Flagetara	20.25	7.5	64.31	-	-	4.25	84.92	2.0	94.26	81.16[a]
Gold	20.0	-	-	12.75	45.84	5.75	79.35	2.75	92.01	72.40[b]
Sumithion	19.5	6.75	66.65	-	-	4.5	83.42	2.5	92.55	80.87[a]
Basudin	20.5	7.75	63.57	-	-	3.75	86.86	2.25	93.62	81.35[a]
Control	19.75	20.5	-	23.25	-	27.5	-	34.0	-	-
					2020/2021					
Ematrade	16.5	5.0	70.95	-	-	3.25	85.38	1.5	94.29	83.54[a]
Billy	16.25	5.25	69.03	-	-	3.25	85.16	1.75	93.24	82.47a
Flagetara	16.5	5.0	70.95	-	-	3.5	84.26	2.0	92.39	82.53[a]
Gold	16.75	-	-	11.75	40.97	6.5	71.20	2.75	89.70	67.29[b]
Sumithion	17.50	4.75	73.98	-	-	3.75	84.10	2.5	91.03	83.03[a]
Basudin	17.25	4.5	75.0	-	-	3.0	87.09	1.25	95.45	85.84[a]
Control	17.25	18.0	-	20.5	-	23.25	-	27.5	-	-

The Duncan test at level of 5% probability was applied, the mean followed by the same letter do not differ significantly.

Concentrating the insect predators associated with P. mixta larvae, Table (6) indicate that conventional insecticides (Ematrade, Billy, Flagetara, Sumithion and Basudin) incidence reduction in insect predator's populations with 88.13, 89.82, 91.98, 91.28 and 87.83 % during the first season, respectively. As, the corresponding values were 88.32, 92.15, 92.63, 94.75 and 94.87 % throughout the second season, respectively. In addition to, the alternative insecticides (Gold) caused reductions with 34.77 and 40.60 in the two seasons, respectively.

These findings demonstrated that the alternative insecticides (Gold) is effective in killing the larvae of P. mixta, at the same time this insecticide is safe to insect predators in comparison with conventional ones Babu and sharma (2003) indicated that the broad-spectrum conventional insecticides have been successfully used for controlling insect pests for many years. But these insecticides formed an adverse effect on many bene facial arthropod population including insect predators + parasitoids and con sequent caused out breaks of secondary pests. Now, we have to select effective and highly complimentary tools providing another opportunity to further reduction in the reliance on conventional insecticides

Table 6: Reduction in insect predators populations associated with beet fly, due to some insecticides

Compounds	Before spray	After one day		After 3 days		After 7 days		After 10 days		Overall mean of reduction (%)
	M.	M.	Red. (%)	M.	Red. (%)	M.	Red. (%)	M.	Red. (%)	
					2019/2020					
Ematrade	7.5	1.00	87.47	-	-	1.25	87.08	1.25	89.86	88.13
Billy	8	1.25	85.32	-	-	1.5	85.46	1.75	86.70	89.82
Flagetara	7.5	0.75	90.60	-	-	0.75	92.25	1.0	91.89	91.98
Gold	7.5	-	-	6.25	28.24	6.5	32.83	7.0	43.26	34.77
Sumithion	8.25	0.5	94.30	-	-	1.0	90.60	1.5	88.94	91.28
Basudin	7.5	0.75	90.60	-	-	1.25	87.08	1.75	89.81	87.83
Control	7.75	8.25	-	9.0	-	10.0	-	12.75	-	-
					2020/2021					
Ematrade	8.75	1.25	87.14	-	-	1.5	88.13	1.5	87.71	88.32
Billy	9.00	0.75	92.5	-	-	1.0	92.30	1.25	91.66	92.15
Flagetara	9.25	0.5	95.13	-	-	1.0	92.51	1.5	90.27	92.63
Gold	9.0	-	-	7.5	34.78	7.75	40.38	8.0	46.66	40.60
Sumithion	9.5	0.25	97.63	-	-	0.75	94.53	1.25	92.10	94.75
Basudin	8.75	0.25	97.42	-	-	0.75	94.06	1.0	93.14	94.87
Control	9.0	10.0	-	11.5	-	13.0	-	15.0	-	-

The Duncan test at level of 5% probability was applied, the mean followed by the same letter do not differ significantly.

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