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A Comparative Analysis of Chemical and Bio-Rational Management of Insect Pests of Cabbage

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

To test certain bio-rational insecticides against the diamondback moth, *Plutella xylostella* Linnaeus and cabbage butterfly, *Pieris brassicae* Linnaeus and their toxic effect on the population of ladybird beetle, *Coccinella septempunctata* Linnaeus in the Manipur valley cabbage crop-ecosystem, a field trial was carried out during *Rabi*, 2022–23 at the Vegetable Research Farm of the College of

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Agriculture, Central Agricultural University, Imphal. The mean extent of damage caused by *P. xylostella* and *P. brassicae* was high ranging from 62.67 to 88.34% and 83.33 to 92.11%, respectively, over the investigation period. The effectiveness of bio-rational pesticides against *P. xylostella* and *P. brassicae* was determined by the results of the insecticidal treatments, which showed a considerable reduction in the incidence of these pests. Malathion 50 EC applied @ 500 ml/ha witnessed the most effective insecticide against the diamondback moth, *P. xylostella* with a record of minimum mean leaf damage of 19.36% as against 50.08% in untreated control, closely followed by Greenracer (*Beauveria bassiana*) @ 1000 ml/ha (20.37%), and Neemajal (Azadirachtin 1500 ppm) @ 1000 ml/ha (22.37%) but, differed significantly from each other except with green racer. Among the phytoproducts, the plots treated with Neemajal (Azadirachtin 1500 ppm) @1000 ml/ha recorded the lowest DBM incidence (22.37% leaf damage) which was at par with Pestoneem (Azadirachtin 1500 ppm) @ 1000 ml/ha (24.57% leaf damage). Against *P. brassicae* also Malathion @ 500 ml/ha substantially recorded the lowest mean leaf damage of 22.67 vs 82.56% in the untreated check, followed by Greenracer with a record of 26.12% leaf damage, however, there were significant differences. Neemajal (Azadirachtin 1500 ppm) @1000 ml/ha was demonstrated to be the most effective treatment in reducing the pest incidence with the lowest mean leaf damage of 28.67% among the botanical insecticides field tested against cabbage butterfly butterflies. The highest mean leaf damage incidence (37.11% LD) was noticed in the plots treated with Pacer (*Metarrhizum anisoplae*) @ 1000 ml/ha. The efficacy of Pestoneem (Azadirachtin 1500 ppm) @ 1000 ml/ha, Multineem (Azadirachtin 300ppm) @1500ml/ha and Neemta (Azadirachtin 300ppm) @1500ml/ha was at par from each other recording mean leaf damage of 34.78, 35.56 and 36.89% respectivelyThe plots treated with Malathion @ 500 ml/ha yielded the highest mean cabbage yield (23.67 t/ha), with a maximum yield increase over control of 9.34 t/ha and 65.17%. These yield increases were non-significantly different from those of the Green Racer plots (22.67 t/ha), Neemajal (20.09 t/ha), Pestoneem (20.04 t/ha), Mutlineem (19.44 t/ha), and Neemta (19.32 t/ha), which yield increases of 8.34 t/ha, 5.76 t/ha, 5.71 t/ha, 5.11 t/ha, and 5.00 t/ha, respectively, whereas Pacer treated plots accrued significantly lowest cabbage yield of (18.43%) with a record of lowest yield increase over control of 4.1 t/ha and 28.61%. The avoidable yield loss was computed to be 40.82 percent in the untreated control plots. Application of insecticides resulted in a reduction of the mean avoidable yield loss, which ranges between 4.22 and 20.74 percent in different insecticidal treatments, the lowest being in Greenracer (*Beauveria bassiana*) and the highest in Pacer *(Metarrhizum anisoplae).* The net profit of the insecticidal treatments varied from Rs. 19595.60 (Pacer) to Rs. 35364.7 (Malathion 50 EC) with the cost: benefit ratios ranging between 1:11 to 1:46, the minimum and maximum being with Neemajal and Green Racer, respectively.

The results on the toxic effect of insecticides on the population of *C. septempunctata* indicated that the minimum mean population (0.52 beetles/plant) was recorded from Malathion 50 EC @ 500 ml/ha treated plots which were at par with Neemta (Azadirachtin 300ppm) (0.84 beetles/plant), Multineem (Azadirachtin 300ppm) (0.90 beetles/plant) and Pestoneem (Azadirachtin 1500ppm) (0.93 beetles/plant), respectively. However, the maximum population of beetles (1.39 beetles /plant) was marked in the plots of Greenracer which did not differ significantly from the rest of the insecticidal treatments.

Keywords: Bio-rational; phytoproducts; Malathion; crop-ecosystem; Beauveria bassiana.

1. INTRODUCTION

Cabbage (*Brassicae oleracea* var. *capitata* Linn.) is one of the most significant and widely produced vegetable crops because of its nutritional and economic benefits for both producers and consumers. In addition to these cabbage leaves are used to produce compost, a type of bio-fertilizer that is safe for humans and other beneficial wildlife to consume. It is primarily cultivated for its edible, expanded terminal buds, or "head," which contains high levels of the vitamins A (2000 IU), B1 (50 1.U), and C (124 mg/100 g), as well as minerals like phosphorus, potassium, sodium, calcium, and iron [1,2,3].

“Cabbage is prone to infestation by a number of insect pests consisting of sucking and defoliating insects starting from germination to the harvesting stage of the crop. In India, a total of 37 (thirty-seven) insect pests have been reported to feed on cabbage, of which the diamondback moth, *Plutella xylostella* Linneaus and cabbage butterfly, *Pieris brassicae* Linneaus are the major constraints for profitable cultivation of the crop" [4,5]. "The effect of synthetic chemicals on agriculture has been so dramatic that conventional agriculture now means using chemicals" [6]. However, "only 0.1% of the agro-chemicals used in pest control reach the target pests leaving the remaining 99.9% to enter the environment to cause hazards to non-target organisms" [7]. Alternative forms of crop protection have entitled interest for decades.

" To counteract the problems caused by conventional synthetic insecticides, bio-rational materials like neem products and microbial insecticides have been found promising in tackling the pest problem" [8,9,10,11]. Although from other parts of the country, several workers had reported in the management of cabbage pests on these aspects, limited attempts had been made in the North-east region.

2. MATERIALS AND METHODS

A field experiment was carried out in randomized block design (RBD) with 8 treatments including the control during *Rabi*, 2022-23 at the College of Agriculture, Central Agricultural University, Iroisemba, Imphal, in cabbage crop variety "Rare ball". The seedbed was prepared well and the seeds were sown in the beds followed by light irrigation to facilitate better germination. The experimental field was thoroughly plowed with the help of tractor followed by three crosses ploughed a by power tiller and the soil was pulverized and leveled properly to ensure better growth. The thirty-day-old seedlings were transplanted in the main field with a spacing of 45 × 45 cm followed by life-saving irrigations to ensure the better establishment of seedlings and to maintain a good crop stand. After transplanting, the field was irrigated at weekly intervals to facilitate proper vegetative growth of the seedlings and thus enlarged the head of cabbage. The NPK was applied @ 100: 80: 60 Kg/ha. The field was kept weed-free with two hand weedings at 30 and 60 days after transplanting. The experiment was carried out at latitudes of 24^0 45'N and 93^0 56' E with an elevation of 790 m above Mean Sea Level, where the soil was clay loam and showed acidic 5.5 reactions [12-15].

The percent leaf damaged was calculated by using the following formulae

$$\text{Leaf damage percent} = \frac{\text{No.of infested leaves/5plants}}{\text{Total No.of leaves/5plants}} \times 100$$

Percent yield increased over control was calculated by using the following formulae:

$$\text{Percent yield increase over control} = \frac{T-C}{C} \times 100$$

Where,

T= Yield in respected treatment

C= Yield in control

3. RESULTS AND DISCUSSION

Effect of bio-rational insecticides against *Plutella xylostella* Linnaeus: The results of the bio-rational insecticides against diamondback moth, *Plutella xylostella* is presented are (Table 1). From the pooled mean leaf damage data of three sprays over the three post-applications periods of observations, it is amply clear that all the insecticidal treatments were superior in controlling the damage caused by *P. xylostella* in comparison to untreated control. Malathion 50 EC @ 500 ml/ha treated plots harboring the lowest leaf damage of 19.00% as against 49.31% in the untreated control (Tables 2). Malathion 50 EC was closely followed by Green Racer (*Beauveria bassiana*) @ 1000 ml/ha (20.89%) and Neemajal (Azadirachtin 1500ppm) @ 1000 ml/ha (22.37%) but differed significantly from each other except between Malathion 50 EC and Green Racer (*Beauveria bassiana*). These insecticidal treatments performed significantly better than the rest of the treatments. Pacer (*Metarhizium anisoplae*) @ 1000 ml/ha was found to be the least effective treatment against *P. xylostella* with a record of maximum leaf damage incidence of (32.46%). The effectiveness of Pestoneem (Azadirachtin 1500ppm) @ 1000 ml/ha (25.00% LD), Multineem (Azadirachtin 300ppm) @ 1500 ml/ha (27.78% LD) and Neemta (Azadirachtin 300 ppm) @ 1500 ml/ha showed insignificant difference from one another. The order of efficacy of each of treatments along with the test of significance is depicted below:

The mean of three sprays based on 3, 5 and 7 DAA: Malathion 50 EC > Green Racer (*Beauveria bassiana*)> Neemajal (Azadirachtin 1500ppm) > Pestoneem (Azadirachtin 1500ppm) > Multineem (Azadirachtin 300ppm) > Neemta (Azadirachtin 300 ppm) > Pacer (*Metarhizium anisoplae*) > Untreated control [16,17].

Table 1. Efficacy of certain bio-rational insecticides against the diamondback moth, *Plutella xylostella* Linnaeus in cabbage var. "Rare ball" during *Rabi,* 2022-23

Treatments	Dosage/ha (ml/ha)	[1]Mean percent leaf damage due to *P. xylostella* recorded during			Pooled Mean	DBA	[2]Days after Application		
		1st spray	2nd spray	3rd spray			3DAA	5DAA	7DAA
Neemajal (Azadirachtin 1500ppm)	1000	24.32 (2.03)	21.67 (5.36)	20.54 (4.65)	22.37 (5.66)	36.12 (6.01)	19.33 (5.68)	18.42 (5.50)	17.45 (5.19)
Multineem (Azadirachtin 300 ppm)	1500	31.33 (1.75)	27.34 (5.71)	26.47 (5.09)	27.78 (6.32)	40.22 (6.34)	25.67 (6.02)	24.32 (5.75)	23.67 (5.49)
Pestoneem (Azadirachtin 1500ppm)	1000	26.37 (2.05)	25.63 (5.85)	22.72 (4.82)	24.57 (5.64)	37.33 (6.09)	24.37 (5.92)	21.33 (5.68)	21.33 (5.34)
Neemta (Azadirachtin 300ppm)	1500	30.33 (1.97)	28.47 (5.95)	26.52 (5.59)	28.34 (6.58)	38.76 (6.19)	28.47 (6.50)	27.22 (6.13)	24.00 (5.93)
Green racer (*Beauveria bassiana*)	1000	21.33 (1.99)	20.47 (4.93)	19.32 (4.19)	20.37 (5.36)	35.11 (5.92)	16.67 (5.01)	17.67 (4.80)	14.33 (4.37)
Pacer (*Metarhizium anisopliae*)	1000	35.33 (1.98)	32.00 (4.83)	30.33 (4.60)	32.46 (5.70)	33.78 (5.81)	29.33 (5.69)	26.67 (5.53)	25.34 (4.92)
Malathion	500	20.32 (1.87)	19.32 (4.38)	18.45 (4.03)	19.36 (4.87)	27.23 (5.21)	17.68 (4.81)	15.33 (4.59)	12.68 (4.15)
Control (water)	500	52.23 (2.02)	50.34 (7.04)	47.67 (6.52)	50.08 (7.09)	52.45 (7.2)	49.00 (7.09)	47.33 (7.04)	44.33 (6.89)
S.E(d) $_-^+$		0.11	0.17	0.23	0.13	0.19	0.12	0.25	0.28
CD(P=0.05)		0.24	0.31	0.46	0.25	NS	0.20	0.46	0.52

Figures in parentheses are angular transformed values;
DBA= Day before application;
NS= Non-Significant
[1]*Composite means of three post-treatment observations recorded at 3, 5 and 7 days after application*
[2]*Mean of 3 replications based on 3 applications data*

Table 2. Efficacy of certain bio-rational insecticides against the cabbage butterfly *Pieris brassicae* Linnaeus in cabbage var. "Rare ball" during *Rabi*, 2022-23

Treatments	Dosage/ha (ml/ha)	[1]Mean percent leaf damage due to *P. brassicae* recorded during			Pooled Mean	DBA	[2]Days after Application		
		1st spray	**2nd spray**	**3rd spray**			**3DAA**	**5DAA**	**7DAA**
Neemajal (Azadirachtin 1500ppm)	1000	33.54 (5.84)	27.65 (5.91)	25.32 (5.70)	28.67 (5.84)	83.33 (9.12)	30.33 (5.94)	33.25 (5.38)	31.67 (5.62)
Multineem (Azadirachtin 300 ppm)	1500	37.33 (6.10)	36.67 (6.04)	34.67 (5.97)	35.56 (6.05)	87.33 (9.34)	34.12 (6.11)	36.67 (6.06)	34.33 (5.85)
Pestoneem (Azadirachtin 1500ppm)	1000	35.67 (5.45)	34.67 (5.83)	34.00 (5.78)	34.78 (5.90)	88.67 (9.42)	33.45 (5.95)	34.78 (5.90)	32.45 (5.69)
Neemta (Azadirachtin 300ppm)	1500	38.33 (6.17)	36.33 (5.93)	36.00 (5.87)	36.89 (6.07)	92.33 (9.61)	35.89 (6.23)	37.22 (6.10)	35.89 (6.00)
Green racer (*Beauveria bassiana*)	1000	27.67 (5.22)	26.33 (5.11)	24.33 (4.92)	26.12 (5.11)	87.67 (9.36)	24.67 (5.26)	21.33 (5.03)	20.33 (4.92)
Pacer (*Metarhizium anisopliae*)	1000	38.33 (5.87)	37.67 (5.72)	34.56 (5.59)	37.11 (5.80)	91.33 (9.55)	36.67 (5.80)	32.33 (5.68)	36.33 (5.68)
Malathion	500	23.67 (4.86)	23.00 (4.79)	21.33 (4.62)	22.67 (4.76)	86.33 (9.29)	23.56 (4.85)	20.56 (4.51)	19.57 (4.51)
Control (water)	500	82.65 (7.05)	83.34 (6.90)	80.45 (6.80)	82.56 (6.84)	90.33 (9.50)	88.45 (6.96)	86.11 (6.79)	84.45 (6.81)
S.E(d)		0.55	0.64	0.58	0.06	0.15	0.17	0.19	0.24
CD(P=0.05)		1.18	1.37	1.24	0.13	NS	0.25	0.41	0.52

Figures in parentheses are angular transformed values;
DBA= Day before application;
[1]Composite means of three post-treatment observations recorded at 3, 5 and 7 days after application
[2]Mean of 3 replications based on 3 applications data

Table 3. The Overall effect of insecticides on the extent of leaf damage due to *Plutella xylostella* Linnaeus & *Pieris brassicae* Linnaeus and yield of cabbage during *Rabi,* 2022-23

Treatment	Dosage/ha (ml/ha)	[1]Mean percent leaf damage due to		Cabbage Yield (t/ha)
		P. xylostella	***P. brassicae***	
Neemajal (Azadirachtin 1500 ppm)	1000	22.37 (5.31)	28.67 (5.84)	20.09
Multineem (Azadirachtin 300 ppm)	1500	27.78 (5.62)	35.56 (6.05)	19.44
Pestoneem (Azadirachtin 1500 ppm)	1000	24.57 (5.54)	34.78 (5.90)	20.04
Neemta (Azadirachtin 300 ppm)	1500	28.34 (5.90)	36.89 (6.07)	19.32
Green racer (*Beauveria bassiana*)	1000	20.37 (4.56)	26.12 (5.11)	22.67
Pacer (*Metarrhizum anisoplae*)	1000	32.46 (5.02)	37.11 (5.80)	18.43
Malathion 50 EC	500	19.36 (4.35)	22.67 (4.76)	23.67
Control (water)	500	50.08 (7.01)	82.56 (6.84)	
SEm		0.13	0.06	
CD (P= 0.05)		0.25	0.13	

Figures in parentheses are angular transformed values;
[1]Mean percent leaf damage of three-time intervals under observations based on 3 applications data

Effect of bio-rational insecticides against *Pieris brassicae* Linnaeus: The results of the bio-rational insecticides against the cabbage butterfly, *Pieris brassicae* are presented in (Table 2). From the pooled mean leaf damage data of three sprays over the three post applications periods of observations, it is indicated that Malathion 50 EC applied @ 500 ml/ha performed significantly better than rest of the insecticidal treatments with a record of lowest mean leaf damage incidence of 22.67% as against 82.56% in untreated check, followed by Green Racer (*Beauveria bassiana*) @ 1000 ml/ha (26.12%) and Neemajal (Azadirachtin 1500ppm) @ 1000 ml/ha (28.67%) differed significantly from each other. The treatments with Pestoneem (Azadirachtin 1500ppm) @ 1000 ml/ha and Multineem (Azadirachtin 300ppm) @ 1500 ml/ha also recorded comparatively lower mean leaf damage of (34.78%) and (35.56%), respectively which showed non-significant difference between them. The mean percent leaf damage recorded in the plots treated with Neemta (Azadirachtin 300 ppm) @ 1500 ml/ha was (36.89% LD). However, all the insecticidal treatments were effective in restricting the infestation due to *P. brassicae* when compared with untreated control. The following are the descending order of mean efficacy of the different treatments against the cabbage butterfly, *P. brassicae.*

The mean of three sprays based on 3,5 and 7 DAA: Malathion 50 EC > Green Racer (*Beauveria bassiana*)> Neemajal (Azadirachtin 1500ppm) > Pestoneem (Azadirachtin 1500ppm) > Multineem (Azadirachtin 300ppm) > Neemta (Azadirachtin 300 ppm) > Pacer (*Metarhizium anisoplae*) > Untreated control.

Effect of bio-rational insecticides on the yield of cabbage crop: “The yield of a crop is the interaction product of Genetic potential of the variety, the effect of the prevailing environment and crop management practices including the pest management system adopted. It is expected that the treatment providing good protection against pests will give a higher yield under a uniform ecological and crop management system. In the present investigation, there was clear evidence that all the bio-rational insecticidal treatments registered a significant reduction of *Plutella xylostella* and *Pieris brassicae* incidence which results in significantly higher yield in comparison to untreated control”. The mean data on cabbage var. “Rare ball” yield presented in Table 3 indicated that the minimum yield (14.33 t/ha) was obtained from the untreated control plot, which was significantly lower than the yields harvested from the insecticidal treated plots (18.47 to 23.67 t/ha), the highest being recorded in Malathion 50 EC treatment with maximum yield increase over control of 9.34 t/ha and 65.17%, and lowest in Pacer (*Metarrhizum anisoplae*) treatment with a minimum yield increase of 4.14 t/ha and 28.61%.The yield of Malathion 50 EC was followed by Green Racer (*Beauveria bassiana*) (22.67 t/ha) exhibiting yield increase over control of 8.34 t/ha and 58.19% which had a non-significant difference between them. The mean cabbage yield harvested from the plots of Neemajal (Azadirachtin 1500ppm) (20.09 t/ha) with yield increase over control of 5.76 t/ha & 40.19%) Pestoneem (Azadirachtin 1500ppm) (20.04 t/ha, increase yield of 5.71t/ha & 39.84%), Multineem (Azadirachtin 300 ppm) (19.44 t/ha, yield increase of 5.11t/ha & 35.65%), Neemta (Azadirachtin 300 ppm) (19.32 t/ha with the yield increase over control of 5.10 t/ha & 34.82%) did not differ significantly from one another.

4. CONCLUSION

In the Manipur valley, the bio-rational treated against the two main pests—Plutella xylostella and Pieris brassicae—proved to be much more successful than the untreated control. But based on the three sprays' combined mean of leaf damage, it appears that Malathion 50 EC was the most effective treatment at controlling both pests and restoring better yields. Green racer (Beauveria bassiana) came next. The biorationals utilized in these experiments were environmentally safe and might be further suggested for the management of these important cabbage pests in the Manipur valley in farmer's fields as needed.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Kebe, Alhaji Alusine, Shumaila Hameed, Muhammad Sohail Farooq, Abu Sufyan, Muhammad Babar Malook, Sayed Awais, Muhammad Riaz, Muhammad Waseem, Usman Amjad, Nasir Abbas. Enhancing crop protection and yield through precision agriculture and integrated pest management: A comprehensive review. Asian Journal of Research in Crop Science. 2023;8(4):443-53. Available:https://doi.org/10.9734/ajrcs/2023/v8i4225
2. Mahala, Abhishek, and Usha Yadav. Field efficacy of selected chemicals and biopesticides against brinjal shoot and fruit borer (*Leucinodes orbonalis*) on Brinjal (*Solanum melongena*) at Prayagraj. Journal of Advances in Biology & Biotechnology. 2024;27(7):51-58. Available:https://doi.org/10.9734/jabb/2024/v27i7965
3. Ngosong NT, Boamah ED, Fening KO, Kotey DA, Afreh-Nuamah K. The efficacy of two bio-rational pesticides on insect pests complex of two varieties of white cabbage (*Brassica oleracea* var. capitata L.) in the coastal savanna region of Ghana. Phytoparasitica. 2021 Jul;49:397-406.
4. Sachan JN, Gangwar SK. Vertical distribution of important pests of cole crops in Meghalaya as influenced by environmental factors. Indian Journal of Entomology. 1980;42(3):414-421.
5. Lal OP. A compendium of insect pests of vegetables in India. Bull. Ent. 1975;16:51-56.
6. Debbarma A, Singh KI, Gupta MK, Sobitadevi P. Bio-rational management of major lepidopterous pests and their influence on yield of cabbage crop under Manipur valley. J Entomol Zool Stud. 2017;5(5): 1546-51.
7. Verma RK. Advances in cockroach control. Asian J. Microvial. Biotech. Env. Sci. 2002;4:245-249.
8. Singh K, Sharma PL, Singh K. Evaluation of antifeedant and repellent qualities of various neem (*Azadirachta indica*) formulations against *Pieris brassicae* Linn. Larvae on cabbage and cauliflower. Research Developmental Reporter. 1987; 4(1):76-78.
9. Osman MZ. Effect of neem seed extract on growth and development of larvae of *Pieris brassicae* Linn. (Lepidoptera; Pieridae). J. Appl. Ent. 1993;15(3):254-258.
10. Asokan AS, Mohan KS, Gopalkrishnan C. Effect of commercial formulation of *Bacillus thuringiensis* Berliner on yield of cabbage. Insect Environment. 1996; 2(2):58-59.
11. Gopalakrishnan C. Field evaluation of commercial formulations of *Bacillus thuringiensis* var. kurstaki against *Plutella xylostella* L on cabbage. Pestology. 2001;25(6):7-10.
12. Dikshit AK, Alappat BJ. Ecofriendly pest and insect control. Yozna. 1997;4:30-42.
13. Puri SN. Integrated pest management. In Agriculture in the 21st century. 1998;35-52.
14. Ram S, Sachan JN, Pathak KA. Insect pests of crops in Manipur. Res. Bull., No.12., ICAR Res. Complex for NEH Region, Shillong. 1981;113.
15. Sagolsem S, Singh RN, Singh CY. JANS effects of agrochemicals practices in the economic production of cabbage in valley districts of Manipur, India. Journal of Applied and Natural Science. 2016; 8(1):459 – 463.
16. Verma RK, Chaurasia L. Alternative insecticides for termite control study and evaluation. Manthan (Hindi). 2003;1:58-64.
17. Yawalkar KS. Vegetable crops in India. Eds.- II. 1980;36-46.

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