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Assessment of quantitative yield losses due to chemical intervention in cabbage (*Brassica oleracea* var. *capitata*) under field conditions

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Abstract
A study was carried out at the College of Agriculture, Rajendranagar, during the *Rabi* Season of 2022-2023.The field experiment was divided into 13 quadrates with a 1.5 X 0.5 m spacing between each of the 100 m² protected and unprotected plots. While the unprotected plots were left to natural infestation during the crop growth period, the protected plots were regularly treated with pesticides to prevent insect infestation. Significant variations in plant height, head diameter, cabbage head weight, and head damage loss were found between the two treatments when compared. The mean reductions in the unprotected plots were 20.2 cm, 10.59 cm, 0.88 kg, and 40%, whereas the protected plots showed mean reductions of 23.2 cm, 12.54 cm, 1.25 kg, and 11.69%, respectively. These variations led to quantitative losses estimates for plant height, head diameter, weight of cabbage heads, and head damage loss of 12.92%, 15.46%, 30.18%, and 64.1%, respectively. This indicates the effectiveness of chemical intervention in reducing yield losses in field-grown cabbage cultivation.

Keywords: Insect pests, losses, *Rabi*, infestation, mean reduction, cabbage, protected, unprotected

Introduction
Cabbage, thought to have originated in the Mediterranean, made its way to India during the Mughal era. In the 2020-21 agricultural year, India produced 9.60 million tonnes of cabbage from 4.12 lakh hectares, with an average yield of 23.27 tonnes per hectare (Indiastat.com 2022). Despite its high production, cabbage cultivation faces a significant challenge in the form of insect pest infestations. Abhijith *et al*. (2019) [1] identified the diamondback moth, *Plutella xylostella* (Linnaeus), as a primary pest capable of causing 14 to 84% damage. Other lepidopteran pests, such as the cabbage butterfly (*Pieris brassicae*), cabbage semilooper (*Trichoplusia ni*), tobacco caterpillar (*Spodoptera litura*), cabbage head borer (*Hellula undalis*), and cabbage leaf webber (*Crocidolomia binotalis*), as well as sucking pests like cabbage aphid (*Brevicornye brassicae*), green peach aphid (*Myzus persicae*), and painted bug (*Bagrada cruciferum*), cause extensive damage. Among these pests, *Spodoptera litura* (Fabricius) emerges as a significant threat, causing severe defoliation in nurseries within a week. Under favourable conditions, this pest can cause 80-100% damage (Chari, M. S., Rao, R. S. N, and Sreedhar U, 1994) [8]. Climate change has made most vegetables, including cabbage, more vulnerable to weather extremes, low soil moisture, and high temperatures. Biological pressures pose a problem for field-cultivated vegetables such as capsicum, cucumber, tomato, hot pepper, okra, cauliflower, cabbage, and leafy greens, particularly in the wet and winter months. Reduced output is a result of both biological and abiotic stressors; economic losses for cabbage plant height during the *Rabi* season are estimated to be 20.15 % (Jat *et al*., 2017) [15]. The impact of insect pests on cabbage yield is examined in this study, along with other yield-related parameters such as plant height, cabbage head diameter, weight of heads, and head damage loss.

Materials and Methods
During the *Rabi* season of 2022-2023, a field experiment was conducted at the Horticultural Polyhouse, College of Agriculture, Rajendranagar, to evaluate quantitative yield losses caused by chemical intervention in cabbage (*Brassica oleracea* var. *capitata*). The experimental site, located at an elevation of 542.3 metres above mean sea level at coordinates

17.3850° N latitude and 78.4867° E longitude, has a semi-arid tropical climate. The selected cabbage variety, "INDU SEMINIS," was sown at a 45X30 cm spacing. The experiment included two treatments: unprotected and protected plots, each covering 100 m^2. Furthermore, each treatment was divided into 13 quadrates spaced 1.5m X 0.5m apart. Unprotected plots went untreated with insecticides, whereas protected plots were protected from pest damage by applying pesticides at regular intervals throughout the crop growth period. Tolfenpyrad 15 EC at 1.5 ml lit^{-1} and Cyantraniliprole 10.26 OD at 0.6 ml lit^{-1} were sprayed in the protected plots on a 10th day rotation beginning the first week of transplanting. Data on plant height, cabbage head diameter, cabbage head weight, and head damage loss were collected separately at harvest for both protected and unprotected plots.

The yield from treated and untreated plots was recorded and the avoidable yield losses by timely management of insect pests in cabbage was computed.

The losses consequent to infestation by insect pests was calculated by the formula given by Le Clerg (1971) [23].

$$\text{Percent yield loss over control (\%)} = \frac{\text{Yield of protected plot} - \text{Yield of unprotected plot} * 100}{\text{Yield of unprotected plot}}$$

$$\text{Avoidable yield loss (\%)} = \frac{X_1 - X_2}{X_1}$$

Where,

X_1= Yield in treated (protected plot)

X_2= Yield in untreated (Unprotected plot)

Statistical analysis to ascertain the notable distinctions between the two treatments, protected and unprotected plots, was conducted using a two-sample t-test for each parameter. These parameters included plant height, diameter of cabbage heads, weight of cabbage heads, and head damage loss.

Results

Plant height (cm)

A notable difference in cabbage plant heights between protected and unprotected plants was observed under field conditions (Table 1). In protected plots, the plant height ranged from 22.50 to 24 cm, with a mean of 23.2 cm, whereas in unprotected plots, it varied from 19.2 to 21.1 cm, with a mean of 20.2 cm. The observed significant difference in mean height, attributed to insecticidal intervention, amounted to 12.92 percent (Figure 1).

Table 1: Difference (%) in protected and unprotected plots of field condition with respect to mean plant height of cabbage

No. of quadrates	Mean height of cabbage head(cm)			
	Protected plot	Unprotected plot	Difference	Difference (%)
1	23.0	19.2	3.8	16.43
2	24.0	20.3	3.7	15.29
3	23.0	19.7	3.4	14.57
4	23.3	21.0	2.3	9.99
5	22.6	20.2	2.4	10.61
6	23.0	20.2	2.8	12.17
7	24.0	20.1	3.9	16.08
8	23.3	20.1	3.2	13.69
9	23.3	21.1	2.2	9.56
10	22.6	19.5	3.1	13.53
11	23.9	20.3	3.5	14.82
12	22.7	20.0	2.7	11.78
13	22.5	20.3	2.1	9.44
Total	301.1	262.1	39.0	167.97
Mean	23.2	20.2	3.0	12.92
	't' Tabulated at 5%			2.179
	't' Calculated at 5%			17.51*

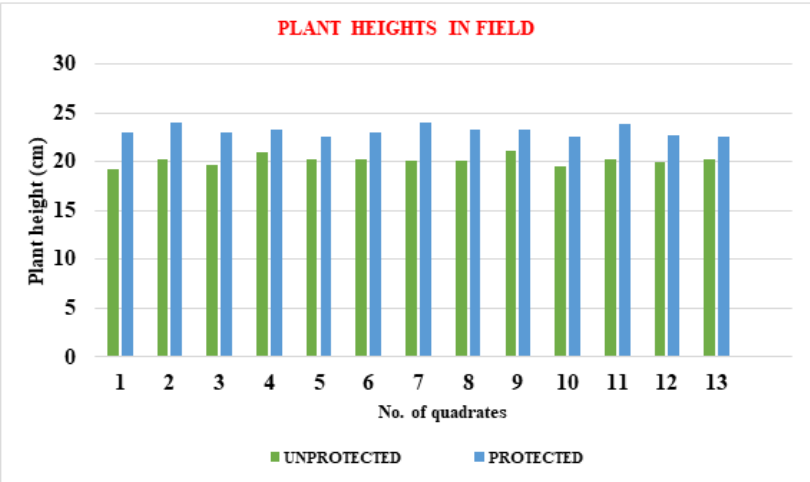

Fig 1: Plant height in protected and unprotected in field *Rabi*, 2022-23

Diameter of cabbage head (cm)

A noteworthy difference in the diameter of cabbage heads between protected and unprotected plants was noted under field conditions (Table 2). In protected plots, the diameter of heads ranged from 11.50 to 13.50 cm, with a mean of 12.54 cm, while in unprotected plots, it varied from 9.80 to 11.10 cm, with a mean of 10.59 cm. The observed significant difference in mean diameter due to insecticidal intervention amounted to 15.46 percent (Figure 2).

Table 2: Difference (%) in protected and unprotected plots of field condition with respect to mean diameter of cabbage head

No. of quadrates	Mean diameter of cabbage head (cm)			
	Protected plot	Unprotected plot	Difference	Difference (%)
1	13.00	11.00	2.00	15.38
2	13.33	10.50	2.83	21.23
3	12.30	10.40	1.90	15.45
4	13.00	10.60	2.40	18.46
5	13.50	10.22	3.28	24.30
6	12.33	10.40	1.93	15.65
7	12.17	11.10	1.07	8.79
8	11.90	10.90	1.00	8.40
9	12.80	10.80	2.00	15.63
10	12.08	10.50	1.58	13.08
11	12.33	10.60	1.73	14.03
12	12.83	10.80	2.03	15.82
13	11.50	9.80	1.70	14.78
Total	163.07	137.62	25.45	201.01
Mean	12.54	10.59	1.96	15.46
	‘t’ Tabulated at 5%			2.179
	‘t’ Calculated at 5%			11.29*

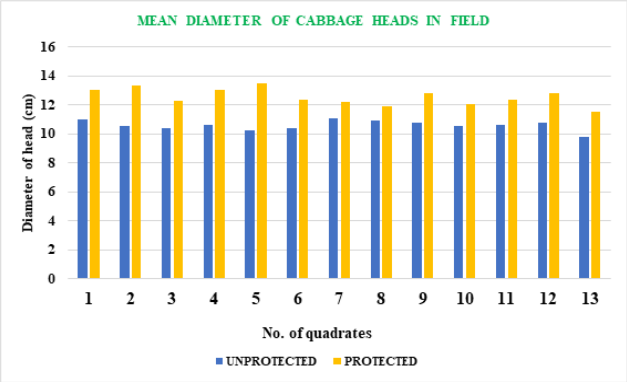

Fig 2: Mean diameter in protected and unprotected in field *Rabi*, 2022-23

Weight of cabbage head (kg)

The data presented in (Table 3) revealed a significant difference in the weight of cabbage heads between protected and unprotected plants. In protected plots, the weight ranged from 1.00 to 1.40 kg, with a mean of 1.25 kg, while in unprotected plots, it varied from 0.54 to 1.10 kg, with a mean of 0.88 kg. The substantial increase in head weight due to insecticidal intervention was 30.08 percent (Figure 3).

Table 3: Difference (%) in protected and unprotected plots of field condition with respect to mean weight of cabbage head

No. of quadrates	Mean weight of cabbage head (kgs)			
	Protected plot	Unprotected plot	Difference	Difference (%)
1	1.35	1.05	0.30	22.22
2	1.40	1.00	0.40	28.57
3	1.15	0.87	0.28	24.35
4	1.20	0.60	0.60	50.00
5	1.29	0.90	0.39	30.23
6	1.28	1.00	0.28	21.88
7	1.32	1.10	0.22	16.67
8	1.25	0.80	0.45	36.00
9	1.30	1.00	0.30	23.08
10	1.25	0.79	0.46	36.80
11	1.35	1.05	0.30	22.22
12	1.12	0.75	0.37	33.04
13	1.00	0.54	0.46	46.00
Total	16.26	11.45	4.81	391.05
Mean	1.25	0.88	0.37	30.08
	‘t’ Tabulated at 5%			2.179
	‘t’ Calculated at 5%			12.80*

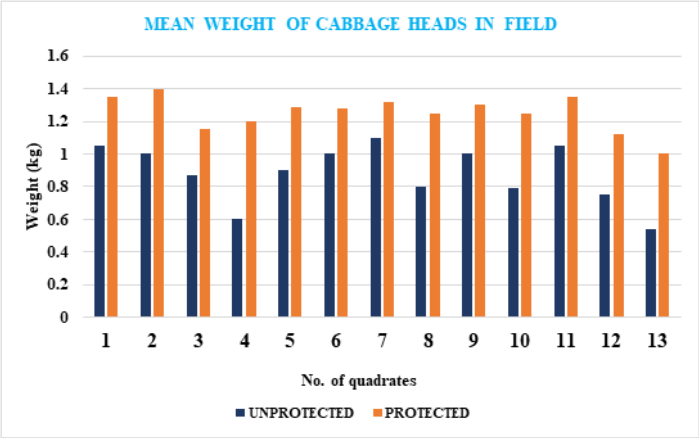

Fig 3: Mean weight in protected and unprotected in field *Rabi*, 2022-23

Mean damage of cabbage head (%):

The results presented in the (Table 4) illustrated that there was a significance difference in damage of cabbage head between protected and unprotected treatments. The damage (%) of cabbage head in protected plots ranged from 2.0 to 20 with a mean of 11.69 as against 10.0 to 80.0 with a mean of 40.0 in unprotected plots. The reduction in mean damage of head due to spraying of insecticides was 64.1 percent (Figure 4).

Table 4: Difference (%) in protected and unprotected plots of field condition with respect to mean damage of cabbage head

No. of quadrates	Mean damage of cabbage head (%)			
	Unprotected plot	Protected plot	Difference	Difference (%)
1	32	12	20	62.5
2	20	16	4	20.0
3	40	20	20	49.5
4	80	6	74	91.8
5	24	16	8	37.5
6	30	8	22	73.3
7	50	2	48	96.0
8	60	20	40	66.7
9	10	6	4	40.0
10	40	10	30	75.0
11	24	6	18	75.0
12	50	10	40	80.0
13	60	20	40	66.7
Total	520	152	368	833.9
Mean	40	11.69	28.31	64.1
	‘t’ Tabulated at 5%			2.179
	‘t’ Calculated at 5%			9.638*

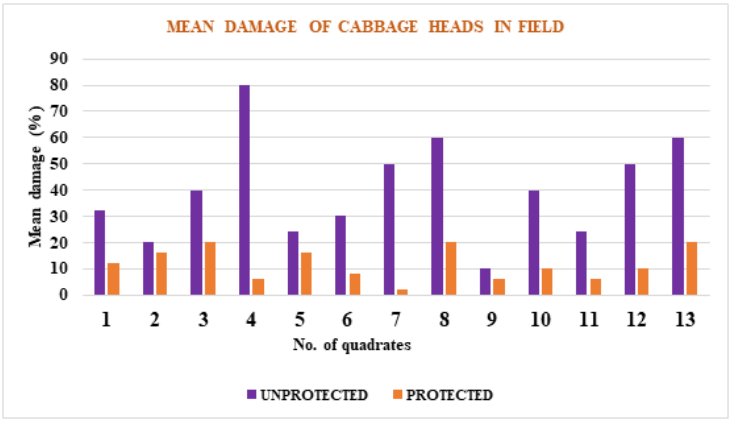

Fig 4: Mean damage in protected and unprotected in field Rabi, 2022-23

Discussion

The findings align with Krishnamoorthy (2004) [18] observation of a 52.00 percent yield loss in cabbage attributed to the diamondback moth. The cabbage aphid, as reported by Khan and Munir (1986) [17] and Ellis and Singh (1993) [12], plays a significant role in reducing yields by 50.00 to 80.00 percent.

Similarly, Agarwal and Dadheech (1990) [2] reported cauliflower yields in protected plots ranging from 22.50 to 25.80 kg per plot (considering a plot size of 4 x 2.5 meters),

while in unprotected plots, yields varied from 16.10 to 20.00 kg per plot. The percentage of yield loss ranged from 19.24 to 30.30 percent, with an average of 25.80 percent. Chand and Tripathi (2008) [7] noted extensive crop losses caused by *S. litura* in different parts of India. Ahmed *et al*. (2009) [3] reported 100.00 percent yield losses in cabbage due to *P. xylostella* infestation starting from the first fortnight of August. Kular and Kumar (2011) [19] highlighted that mustard aphid and cabbage caterpillar caused seed yield reduction ranging from 6.5 to 26.4 percent. *E. sativa* experienced the least seed production loss with the fewest cabbage caterpillars (2.4 larvae/plant) and mustard aphids (2.1 aphids/plant), while *B. carinata* had the highest production loss (26.4%), particularly sensitive to cabbage caterpillars (26.2 larvae/plant).

Jat *et al*. (2017) [15] reported that insect-pest infestations reduced cabbage plant height by 21.76 and 20.15 percent in the *Rabi* seasons of 2012-13 and 2013-14, respectively. The mean loss of 25.17 and 23.73 percent during *Rabi* 2012-13 and 2013-14, respectively, also impacted the weight of cabbage heads per plant. The assessed quantitative loss was 32.67 percent in 2012 and 29.33 percent in 2013, based on the difference in net yield between protected and unprotected plots.

Conclusions

It can be concluded from this study the avoidable yield losses in cabbage grown in field conditions in Telangana. The mean difference (%) 12.92%, 15.46%, 30.08%, 64.1% in height of plant, diameter of cabbage head, weight of cabbage head, mean percent head damage, respectively in field protected and unprotected conditions. The cabbage grown in protected in open field conditions are superior in yield and other parameters due to chemical intervention compared to unprotected respectively.

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Conflict of interest: None.

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