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Influence of Date of Sowing and Boron Fertilization on Incidence of Yellow Vein Mosaic Virus in Kharif Okra, *Abelmoschus esculentus*

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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

Background: Okra requires a long period of warm and humid weather. It may be cultivated effectively in hot, humid climates. It is susceptible to frost and very low temperatures. Temperatures between 24°C to 28°C are considered ideal for regular growth and development.
Aim: The experiment was carrying the objective of establishment the relationship between

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incidence of YVMV and weather parameters during growing season of okra and to access the relation between YVMV incidence and boron application.

Methodology: A field experiment was conducted at farmer's field at Andharua Bhubaneswar with Okra (cv-lily) as test crop at two dates of sowing i.e., 30th January (D1) and 15th February 2021 (D2) with 10 boron treatments comprising of B-0, b-1.5kg/ha soil, 0.25%, 0.5%, 0.75%, 1.0% borax once and twice foliar spray in a low boron (0.35 mg/kg) and low fertile acidic soil. The crop experienced 109.7mm rainfall, 10 rainy days, 29.1°C-39.9°C Tmax, 13.2°C-27.3°C Tmin.The BSH was 2.7-8.1 hrs.

Results: The emergence count, plant height, plant population and leaf area were better in D2. The fresh fruit yield of Okra varied from 6.52-9.15 t/ha where D2 produced more than D1. The boron content of fruit varied from 0.09 to 0.18mg/kg where T8 contain more boron. The YVMV PDI attend the peak 12.59-29.62 during the 2nd week of April at 77 DAS in D1(first date of sowing. Similarly in D2 (second date of sowing, the peak was attended at 63 DAS i.e., the 3rd week of April varied from 11.85-29.62%. From this experiment, out of seven weather parameters, Tmin and Evaporation have got the higher contributing factor for the incidence of YVMV. The D1 experiences prolonged favourable weather condition for YVMV incidence compared to D2.

Conclusion: Twice foliar spray or soil application of boron reduced the severity of YVMV to a greater extent compared to no or once application among different concentrations @ 0.5% borax was the most suitable dose for Okra crop in the east and south-east coastal plain zone of Odisha.

Keywords: Okra; yellow vein mosaic virus; boron; temperature; date of sowing.

1. INTRODUCTION

Okra (*Abelmoschus esculentus* (L.) Moench), often known as ladies' finger or bhendi, is the world's most popular vegetable. It is a popular vegetable grown across India, especially in the states of Andhra Pradesh, West Bengal, Jharkhand, Odisha, Uttar Pradesh, Madhya Pradesh, Karnataka, Gujarat, and Maharashtra. In Odisha, it is produced on an area of 70 thousand hectares with a production of 651.80 thousand tones and productivity of 9.30 t/ha (2018-19). In Turkey, Okra seeds are utilized in the manufacturing of several medications to reduce inflammation, and they are also utilized as a mucilaginous dietary ingredient against stomach ulcers (Mehta, 1959). Okra mucilage is also utilized for medical and industrial purposes (Akinyele & Temikotan, 2007). According to Fagbohun et al. (2012), biochemical changes in minerals in okra revealed that the quantity of ash, lipid content, crude protein, and fibre dropped while the amount of carbs rose.

Despite all of the positive characteristics of the okra vegetable, output has been poor owing to a variety of factors such as insufficient fertilizer usage, irrigation, and the prevalence of numerous diseases and pests. Bhendi yellow vein mosaic was originally seen in okra plants in India and Sri Lanka in 1924. Symptoms include alternating green and yellow spots on the leaves, vein clearing, and vein chlorosis. The yellow vein network is prominent, and veins and veinlets are thickened. Chlorosis can spread to the interveinal region and cause total yellowing of the leaves in extreme instances. The fruits are undersized, deformed, and yellow-green in colour. The whitefly *Bemisia tabaci* (Genn.) sibling species group is the insect vector. During the summer, when the virus is transmitted between okra plants, the whitefly vector reproduces in large numbers. Micronutrient supplementation is critical for an established variety's enhanced productivity. Boron is essential for plant nutrition. Boron deficiency decreased okra performance and productivity. Boron deficiency has been linked to internal tissue disintegration in root crops, groundnut/peanut cultivars, and certain bean cultivars. Warncke (2005) discovered that applying B to cranberry bean seed improved the interior black spot. Huang and Ye (2005) results also indicate significant effect of boron nutrition in wheat crops in relation to chilling tolerance. Rust attack was severe in B-deficient wheat plants exposed to drought stress, while no disease was seen in B-treated plants (Anonymous, 2007a). Considering these aspects in mind, our experiment was done in farmer's field.

2. MATERIALS AND METHODS

2.1 Experimental Site

The field experiment was conducted at Farmer field Andharua, Bhubaneswar, Odisha located at a latitude of 200 15' N and longitude of 850 52' E with an altitude of 25.9 m above the MSL. Bhubaneswar comes under subtropical climate of Odisha. It comes under the east and southeast coastal plain zone.

Table 1. Treatment Details for this study

Treatment		DAP(g)	MOP 2 Split(g)	Borax
T_1	STD	10.8/sq.m	12.5	0
T_2	STD+ B @1.5kgsoil application	109.62/plot	84.42/plot(40+44.42)	24g
T_3	STD+FS @0.25% Borax once	109.62/plot	84.42/plot(40+44.42)	12.5g/5lt
T_4	STD+FS@0.5% Borax once	109.62/plot	84.42/plot(40+44.42)	25gm/5lit
T_5	STD+FS@0.75% Borax once	109.62/plot	84.42/plot(40+44.42)	37.5g/5lit
T_6	STD+FS@1.0% Borax once	109.62/plot	84.42/plot(40+44.42)	50gm/5lit
T_7	STD+FS@0.25% Borax twice	109.62/plot	84.42/plot(40+44.42)	12.5gm/5lit
T_8	STD+FS@0.5% Borax twice	109.62/plot	84.42/plot(40+44.42)	25gm/5lit
T_9	STD+FS@0.75% Borax twice	109.62/plot	84.42/plot(40+44.42)	37.5gm/5lit
T_{10}	STD+FS@1.0% Borax twice	109.62/plot	84.42/plot(40+44.42)	50gm/5lit

2.2 Climatic Conditions During Summer 2021

Geographically Bhubaneswar located at a latitude of 200 15' N and longitude of 850 52' E with an altitude of 25.9 m above the MSL. The weekly meteorological data pertaining to rainfall, temperature and relative humidity prevailed during crop growth period from 30th January 2021 to May 2021 was recorded at Central Meteorological Observatory, Orissa University of Agriculture and Technology, Bhubaneswar. The total rainfall received during the crop growth period was 78.5 mm over 9 rainy days. During this period, average monthly maximum rainfall mm was received in the month of May and minimum rainfall mm was received in the month of April and no rainfall occurred in January to March. The weekly maximum temperature of 39.9 º C was recorded in April and minimum of 13.2 ºC in February. Mean morning and evening relative humidity was 69.66% and 23.66%, respectively during the crop growing period. The mean maximum BSS during crop growth period was 8.98 (hrs per day) and mean EVP during crop growth period was 9.12 (mm) week-1. The average wind velocity recorded during the crop growing period was 5.08 km per hour.

2.3 Design and Layout

The experiment was laid out in a factorial random block design with dates of planting and boron treatment. The treatment consisted of 2 levels of sowing date:D1,D2 conducted prior to 10 boron treatments : T1, T2 , T3 , T4 , T5 , T6, T7, T8 ,T9 , T10 assigned in a Factorial Randomized Block Design with three replication in a 2 x 10 factorial experiment. The dimension of the experimental area was 39.5m X 22m(869m2) with each plot dimension of 4.2m X 3m(12.6 m2).The experimental plot was provided with irrigation channels as shown in the layout plan.

2.4 Treatment Details

There were 20 treatment combinations consisting of 2 dates of planting and boron application in the plots. The details of the treatment combinations are given.

2.5 Emergence Count

The number of emerged plants from each net plot was recorded on 8 days after sowing, when complete emergence was noticed.

2.6 Height of Plant (cm)

Height of the randomly selected five plants was measured in cm from ground level to the base of last fully opened leaf at various dates of observations starting from 30 DAS with 15 days interval.

2.7 Leaf Area Plant-1 (cm^2)

The leaflets were separated from each sampled plant which was uprooted for dry matter studies. The leaflets were graded into three categories viz. small, medium and big. The leaf number in each group was counted. The representative sample from each category was taken from its linear measurement of maximum length and breadth in cm. It was measured and recorded.

$LA = L \times B$

Where,
LA = Leaf Area in cm^2
L = Length of leaf in cm^2 B = Breadth of leaf in cm^2

2.8 Plant Population Per m²

The number of plants per square meter from each net plot was recorded on 30 and 60 days after sowing.

2.9 Pathological Observations

Observations will be recorded on disease incidence and of YVMV okra 28 days after sowing 7 days interval with five randomly selected plants.

$$PDI = \frac{Damaged\ plant}{Randomly\ selected\ plant\ with\ maximal\ disease\ index} \times 100$$

2.10 Statistical Analysis

The data was calculated to the incidence of yellow vein mosaic virus correlated with various weather factors. The correlations between weather parameters and disease incidence were studied. The data generated from the field experiment was analysed as per the FRBD procedure with the necessary transformation (Gomez & Gomez, 1984). Also, we found the correlation between boron application and incidence of YVMV on okra.

2.11 Correlation Studies

The simple correlation between weather parameters viz., rainfall, rainy days, maximum temperature, minimum temperature, relative humidity, evaporation and bright sunshine hours on the development of Yellow Vein Mosaic of okra was estimated to know the correlation between these weather parameters and disease incidence and boron application on the crop. The data used in the study were the mean values of replicated observations. Online computer program OPSTAT was used for all the statistical analysis of the research field data.

2.12 Observation on Tagged Plant

Biometric Observations such as emergence count in percentage, plant height in cm, leaf area in cm², plant population in m2 and yield per net plot were taken.

3. RESULTS

3.1 Emergence Count

The test crop was Okra with crop variety –LILY. 2-3 seeds no. were put in the hill. The emergence of siblings was counted after 8 days of sowing. The percentage of emergence is shown in Table 2. It was observed that the emergence count on the 1st date of sowing(d1) is on 30th January varied from 71.8% to 75.5%. Similarly in the 2nd Date of sowing (d2), That is February 15th varied from 79.5% to 85.6%. The CD at 5% level for Boron(N) application was 1.90 and for Date of sowing 0.85, with a CV value of 2.07%. Emergence Count was found to be higher in D2 compared to D1.

3.2 Plant Population (Number/Plot)

The number of plants per unit area (per plot) is the resultant of the quality of seed, the influence of soil, pathogens, and climatic parameters. The plant population at 30 were counted in each treatment plot (4.2×3m²) and presented in Tables .3. The mean plant population during D1 varied from 82.3 to 85.6 and that of D2 87.0 to 91.6. The plant population was less in D1 compared to D2. The coefficient of dispersion (5%) was 0.84 for the date of sowing,1.89 for Boron treatment, and 2.67 for interaction. Plant population was statistically significant between two dates of sowing but it was not statistically significant due to Boron treatment within 1st date of sowing. The CV was very less.

Table 2. Emergence count (%) at 8DAS

Treatments	R1	R2	R3	Mean (%)
D1T1	73.2	70.6	74.6	72.8
D1T2	76.6	72.9	74.9	74.8
D1T3	70.8	75.2	73.9	73.3
D1T4	75.6	76.2	72.6	74.8
D1T5	70.5	74.3	72.6	72.4
D1T6	76.2	73.0	76.4	75.2
D1T7	70.3	73.1	72.0	71.8
D1T8	74.2	71.8	75.2	73.8
D1T9	71.8	74.2	73.9	73.3
D1T10	76.4	74.2	75.9	75.5

Treatments	R1	R2	R3	Mean (%)
D2T1	78.6	82.1	81.4	80.7
D2T2	86.1	84.7	84.5	85.1
D2T3	82.5	81.6	85.5	83.2
D2T4	86.8	84.8	85.2	85.6
D2T5	80.2	80.6	83.1	81.3
D2T6	83.2	82.4	81.0	82.2
D2T7	77.5	80.2	80.8	79.5
D2T8	84.2	86.2	86.7	85.7
D2T9	80.6	83.2	84.9	82.9
D2T10	83.4	81.8	82.3	82.5
	S Em	CD 5%		
D	0.297171	0.85078		
N	0.664495	1.902401		
DxN	0.939738	2.690401		
CV	2.078236			

D1T1=first date of sowing with first treatment

Table 3. Plant population (30 DAS)

Treatments	R1	R2	R3	MEAN
D1T1	83	85	79	82.3
D1T2	85	83	86	84.6
D1T3	83	85	82	83.3
D1T4	83	84	85	84.0
D1T5	79	82	80	80.3
D1T6	84	86	87	85.6
D1T7	82	80	82	81.3
D1T8	82	84	85	83.6
D1T9	83	82	82	82.3
D1T10	85	87	85	85.6
D2T1	90	88	87	88.3
D2T2	92	94	89	91.6
D2T3	88	91	90	89.6
D2T4	90	92	90	90.6
D2T5	87	89	89	88.3
D2T6	91	90	87	89.3
D2T7	92	89	93	91.3
D2T8	90	92	90	90.6
D2T9	87	90	88	88.3
D2T10	89	86	86	87.0
	S Em	CD 5%		
D	0.295829	0.846936		
N	0.661493	1.893806		
DxN	0.935492	2.678245		
CV	1.874648			

D1T1=first date of sowing with first treatment

3.3 Plant Height (cm)

Plant height is an important growth parameter and helps in increasing yield by acquiring more sunshine and air. The height of the Okra crop of different treatments was measured at different time intervals like 30,40,60,75 and 90 DAS. The recoded average height was presented in Table 4. The plant height of 90 DAS of Okra crop for different boron treatments under D1 varied from 75.1 to 93.2cm and that of D2 ranged between 79.8 to 108.6 cm. There was a significant difference in height between the two dates of sowing were found. But within boron treatments, some treatments were seen higher height and found statistically different. The difference of height in respective boron treatment in two dates of sowing significantly higher height

was recorded in D2. Within the date of sowing, maximum height was recorded or measured in T8 followed by T2, T9, T5, T10, T7, T6, T4, T3, and T1 in decreasing sequence. Similar types of sequence in plant height were observed for all heights measured at different DAS above except 30 days after sowing.

Table 4. Plant height of okra at 30 DAS- 90 DAS

Treatments	30DAS	45DAS	60DAS	75DAS	90DAS
D1T1	15.3	34.7	48.8	68.2	75.1
D1T2	16.9	38.2	56.7	85.1	92.6
D1T3	17.1	35.4	52.6	76.5	88.5
D1T4	16	36.7	53.2	77.4	84.90
D1T5	16.4	34.1	55.2	83.2	90.3
D1T6	16.5	36.5	53.9	80.4	85.7
D1T7	17.3	35.4	54.5	81.8	87.5
D1T8	17.6	38.9	59.3	86.3	93.20
D1T9	17.4	37.8	56.1	85.8	91.8
D1T10	17.3	36.9	55.1	82.3	89.20
D2T1	20.4	42.1	56.1	76.5	79.8
D2T2	21.6	43.4	70.3	95.3	105.8
D2T3	21.5	43.9	60.7	85.7	93.7
D2T4	21.2	43.0	61.5	86.5	94.50
D2T5	22.2	46.5	65.8	93.3	101.3
D2T6	21.4	43.7	62.5	88.5	96.40
D2T7	21.9	45.6	63.1	90.5	97.20
D2T8	21.8	48.8	71.2	97.5	108.60
D2T9	22.4	46.8	68.7	95.1	103.50
D2T10	21.8	45.1	64.4	91.4	98.6
CD(0.05) D	0.550388	0.62953	0.59219	0.834003	0.727174
N	1.230705	1.407671	1.324176	1.864887	1.62601
DXN	1.740479	1.990748	1.872668	2.637348	2.299525

D1T1=first date of sowing with first treatment

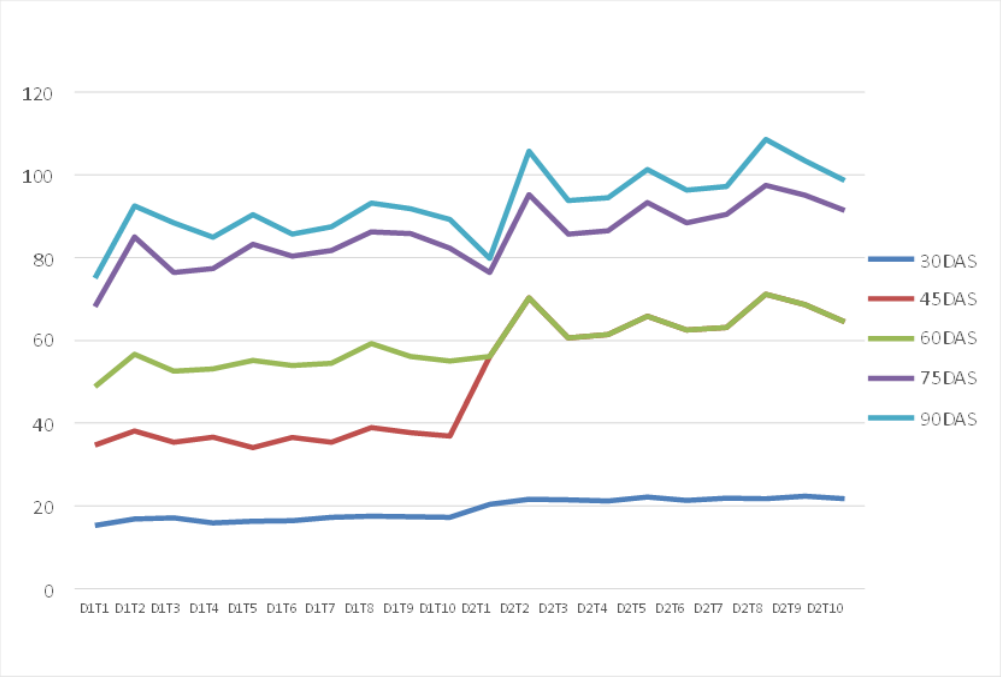

Fig. 1. Periodic changes of Plant height of okra crop

3.4 Leaf Area of Okra crop

The leaf area of a crop is directly proportional to the quantity of photosynthate production, yield, and growth of plant parts. It is the sight of capturing solar radiation, air, water, and minerals. Its size depends on the age of the plant. It gradually increases with age up to a certain stage. These particular growth parameters are also influenced by plant nutrition and weather parameter and other growth factors. To know the effect of boron application and date of sowing, leaf areas at 30,45,60,75, and 90 DAS were recorded by leaf area meter following standard procedure. The leaf area at 30 DAS of Okra crop recorded 97.6 to 106.3 for D1. Similarly in D2, it ranged from 117.6-128.6. The maximum leaf area at 30 DAS was observed in T2 and less in other treatments. The average leaf area values in D2 were more compare to its counterpart D1 treatment.

The leaf area at 90 DAS of Okra crop were measured and presented, it was found that the leaf area in D1 varied from 226.4 cm^2 to 315.2 cm^2. Similarly in D2, it varied from 280.62 cm^2 to 435.4 cm^2. The maximum values were obtained in T8 followed by T2, T9, T5, T10, T7, T6, T4, T3, and T1. The leaf area observed in D1 were smaller than D2 in their respective boron treatments. In general, the leaf area was smaller at 90 DAS compared to 75 DAS.

3.5 Fresh Fruit Yield of Okra (t/ha)

The fresh fruit of Okra being a vegetable crop is the most important economic part. All management interventions target for a good fruit yield. Seed production is another way of yield. But that is restricted to selected number of farmers. In the present study, the fresh fruit of Okra as a vegetable crop is of prime importance. The tender soft fruit were plucked at 3 days interval after 65 DAS. Thereafter seeing the tenderness of the fruit, it was harvested. Mass of fruit per treatment were recorded every time. Finally, all masses seemed up and converted to 1 ha and the data were presented in Tables 6 and 7, Fig. 2.

3.6 Yield (t/ha)

The mean yield of fresh Okra fruit varied from 6.52 to 8.64 t/ha due to different doses and frequency of boron application. The maximum fruit yield obtained from the treatment (T8) receiving twice foliar spray @ 0.5% borax followed by T2, T9, T5, T10, T7, T6, T4, T3, and T1.

Table 5. Periodic mean leaf area of okra

Treatments	30DAS	45DAS	60DAS	75DAS	90DAS
D1T1	102.8	125.5	176.1	231.5	226.4
D1T2	106.3	146.8	221.3	314.5	310.6
D1T3	101.6	135.4	198.6	279.5	274.5
D1T4	101.8	137.6	202.6	288.4	285.7
D1T5	103.2	142.6	217.4	305.2	302.8
D1T6	97.6	138.6	207.3	293.4	290.4
D1T7	99.7	139.5	210.6	297.6	294.6
D1T8	105.4	144.6	225.5	318.2	315.2
D1T9	105.5	143.2	219.6	309.6	307.4
D1T10	101.5	141.7	213.8	301.5	298.5
D2T1	117.6	135.4	209.5	285.6	280.6
D2T2	128.3	172.1	328.6	432.5	426.8
D2T3	126.4	161.2	298.1	395.6	386.4
D2T4	123.8	162.3	302.5	401.3	391.5
D2T5	124.8	168.5	318.6	421.4	416.3
D2T6	127.2	164.2	308.6	408.2	397.6
D2T7	125.4	165.1	312.1	411.9	404.5
D2T8	128.6	174.6	334.5	441.2	435.4
D2T9	125.8	169.3	322.7	427.3	421.5
D2T10	126.1	166.2	315.4	415.6	408.6
CD(0.05) D	1.350246	0.795684	1.434115	1.54835	1.419773
N	3.019242	1.779203	3.206778	3.462216	3.174708
DXN	4.269852	2.516173	4.535069	4.896312	4.489715

D1T1=first date of sowing with first treatment

The yield increase over control (B-O) were varied from 5.06 to 32.51/%. Due to differential boron application, the yield was the statistically significant in treatment T2, T5, T7, T8, T9, T10. Soil application of boron and twice foliar spray were found to be suitable for giving higher yield compared to no or once foliar application, except 0.75% borax (T5). Fresh fruit yield of Okra in boron applied different treatments varied from 7.35- 9.15 t/ha. The maximum yield was recorded in T8 and on other treatments followed the same trend as D1. But the yield was more in D2 compared to respective D1. Treatments receiving double foliar spray and soil application yielded higher than no boron and once foliar spray except 0.75% borax(T5). Former values were statistically significant than later and D2 produced significantly higher fresh fruit compared to D1. The increase or decrease of fruiting in different boron applied were calculated over no boron treatment (control) and expressed in %. Similar values of comparison between D1 and

Table 6. Fresh fruit yield of okra (t/ha)

Treatments	R1	R2	R3	MEAN
D1T1	5.85	6.92	6.79	6.52
D1T2	9.12	7.98	8.58	8.56
D1T3	5.95	7.02	7.58	6.85
D1T4	5.82	7.12	7.94	6.97
D1T5	9.26	7.60	7.50	8.12
D1T6	8.34	6.29	6.52	7.05
D1T7	8.45	7.80	6.97	7.74
D1T8	7.56	7.77	10.60	8.64
D1T9	7.82	6.90	10.60	8.44
D1T10	7.33	8.30	8.13	7.92
D2T1	7.94	8.02	6.09	7.35
D2T2	8.88	9.46	8.72	9.02
D2T3	7.75	6.92	7.59	7.42
D2T4	7.82	7.65	6.91	7.46
D2T5	9.01	8.12	8.40	8.51
D2T6	6.95	7.86	8.47	7.76
D2T7	7.25	7.96	8.94	8.05
D2T8	10.03	8.85	8.57	9.15
D2T9	7.95	8.86	9.68	8.83
D2T10	8.20	7.85	8.73	8.26
	S Em	CD 5%		
D	0.168045	0.481099		
N	0.375759	1.07577		
DxN	0.531404	1.521369		
CV	11.60581			

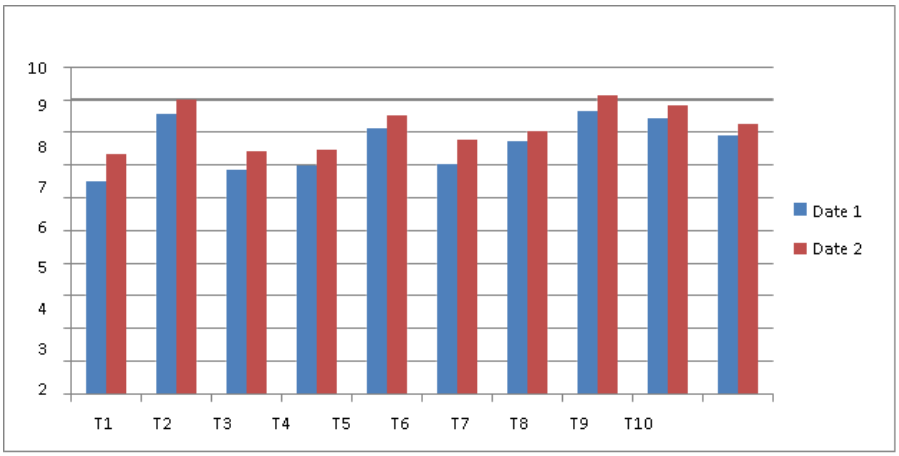

Fig. 2. Fresh fruit yield of okra crop

Table 7. Effect of treatments on fresh fruit yield of okra (t/ha)

Treatment	Yield DA (t/ha)	Yield % increase	Yield D2 (t/ha)	Yield %	Yield of D2 over D1
T1	6.52	-	7.35	-	12.73
T2	8.56	31.3%	9.02	22.72%	5.37
T3	6.85	5.06%	7.42	1.0%	8.32
T4	6.97	7.00%	7.46	1.49%	7.03
T5	8.12	24.53%	8.51	15.78%	4.80
T6	7.05	8.12%	7.76	5.57%	10.07
T7	7.74	18.71%	8.05	9.5%	4.00
T8	8.64	32.51%	9.15	24.48%	6.0
T9	8.44	29.44%	8.83	20.13%	4.62
T10	7.92	21.47%	8.26	12.38%	4.29
CD(0.05) D	0.481099				
N	1.07577				
DXN	1.521369				
CV%	11.60581				

D2 considering respective D1 value as 100, D2 values were calculated. The above data were present in Table no. 7. The data presented in the table showed that the increase over control in D1 due to boron application from 5.06-32.21%. On D2, it varied from 1.0 to 24.48%.

Comparing the fruit yield value of D2 with its counterpart D1 treatment, it was found that in D2, the yield was higher over D1, and the increase in D2 over D1 varied from 4.0-12.73%. The maximum increase was observed in control followed by boron application, that means meteorological parameters particularly temperature played an important role in deciding the growth and fruit yield of Okra.

3.7 Yellow Vein Mosaic Virus

Yellow Vein Mosaic Virus (YVMV) is a serious pathogen for the Okra crop. Whitefly is its vector, weather parameters especially temperature plays an important role in the transmission of this virus. The optimum temperature of 24.-26° C, helps in the spreading of the virus.

The infected plant losses chlorophyll of leaf. Reduces plant height, leaf area, photosynthates, fruit size, and fruit density. Ultimately it also reduces the yield as reported by Sheikh et al., (2013).

Boron plays a vital role in reducing the harmful effect of the YVMV attack as reported by Ahmad et al., (2007), Ali et al., (2015), Iftikhar et al., (2020).

The periodic YVMV infestation index were recorded in different treatment plants at weekly interval starting from 28 DAS to 84 DAS following the standard procedure. The YVMV index percentage data were recorded treatment wise and Table 8. It is revealed from the table that, mean YVMV index percentage at 28 DAS varied from 6.47 to 17.03 under D1 and 7.65 to 17.03 on D2. There was very less infestation during this period.

Similarly at 35 DAS, it varied from 7.77 to 18.52 in D1 and 8.21-22.96 in D2. In 42 DAS, it varied from 9.25-21.48 in D1 whereas in D2 it ranged between 10.66-24.In 49 DAS, it varied from 9.66 to 22.96 in D1 and in D2 10.73 to 25.92.In 56 DAS, the above values were 10.59-25.18 in D1 and 10.92 to 27.40 in D2. In 63 DAS, the values were 11.11 to 24.40% in D1 and in D2 11.85 to 29.62.

In 70 DAS, it varied from 11.85 to 28.88 in D1 and it varied from 10.92 to 28.88 in D2. In 77 DAS, the value ranged from 12.59 to 29.62, and in D2 10.73 to 27.40.In 84 DAS, the value ranged from 11.85 to 28.88, and in D2 10.54 to 25.92.

3.8 Boron Concentration of Okra Fruit

Boron is an important micro-nutrient in Odisha soil. Its content in a fruit-edible part of the Okra plant was determined on a dry weight basis using the Azo-methine indicator. It was observed from the data table that the value of the concentration of boron in Okra fruit in different treatments varied from 0.09 to 0.17 mg/kg.

Table 8. PDI of YVMV on okra crop(%)

Treatments	28DAS	35DAS	42DAS	49DAS	56DAS	63DAS	70DAS	77DAS	84DAS
D1T1	17.03	18.52	21.48	22.96	25.18	27.4	28.88	29.62	28.88
D1T2	6.47	7.77	9.25	10.18	11.11	11.85	12.59	13.33	12.59
D1T3	14.14	14.81	15.55	17.03	17.77	18.51	19.26	20	20.00
D1T4	13.33	14.07	14.81	16.29	17.03	17.77	18.51	19.26	18.51
D1T5	10.4	10.59	11.11	11.85	12.59	13.33	14.07	14.81	14.07
D1T6	12.59	13.33	14.07	15.55	16.29	17.03	17.77	18.51	17.77
D1T7	11.85	12.59	13.33	14.81	15.55	16.29	17.03	17.77	17.03
D1T8	7.65s	8.32	8.73	9.66	10.59	11.11	11.85	12.59	11.85
D1T9	10	10.4	10.59	11.11	11.85	12.59	13.33	14.07	13.33
D1T10	11.66	11.85	12.59	14.07	14.81	15.55	16.29	17.03	16.29
D2T1	21.48	22.96	24.44	25.92	27.4	29.62	28.88	27.4	25.92
D2T2	7.65	8.21	10.66	11.11	11.85	12.59	11.85	11.11	10.92
D2T3	17.03	17.77	18.51	19.26	20.74	21.48	20.74	19.26	19.26
D2T4	16.29	17.03	17.77	18.7	20.00	20.74	20.00	18.51	17.77
D2T5	12.59	13.33	14.81	17.03	16.29	17.03	16.29	15.55	14.81
D2T6	15.55	16.29	17.03	18.51	19.26	20.00	19.26	17.77	17.03
D2T7	14.81	15.55	16.29	17.77	18.51	19.26	18.51	17.03	16.29
D2T8	9.13	10.06	10.47	10.73	10.92	11.85	10.92	10.73	10.54
D2T9	10.4	10.92	11.11	11.85	12.59	13.33	12.59	11.85	11.85
D2T10	14.07	14.07	15.55	17.22	17.77	18.51	17.77	16.29	15.55

D1T1=first date of sowing with first treatment

The maximum concentration was found in T8 where twice foliar spray of boron was done and the minimum was found in the control treatment. The concentration value in treatment where foliar spray was done twice with a concentration of more than 0.5% and soil application were found to be statistically higher than once applied treatments as well as no application of borax. The borax concentration of Okra fruit of different boron treatments in D2 varied from 0.10-0.18 mg/kg fruit. The trend of boron concentration in different treatments were as like treatments of D1 but the values were higher.

3.9 Correlation between Boron and YVMV

The incidence of YVMV attack on Okra crop in relation to different boron applications was studied through correlation and presented in Fig 3. It was found that with the application of more boron that is soil application and twice foliar spray, reduced the severity of YVMV to a great extent, but no application or once foliar spray increase the YVMV attack. The extent of the period of incidence of YVMV in D1 was found to be more prolonged compared to D2.

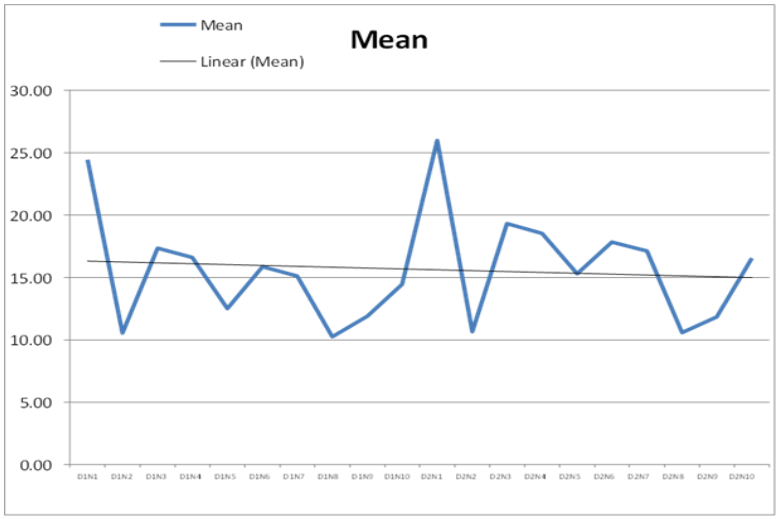

Fig. 3. Correlation of YVMV PDI with boron treatments.

Table 9. Correlation of OYVMV with weather parameters under two sowing dates

Date of Sowing	Disease	Tmax	Tmin	RHI	RHII	BSSH	Evapo	RF	WS
1st DOS	YVMV	0.739*	0.977**	-0.084NS	0.745*	-0.302NS	0.964**	0.676*	0.798*
2nd DOS	YVMV	0.331 NS	0.780*	-0.511 NS	-0.653 NS	0.083*	0.870**	0.378 NS	0.474 NS

Pearson's correlation is measure of strength of linear relationship in between two variables. Association and correlation in between characters are represented in Table 9 YVMV was correlated with Tmax, Tmin, RHII, Evaporation, Rainfall and wind speed. Tmin and Evaporation is correlated both at 1 and 5% significant level in case of first date of sowing. RHI is not significant. It can be said that the degree of association between YVMV incidence and Tmax, Tmin, RHII, Evaporation, Rainfall and wind speed is high in comparison to the RHI and BSSH. In the second date of sowing, the association and correlation in between characters are represented in Table 9. YVMV was highly correlated with Tmin and Evaporation. The other weather parameters like RHI, RHII, BSSH, Rainfall and wind speed is poorly associated with the incidence of YVMV.

10. DISCUSSION

10.1 Emergence Count (%)

The no. of seeds sprouted was counted on 8 days of sowing and expressed in percentage. There was no significant difference due to boron application on emergence count but there was a significant difference within the date of sowing due to lower temperature 13.6°C in D1, whereas in D2 is 16.7°C. The maximum temperature was 29.1°C and D2 is 33.6°C. It was less in D1 compared to D2. The low CV value confirmed that the seed material was of uniform germination ability which created very less difference of emergence count.

10.1 Plant Population

Plant population directly affects the yield of any crop at 30 DAS. Plant population was significantly lower in D1 compared to D2 because of less emergence count and low temperature in D1 lower temperature from D2, due to boron application within one date of sowing, there is no difference in plant population because this treatment experienced the same temperature and other climatic factors as their date of sowing is one. Similar type of observation were recorded by Talukder et al., (2003) in okra crop infested by Jassid.

10.2 Plant Height

The Okra crop plant at 90 DAS was found to be a lower value compared to that of 75 DAS confirming the senescence stage of the crop. Similar to 75 DAS, during this stage, the difference in height was recorded because of the cumulative effect of the age of the plant. The consequence of boron application, date of sowing, and incidence of YVMV attack. The height in the 1st Date (D1) of sowing was less than the 2nd Date (D2) of sowing confirms the likingness of higher temperature by Okra crop. Due to twice foliar spray 0.5% borax, the average plant height were 93.2 and 108.6cm in D1and D2 respectively followed by soil application of boron. A similar sequence of the height of Okra crop was observed all DAS except 30 DAS because at that time boron was not applied except T2(soil application), but afterward effect of boron was found clearly in different treatments. However, due to different dates of sowing, the height of the Okra crop was statistically significant. Dinesh et al., (2007) and Dash et al., (2013) reported similar type of facts of okra plant height with different date of sowing.

10.3 Leaf Area cm^2

Leaf area at 90 DAS due to different boron applications followed the same trend as before but their values were smaller compared to that of 75 DAS. This was due to the attainment of senescence by the crop. Optimum boron receiving plants showed higher leaf size as well as prevented the YVMV attack. In 2nd date sown Okra plants have bigger leaves because of higher temperature compared to the earlier (D1) sown plants. Hence, D2 (15th February) was a better sowing time compared to D1, that is on 30th January. Katung (2007) observed above type of result in okra crop.

10.4 Fresh Fruit Yield

The fresh fruit yield of Okra was found to be maximum in twice foliar spray @ borax 0.5% (T8) followed by T2, T9, T5, T10, T7, T6, T4, T3, T1 in

both dates of sowing. The percentage yield increase over control were 32.51%, 31.3%, 29.44%, 25.5%, 21.47%, 18.71%, 7.01% and 5.06% respectively for the above treatment in D1.Twice foliar spray of boron for all concentrations with 0.75% once foliar spray and soil application @ 1.5kg boron /ha were found to be giving more yield over no application and single foliar spray. Twice foliar spray satisfied the boron requirement of Okra crop and the optimum dose is 0.5% borax (T8) which is even better than the soil application as reported by Ali et al., (2015) and Ashraf et al., (2018) in Okra crop and Ilyas, (2019) in Tomato crop.

In D2, followed the same trend as D1 for the application of Boron. But the yield were higher compared to its respective D1 treatment. The February date of sowing with more temperature and weather parameters were found suitable compared to January sowing for Okra crop in Bhubaneswar climatic condition. Dilruba et al., (2009) found similar type of result in fruit yield of okra due to different date of sowing.

10.5 YVMV

The YVMV infestation index is an indicator of its magnitude of the infestation. It influences the yield of the crop through physiological disorders. Boron application decreases the severity of YVMV infestation. A similar type of observations were repeated by scientist Brown et al., (2002) pronounced that boron reduces the severity of plant disease by strengthening the plant cell and Iftikhar et al., (2020) concluded that treatment disease incidence OYVMV was 50%, after application of boron treatment it was lower then 25%.

YVMV virus has suitable meteorological parameters. It proliferates maximum at the congenial environment. On the first date of sowing (D1) that is on 30th January, the crop passed through the congenial weather parameter up to 77 days of its growth, whereas 2nd date of sowing (15th February) crop passed through 63 DAS of its lifespan. Thereafter high temperature reduces the infestation index. Hence the D2 sowing has performed better than the D1 sowing.

10.6 Boron Concentration

Boron is a deficient micro-nutrient in the soils of Odisha. Crops respond to boron application positively. Vegetables crops like Okra are sensitive towards boron application. The concentration of boron was found to be maximum in 0.5% borax twice foliar spray because of the optimum dose of it. Boron applied to soil and twice foliar spray with more concentration of solution help in increasing the concentration of boron in Okra fruit. Due to ambient meteorological parameters in D2 (15th February), the boron concentration was higher in treatments compared to earlier sowing in D1 (30th January)

10.7 Correlation between YVMV and Boron

The incidence of YVMV in Okra Crop has showed a relationship with boron application. More the dose of boron less was the severity. This type of result were published by Scientist Ali et al., (2015), Ahmed et al., (2007), Iftikhar et al., (2020) and Prasad et al., (2014) concluded that foliar application of boron to plant reduced mite and YVMV.

Boron reduces the severity of YVMV and many other diseases because of its role in strengthening the structure of all wall, plant membranes, and metabolism of phenolics or lignin. It also helps in the translocation of photosynthates and water to different parts of the plant and infected site.

10.8 Correlation between YVMV and Weather Parameters

Weather parameters have deep relationship with occurrence of YVMV in okra crop. Out of eight parameters related to YVMV incidence the correlation study of these parameters showed that, The step wise linear regression model regarding the impact of weather factors on YVMV, the Tmin explained 95% of the variation in the incidence but in the first model the variation was explained due to RHII was 55% and in second model the variation of YVMV due to both RHII and evaporation was explained by 77%. The present findings are in line with Akram et al. (2013) who founded that the combination of all the weather parameters under hierarchical linear regression explained 75% role in the fluctuation of thrips population in Cotton and also similar findings were reported by Janu et al., 2017.

11. CONCLUSION

YVMV infestation in D1 increased up to 77 DAS whereas, in D2, it increased up to 63 DAS due to

prevailing of maximum temperature 37.0°C or more. With application of more boron through the twice foliar spray and soil, application reduced the severity of YVMV attacked to a great extent but no application or once foliar spray increased the infestation index. In correlation of YVMV and weather parameter, in the 1st date of sowing (D1) 30th January Tmin and Evaporation is correlated both at 1 and 5% significant level in case of first date of sowing. RHI is not significant. It can be said that the degree of association between YVMV incidence and T_{max}, T_{min}, RHII, Evaporation, Rainfall and wind speed is high in comparison to the RHI and BSSH. In 2nd date of sowing (D2) 15th February YVMV is highly correlated with Tmin and Evaporation. The other weather parameters like RHI, RHII, BSSH, Rainfall and wind speed is poorly associated with the incidence of YVMV.

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 this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

Ahmad, W., Niaz, A., Kanwal, S., Rahmatullah, & Rasheed, M. K. (2007). Role of boron in plant growth: A review. *Journal of Agricultural Research, 47*, 329–338.

Akinyele, B. O., & Temikotan, T. (2007). Effect of variation in soil texture on the vegetative and pod characteristics of okra (*Abelmoschus esculentus* (L.) Moench). *International Journal of Agricultural Research, 2*, 165–169.

Akram, M., Hafeez, F., Farooq, M., Arshad, M., Hussain, M., & Ahmed, S. (2013). A case study of population dynamics of thrips in cotton. *Pakistan Journal of Agricultural Sciences, 50*(4), 617–623.

Ali, M. R., Mehraj, H., & Jamal Uddin, A. F. M. (2015). Effects of foliar application of zinc and boron on growth and yield of summer tomato. *Journal of Bioscience and Agriculture Research, 6*(1), 512–517.

Anonymous. (2007a). Soybean response to boron fertilization, 2007 [Online]. Retrieved May 15, 2010, from http://ipni.net/far/farguide.nsf/$webindex/article=5F51B22A852573F10001A460FBF6FC76!opendocument

Ashraf, M. I., Shoukat, S., Hussain, B., Sajjad, M., & Adnan, M. (2018). Foliar application effect of boron, calcium, and nitrogen on vegetative and reproductive attributes of tomato (*Solanum lycopersicum* L.). *Journal of Agricultural Science and Food Research, 9*, 199.

Dash, P. K., Rabbani, Md. G., & Mandal, Md. F. (2013). Effect of variety and planting date on the growth and yield of okra. *International Journal of Biosciences, 3*(9), 123–131.

Dilruba, S., Hasanuzzaman, M., Karim, R., & Naha, K. (2009). Yield response of okra to different sowing times and application of growth hormones. *Journal of Horticultural Science & Ornamental Plants, 1*(1), 10–14.

Dinesh, Rabbani, Md., & Mondal, Md. (2007). Effect of variety and planting date on the growth and yield of okra. *International Journal of Biosciences, 3*, 123–131. https://doi.org/10.12692/ijb/3.9.125-101

Fagbohun, E. D., & Faleye, S. O. (2012). Effect of storage on chemical composition and mycoflora of okra (*Abelmoschus esculentus*). *International Journal of Bioscience, 2*(7), 83–89.

Gomez, K. A., & Gomez, A. A. (1984). *Statistical procedures for agricultural research*. John Wiley & Sons.

Huang, L., Ye, Z., Bell, R. W., & Dell, B. (2005). Boron nutrition and chilling tolerance of warm climate crop species. *Annals of Botany, 96*, 755–767.

Iftikhar, Y., Bilqees, I., Mubeen, M., Shakeel, Q., Sajid, A., Hussain, Z., Abbas, A., Sohail, M. A., Kiptoo, J. J., & Iqbal, S. (2020). Use of nutrients and plant extract to manage okra yellow vein mosaic disease (OYVMD) in Sargodha, Punjab, Pakistan. *Pakistan Journal of Agricultural Research, 33*(4), 754–758.

Janu, A., Dahiya, K. K., Kumar, Y., & Jakhar, P. (2017). Influence of meteorological parameters on population dynamics of thrips in cotton. *Journal of Entomology and Zoology Studies, 5*(5), 1991–1993.

Katung, M. D. (2007). Productivity of okra varieties as influenced by seasonal changes in northern Nigeria. *Notulae*

Botanicae Horti Agrobotanici Cluj-Napoca, 35(1).

Osman, I. M. (2019). Effect of boron and zinc on the growth, yield, and yield-contributing traits of tomato. *IOSR Journal of Agriculture and Veterinary Science (IOSR-JAVS, 12*(2), 25–37.

Prasad, R., Shivay, Y. S., & Kumar, D. (2014). Agronomic biofortification of cereal grains with iron and zinc. *Advances in Agronomy, 125*, 55–91.

Sheikh, M. A., Safiuddin, Z., Khan, & Mahmood, I. (2013). Effect of Bhendi YVMV on yield components of okra plants. *Journal of Plant Pathology, 95*(2), 391–393.

Talukder, M. A. H., Munnaf, M. A., Alam, M. K., Salam, M. A., & Amin, M. M. U. (2003). Influence of sowing time, plant spacing, and picking interval on the growth and yield of okra. *Pakistan Journal of Biological Sciences, 6*(18), 1626–1630.

Warncke, D. D. (2005). Ameliorating internal black spot in cranberry bean seed with boron application. *Communications in Soil Science and Plant Analysis, 36*, 775–781.

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