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Impact of plant growth regulators on okra seed quality and storability under ambient conditions

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Abstract

During kharif 2020 and 2021, an investigation was conducted to investigate the role of plant growth regulators as foliar spray on okra seed yield and quality. The experiment was laid out in RBD with three replications and eleven treatments. Foliar sprays were done at 15 and 30 DAS. Observations on various plant growth parameters, yield attributing characters, seed yield, seed storability and quality were recorded. Harvested seeds were stored in poly bags for a period of twelve months to study the storability of seeds. Results revealed that treatment with Cycocel 250 ppm recorded highest germination percentage (83.37%) followed by GA_3 150 ppm (80.50%) whereas control plot recorded (73.00 %) of germination one year after storage. The rate of decrease in germination was (8.09%) with Cycocel (250 ppm) as compared to control (15.02%). The lowest increase in seed moisture content was recorded with Cycocel (250 ppm) (3.43%) followed by GA_3 (150 ppm) as compared to control (4.98%). Up to twelve months of storage the progressive decline of Vigour Index -I and Vigour Index -II was demonstrated with Cycocel (250 ppm), GA_3 (150 ppm) and NAA (200 ppm) with a decreased rate which expressed their potentiality as effective growth regulators . The electrical conductivity increased with a very decreased rate in Cycocel (250 ppm) (255.77%) followed by GA_3 (150 ppm) (324.11%) and NAA (200 ppm) (384.31%) as compared to control (583.98%). Hence Cycocel (250 ppm) may be considered as best plant growth regulators increasing yield, seed quality and storability of okra.

Key words: Okra, seed quality, storability, plant growth regulators

Introduction

Okra (*Abelmoschus esculentus* L. Moench), commonly referred to as Ladies finger or "Bhendi", holds significant agricultural importance as a key vegetable crop cultivated across the country during both Kharif and summer seasons. Being a predominantly self-pollinated crop with occasional cross-pollination, okra, like many other vegetables, exhibits the potential for enhanced production and physiological traits through the application of plant growth regulators. The positive impact of these regulators is particularly observed in the increased yield of green pods, where the translocation of photosynthates is stimulated by growth hormones, as highlighted by Solamalai *et al.* (2001).

Recognizing the potential benefits of plant growth regulators, Khan and Choudhury (2006) emphasized the importance of strategic planning in terms of application timing, method, and proper concentration to optimize growth parameters and overall crop productivity. Physicochemical properties, influencing cooking quality, have been noted in edible seeds such as common beans (Sofi *et al.*, 2014). In the case of okra, challenges related to climatic factors and storage issues have led to the degradation of seed potency and nutritional quality (Anonymous, 2003). Moreover, the inoculation of microbial consortia has been identified as a method to enhance seed quality and vigor (Raja *et al.*, 2019).

Aligned with the increasing demand for tender pods and the need for high-quality seed production, this study aims to investigate various postharvest seed parameters, including germination, seed moisture content, seedling vigor, and electrical conductivity of seed leachates. The research also seeks to evaluate the influence of different growth regulators on these parameters and assess the postharvest storability of okra seeds. Through this exploration, we aim to contribute valuable insights into optimizing postharvest practices for sustainable okra cultivation, ensuring both quantity and quality in crop production.

Materials and methods

The experiment was conducted in the Department of Vegetable Science and Department of Seed Science and Technology, Odisha University of Agriculture and Technology, Bhubaneswar, during kharif season of 2020 and 2021. Foliar spray of PGRs at various concentrations were given to okra seed crop *cv.* Utkal Gourav. The experiment was laid out in RBD with three replications consisting of eleven treatments *viz.*, GA_3 (100 ppm) (T_1), GA_3 (150 ppm) (T_2), NAA (150ppm) (T_3), NAA (200 ppm) (T_4), Thiourea (250 ppm) (T_5), Thiourea (500 ppm) (T_6), Cycocel (200 ppm) (T_7), Cycocel (250 ppm) (T_8), Paclobutrazol (100 ppm) (T_9), Paclobutrazol (200 ppm) (T_{10}), Control (T_{11}). The foliar spray was done at 15 DAS and 30 DAS. In Control, equal quantity of water was sprayed twice as in case of other treatments.

Seed germination percentage: The germination test of okra seeds was conducted as per the (ISTA, 2007) Rules by adopting between paper (BP) method. The number of normal seedlings were counted and the percent seed germination was calculated as follows.

$$\text{Germination percentage} = \frac{\text{Number of normal seedlings}}{\text{Total number of seeds}} \times 100$$

Seedling vigour index-I and II: Seedling Vigour Index-I and II were measured for twenty normal seedlings selected randomly from the germination test. The mean seedling length was calculated as per the formula developed by Abdul Baki and Anderson (1973). The seedling Vigour Index-I and II were recorded after harvest, 2nd, 4th, 6th, 8th, 10th and12th months of storage.

The seedling vigour index was computed by adopting the formula as given below:

Seedling Vigour Index - I= Germination% x Seedling length

Seedling Vigour Index - II= Germination % x Seedling dry weight

Seed moisture content: The weights of moisture box and seed before and after drying were recorded. Seed moisture content was calculated in percentage on wet basis with the following formula.

$$\text{Seed moisture content (\%)} = \frac{(M2-M3)/(M2-Ml)}{\text{Initial weight of seed}} \times 100$$

Where,

M1=weight of empty moisture box with lid

M2=Weight of moisture box with lid + seed before drying

M3=weight of moisture box with lid + seeds after drying

Electrical conductivity (ds/m): The electrical conductivity of seed leachate was measured after harvest, at 2nd, 4th, 6th, 8th, 10th and12th months after storage under ambient conditions in poly bags. The electrical conductivity of seed leachates was measured using a digital conductivity meter with a cell constant of one, and the result was reported as dS/m (Presley, 1958).

Results

Seed moisture content: The impact of growth regulators on seed moisture content exhibited a dynamic pattern when assessed at bi-monthly intervals. In the kharif season of 2020, the seed moisture content across different treatments showed nonsignificant differences immediately after harvest and two months into storage. However, notable distinctions among treatments became apparent during subsequent observations at the 4th, 6th, 8th, 10th, and 12th months (Table 1).

A progressive increase in moisture content was observed, reaching the highest level in the control group (6.5 to 7.25%) at both harvest and one year after storage. In contrast, the treatments with GA_3 (150 ppm) and Cycocel (250 ppm) exhibited the least increase in seed moisture (6.68 to 6.92 and 6.65 to 6.89%, respectively) at harvest and after 12 months of storage. The rates of moisture content increase were notably lower in GA_3 (150 ppm) at 4.02 and Cycocel (250 ppm) at 3.90%, compared to the control with a substantial increase of 10.34%.

In kharif season of 2021, a similar progressive increase in seed moisture content was observed, with the control group displaying the highest values (6.63 to 7.33%) at both harvest and after 12 months of storage (Table 1). The growth regulators GA_3 (150 ppm) and Cycocel (250 ppm) maintained a relatively lower increase in seed moisture, with values ranging from 6.62 to 6.93 and 6.48 to 6.88% at harvest and after 12 months of storage, respectively. The rates of seed moisture increase during storage were 3.32% in GA_3 (150 ppm) and 5.81% in Cycocel (250 ppm), representing a significant reduction compared to the control, which exhibited a higher rate of increase in moisture at 9.55% (Fig. 1).

Seed germination percentage: The impact of foliar application of plant growth regulators on the seed germination of okra cv Utkal Gourav during kharif 2020 was examined at bi-monthly intervals for up to 12 Months after harvest (Table 2). Cycocel at 250 ppm exhibited the highest seed germination (90.70%), while the control recorded 85.9% germination after harvest. Notably,

Table 1. Effect of foliar application of plant growth regulators in okra *cv.* Utkal Gourav during kharif 2020 and 2021 on seed moisture content at bi-monthly interval up to 12 months after harvest

Treatments	After Harvest	Months after harvest (2020)						After Harvest	Months after harvest (2021)					
		2	4	6	8	10	12		2	4	6	8	10	12
T_1-GA_3 (100 ppm)	6.54	6.56	6.58	6.83	6.93	6.99	7.05	6.57	6.63	6.71	6.79	6.86	7.08	7.16
T_2-GA_3 (150 ppm)	6.68	6.70	6.73	6.80	6.85	6.90	6.92	6.62	6.65	6.71	6.79	6.83	6.88	6.95
T_3-NAA (150 ppm)	6.59	6.62	6.64	6.73	6.81	6.97	7.09	6.65	6.68	6.73	6.86	6.85	6.98	7.13
T_4-NAA (200 ppm)	6.56	6.66	6.74	6.75	6.89	6.93	6.96	6.48	6.52	6.59	6.65	6.77	6.81	6.88
T_5-Thio urea (250ppm)	6.57	6.59	6.61	6.72	6.83	6.97	7.11	6.60	6.70	6.78	6.83	6.92	6.98	7.29
T_6-Thiourea (500 ppm)	6.56	6.58	6.62	6.74	6.89	6.99	7.14	6.68	6.72	6.9	6.93	6.97	7.10	7.22
T_7-Cycocel (200 ppm)	6.53	6.55	6.56	6.63	6.69	6.78	7.00	6.57	6.64	6.81	6.81	6.89	7.02	7.17
T_8-Cycocel (250 ppm)	6.65	6.67	6.73	6.82	6.84	6.92	6.89	6.70	6.73	6.88	6.88	6.94	7.02	6.93
T_9-Paclobutrazol (100 ppm)	6.55	6.57	6.60	6.71	6.80	6.90	7.13	6.52	6.59	6.8	6.77	6.83	6.90	7.11
T_{10}-Paclobutrazol (200 ppm)	6.66	6.69	6.72	6.78	6.86	6.95	7.02	6.56	6.64	6.82	6.82	6.89	7.04	7.06
T_{11}-Control	6.50	6.00	6.79	6.81	6.9	7.12	7.25	6.63	6.74	6.88	6.94	7.05	7.12	7.33
Grand Mean	6.58	6.63	6.67	6.76	6.84	6.95	7.08	6.58	6.63	6.67	6.76	6.84	6.95	7.08
SEm(±)	0.32	0.32	0.05	0.04	0.04	0.05	0.09	0.32	0.32	0.05	0.04	0.04	0.05	0.09
CD (P=0.05)	0.95	0.94	0.14	0.12	0.12	0.16	0.28	0.95	0.94	0.14	0.12	0.12	0.16	0.28

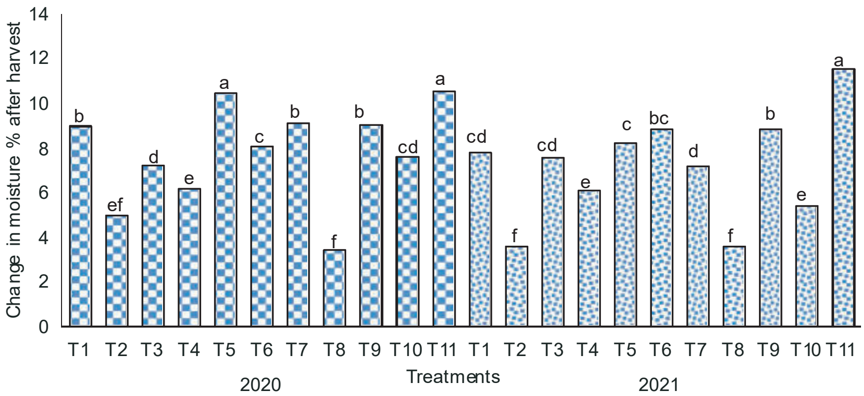

Fig.1. Percent increase in moisture % in *kharif* 2020 and 2021 after twelve months storage of okra seeds *cv.* Utkal Gourav as influenced by foliar application of growth regulators during seed production. Similar letters above each bar indicates the nonsignificant (DMRT, *P*=0.05); both the year analysed separately.

seed germination remained nonsignificant up to the 2nd month of storage, after which a progressive decline was observed over the twelve-month storage period, compared to the initial germination at harvest. Among the treatments, Cycocel at 250 ppm consistently showed the highest germination percentage at both the initial (90.70%) and twelve months after storage (83.37%), whereas the control exhibited the lowest values (85.90 and 73.00%) at these respective time points. GA_3 at 150 ppm emerged as the next best treatment, with germination percentages of 89.9 and 80.5% after harvest and twelve months after storage, respectively. The percent decline in germination was 8.09% in Cycocel, 10.46% in GA_3 (150 ppm), and 15.02% in the control.

For storage under ambient conditions, okra seeds from different plant growth regulator treatments were stored in poly bags, and their impact on seed quality was studied every two months up to 12 months (Table 3). Seed germination progressively declined over the 12-month storage period compared to the initial germination at harvest, with all treatments consistently exhibiting significantly higher germination than the control at the initial stages. In the first year (kharif 2020-21), Cycocel at 250 ppm recorded the highest germination (90.7 and 83.37%) at the initial and 12 months after storage, while the control exhibited germination rates of 85.90 and 73.00%. In the second year (kharif 2021), a similar trend was observed, with Cycocel at 250 ppm recording the highest germination (92.40 and 86.80%), and the control exhibiting lower rates (87.30 and 74.50%) at the initial and 12 months after storage. GA_3 at 150 ppm was identified as the next best treatment in both years, with germination percentages of 91.30 and 84.80% at harvest and one year after storage. The rate of decline was 6.06%, 7.12%, and 14.66% in Cycocel at 250 ppm, GA_3 at 150 ppm, and the control, respectively (refer to Fig. 2).

Vigour Index-I: The data presented in Table 4

Table 2. Effect of foliar application of plant growth regulators in okra during kharif 2020 on seed germination percentage at bi-monthly interval

Treatment	After harvest	Months after harvest					
		2	4	6	8	10	12
T_1-GA_3 (100 ppm)	88.70 (9.45)	87.40 (9.38)	86.90 (9.35)	84.00 (9.19)	81.20 (9.04)	77.70 (8.84)	72.10 (8.52)
T_2-GA_3 (150 ppm)	89.90 (9.51)	89.70 (9.50)	88.80 (9.45)	86.10 (9.31)	84.90 (9.24)	82.60 (9.12)	80.50 (9.00)
T_3-NAA (150 ppm)	85.30 (9.26)	85.00 (9.28)	84.40 (9.21)	82.60 (9.15)	80.50 (9.00)	77.80 (8.85)	74.30 (8.65)
T_4-NAA (200 ppm)	88.60 (9.44)	86.30 (9.32)	84.20 (9.20)	81.90 (9.08)	78.30 (8.88)	75.40 (8.71)	71.80 (8.50)
T_5-Thio urea (250ppm)	84.00 (9.19)	84.50 (9.22)	83.50 (9.17)	81.10 (9.03)	79.50 (8.94)	76.20 (8.76)	73.50 (8.60)
T_6-Thiourea (500 ppm)	86.30 (9.32)	85.10 (9.25)	82.40 (9.10)	79.30 (8.93)	78.20 (8.87)	76.70 (8.79)	75.70 (8.73)
T_7-Cycocel (200 ppm)	87.20 (9.36)	86.80 (9.34)	85.30 (9.26)	83.60 (9.17)	82.90 (9.13)	79.70 (8.96)	77.80 (8.85)
T_8-Cycocel (250 ppm)	90.70 (9.55)	90.90 (9.56)	89.39 (9.48)	88.40 (9.43)	87.60 (9.39)	86.50 (9.33)	83.37 (9.16)
T_9-Paclobutrazol (100 ppm)	86.70 (9.34)	84.80 (9.24)	81.00 (9.03)	79.30 (8.93)	76.80 (8.79)	74.00 (8.63)	72.27 (8.53)
T_{10}-Paclobutrazol (200 ppm)	88.10 (9.41)	87.10 (9.36)	85.30 (9.26)	83.20 (9.15)	80.70 (9.01)	77.60 (8.84)	75.73 (8.73)
T_{11}-Control	85.90 (9.30)	84.20 (9.20)	83.90 (9.19)	81.10 (9.03)	77.50 (8.83)	75.80 (8.73)	73.00 (8.57)
Grand mean	87.4	86.53	85.10	82.78	80.74	78.18	75.70
SEm (±)	1.26	1.30	1.09	1.79	1.98	2.32	2.40
CD (*P*=0.05)	3.71	3.83	3.20	5.29	5.85	6.84	7.08

*Figure in parenthesis indicated the square root transformation values

Table 3. Effect of foliar application of plant growth regulators in okra during kharif 2021 on seed germination percentage at bi-monthly interval

Treatment	After harvest	Months after harvest					
		2	4	6	8	10	12
T_1-GA_3 (100 ppm)	90.70 (9.55)	89.90 (9.51)	87.50 (9.38)	85.90 (9.30)	83.97 (9.19)	81.90 (9.08)	80.50 (9.00)
T_2-GA_3 (150 ppm)	91.30 (9.58)	90.00 (9.51)	88.60 (9.44)	86.70 (9.34)	85.90 (9.30)	85.30 (9.26)	84.80 (9.24)
T_3-NAA (150 ppm)	89.20 (9.47)	88.30 (9.42)	87.00 (9.35)	85.60 (9.28)	84.00 (9.23)	82.70 (9.12)	79.60 (8.95)
T_4-NAA (200 ppm)	90.50 (9.54)	89.00 (9.46)	88.80 (9.45)	86.50 (9.33)	84.70 (9.23)	83.90 (9.19)	82.70 (9.12)
T_5-Thio urea (250ppm)	87.20 (9.36)	86.70 (9.34)	85.90 (9.33)	84.30 (9.21)	82.60 (9.12)	79.50 (8.94)	75.34 (8.71)
T_6-Thiourea (500 ppm)	88.90 (9.46)	87.00 (9.35)	86.10 (9.31)	85.20 (9.26)	83.90 (9.19)	80.30 (8.99)	76.25 (8.76)
T_7-Cycocel (200 ppm)	89.60 (9.49)	88.30 (9.42)	87.30 (9.37)	86.70 (9.34)	84.80 (9.24)	82.60 (9.12)	79.34 (8.94)
T_8-Cycocel (250 ppm)	92.40 (9.64)	91.30 (9.58)	90.60 (9.54)	89.50 (9.49)	88.10 (9.41)	87.40 (9.38)	86.80 (9.34)
T_9-Paclobutrazol (100 ppm)	89.50 (9.49)	88.70 (9.44)	87.70 (9.39)	86.10 (9.31)	84.70 (9.23)	81.40 (9.05)	77.17 (8.81)
T_{10}-Paclobutrazol (200 ppm)	90.90 (9.56)	90.30 (9.53)	89.20 (9.47)	87.80 (9.40)	85.50 (9.27)	82.50 (9.11)	78.20 (8.87)
T_{11}-Control	87.30 (9.37)	86.80 (9.34)	85.50 (9.27)	84.73 (9.23)	81.30 (9.04)	78.60 (8.89)	74.50 (8.66)
Grand mean	89.77	88.75	87.65	86.28	84.50	82.37	79.56
S.E.m(±)	1.34	0.99	0.95	0.89	1.13	1.57	2.41
CD (*P*=0.05)	3.94	2.93	2.81	2.63	3.33	4.63	7.12

*Figure in parenthesis indicated the square root transformation values

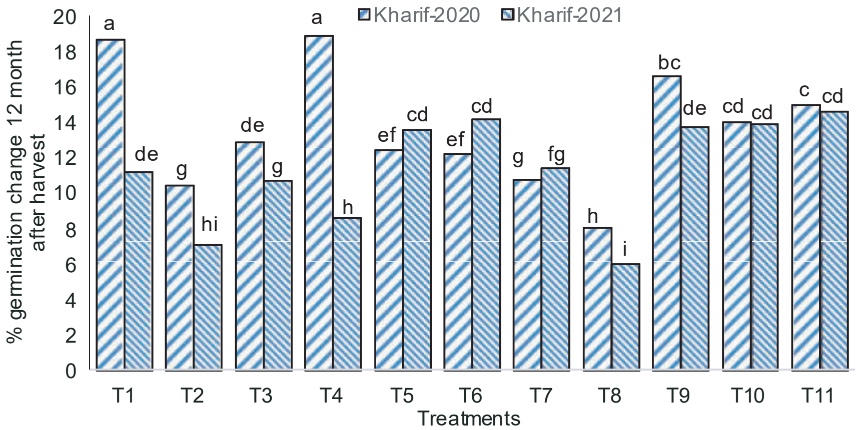

Fig.2 Percent decrease in germination % in kharif 2020 and 2021 after twelve months storage of okra seeds *cv.* Utkal Gourav as influenced by foliar application of growth regulators during seed production. Similar letters above each bar indicates the nonsignificant differnce (DMRT, P=0.05)

illustrates the impact of foliar application of plant growth regulators on Vigour Index-I in okra during the kharif seasons of 2020 and 2021. Cycocel at 250 ppm exhibited the highest Vigour Index-I (2895.10 and 2586.30) after harvest and at 12 months of storage, respectively. This treatment was statistically at par with GA_3 (100 and 150 ppm) and NAA (150 and 200 ppm). However, all three treatments showed significantly higher Vigour Index-I than the control (2580.5 and 1490.40) at harvest and after 12 months of storage.

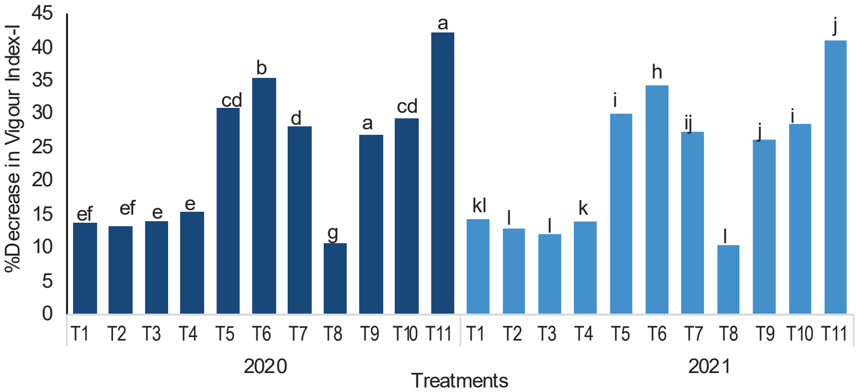

Fig. 3. Percent decrease in Vigour Index-I in *kharif* 2020 and 2021 after twelve months storage of okra seeds as influenced by foliar application of growth regulators

In kharif 2021 (Table 4), Vigour Index-I recorded 2973.10 and 2664.30 at harvest and after 12 months of storage, respectively. The control plot exhibited Vigour Index-I of 2658.50 at harvest and 1568.40 after 12 months of storage. The rate of decrease in Vigour Index-I was 10.67 and 42.24% with Cycocel at 250 ppm and the control, respectively. In the second year, the percentage decrease in Vigour Index-I was 10.39 and 41.00% for Cycocel at 250 ppm and the control, respectively (Fig. 3).

Vigour index-II: The data for both years (2020 and 2021) showed that, just after harvest, all treatments exhibited significantly higher Vigour Index-II than the control (Tables 5). In the first year, Cycocel at 250 ppm recorded the highest Vigour Index-II (24.70) compared to the control (16.63) after harvest. However, after one year, Cycocel at 250 ppm recorded Vigour Index-II (20.12) compared to the control (10.89). In the second year, all treatments displayed significantly better performance than the control, with Cycocel at 250 ppm recording Vigour Index-II (27.58) compared to the control (18.65) at harvest. After one year of storage, Vigour Index-II recorded (22.14), (21.15), and (20.63) in Cycocel at 250 ppm, GA_3 at 150 ppm, and NAA at 200 ppm, respectively, which were statistically at par but significantly higher than the control (12.91) (refer to Table 7). The rate of decline was found to be 15.62, 18.31 and 19.72% in NAA (200 ppm), GA_3 (150 ppm), and Cycocel (250 ppm), respectively. However, the control plot recorded a high decline in Vigour Index-II (30.78%) (Fig. 4).

Electrical conductivity: The treatment effect on electrical conductivity was nonsignificant (Fig. 5). after harvest up to two months of storage, but it varied significantly from the second month of

Table 4. Effect of foliar application of plant growth regulators on okra during kharif 2020 and 2021 on Vigour Index-I

Treatments	After Harvest	Months after harvest (2020)						After Harvest	Months after harvest (2021)					
		2	4	6	8	10	12		2	4	6	8	10	12
T_1-GA_3 (100 ppm)	2794.5	2736.6	2666.2	2618.7	2548.4	2564.2	2410.9	2872.5	2784.4	2736.6	2681.3	2606.1	2534.7	2462.1
T_2-GA_3 (150 ppm)	2852.3	2732.2	2648.2	2656.0	2594.6	2580.6	2475.5	2930.3	2810.2	2744.2	2733.0	2672.6	2658.6	2553.5
T_3-NAA (150 ppm)	2802.6	2722.4	2634.3	2598.1	2562.6	2546.6	2412.3	2830.3	2800.4	2712.3	2676.1	2640.6	2624.6	2488.9
T_4-NAA (200 ppm)	2815.9	2706.4	2658.6	2603.3	2528.1	2456.7	2384.1	2893.9	2814.6	2783.4	2696.7	2626.4	2642.2	2490.3
T_5-Thio urea (250ppm)	2618.2	2558.5	2408.7	2194.8	1904.5	1875.2	1808.4	2696.2	2636.5	2486.7	2272.8	1982.5	1953.2	1886.4
T_6-Thiourea (500 ppm)	2658.1	2525.6	2313.8	2163.0	2017.7	1909.4	1718.4	2736.1	2603.6	2391.8	2241.3	2095.7	1987.4	1796.4
T_7-Cycocel (200 ppm)	2802.2	2705.7	2555.9	2408.6	2295.4	2202.5	2012.2	2880.2	2783.7	2633.9	2486.6	2373.4	2280.5	2090.2
T_8-Cycocel (250 ppm)	2895.1	2776.8	2705.4	2665.9	2628.5	2605.8	2586.3	2973.1	2854.8	2792.9	2743.9	2706.5	2683.8	2664.3
T_9-Paclobutrazol (100 ppm)	2612.2	2584.7	2518.1	2392.1	2298.1	2171.3	1908.8	2690.2	2662.7	2596.1	2470.1	2376.1	2216.0	1986.8
T_{10}-Paclobutrazol (200 ppm)	2755.3	2712.6	2555.8	2415.8	2382.3	2186.5	1945.6	2833.3	2781.6	2633.8	2493.8	2460.3	2264.0	2023.6
T_{11}-Control	2580.5	2424.7	2188.4	2005.2	1841.2	1714.3	1490.4	2658.5	2562.7	2266.4	2083.2	1912.2	1792.3	1568.4
Grand mean	2744.3	2653.3	2532.1	2429.2	2327.4	2254.7	2104.8	2817.7	2735.9	2616.2	2507.2	2404.8	2330.7	2182.8
S.E.m(±)	144.9	72.4	94.0	114.7	111.4	69.2	99.1	67.9	86.0	106.8	128.2	123.0	125.1	110.5
CD (P=0.05)	427.4	213.6	277.4	338.4	328.6	204.3	292.2	200.3	253.7	315.0	378.1	363.0	369.0	325.9

Table 5. Effect of foliar application of plant growth regulators on vigour index-II in okra during kharif 2020 and 2021

Treatment	After Harvest	Months after harvest (2020)						After Harvest	Months after harvest (2021)					
		2	4	6	8	10	12		2	4	6	8	10	12
T_1-GA_3 (100 ppm)	21.80	21.63	20.83	19.91	19.05	17.44	16.55	23.82	23.65	22.85	21.93	20.74	19.46	18.56
T_2-GA_3 (150 ppm)	23.87	23.55	22.76	21.67	20.87	19.95	19.13	25.89	25.57	24.78	23.69	22.89	21.97	21.15
T_3-NAA (150 ppm)	21.53	20.42	19.26	19.12	18.77	17.65	15.62	23.55	22.44	21.28	21.14	20.79	19.67	17.84
T_4-NAA (200 ppm)	22.43	21.7	20.67	20.11	20.84	19.71	18.61	24.45	23.72	23.69	23.35	22.86	21.73	20.63
T_5-Thio urea (250ppm)	21.54	20.13	20.63	19.45	18.12	17.9	15.69	23.56	22.15	22.65	21.47	20.14	19.92	17.71
T_6-Thiourea (500 ppm)	23.13	22.9	22.26	21.12	19.61	18.68	16.63	25.15	24.92	24.28	22.13	21.63	20.7	18.65
T_7-Cycocel (200 ppm)	24.7	23.64	22.67	21.33	19.44	18.67	17.33	26.72	25.66	24.69	23.14	21.46	20.69	19.35
T_8-Cycocel (250 ppm)	25.56	24.78	24.11	22.56	22.12	20.7	20.12	27.58	26.66	26.13	24.58	24.14	22.72	22.14
T_9-Paclobutrazol (100 ppm)	20.55	19.56	18.75	17.7	16.64	15.33	14.13	22.57	21.58	20.77	19.72	18.66	17.35	16.15
T_{10}-Paclobutrazol (200 ppm)	21.63	20.61	19.82	18.68	17.75	16.69	15.67	23.65	22.63	21.84	20.7	19.77	18.71	17.69
T_{11}-Control	16.63	16.8	15	14.11	12.67	11.23	10.89	18.65	18.15	17.02	16.13	14.69	13.25	12.91
Grand mean	22.12	21.43	20.61	19.61	18.72	17.63	16.4	24.14	23.38	22.63	21.63	20.71	19.65	18.43
S.E.m(±)	1.35	1.09	1.32	1.26	1.08	0.85	0.79	0.76	1	1.29	0.63	1.23	0.64	0.68
CD (P=0.05)	3.97	3.21	3.89	3.71	3.18	2.49	2.33	2.24	2.96	3.8	1.87	3.63	1.9	1.99

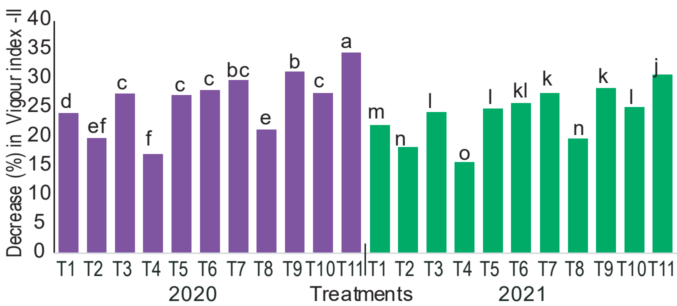

Fig. 4. Percent decrease in Vigour Index-II in kharif 2021 after twelve months storage of okra seeds *cv.* Utkal Gourav as influenced by foliar application of growth regulators during seed production. Similar letters above each bar indicates the nonsignificant (DMRT, P=0.05). both the year analysed separately.

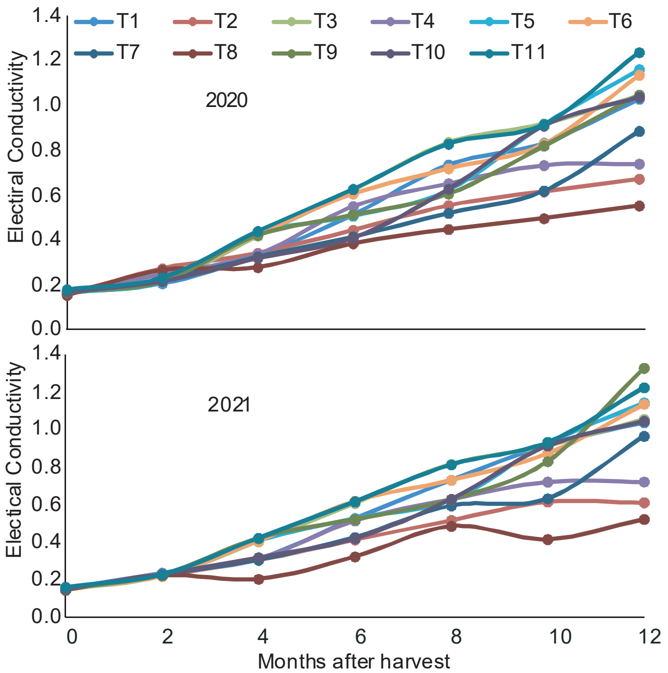

Fig. 5. Percent increase in electrical conductivity in *kharif* 2020 and 2021 after twelve months storage of okra seeds *cv.* Utkal Gourav as influenced by foliar application of growth regulators during seed production

storage up to the end of the storage period (*i.e.*, twelve months). Over 12 months of storage under ambient conditions, there was a gradual increase in electrical conductivity. In the first year, among the treatments, the lowest electrical conductivity was recorded in Cycocel at 250 ppm (0.156 dSm^{-1}) at the initial stage and (0.555 dSm^{-1}) after 12 months of storage. This was closely followed by GA_3 at 150 ppm, where the initial and after 12 months of storage electrical conductivity was (0.159 dSm^{-1}) and (0.674 dSm^{-1}), respectively. The highest electrical conductivity was observed in the control (0.181 dSm^{-1} and 1.238 dSm^{-1}) at the initial stage and after 12 months of storage, respectively. In the second year, during kharif 2021, electrical conductivity was recorded as (0.147 dSm^{-1}) and (0.524 dSm^{-1}) at harvest and after 12 months of storage in Cycocel at 250 ppm, respectively. This was closely followed by GA_3 at 150 ppm, where the initial and after 12 months of storage electrical conductivity was (0.148 dSm^{-1}) and (0.613 dSm^{-1}), respectively. The highest electrical conductivity was recorded in the control (0.161 dSm^{-1}) initially after harvest and (1.226 dSm^{-1}) after 12 months of storage.

Discussion

Limited literature exists on the influence of growth regulators on storability and various seed quality parameters. In the current investigation, a gradual decline in seed germination was observed, with Cycocel at 250 ppm showing the slowest decline, followed by GA_3 at 150 ppm and NAA at 200 ppm. Similar findings were reported for chilli seeds by Singh and Lal (1995), Balraj (1999), and Sony *et al.* (2022), where NAA was effective in maintaining higher seed germination after 6 months of storage.

During 2021-22, Cycocel at 250 ppm exhibited the highest germination (92.40 and 86.80%) at initial and after 12 months of storage, surpassing other treatments. GA_3 at 150 ppm also demonstrated good performance, with germination rates of 91.30 and 84.80% at initial and after 12 months. Although all treatments initially showed comparable germination, Cycocel at 250 ppm and GA_3 at 150 ppm exhibited a slower decline over both years. The use of poly bags (700 gauge) demonstrated higher storability and less decline in germination, consistent with Barua *et al.* (2009) and Karivartha Raju *et al.* (1987).

Contrary to germination, seed moisture content increased at a slower rate with Cycocel at 250 ppm (6.65 to 6.92) compared to the control (6.5 to 7.25 and 6.63 to 7.33 in 2020-21 and 21-22, respectively). GA_3 at 150 ppm and NAA at 200 ppm also exhibited a slow increase in moisture content, indicating good storability. The moisture content of 6.65 in Cycocel at 250 ppm aligns with Saisantosh *et al.* (2018), who reported higher germination and quality parameters with 5% moisture in onion seeds.

Vigour Index-I for both years revealed that Cycocel at 250 ppm was statistically at par with NAA at 150 and 200 ppm and GA_3 at 100 and 150 ppm, showing less decline up to 12 months of storage and significantly outperforming the control and other treatments. Vigour Index-II also showcased better performance of Cycocel at 250 ppm followed by GA_3 at 150 ppm, with a reduced decline up to 12 months, while the control exhibited a significantly higher decrease. Similar findings on seedling vigour index were reported by Ninganna and Vyakaranahal (2019), Kumar *et al.* (2020), and Ray and Bardouli (2022).

The increase in electrical conductivity (EC) with storage period, as noted by Saisantosh *et al.* (2018), was not markedly observed in the present study, aligning with findings by Ray and Bardouli (2022). The best treatment, Cycocel at 250 ppm, stored in a 700-gauge polythene bag, recorded lower EC (0.555 and 0.524 dsm^{-1}) in the first and second years, respectively. Other effective growth regulators, including GA_3 at 150 ppm and NAA at 200 ppm, also showed favorable EC values after one year of storage (0.524 to 0.741 dsm^{-1}), consistent with Ninganna *et al.* (2018).

In conclusion, foliar spray treatments with plant growth regulators, particularly Cycocel and GA_3, proved more effective in enhancing okra seed yield and quality. These treatments offer a cost-effective technique to improve seed attributes and reduce qualitative loss during storage, presenting a valuable solution for farmers to obtain higher-quality seeds.

Reference

Abdul-Baki, A.A. and J.D. Anderson, 1973. Vigour determination in soyabean seeds by multiple criteria. *Crop Sci*., 13: 630-633.

Aladele, S.E., A.A. Olosunde, M.R. Olubiyi, G.R. Afolayan, A.O. Kuyebi and I.J. Aluko, 2020. Impact of storage conditions and packaging materials on seed germination and field emergence of okra (*Abelmoschus callei*) at different seasons. *J. Bio. Life Sci*., 11(1): 1-17.

Anonymous, 2003. Indian Agriculture. Vikas Singhal for Indian Economic Data Research Centre, Maya Puri, New Delhi, India. pp. 271-275

Barua, H., M.M. Rahman and M.M. Masud, 2009. Effect of storage containers environment at different storage period on the quality of chilli seed. *Int. J. Sustain. Crop Prod.,* 4(4): 28-32.

El-Otmani, M., C.W. Coggins, M., Agusti and C.J. Lovatt, 2000. Plant growth regulators in citriculture: world current uses. *Crit. Rev. Plant Sci.*, 19: 395-447.

Kavitha, M., V.K. Deshpande, B.S. Vyakaranahal, J.S. Awakkanavar, Y. Hegde and J.C. Mathad, 2009. Seed pelleting with organic and inorganic inputs for vigour and viability in chilli seeds. *Karnataka J. Agric. Sci.,* 22(2): 15-19.

Khan, A.S. and N.Y. Chaudhary, 2006. GA_3 improves flower yield in some cucurbits treated with lead and mercury. *Afr. J. Biotechnol*., 5: 149-153.

Ninganna, J.S.H. and B.S. Vyakaranahal, 2019. Effect of desiccants on seed quality of Brinjal during ultra-dry storage. *Pharma Innovation J.*, 8(1): 71-73.

Raja, K., K. Sivasubramaniam and R. Anandham, 2019. Seed treatment with liquid microbial consortia for germination and vigour improvement in tomato (*Solanum lycopersicum* L.). *J. Appl. Hortic.*, 21(3): 195-200.

Ray, J. and S.K. Bordolui, 2022. Effect of seed treatments and storing period on physiological and biochemical parameters of tomato during storage. *J. Crop Weed*, 18(2): 230-239.

Saisanthosh, K. and N.K.B. Patil, 2018. Effect of packaging materials and moisture content on seed storability of onion. *J. Pharmacogn. Phytochem*., 7(4): 1745-1750.

Sofi, P.A., S.A. Wani, M.Y. Zargar, F.A. Sheikh and T. Shaf, 2014. Comparative evaluation of common bean (*Phaseolus vulgaris* L.) germplasm for seed physical and culinary traits. *J. Appl. Hortic.*, 16(1): 54-58.

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