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Seed Quality Parameters as Influenced by Plant Growth Regulators and Fresh Fruit Harvesting in Okra

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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

The research work was conducted to find out the most suitable level of plant growth regulator (PGR) and stage of plant for spray as well as fresh fruit pickings to increase the seed yield of okra. The experiment was laid out in randomized block design (factorial) with three replications to at the Vegetable seed production area BAU, Sabour, Bhagalpur. Present investigation was framed with Sixty (60) treatments consisting of 10 PGR's level, P0 (distilled water), GA_3 (100 ppm, 150 ppm and 200 ppm), NAA (100 ppm, 150 ppm and 200 ppm), IAA (30 ppm, 60 ppm and 90 ppm), 2 Stage of plant for spraying of PGRs, S1 (4 leaf stage), S2 (4 leaf stage + Flower initiation) and 3 pickings of fruits, H1 (3 Pickings of fresh fruits + rest fruits left for seed production), H2 (6 Pickings of fresh fruits + rest fruits left for seed production), H3 (No pickings of fresh fruits + all fruits left for seed production. It was observed that the different levels of treatments affected the seed quality attributes of the crops. Among the treatments, P2S1H1 treatment was recorded maximum Germination % (86.36), Seedling length (31.04 cm), Vigour index-I (2787.73), Vigour index-II (5.27) and seed viability test (88.00). Thus, P2S1H1 was superior among all treatments.

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Keywords: Okra; plant growth regulators; seed quality; fruit pickings.

1. INTRODUCTION

Okra (*Abelmoschusesculentus* (moench) L.) an annual, often cross-pollinated crop belonging to the family Malvaceae (Naveed et al., 2009). It is an economically important vegetable crop grown in tropical and sub-tropical parts of the world (Oyelade et al., 2003) [1]. Okra requires a long, warm and humid growing period. The quality seed is basic input for increasing the crop productivity Prolonged flowering and maturity of fruit in okra necessitates the picking of fruits at different stages. The seed qualities are changed in fruits harvested at different picking due to differential supply of nutrient by mother plant. Seed is crucial and basic unit to increase yield per unit area and to improve the agricultural economy of a country. The seed is basic element of agriculture that determines the quantitative and qualitative traits of the crop that is going to be harvested later on. So there is need to enhance the yield of seed and maintaining its quality. Foliar spray of growth regulator has been found effective in increasing vegetative growth, early fruiting, total yield and quality of fruits in many vegetables [2]. Application of plant growth regulator is effective tool in hands of horticulturist to get more yields. Although plant growth regulators have great potential but their application has to be planned sensibly in terms of optimal dose, stage of application, crop specificity and seasons. Even the same growth regulator at different dose can bring about different results. Keeping these points in view, the present study was undertaken to ascertain the most suitable PGR's level and stage of plant for spray as well as fresh fruit pickings to increase the seed yield of Okra.

2. MATERIALS AND METHODS

The present investigation was carried out at Vegetable Research farm, Bihar Agricultural College, BAU, Sabour, Bhagalpur (Bihar) during two consecutive years of 2018-19 and 2019-20. The design of the experiment was RBD (Factorial), replicated thrice. Seeds were sown and covered with thin layer of soil mixed with FYM. The soil and the weather condition prevailing during the period of investigation was close to normal for the place and could be termed congenial for growth and development of okra.

The treatment comprised Sixty (60) treatments consisting of 10 PGR's level, P0 (distilled water), GA_3 (100 ppm: , 150 ppm and 200 ppm i.e. P1, P2, P3), NAA (100 ppm, 150 ppm and 200 ppm i.e. P3, P4, P5), IAA (30 ppm, 60 ppm and 90 ppm i.e. P7, P8, P9) 2 Stage of plant for spraying of PGRs, S1 (4 leaf stage), S2 (4 leaf stage + Flower initiation) and 3 pickings of fruits, H1 (3 Pickings of fresh fruits + rest fruits left for seed production), H2 (6 Pickings of fresh fruits + rest fruits left for seed production), H3 (No pickings of fresh fruits + all fruits left for seed production).Half of nitrogen as per treatment and full of phosphorus and potassium as a common dose were applied as basal at the time of transplanting and remaining half of nitrogen as per treatments was applied at 30 days after planting of crop. Five plants in each treatment combination and each replication were randomly selected and tagged properly for recording various observations. The observation recorded for the aforesaid five plants were worked out to give mean in respect of all the characters, *viz*. Germination (%), Seedling length (cm), Vigour Index (VI-I), Vigour Index (VI-II), Seed viability test(%). The statistical analysis of the data recorded in all observations was carried out by the method of "Analysis of the variance" prescribed by Fisher and Yates [3]. Comparison of treatment was made with the help of critical difference (C.D.).

3. RESULTS AND DISCUSSION

3.1 Germination (%)

The maximum germination (%) (86.36) was recorded when the plants were sprayed with P2 (GA_3-150 ppm). The maximum germination (%) (81.12) was observed in S2 (4 leaf stage + flower initiation). The maximum germination (%) (82.41) was recorded along with three picking of fresh fruit + rest fruits left for seed production (H1) (Table 1).

The germination percent of okra was significantly influenced by the treatment of plant growth regulators, stage of plant for spray and fresh fruit picking. The highest germination (%) (88.18) was observed when plant growth regulators P2 (GA3-150 ppm) were used with three pickings of fresh fruits + rest fruits left for seed production (H1) in stage S1 (4 leaf stage) (Table 2).

Table 1. Effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on germination (%) *cv.* super green

	S1	S2	Mean	H1	H2	H3
P0	74.80	74.99	74.89	76.54	72.83	75.31
P1	85.22	85.21	85.21	87.19	83.72	84.71
P2	86.53	86.20	86.36	88.18	84.71	86.20
P3	81.40	81.74	81.57	82.97	80.75	81.00
P4	83.89	82.90	83.39	83.98	82.48	83.72
P5	82.57	81.74	82.15	84.21	81.00	81.25
P6	80.59	80.25	80.42	80.24	80.26	80.75
P7	76.62	75.99	76.30	77.04	75.57	76.30
P8	79.26	80.92	80.09	82.24	78.52	79.52
P9	80.10	81.25	80.67	81.50	80.49	80.02
Mean	81.10	81.12		82.41	80.03	80.88
H1	82.19	82.63	82.41			
H2	79.75	80.31	80.03			
H3	81.35	80.41	80.88			

	SEm±	CD (P = 0.05)		SEm±	CD (P = 0.05)
P	0.932	NS	P*S	1.318	3.69
S	0.417	NS	P*H	1.615	4.52
H	0.511	NS	H*S	0.722	NS

Table 2. Interaction effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on germination (%) *cv.* super green

Treatments		H1	H2	H3
S1	P0	76.76	74.84	72.80
	P1	87.19	84.71	83.73
	P2	88.18	86.69	84.72
	P3	82.24	81.24	80.75
	P4	85.71	83.72	82.24
	P5	83.73	82.73	81.24
	P6	77.75	82.74	81.26
	P7	76.76	77.32	75.78
	P8	82.75	78.26	76.77
	P9	80.80	81.24	78.25
S2	P0	76.33	75.77	72.87
	P1	87.18	84.72	83.72
	P2	88.15	85.71	84.71
	P3	83.71	80.75	80.74
	P4	82.25	83.73	82.73
	P5	84.70	79.78	80.75
	P6	82.72	78.76	79.26
	P7	77.33	75.29	75.35
	P8	81.73	80.77	80.27
	P9	82.21	78.80	82.74
SEm±	2.284			
CD (P=0.05%)	6.40			

The progressive improvement in parameters under the treatment might be due to the higher value of 100 seed weight or bold seed count, which would have produced the highest germination rate (%). Seeds become more viable and vigorous due to proper development of the embryo and endosperm by proportionate use of growth regulators. Similar results were recorded in Khan et al. [4] in okra. Similar results were observed earlier by Shahid et al. [5], Kumar and Sen [6], Singh et al. [7], Ambreen et al. [8], Ravat and Makani [9], and Prasad and Srihari [10] in okra,. Seed germination per cent was favourably influenced due to the metabolic activity of the

embryo in the seed, which may be accelerated by gibberillic acid, which might have ultimately led to quicker germination. And it may be due to the stimulating activities of the seed embryo by the plant growth regulators. Similar results were obtained by Patil and Patel [11] and Patil et al. [12] in okra. GA3 increases the activity of hydrolytic enzymes during the germination process. Hydrolytic enzymes get diffused into endosperm, where they catalyse the digestion of stored food material into sugar, amino acids etc. These products are used during germination and seedling emergence. The increase in seed quality parameters obtained due to spraying of (GA3 @ 100 ppm) might be due to a higher percentage of bolder seeds coupled with the higher test weight of seeds and to increased translocation and assimilation of photosynthates from the source to the sink (seeds).

3.2 Seedling Length (cm)

The maximum seedling length (31.04cm) was recorded with the application of P2 (GA_3-150 ppm). Maximum seedling length (27.85cm) was observed in S2 (4 leaf stage + flower initiation). The maximum seedling length (29.77cm) was associated with three picking of fresh fruit + rest fruit left for seed production (H1) (Table 3).

The pooled interaction effect of plant growth regulators, stage of plant for spray and fresh fruit picking was found significant with respect to seedling length (cm) and seedling dry weight (g). The maximum seedling length (34.00cm) was observed in the application of plant growth regulators P2 (GA_3-150 ppm) with three pickings of fresh fruits + rest fruits left for seed production (H1) in stage S2 (4 leaf stage + flower initiation) (Table 4).

This may be due to better diversion of photosynthesis to the fruit and a better accumulation of food reserves in the seeds. Similar results have been confirmed by Reddy and Subramaniayam (2001) in tomato. Seeds become more viable and vigorous due to proper development of the embryo and endosperm by proportionate use of growth regulators. Similar results were recorded in Khan et al. [4]. GA3 increases the activity of hydrolytic enzymes during the germination process. Hydrolytic enzymes get diffused into endosperm, where they catalyze the digestion of stored food material into sugar, amino acids, etc. These products are used during germination and seedling emergence. The increase in seed quality parameters obtained due to spraying of (GA3 100 ppm) might be due to a higher percentage of bolder seeds coupled with the higher test weight of seeds due to increased translocation and assimilation of photosynthates from the source to the sink (seeds). Similar findings were also reported by Balsubramanian et al. [13] in Okra, and Patil [14] in Brinjal.

Table 3. Effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on seedling length (cm) *cv.* super green

	S1	S2	Mean	H1	H2	H3
P0	23.20	24.63	23.91	25.78	22.55	23.40
P1	30.11	30.38	30.25	32.86	27.78	30.10
P2	30.74	31.33	31.04	33.63	28.73	30.76
P3	27.69	28.04	27.87	30.39	25.95	27.27
P4	29.16	29.96	29.56	32.21	27.21	29.26
P5	28.52	28.92	28.72	31.14	26.88	28.14
P6	27.16	27.62	27.39	29.55	25.76	26.87
P7	24.51	25.21	24.86	26.39	23.70	24.49
P8	25.98	26.44	26.21	28.10	25.00	25.53
P9	26.15	25.93	26.04	27.64	24.50	25.99
Mean	27.32	27.85		29.77	25.80	27.18
H1	29.22	30.32	29.77			
H2	25.93	25.68	25.80			
H3	26.81	27.54	27.18			

	SEm±	CD (P = 0.05)		SEm±	CD (P = 0.05)
P	0.322	0.90	P*S	0.455	1.27
S	0.144	NS	P*H	0.557	1.56
H	0.176	NS	H*S	0.249	NS

Table 4. Interaction effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on seedling length (cm) *cv.* super green

Treatments		H1	H2	H3
S1	P0	24.69	22.05	22.85
	P1	32.73	30.20	27.40
	P2	33.25	30.52	28.45
	P3	30.02	27.41	25.65
	P4	31.68	29.40	26.42
	P5	30.78	28.03	26.75
	P6	28.85	26.12	26.53
	P7	25.43	23.55	24.55
	P8	27.70	24.98	25.25
	P9	27.05	25.90	25.50
S2	P0	26.88	24.75	22.25
	P1	33.00	30.00	28.15
	P2	34.00	31.00	29.00
	P3	30.75	27.13	26.25
	P4	32.75	29.13	28.00
	P5	31.50	28.25	27.00
	P6	30.25	27.62	25.00
	P7	27.35	25.43	22.85
	P8	28.50	26.08	24.75
	P9	28.23	26.08	23.50
SEm±	0.788			
CD (P=0.05%)	2.20			

3.3 Vigour Index-I and Vigour Index-II

The maximum vigour index-1 (2787.73) was recorded under the application of P2 (GA_3-150 ppm). The maximum vigour index-1 (2434.71) was observed in S2 (4 leaf stage + flower initiation). The maximum vigour index-1 (2577.88) was recorded with three picking of fresh fruits + rest fruits left for seed production (H1) (Table 5).

Table 5. Effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on vigour index-1(VI-I) *cv.* super green

	S1	S2	Mean	H1	H2	H3
P0	1821.67	1833.93	1827.80	1950.00	1691.25	1842.15
P1	2652.50	2730.67	2691.58	2883.75	2481.00	2710.00
P2	2760.75	2814.70	2787.73	2954.55	2574.50	2834.13
P3	2433.33	2484.92	2459.13	2675.00	2227.38	2475.00
P4	2556.67	2634.17	2595.42	2792.50	2381.25	2612.50
P5	2475.83	2567.50	2521.67	2701.25	2320.00	2543.75
P6	2380.00	2462.83	2421.42	2605.50	2213.75	2445.00
P7	1973.33	2090.00	2031.67	2252.50	1802.50	2040.00
P8	2350.83	2402.50	2376.67	2526.25	2226.25	2377.50
P9	2275.83	2325.83	2300.83	2437.50	2126.25	2338.75
Mean	2368.08	2434.71		2577.88	2204.41	2421.88
H1	2529.60	2626.16	2577.88			
H2	2243.75	2165.08	2204.41			
H3	2330.88	2512.88	2421.88			

	SEm±	CD (P = 0.05)		SEm±	CD (P = 0.05)
P	30.731	86.07	P*S	43.460	121.73
S	13.743	NS	P*H	52.228	149.09
H	16.832	NS	H*S	23.804	NS

Table 6. Interaction effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on vigour index-1(VI-I) *cv.* super green

Treatments		H1	H2	H3
S1	P0	2000.00	1605.00	1860.00
	P1	2837.50	2520.00	2600.00
	P2	2893.50	2625.00	2763.75
	P3	2650.00	2300.00	2350.00
	P4	2745.00	2400.00	2525.00
	P5	2625.00	2365.00	2437.50
	P6	2530.00	2297.50	2312.50
	P7	2190.00	1690.00	2040.00
	P8	2425.00	2382.50	2245.00
	P9	2400.00	2252.50	2175.00
S2	P0	1900.00	1777.50	1824.30
	P1	2930.00	2442.00	2820.00
	P2	3015.60	2524.00	2704.50
	P3	2700.00	2154.75	2600.00
	P4	2840.00	2362.50	2700.00
	P5	2777.50	2275.00	2650.00
	P6	2681.00	2130.00	2577.50
	P7	2315.00	1915.00	2040.00
	P8	2627.50	2070.00	2510.00
	P9	2475.00	2000.00	2502.50
SEm±	75.275			
CD (P=0.05%)	210.84			

Table 7. Effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on vigour index-2(VI-II) *cv.* super green

	S1	S2	Mean	H1	H2	H3
P0	3.10	2.92	3.01	3.10	2.94	3.01
P1	4.47	3.79	4.13	4.35	3.74	4.30
P2	5.31	5.24	5.27	5.29	5.21	5.32
P3	3.05	2.76	2.90	2.79	2.94	2.99
P4	3.16	3.21	3.19	3.37	3.06	3.13
P5	3.13	3.06	3.10	3.00	3.02	3.27
P6	2.99	3.07	3.03	2.81	2.98	3.29
P7	3.01	2.82	2.92	2.98	3.00	2.77
P8	3.06	3.05	3.06	3.15	2.95	3.06
P9	3.13	2.92	3.02	3.22	2.99	2.86
Mean	3.44	3.28		3.41	3.28	3.40
H1	3.57	3.24	3.41			
H2	3.26	3.30	3.28			
H3	3.48	3.32	3.40			

	SEm±	CD (P = 0.05)		SEm±	CD (P = 0.05)
P	0.038	0.11	P*S	0.053	0.15
S	0.017	0.05	P*H	0.065	0.18
H	0.021	NS	H*S	0.029	0.08

The maximum vigour index-2 (5.27) was recorded under the application of P2 (GA_3-150 ppm), which was superior among all plant growth regulators. The maximum vigour index-2 (3.44) was observed in S1 (4 leaf stage). The maximum vigour index-2 (3.41) was recorded in three picking of fresh fruits + rest fruits left for seed production (H1) (Table 7).

Table 8. Interaction effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on vigour index-2(VI-II) *cv.* super green

Treatments		H1	H2	H3
S1	P0	3.45	2.91	2.94
	P1	4.92	4.72	3.75
	P2	5.44	4.35	5.12
	P3	2.94	3.20	3.00
	P4	3.36	3.33	2.78
	P5	3.13	3.28	2.99
	P6	2.56	3.41	2.99
	P7	3.26	2.69	3.09
	P8	3.20	2.99	3.00
	P9	3.46	2.93	2.99
S2	P0	2.74	3.10	2.93
	P1	3.77	3.88	3.73
	P2	5.14	4.28	5.30
	P3	2.64	2.78	2.87
	P4	3.37	2.92	3.34
	P5	2.88	3.25	3.05
	P6	3.06	3.17	2.98
	P7	2.69	2.85	2.92
	P8	3.10	3.14	2.90
	P9	2.98	2.79	2.99
SEm±	0.092			
CD (P=0.05%)	0.26			

Table 9. Effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on seed viability test (%) *cv.* super green

	S1	S2	Mean	H1	H2	H3
P0	75.83	78.17	77.00	77.00	73.75	80.25
P1	84.33	85.83	85.08	86.25	83.00	86.00
P2	86.67	89.33	88.00	88.75	84.75	90.50
P3	76.17	76.50	76.33	77.25	76.00	75.75
P4	79.17	79.33	79.25	79.75	80.00	78.00
P5	77.17	77.17	77.17	76.50	77.25	77.75
P6	80.17	79.50	79.83	80.00	79.25	80.25
P7	77.33	78.00	77.67	78.50	78.00	76.50
P8	78.00	77.00	77.50	79.75	77.50	75.25
P9	79.83	79.67	79.75	81.50	76.75	81.00
Mean	79.47	80.05		80.53	78.63	80.13
H1	80.50	80.55	80.53			
H2	78.35	78.90	78.63			
H3	79.55	80.70	80.13			

	SEm±	CD (P = 0.05)		SEm±	CD (P = 0.05)
P	1.029	2.88	P*S	1.455	4.08
S	0.460	NS	P*H	1.782	4.99
H	0.564	NS	H*S	0.797	NS

Table 10. Interaction effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on seed viability test (%) *cv.* super green

Treatments		H1	H2	H3
S1	P0	74.50	73.00	80.00
	P1	84.50	82.00	86.50
	P2	87.00	84.00	89.00
	P3	77.00	74.50	77.00
	P4	80.50	79.00	78.00
	P5	76.50	78.00	77.00
	P6	81.50	81.00	78.00
	P7	76.50	77.50	78.00
	P8	84.50	77.50	72.00
	P9	82.50	77.00	80.00
S2	P0	79.50	74.50	80.50
	P1	88.00	84.00	85.50
	P2	90.50	85.50	92.00
	P3	77.50	77.50	74.50
	P4	79.00	81.00	78.00
	P5	76.50	76.50	78.50
	P6	78.50	77.50	82.50
	P7	80.50	78.50	75.00
	P8	75.00	77.50	78.50
	P9	80.50	76.50	82.00
SEm±	2.520			
CD (P=0.05%)	7.06			

Table 11. Effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on electrical conductivity test *cv.* super green

	S1	S2	Mean	H1	H2	H3
P0	586.17	576.12	581.14	593.65	562.90	586.88
P1	356.13	348.18	352.16	382.75	341.50	332.23
P2	313.60	291.38	302.49	305.20	320.88	301.40
P3	479.60	506.38	492.99	511.43	481.70	485.85
P4	437.55	447.48	442.52	424.73	476.55	426.28
P5	499.28	482.08	490.68	437.35	543.90	490.80
P6	450.40	441.40	445.90	395.53	486.33	455.85
P7	548.45	565.15	556.80	577.53	519.63	573.25
P8	486.42	492.32	489.37	433.40	488.50	546.20
P9	501.98	482.02	492.00	491.30	511.83	472.88
Mean	465.96	463.25		455.29	473.37	467.16
H1	444.86	465.72	455.29			
H2	486.33	460.42	473.37			
H3	464.70	469.63	467.16			

	SEm±	CD (P = 0.05)		SEm±	CD (P = 0.05)
P	5.446	15.25	P*S	7.702	21.57
S	2.435	NS	P*H	9.433	26.42
H	2.983	8.36	H*S	4.218	11.82

Table 12. Interaction effect of plant growth regulators, stage of plant for spray and number of fresh fruit picking on electrical conductivity test *cv.* super green

Treatments		H1	H2	H3
S1	P0	588.95	584.20	585.35
	P1	398.25	433.65	336.50
	P2	332.25	352.70	305.85
	P3	473.10	416.95	548.75
	P4	406.30	411.85	494.50
	P5	402.65	502.75	592.45
	P6	368.15	465.25	517.80
	P7	531.75	596.65	516.95
	P8	447.05	540.35	471.85
	P9	500.10	492.60	513.25
S2	P0	598.35	589.55	540.45
	P1	327.25	340.80	346.50
	P2	278.15	340.10	295.90
	P3	549.75	554.75	414.65
	P4	443.15	440.70	458.60
	P5	472.05	478.85	495.35
	P6	422.90	446.45	454.85
	P7	623.30	549.85	522.30
	P8	419.75	552.05	505.15
	P9	482.50	453.15	510.40
SEm±	13.340			
CD (P=0.05%)	37.36			

Note - Control (P0)- Distilled water, GA3-100 ppm (P1), GA3-150 ppm (P2), GA3- 200 ppm (P3), NAA-100 ppm (P4), NAA-150 ppm (P5), NAA- 200 ppm (P6), IAA -30 ppm (P7), IAA- 60 ppm (P8), IAA -90 ppm (P9) and 2 stage of plant for spray; 4 leaf stage (S1), 4 leaf stage + flower initiation (S2) as well as 3 pickings of fresh fruit; three picking of fresh fruits + rest of fruits for seed production (H1), Six picking of fresh fruits + rest of fruits for seed production (H2), No picking of fresh fruits +all fruits for seed production (H3)

The vigour index-I and vigour index-II of okra were significantly influenced by the treatment of plant growth regulators, stage of plant for spray and fresh fruit picking. The maximum vigour index-1 (3015.60) was observed in the application of plant growth regulators P2 (GA_3-150 ppm) with three pickings of fresh fruits + rest fruits left for seed production (H1) in stage S2 (4 leaf stage + flower initiation) and the maximum vigour index-2 (5.44) was observed in the application of plant growth regulators P2 (GA_3-150 ppm) with three pickings of fresh fruits + rest fruits left for seed production (H1) in stage S1 (4 leaf stage) (Table 6 & 8) . These results are in conformity with those of Ambreen et al. [8]; Khan et al. [4]; Ravat and Makani [9] and Velumani & Ramaswamy [15] in Okra. Seeds become more viable and vigorous due to proper development of the embryo and endosperm by proportionate use of growth regulators. The vigour index potential of seeds extracted from three picking green fruit was highest due to better mobilization of reserved food material, which could be supplied by the mother plant for proper development of seeds. Similar trends were observed in study of [16-18].

3.4 Seed Viability Test (%) and Electrical Conductivity Test

The maximum seed viability test (%) (88.00) was noted when the plant developed under the influence of plant growth regulators P2 (GA_3-150 ppm), which was superior among all plant growth regulators. The maximum seed viability test (%) (80.05) was observed in S2 (4 leaf stage + flower initiation). The maximum seed viability test (%) (80.53) was recorded in three picking of fresh fruits + rest fruits left for seed production (H1) (Table 9).

The minimum electrical conductivity (302.49) was recorded under the foliar spray of P2 (GA_3-150 ppm), which was lowest among all plant growth regulators. The minimum electrical conductivity (463.25) was observed in S2 (4 leaf stage + flower initiation). The minimum electrical conductivity (455.29) was recorded in three

picking of fresh fruits + rest fruits left for seed production (H1) (Table 11).

The pooled interaction effect of plant growth regulators, stage of plant for spray and fresh fruit picking was found significant with respect to seed viability test (%) and electrical conductivity test. The maximum seed viability test (%) (92.00) was observed in the application of plant growth regulators P2 (GA_3-150 ppm) with no picking for fresh fruits + all fruits left for seed production (H3) in stage S2 (4 leaf stage + flower initiation) and the minimum electrical conductivity test (278.15) was observed in the application of plant growth regulators P2 (GA_3-150 ppm) with three pickings for fresh fruits + rest fruits left for seed production (H1) in stage S2 (4 leaf stage + flower initiation) (Table 10 &12). It might be due to a higher percentage of bolder seeds coupled with the heavier seed weight due to increased translocation and assimilation of photosynthates from the source to the sink (seeds). These results are in conformity with those of Singh et al. [7] and Ambreen et al. [8] in Okra and Patil [14] in brinjal. gourd. Low value of electrical conductivity is an indication of seed viability. Since electrical conductivity value is negatively correlated with standard germination and other seed quality traits. The difference in sugar loss from seeds of crops sown on different dates might be due to difference in relative amount of soluble sugars present in seeds or due to difference in sensitivity to the intake of water during imbibitions or both.

4. CONCLUSION

From the findings and discussions made so far it may be concluded that among the treatments, the application of plant growth regulators P2 (GA3-150 ppm) along with three pickings of fresh fruits + rest of fruits for seed production (H1) in stage S1 (4 leaf stage) i.e. P2S1H1 treatment recorded maximum germination % (86.36), seedling length (31.04 cm), vigour index-I (2787.73), vigour index-II (5.27) and seed viability (88.00).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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