Original Research Article

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Influence of Plant Growth Regulators on Seed Yield, Quality and Storability of Soybean [Glycine max (L.) Merrill] Genotypes

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A B S T R A C T

A field experiment was conducted during kharif 2018 to study the influence of plant growth regulators on seed yield, quality and storability of soybean genotypes. Among the six genotypes, DSb-21 recorded significantly highest number of branches per plant (4.91) and number of pods per plant (78.34), whereas DSb-31 recorded highest pod length (3.36 cm), number of seeds per pod (3.42) and test weight (14.21 g). Foliar application of cycocel @ 250 ppm furnished significantly higher number of branches per plant (4.46), number of pods per plant (54.82), pod length (2.67 cm), number of seeds per pod (2.67) and test weight (13.15 g) as compared to control. Interaction between genotypes and plant growth regulators were found to be non-significant for morpho-physiological and yield attributes of soybean. The genotype Kalitur recorded highest initial seed quality parameters among the genotypes. Initial seed quality parameters viz., seed germination (93.82%) and seedling vigour index-II (112.60) were found to be significantly higher in salicylic acid @ 50 ppm spray. The interaction effect between genotypes and plant growth regulators were found to be non-significant for seed quality parameters except peroxidase activity and electrical conductivity. Similar trend was noticed up to nine months of storage for seed quality parameters.

Keywords
Plant growth regulators, Soybean, Seed yield

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Introduction

Soybean [Glycine max (L.) Merrill] is an annual diploid species grown widely in South East Asia and Europe for its edible oil purpose. India is the fifth largest producer of soybean after USA, China, Brazil and Argentina with an area of 11.66 mha and 8.59 mt production (Anon., 2018). In India, crop has been cultivated largely in states viz., Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Chhattisgarh and Tamil Nadu. Karnataka stands in fifth place cultivated over an area of 2.4 mha and production of 1.4 mt (Anon., 2018).

The yield plateau of soybean is greatly fluctuated by several factors, among them physiological limitations viz., photorespiration, N-fixation metabolism and transpiration leads to lower photosynthetic rate and biomass accumulation. Cycocel is an
anti-gibberellin compound acting as growth retardant, thereby reduces plant height enhancing lateral growth by checking apical dominance and promoting reproductive growth. Exogenous application of cycocel and salicylic acid through foliar spray are known to increase the seed yield of soybean by modulating the physiological pathways within the plants (Devi et al., 2011; Tarun et al., 2016). Salicylic acid is an ortho-hydroxybenzoic acid and is a secondary metabolite acting as an analogous of growth regulating substances existing in minor concentration (1 µg/g) in plants such as rice, barley and soybean having diverse role in biotic and abiotic stresses (Raskin et al., 1990; Aydin and Nalbantoglu, 2011).

Soybean is such a crop which loses viability very rapidly under warm and humid tropics (Delouche and Baskin, 1973) leading to poor field emergence and stand establishment. Loss of seed viability in soybean is also correlated with increased rate of lipid peroxidation (Hosamani et al., 2013) in storage due to higher amount of polyunsaturated fatty acids (PUFA) in its seed oil. Hence, in the present study an attempt has been made to know the influence of plant growth regulators on seed yield, quality and storability of soybean genotypes.

**Materials and Methods**

A field experiment was conducted at Agricultural Research Station, Arabhavi, Belagavi district, Karnataka, India during kharif 2018 to study the effect of foliar spray of plant growth regulators on seed yield, quality and storability of soybean genotypes. The experiment was laid out in split plot design consisting of different soybean genotypes viz., DSb 21, DSb 23, DSb 31, JS 335, JS 93-05 and Kalitur in main plot and plant growth regulators viz., Control, Cycocel @ 250 ppm and Salicylic acid @ 50 ppm in sub plot. The crop was raised with a spacing of 30 x 10 cm by following all the recommended package of practices of University of Agricultural Sciences, Dharwad (Anon., 2016). The plant growth regulators were sprayed at flowering, pod initiation stage and a week prior to harvest. The observations on all the plant morphometric characters were recorded at harvesting stage from a group of five randomly selected plants and average is worked out. The seeds harvested from individual plot were dried to safe moisture level and further used for storage studies over a period of nine months. Harvested seeds were stored in HDPE bags for nine months and observations on per cent seed germination and seedling vigour index-II were recorded at monthly intervals (ISTA, 2018). Electrical conductivity (Agrawal and Dadlani, 1992) of seed leachates was measured at monthly intervals and peroxidase activity (Castillo et al., 1994) was assessed once in three months.

The data collected from field and laboratory experiment was subjected to statistical analysis by using ANOVA test for split plot design and factorial CRD, respectively (Panse and Sukhatme, 1989).

**Results and Discussion**

The genotypes differed significantly for morpho-physiological and yield attributing traits of soybean. The genotype DSb 21 recorded significantly highest plant height (56.06 cm), number of branches per plant (4.91) and number of pods per plant (78.34), whereas DSb 31 recorded statistically highest pod length (3.36 cm), number of seeds per pod (3.42) and test weight (14.21 g) among the genotypes. This differential genotypic response was due to genetic potential of the genotype and similar differences for morpho-physiological and yield attributes were also observed by Kumar et al., (2002) and Chavan (2010) in soybean. Among the plant growth
regulators, cycocel @ 250 ppm furnished significantly highest number of branches per plant (4.46), number of pods per plant (54.82), pod length (2.67 cm), number of seeds per pod (2.67), test weight (13.15 g), seed yield per plant (17.27 g) and seed yield (21.21 q/ha) followed by salicylic acid @ 50 ppm (3.82, 50.35, 2.40 cm, 2.61, 12.15 g, 15.27 g and 19.99 q/ha, respectively) as compared to control (3.43, 46.25, 2.34 cm, 2.39, 11.45 g, 12.25 g and 18.61 q/ha, respectively). Plant height (42.24 cm) reduced significantly over the control (47.38 cm) due to foliar spray of cycocel @ 250 ppm, whereas salicylic acid @ 50 ppm promoted plant height (53.0 cm). Cycocel is a growth retardant which checks apical dominance and acts as an anti-gibberellin compound inhibiting biosynthesis of GA₃ in plants. Hence, foliar spray of cycocel resulted in reduced plant height. Foliar application of plant growth regulators strengthened physiological relationship between source and sink resulting in effective partitioning and translocation of photosynthates from leaves to seeds within the plant. Similar results for yield attributes of soybean as influenced by cycocel and salicylic acid spray were also reported by Kalyankar et al., (2008), Devi et al., (2011), Tarun et al., (2016) and Solanke et al., (2018) in soybean and Kumar et al., (2018) with salicylic acid spray in green gram.

The interaction effects between genotypes and plant growth regulators were found to be non-significant for morpho-physiological and yield attributes of soybean. Among the different treatment combinations, DSb 21 with foliar spray of cycocel @ 250 ppm (G₁P₂) recorded significantly highest number of branches per plant (5.60), number of pods per plant (84.03), seed yield per plant (29.14 g) and seed yield (28.56 q/ha), whereas DSb 31 with foliar application of cycocel @ 250 ppm (G₃P₂) recorded significantly highest pod length (3.77 cm), number of seeds per pod (3.73) and test weight (15.21 g). Similar non-significant interaction variations for morpho-physiological and yield attributes were also reported by Devi et al., (2011) and Kaur et al., (2015) in soybean with cycocel and salicylic acid foliar spray.

Among the genotypes, Kalitur recorded highest initial seed quality parameters viz., seed germination (96.31%), seedling vigour index-II (123.06) and peroxidase activity (37.39 µ moles H₂O₂/cm/min/g), whereas electrical conductivity was found to be significantly lowest (0.035 dS/m). Such genotypic variability for seed quality parameters were also observed by Vanagamudi (1988), Hosamani et al., (2013) and Yaklich et al., (1979) in soybean. Foliar spray of salicylic acid @ 50 ppm recorded significantly higher initial seed quality parameters viz., seed germination (93.82%), seedling vigour index-II (112.60) and peroxidase activity (19.57 µ moles H₂O₂/cm/min/g), whereas electrical conductivity was found to be significantly lowest (0.048 dS/m) followed by cycocel @ 250 ppm (91.77%, 108.31, 16.90 µ moles H₂O₂/cm/min/g and 0.061 dS/m, respectively) as compared to control (89.95%, 103.29, 15.27 µ moles H₂O₂/cm/min/g and 0.074 dS/m, respectively). Similar results were also drawn by Kuchlan et al., (2017) in soybean genotype JS 335 with foliar spray of salicylic acid. Seed germination and seedling vigour index-II enhanced significantly due to increased seed vigour potential as a result of foliar spray of plant growth regulators. Nambiar et al., (2006) reported similar kind of results with foliar application of plant growth regulators on seed quality and storability of soybean in JS 335 cultivar over a period of six months of storage. The interaction effects between genotypes and plant growth regulators were found to be significant for electrical conductivity and peroxidase activity (Table 1 and 2).
Table 1: Effect of foliar spray of plant growth regulators on morpho-physiological and yield attributing traits of soybean genotypes

| Treatments | Plant height at harvest (cm) | Number of branches per plant at harvest | Number of pods per plant | Pod length (cm) | Number of seeds per pod | Test weight (g) | Seed yield per plant (g) | Seed yield (q/ha) |
|------------|-----------------------------|----------------------------------------|--------------------------|----------------|------------------------|----------------|--------------------------|-----------------|
| Genotypes: (G) |                             |                                        |                          |                |                        |                |                          |                  |
| G₁: DSB-21  | 56.06                       | 4.91                                   | 78.34                    | 2.68           | 2.67                   | 13.43          | 25.73                    | 27.95           |
| G₂: DSB-23  | 51.40                       | 4.71                                   | 68.33                    | 2.66           | 2.42                   | 12.92          | 17.30                    | 26.17           |
| G₃: DSB-31  | 46.63                       | 3.33                                   | 34.40                    | 3.36           | 3.42                   | 14.21          | 14.21                    | 24.02           |
| G₄: JS 335  | 50.69                       | 3.93                                   | 51.33                    | 2.41           | 2.39                   | 12.21          | 15.30                    | 18.87           |
| G₅: JS 9305 | 50.30                       | 3.72                                   | 42.30                    | 2.16           | 2.30                   | 11.47          | 11.92                    | 15.30           |
| G₆: Kalitur | 30.15                       | 2.80                                   | 28.12                    | 1.57           | 2.13                   | 9.26           | 5.12                     | 7.30            |
| S.Em±       | 1.67                        | 0.20                                   | 1.99                     | 0.08           | 0.10                   | 0.49           | 0.60                     | 64.85           |
| CD at 5%    | 5.25                        | 0.63                                   | 6.26                     | 0.26           | 0.31                   | 1.55           | 1.90                     | 204.36          |

Plant growth regulators: (P)

| P₁: Control | 47.38 | 3.43 | 46.25 | 2.34 | 2.39 | 11.45 | 12.25 | 18.61 |
| P₂: Cycocel @ 250 ppm | 42.24 | 4.46 | 54.82 | 2.67 | 2.67 | 13.15 | 17.27 | 21.21 |
| P₃: Salicylic acid @ 50 ppm | 53.00 | 3.82 | 50.35 | 2.40 | 2.61 | 12.15 | 15.27 | 19.99 |
| S.Em±       | 0.82  | 0.08 | 0.75  | 0.04 | 0.04 | 0.20  | 0.31  | 20.26 |
| CD at 5%    | 2.40  | 0.25 | 2.18  | 0.11 | 0.12 | 0.59  | 0.90  | 59.14 |

Interactions: (G X P)

| G₁P₁        | 54.14 | 4.20 | 72.00 | 2.58 | 2.56 | 12.48 | 21.69 | 27.22 |
| G₁P₂        | 53.14 | 5.60 | 84.03 | 2.85 | 2.72 | 14.67 | 29.14 | 28.56 |
| G₁P₃        | 60.90 | 4.93 | 79.00 | 2.61 | 2.71 | 13.13 | 26.35 | 28.08 |
| G₂P₁        | 52.60 | 4.05 | 66.01 | 2.57 | 2.15 | 12.17 | 14.31 | 24.99 |
| G₂P₂        | 45.87 | 5.33 | 70.83 | 2.82 | 2.58 | 13.93 | 19.71 | 27.23 |
| G₂P₃        | 55.72 | 4.73 | 68.13 | 2.61 | 2.51 | 12.66 | 17.90 | 26.27 |
| G₃P₁        | 47.15 | 3.20 | 31.52 | 3.02 | 2.99 | 13.52 | 13.23 | 22.45 |
| G₃P₂        | 39.87 | 3.50 | 37.54 | 3.77 | 3.73 | 15.21 | 15.10 | 26.08 |
| G₃P₃        | 52.87 | 3.30 | 34.15 | 3.28 | 3.53 | 13.91 | 14.29 | 23.53 |
| G₄P₁        | 50.66 | 3.47 | 47.56 | 2.32 | 2.26 | 11.45 | 11.58 | 17.32 |
| G₄P₂        | 44.46 | 4.60 | 56.41 | 2.57 | 2.48 | 12.61 | 18.83 | 20.67 |
| G₄P₃        | 56.97 | 3.73 | 50.01 | 2.33 | 2.43 | 12.58 | 15.49 | 18.63 |
| G₅P₁        | 51.08 | 3.00 | 36.27 | 2.08 | 2.29 | 10.54 | 9.48  | 13.06 |
| G₅P₂        | 44.28 | 4.70 | 48.31 | 2.25 | 2.29 | 12.42 | 13.92 | 16.93 |
| G₅P₃        | 55.55 | 3.47 | 42.33 | 2.14 | 2.31 | 11.47 | 12.35 | 15.92 |
| G₆P₁        | 28.65 | 2.63 | 24.13 | 1.50 | 2.07 | 8.56  | 3.18  | 6.61 |
| G₆P₂        | 25.80 | 3.03 | 31.79 | 1.77 | 2.19 | 10.08 | 6.92  | 7.76 |
| G₆P₃        | 36.00 | 2.73 | 28.45 | 1.45 | 2.14 | 9.14  | 5.24  | 7.53 |
| S.Em±       | 2.02  | 0.21 | 1.83  | 0.09 | 0.10 | 0.50  | 0.75  | 49.63 |
| CD at 5%    | NS    | NS   | NS    | NS   | NS   | NS    | NS    | NS    |

*NS-Non-significant
Table 2: Effect of foliar spray of plant growth regulators on seed quality and storability of soybean genotypes

| Treatments | Seed germination (%) | Seedling vigour index-II | Electrical conductivity (dS/m) | Peroxidase activity (µ moles H₂O₂/cm/min/g) |
|------------|----------------------|--------------------------|-------------------------------|-------------------------------------------|
|            | Initial | 9 MAS | Initial | 9 MAS | Initial | 9 MAS | Initial | 9 MAS |                  |                  |
| Genotypes (G): |         |       |         |       |         |       |         |       |                  |                  |
| G₁: DSb-21 | 95.35 (77.76) | 79.22 (62.88) | 118.02 | 58.95 | 0.049 | 0.466 | 26.02 | 67.41 |                  |                  |
| G₂: DSb-23 | 92.51 (74.31) | 77.93 (61.99) | 108.98 | 56.83 | 0.056 | 0.475 | 13.84 | 60.01 |                  |                  |
| G₃: DSb-31 | 89.38 (79.98) | 75.01 (60.02) | 102.57 | 45.86 | 0.059 | 0.489 | 9.99 | 52.94 |                  |                  |
| G₄: JS 335 | 88.32 (70.08) | 71.04 (57.45) | 95.31 | 41.59 | 0.093 | 0.537 | 6.33 | 30.38 |                  |                  |
| G₅: JS 9305 | 89.19 (71.13) | 72.81 (58.58) | 100.46 | 47.21 | 0.073 | 0.508 | 9.90 | 46.73 |                  |                  |
| G₆: Kalitur | 96.31 (79.21) | 80.95 (64.13) | 123.06 | 67.93 | 0.035 | 0.372 | 37.39 | 73.81 |                  |                  |

| S.Em±       | 0.685   | 0.11   | 0.71   | 0.44   | 0.001 | 0.007 | 0.21 | 0.54   |
| CD at 1%    | 2.633   | 0.43   | 2.73   | 1.71   | 0.004 | 0.029 | 0.81 | 2.09   |

Plant growth regulators (P):

| P₁: Control | 89.95 (71.85) | 74.56 (59.77) | 103.29 | 49.40 | 0.074 | 0.545 | 15.27 | 51.67 |
| P₂: Cycocel @ 250 ppm | 91.77 (73.78) | 76.27 (60.91) | 108.31 | 53.48 | 0.061 | 0.463 | 16.90 | 55.61 |
| P₃: Salicylic acid @ 50 ppm | 93.82 (76.10) | 77.65 (61.85) | 112.60 | 56.31 | 0.048 | 0.415 | 19.57 | 58.36 |

| S.Em±       | 0.484   | 0.08   | 0.50   | 0.31   | 0.001 | 0.005 | 0.15 | 0.38   |
| CD at 1%    | 1.862   | 0.30   | 1.93   | 1.21   | 0.003 | 0.020 | 0.57 | 1.48   |

Interactions (G X P):

| G₁P₁        | 94.16 (76.13) | 78.27 (62.22) | 114.37 | 56.67 | 0.057 | 0.511 | 24.85 | 62.31 |
| G₁P₂        | 95.49 (77.87) | 79.11 (62.81) | 118.09 | 58.89 | 0.048 | 0.471 | 26.23 | 67.50 |
| G₁P₃        | 96.40 (79.27) | 80.27 (63.63) | 121.59 | 61.28 | 0.041 | 0.417 | 26.97 | 72.42 |
| G₂P₁        | 90.74 (72.43) | 76.18 (60.79) | 104.85 | 53.79 | 0.066 | 0.533 | 11.74 | 55.23 |
| G₂P₂        | 92.23 (73.91) | 78.24 (62.20) | 108.92 | 56.88 | 0.056 | 0.459 | 12.03 | 60.61 |
| G₂P₃        | 94.56 (76.59) | 79.37 (62.98) | 113.18 | 59.81 | 0.047 | 0.433 | 17.76 | 64.18 |
| G₃P₁        | 86.80 (68.72) | 72.60 (58.44) | 95.88 | 40.77 | 0.065 | 0.563 | 9.02 | 48.74 |
| G₃P₂        | 88.57 (70.27) | 75.14 (60.09) | 102.78 | 46.76 | 0.061 | 0.483 | 9.13 | 53.37 |
| G₃P₃        | 92.21 (73.95) | 77.30 (61.54) | 109.04 | 50.04 | 0.050 | 0.421 | 11.82 | 56.72 |
| G₄P₁        | 86.39 (68.36) | 69.64 (56.57) | 91.21 | 38.01 | 0.123 | 0.646 | 5.18 | 26.62 |
| G₄P₂        | 88.08 (69.81) | 70.86 (57.33) | 95.04 | 41.36 | 0.090 | 0.518 | 5.85 | 30.30 |
| G₄P₃        | 90.50 (72.07) | 72.60 (58.44) | 99.69 | 45.40 | 0.065 | 0.447 | 7.96 | 34.21 |
| G₅P₁        | 87.08 (68.98) | 71.25 (57.57) | 94.71 | 43.42 | 0.088 | 0.586 | 9.00 | 45.22 |
| G₅P₂        | 89.56 (71.24) | 73.04 (58.72) | 101.18 | 47.65 | 0.071 | 0.501 | 9.92 | 47.41 |
| G₅P₃        | 91.50 (73.16) | 74.16 (59.45) | 105.50 | 50.58 | 0.061 | 0.437 | 10.78 | 47.54 |
| G₆P₁        | 94.53 (76.50) | 79.44 (63.04) | 118.70 | 63.73 | 0.042 | 0.433 | 31.86 | 71.88 |
| G₆P₂        | 96.66 (79.58) | 81.21 (64.31) | 123.85 | 69.33 | 0.036 | 0.348 | 38.22 | 74.49 |
| G₆P₃        | 97.73 (81.54) | 82.19 (65.04) | 126.62 | 70.74 | 0.026 | 0.334 | 42.10 | 75.07 |

| S.Em±       | 1.186   | 0.19   | 1.23   | 0.77   | 0.002 | 0.01  | 0.37 | 0.94   |
| CD at 1%    | NS      | NS     | NS     | NS     | 0.006 | 0.05  | 1.40 | 3.62   |

* NS-Non-significant, MAS-Months after storage
* Values in parenthesis are arcsine transformed germination values
The increased peroxidase activity as a result of foliar spray of salicylic acid @ 50 ppm may be due to up-regulation of genes involved in biosynthesis of antioxidant enzymes (Mohamed et al., 2017) alleviating catalytic activity of peroxidase. Electrical conductivity of seed leachates reduced significantly as a result of increased peroxidase activity which scavenges free radicals and organic peroxides in the cell. Thus, preventing oxidative damage to cell membrane thereby reducing release of volatile aldehydes and electrolytes from the seed. Jakhar and Sheokand (2015) reported that foliar application of salicylic acid modulates oxidative stress in soybean plant and reduces rate of lipid peroxidation process by alleviating activity of antioxidant enzymes. Similar trend was noticed for seed germination, seedling vigour index-II, electrical conductivity and peroxidase activity of soybean genotypes up to nine months of storage.

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