Effect of Foliar Nutrient on Growth, Seed Yield and Quality Parameters in Quinoa (Chenopodium quinoa wildd.)

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Abstract

The experiment was conducted in Field Experimentation Centre, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) during Rabi season 2019-2020, in order to standardize the suitable spraying treatment of Quinoa (variety: EC 507740). Different spraying treatment with control (Unspraying) were evaluated by screening 45 DAS and 60 DAS viz., T0 – Control, T1 – Urea (2%) @ 45 DAS, T2 – DAP (2%) @ 45 DAS, T3 – Chitosan (0.5%) @ 45 DAS, T4 – Moringa Leaf Extract (3%) @ 45 DAS, T5 – Ascorbic Acid (50 ppm) @ 45 DAS, T6 – Salicylic Acid (10 ppm) @ 45 DAS, T7 – Urea (2%) @ 60 DAS, T8 – DAP (2%) @ 60 DAS, T9 – Chitosan (0.5%) @ 60 DAS, T10 – Moringa Leaf Extract (3%) @ 60 DAS, T11 – Ascorbic Acid (50 ppm) @ 60 DAS and T12 – Salicylic Acid (10 ppm) @ 60 DAS. It was found that all the spraying treatments showed significance difference with the control except speed of germination, days to anthesis and biological yield. Foliar application treatment increases the germinability and vigour of quinoa seeds, significantly in both lab and field condition. Spraying with Salicylic Acid 10 ppm @ 45 DAS followed by Chitosan 0.5 % @ 60 DAS, DAP 2% @ 45 DAS, Ascorbic Acid 50 ppm @ 60 DAS and Urea 2 % @ 60 DAS showed maximum increase in germin ability and vigour of quinoa seeds. Foliar application treatment on field and lab condition give best result in Salicylic Acid 10 ppm @ 45 DAS and found to be lowest in Control (untreated). These conclusions are based on the results of six months investigation and therefore further investigation is needed to arrive at valid recommendations. The treatments of quinoa crop with Ascorbic Acid is ecofriendly and economic in use.

Keywords
Quinoa, Salicylic Acid, Moringa Leaf Extract, Quality parameters, Vigour and seed yielding attributes

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Introduction

Quinoa (Chenopodium quinoa Willd) is a halophytic, allotetraploid grain crop of the Amaranth family with the impressive drought tolerance, nutritional content and an increasing the worldwide market (Risi and Galwey, 1984). The nearest wild species to quinoa are C. hicineum and C. berlandieri, which have the same number of chromosomes (2n = 4x = 36), and C. pallidicaule with 2n = 2x 18 chromosomes. It is dicotyledonous
annual plant grown as a grain crop primarily for its edible seeds. As it is having high protein content (14.1 gm/100gm) in the grains. It is neglected crop in the past years, now it is gaining popularity due to its many health benefits. It is commonly called as quinoa, parka, dawe, chuppah and kinwah and quinoa is not a grass, but a pseudo cereal botanically related to spinach and amaranth (Amaranthus spp.) Quinoa provides protein, dietary fibre, vitamin B and dietary minerals in rich amounts above those of wheat, corn, rice or oats. It is gluten free, after harvest the seeds are processed to remove the bitter tasting outer seed coat. FAO declared 2013 as International year of Nutritional characteristics are the result of environmental conditions, such as temperature, light intensity, relative humidity and precipitation. These conditions are key factors in the quality and number of grains per panicle (Morales et al., 2017), as well as in the phonological and physiological performance of the plants related to the adaptive capacity to diverse environmental conditions (Winkel et al., 2016). The plant has adaptive advantages that allow it to express a great productive potential. It is considered a crop with great potential because of its high agronomic characteristics and nutritional value, and especially for its inclusion in children and elderly people’s diets (Valcárcel- Yamany and Silva, 2012). According to Escuredo et al., (2014), this plant has the capacity to produce grains of high quality and protein content. Additionally, it contains amino acids such as lysine, threonine and methionine, which are considered as essential.

Crop nutrients are the elements, which are essential in providing healthy and vigorous plants. They initiate all processes which are vital for crop development. Therefore, plant needs nutrients throughout its growing cycle. Plant nutrients are available in various forms and nutrient ratios. Among the various plant nutrients, whether based on organic or mineral composition, they can be applied to crops by foliar and granular application. By foliar spray plants take nutrients more efficiently through stomata. Application is done when there is lack of particular nutrient in the soil or when the plant roots are not able to absorb the required amounts of nutrients. Ascorbic acid plays role in plant growth and development, cell division, cell wall metabolism and cell expansion, shoot apical meristem formation, root development, photosynthesis, regulation of florescence and regulation of leaf senescence. Also, it is cofactors for enzyme activity, and effects on plant antioxidation capacity, heavy metal evacuation and detoxification and stress defense (Zhang, 2012).

Materials and Methods

The present investigation was carried using genetically pure seeds of Quinoa (variety:- EC 507740). Experiment was conducted in Field Experimentation Centre, Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.). The experiment was conducted during Rabi season of 2019-20 in Randomised Block design consisting of 12 combinations with three replications and laid out with different treatments allocated randomly in each replication. $T_0$ – Control, $T_1$ – Urea (2%) @ 45 DAS, $T_2$ – DAP (2%) @ 45 DAS, $T_3$ – Chitosan (0.5%) @ 45 DAS, $T_4$ – Moringa Leaf Extract (3%) @ 45 DAS, $T_5$ – Ascorbic Acid (50 ppm) @ 45 DAS, $T_6$ – Salicylic Acid (10 ppm) @ 45 DAS, $T_7$ – Urea (2%) @ 60 DAS, $T_8$ – DAP (2%) @ 60 DAS, $T_9$ – Chitosan (0.5%) @ 60 DAS, $T_{10}$ – Moringa Leaf Extract (3%) @ 60 DAS, $T_{11}$ – Ascorbic Acid (50 ppm) @ 60 DAS and $T_{12}$ – Salicylic Acid (10 ppm) @ 60 DAS.
**Results and Discussion**

According to the results, all studied traits were affected by the treatments and there was completely significant difference between control (non-spraying seeds) and spraying seeds in Table-2.

Spraying treatment with SA (10 ppm) @ 45 DAS recorded maximum field emergence percent (87.00%) followed by T0- Chitosan (0.5%) @ 60 DAS (85.67%), T2- DAP (2%) @ 45 DAS (85.00%) and T1- Moringa leaf extract (3%) @ 45 DAS (84.33%). Minimum field emergence percentage was recorded by T0 – Control (78.33%). The positively effect of spraying treatment on field emergence percentage was found to be significant and similar finding observed by Abd El Wahab and Mohamad, (2008); El-Keltawi and Croteau, (1987); Vani et al., (2004) and Aishwath et al., (2011).

Maximum plant height at 60 DAS(106.67 cm) was recorded by T6- SA (10 ppm) @ 45 DAS followed by T11- Ascorbic Acid (50 ppm) @ 60 DAS (105.00 cm), T2- DAP (2%) @ 45 DAS (99.67) and T9- Chitosan (0.5%) @ 60 DAS (98.60). Minimum plant height at 60 DAS was recorded by T0 – Control (83.01 cm). Maximum plant height at 90 DAS (127 cm) was recorded by T6- SA (10 ppm) @ 45 DAS followed by T9- Chitosan (0.5%) @ 60 DAS (125.00 cm), T3- Chitosan (0.5%) @ 45 DAS (123.67) and T11- Ascorbic Acid (50 ppm) @ 60 DAS (120.67 cm). Minimum plant height at 90 DAS was recorded by T0 – Control (100 cm). The positively effect of spraying treatment on plant height was found to be significant and similar finding observed by Abd El Wahab and Mohamad, (2008); El-Keltawi and Croteau, (1987); Vani et al., (2004) and Aishwath et al., (2011).

Number of branches per plant (10.33) was recorded highest in T0- SA (10 ppm) @ 45 DAS followed by T9- Chitosan (0.5%) @ 60 DAS (10.00), T2- DAP (2%) @ 45 DAS (9.70) and T4- Moringa leaf extract (3%) @ 45 DAS (9.67). Minimum number of branches per plant was recorded by T0 – Control (7.00). The positively effect of spraying treatment on number of branches per plant was found to be significant and similar finding observed by El-Tohamy et al., (2007); Verma and Sen, (2008) and Giannakoula et al., (2012).

Total number of panicles per plant (9.67) was recorded highest in T0- SA (10 ppm) @ 45 DAS followed by T2- DAP (2%) @ 45 DAS (9.02), T9- Chitosan (0.5%) @ 60 DAS (9.00) and T11- Ascorbic Acid (50 ppm) @ 60 DAS (8.15). Minimum total number of panicles per plant was recorded by T0 – Control (5.86). The positively effect of spraying treatment on total number of panicles per plant was found to be significant and similar finding observed by Bate et al., (2003); Sivakumar et al., (2002) and El-Sherbeny and Abou Zeid, (1986).

Total number of productive panicles per plant (7.33) was recorded highest in T0- SA (10 ppm) @ 45 DAS followed by T9- Chitosan (0.5%) @ 60 DAS (7.02), T2- DAP (2%) @ 45 DAS (6.53) and T11- Ascorbic Acid (50 ppm) @ 60 DAS (6.10). Minimum total number of productive panicles per plant was recorded by T0 – Control (3.00). The positively effect of spraying treatment on total number of productive panicles per plant was found to be significant and similar finding observed by Aftab et al., (2010); Rathod et al., (2005); Sivakumar et al., (2002) and Tarraf et al., (1999).

Minimum taken days to anthesis (43.33) was recorded by T11- Ascorbic Acid (50 ppm) @ 60 DAS followed by T6- SA (10 ppm) @ 45 DAS (43.43), T9- Chitosan (0.5%) @ 60 DAS (44.00) and T8- DAP (2%) @ 60 DAS (44.07). Maximum taken days to anthesis was recorded by T0 – Control (46.02). The positively effect of spraying treatment on
days to anthesis was found to be non-significant and similar finding observed by Bhat et al., (2011); Patel and Vyas, (2007) and Purbey and Sen, (2005).

Minimum taken days to 50% flowering (46.00) was recorded by T6- SA (10 ppm) @ 45 DAS followed by T2- DAP (2%) @ 45 DAS (46.67), T9- Chitosan (0.5%) @ 60 DAS (47.00) and T3- Ascorbic Acid (50 ppm) @ 45 DAS (47.33). Maximum taken days to 50% flowering were recorded by T0 – Control (50.67). The positively effect of spraying treatment on days to 50% flowering was found to be significant and similar finding observed by Beena and Mercy, (2003) and Kataria et al., (2003);.

Minimum taken days to maturity (86.67) was recorded by T6- SA (10 ppm) @ 45 DAS followed by T9- Chitosan (0.5%) @ 60 DAS (87.33), T2- DAP (2%) @ 45 DAS (88.00) and T10- Moringa leaf extract (3%) @ 45 DAS (88.33). Maximum taken days to maturity was recorded by T0 – Control (90.00). The positively effect of spraying treatment on days to maturity was found to be significant and similar finding observed by Das et al., (1996); Patel, (2006); Purbey and Sen, (2005) and Khalifa et al., (2012).

Observed maximum seed yield per plant (90.76 gm) was recorded by T6- SA (10 ppm) @ 45 DAS followed by T9- Chitosan (0.5%) @ 60 DAS (89.80 g), T2- DAP (2%) @ 45 DAS (86.53 g) and T11- Ascorbic Acid (50 ppm) @ 60 DAS (83.75 g). Minimum seed yield per plant was recorded by T0 – Control (63.90 gm). Seed yield per plot (756.30 gm) found to be highest in T6- SA (10 ppm) @ 45 DAS followed by T9- Chitosan (0.5%) @ 60 DAS (741.68 g), T2- DAP (2%) @ 45 DAS (709.10 g) and T11- Ascorbic Acid (50 ppm) @ 60 DAS (698.77 g). Minimum seed yield per plot was recorded by T0 – Control (516.05 gm). The positively effect of spraying treatment on seed yield was found to be significant and similar finding observed by Aftab et al., (2011); Hesami et al., (2012); Krishnamoorthy and Madalageri, (2000); Rohamare et al., (2013) and Prasad et al., (2003).

### Table 1 Analysis of variance for 13 growth and yielding attributes in quinoa

| S.No. | Characters                                      | Replications (df=2) | Treatments (df=12) | Error (df=24) |
|-------|------------------------------------------------|--------------------|--------------------|---------------|
| 1     | Field emergence percentage                     | 4.41               | 20.06*             | 4.91          |
| 2     | Plant height at 60 DAS (cm)                    | 124.89             | 154.43*            | 16.14         |
| 3     | Plant height at 90 DAS (cm)                    | 47.49              | 219.53*            | 8.53          |
| 4     | Number of branches per plant                   | 1.12               | 3.62*              | 1.56          |
| 5     | Total number of panicles plant\(^{-1}\)        | 1.14               | 4.18*              | 1.59          |
| 6     | Total number of productive panicles plant\(^{-1}\) | 0.79               | 4.01*              | 1.18          |
| 7     | Days to anthesis                               | 46.39              | 2.34               | 9.68          |
| 8     | Days to 50% flowering                          | 2.15               | 6.91*              | 2.96          |
| 9     | Days to maturity                               | 1.62               | 3.03*              | 4.89          |
| 10    | Seed yield per plant (g)                       | 54.79              | 242.89*            | 82.81         |
| 11    | Seed yield per plot (g)                        | 530.43             | 16993.21*          | 5467.86       |
| 12    | Biological yield                               | 58908.84           | 8198.37            | 25267.03      |
| 13    | Harvest index                                  | 42.29              | 50.27*             | 2.25          |

* Significant at 5% level of significance
### Table 2 Mean performance of quinoa for 13 growth and yielding attributes

| S.No. | Treatments | Field Emergence percentage | Plant height at 60 DAS (cm) | Plant height at 90 DAS (cm) | Number of branches per plant | Total number of panicles plant^-1 | Total number of productive panicles plant^-1 | Days to anthesis | Days to 50% flowering | Days to maturit y | Seed yield per plant (g) | Seed yield per plot (g) | Biological yield (g) | Harvest index |
|-------|------------|-----------------------------|-----------------------------|-----------------------------|-------------------------------|-----------------------------------|-----------------------------------------------|-----------------|-------------------------|------------------|------------------------|-----------------------|-----------------------|---------------|
| 1     | T₀         | 78.33                       | 83.01                       | 100.00                      | 7.00                          | 5.86                             | 3.00                                           | 46.02           | 50.67                   | 90.00           | 63.90                  | 516.05                | 1199.37              | 43.05         |
| 2     | T₁         | 79.67                       | 98.00                       | 108.00                      | 8.00                          | 6.37                             | 5.01                                           | 45.42           | 49.33                   | 89.67           | 67.33                  | 561.10                | 1256.70              | 44.67         |
| 3     | T₂         | 85.00                       | 99.67                       | 120.33                      | 9.70                          | 6.53                             | 44.74                                          | 46.67           | 88.00                   | 86.53           | 709.10                 | 1338.94              | 53.31                 |               |
| 4     | T₃         | 81.67                       | 90.00                       | 123.67                      | 7.57                          | 7.05                             | 4.90                                           | 45.67           | 50.00                   | 89.67           | 78.29                  | 652.45                | 1284.74              | 50.82         |
| 5     | T₄         | 84.33                       | 93.33                       | 116.00                      | 9.67                          | 7.33                             | 5.50                                           | 45.33           | 50.33                   | 89.33           | 76.44                  | 637.00                | 1280.31              | 49.83         |
| 6     | T₅         | 80.00                       | 93.00                       | 114.00                      | 7.67                          | 7.38                             | 5.23                                           | 44.67           | 47.33                   | 89.67           | 72.28                  | 602.30                | 1263.53              | 47.69         |
| 7     | T₆         | 87.00                       | 106.67                      | 127.00                      | 10.33                         | 9.67                             | 7.33                                           | 43.42           | 46.00                   | 86.67           | 90.76                  | 756.30                | 1339.48              | 56.68         |
| 8     | T₇         | 83.67                       | 87.00                       | 116.33                      | 8.66                          | 6.67                             | 4.33                                           | 44.33           | 48.33                   | 89.33           | 79.63                  | 663.60                | 1261.99              | 52.60         |
| 9     | T₈         | 82.33                       | 87.02                       | 101.00                      | 7.32                          | 6.50                             | 4.67                                           | 44.07           | 50.00                   | 88.67           | 65.96                  | 549.65                | 1206.85              | 45.91         |
| 10    | T₉         | 85.67                       | 98.60                       | 125.00                      | 10.00                         | 9.00                             | 7.02                                           | 44.00           | 47.00                   | 87.33           | 89.80                  | 741.68                | 1356.53              | 54.95         |
| 11    | T₁₀        | 81.00                       | 88.60                       | 110.00                      | 8.33                          | 6.53                             | 5.20                                           | 44.26           | 49.67                   | 88.33           | 69.86                  | 582.20                | 1239.58              | 46.98         |
| 12    | T₁₁        | 84.00                       | 105.00                      | 120.67                      | 9.30                          | 8.15                             | 6.10                                           | 43.33           | 48.67                   | 89.00           | 83.85                  | 698.77                | 1352.61              | 51.71         |
| 13    | T₁₂        | 81.00                       | 92.67                       | 115.00                      | 8.30                          | 7.01                             | 5.30                                           | 45.71           | 49.00                   | 89.33           | 73.51                  | 612.60                | 1275.16              | 48.05         |
|       | Grand Mean | 82.59                       | 94.04                       | 115.15                      | 8.60                          | 7.43                             | 5.39                                           | 44.69           | 48.69                   | 88.85           | 76.78                  | 637.14                | 1281.22              | 49.71         |
|       | C.D.(5%)   | 3.73                        | 6.77                        | 4.92                        | 2.11                          | 2.12                             | 1.83                                           | 5.24            | 2.90                    | 3.73            | 15.33                  | 124.61                | 267.87               | 2.53          |
|       | SE(m)      | 1.28                        | 2.32                        | 1.69                        | 0.72                          | 0.73                             | 0.63                                           | 1.80            | 0.99                    | 1.28            | 5.25                   | 12.69                 | 91.77                | 0.87          |
|       | SE(d)      | 1.81                        | 3.28                        | 2.38                        | 1.02                          | 1.03                             | 0.89                                           | 2.54            | 1.40                    | 1.81            | 7.43                   | 60.38                 | 129.79               | 1.22          |
|       | C.V.       | 2.68                        | 4.27                        | 2.54                        | 14.53                         | 6.98                             | 20.14                                          | 3.53            | 2.49                    | 11.85           | 12.41                  | 11.61                 | 12.41                | 3.02          |
Biological yield (1356.53 gm) was observed highest in T_9- Chitosan (0.5%) @ 60 DAS followed by T_{11}- Ascorbic Acid (50 ppm) @ 60 DAS (1352.61 g), T_6- SA (10 ppm) @ 45 DAS (1339.48 g) and T_2- DAP (2%) @ 45 DAS (1338.94 g). Minimum biological yield was recorded by T_0– Control (1199.37 gm). The positively effect of spraying treatment on biological yield was found to be non-significant and similar finding observed by Ezz El-Din and Khalil, (2004); Naidu and Swamy, (1995) and Giannakoula et al., (2012).

Maximum harvest index (56.68%) was recorded by T_6- SA (10 ppm) @ 45 DAS followed by T_9- Chitosan (0.5%) @ 60 DAS (54.95%), T_2- DAP (2%) @ 45 DAS (53.31%) and T_7- Urea (2%) @ 60 DAS (1338.94 g). Minimum harvest index was recorded by T_0– Control (43.05%). The positively effect of spraying treatment on harvest index was found to be significant and similar finding observed by Gomaa, (2001); Narra et al., (2010); Farooqi et al., (1999) and; Rohamare et al., (2013).

On the basis of results obtained from the present experiment following conclusions are drawn. Foliar application treatment increases the germinability and vigour of quinoa seeds, significantly in field condition. Spraying with Salicylic Acid 10 ppm @ 45 DAS followed by Chitosan 0.5 % @ 60 DAS, DAP 2% @ 45 DAS, Ascorbic Acid 50 ppm @ 60 DAS and Urea 2 % @ 60 DAS showed maximum increase in germinability and vigour of quinoa seeds. Foliar application treatment on field condition give best result in Salicylic Acid 10 ppm @ 45 DAS and found to be lowest in Control (untreated).

These conclusions are based on the results of six months investigation and therefore further investigation is needed to arrive at valid recommendations. The treatments of quinoa crop with Ascorbic Acid is ecofriendly and economic in use.

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