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Enhancing the Resistance of Quinoa to Alternaria Leaf Spot through the Application of Microalgae and Organic Manure

Jasveer Singh [a*], Rajveer [b], P. N. Kalla [c], Sobita Simon [a], Shubham Singh [a] and Naseeb Choudhary [d]

[a] Department Plant Pathology, Sam Higginbottom University of Agriculture, Technology, and Sciences, Prayagraj, India.
[b] SMS Soil Science, Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India.
[c] Department of Extension Education, Jagannath University, Jaipur, Rajasthan, India.
[d] Department of Agricultural Economics, CCSHAU, Hisar, Haryana, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the finalmanuscript.

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ABSTRACT

In order to assess the impact of an eco-friendly approach on plant development and yield of the quinoa crop, a Randomized Block Design (RBD) field experiment was carried out in Central Research Farm (CRF) at Department of Plant Pathology, SHUATS, Prayagraj, U.P. during the Rabi season of 2019-2020. Alternaria are extremely difficult to control, result in significant yield losses, and lower the economic value of the crop plants in traditional production systems. Chemical fungicides including antrocol, captan, difolaton, dithane M-45, and blitox-50 provided effective

**Corresponding author: E-mail: Choudharyjasveer7@gmail.com;*

control but are harmful to the environment. Other potential management strategies for Alternaria diseases include the use of bio-control agents, therapeutic plants, other plant-based products, etc. Cow dung, goat manure, and microalgae were the organic amendments employed as treatment. The Alternaria spp. that cause Quinoa leaf spot were shown to be most susceptible to the treatment T6, which contained cow dung at a rate of 6 tons per hectare, microalgae at a rate of 2.5 kilograms per hectare, and goat manure at a rate of 3 tons per hectare. The maximum plant height (cm) at 40, 80, and 120 DAS is 62.29, 90.48, and 117.31, respectively. At 120 DAS, the same treatment produced a maximum yield of (23.45 q/ha). The same treatment yielded the highest gross return, net return, and cost- benefit ratio, which were, respectively, Rs. 70350/ha, 41326/ha, and 1:1.42. Based on the results, it was determined that cow dung at 6 tons per hectare, microalgae at 2.5 kg per hectare, and goat manure at 3 tons per hectare were the most effective pesticides against Alternaria spp. of Quinoa in Prayagraj.

Keywords: Quinoa; microalgae; cow dung; goat manure; Alternaria spp.

1. INTRODUCTION

The Andean region has been cultivating quinoa (Chenopodium quinoa Wild.) for thousands of years. It has now been introduced abroad as a source of carbohydrates and high-quality proteins. The grains' great nutritional content is what has recently sparked interest in their production in the USA and other European nations. Quinoa has been known to experience germination issues in both Andean and European environments.

Quinoa is most vulnerable to the pathogen before emergence, throughout germination to the end of the stage of the first pair of true leaves, according to a comparison of the response of quinoa with other susceptible plants (spinach, cabbage, sugar beet). Quinoa seeds that were still in the ground appeared to have less ability to sprout. This major issue is mostly brought on by a mix of numerous unfavorable conditions during germination, when quinoa is most vulnerable, rather than only pre-emergence damping-off by pathogens [1]. Despite the recent increase in interest in the study of endophytic fungal communities in plants, little is known about the variety and makeup of endophytic fungi associated with agricultural crops [2].

According to estimates of yield losses brought on by downy mildew, which range between 20 and 25%, quinoa production is significantly hampered. Further research is needed in order to assess the impact of downy mildew on quinoa yield because these results are based solely on one experiment with one cultivar Danielsen et al. [3]. Another serious quinoa disease is leaf spot disease. Round, yellow, brown, or black patches, frequently with concentric rings, have been linked to fungi including Ascochyta spp. and Alternaria spp. In plants belonging to the Chenopodiaceae family, the mortality of the foliage is estimated to be between 10 and 60 percent [4]. South America's traditional crop is quinoa. Quinoa has recently gained popularity on a global scale because of its outstanding nutritional qualities. The seeds are devoid of gluten and high in vitamins, minerals, and proteins (Vega-Galvez et al., 2010); [5]. Determine the macronutrient needs for quinoa in order to sustain the crop metabolism for optimum growth and development [6]. Utilizing microalgal biomass as both a fuel source and a biofertilizer can improve the recycling of nutrients [7,8]. Compost digested by EWs contains phytohormones that aid in crop growth, including auxin, gibberellic acid, and cytokinin [9]. The soil microbiota, which includes organisms that fix nitrogen and dissolve phosphorus, also improves vermicompost [10].

2. METHODS AND MATERIALS

Six soil treatments were applied to the plots namely cow dung @ 6 ton/ha(T1), Goat manure @ 3 ton/ha (T2), Microalgae @ 9 kg/ha (T3), cow dung @ 6 ton/ha + Microalgae @ 9 kg/ha (T4), Goat manure @ 3 ton/ha + Microalgae @ 5 kg/ha (T5) and cow dung @ 6 ton/ha + Microalgae @ 2.5 kg/ha + Goat manure @ 3 ton/ha (T6). The untreated control, T0, was preserved. Prior to seeding, organic manures were used, and microalgae were added later.

2.1 Evaluation of Growth Parameters

The plants' condition was evaluated. The growth parameters were observed, and the plants were checked for signs of disease and any other influencing variables. At 40, 80, and 120 days after sowing (DAS), measurements of plant height (cm) and leaf count were made. Grain yield was calculated after harvest.

2.2 Plant Height (cm)

At 40 and 80 days following transplant and during the time of harvest, the heights of crop plants receiving various treatments were measured. For this reason, three plants at random from each plot were chosen and tagged for observation and recording. The height of the plant, measured in centimetre, was measured from the ground to the base of the final completely opened leaf on the main branch.

2.3 Number of Leaves Plant^{-1}

At 40, 60, and 120 days following seeding, the total leaves of the three tagged plants were counted, and the average number of leaves was computed.

2.4 Crop Yield

The ear heads were removed from the net plots separately and allowed to dry in the threshing yard. The ear heads were washed, threshed, and winnowed before being weighed.

2.5 Gross Profit

The cost of production and the produce's market price were taken into account when calculating the gross return from each treatment.

2.6 Net Income

The following formula was used to individually determine the net profit for each treatment.

Gross return = Total yield per plot × Selling rate
Net return = Gross return - Total cost of cultivation

3. RESULTS AND DISCUSSION

The experimental findings of the current study, "Evaluate the effect of eco-friendly approach on plant growth and yield of the quinoa crop," comprise a field experiment that was conducted at the Plant Pathology Research Farm, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during Rabi season 2019-2020. They are presented in the following pages under pertinent headings for an easy understanding of the results.

3.1 Height of Plants (cm)

Table 1 and Fig. 1 display the Quinoa plant height for the various treatments measured at 40,80, and 120 days after sowing (DAS). The variance analysis is provided in Appendixes (4-6). The table shows that at 40, 80, and 120 DAS, there was a noticeable difference in the effect of several treatments on plant height. When compared to the control group, all therapies were determined to be statistically significant when compared to other treatments. At 40, 80, and 120 DAS, treatment T6 (Cow dung at 6 tons per hectare plus microalgae at 2.5 kilograms per hectare plus goat manure at 3 tons per hectare) recorded the highest plant heights (62, 29, 90, and 117.31 cm, respectively), followed by treatment T5 (Goat manure at3 tons per hectare plus microalgae at 5 kilograms per hectare) (55.03, 83.22, and 111. All therapies were shown to be statistically different from the control when compared to other treatments. The relationships between T6, T5, T4, and T3 are important. T0, T1, and T2 are not significantly correlated.

Image 1. Data collection

Image 2. Applying microalgae @ 7.5 gm / plot

Table 1. Shows the impact of adding microalgae singly to organic manure on the plant height (cm) of quinoa

Treatments	Plant height (cm)		
	40 DAS	**80 DAS**	**120 DAS**
T0 Control	39.51	48.73	71.86
T1 Cow dung @ 6 tons/ha	41.97	61.42	93.50
T2 Goat manure @ 3 tons/ha	44.35	67.16	99.30
T3 Micro algae @ 9kg/ha	50.82	74.61	102.40
T4 Microalgae @ 5 kg/ha + Cow Dung @ 6 tons/ha	54.24	80.97	106.58
T5 Goat manure @ 3 tons/ha + microalgae @ 5kg/ha	55.03	83.22	111.89
T6 Goat manure @3ton/ha + 2.5kg micro algae + 6ton/ha cow dung	62.29	90.48	117.31
F-test	S	S	S
S.Ed (±)	1.16	1.13	1.01
CD at 5%	2.52	2.46	2.20

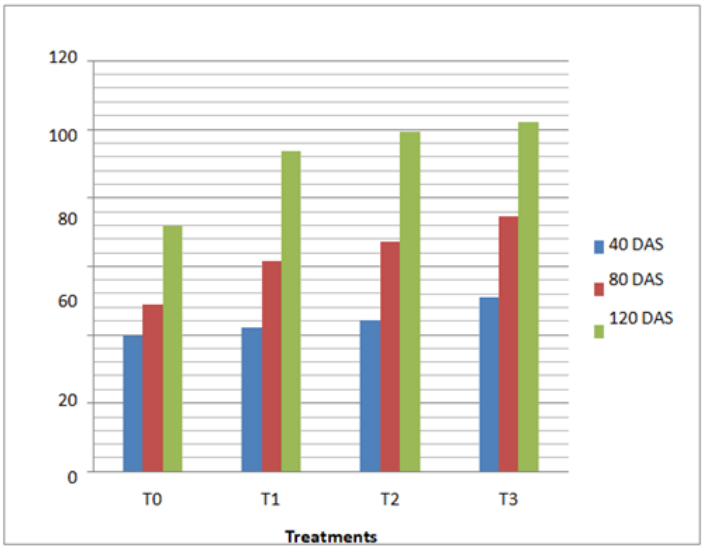

Fig. 1. Effect of microalgae and organic fertilizers on Quinoa Plant Height (cm)

Combined application of micro algae and organic manure contains balance composition of nutrients which favour the proper development of quinoa plants. Organic manures supply NPK in available form to the plant through biological decomposition. They are also rich in micronutrients besides having plant growth promoting substance and humus forming microbes. Application of micro algae and organic manure increased the concentration of nutrient ions in soil solution. These results are in close conformity with the finding of Smitha et al. [11] in Amaranth, Bilalis et al. [12] who showed that inorganic fertilizer give better response in vegetative growth of quinoa.

3.2 Number of Leaves

Table 2 and Fig. 2 display the quantity of Quinoa leaves harvested under various conditions at 40, 80, and 120 days after sowing (DAS). The Table 2 shows that there was a substantial impact of several treatments on the number of leaves at 40, 80, and 120 DAS. All of the therapies, including the control, were shown to be statistically significant when compared to other treatments.

At 40, 80, and 120 DAS, treatment T6 (cow dung at 6 tons per hectare plus microalgae at 2.5 kilograms per hectare plus goat manure at 3 tons per hectare) recorded the highest number of leaves, which were 44.37, 68.56, and 93.41 cm, respectively. Treatment T5 (goat manure @ 3 tons per hectare plus microalgae at 5 kilograms per hectare) recorded the lowest number of leaves, which were 19. All of the therapies, including the control, were shown to be statistically significant when compared to other treatments. All of the therapies, including the control, were shown to be statistically significant when compared to other treatments.

The largest number of leaves per plant were produced by the combined effects of micro algae and organic manure. The photosynthetic activity of plants is governed by microalgae and organic waste. The allocation of nitrogen from the roots to new leaves encourages the growth of more leaves. Similar to this, the growth of new cells and the flow of nutrients inside the plants depend on an adequate supply of P. Thus, the production of leaves is greatly influenced by microalgae and organic manure. These findings closely match those made on quinoa by Parvin et al. (2013) and Buhrig [13]. According to Nasir et al. [14], inorganic fertilizer promotes quinoa vegetative development more effectively.

3.3 Grain (q/ha.)

Table 2 displays the yield (q/ha) under various treatments that was counted and recorded at harvest time. The table shows that there was a considerable impact of various treatments on Yield (q/ha).

Maximum Yield (23.45 q/ha) was recorded with Treatment T6 (Cow dung@6ton/ha + micro algae@2.5kg/ha + goat manure@3ton/ha), followed by (22.50 q/ha) with Treatment T5 (Goat manure @3ton/ha + micro algae@5kg/ha), while the lowest yield (11.33 q/ha) was recorded with Treatment T0 (Control).

These findings closely align with those made by Bhargava et al. [15] and Christiansen et al. [16] in quinoa, which demonstrated that organic fertilizer increased amaranth yield.

3.4 Costs of Various Therapies

All treatments economics were calculated based on the costs associated with clearing the area and harvesting the quinoa. The cost-benefit ratio, gross return, and net return have all been calculated.

The treatment T6 (Cow dung@6ton/ha + micro algae@2.5kg/ha + goat manure@3ton/ha) had the highest gross return, net return, and cost-benefit ratio; it cost Rs. 70350/ha. Treatment T5 (Goat manure @3ton/ha + micro algae@5kg/ha) had the lowest gross return, Rs. 33990/ha, and treatment T0 (Control) had the highest.

3.5 Discussion

Studies on the use of microalgae and organic manure have revealed a favourable impact on plant development. In addition to providing plant growth hormones like auxins, organic manure helps to enhance the number of soil microbes that may aid to defend plants against diseases. Thus, as shown in reports by Usman [17] as well, the application of organic manure has been found to be efficient in boosting plant height, number of branches, and number of leaves. Furthermore, research by Basak and Lee [18] and Mary et al. [19] suggests that organic manures can lower the incidence of disease brought on by a variety of plant diseases.

Table 2. Shows the impact of adding microalgae singly to organic manure on the number of leaves and yield (q/ha) quinoa

Treatments	Leaves in number			Yield (q/ha)
	40 DAS	**80 DAS**	**120 DAS**	**120 DAS**
T0 Control	19.32	42.67	68.51	11.33
T1 Cow dung @ 6 tons/ha	26.84	48.17	71.35	13.84
T2 Goat manure @ 3 tons/ha	31.26	50.91	73.30	18.24
T3 Micro algae @ 9kg/ha	34.80	56.43	77.28	20.32
T4 Microalgae @ 5 kg/ha + Cow Dung @ 6 tons/ha	37.55	60.28	81.94	21.07
T5 Goat manure @ 3 tons/ha + microalgae @ 5kg/ha	41.61	63.44	89.07	22.50
T6 Goat manure @3ton/ha + 2.5kg micro algae + 6ton/ha cow dung	44.37	68.56	93.41	23.45
F-test	S	S	S	S
S.Ed (±)	0.79	1.30	1.14	0.44
CD at 5%	1.73	2.83	2.48	0.96

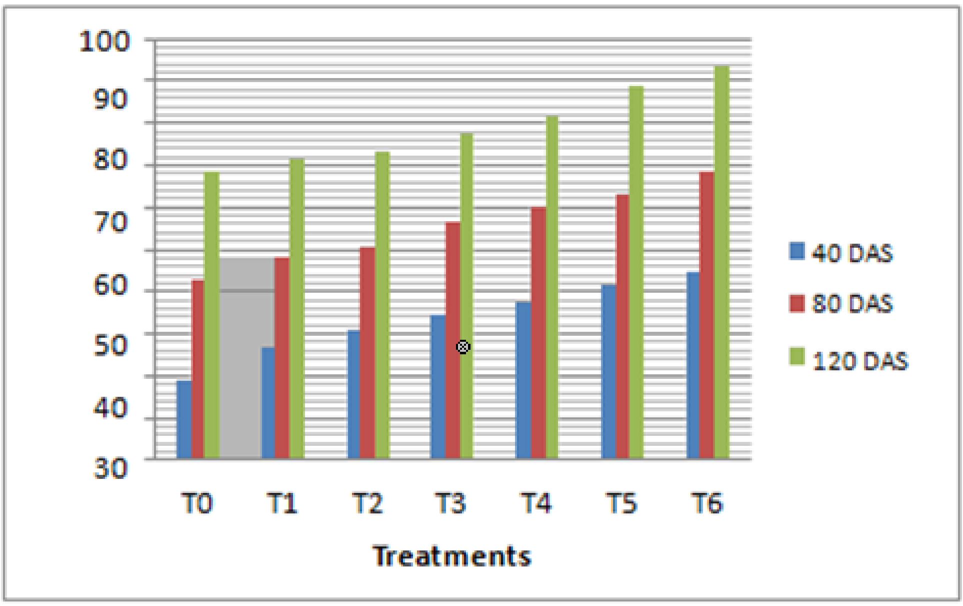

Fig. 2. Effect of microalgae and organic manures on Quinoa's leaf countx

This is probably because of the presence of numerous compounds, including polysaccharides, betaines, minerals, and plant growth hormones (cytokinins, auxins, abscisic, and gibberellic acid). Microalgae shown antifungal efficacy against various plant diseases in response to biotic stressors. As a result of their positive impacts on plant health and productivity, microalgae are utilized in agriculture as a soil amendment. Both Righini and Roberti [20] and Kempenaar et al. [21] found findings that were comparable.

4. CONCLUSION

Treatment T6 had the greatest plant height (cm), number of branches, number of leaves, yield (q/ha), and cost-benefit ratio (CBR) (cow dung@6ton/ha + microalgae@2.5kg/ha + goat manure@3ton/ha). The results of the current study are restricted to one crop season (November 2019 to March 2020) under Prayagraj agroclimatic conditions; hence, additional trials of this nature should be conducted in the future to validate the findings.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

1. Plant height (cm) at (40, 80 and 120 DAS) Anova:

Source of Variation	DF	Sum of Squares			Mean Squares			F-Calculated			Significance
		40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS	40 DAS	80DAS	120DAS	
Replication	2	0.68	4.09	0.33	0.34	2.05	0.17	0.17	1.08	0.12	
Treatment	6	1202.84	3691.94	3970.39	200.48	615.33	661.74	99.58	323.13	431.50	0.00000
Error	12	24.16	22.86	18.40	2.02	1.90	1.54				
Total	20	1227.66	3718.88	3989.12							

2. No. of leaves (40, 80 and 120 DAS)

Source of Variation	DF	Sum of Squares			Mean Squares			F-Calculated			Significance
		40 DAS	80 DAS	120 DAS	40 DAS	80 DAS	120 DAS	40 DAS	80DAS	120DAS	
Replication	2	0.41	0.86	5.50	0.21	0.43	2.75	0.23	0.17	1.42	
Treatment	6	1356.71	1488.38	1563.00	226.11	248.07	260.51	238.60	98.08	134.16	0.00000
Error	12	11.38	30.36	23.30	0.94	2.53	1.95				
Total	20	1368.50	1519.59	1591.80							

3. Yield (q/ha.) Anova:

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Replication	2	0.13	0.06	0.21	
Treatment	6	370.26	61.70	213.30	0.00000
Error	12	3.48	0.28		
Total	20	373.85			

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