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Effect of organic and bio fertilizer on the growth and yield of quinoa

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Abstract

A field experiment was carried out during the Rabi season at Himalayan University, Jollang, Itanagar (Arunachal Pradesh) to evaluate the effect of organic manure and bio fertilizer on the growth and yield of quinoa (*Chenopodium quinoa Willd.*). The study was laid out in a randomized block design with seven treatment combinations involving spacing (25 cm × 15 cm,) and two bio fertilizers PSB(*Phosphate solubilizing bacteria*) AMF(*arbuscular mycorrhizal fungi*) and three organic manure was applied alone and in combination. Among all treatments, T₃ (chicken manure+ *phosphate solubilizing bacteria*) performed the best, recording the highest plant height (79.3 cm), number of leaves per plant (45), crop growth rate (0.38 g m⁻² day⁻¹), and relative growth rate (0.16 g g⁻¹ day⁻¹). T₂ also produced the highest test weight (3.85 g), grain yield (21.3 t/ha), stover yield (8.23t/ha), and harvest index (41.4%). Additionally, it recorded the highest protein content (18.4%), gross returns (Rs75186.67/ha), net returns (Rs 59453.33/ha), and benefit-cost ratio (3.49). All these improvements were statistically significant (p < 0.05) compared to the control (T₁).

Keywords: Quinoa, PSB (*Phosphate solubilizing bacteria*), AMF (*arbuscular mycorrhizal fungi*), chicken manure, grain yield, test weight, B:C ratio, stover yield, harvest index, cost ratio

Introduction

Quinoa (*Chenopodium quinoa Willd.*) is a stress-tolerant, highly nutritious crop with grains rich in protein (approx. 14.6%), essential amino acids, vitamins, minerals, and saponins. It contains about 60% starch and 8% lipids, with 54% linoleic and 20% oleic acid. Quinoa is also a good source of thiamine, folic acid, and vitamin C. In 2017, 146.7 tons were harvested from 173.2 ha, with an average yield of 847 kg/ha. Quinoa flour can be blended with wheat for more nutritious bread (Mansour, 2019). Compost improves soil health and yield, making its use essential for sustainable farming.

The addition of organic amendments increased plant growth, height, fresh biomass, and grain yield in quinoa. The combined use of compost and bio-fertilizer has a significant impact when compared to bio-fertilizer application alone (Gill *et al.*, 2020) [3].

The aim of this work is to evaluate the effect of bio-fertilizers and compost application to study the effect on the growth, yield and quality of quinoa. As the global demand for quinoa rises, there is a need to adopt sustainable agricultural practices to enhance its yield while maintaining environmental health. Organic and biofertilizers offer a promising alternative to synthetic fertilizers. Organic fertilizers, such as compost and farmyard manure, improve soil structure and nutrient content, while biofertilizers like *phosphate solubilizing bacteria* biofertilizer and *arbuscular mycorrhizal fungi* enhance nutrient availability through biological processes. This study investigates the effects of different organic and biofertilizers on quinoa's growth and yield.

The crop growth was stunted however AMF symbiosis improves nutrient acquisition, particularly phosphorus and nitrogen, which are vital for quinoa growth. According to a study by Benaffari *et al.* (2022) [1], AMF inoculation has been shown to enhance quinoa's ability to withstand drought stress. In a study by Benaffari *et al.* (2022) [1], AMF application increased the total protein content in quinoa seeds by 8% under water-stressed conditions. PSB strains significantly improved plant height, root length, shoot and root dry weight in quinoa under field conditions Rafique *et al* (2022) [5]

Benaffari *et al.* (2022) ^[1] investigated the residual effects of compost and manure fertilizers on quinoa production. The study found that manure applied at 40 tons per hectare resulted in the highest quinoa plant height, chlorophyll content index (CCI), grain yield, total plant biomass, and nutrient uptake over three years. This improvement was attributed to the enhanced soil organic matter (SOM) content, which improved soil health and nutrient availability.

Bone meal, a phosphorus-rich organic fertilizer, can enhance quinoa (*Chenopodium quinoa*) growth and yield by improving phosphorus availability and soil health. Although direct studies on quinoa are limited, related research on phosphorus fertilization and organic inputs supports its positive effects.

Research by Ghosh *et al.* (2022) ^[2] examined the impact of rice straw incorporation on soil fertility and microbial activity. The study found that incorporating rice straw into the soil increased organic matter content, improved nutrient availability, and enhanced microbial biomass, which are beneficial for quinoa growth.

Materials and Methods

The experiment entitled “Effects of organic and bio-fertilizer on

growth and yield of quiona. (*Chenopodium quinoa Willd*)’’was carried out at agriculture field, Jollang, college of agriculture, Himalayan University, during the period of Rabi season of November 7 2024. The experimental farm is situated at 27.074684, N latitude and 93.652878 E longitude with an average elevation of 320 meters. It was undertaken with the objective to analyze the different rice verities and to assess their performance in Rabi season. The result of experiment entitled “effect of organic and bio fertilizer on the growth and yield of quinoa (*Chenopodiom quinoa wild*)” was carried out during Rabi season of 2024 with 7 treatments and with 2 replication in randomized block design at the central crop research farm, department of agriculture, Himalayan university. The different treatments were allocated randomly in each replication of the investigation are summarized.

The experiment was conducted in a medium land with irrigation facility. The soil was sandy loam and loamy sandy in texture. The bulk soil samples (0-15 cm depth) were collected from the field before the commencement of the experiment (2024) and tested for important soil properties using the standard procedures.

Treatment	Combination
T ₀	CONTROL
T ₁	CHICKEN MANURE + ARBASCULAR MYCORRHIZAL FUNGI
T ₂	CHICKEN MANURE + PHOSPHATE SOLUBILIZING BACTERIA
T ₃	RICE STRAW + ARBASCULAR MYCORRHIZAL FUNGI
T ₄	RICE STRAW + PHOSPHATE SOLUBILIZING BACTERIA
T ₅	BONE MEAL + ARBASCULAR MYCORRHIZAL FUNGI
T ₆	BONE MEAL + PHOSPHATE SOLUBILIZING BACTERIA

Yield parameters such as grain yield, number stover yield, test weight of 1000 seeds, panical length, harvest index were recorded at different intervals of 30,60 and 90 days after sowing (DAS).

Results and Discussions of Yield Attributes

A. effect of organic and bio fertilizer on grain yield plant⁻¹ (g) of quinoa (*chenopodium quinoa wild*)

At harvest, the highest grain yield was recorded in T₃ (chicken

manure + *phosphate solubilizing bacteria*) at 64 t/ha, followed by T₂ (chicken manure + *arbuscular mycorrhizal fungi*) at 58.5 t/ha. The lowest yield was in the control (T₁) at 42.9 t/ha. The increased yield in T₃ is due to improved phosphorus availability, root development, and resource allocation to seed production, as supported.

Table 1: effect of organic and bio fertilizer on grain yield plant⁻¹ (g) of quinoa (*chenopodium quinoa wild*)

Treatments	Grain yield (t ha)
T ₁ - CONTROL	14.3
T ₂ - Chicken Manure + Arbascular Mycorrhizal Fungi	19.5
T ₃ - Chicken Manure + Phosphate Solubilizing Bacteria	21.3
T ₄ - Rice Straw + Arbascular Mycorrhizal Fungi	18.5
T ₅ - Rice Straw + Phosphate Solubilizing Bacteria	19.6
T ₆ - Bone Meal + Arbascular Mycorrhizal Fungi	17.6
T ₇ -Bone Meal + Phosphate Solubilizing Bacteria	18.4
F test	S
SEd (±)	0.26
CD (P=0.05)	0.58

B. effect of organic and bio fertilizer on Test weight of 1000 seeds (gm) of quinoa (*Chenopodium quinoa wild*)

The test weight (gm) was recorded at harvest, is presented in the table. the data shows that there was significant effect of different treatment on the seed yield (gm).the significant and highest grain yield (gm) was recorded in T₃ (chicken manure + *phosphate solubilizing bacteria*) i.e. 4.27 (gm)and T₃ was found

to be statistically at par with T₂ (chicken manure + *arbascular mycorrhizal fungi*) i.e. 3.18 (gm). Lowest grain yield was observed in treatment T₁ (control) i.e.2.08 (gm). The increase in test weight is due to improved nutrient availability and seed filling from the combined use of chicken manure and PSB, as noted by Yadav *et al.* (2018) ^[7]

Table 2: effect of organic and bio fertilizer on Test weight of 1000 seeds(gm) of quinoa (*Chenopodium quinoa wild*)

Treatments	Test weight of 1000 seeds
T ₁ - Control	2.09
T ₂ - Chicken Manure + Arbuscular Mycorrhizal Fungi	3.14
T ₃ - Chicken Manure + Phosphate Solubilizing Bacteria	3.85
T ₄ - Rice Straw + Arbuscular Mycorrhizal Fungi	3.11
T ₅ - Rice Straw + Phosphate Solubilizing Bacteria	2.99
T ₆ - Bone Meal + Arbuscular Mycorrhizal Fungi	2.74
T ₇ -Bone Meal + Phosphate Solubilizing Bacteria	2.62
F test	S
S.Ed (±)	0.29
CD (P=0.05)	0.65

C. effect of organic and bio fertilizer on Stover yield plant⁻¹ (t/ha) of quinoa (*Chenopodium quinoa wild*)

The highest stover yield was observed in T₃ (chicken manure + PSB) at 24.7 t/ha, followed by T₂ (chicken manure + AMF) at

22.23 t/ha, while the lowest was in T₁ (control) at 13.36 t/ha.

The increase in stover yield is due to enhanced nutrient uptake, soil fertility, and biomass production from the combined use of chicken manure and PSB.

Table 3: effect of organic and bio fertilizer on Stover yield plant⁻¹ (t/ha) of quinoa (*Chenopodium quinoa wild*)

Treatments	Stover Yield ⁻¹
T ₁ - Control	4.45
T ₂ - Chicken Manure + Arbuscular Mycorrhizal Fungi	7.41
T ₃ - Chicken Manure + Phosphate Solubilizing Bacteria	8.23
T ₄ - Rice Straw + Arbuscular Mycorrhizal Fungi	7.4
T ₅ - Rice Straw + Phosphate Solubilizing Bacteria	6.5
T ₆ - Bone Meal + Arbuscular Mycorrhizal Fungi	5.57
T ₇ -Bone Meal + Phosphate Solubilizing Bacteria	6.6
F test	S
S.Ed (±)	0.27

D. effect of organic and bio fertilizer on Panicle length(cm) of quinoa (*Chenopodium quinoa wild*)

Panicle length (cm) at harvest showed significant variation across treatments. The highest panicle length was recorded in T₃ (chicken manure + phosphate solubilizing bacteria) at 19.3 cm, statistically at par with T₂ (chicken manure + arbuscular mycorrhizal fungi) at 17.5 cm. The shortest panicle length was

observed in T₁ (control) at 12.6 cm. The combined use of chicken manure and PSB significantly enhanced panicle length by improving phosphorus and nitrogen availability, boosting plant metabolism and reproductive growth. Organic fertilizers like chicken manure improve soil health and nutrient uptake (Verma *et al.*, 2019) [6], while PSB enhances phosphorus acquisition, leading to better yields (Ali *et al.*, 2021).

Table 4: effect of organic and bio fertilizer on panical length(cm) of quinoa (*Chenopodium quinoa wild*)

Treatments	Panicle Length
T ₁ - Control	12.5
T ₂ - Chicken Manure + Arbuscular Mycorrhizal Fungi	17.3
T ₃ - Chicken Manure + Phosphate Solubilizing Bacteria	18.7
T ₄ - Rice Straw + Arbuscular Mycorrhizal Fungi	16.5
T ₅ - Rice Straw + Phosphate Solubilizing Bacteria	15.3
T ₆ - Bone Meal + Arbuscular Mycorrhizal Fungi	14.4
T ₇ -Bone Meal + Phosphate Solubilizing Bacteria	13.5
F test	S
S.Ed (±)	0.31
CD (P=0.05)	0.68

Harvest index

E. effect of organic and bio fertilizer on harvest index of quinoa (*Chenopodium quinoa wild*)

Recorded at harvest, showed significant variation across treatments. The highest HI was in T₃ (chicken manure + PSB) at 42.1, followed by T₂ (chicken manure + AMF) at 35.8, both

significantly higher than the control (T₁) at 22.2. reflects the plant's efficiency in converting biomass to grain. Organic amendments like chicken manure enhance assimilate partitioning (Singh *et al.*, 2020), while PSB improves phosphorus uptake and yield traits, increasing HI (Sharma *et al.*, 2018).

Table 5: effect of organic and bio fertilizer on harvest index of quinoa (*Chenopodium quinoa wild*)

Treatments	Harvest INDEX
T ₁ - Control	23.4
T ₂ - Chicken Manure + Arbuscular Mycorrhizal Fungi	35.2
T ₃ - Chicken Manure + Phosphate Solubilizing Bacteria	41.4
T ₄ - Rice Straw + Arbuscular Mycorrhizal Fungi	33.5
T ₅ - Rice Straw + Phosphate Solubilizing Bacteria	30.3
T ₆ - Bone Meal + Arbuscular Mycorrhizal Fungi	31.4
T ₇ -Bone Meal + Phosphate Solubilizing Bacteria	28.7
F test	S
S.Ed (±)	0.73
CD (P=0.05)	1.60

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