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Effect of spacing and nitrogen management on yield and economics of quinoa (*Chenopodium quinoa*)

Karasani Rajasekhar Reddy, Rajesh Singh and Ektha Singh

Abstract
A field trial was conducted during *rabi* 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P). The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorous and low in potassium. The experiment was laid out in Randomized Block Design with nine treatments each replicated thrice. The treatments which are with T_1 - 20×10 cm + 100% RDN, T_2 - 20×10 cm +75% RDN + 25% N through VC + Azotobacter, T_3 - 20×10 cm +50% RDN + 50% N through VC + Azotobacter, T_4 - 25×10 cm + 100% RDN, T_5 - 25×10 cm +75% RDN + 25% N through VC + Azotobacter, T_6 - 25×10 cm +50% RDN + 50% N through VC + Azotobacter, T_7 - 30×10 + 100% RDN, T_8 - 30×10 +75% RDN + 25% N through VC + Azotobacter, T_9 – 30×10 +50% RDN + 50% N through VC + Azotobacter used. The results showed that Maximum seed yield (19.46 q/ha), stover yield (23.34 q/ha) were significantly recorded with 30×10 +75% RDN + 25% N through VC + Azotobacter compared to all other treatments. However, the maximum gross returns (116760.00 INR/ha), net returns (69540.00 INR/ha) and B:C ratio (1.47) was significantly higher recorded with the application of 20×10 cm +75% RDN + 25% N through VC + Azotobacter as compared to all other treatments.

Keywords: Quinoa, spacing, vermicompost, azotobacter, yield and economics

Introduction
Quinoa (*Chenopodium quinoa*) is a pseudo-cereal crop and member of *Chenopodiaceae* family. It is a seed crop that has been cultivated for thousands of years for its nutritious grain and leaves (Pearsall, 1992) [9]. Quinoa is discovered as a healthy food by North Americans and Europeans in the 1970's and its popularity is dramatically increased in recent years because it is gluten-free (helpful for diabetic patients) and high in protein. It is an annual broad-leaved plant, also adaptable to the conditions of marginal lands (Rea *et al*., 1979) [11], allotetraploid (2n=36). Plants grow upto 1–2 meter tall with deep penetrating roots. Each inflorescence produces hundreds of small achenes, around 2 mm in diameter. Quinoa is an achene (a seed-like fruit with a hard coat) with diversified colours ranging from white or pale yellow to orange, red, brown and black. Quinoa has greater plasticity of adaptation to photoperiod, altitude, soil pH etc., (Simmonds, 1971) [12]. Quinoa seeds contains essential amino acids, particularly methionine, threonine and lysine, which are the limiting amino acids in most of the cereal grains (Comai *et al*., 2007) [3]. The organization of the United Nations for Food and Agriculture (FAO) has declared the year 2013 as the year of quinoa (Anonymus, 2013) [1]. In India, quinoa was cultivated in an area of 440 hectares with an average yield of 1053 tonnes (Srinivasa Rao, 2015) [13].

Vermicomposting involve biological decomposition of organic waste to produce a stabilized organic fertilizer. However, vermicomposting is distinguished from all other pollution control processes, including composting, in that an animal-an earthworm-facilitates the microbial action on the waste. This occurs because the waste is exposed to certain bacteria and enzymes present in the earthworm gut which are not available during composting or other biological degradation processes and which bestow special attributes to a vermicompost (Hussain *et al*., 2018) [6].

Vermicomposting is an effective means of composting the decomposable organic wastes using earthworms and its nutrient level 1-1.5%N, 0.6-0.8%P and 1.2-1.5% Biofertilizer, an alternate low cost resource have gained prime importance in recent decades and play a vital role in maintaining long term soil fertility and sustainability. They are cost effective, eco-friendly and renewable sources of plant nutrients to supplement chemical fertilizers. Azotobactor has been recognized as an important diazotoph colonizing root environment of cereal crops.

It fixes atmospheric nitrogen, 25 to 30 kg per ha. (Singh *et al.*, 2015) [14].

Materials and Methods

A field experiment was conducted during Rabi season 2020 at Crop Research Farm, Department of Agronomy, SHUATS, Prayagraj (U.P) during Kharif season 2020. The soil was sandy loam in texture, low in organic carbon and medium in available nitrogen, phosphorous and low in potassium. Nutrient sources were Urea, DAP, MOP to fulfill the requirement of Nitrogen, phosphorous and potassium. The treatments which are with T_1 - 20×10 cm + 100% RDN, T_2 - 20×10 cm +75% RDN + 25% N through VC + Azotobacter, T_3 - 20×10 cm +50% RDN + 50% N through VC + Azotobacter, T_4 - 25×10 cm + 100% RDN, T_5 - 25×10 cm +75% RDN + 25% N through VC + Azotobacter, T_6 - 25×10 cm +50% RDN + 50% N through VC + Azotobacter, T_7 - 30×10 + 100% RDN, T_8 - 30×10 +75% RDN + 25% N through VC + Azotobacter, T_9 - 30×10 +50% RDN + 50% N through VC + Azotobacter used.The Experiment was laid out in Randomized Block Design, with nine treatments which are replicated thrice. Date of sowing was on 10th December 2020 with the seed rate of 15 kg/ha. In the period from germination to harvest several plant growth parameters were recorded at frequent intervals along with it after harvest several yield parameters were recorded those yield parameters like seeds per panicle, grain yield, test weight (1000 seeds), stover yield, harvest index and economics were recorded and statistically analyzed using analysis of variance (ANOVA) as applicable to Randomized Block Design (Gomez K.A. and Gomez A.A. 1984).

Results

Yield

Data in table 1 tabulated that 30×10 +75%RDN + 25% N through VC + Azotobacter resulted maximum seed yield (19.46 q/ha), stover yield (23.34 q/ha). However harvest index (22.38%) which are recorded maximum with the application of 25×10 cm +75%RDN + 25% N through VC + Azotobacter which was significantly higher. Minimum seed yield (12.85 q/ha) and stover yield (16.69 q/ha) were recorded in 30×10 + 100% RDN.

Table 1: Effect of Spacing and Nitrogen management yield of quinoa

S. No	Treatments	Seed yield (q/ha)	Stover yield (q/ha)	Harvest index (%)
1.	20×10 cm + 100% RDN	13.99	18.17	43.50
2.	20×10 cm +75%RDN + 25% N through VC + Azotobacter	15.47	19.23	45.46
3.	20×10 cm +50%RDN + 50% N through VC + Azotobacter	14.67	18.51	44.93
4.	25×10 cm + 100% RDN	13.35	17.41	43.38
5.	25×10 cm +75%RDN + 25% N through VC + Azotobacter	18.40	21.94	45.59
6.	25×10 cm +50%RDN + 50% N through VC + Azotobacter	17.18	21.30	44.65
7.	30×10 + 100%RDN	12.85	16.69	43.50
8.	30×10 +75%RDN + 25% N through VC + Azotobacter	19.46	23.34	44.58
9.	30×10 +50%RDN + 50% N through VC + Azotobacter	18.91	23.18	44.20
S. EM (±)		0.02	0.37	0.42
C. D. (P = 0.05)		0.07	1.12	1.26

Economics

Data in table 2 tabulated Experimental results revealed that application of 20×10 cm +75%RDN + 25% N through VC + Azotobacter recorded higher gross returns (116760.00 INR) net returns (69540.00INR) and benefit: cost ratio (1.47).

Table 2: Effect of Spacing and Nitrogen management on economics of Quinoa

S. No	Treatments	Cost of Cultivation (INR/ha)	Gross return (INR/ha)	Net Return (INR/ha)	B:C ratio
1.	20×10 cm + 100% RDN	41334.50	83940.00	42605.50	1.03
2.	20×10 cm +75%RDN + 25% N through VC + Azotobacter	47220.00	116760.00	69540.00	1.47
3.	20×10 cm +50%RDN + 50% N through VC + Azotobacter	52981.20	113460.00	60487.80	1.14
4.	25×10 cm + 100% RDN	41034.50	80100.00	39065.50	0.95
5.	25×10 cm +75%RDN + 25% N through VC + Azotobacter	46920.00	110400.00	63480.00	1.35
6.	25×10 cm +50%RDN + 50% N through VC + Azotobacter	52681.20	103080.00	50398.80	0.95
7.	30×10 + 100%RDN	40584.50	77100.00	36515.50	0.89
8.	30×10 +75%RDN + 25% N through VC + Azotobacter	46470.00	92820.00	46350.00	0.99
9.	30×10 +50%RDN + 50% N through VC + Azotobacter	52231.20	88020.00	35788.80	0.68

Discussion

Increasing grain yield might be due to under 30 × 10 cm because the less intra row spacing in other treatments increases competition in solar radiation that ultimately stunt growth of some intra row plant in vegetative phase and they were unable to reach reproductive phase even though the yield contributing variables were high when compared to the recommended spacing, the productivity was low due to the lesser plant population reached to reproductive phase. The findings were in accordance with Çiftçi *et al.* (2020) [4]. This positive effect might be due to the fact that nitrogen is well known for its role in development and growth of plant and in various vitally important metabolic processes in the plant, the positive results of RDF and vermicompost application helped in increase of plant growth which led to higher stover yield. The similar findings were found by Himanshi and Shroff (2020) [5]. Jadhav *et al.* (2011) in their study found that significantly higher grain (3707 and 3503 kg/ha) and stover (8120 and 7743 kg/ha) yields with application of 120 and 90 kg N/ha, respectively was observed. Whereas, the grain yield of 3674 kg/ha was recorded with vermicompost @1.5 t/ha. Ramesh *et al.* (2017) [10] reported that the maximum net returns (Rs.192640 ha^{-1}), benefit cost ratio (4.13) was recorded higher on 15th October date of sowing at 15×10 cm spacing compared to other treatments. Marwein *et al*. (2019) [7] in their experiment revealed that variety SIA 3156, integration of inorganic fertilizer of 75% RD N through Urea + 25% N through PM + Azospirillum Seed Inoculation found maximum higher Net return (₹ 32,229.35 /ha) and maximum B: C ratio (2.59) in foxtail millet. Maurya *et al*. (2019) [8] found that grain yield and straw yield (kg ha^{-1}) were found under incorporation of 125% recommended dose of fertilizer + 25% N through vermicompost. the highest net return (Rs.42909 ha^{-1}) and benefit: cost ratio (1.16) was observed under 100% RDF + 25% through vermicompost. Aparna *et al*. (2020) [2] found that highest gross returns (Rs. 72931 ha^{-1}), net returns (49772 ha^{-1}) and B: C ratio (3.15) were accrued from T_7- 75% RDN +25% N through cotton stubbles vermicompost + 2% rock phosphate and it was on par with T_5- 75% RDN +25% N through cotton stubbles vermicompost.

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