

Response of quinoa to different levels of spacing and fertilizer

ABSTRACT

In recent years, quinoa has been considering as extraordinary and promising nutri-rich crop, therefore supplementing or replacing of common cereal grains with quinoa carries high potential benefits to consumers worldwide. This is considered as pseudo-cereal crop, as it is a broad leaf plant with starchy dicotyledonous seed and therefore not a cereal. A field experiment entitled response of quinoa (*Chenopodium quinoa*) to different levels of spacing and fertilizer was conducted during *rabi* season of 2018-19, 2019-20 and 2020-21 at Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The result of ~~experiment~~the experiment indicated Plant height at 30, 60 DAS and at harvest was found significantly the highest in spacing S₃ (22.5 cm X 15 cm). In case of fertilizer levels, F₃ (60-40-40 NPK kg/ha) treatment was found significantly the highest plant height at 30, 60 DAS and at harvest. The Inflorescence length and girth was recorded ~~non-significant~~nonsignificant in different spacing but which was recorded significantly the highest in treatment F₃ (60-40-40 NPK kg/ha) among different fertilizer levels. In Pooled basis of spacing, the grain and straw yield were found significantly higher in treatment S₁ (30 cm X 10 cm) and in case of fertilizer levels, the grain and straw yield were recorded ~~significantly the highest~~significantly higher in treatment F₃ (60-40-40 NPK kg/ha). In economics, the spacing treatment of S₁ (30 cm X 10 cm) gave maximum net return and BCR. In the different fertilizer levels, treatment F₃ (60-40-40 NPK kg/ha) gave maximum net return and BCR.

Keywords: Quinoa, *Chenopodium quinoa*, Spacing and fertilizer

Introduction

Quinoa (*Chenopodium quinoa* Willd.) is ~~aan~~ herbaceous annual plant in the

Amaranthaceae family. It originated in South America's Andean region, where indigenous Inca civilizations in Bolivia, Chile, Ecuador, and Peru cultivated it between 5000 and 750 B.C. (Ruas *et al.*, 1999). Quinoa cultivation is one of the main sources of income for Andean farmers in South America, but it is no longer limited to them as it has spread to other areas of the world. Quinoa farming has expanded significantly in North America and Europe in recent years. Because of its wider resilience to varying climatic conditions and abundant nutrient supplies, India has lately joined the list of countries cultivating quinoa. It is taken in a variety of forms, including grains, flakes, pasta, bread, biscuits, beverages, and meals. North Americans and Europeans discovered it as a healthy snack around 1970, and its popularity has skyrocketed in recent years because to its gluten-free (useful for diabetic patients) and high protein content. According to the United Nations Organisation for Agriculture and Food (UNOAF), quinoa grain is the only vegetable food that delivers all essential amino acids that are important for human health and is nutritionally comparable to milk. It has a high protein level ranging from 14 to 18%, which is substantially higher than that of regularly used cereals and millets. It contains a variety of important amino acids, including lysine, isoleucine, methionine, histidine, cystine, and glycine. It has a high concentration of Ca, Fe, Zn, Cu, and Mn, as well as important fatty acids like linoleate and linolenate. Furthermore, 100 g of seed contains vitamins such as thiamine (0.4 mg), folic acid (78.1 mg), vitamin C (16.4 mg), riboflavin (0.39 mg), and carotene (0.39 mg) (Bhargava *et al.*, 2007).

It is a resilient plant that thrives under moisture stress and can even be cultivated in marginal soils. However, sandy loam is the best soil for growing quinoa. It grows natively in the Himalayan area of India, where temperatures range from 0 to 20 degrees Celsius. Sardarkrushinagar Dantiwada Agricultural University in Gujarat has begun evaluating various quinoa germplasms and developing agro-techniques for the semiarid plain region as part of a research effort in the [All-India All-India](#) Co-ordinated Research Network on Potential Crops.

One of the most essential components of systematic cultivation that could improve crop productivity is inter and intra row spacing. Plants can obtain sufficient water, sunlight, and nourishment from the soil ~~as a result of~~[because of](#) optimal spacing, which can influence healthy seed output and yield qualities. Despite its versatility and nutritional superiority, its commercial potential has mostly gone unfulfilled. There is little literature on the date of planting, optimum density, seed rate, spacing, and other agro-techniques for its production in India. In India, very little research has been conducted on the acceptability and ~~standardisation~~[standardization](#) of quinoa packing ~~praetises~~[practices](#). In view of above facts, the research entitled “Response of quinoa (*Chenopodium quinoa* Willd.) to different level of spacing and fertilizer” was ~~under~~

~~taken~~undertaken with an objective to standardize the optimum spacing and fertilizer levels for quinoa crop.

Materials and methods

A field experiment entitled response of quinoa (*Chenopodium quinoa*) to different levels of spacing and fertilizer was conducted during *rabi* season of 2018-19, 2019-20 and 2020-21 at Centre for Crop Improvement, Sardarkrushinagar Dantiwada Agricultural University, Sardarkrushinagar. The soil of the experimental site was loamy sand in texture, low in organic carbon (0.21%) and available nitrogen (137.6 kg/ha), medium in available phosphorus (25.67 kg/ha) and available potassium (102.7 kg/ha) having pH value of 7.55. The experiment consist of 9 treatment combinations comprised of three levels of Spacing viz., S₁: 30 cm X 10 cm, S₂: 30 cm X 15 cm and S₃: 22.5 cm X 15 cm as well as three levels of fertilizers were taken in randomized block design (with factorial concept) with three ~~replication~~replications. The quinoa variety EC 507748 was sown on December 4, 2018, November 20, ~~2019~~2019, and November 13, 2020. The sowing was done manually in previously opened furrows at a depth of 2 cm. Seeds were covered properly with the soil and a light irrigation was given carefully in each plot after sowing. Besides ~~above~~the above crop was grown with recommended package of practices. For effective weed control one hand weeding and interculturing was carried out during crop growing period. The observations were recorded as per the standard procedures. The data were statistically analyzed for various characters as described by Panse and Sukhatme (1967).

Results and Discussion

In Pooled basis (Table.1), The plant stand was recorded non-significant in different spacing, also same trend was found in fertilizer levels. Plant height at 30, 60 DAS and at harvest was found significantly the highest in spacing S_3 (22.5 cm X 15 cm). In case of fertilizer levels, F_3 (60-40-40 NPK/ha) treatment was found significantly the highest plant height at 30, 60 DAS and at harvest. Interaction effect was found non-significant in plant stand and plant height. This might be due to competition between plants for natural resources in narrow spacing resulted in vertical growth of plants as compared to wider spacing. In Pooled basis (Table.2), The Inflorescence length and girth was recorded non-significant in different spacings, but which was recorded significantly the highest in treatment F_3 (60-40-40 NPK/ha) among different fertilizer levels. In case of spacing, Test weight, days to 50 % flowering and HI was found non-significant. In the case of fertilizer levels, Test weight and days to 50 % flowering was found non-significant but HI was found significantly higher in treatment F_3 (60-40-40 NPK/ha) among different fertilizer levels. Interaction effect was found non-significant in Inflorescence girth, Test weight, days to 50 % flowering and HI but which was recorded significantly in inflorescence length (Table.3). In inflorescence length, Treatment combination S_2F_3 was found significantly higher which was at par with S_3F_3 and S_1F_3 under different interaction.

In Pooled basis (Table.4) of spacing, the grain and straw yield were found significantly higher in treatment S_1 (30 cm X 10 cm) which was at par with treatment S_3 (22.5 cm X 15 cm) therefore all yield attributes character were recorded higher in this spacing to other treatment. This indicates that wider spacing could not compensate in the grain yield mainly due to lesser plant density but more plant density in narrow spacing could compensate with grain yield though lower growth and yield parameters. This could be due to efficient utilization of natural resources (water, light and nutrients) with optimum vegetative growth and higher translocation of photosynthates from source to sink. The above results were in conformity with the findings of Yarnia (2010) and Pourafarid *et al.* (2014). This indicates that wider spacing could not compensate in the grain yield mainly due to lesser plant density. In case of Fertilizer levels, the grain and straw yield were recorded significantly as the highest in treatment F_3 (60-40-40 NPK/ha) due to all yield attributes parameters were recorded higher in this treatment among different treatments. As fertilizer frequencies increased there was remarkable increase in yield of quinoa was observed. This could be due to adequate availability of major nutrients which are required in larger quantity thus directly help the plants to register higher growth and

development and finally grain yield. The above results ~~were in agreement~~agreed with the findings of Parmar and Patel (2009) and Gunjal (2011). Interaction effect (S×F) was found ~~non significant~~nonsignificant in grain and straw yield at pooled basis result.

In economics, the spacing treatment of S₁ (30 cm X 10 cm) had ~~gave given~~ maximum net return (73,571 Rs/ha) and BCR (3.08) to rest of the spacing. In the different fertilizer levels, treatment F₃ (60-40-40 NPK/ha) had gave maximum net return and BCR to among different levels.

Nitrogen content in seed and straw were found to be non-significant due to different spacing, fertilizer levels and its interaction (Table 5). Phosphorous content in seed & straw were found to be non-significant under different spacing and its interaction. whereas Phosphorous content in seed, fertilizer level F₁ was found significantly higher which was at par with F₂ level and Phosphorous content in straw, fertilizer level F₁ was found significantly the highest (Table 5). Potassium content in seed was found to be non-significant under different fertilizer levels and its interaction whereas in spacing S₃ was found significantly higher which was at par with S₂. Potassium content in straw was found to be non-significant due to different spacing, fertilizer levels and its interaction (Table 5).

The data (Table 6) regarding available nitrogen (kg/ha) in soil after harvest of quinoa was found to be non-significant under different spacing, fertilizer levels and its interaction effect. The data (Table 6) regarding available phosphorous (kg/ha) in soil after harvest of quinoa was found to be non-significant under different spacing, fertilizer levels and its interaction effect. The data (Table 6) regarding available potassium (kg/ha) in soil after harvest of quinoa was found to be non-significant under different spacing, fertilizer levels and its interaction effect.

Conclusion

Based on the pooled results of the ~~three year~~three-year experimentation, it is concluded that, for getting higher grain yield and net returns of quinoa the crop, should be sown 30 cm × 10 cm of spacing and applied fertilizer dose 60-40-40 NPK kg/ha during *rabi* season.

References

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Table 1: Effect on plant stand <u>stand and</u> height of quinoa under different levels of spacing and fertilizer				
Treatments	Plant stand <u>stands</u> at harvest	Plant Height at 30 DAS (cm)	Plant Height at 60 DAS (cm)	Plant Height at Harvest (cm)
Spacing (S)				
S1	220	18.68	81.88	121.14
S2	170	18.75	77.27	113.7
S3	245	19.83	87.61	124.15
S_Em	16.00	0.308	1.462	1.868
CD (5 %)	NS	0.876	4.153	5.304
Fertilizer levels (F)				
F1	206	12.51	70.33	106.38
F2	213	20.48	82.79	120.43
F3	216	24.28	93.64	132.19
S_Em	3.60	0.978	1.382	3.366
CD (5 %)	NS	3.839	3.925	13.215
Interaction (S×F)				
S_Em	10.770	0.517	2.357	3.162
CD (5 %)	NS	NS	NS	NS
C.V %	8.81	8.63	8.77	8.27

Table 2: Effect on <u>Yield</u> attributes and HI <u>of HI</u> of quinoa to different levels of spacing and fertilizer					
Treatments	Inflorescence length (cm)	Inflorescence girth <u>girth</u> (cm)	Test weight (g/10ml)	Days to 50% Flowering	Harvest index (%)
Spacing (S)					
S1	25.16	39.5	7.29	47.0	46.31
S2	24.05	39.9	7.32	46.6	46.51
S3	25.34	39.6	7.22	47.6	45.97
S_Em	0.446	0.61	0.555	0.379	0.333
CD (5 %)	NS	NS	NS	NS	NS
Fertilizer levels (F)					
F1	21.05	33.6	7.22	47.18	45.68
F2	25.43	40.8	7.29	46.89	46.2
F3	28.07	44.6	7.32	47.17	46.91
S_Em	1.307	1.05	0.555	0.391	0.141
CD (5 %)	5.131	4.124	NS	NS	0.401
Interaction (S×F)					
S_Em.	0.775	1.018	0.1	0.633	0.234
CD (5 %)	2.197	NS	NS	NS	NS
C.V %	9.27	8.31	4.09	4.28	1.52

Treatment	Fertilizer Levels		
Spacing	F1	F2	F3
S1	21.56	25.65	28.26
S2	18.50	25.17	28.50
S3	23.11	25.47	27.45
S.Em	0.775		
CD (5 %)	2.197		
C.V %	9.27		

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Gross Income (Rs/ha)	Cost of cultivation (Rs/ha)	Net Income (Rs/ha)	BCR
Spacing (S)						
S1	20.8	24.0	93735	30339	63397	3.09
S2	18.8	21.5	84645	30339	54307	2.79
S3	20.0	23.4	90000	30339	59662	2.97
S.Em	0.392	0.395	-	-	-	-
CD (5 %)	1.11	1.12	-	-	-	-
Fertilizer levels (F)						
F1	14.9	17.67	67230	30339	36892	2.22
F2	20.5	23.86	92295	32002	60293	2.88
F3	24.2	27.28	108900	35329	73571	3.08
S.Em	0.393	0.404	-	-	-	-
CD (5 %)	1.12	1.15	-	-	-	-
Interaction (S×F)						
S.Em	0.694	0.68	-	-	-	-
CD (5 %)	NS	NS	-	-	-	-
C.V %	10.31	8.86	-	-	-	-
Quinoa selling Price: 45 rs/kg						

Table 5: N, P & K Content in seed & straw of quinoa under different levels of spacing and fertilizer						
Treatments	Nutrients content (%) in seed			Nutrients content (%) in straw		
	N	P	K	N	P	K
Spacing (S)						
S1	13.86	0.38	1.03	1.68	0.37	4.07
S2	16.42	0.40	1.23	1.27	0.39	4.02
S3	0.85	0.34	1.33	1.45	0.33	3.84
S.Em	0.147	0.0232	0.074	0.15	0.026	0.22
CD (5 %)	NS	NS	0.222	NS	NS	NS
Fertilizer levels (F)						
F1	0.17	0.43	1.23	1.57	0.46	4.18
F2	0.05	0.36	1.15	1.42	0.33	4.07
F3	0.46	0.33	1.21	1.40	0.30	3.68
S.Em	0.147	0.0232	0.074	0.15	0.026	0.22
CD (5 %)	NS	0.069	NS	NS	0.08	NS
Interaction (S×F)						
S.Em	0.255	0.04	0.128	0.26	0.046	0.381
CD (5 %)	NS	NS	NS	NS	NS	NS
C.V %	18.61	18.69	18.62	30.8	22.17	16.62

Table 6: Available N, P & K status of soil aftersoil after harvest of quinoa			
Treatments	Available nutrient status (kg/ha) in soil		
	Available N	Available P ₂ O ₅	Available K ₂ O
Spacing (S)			
S1	140.8	20.1	102.3
S2	124.8	21.9	91.7
S3	147.7	25.4	108.7
S.Em	7.692	3.094	5.42
CD (5 %)	NS	NS	NS
Fertilizer levels (F)			
F1	139.4	22.1	108.0
F2	142.9	20.4	97.5
F3	131.0	24.8	97.2
S.Em	7.692	3.094	5.42
CD (5 %)	NS	NS	NS
Interaction (S×F)			
S.Em	13.324	5.36	9.388
CD (5 %)	NS	NS	NS
C.V %	16.75	41.38	16.11



Fig .1 Field view of experiment at harvest time



Fig .2 Treatment S1F3 (30 cm X 10 cm) X (60-40-40 N,P,N,P & K)