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Growth, Yield Attributes, Yield and Economics of Quinoa (*Chenopodium quinoa* willd.) as Influenced by Variable Irrigation Water Supply through Drip and Surface Methods

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A field experiment was conducted at college farm, college of Agriculture, PJTSAU, Rajendranagar, Hyderabad , Telangana, during *rabi* 2016-17 to evaluate effect of irrigation treatments on growth, yield parameters yield and economics of quinoa (*Chenopodium quinoa* Willd.) in Semi-Arid region of Telangana, India. The experiment was laid out in Randomized Block design with three replications and ten treatments, comprising varied levels of irrigation scheduled in different stages of crop growth in both drip and surface method of irrigation. Quinoa is the newly introduced crop to Indian subcontinent its performance under variable irrigation water at various growth stages was evaluated. Results revealed that growth parameters like plant height, number of branches at different stages of crop and yield attributes i.e. main panicle length, number of panicles plant^{-1}, test weight (1000-grain weight), grain yield, stalk yield and harvest index were significantly higher with 1.0 E_{pan} throughout cropping period (T_2) followed by mild stress treatment at flowering stage (T_8) under drip irrigated treatment and 1.0 IW: CPE in surface method of irrigation (T_{10}). The highest grain yield and stalk yield was recorded with 1.0 E_{pan} throughout cropping period (T_2). Higher cost of cultivation, gross and net return was recorded in T_2 followed by T_8

Introduction

Quinoa (*Chenopodium quinoa* willd.) is an annual herbaceous plant, belongs to the Chenopodiaceae, growing up to 1.5 m long having the broad leaves with tap root system. Quinoa is native to the South America where it is grown in large scale since thousand years. Crop is well adapted to poor soil and unfavorable climatic conditions (Garcia *et al.*, 2003). It has the ability to tolerate low temperatures (8°C) (Jensen *et al.* 2000) drought (Vacher, 1998). Quinoa is new crop for India and can be successfully grown in the Himalayas and the plains of Northern India with reasonably high yields (Bhargava *et al.*, 2006). In India, quinoa was cultivated in an area of 440 hectares with an average yield of 1053 tons (Srinivasa Rao, 2015). Since Independence, India experienced green revolution (rice & wheat), white revolution (milk) and still India tops in chronic malnutrition. Very high per cent population was suffering with diabetes due to over dependence on few cereal foods (rice or wheat) (APARD, 2013-14). Quinoa is good source of food with high nutritional and medicinal values especially amino acids, high quality protein content, vitamins, minerals *etc.* are twice the normally consuming cereals. It can be introduced in India to check malnutrition as well as to increase foreign exchange. Quinoa is considered as strategic crop with higher potential in contributing to food and nutritional security due to higher nutritional quality, genetic variability, adaptability to adverse climate and soil conditions and economically low production cost or cultural adaptability to Indian farming system. Great potential of the crop is not yet fully exploited under Indian condition mainly because of lack of research on biotic and non-biotic stresses. As the people are conscious about their health, quinoa is gaining the increased demands in domestic and international market. Introduction of quinoa in the cropping systems adds to additional income to the farmer as the B: C ratio is proved. The cultivation of quinoa provides an alternative for countries with limited food production which are therefore forced to import or receive food aid.

Under Semi-arid weather conditions, every drop of water counts and nearly 80% of water resource in India are using for agriculture purposes (Dhavan, 2017). Water demand goes on increasing day by day and on other hand the depletion of ground water and insufficient water availability to agriculture has made the irrigation specialists and agronomist to adopt new crops and cropping systems. Water demand originates not only from the physical constraints of fresh water resources, but also due to its inefficient use and poor quality which are likely to widen the gap between water supply and demand in most parts of the world. Precise quantity of water need to be optimized for the crops for reasonable yields. Quinoa is one such drought tolerant crop that suits in cropping systems of arid and semi-arid areas (Jensen *et al*., 2000). Garcia (2003) and Geerts *et al*. (2009) demonstrated yield optimization in quinoa through deficit irrigation with maximum water productivity in other countries. Hence an experiment was formulated to study the response of quinoa to variable water supply in drip and surface method of irrigation on growth, yield attributes, yield and economics in Southern Telangana zone, India.

Materials and Methods

The field experiment framed out and was conducted at college farm. College of Agriculture, Rajendranagar, Hyderabad during *rabi* season 2016-17. Geographically experimental site is situated at an altitude of 542.3 m above mean sea level at 17°19'21.1"N 78°24'36.6"E longitudes and categorised under the South Agro-climatic region of Telangana. The soil of the experimental site was sandy loam in texture, slightly alkaline in reaction (7.8), non-saline (0.14 dsm^{-1}), low in organic carbon content (0.43 %), medium in available nitrogen (256.5 kg ha^{-1}), medium in available phosphorous (66.68 kg ha^{-1}) and high in available potassium (344.61 kg ha^{-1}). Moisture retention capacity of the experimental field was estimated at saturation, field capacity (FC) and permanent wilting point (PWP) using pressure plate apparatus. Average available soil moisture in 0-60 cm was 96.2 mm

The main objective of this study was how quinoa, a newly introduced crop responds to water stresses under Indian condition and to know effect of irrigation on growth and yield. The experiment was conducted in Randomized block design with three replications. Ten treatment combinations comprised of 0.5 E_{pan} throughout cropping period (T_1), 1.0 E_{pan} throughout cropping period (T_2), irrigation with 0.5 E_{pan} at vegetative and 1.0 E_{pan} at both flowering and at grain filling stage (T_3), Irrigation with 0.5 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stage (T_4), Irrigation with 0.5 E_{pan} at vegetative, 0.5 at flowering and 1.0 at grain filling stage (T_5), Irrigation with 1.0 E_{pan} at vegetative, 0.50 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages (T_6), Irrigation with 1.0 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 at grain filling stages(T_7), Irrigation with 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages (T_8), Irrigation with 0.5 IW: CPE throughout crop growth by flatbed method (T_9) and Irrigation with 1.0 IW:CPE throughout crop growth by flatbed method (T_{10}). Spacing followed was 30 x10 cm. The T_1 to T_8 are drip and T_9 and T_{10} are surface irrigated treatments. In Drip irrigation treatments, irrigation was scheduled at three days interval based on Class-A open $_{pan}$ evaporimeter. Irrigation water depth of 50 mm was fixed in surface method of irrigation. In drip method of irrigation, 16 mm linear low density polyethylene (LLDPE) drip laterals were laid at a spacing of 0.6 m with 2 lph emitters fixed at a distance of 0.20 m. The total available soil moisture is the difference between - 0.2 MPa and -1.5 MPa in 0-60 cm soil depth amounted to 96.20 mm. The fertilizer dose of 80:50:40 kg ha^{-1} N, P_2O_5 and K_2O respectively was applied to quinoa in the form of urea, single super phosphate and muraite of potash respectively. Total amount of P was applied as basal, K in equal two splits half as basal and other half at 30 DAS. The N was applied in three equal splits at basal, 30 DAS and at flowering stage. Crop was sown on 29thOctober 2016 and necessary agronomic and plant protection operations were taken during crop growth period. Crop was harvested on 10th of February 2017. The data on growth, yield attributes and yield was recorded at harvest and statistically analysed. Economics is calculated based on prevailing market price of quinoa.

Results and Discussion

Number of plants m^{-2} was influenced by irrigation treatments. Highest plant population (lakh ha^{-1}) was observed in T_2 at initial and at harvest (3.0 and 2.7), lower plant population was recorded in T_1 and T_9 (Table 1). The plant height of quinoa was significantly influenced by different irrigation treatments (Table 1). The results indicated that the plant height of quinoa increased progressively with the advancement of crop age up to harvest, irrespective of the treatments. Plant height ranges from 30.4 to 42.1 cm at vegetative stage. Treatment T_8 recorded the higher plant height (42.1cm) and surface method of irrigation at 0.5 IW: CPE (T_9) recorded the less height. Stress free condition at initial stages of the crop might be the cause for increment in the plant height in superior treatments. At flowering, T_4 recorded higher plant height (107.8 cm). Lower plant height was observed under surface irrigation of 0.5 IW: CPE and 1.0 IW: CPE (87.9 and 83.7 cm) respectively. It might be due to insufficient soil moisture in the root zone that resulted in reduced plant height. Similar results were presented by Singh and Singh (2014) in mustard. Higher plant height (134.3 cm) at grain filling was observed T_4, shorter plant was recorded in $T_{1.}$ Increment in the plant height due to water stress is linked to increased xylem ion content (Yang *et al*., 2016). Similar results are reported by Ramesh *et al*., (2017) when crop was at 90 days after sowing of quinoa in Telangana regions of India.

Leaf area index (LAI) gradually increased with stage of the crop and reached peak at grain filling stage and declined at maturity

(Table 2) due to drying and senescence of foliage. The non-stressed treatment T_2 reported significantly higher LAI at all stages of the crop, it is followed by non-stressed treatments at grain filling stages (T_3, T_5 and T_8). No stress at grain filling stages increased LAI of the crop significantly over that of mild stress imposed treatments. Sufficient supply of irrigation to crop is known to increase the turgidity of leaves and cell division resulting in higher meristematic activity leading to higher leaf area and LAI. The increase in LAI of quinoa with irrigation has also been reported by Garcia *et al*. (2000) and Vocher (2014). Higher LAI at mild stress condition was reported by Razzhagi *et al*. (2012) the same was expected however, mild stress treatment (T_1) recorded lower leaf area index.

At flowering and grain filling stages, number of branches were significantly higher (16.9 and 20.3) with surface irrigated treatments (T_9 and T_{10}) and might be due to less number of plants m^{-2} (insufficient plant population) that helped in horizontal growth of the plant (more branches plant^{-1}) but resulted in less sink (panicle) reported. The plasticity of quinoa plant to adjust to varied plant population was reported by Ramesh *et al*., (2017).

Yield attributes, grain and stalk yield of quinoa were significantly influenced by different irrigation scheduling treatments (Table 4). Yield attributes like number of panicle plant^{-1}, length of panicle and 1000-seed weight were higher in crop irrigated at 1.0 E_{pan} throughout cropping period (T_2) followed by irrigation with 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages (T_8) grain yield of quinoa in T_2 and T_8 was comparable with the results of Geren and Geren (2015). Better vegetative growth was ultimately associated with higher yield attributing characters due to increased absorption of mineral nutrients under adequate available soil moisture (Yazar *et al*., 2015 and Singh and Singh. 2014). Higher grain and stalk yields were recorded under irrigation given at 1.0 E_{pan} throughout cropping period (T_2) which might be due to better translocation of photosynthats from source to sink as the result of moisture availability led to higher yields. Higher grain yield of quinoa with optimum irrigation schedule was supported by Geerts *et al.* (2009), Walter *et al* (2016) and Geren and Geren (2015). The highest stalk yield of quinoa (3426.9 kg ha^{-1}) was obtained with 1.0 E_{pan} throughout the cropping period. This could be attributed to better vegetative growth, optimum plant stand, more dry matter production and biological yield under favored soil moisture availability especially at grain filling stages of the crop, as compared to less frequent irrigation scheduling treatments (T_1 and T_9). The harvest index in drip irrigation at 1.0 E_{pan} throughout the cropping period was higher (45.9%). The range of harvest index was higher among the treatments but was found insignificant. Lower harvest index was observed in continuous stress (0.5 IW: CPE) imposed in surface method of irrigation in (T_9) (38.5 %).

Economics

Different levels of irrigation both in drip and surface treatments showed variation in cost of cultivation, gross and net returns and B:C ratio are presented in Table 5. Economics of quinoa were calculated by considering market price of quinoa @ Rs 120 kg^{-1}. The variable cost was calculated which is Rs 10/- for ha^{-1} mm of water. An amount of 5000 season^{-1} was added to treatments T_1 to T_8 towards the cost of cultivation of drip irrigation spread over seven years and two seasons a year. Higher cost of cultivation, gross and net returns were recorded with drip irrigation scheduled at 1.0 E_{pan} throughout cropping season (T_2) compared to all other surface and drip irrigation scheduling treatments. Lower gross and net return was observed in 0.5 IW: CPE throughout crop growth period by flatbed method (T_9) and comparable with T_1.

Table.1 Plant population (lakh ha^{-1}) and plant height of quinoa as influenced by irrigation treatments at different stages of quinoa

	Treatments	**Population (lakh ha^{-1})**		**Plant height (cm)**		
		Initial (15 DAS)	Final (105 DAS)	Vegetative (35 DAS)	Flowering (60 DAS)	Grain filling (82 DAS)
T_1	0.5 E_{pan} throughout cropping period	2.9	2.5	38.5	96.9	119.1
T_2	1.0 E_{pan} throughout cropping period	3.0	2.7	41.0	102.5	126.7
T_3	Irrigation with 0.5 E_{pan} at vegetative and 1.0 E_{pan} at both flowering and at grain filling stage	2.9	2.6	37.2	100.1	132.9
T_4	Irrigation with 0.5 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stage	2.8	2.7	41.0	107.8	134.3
T_5	Irrigation with 0.5 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stage	3.0	2.6	41.8	106.0	122.9
T_6	Irrigation with 1.0 E_{pan} at vegetative, 0.50 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	2.9	2.6	40.4	94.0	130.5
T_7	Irrigation with 1.0 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 at grain filling stages	2.8	2.4	33 .4	94.6	112.7
T_8	Irrigation with 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages	3.0	2.6	42.1	103.8	129.6
T_9	Irrigation with 0.5 IW: CPE throughout crop growth by flatbed surface method	2.7	2.2	30.4	87.9	111.8
T_{10}	Irrigation with 1.0 IW: CPE throughout crop growth by flatbed surface method	2.9	2.4	41.8	83.7	117.4
	SEm ±	0.1	0.07	2.4	4.7	4.5
	CD (P=0.05)	NS	0.2	7.2	14.1	13.1

Table.2 Leaf area index of quinoa as influenced by irrigation treatments at different stages of crop

	Treatments	Leaf area index			
		Vegetative (35 DAS)	Flowering (60 DAS)	Grain filling (82 DAS)	Harvest (105 DAS)
T_1	0.5 E_{pan} throughout cropping period	0.7	2.1	2.4	1.3
T_2	1.0 E_{pan} throughout cropping period	1.0	2.6	3.0	1.7
T_3	Irrigation with 0.5 E_{pan} at vegetative and 1.0 E_{pan} at both flowering and at grain filling stage	0.7	2.3	2.6	1.4
T_4	Irrigation with 0.5 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stage	0.7	2.4	2.7	1.3
T_5	Irrigation with 0.5 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stage	0.7	2.4	2.7	1.3
T_6	Irrigation with 1.0 E_{pan} at vegetative, 0.50 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	0.7	2.4	2.7	1.3
T_7	Irrigation with 1.0 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	0.7	2.3	2.6	1.4
T_8	Irrigation with 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages	0.8	2.5	2.8	1.5
T_9	Irrigation with 0.5 IW: CPE throughout crop growth by flatbed surface method	0.8	2.3	2.7	1.2
T_{10}	Irrigation with 1.0 IW: CPE throughout crop growth by flatbed surface method	0.8	2.5	2.8	1.2
	SEm ±	0.1	0.2	0.2	0.1
	CD (P=0.05)	0.2	0.5	0.6	0.3

Table.3 Number of branches $plant^{-1}$ of quinoa as influenced by irrigation treatments at different stages of crop

	Treatments	**Vegetative (35 DAS)**	**Flowering (60 DAS)**	**Grain filling (82 DAS)**
T_1	0.5 E_{pan} throughout cropping period	5.4	8.1	11.2
T_2	1.0 E_{pan} throughout cropping period	6.3	12.9	16.0
T_3	Irrigation with 0.5 E_{pan} at vegetative and 1.0 E_{pan} at both flowering and at grain filling stage	4.9	11.9	15.0
T_4	Irrigation with 0.5 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stage	5.3	9.5	13.4
T_5	Irrigation with 0.5 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 at grain filling stage	5.4	9.2	13.8
T_6	Irrigation with 1.0 E_{pan} at vegetative, 0.50 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	4.8	8.0	9.4
T_7	Irrigation with 1.0 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	5.1	11.3	14.8
T_8	Irrigation with 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages	5.3	12.7	16.1
T_9	Irrigation with 0.5 IW: CPE throughout crop growth by flatbed surface method	5.5	16.9	17.8
	Irrigation with 1.0 IW: CPE throughout crop growth by flatbed surface method	5.8	16.9	20.3
	SEm ±	0.46	1.03	1.18
	CD (P=0.05)	1.4	3.1	3.5

Table.4 Yield contributing characters, yield, harvest index and B:C ratio of quinoa as influenced by irrigation treatments

	Treatments	**Number of panicles**	**Main panicle length (cm)**	**Test weight (g)**	**Grain yield (kg ha^{-1})**	**Stalk yield (kg ha^{-1})**	**Harvest index (%)**
T_1	0.5 E_{pan} throughout cropping period	5.3	32.5	2.1	1736.4	2465.4	41.4
T_2	1.0 E_{pan} throughout cropping period	8.1	35.8	2.4	2911.5	3426.9	45.9
T_3	Irrigation with 0.5 E_{pan} at vegetative and 1.0 E_{pan} at both flowering and at grain filling stage	6.1	35.3	2.3	2332.0	2892.3	44.6
T_4	Irrigation with 0.5 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stage	5.3	34.6	2.0	1823.0	2397.6	43.2
T_5	Irrigation with 0.5 E_{pan} at vegetative, 0.5 at flowering and 1.0 at grain filling stage	5.7	32.7	2.1	1961.9	2513.3	44.8
T_6	Irrigation with 1.0 E_{pan} at vegetative, 0.50 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	4.7	33.5	2.0	1868.5	2641	41.5
T_7	Irrigation with 1.0 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 at grain filling stages	5.1	32.3	2.2	1884.8	2577.1	42.2
T_8	Irrigation with 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages	5.3	36.2	2.2	2481.5	2998.0	45.3
T_9	Irrigation with 0.5 IW: CPE throughout crop growth by flatbed surface method	6.7	30.6	2.3	1555.3	2493.4	38.5
T_{10}	Irrigation with 1.0 IW: CPE throughout crop growth by flatbed surface method	8.4	33.4	2.0	2088.6	2952.1	41.4
	SEm ±	0.4	1.25	0.1	114.6	145.8	2.4
	CD (P=0.05)	1.2	3.7	NS	340.4	433.0	7.2

Table.5 Gross return (₹ ha^{-1}) net returns (₹ ha^{-1}) and benefit cost ratio of quinoa influenced by irrigation treatments

	Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:Cratio
T_1	0.5 E_{pan} throughout cropping period	45976	208369	162393	3.5
T_2	1.0 E_{pan} throughout cropping period	47174	349379	302205	6.4
T_3	Irrigation with 0.5 E_{pan} at vegetative and 1.0 E_{pan} at both flowering and at grain filling stage	46628	279840	233212	5.0
T_4	Irrigation with 0.5 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stage	45852	218759	172907	3.8
T_5	Irrigation with 0.5 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stage	46451	235426	188975	4.1
T_6	Irrigation with 1.0 E_{pan} at vegetative, 0.50 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	46021	224220	178199	3.9
T_7	Irrigation with 1.0 E_{pan} at vegetative, 1.0 E_{pan} at flowering and 0.5 E_{pan} at grain filling stages	46399	226170	179771	3.9
T_8	Irrigation with 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages	46797	297784	250987	5.4
T_9	Irrigation with 0.5 IW: CPE throughout crop growth by flatbed method	40812	186631	145819	3.6
T_{10}	Irrigation with 1.0 IW:CPE throughout crop growth by flatbed method	42712	250638	207926	4.9

Benefit cost ratio was higher (6.4) in treatment T_2, followed by mild stress at flowering and vegetative stage treatments (T_8 and T_3). Lower benefit cost ratio of 3.5 and 3.6 was observed in irrigation with 0.5 E_{pan} throughout cropping period (T_1 drip method) and 0.5 IW: CPE throughout crop growth by flatbed method (T_9), respectively.

It is concluded that drip irrigation scheduled at 1.0 E_{pan} throughout cropping period (T_2) recorded higher growth, yield attributes and yield and water use efficiency compared to other surface and drip irrigation treatments. In deficit water supply, drip irrigation with 0.5 E_{pan} at vegetative and 1.0 E_{pan} at both flowering and at grain filling stage (T_3) and drip irrigations at 1.0 E_{pan} at vegetative, 0.5 E_{pan} at flowering and 1.0 E_{pan} at grain filling stages (T_8) can be recommended. With the application of equal amount of irrigation water to drip and surface irrigation treatments, drip irrigated treatments recorded higher values of growth, yield attributes and yield. In the scenario of adequate water supply, scheduling of surface method of irrigation at 1.0 IW: CPE ratio (T_{10}) can be recommended for higher growth, yield attributes and yield.

References

APARD, 2013-14. Annual Report, Andhra Pradesh Academy of Rural Development.114-117.

Bhargava, A., Sudhir, S and Deepak Ohri. 2006. Chenopodium quinoa-An Indian perspective. *Industrial crops and products*. 23:73-87

Dhavan Vibha. 2017. Water and Agriculture in India. pp-1-27 https://www.oav.de

FAO.2013. International year of quinoa. http://www.fao.quinoa.org

Garcia, M., Raes, D and Jacobsen, S.E. 2003.Evapotranspiration analysis and irrigation requirements of quinoa. (*Chenopodium quinoa* Willd.) in the Bolivian highlands. *Agricultural Water Manage*ment. 60: 119–134

Geerts, S., Raes, D., Garcia, M., Mianda, R., Cusicanqui, J, A.,Taboda, C., Mendoza, J., Huanca, R., Mamani, A.,Condori, O., Mamani, J., Morals, B., Osco, V and Steduto, P. 2009. Simulating yield response of quinoa to water availability with AquaCrop.*Agronomy Journal*.101:499-508

Geren, H and Geren. 2015. A preliminary study on the effect of different irrigationwater on the grain yield and related characters of quinoa (*Chenopodium quinoa* willd). *Works of faculty of Agriculture and food sciences*. 61(66-1):269-272

Gonzalez, J.A., Gallardo, M., Hilal, M., Rosa, M., and Prado, F.E. 2009. Physiological responses of quinoa (*Chenopodium quinoa* Willd.) to drought and waterlogging stresses:drymatter partitioning. *Botanical Studies*.50: 35-42.

Jensen, C.R., Jacobsen, S.E., Andersen, M.N., Nunez, N., Andersen, S.D., Rasmussen, L and Mogensen, V, O. 2000. Leaf gas exchange and water relation characteristics of field quinoamodel (*Chenopodium quinoa* Willd.) during soil drying. *European Journal of Agronomy*.13: 11–25.

Ramesh, K., Suneetha Devi, K.B., Gopinath, K.A. and Uma Devi, M., 2017.Growth, Yield and Economics of Quinoa as Influenced by Different Dates of Sowing and Varied Crop Geometry, *International Journal of Pure and Applied Bioscience*. 5(6): 849-854

Singh, P.K and Singh A.K. 2014.Effect of different dates of sowing and irrigation scheduling on growth and yield of mustard (*Brassica juncea*).*Journal of progressive*

Agriculture. 5(2): 18-21

SrinivasaRao, K., Sarikotha panta quinoa, *Sakhi News Paper* page:10 on 11.08.2015

Vacher, J. 1998. Responses of two main crops, quinoa (*Chenopodium quinoa* Willd) and papa amarga (*Solanum juzepczukii* Buk.) to drought on the Bolivian Altiplano: significance of local adaptation. *Agriculture Ecosystem and Environmen*t. 68: 99–108.

Walters. H., Boggs. L.C., Desta. K., Yan. L., Matanguihan. J., and Murphy. K. 2016.Effect of irrigation, intercrop, and cultivar on agronomic and nutritional characteristics of quinoa. *Agroecology and Sustainable Food Systems.*40(8): 783–803

Yazer. A., Kaya, C., Sezen. S. M and Jacobson. S. 2015. Saline water irrigation of quinoa (*Chenopodium quinoa*) under Mediterranean conditions. *Crop & Pasture Science.*66(10):993- 1002

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