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Quinoa in Pakistan: A Case Study

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Background / Introduction

The human being relies on fewer plants to feed much of the planet

Total flowering species	=	10,00,000
Species described	=	2,50,000
Edible species	=	50,000
Used as source of food by mankind	=	**3,000**

More worryingly

75% of human food **= 11 crops (**wheat, rice, corn, barley, sorghum/millet, potato, sweet potato/ yam, sugarcane and soybean

60% of the calories consumed in the world **= 3** (rice, corn and wheat)

Pakistan = rice, corn and wheat, cotton, maize, sugarcane

So potential of these plants is at risk due to climate change

Quinoa (*Chenopodium quinoa* Willd.) was introduced as a climate resilient crop with potential to add into food security due to very good nutritional value, wide range of adaptability, low production cost and sustain the livelihoods of the poor farmers.

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Germplasm Screening for local adaptation

Quinoa was introduced in Pakistan during 2008 from USDA and some lines from Dr. Jacobsen

Initial Screening under following local conditions

- Faisalabad 31.4187° N, 73.0791° E
- Chakwal 32.9311° N, 72.8551° E
- RY Khan 28.4212° N, 70.2989° E

Gujrat 32.5711° N, 74.0750°

Bahawalpur 29.3957° N, 71.6833° E

Sr.	Code*	G. Line**	Plant name**	Origin
1	Ames30	Ames-13730	IESP	New Mexico, USA
2	Ames37	Ames 13737	2WANT	New Maxico, USA
3	Ames37	Ames-13739	29TES	New Maxico, USA
4	Ames60	Ames 13760	22GR	New Maxico, USA
5	Ames62	Ames 13762	47TES	New Maxico, USA
6	P32	PI 510532	Quinoa de Quiaca.	Peru
7	P33	PI 510533	K'ello quinoa (Quechua)	Peru
8	P37	PI 510537	Koito Juira (Aymara) Qu	Peru
9	P40	PI 510540	Grande (spain.)	Peru
10	P42	PI 510542	Villa Juira (Aymara) Qu	Peru
11	P79	PI 643079	Pasankalla	Peru
12	P18	PI 634918	Baer	Chile
13	P19	PI 634919	Pichaman	Chile
14	P21	PI 634921	UDEC-2	Chile
15	P22b	PI 634922	UDEC-4	Chile
16	P93	PI 596293	Colorado 407D	Colorado, USA
17	P98	PI 596498	Rosa junin	Peru
18	P22a	PI 614922	Sayana	Bolivia
19	P10	PI 478410	R-66	Bolivia
20	P24	PI 584524	QQ056	Chile
21	P05	PI 614905	CQ105	Bolivia (Oruro)
22	P06	PI 614906	CQ106	Bolivia (Oruro)
23	P07	PI 614907	CQ107	Bolivia (Oruro)
24	P08	PI 614908	CQ108	Bolivia (Oruro)
25	P09	PI 614909	CQ109	Bolivia (Oruro)

Out of 164 germplasm 25 were screened initially on the base of germination and seedling vigor. 10 lines having minimum 1500 kg ha^{-1} were selected for further experimentation

Code[1]	G. Line*
Ames30	Ames-13730
Ames37	Ames 13737
P37	PI 510537
P40	PI 510540
P42	PI 510542
P79	PI 643079
P19	PI 634919
P93	PI 596293
P22a	PI 614922
P10	PI 478410

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Germplasm Screening for sowing time

Final emergence (%) of different quinoa genotypes grown under different sowing dates at Faisalabad, Pakistan

Final emergence (%) of different quinoa genotypes grown under different sowing dates at Faisalabad, Pakistan				
GENOTYPE	15 OCT	15 NOV	15DEC	15 JAN
Ames30	51.68 g-i	**71.39 b**	84.50 a	37.53 lm
Ames37	**75.00** b	**73.29 b**	80.54 a	28.21 op
P10	33.85 mn	53.21 f-i	58.87 e	0 u
P37	19.40 r	63.99 d	65.92 cd	0 u
P40	25.17 pq	21.41 qr	57.36 ef	17.87 rs
P42	35.177 mn	49.02 ij	54.30 e-h	0 u
P93	41.36 kl	69.95 bc	55.05 e-g	9.62
P22b	22.70 qr	49.59 h-j	34.53 mn	13.83 st
P19	**71.87 b**	**71.98 b**	**85.25 a**	19.36 r
P79	34.94 mn	44.60 jk	32.24 no	9.09 t

Economic yield (kg/ha) of different quinoa genotypes grown under different sowing dates at Faisalabad, Pakistan

Economic yield (kg/ha) of different quinoa genotypes grown under different sowing dates at Faisalabad, Pakistan				
Genotypes	15 OCT	15 NOV	15 DEC	15 JAN
Ames30	1611.52 f	**2470.54** c	**2505.11** bc	542.70 j-m
Ames37	1672.33 f	**2643.94** b	**2909.25** a	425.82 l-n
P10	551.98 j-m	678.11 j	484.80 l-n	0.00 q
P37	385.91 no	651.91 j	408.20 m-o	0.00 q
P40	0.00 q	0.00 q	0.00 q	0.00 q
P42	0.00 q	0.00 q	0.00 q	0.00 q
P93	2051.52 e	1757.71 f	**2488.54** c	406.37 m-o
P22b	389.44 m-o	831.03 i	901.86 i	0.00 q
P19	1262.74 g	2061.30 de	**2207.95** d	641.15 m-o
P79	0.00 q	1089.51 h	469.89 l-n	0.00 q

Field trials showed optimum quinoa sowing time varies with agro ecological zones from first week of November to 2nd week of December. However, northern areas (Sakardhu) quinoa is planted after melting snow during Spring

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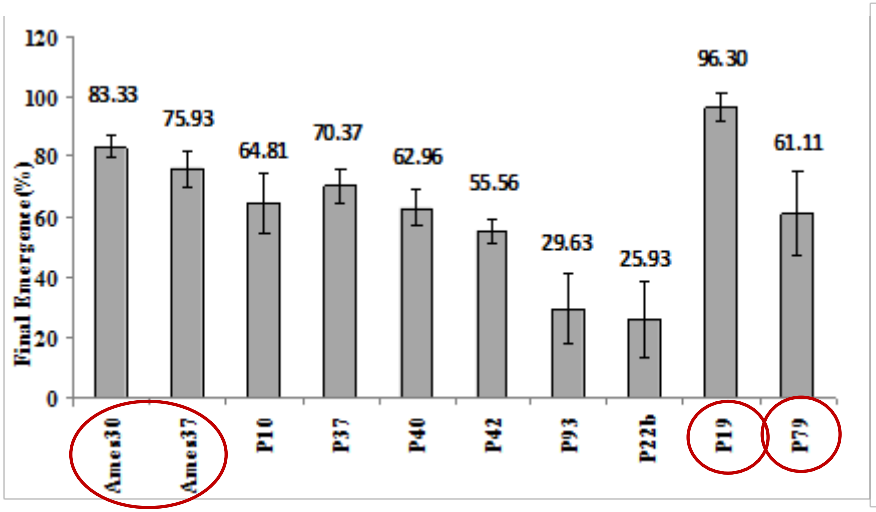
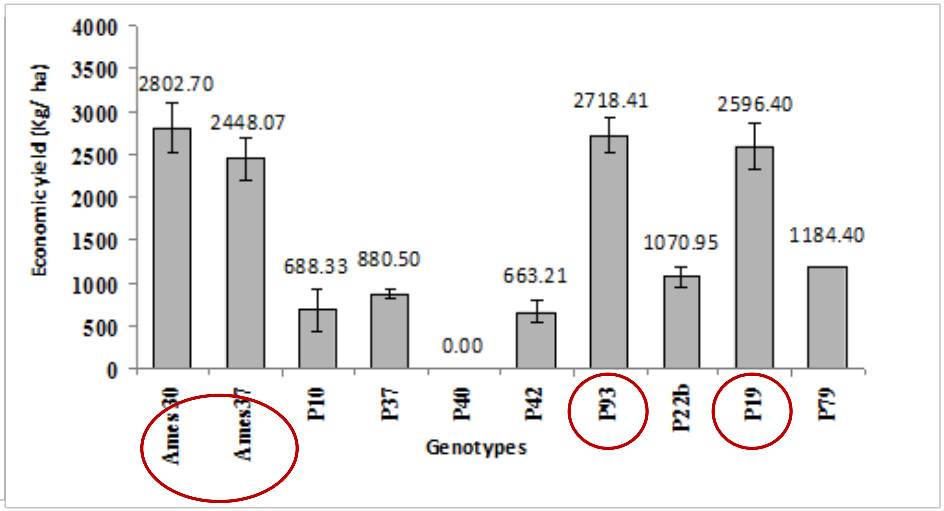
Field appraisal 2009-10

Final emergence (%) of quinoa genotypes under field conditions



Grain yield (kg ha^{-1}) of quinoa genotypes under field conditions



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Optimization of sowing methods

Plant survival (%) in direct sown and transplanted quinoa genotypes under field conditions

Genotypes	Direct sown	Transplanted
Ames30	**98.82 a**	**85.83 b**
Ames37	**97.60 a**	**98.24 a**
P10	74.16 c	36.34 g
P37	69.76 cd	64.25 d
P40	56.88 e	48.38 f
P42	56.70 e	24.58 h
P93	74.89 c	0.00 i
P22b	40.05 g	0.00 i
P19	**88.53 b**	**86.38 b**
P79	27.65 h	0.00 i

Economic yield (kg/ha) of direct sown and transplanted quinoa genotypes under field conditions

Genotypes	Direct sown	Transplanted
Ames30	**2689.3 a**	**1166.5 ef**
Ames37	**2352.5** c	1234.1 e
P10	663.35 h	129.89 i
P37	845.18 g	82.62 ij
P40	0.00 ij	0.00 j
P42	635.74 h	136.84i
P93	**2611.0 a**	0.00 j
P22b	1029.01f	0.00 j
P19	**2489.9 b**	1381.1 d
P79	1138.1ef	0.00 j

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Germplasm Screening under different agro-ecological zones

Emergence (%) of different quinoa genotypes under different agro ecological zones			
Genotypes	Faisalabad	Chakwal	Bahawalpur
Ames30	**87.94** ab	71.82 de	75.26 d
Ames37	**83.21** bc	58.67 hi	69.47 ef
P10	55.05 i-k	43.53 n	19.56 p
P37	64.71 fg	84.57 bc	50.93 k-m
P40	56.63 ij	68.07 ef	45.92 mn
P42	55.40 i-k	53.14 jk	25.57 o
P93	56.46 ij	67.86 ef	71.41 de
P22b	24.72 op	**81.61** c	**83.41** bc
P19	**90.43 a**	51.62 j-l	74.84 d
P79	55.08 i-k	47.45 l-n	62.38 gh

Economic yield (kg ha^{-1}) of different quinoa genotypes under different agro ecological zones			
Genotypes	Faisalabad	Chakwal	Bahawalpur
Ames30	**2744.16** a	1300.41 e	468.19 kl
Ames37	**2686.94** ab	1300.00 e	539.86 j
P10	685.05 i	986.57 f	298.68 m
P37	712.02 hi	1626.95 c	199.72 n
P40	0.00 o	0.00 o	0.00 o
P42	591.93 j	764.45 h	0.00 o
P93	**2638.65** b	1474.16 d	850.46 g
P22b	880.46 g	436.85 l	0.00 o
P19	**2746.35** a	888.53 g	771.72 h
P79	1053.72 f	534.86 jk	0.00 o

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Germplasm Screening

Code*	G. Line	Origin	Plant name
PI 596293	Q 1	Colorado, USA	Colorado 407D
Ames 13730	Q 2	New Mexico, USA	IESP
Ames 13737	Q 7 (UAF-Q7)	New Mexico, USA	2WANT
PI 634919	Q 9	Chile	Pichaman

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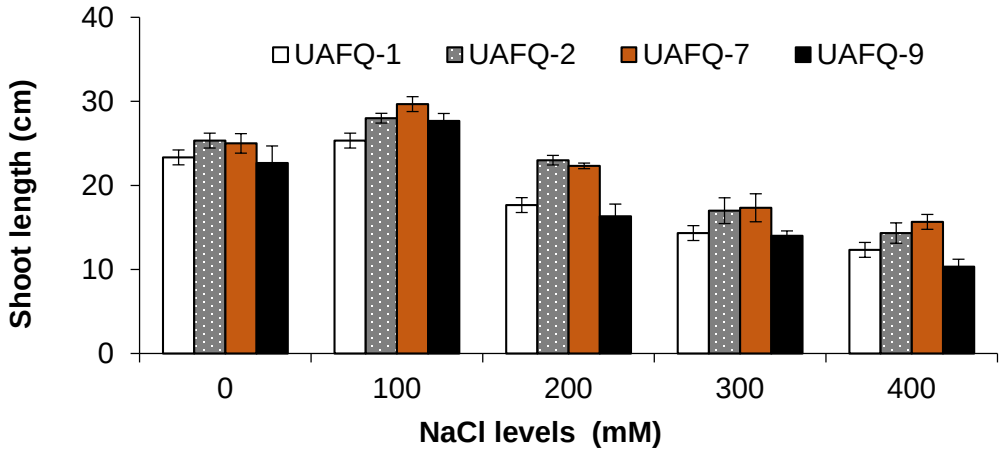
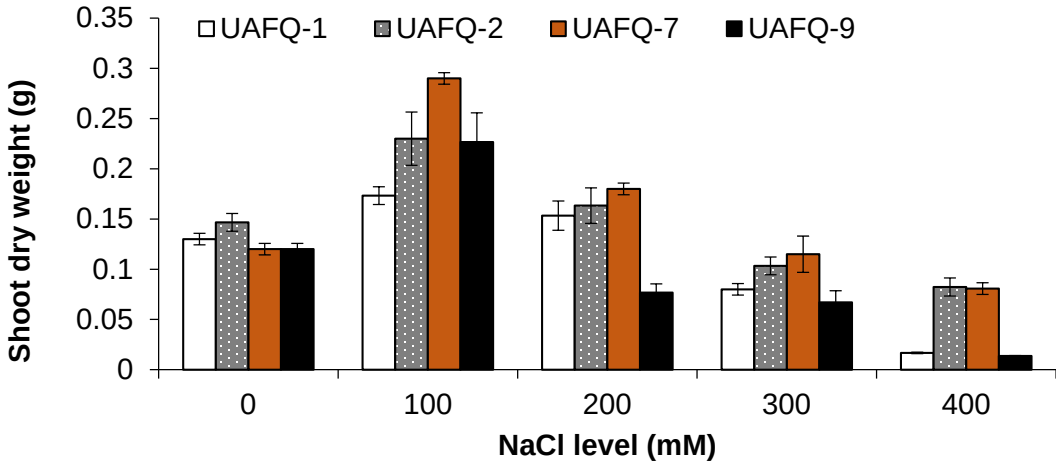
Germplasm testing for salt tolerance (hydroponics)

Influence of salt stress on shoot length and shoot dry weight of of quinoa genotypes 35 days old plants





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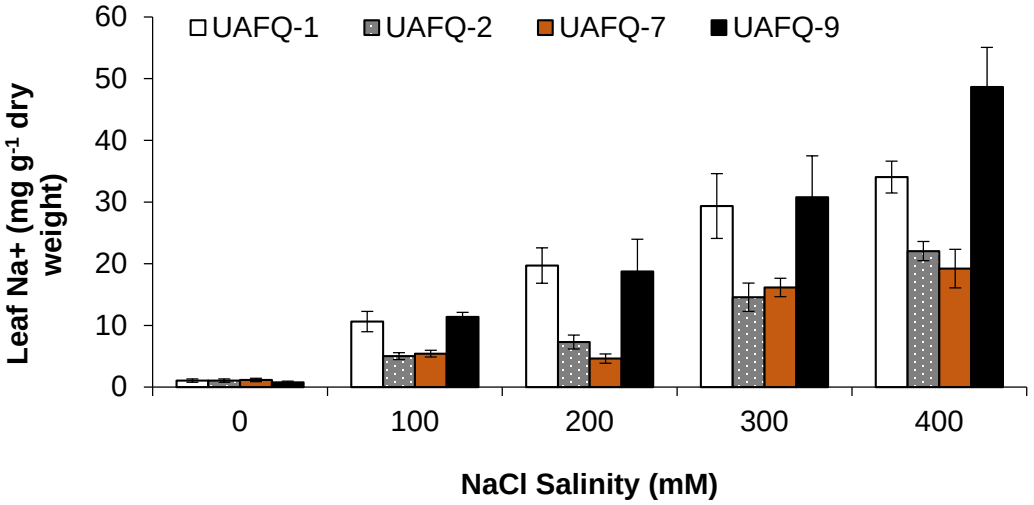
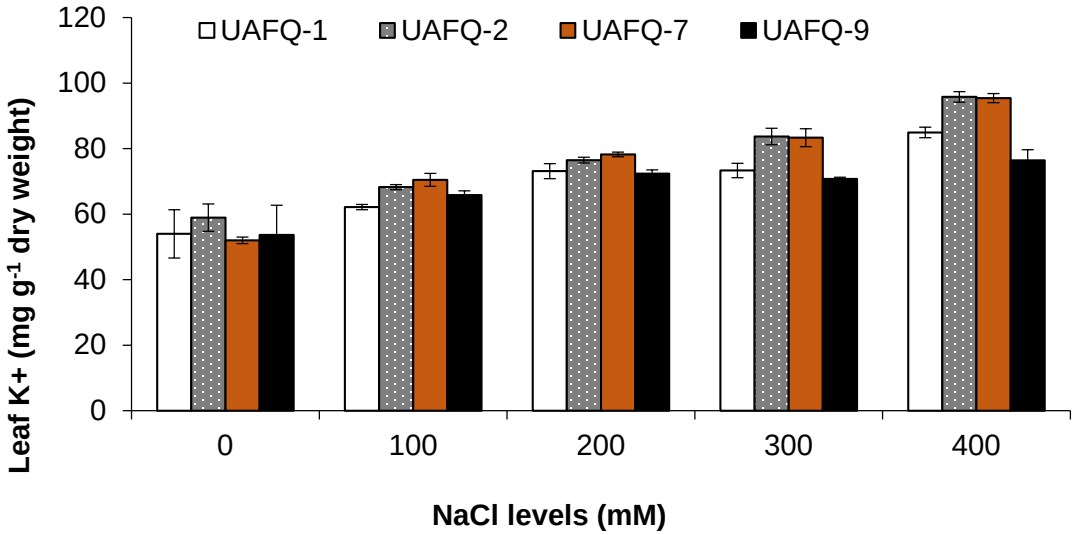
quinoa under saline conditions (Hydroponics)

Influence of salt stress on leaf K^+ concentration of quinoa genotypes





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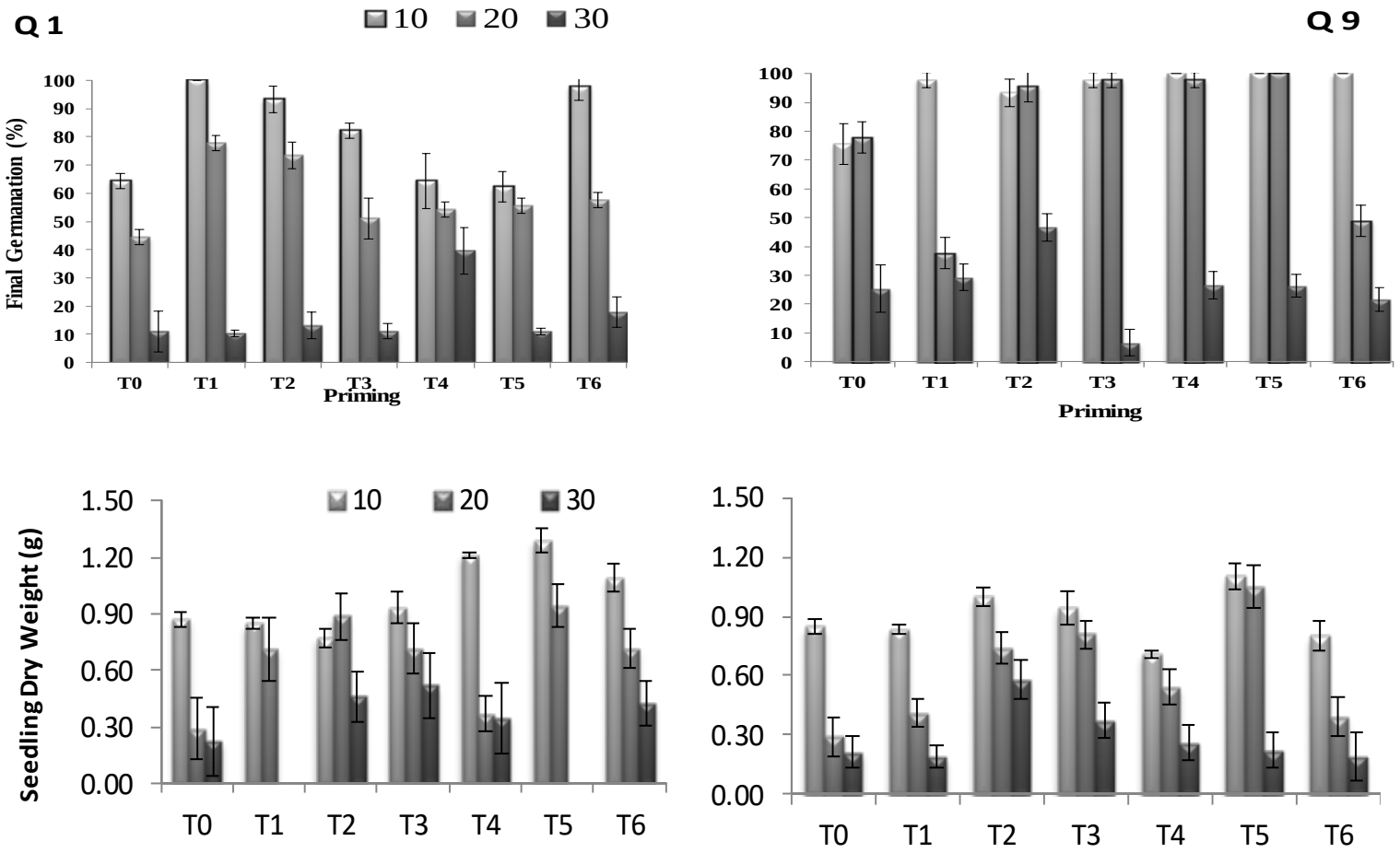
Effect of seed priming on final germination (%) of quinoa under saline conditions



Priming agents

T_0: Control, T_1: Moringa leaf extract,
T_2:Hydropriming, T_3: $CaCl_2$,
T_4: Ascorbate T_5: BAP T_6: H_2O_2

Salinity levels=10, 20, 30 dS/m

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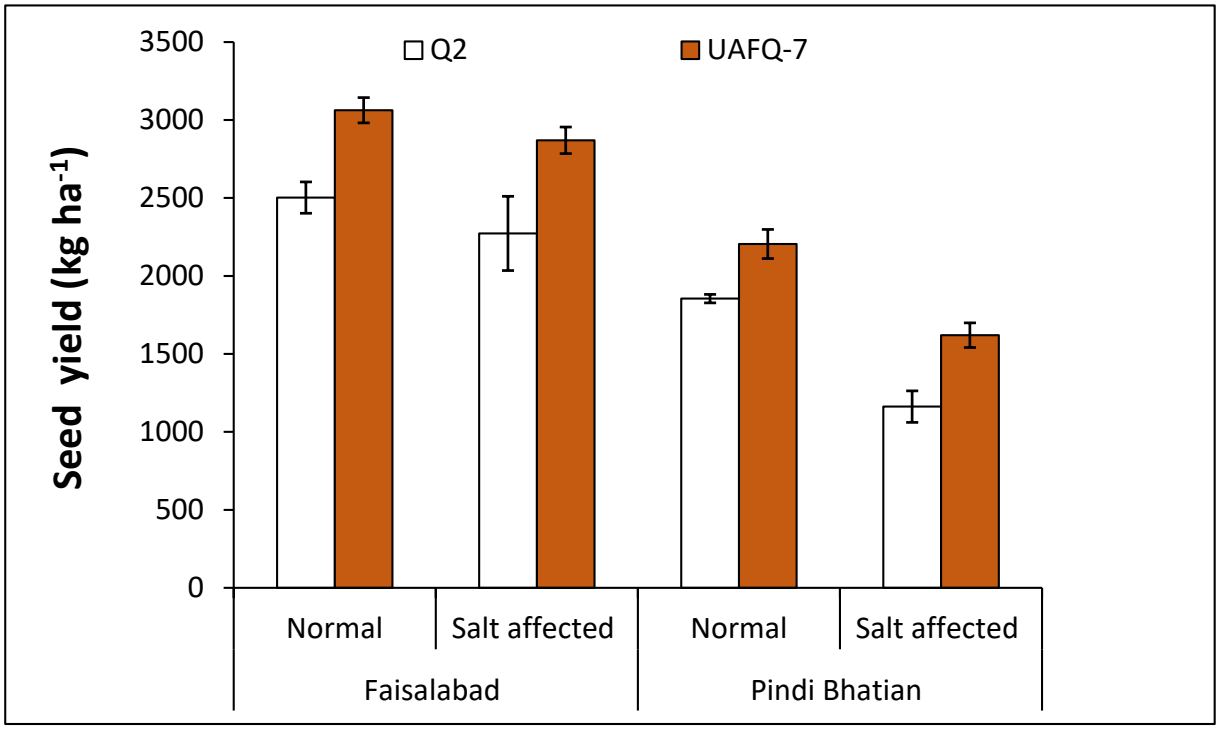
Seed yield of quinoa genotypes harvested from normal and salt affected fields



P values

Faisalabad: Soil type : 0.0540, Genotype: 0.0254, Interaction: 0.7745

Pindi Bhatiaan: Soil type: 0.0401, Genotype: 0.0183, Interaction: 0.6836

	Faisalabad		Pindi Bhatiaan	
Parameters	Normal	Salt affected	Normal	Salt affected
ECe (dS m^{-1})	2.11	9.8	3.21	13.9
SAR (mmol L^{-1})1/2	5.2	25	11.9	42
pH	7.4	8.1	7.9	8.8

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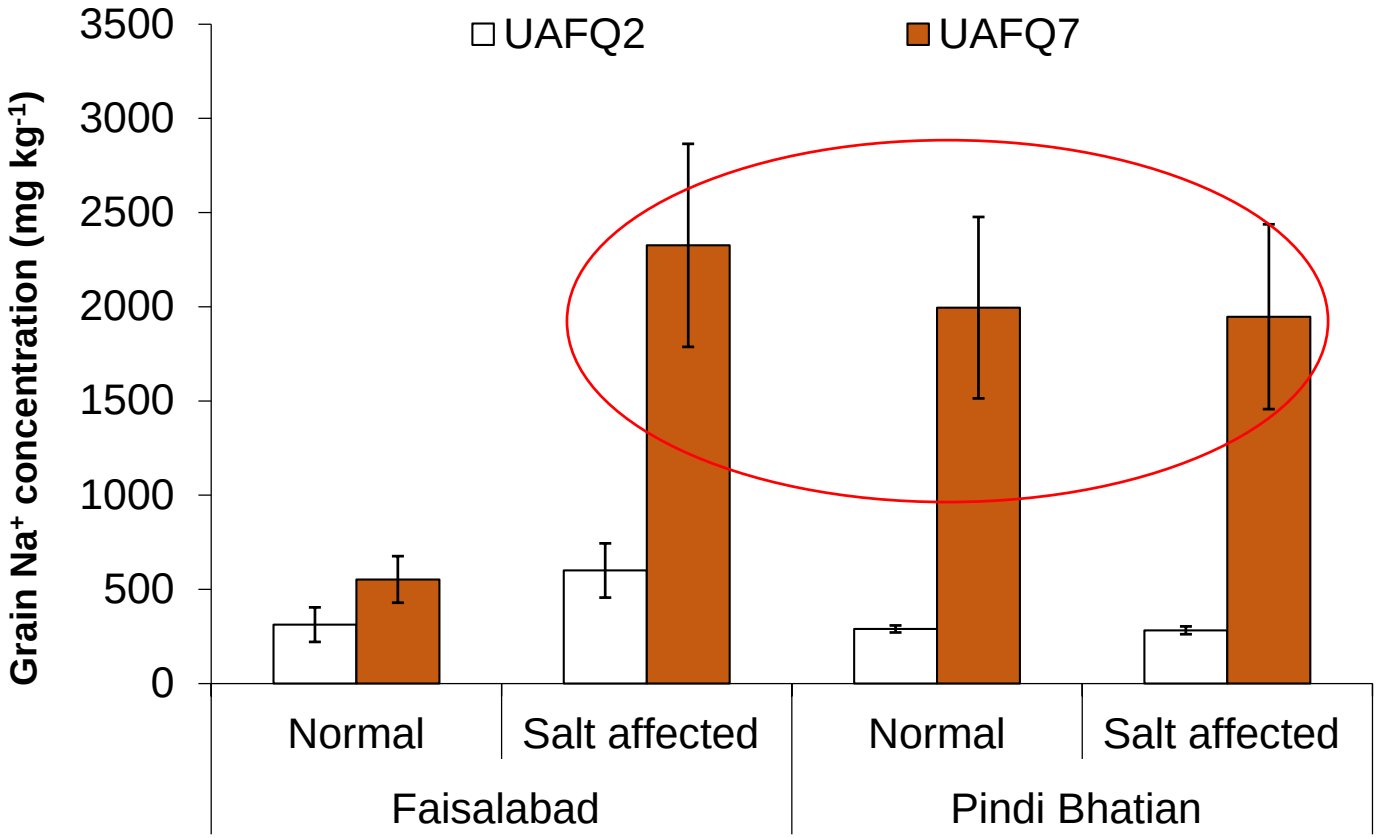
Grain Na^+ concentration of quinoa genotypes grown on salt affected soils



UAF-Q7 is more salt tolerant but high grain Na^+ concentration

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Proximate analysis of quinoa seeds obtained from normal and salt affected soils

Genotypes	Protein%		Crude Fiber%		Crude Fat%		Ash contents%	
	N	SA	N	SA	N	SA	N	SA
Q1	14.29	13.25	1.25	1.1	2.5	2.08	1.6	1.66
Q2	13.64	11.89	1.3	1.2	1.41	4.7	1.13	1.6
Q7	11.30	11.95	0.95	1.25	3.5	2.08	0.96	1.26
Q9	11.30	12.93	0.95	1.15	3.5	2.75	1.4	2
N= Normal soil, SA = salt affected soil								

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Germplasm testing under drought (pot study)

Effect of drought on plant height (cm) of quinoa genotypes

Genotypes	Control	50% F.C.
Q 1	76.93 c	49.33 e
Q 2	85.00 b	52.07 de
Q 7	94.70 a	51.86 de
Q 9	56.94 d	45.22 e

Effect of drought on the root length (cm) of quinoa genotypes

Genotypes	Control	50% F.C.
Q 1	22.94 c	**27.94** a
Q 2	23.37 c	**25.24** b
Q 7	19.70 d	**22.82** c
Q 9	22.27 c	**28.28** a

Effect of drought on leaf K:Na ratio of quinoa genotypes

Genotypes	Control	50% F.C.
Q 1	139.79 b	62.77 e
Q 2	157.74 a	72.79 e
Q 7	127.32 b	69.63 e
Q 9	92.24 d	108.29 c

Emergence, growth, gases exchange parameters and analytic parameters like antioxidants, chlorophyll contents were studies

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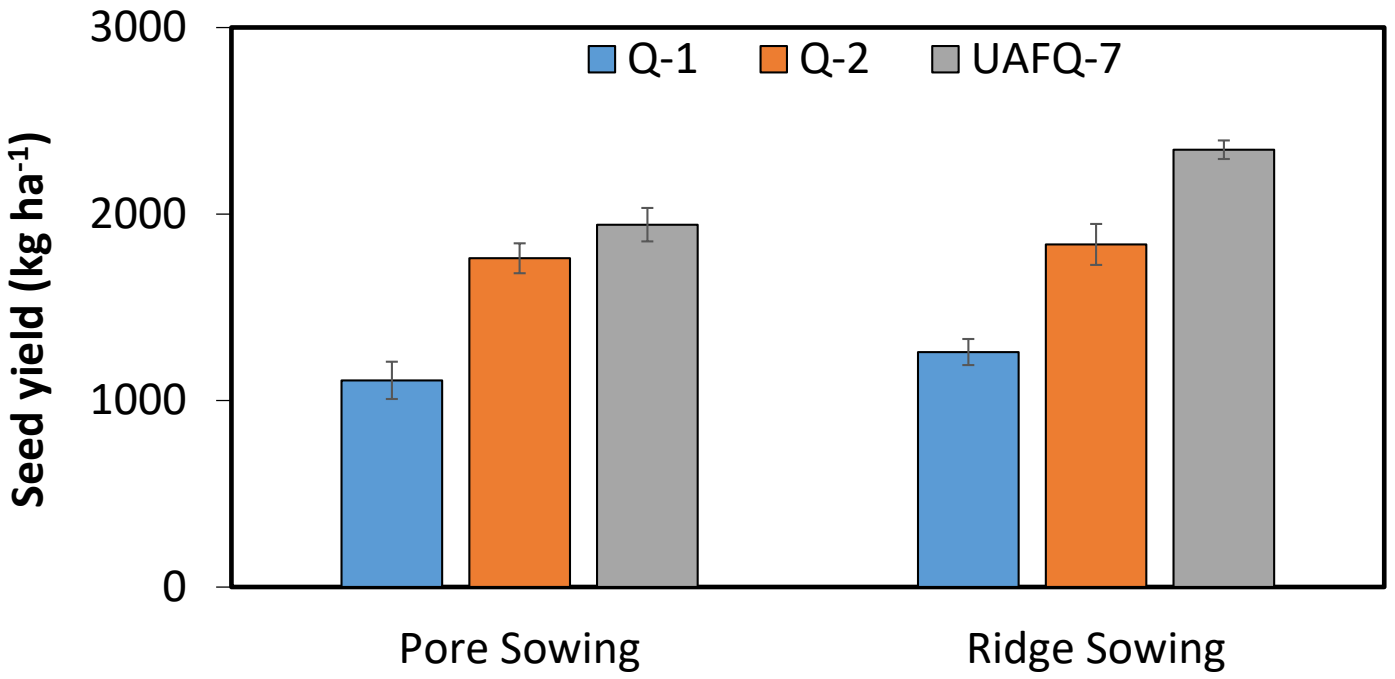
Influence of sowing methods on seed yield (kg ha^{-1}) of quinoa



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Optimized sowing methods for quinoa

Quinoa can be sown by broadcast, pore, hand sowing called choppa, hand sowing on ridges

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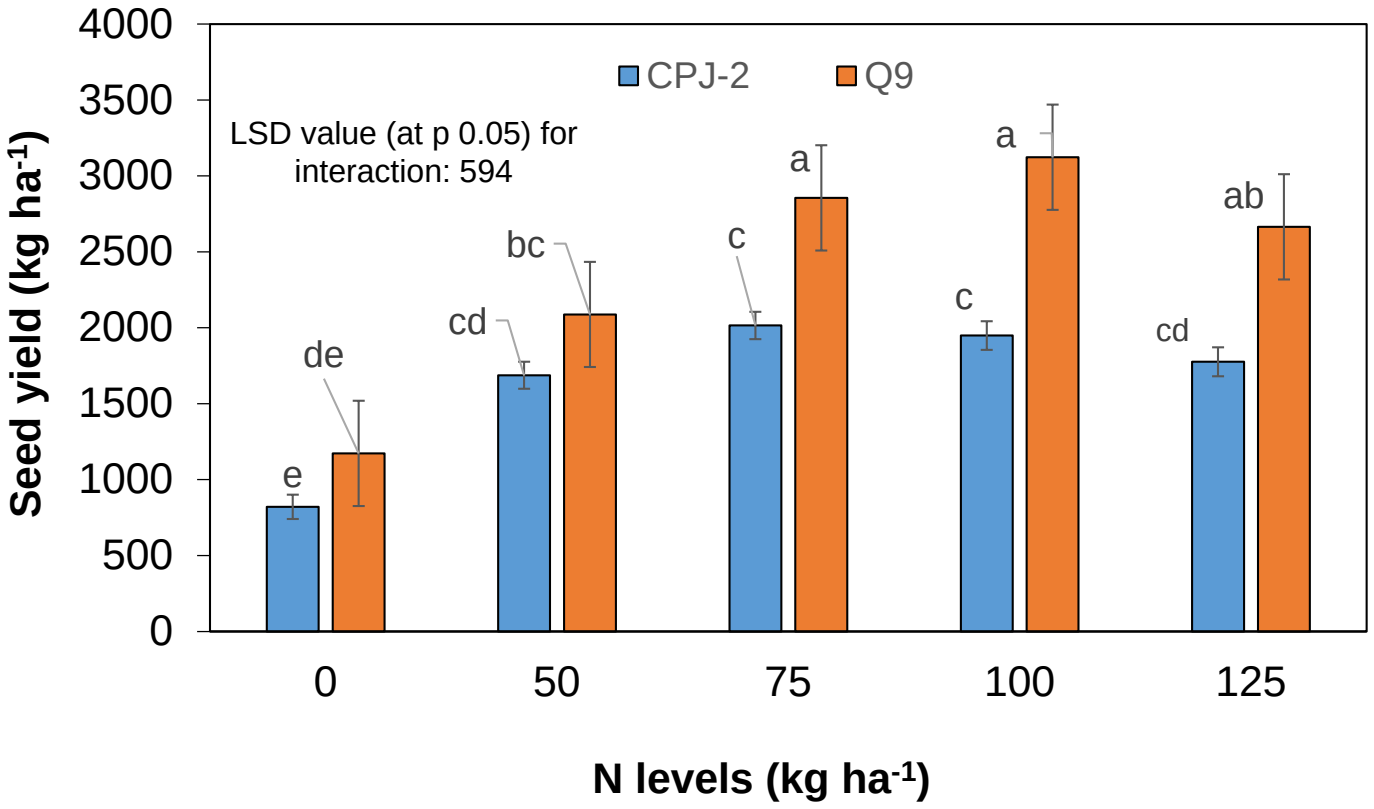
Influence of different Nitrogen levels on seed yield (kg ha^{-1}) of quinoa



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Influence of soil applied phosphorus and potassium on seed yield of quinoa

Treatments (kg ha^{-1})	P_0 (Control)	P_1 (25)	P_2 (50)	Mean (K)
K_0 (Control)	964.00 d	1070.33 d	1443.33 bc	1159.22
K_1 (25)	1166.33 cd	1456.33 bc	1651.67 b	1424.78
K_2 (50)	1268.00 cd	1602.33 b	2096.00 a	1655.44
Mean (P)	1132.78	1376.33	1730.33	

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Evaluation of the growth and yield of quinoa genotypes under heavy metals contaminated soil

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Soil Characteristics

	UAF	CHAKERA	LEHLAN
pH	7.7	6.97	6.92
Organic matter	0.93	1.4	1.33
EC (dS m^{-1})	0.82	1.78	1.66
Textural class	Loam	Sandy loam	Sandy loam
Cd (mg/kg)	0.02	6	8.6
Cr (mg/kg)	2	18	24
Pb (mg/kg)	0.04	5	9.7
Ni (mg/kg)	0.44	27	36

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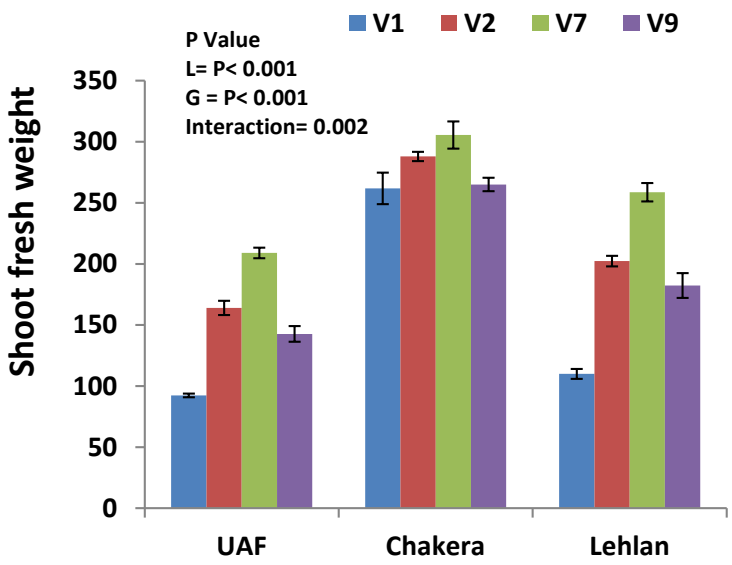

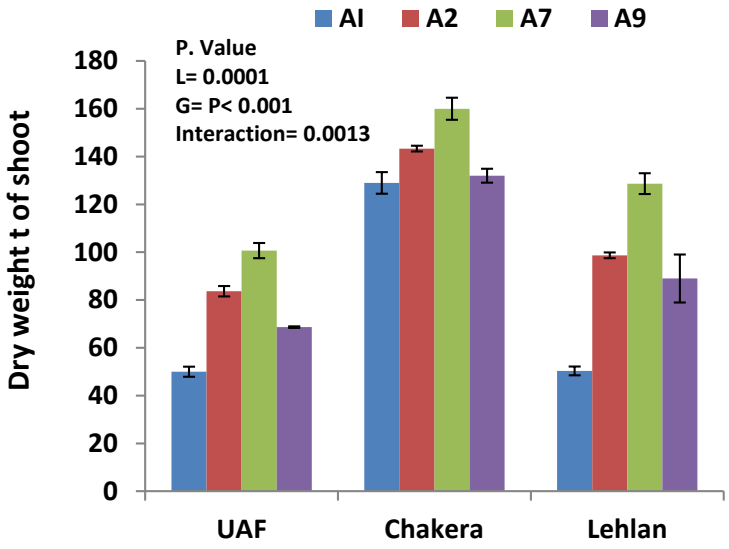

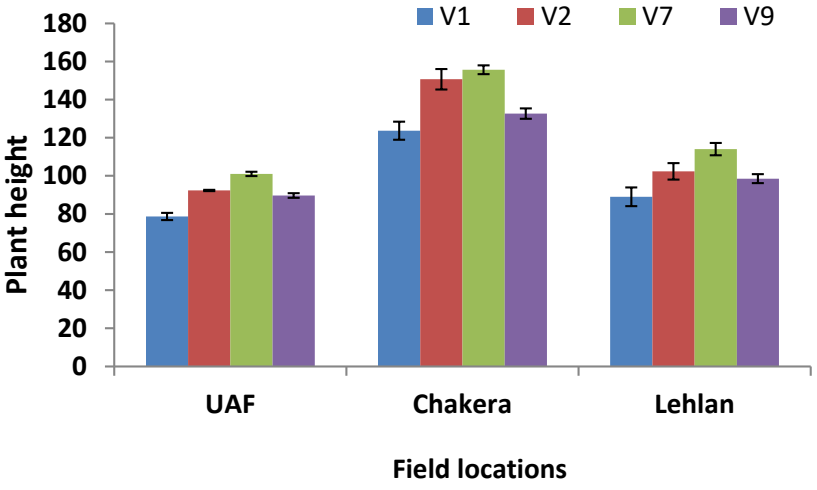

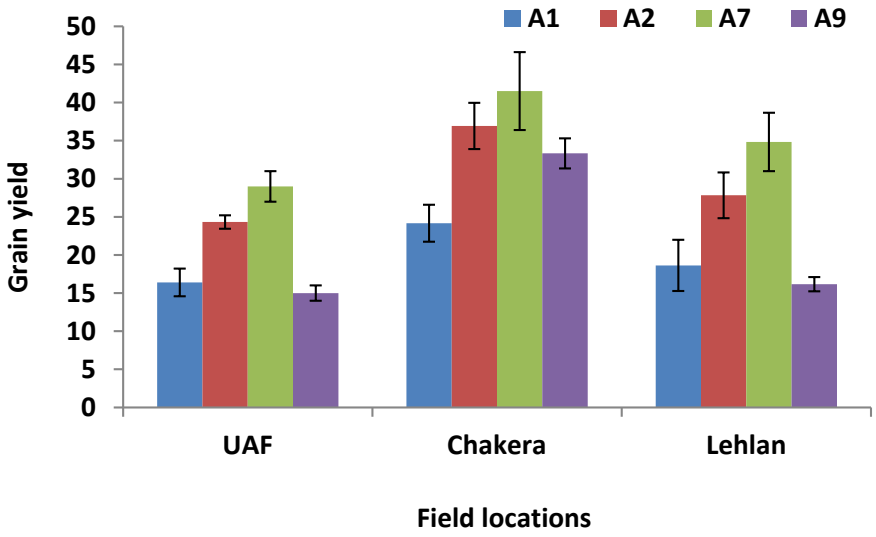

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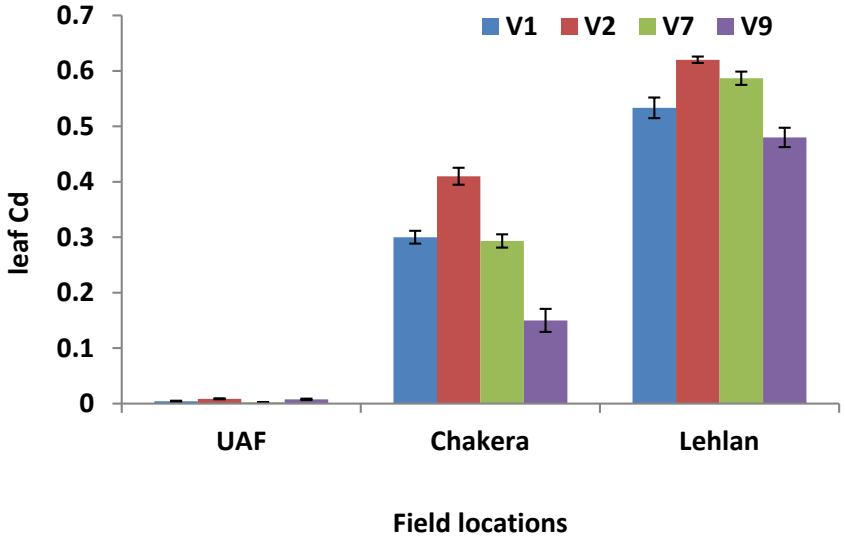

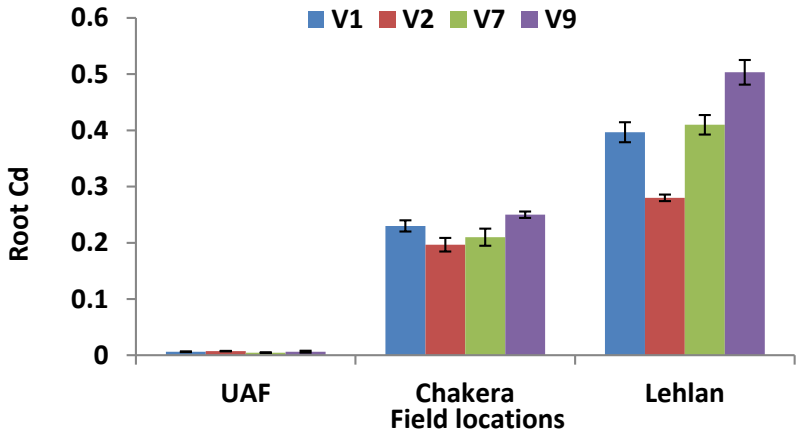

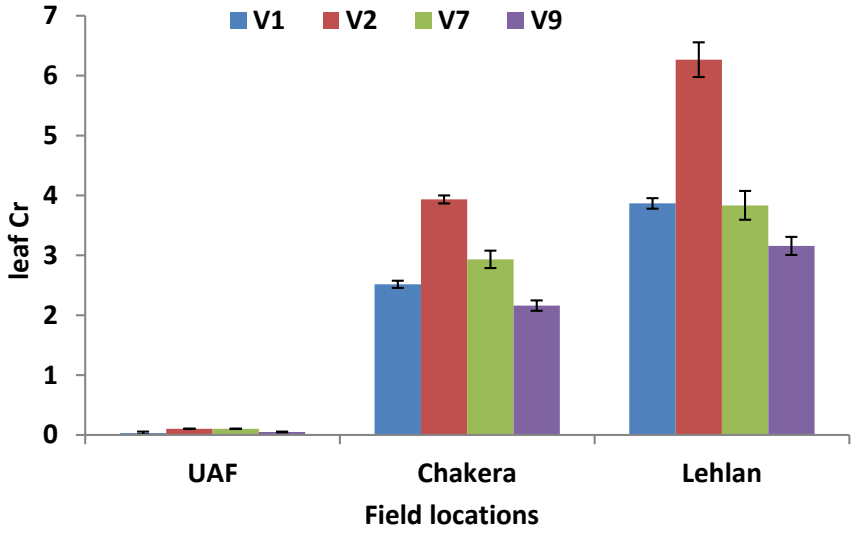

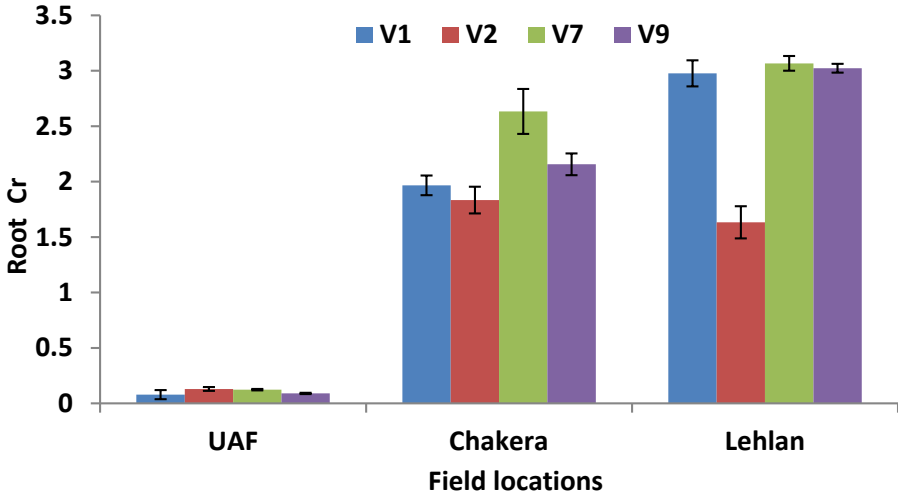

Evaluation of the growth and yield of quinoa genotypes under heavy metals contaminated soil

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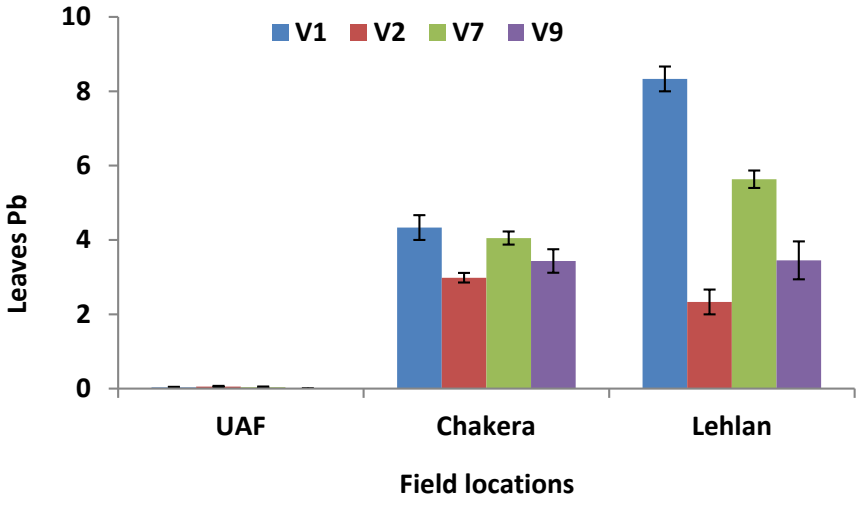
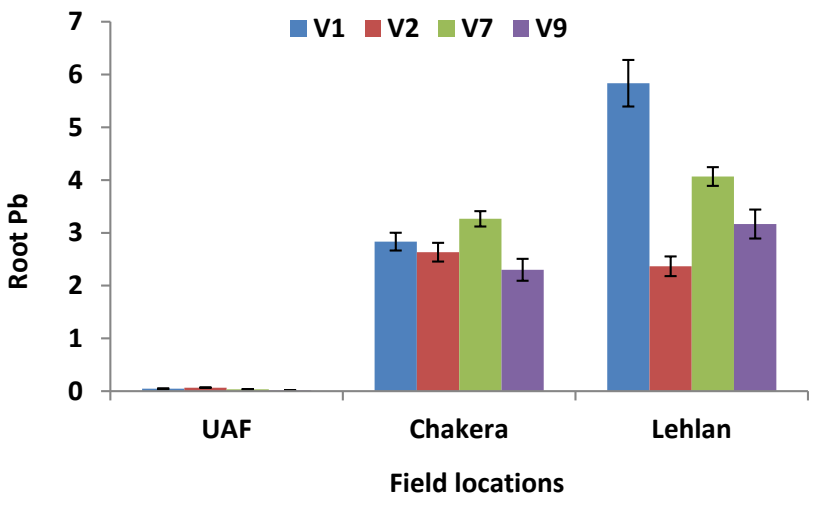
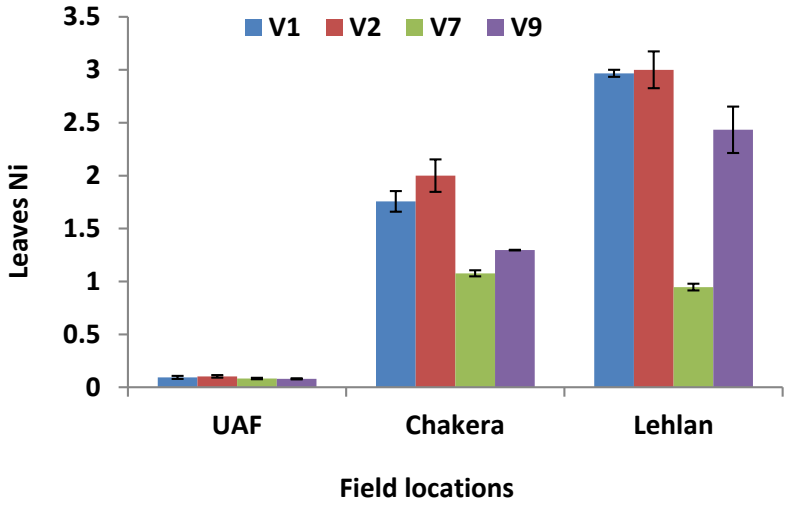
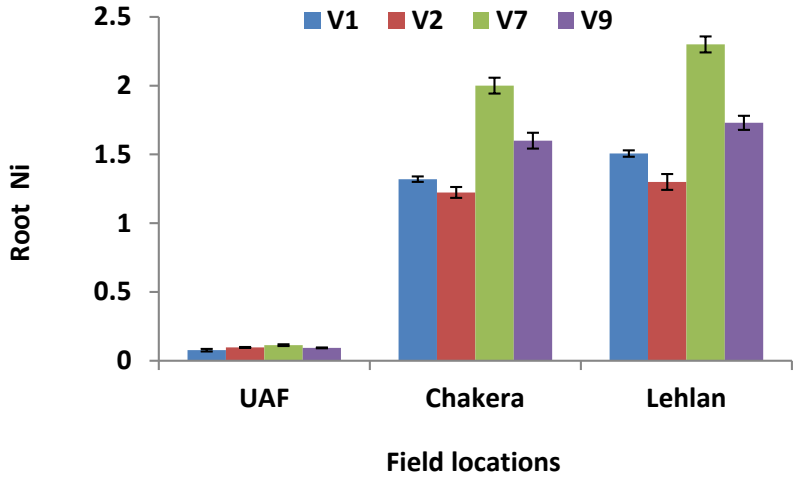
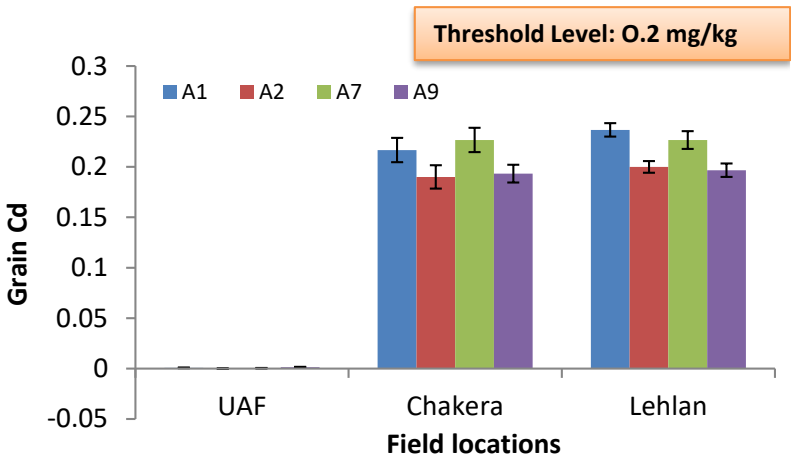


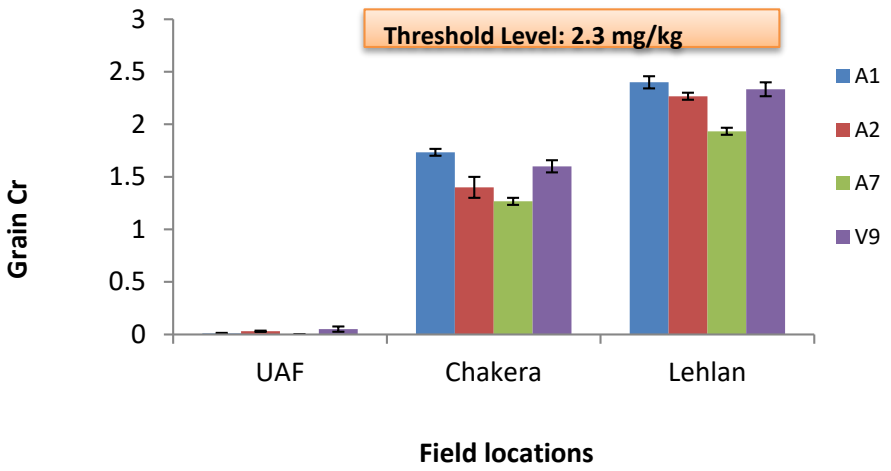


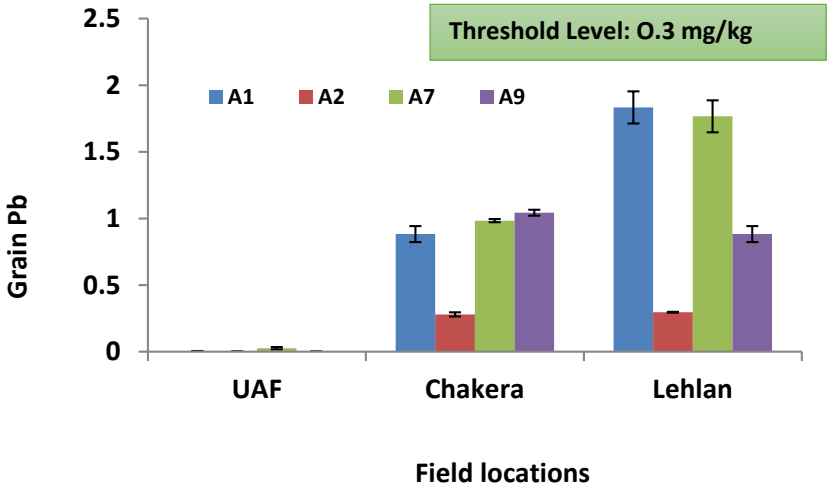


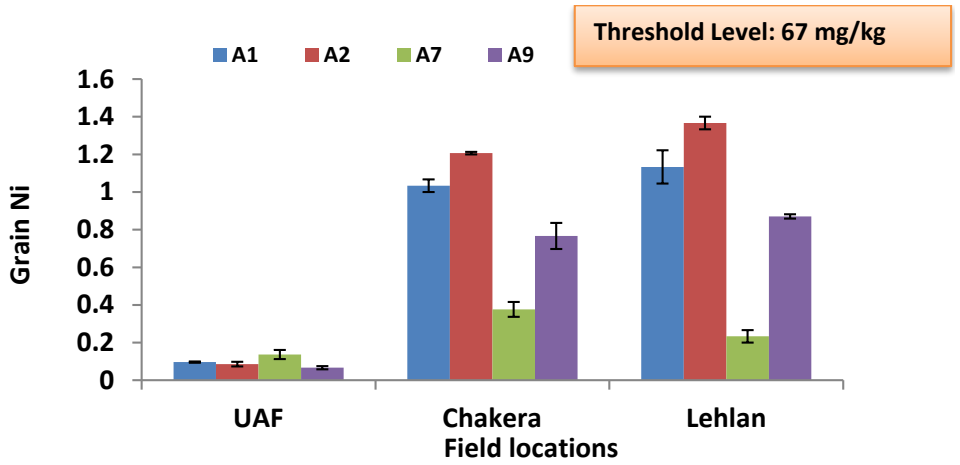


Grain cadmium (mg/kg) of quinoa genotypes under heavy metals contaminated soils

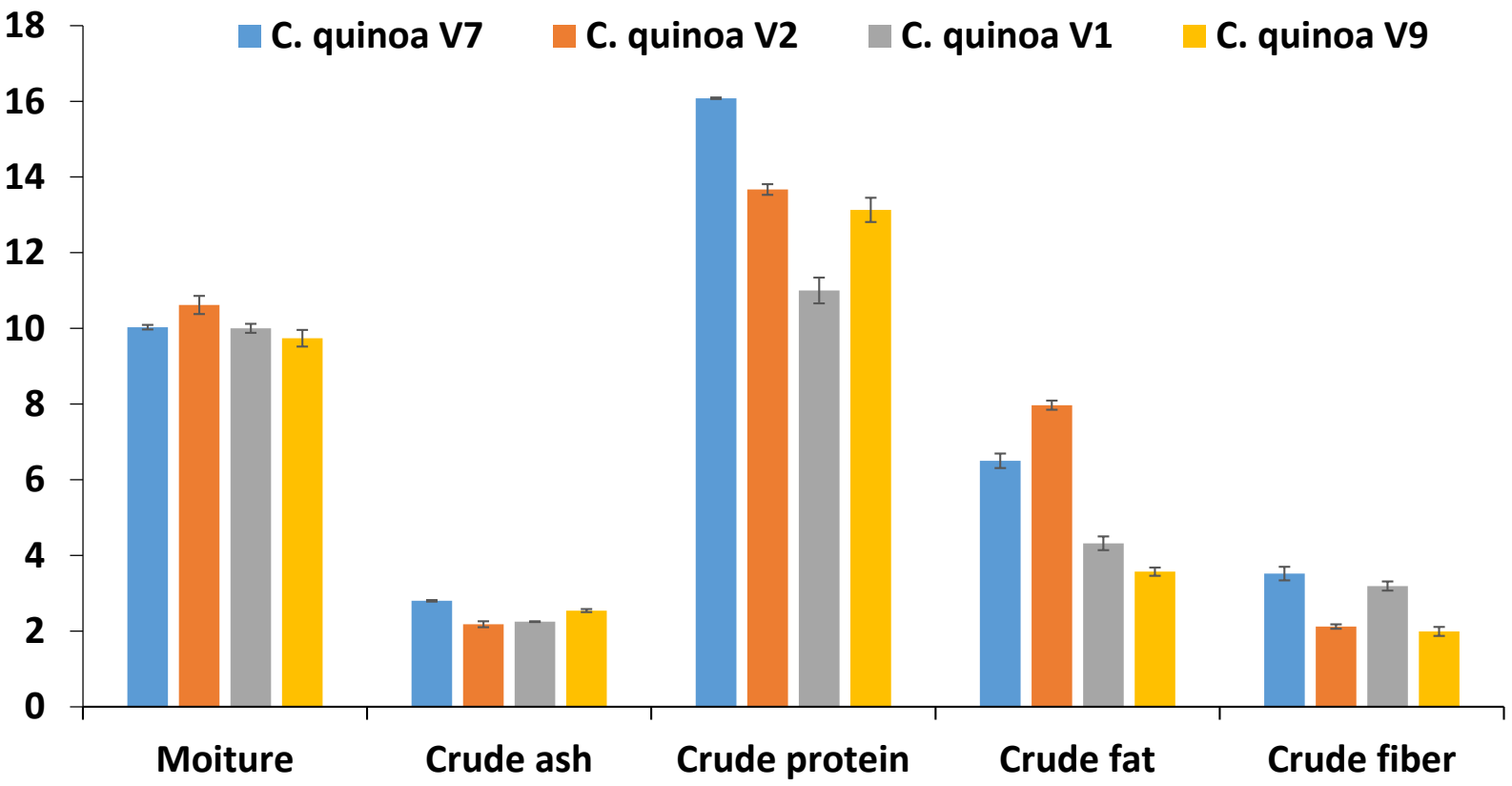








Proximate analysis of quinoa grain



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Mineral composition of quinoa (mg/kg)

Quinoa genotypes	Q 1	Q 2	Q 7	Q 9
Calcium	578.35±4.53	598.56±5.28	**699.45±5.2**	621.13±6.37
Copper	4.01±0.02	**5.04±0.06**	4.73±0.03	4.19±0.05
Iron	63.13±0.55	**68.89±0.5**	61.31±0.17	64.55±0.29
Potassium	8497.08±51.97	8920.79±35.06	8650.63±28.82	**9443.41±114.7**
Magnesium	2068.1±28.88	**2173.4±23.12**	2163.2±34.61	2058.1±28.28
Manganese	30.66±0.21	33.49±0.24	**35.28±0.12**	31.46±0.27
Sodium	51.45±0.26	54.18±0.52	62.81±0.52	**24.46±0.29**
Phosphorus	4491.6±20.78	4542.6±23.03	4500.6±28.93	**4560±16.16**
Sulpher	1499.21±9.3	**1606.3±8.29**	1508.58±4.58	1582.37±5.84
Zink	29.15±0.52	29.4±0.25	**32.12±0.52**	24.3±0.22

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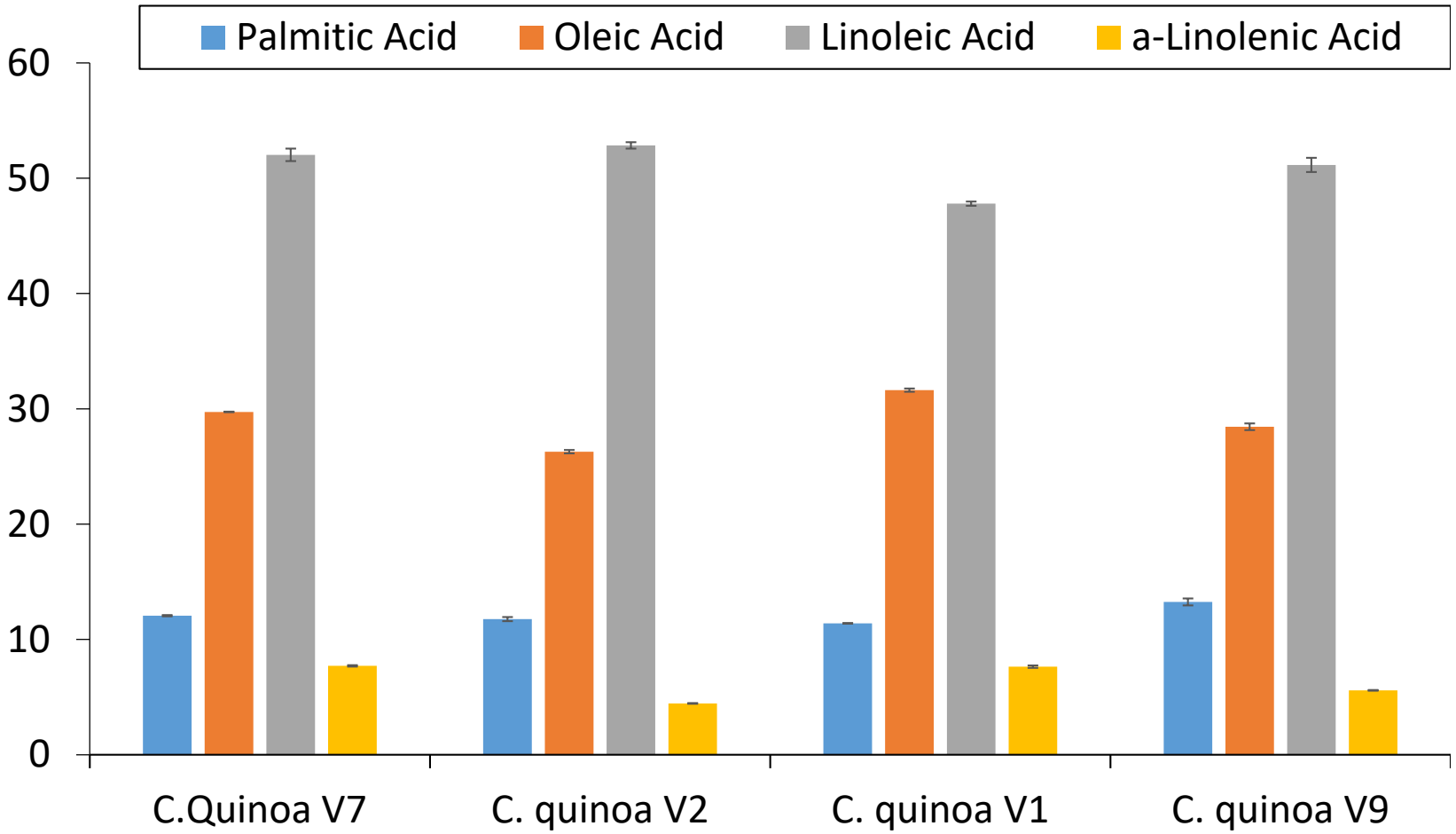
Fatty acid composition of quinoa (%)



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Quinoa Production Technology

Crop duration	120-140 days
Sowing date	Quinoa can be grown in Pakistan as Rabi Crop. It can be sown between mid November to mid-December throughout the Pakistan except the northern areas.
Soil Requirement	It performs well on loamy soils
Land preparation	2-3 ploughing followed by planking is done to prepare soil for sowing
Seed rate	Optimum seed rate is 5-8 kg ha^{-1}
Sowing method	It can be sown by flat or ridge sowing in lines manually or by seed drills on well drained soils in watter condition.
Planting geometry	Row to row distance =65 cm and plant to plant distance =15 cm
Fertilizer requirements	Quinoa is very responsive to nitrogen so a fertilizer at the rate of N: P: K 75: 50: 50 kg $ha^{-1}$is recommended. Phosphorous and Potash should be applied as basal dose while nitrogen in two splits half at the time of sowing and half at 70 days after sowing.
Irrigation requirement	3-4 irrigations depending upon weather, First after 40 days after sowing, second after 75 days of sowing and Third after 100 days of sowing. If weather become hot than 4rth irrigation can be done after 120 days of sowing.
Weed control	Weed infestation could cause severe damage during early phonological stage up to bud formation stage. Mostly weeding is done manually. However, experimentation is under progress for chemical weed control. Quinoa plants resemble with its wild relatives *Chenopodium album, Chenopodium murale,* so care must be taken for proper weeds identification and their removal.
Plant Protection	No insect pest disease reported under most of the conditions.
Harvesting/ threshing	In Aprill at maturity quinoa plant changes color from green to brown, orange or red depending upon the accession. At nail dented stage, the crop is harvested manually or by combined harvest. Normally threshing is done after 7 days of cutting when seed hull is removed easily by wheat thresher with slight modification.
Seed storage	Quinoa seeds should be stored in air tight/moisture proof bags at low temperature and relative humidity.

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Quinoa threshing demonstration video

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Well adapted genotypes of quinoa in Pakistan

Genotype	USDA Coding	Origin	Plant name	Yield Potential (kg ha^{-1})
Q1	PI 596293	Colorado, USA	Colorado 407D	2000
Q2	Ames 13730	New Mexico, USA	IESP	2800
Q7	Ames 13737	New Mexico, USA	2WANT	3100
Q9	PI 634919	Chile	Pichaman	3200

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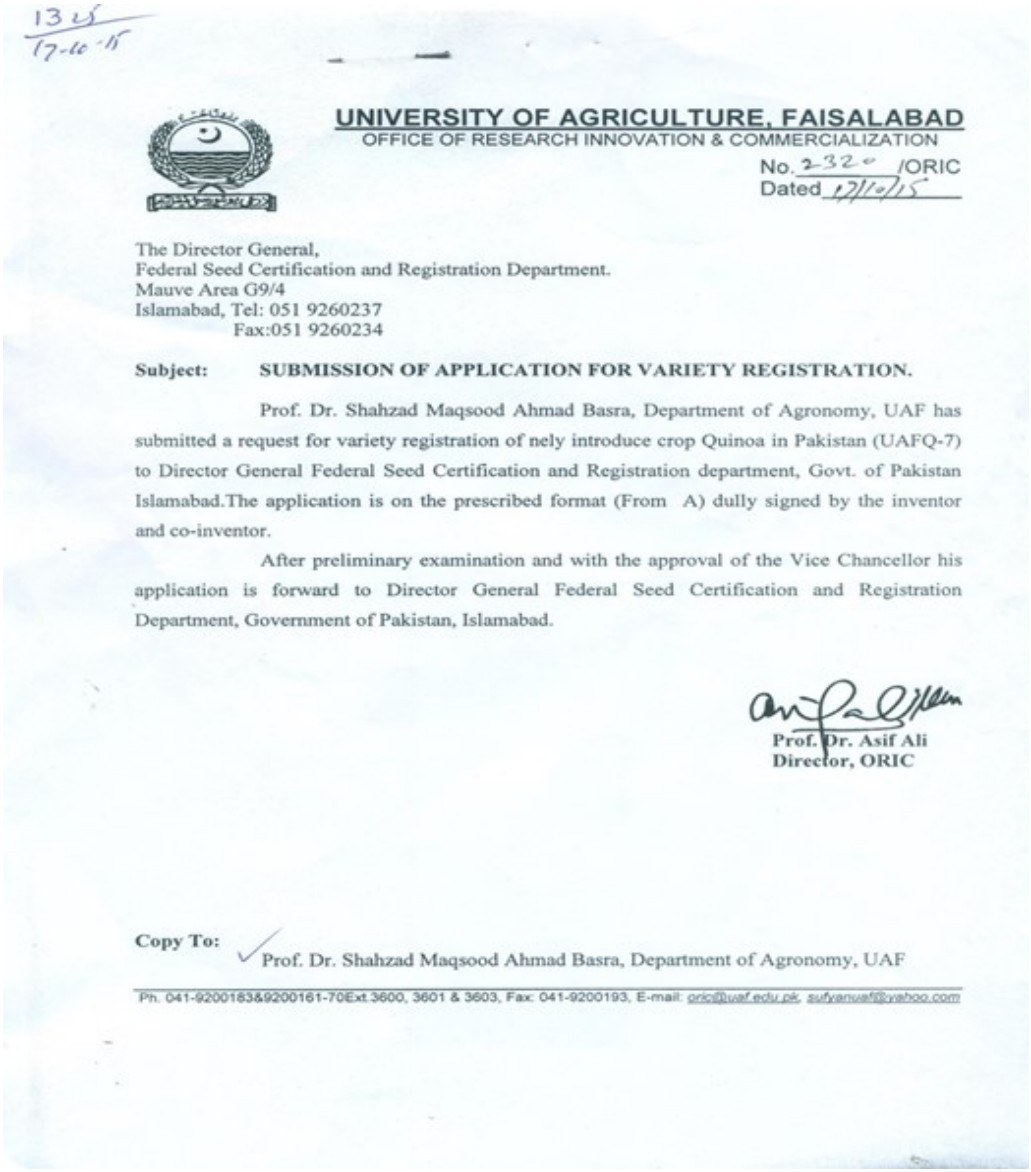
Varietal registration



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17-10-15

UNIVERSITY OF AGRICULTURE, FAISALABAD
OFFICE OF RESEARCH INNOVATION & COMMERCIALIZATION

No. 2320 /ORIC
Dated 17/10/15

The Director General,
Federal Seed Certification and Registration Department.
Mauve Area G9/4
Islamabad, Tel: 051 9260237
Fax:051 9260234

Subject: **SUBMISSION OF APPLICATION FOR VARIETY REGISTRATION.**

Prof. Dr. Shahzad Maqsood Ahmad Basra, Department of Agronomy, UAF has submitted a request for variety registration of nely introduce crop Quinoa in Pakistan (UAFQ-7) to Director General Federal Seed Certification and Registration department, Govt. of Pakistan Islamabad.The application is on the prescribed format (From A) dully signed by the inventor and co-inventor.

After preliminary examination and with the approval of the Vice Chancellor his application is forward to Director General Federal Seed Certification and Registration Department, Government of Pakistan, Islamabad.

Prof. Dr. Asif Ali
Director, ORIC

Copy To:
✓ Prof. Dr. Shahzad Maqsood Ahmad Basra, Department of Agronomy, UAF

Ph. 041-9200183&9200161-70Ext.3600, 3601 & 3603, Fax: 041-9200193, E-mail: oric@uaf.edu.pk, sufyanuaf@yahoo.com

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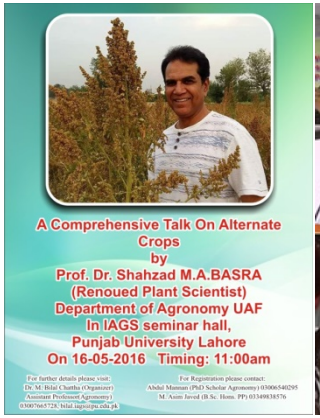
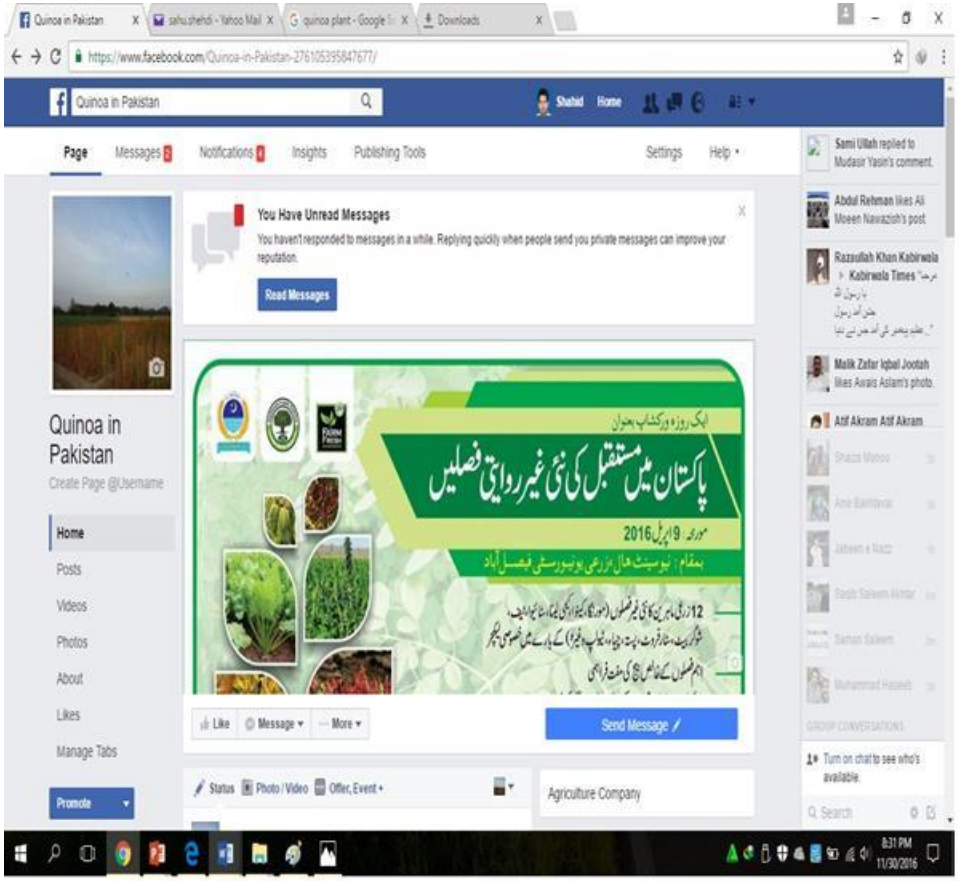
Extensive outreach activities



An awareness lecture, Quinoa: a super food in Pakistan and Stakeholders Meeting at Institute of Agricultural Sciences, University of the Punjab, June 15, 2015

Moringa: a case study of biodiversity conservation, at University of Sargodha. As usual moringa awareness message was strongly delivered. Response was very good.

Use of social media



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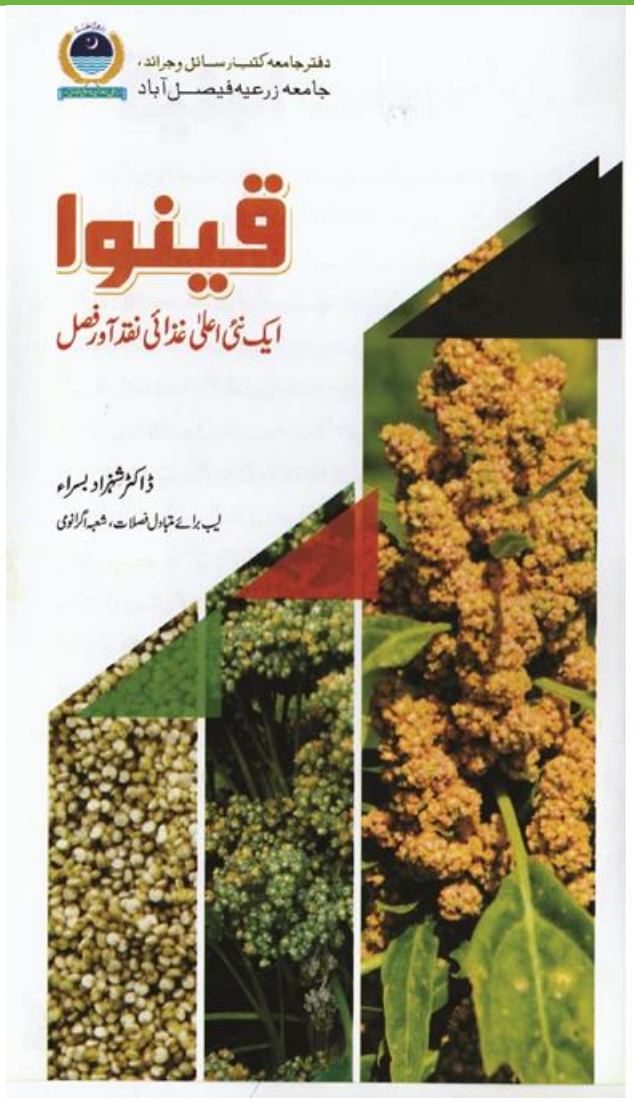
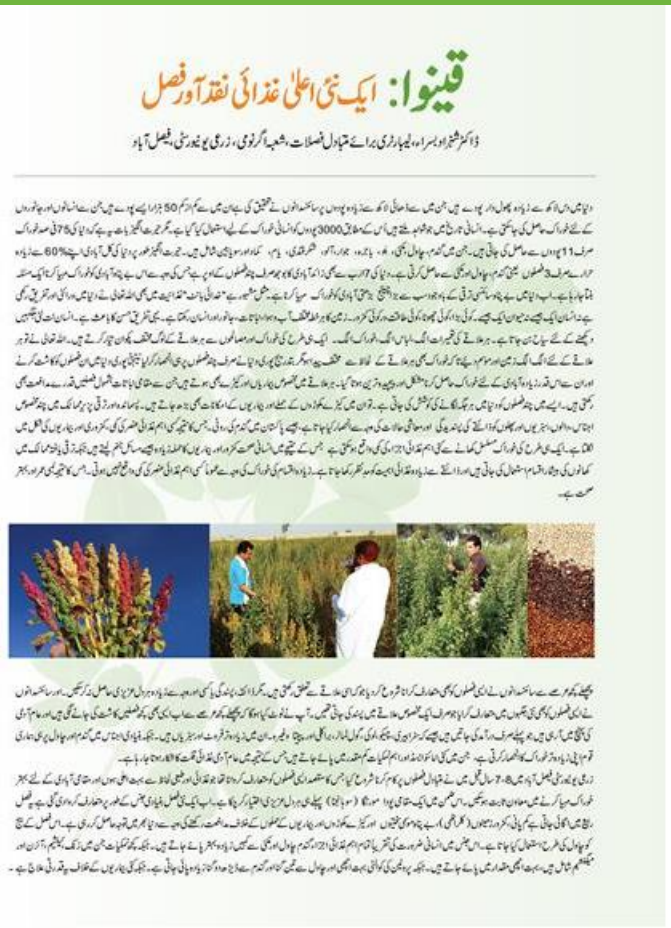
Quinoa pamphlets in local language





قینوا: ایک نئی اعلیٰ غذائی نقد آور فصل

ڈاکٹر شہزاد بسراء، لیبارٹری برائے متبادل فصلات، شعبہ اگرانومی، زرعی یونیورسٹی، فیصل آباد

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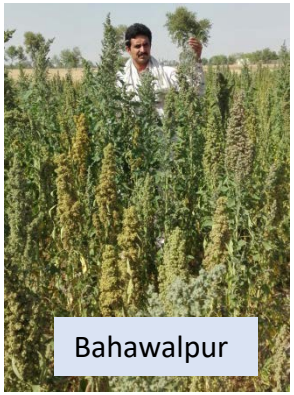
Quinoa cultivation as alternate crop


Faisalabad


Mian channu


Bahawalpur


Gujranwala


Muridke


Hydrabad


Sheikhupura


JK farms


Faisalabad


Sahiwal

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Quinoa being introduced as superfood

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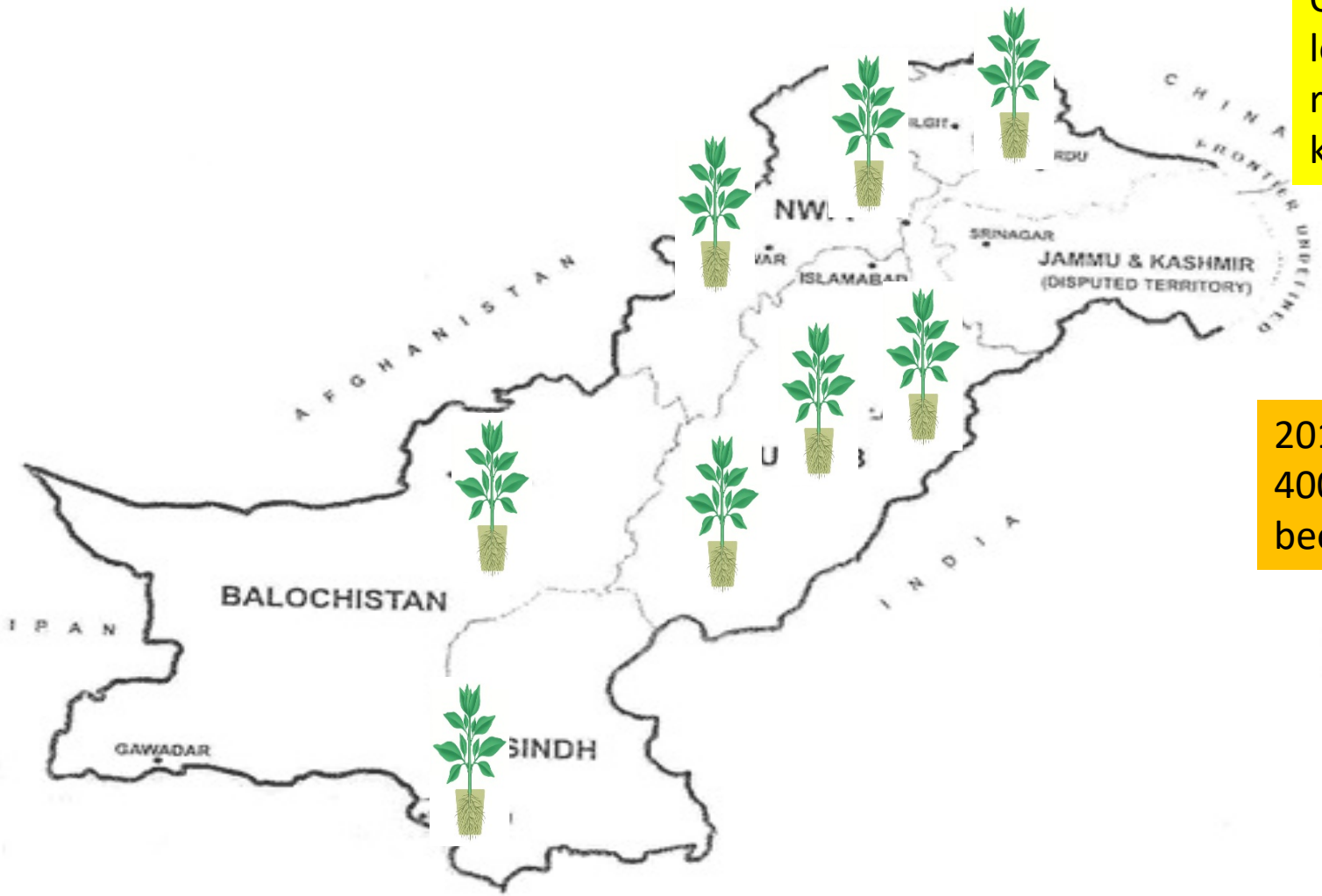
Quinoa now in Pakistan



2015= 800 acres On 27 different locations. Yield ranged from 200 kg 51000 kg ha^{-1}

2016 = more than 400 acres have been cultivated

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Conclusions and **recommendations:**

Quinoa crop has been well adapted to Faisalabad conditions and its growth on saline sodic soils also confirmed its halophytic behavior.

Yields obtained were very encouraging and even more than most of the countries outside the countries of origin with comparable nutritional profile.

Outreach was very successful and a number of progressive farmers and exporters have been motivated to grow and export.

Challenges

Weed control
Marketing
Saponin removal

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Acknowledgements

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Manzoor Qadir

Sven- Erik Jacobsen

USDA

David Brenner

Thanks

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