Identification of Suitable Sowing Time for Quinoa (*Chenopodium quinoa* Willd.) at Samtenling

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ABSTRACT

Trials on different sowing dates were conducted at the Agriculture Research and Development Centre, Samtenling to determine suitable planting time for quinoa. Four quinoa varieties: Ivory 123, DoA-1-PMB 2015, Amarilla Sacaca and Amarilla Marangani were sown at six different planting dates starting from 17 September to 6 December 2018. The exact sowing dates were 17 September, 2 October, 17 October, 6 November, 16 November and 6 December. Each sowing date was staggered at an interval of 15 days. The effects of sowing time on grain yield and other agronomic traits were analyzed. No data were obtained from first sowing and sixth sowing (17 September and 6 December 2018) due to poor seed germination. The results indicated that mid October to mid-November is the most suitable sowing time for quinoa in Samtenling which represents the humid-subtropical agro-ecological zone. Comparative analyses between the four varieties indicate that Ivory 123 and DoA-1-PMB could be preferably sown in mid-October. Mid-November is a preferred sowing time for Amarilla Sacaca and Amarilla Marangani since significantly greater yields (2.49 t/ha and 2.56 t/ha respectively) were obtained as compared to seeds sown in October. Although there were no significant differences in grain yields both Ivory 123 and DoA-1-PMB 2015 took significantly shorter durations (82.8 days and 84.6 days respectively) to mature and produced significantly shorter plant heights (75.5cm and 93.6 cm respectively) when seeds were sown in mid-October. Amarilla Sacaca and Amarilla Marangani took longer durations to mature (110.6-132 days) and produced significantly longer plant heights (135.6cm and 145.2 cm respectively) when seeds were sown in mid-November as compared to seeds sown in October. Based on the result of a one-year trial, it can be concluded that all the four released quinoa varieties can be sown from mid-October to mid-November in Samtenling which represents the humid agro-ecological zone.

Keywords: *Sowing time, Humid-subtropical agro-ecological zone, Quinoa varieties, Maturity, Yield*

1. Introduction

Quinoa (*Chenopodium quinoa* Willd.) is a potential, new and a future crop that could play a pivotal role in food security. Quinoa has been reported to have made an important contribution to the staple needs of the population of the Andean countries (Rojas, 2015). The General Assembly of the United Nations declared 2013 as the International Year of Quinoa, highlighting the potential

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role of quinoa in contributing to global food security, given its high nutritional value and tremendous potential to adapt to different agro-climatic conditions (Bazile, D., Chevarria-Lazo, M., Dessauw, D., Louafi, S., Trommetter, M., & Hocdé, H. (2015). The nutritional qualities of quinoa and its suitability for use by people with celiac disease, has resulted in an increased worldwide demand of quinoa-based food products (Casini, 2018).

Quinoa was firstly introduced to Bhutan from Peru in 2015 by the Department of Agriculture (DoA) with the support of the FAO (Katwal, 2018). It is known for its ability to grow in extreme temperatures ranging from -4 ^{0}C to 38 ^{0}C and at relative humidity ranging from 40% to 88% (FAO, 2011), and tolerate adverse abiotic stresses such as drought and saline conditions. Moreover, its efficient use of water makes quinoa an excellent alternative crop in the face of climate change (FAO, 2011).

The main objectives of introducing this new crop to Bhutan are to diversify existing cropping systems, adapt this versatile crop to different growing environments as a climate resilient crop, and to enhance the food and nutritional security of the Bhutanese people (Katwal, Wangdi, & Giri, 2019). Since its introduction evaluations were carried out from 2015-2016 by the National Quinoa Commodity Program to assess its adaptability. Thereafter, general information on quinoa and its package of practices was generated based on the results of the first two years of adaptive evaluations carried out at six different locations across the country. More importantly, the 20th Variety Release Committee (VRC) of the Ministry of Agriculture and Forests (MoAF) released four varieties for cultivation under different cropping systems and agro-ecology (Table 1). Furthermore, to popularize the newly introduced crop among the farmers, the Department of Agriculture also gave local Bhutanese names for Quinoa (Table 1) (Katwal et al., 2019).

Table 1. Information on four released varieties (with local names)

Bhutanese name	Original name	Origin	Plant height (cm)	Maturity (days)	Grain colour	Mean yield (t/ha)
AshiHeychum-AM	Amarilla Marangani	Peru	188	173	Yellow	1.88
AshiHeychum-AS	Amarilla Sacaca	Peru	165	170	Yellow	2.25
Ashi Heychum-123	Ivory 123	India	122	150	Brownish	2.25
AshiHeychum-TW	DoA-1-PMB-2015	Unknown	120	140	Brownish	1.88

Source: Katwal, 2019

Quinoa grows well under a wide range of soil and climate conditions, from cold and arid areas to wet tropical regions. The adaptability of quinoa to various levels of drought is due to the differentiation of a diversity of ecotypes originating in contrasting agro-environments (Silva, 2013). Considering the conditions where quinoa is cultivated and the genetic variability available, quinoa has a remarkable adaptability to different agro-ecological zones. It adapts to different climates and the crop can grow at relative humidity from 40% to 88%. Temperatures between 15 to 20 ° C are ideal for cultivation and can withstand temperatures from -4 ° C to 38 ° C. A water efficient plant, it is tolerant and resistant to lack of soil moisture, obtaining acceptable yields with rainfall of 100 to 200 mm (FAO, 2011)**.** The general climate of Samtenling is humid subtropical which consists of hot and humid summer with monthly mean temperatures of 24^0C to 29^0C, average rainfall of 312.6 mm and average relative humidity of 90.29%. It exhibits cold to mild winters with average monthly temperatures of 14^0Cto 23^0C with negligible mean rainfall of 2.5 mm. Mild temperatures and light rainfall are observed in Autumn months (September to November) with average temperatures of 21^0C to 27^0C and mean rainfall of 133 mm. Similar conditions are observed in spring season (March to May) although much less average rainfall of 61.5 mm is observed (NCHM, 2018).

According to Casini (2019), the identification of the most suitable sowing date is critical for the successful cultivation of quinoa. Although initial on-station observation trials and on-farm demonstrations on quinoa cultivation were carried out by Agriculture Research and Development Centre (ARDC), Samtenling from 2016 to 2017 no data were obtained due to poor seed germination which could have been due to high temperature during the sowing time. Also, the coincidence of heavy rainfall during seedling stage contributed to its failure which was mainly due to the lack of adequate knowledge on its suitable sowing period particularly for Samtenling agro-climatic condition. Later, the results of adaptive trials conducted by the National Commodity Quinoa Program from 2015-2016 as well as repeated failures and experiences gained on quinoa cultivation hinted at the possibility of cultivating quinoa at ARDC Samtenling by adjusting the sowing time within September to December under Samtenling agro-ecological condition. In the lower elevations (<1200 masl) when quinoa was sown in the maize-based dry lands in March, the vegetative growth and flowering were good but there was no grain setting. However, sowing within October to January gave good yield with hastened crop maturity due to low rainfall during winter months and higher temperature at the sites (Katwal et al., 2019).

The aim of this trial was to identify the most suitable sowing period for quinoa under the humid sub-tropical agro ecological zone and to assess the suitability of cultivating quinoa crop in the humid sub-tropical agro-ecology.

2. Materials and Methods

2.1. Experimental site

The experiment was conducted at Agriculture Research and Development Centre (ARDC), Samtenling Gewog, Sarpang Dzongkhag which is located at 375 meters above sea level.

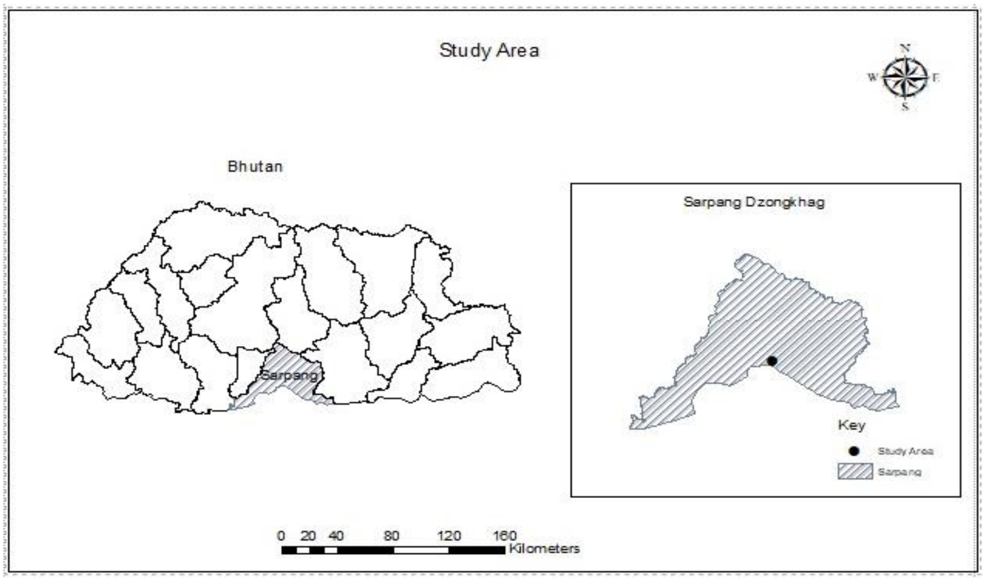


Figure 1. Map of Bhutan showing the experimental site (ARDC Samtenling) in Sarpang

ARDC Samtenling falls under humid subtropical zone which consists of hot and humid summer and cold to mild winters with annual mean temperatures of 200C to 270C and annual average rainfall of 123 mm.The relative humidity ranges from 70% in winter to as high as 90% in summer. Maximum rainfall of up to 360 mm is observed in summer while as low as 0 mm of rainfall is observed in winter. A total rainfall of 400 mm is observed in autumn with average temperatures ranging from 210C to 270C while much lower rainfall of 185 mm with similar mean temperatures are observed in spring season (NCHM, 2018).

2.2. Experimental design

The experiment was laid out in a split-plot design consisting of main plots as well as sub-plots. Six different planting dates were the main-plot factors while the four quinoa varieties were sub-plot factors. In each main plot the sub-plots consisting of four quinoa varieties were laid out in a randomized complete block design with five replications. Each plot size measured 3m x 2m (6m^2). Hence, each main plot had 20 sub-plots making a total of 120 plots (experimental units).

2.3. Treatments and methodology

The seeds of four quinoa varieties were sown on six different sowing dates which were the treatments of this experiment (Table 2). Seeds were sown in line maintaining row to row spacing of 60cm and thinning was carried out after 21 days of sowing to maintain a plant to plant spacing of 10-15cm. A total of 0.12 MT of FYM was applied in the experimental plot to enrich the soil with adequate nitrogen for enhanced growth and development of plants. Three times of manual weeding was carried out to avoid stress due to crop-weed competition.

Table 2. Details of the treatments of the experiment

Treatments (T)	Time of sowing	Treatments (V) (main-plot)	Varieties (sub-plot)
T1	17 September	V1	Ashi Heychum-123
T2	2 October	V2	Ashi Heychum-TW
T3	17 October	V3	Ashi Heychum-AM
T4	6 November	V4	Ashi Heychum-AS
T5	16 November		
T6	6 December		

2.4. Data collection

The data on grain yield, plant height, 1000 grain weight and days to maturity were collected to analyze and compare the effects of sowing time on the performance of the four varieties. Treatments T_1 (1st sowing) and T_6 (6th sowing) were excluded from the experiment as there was no germination in the experimental plots. The data on plant height was recorded one week prior to harvesting while maturity days were calculated from the day of sowing until physiological maturity of the grains. The grain yield per plot was recorded in kilograms after harvesting three middle rows consisting a section of $3.6m^2$ with 60 plants. A section of 2.4 m^2 consisting of two outer rows were discarded to avoid border effect. The harvested plant samples were dried for a week before threshing and weighing using electrical weighing balance. The grain samples were adequately dried in the sunlight to maintain grain moisture content below 10%. 1000 grain weights of each treatment were recorded by weighing three sets of 1000 grain samples using electrical weighing balance which had a calibration in gram unit. The average of 1000 grain weights of three sample sets were taken for data analysis.

2.5. Data analysis

Data collected were analyzed using MS Excel and STAR (Statistical Tool for Agricultural Research) version 2.0.1.

3. Results and Discussion

Results from this trial indicate that quinoa can be successfully cultivated in the humid sub-tropical agro-ecology, represented here by Samtenling, when sown after the second fortnight of October to second fortnight of November.

3.1 Effect of sowing time on maturity days

Upon analysis significant difference was observed in the maturity days of each quinoa variety sown on different dates as given in Table 3. All the four varieties took significantly shorter maturity durations ranging between 82.8 - 110.4 days when seeds were sown on 2 October, 17 October and 6 November as compared to their maturity days resulted from sowing on 6 November which ranged from 116.8 -132.4 days. Seeds of Ashi Heychum-123, Ashi Heychum-TW and Ashi Heychum-AS sown in October matured significantly earlier than seeds sown in November (Table 3). No significant difference was observed in crop maturity duration of Ashi Heychum-AM from the second sowing (2 October) until the fourth sowing (6 November).

Table 3. Effect of sowing time on maturity days of each variety

Treatments (TOS*)	Ashi Heychum - 123	Ashi Heychum - TW	Ashi Heychum - AS	Ashi Heychum - AM
02/10/2018	85.8^{c}	83.0^{c}	97.4 ^{c}	106.4^{b}
17/10/2018	84.6^{c}	82.8^{c}	101.8^{c}	107.0^{b}
06/11/2018	92.2^{b}	88.8^{b}	110.6^{b}	110.6^{b}
16/11/2018	116.8^{a}	118.2^{a}	123.0$^{a`}$	132.4^{a}
P value	**	**	**	**
C.V. (%)	3.72	3.72	3.72	3.72

***P*< (0.05); Means with the same letters are not significantly different, *TOS= Time of sowing

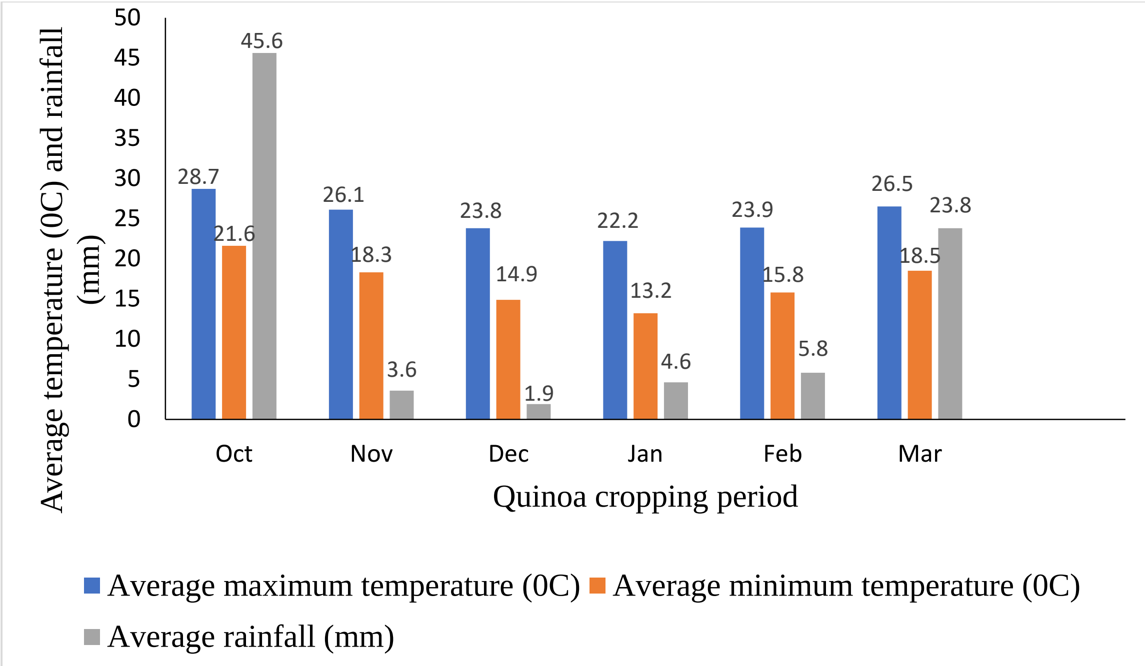
A comparative analysis of varieties at each level of time of sowing (Table 4) indicated that Ashi Heychum-123 and Ashi Heychum-TW matured significantly earlier (82.8-118.2 days) than Ashi Heychum-AS and Ashi Heychum-AM irrespective of sowing time. Katwal (2018) also reported that Ashi Heychum-TW and Ashi Heychum-123 took significantly shorter durations of 120 to 150 days to mature while the other two varieties took 170 to 180 days at high altitude areas above 1200 masl. Therefore, it indicates that the two varieties are inherently early maturing varieties while Ashi Heychum-AS and Ashi Heychum-AM are late maturing varieties.'

Table 4. Comparison of maturity days between varieties at each sowing time

Treatments	Treatments (Time of sowing)			
	02/10/2018	17/10/2018	06/11/2018	16/11/2018
Ashi Heychum-123	85.8^{c}	84.6^{c}	92.2^{b}	116.8^{c}
Ashi Heychum-TW	83.0^{c}	82.8^{c}	88.8^{b}	118.2^{bc}
Ashi Heychum-AS	97.4^{b}	101.8^{b}	110.6^{a}	123.0^{b}
Ashi Heychum-AM	106.4^{a}	107.0^{a}	110.6^{a}	132.4^{a}
P value	**	**	**	**
C.V. (%)	3.72	3.72	3.72	3.72

***P*<(0.5); Means with the same letters are not significantly different

Crop maturity duration of plants is one of the key determining factors of the adaptation of a species (Bertero, 2015). Since, temperature is the environmental factor with the highest relative impact on crop maturity duration (Bertero, 2015) the significant difference observed in the maturity days could be due to considerable differences in the average daily temperature between the cropping periods. The temperature data obtained from National Centre for Hydrology and Meteorology (NCHM) shows a gradual decrease in the average daily temperature with successive delay in sowing time from October to November 2018 (Fig 2). With the decrease in temperature there was delay in physiological maturity of each quinoa variety resulting in significant differences in crop maturity duration of all the four varieties.



Source: NCHM (2018)

Fig 2. Monthly average temperature and rainfall during the cropping period

3.2 Effect of planting time on plant growth

Significant difference was observed in plant heights of different quinoa varieties sown on four different dates. In all the four varieties, shorter plant heights (75.6-99.0 cm) were observed when plants were sown on 17 October while all except Ashi Heychum-TW resulted in a significantly longer plant heights ranging from 127.8-145.2 cm when seeds were sown on 16 November (Table 4).

Table 4. Effect of sowing time on plant heights (cm) of each quinoa variety

Treatments (TOS*)	Ashi Heychum-123	Ashi Heychum-TW	Ashi Heychum-AS	Ashi Heychum-AM
02/10/2018	97.4^{bc}	93.2^{b}	113.4^{b}	114.8^{b}
17/10/2018	94.0^{c}	75.6^{c}	91.6^{c}	99.0^{c}
06/11/2018	111.8^{b}	113.2^{a}	103.8^{bc}	99.6^{c}
16/11/2018	127.8^{a}	107.4^{ab}	135.6^{a}	145.2^{a}
P value	**	**	**	**
C.V. (%)	14.43	14.43	14.43	14.43

**$P<(0.5)$; Means with the same letters are not significantly different, *TOS= Time of sowing

Comparison between the varieties indicated that Ashi Heychum-TW and Ashi Heychum-123 had significantly shorter plants than Ashi Heychum-AS and Ashi Heychum-AM when seeds were sown on 2 October (Table 5). Katwal (2018) also reported that Ashi Heychum-TW and Ashi Heychum-123 had shorter plant heights of 120 cm to 122 cm as compared to Ashi Heychum-AM and Ashi Heychum-AS which had significantly taller plant heights of 173 cm to 170 cm. No significant differences were observed in plant heights among the varieties except Ashi Heychum-TW which had significantly shorter plants (75.6 cm) than the rest of the varieties when plants were sown on 17 October. Ashi Heychum-AM had significantly taller plants as compared to Ashi Heychum-123 and Ashi Heychum-TW when the plants were sown on 16 November 2018.

Table 5. Comparison of plant heights (cm) between varieties at each sowing time

Treatments (Varieties)	Treatments (Time of sowing)			
	02/10/2018	17/10/2018	06/11/2018	16/11/2018
Ashi Heychum-123	97.4^{b}	94.0^{a}	111.8^{a}	127.8^{b}
Ashi Heychum-TW	93.2^{b}	75.6^{b}	113.2^{a}	107.4^{c}
Ashi Heychum-AS	113.4^{a}	91.6^{a}	103.8^{ab}	135.6^{ab}
Ashi Heychum-AM	114.8^{a}	99.0^{a}	99.6^{b}	145.2^{a}
P value	**	**	**	**
C.V. (%)	9.22	9.22	9.22	9.22

**P<(0.5); Means with the same letters are not significantly different

Although no data were recorded on lodging percentage of quinoa plants observations from on-station trials and on-farm demonstrations from 2017-18 indicated association of stem lodging incidence with longer plants than the shorter plants. As significantly shorter plant heights were observed in all the varieties when seeds were sown on 17 October, sowing of quinoa in mid-October could preferably reduce incidence of lodging in quinoa in the sub-tropical humid agro-ecological zone.

3.3 Effect of planting time on grain yield (t/ha)

Time of sowing had significant (P<0.05) effect on grain yield of each quinoa variety (Table 6). Ashi Heychum-123 produced significantly lesser grain yield (0.79 t ha^{-1}) when seeds were sown on 2 October as compared to its grain yields from seeds sown on rest of the sowing periods.

Ashi Heychum-TW produced a significantly greater grain yield (1.51 t ha^{-1}) when seeds were sown on 6 November as compared to its yield result from sowing on 2 and 17 October. Both Ashi Heychum-AS and Ashi Heychum-AM produced significantly higher grain yield (2.50 t ha^{-1} and 2.58 t ha^{-1}) when the varieties were sown on 16 November in comparison to the yield results from other sowing dates.

In general, there was increase in grain yield with successive delay in sowing time. This correlates with the gradual decreasing trend in temperature from October to November (Fig 2). Hightemperatures during flowering and seed set can significantly reduce yield and is one of the major barriers to the global expansion of quinoa (Murphy, Hinojosa, & Matanguihan, 2018). The yield response of Ashi Heychum-AM and Ashi Heychum-AS was significantly higher in plots sown on 16th November which could be attributed to lower temperatures during the growing period. The grain yields of the two varieties are comparable to the results of the adaptation trial in low altitude areas conducted in 2016 which recorded mean yields ranging from 1.52 t ha-1 to 2.63 t ha-1(Katwal et al., 2019).

Table 6. Effect of sowing time on grain yield (t/ha) on each variety

Treatments (TOS*)	Ashi Heychum-123	Ashi Heychum-TW	Ashi Heychum-AS	Ashi Heychum-AM
02/10/2018	0.79[b]	0.54[b]	0.59[b]	0.64[c]
17/10/2018	1.61[a]	0.84[b]	1.10[b]	1.50[b]
06/11/2018	1.98[a]	1.51[a]	0.81[b]	0.86[bc]
16/11/2018	2.10[a]	0.93[ab]	2.50[a]	2.58[a]
P value	**	**	**	**
C.V. (%)	49.15	49.15	49.15	49.15

***P*< (0.5); Means with the same letters are not significantly different, *TOS= Time of sowing

The comparative analysis between the varieties on grain yield also showed significant yield differences (Table 7). The yield responses to different sowing time differed significantly between the varieties. There were no significant differences in grain yield among the varieties when seeds were sown on 2 October. However, yield response of Ashi Heychum-TW was significantly lower (0.84 t ha^{-1}) as compared to Ashi Heychum-123 (1.61 t ha$^{-1)}$ and Ashi Heychum-AM (1.50 t ha^{-1}) when seeds were sown on 17 October.

Both Ashi Heychum-123 and Ashi Heychum-TW gave significantly higher grain yields of 1.98 t ha^{-1} and 1.51 t ha^{-1} respectively as compared to Ashi Heychum-AM and Ashi Heychum-AS when seeds were sown on 6 November. Sowing on 16 November resulted in a significantly lesser grain yield (0.93 t ha^{-1}) for Ashi Heychum-TW as compared to the rest of the varieties.

Interestingly, when seeds were sown on 6 November grain yields indicated similar genetic traits between the varieties. Ashi Heychum-123 and Ashi Heychum-TW gave more or less equal grain yields of 1.98 t ha^{-1} and 1.51 t ha^{-1} respectively while Ashi Heychum-AS and Ashi Heychum-AM produced statistically equal grain yields of 0.81 t ha^{-1} and 0.86 t ha^{-1} respectively when seeds were sown on 6 November (Table 7). This agrees with the findings of Katwal (2019), who pointed out that the mean yield recorded for Ashi Heychum-AM and Ashi Heychum-AS did not show huge difference since both the varieties come from a close pedigree.

Table 7. Comparison of grain yields (t/ha) between varieties at each sowing time

Treatments (Varieties)	Treatments (Time of sowing)			
	02/10/2018	17/10/2018	06/11/2018	16/11/2018
Ashi Heychum-123	0.79^{a}	1.61^{a}	1.98^{a}	2.10^{a}
Ashi Heychum-TW	0.54^{a}	0.84^{b}	1.51^{a}	0.93^{b}
Ashi Heychum-AS	0.59^{a}	1.10^{ab}	0.81^{b}	2.50^{a}
Ashi Heychum-AM	0.64^{a}	1.50^{a}	0.86^{b}	2.58^{a}
P value	ns	**	**	**
C.V. (%)	34.56	34.56	34.56	34.56

***P*<(0.5); Means with the same letters are not significantly different

Based on the yield results Ashi Heychum-123 could be more suitably sown from mid-October to mid-November while Ashi Heychum-TW could be sown within the first week of November. Ashi Heychum-AS and Ashi Heychum-AM could be most preferably sown in mid-November as the yield response of the two varieties were significantly greater (2.50 t ha^{-1} to 2.58 t ha^{-1}) than those observed from rest of the sowing dates.

3.4 Effect of planting time on 1000 grain weight **(g)**

There was a significant difference in 1000 grain weights of varieties as a result of different sowing dates (Table 8). In Ashi Heychum-123 and Ashi Heychum-TW sowing on 6 and 16 November resulted in a significantly greater test weights ranging from 1.70g to 2.40g. This agrees with the findings of Bertero, King, & Hall (1999) in which it was reported that the maximum grain growth was obtained under short day and cool temperature. In Ashi Heychum-AS greater test weights were observed when seeds were sown from 17 October to 16 November. However, there was no significant effect of sowing time on 1000 grain weights of Ashi Heychum-AM.

Table 8. Effect of sowing time on test weights (g) of each variety

Treatments (TOS*)	Ashi Heychum 123	Ashi Heychum-TW	Ashi Heychum-AS	Ashi Heychum-AM
02/10/2018	0.30^{c}	0.97^{b}	0.96^{b}	1.78^{a}
17/10/2018	0.18^{c}	0.23^{c}	1.73^{a}	1.50^{a}
06/11/2018	1.70^{b}	2.40^{a}	1.54^{a}	1.46^{a}
16/11/2018	2.28^{a}	2.02^{a}	1.72^{a}	1.62^{a}
P value	**	**	**	**
C.V. (%)	32.30	32.30	32.30	32.30

***P*<(0.5); Means with the same letters are not significantly different, *TOS= Time of sowing

4. Conclusion

Results from one year experiment using four planting dates and four varieties indicate that quinoa crop can be successfully grown at Samtenling that represents the humid sub-tropical agro-ecological zone. The analysis of the effects of different planting time on grain yield, crop maturity, plant height and test weight showed significant differences. Based on the results of a one-year experiment, it may be concluded that mid-October to mid-November is a suitable sowing time for Samtenling agro-ecological condition for all the four varieties. Higher grain yields (0.81 t ha^{-1} to 2.58 t ha^{-1}) were obtained when seeds were sown from 17 October to 16 November 2018 as compared to the average grain yields from sowing on 2 October 2018. Interestingly, the two varieties Ashi Heychum-AS and Ashi Heychum-AM gave significantly higher yields (2.50 t ha^{-1} and 2.58 t ha^{-1} respectively) accompanied by taller plant heights (135.6 cm and 145.2 cm respectively) and took significantly longer duration to mature (123 days and 132.4 days respectively) when seeds were sown on 16 November. These characteristics correlate with the information on the four varieties provided by Katwal (2019).

Among the varieties Ashi Heychum-AM gave the highest average grain yield (2.58 t ha^{-1}) while Ashi Heychum-TW gave the lowest average grain yield (0.54 t ha^{-1}). Ashi Heychum-123 took the shortest duration to mature (82.8 days) while the longest maturity duration was observed in Ashi Heychum-AM (132.4 days).

Since quinoa is sensitive to day length and is classified as short-day plant it requires relatively cool temperatures for optimum growth. With cool temperatures and lower rainfall in October-November and shorter photoperiods, quinoa can be successfully grown in humid-subtropical agro-ecological zones if factors such as crop management and proper irrigations are also ideal. For definitive conclusions on planting time similar experiments need to be repeated within the humid-subtropical region in the country.

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