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Studies on physiological maturity and assessment of dormancy in white quinoa (*Chenopodium quinoa* Willd)

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Abstract
A field experiment was conducted at Zonal Agricultural Research Station (ZARS), UAS, GKVK, Bangalore during 2018-19, determination of physiological maturity stage in quinoa cv. 507740. The experiment was laid out in RCBD and replicated in three times with seven treatment combination,T_1-30 days after anthesis, T_2-35 days after anthesis, T_3-40 days after anthesis, T_4-45days after anthesis, T_5-50 days after anthesis, T_6-55 days after anthesis,T_7-60 days after anthesis, The results revealed that among the treatments, T_7-60 days after harvest recorded highest seed quality attributes *viz*., highest seed germination (72.00%), 1000 seed weight (3.35 g), seed moisture content (12.67%), seedling vigour index I (1012) and seedling vigour index II (1095). And assessment of dormancy had carried out, there is existence of dormancy period in freshly in harvested seeds of quinoa is about 21 days. As the days advanced dormancy decreased. Seeds could be used for sowing only after 21 days of harvesting.

Keywords: Physiological maturity, dormancy, quality

Introduction

Quinoa (*Chenopodium quinoa* Willd) is a halophytic, allotetraploid grain crop of the *Amaranth* family with the impressive drought tolerance, nutritional content and an increasing the worldwide market (Risi and Galwey, 1984) [12]. The nearest wild species to quinoa are *C. hicinum*and *C. berlandieri*, which have the same number of chromosomes (2n = 4x = 36), and *C. pallidicaule* with 2n = 2x 18 chromosomes. It is dicotyledonous annual plant grown as a grain crop primarily for its edible seeds. Small achenes, measure upto 2 mm in diameter. It has good nutritive value. It is commonly called as quiuna, parka, dawe, chuppah and kinwah and quinoa is not a grass, but a pseudo cereal botanically related to spinach and amaranth (*Amaranthus* spp.) Quinoa provides protein, dietary fibre, vitamin B and dietary minerals in rich

Amounts above those of wheat, corn, rice or oats. It is gluten free, after harvest the seeds are processed to remove the bitter tasting outer seed coat. FAO declared 2013 [6] as International year of Quinoa (Bhargava *et al*., 2006) [5].

Quinoa is a fast-growing plant, measuring up to 0.2 to 3 m in height with alternate, coarsely toothed, triangular to ovate leaves and the racemose inflorescence produce hundreds of fruits (a seed-like fruit with a hard coat) occurs in an indehiscent achene and it is protected by perigonium with diversified colours ranging from white or pale yellow to orange, red, brown and black. Quinoa has greater plasticity of adaptation to photoperiod, altitudes, soil pH range of 6 to 8.5 and temperature from sub-tropical to tropical and humid areas. Base temperature of quinoa is 3 ºC with optimum temperature of 15-30 ºC and maximum temperature is of 50 ºC.

The crop cycle varies from 90 to 240 days and it is well suited to different environmental conditions. The phenology phases are emergence, two, four and six true leaves, branching, start of ear formation, full formation of ear, start of inflorescence, anthesis, woody grain, soft grain and physiological maturity. Quinoa has got wider adaptability to different stress environmental conditions such as cold and drought.

In 2009, production in the Andean region was about 70 thousand tons with almost 40 thousand tons produced by Peru, 28 thousand tons by Bolivia and 746 tons by Ecuador. The main countries producing quinoa in the world are Bolivia and Peru. They both accounted for 90 per cent of the world quinoa production. (FAOSTAT of united nations 2013) [6]. Quinoa was cultivated in an area of 440 hectares with an average yield of 1.053 tonnes hectare^{-1} in India.

The seed yield of the quinoa is generally influenced by genetic, agronomical, physiological and seed production factors by involving potentiality of varieties, maintaining of optimum population of plants by following proper Package of practices. The present objective is to study the physiological maturity (PM) stage, influence of foliar spray plays an eminent role in determination of the seed yield and quality and also to determine the duration of dormancy period, which is helpful to seed preservation. Potential yield of the plants mainly depends upon their genetic constitution and environment under which they are grown and also maximum seed viability and vigor may be achieved at the correct stage of harvest. Delay in harvesting mayleads to decline of seed quality and due to adverse environmental conditions such as high temperature, high humidity etc. It is widely accepted that physiological maturity represents the development of all essential parts and the end of grain filling period. Further it helps to assess the seed yield and quality and maximum yield for any crop harvested as dry seed (Malarkodi and Srimathi, 2007) [11].

Seed dormancy period is a natural phenomenon and after the harvest of crop, seeds maintain their viability in un-favourable conditions. Harvesting of non-dormant seeds during *kharif* season leads to sprouting of seeds and deterioration in the field itself. Several processes are known to be involved in the induction of dormancy and switch from dormant to the germinating state (Leonie and Maarten, 2008) [10]. To optimize germination over time, the seed enters a dormant state. Dormancy prevents pre-harvest germination. So it is necessary to assess the dormancy, since it is a matter and caring factor to handle seeds of quinoa.

Material and Methods

The studies on physiological maturity and assessment of dormancy was carried out in white quinoa cv. 507740 at ZARS, UAS, GKVK, Bangalore. Sowing was taken up in the month of October. The experimental site is situated between 12° 15' N latitude and 77° 35' E longitude at an altitude of about of about 930 m above Mean sea level. The experiment was laid out for the study of physiological maturity in randomized complete block design and replicated in three times with seven treatments,T_1-30 days after anthesis, T_2-35 days after anthesis, T_3-40 days after anthesis, T_4-45 days after anthesis, T_5-50 days after anthesis, T_6-55 days after anthesis,T_7-60 days after anthesis. The seeds were harvested every five days interval from 30 days after anthesis and observations were recorded. And for the determination of dormancy period at the 0th day of the harvest to 42nd day after harvest with the interval of seven days seeds were kept for germination and data was noted down.

Results and Discussion

Results on seed quality attributes such as seed germination (%), 1000 seed weight, seed moisture content, seedling vigor index I and seedling vigor II were significantly different as influenced by physiological maturity.

Seed germination (%)

Seeds were harvested at different intervals and kept for germination significantly higher germination per cent was obtained at 60 DAA (72.00%) and no germination was recorded at 30 DAA. Since, the seeds were not attained the maturity and there was no dry matter accumulation. Data on seed germination as influenced by physiological maturity.

Present investigation results exhibited higher germination at physiological maturity were similar with the findings of Khan and Hussain (1974) [8], improved germination with the increase in dry matter content and decrease in the seed moisture content. In general, seeds attained higher germination percentage only at physiological maturity.

1000 seed weight (g)

Significant results were obtained for test weight at different stages of physiological maturity. It ranged from 3.0 to 3.35 grams. At 60 days after anthesis (DAA), higher test weight was observed (3.35 g) followed by 55 DAA (3.27 g). However, the lower test weight was recorded in the early days of anthesis that is at 30 DAA (3.00 g).

The higher test weight was achieved at 60 days after anthesis, as the days advances from 30 to 60 days after anthesis the test weight of the seeds increased, due to the increase in the dry matter content at the physiological maturity stage and delay in harvest resulting in prolonged exposer of seeds in the field. Similar results have been reported by Livova (1963) [9] and Bapat and Choudhry (1976) [2] also indicated that decrease in the dry matter accumulation of seeds may be due to developed respiration and exhaustion of stored food material in seeds.

Seed moisture content (%)

The moisture content of the quinoa seeds was highest (35.33%) at 30 DAA whichgradually decreased with an increase in the dry matter accumulation as the days advanced from flowering to physiological maturity. The seed moisture content at physiological maturity was 12.67 per cent. In the initial stages loss in moisture content was considerably high and eventually decreased as the days approached for harvest. Parallel results were obtained by Bharduria *et al.*, (1976) [4] in paddy.

Seedling vigor index-I

Significant results were obtained at different harvests after anthesis. The highest data was recorded on 60 DAA (1012) for seedling vigor index I.

Seedling vigour index-II

The data on seedling vigor index II after 60 days of anthesis was recorded (1095.67). The same results were obtained by Abdul Baki and Anderson (1973) [1]. They found that development of shoot and root were influenced to little extent by the initial weight of the seed in soybean. Also said it might change with the species and quantity of food material available.

Table 1: The data on seedling vigor index II after 60 days of anthesis was recorded (1095.67).

Treatments	Germination (%)	Test weight (g)	Seed moisture content (%)	SVI-I	SVI-II
T_1	0.00	3.00	35.33	0	0
T_2	0.00	3.03	33.00	0	0
T_3	27.00	3.10	27.67	277	162
T_4	32.67	3.17	22.00	406	220
T_5	59.67	3.25	17.33	688	553
T_6	66.67	3.27	14.67	1008	1039
T_7	72.00	3.35	12.67	1012	1095
SEm±	1.397	0.068	0.864	26.1	18.3
CD @ 5%	4.238	0.207	2.620	83.6	56.5
CV (%)	6.566	3.727	6.431	9.6	7.3

Influence of physiological maturity on seed quality attributes

Assessment of seed dormancy

Seed germination

The significant results are obtained for seed germination percentage.

The seed germination percentage increased gradually from the date of harvest upto 42 days after harvest (DAH). The highest germination percentage was obtained at the 42ndday after harvest that is (85.67%). At the day of harvest there was 72.66 per cent of germination and It means there is dormancy is existed in freshly harvested quinoa seeds is Table 1.

Taken up only after the 21days after harvest of the crop. The lesser germination immediately after harvest might be due to the inherent dormancy of the crop and also might be due to the agro-ecological factors on dormancy. And duration of dormancy may be depends on the annual weather conditions. Similar results were found in wheat as suggested by Barlo-Szabo *et al.* (1987) [3].

Table 2: The significant results are obtained for seed germination percentage.

Treatments	Normal seedlings (%)	Abnormal seedlings (%)	Fresh un germinated seeds (%)	Dead seeds (%)
T_1 – 0 Days after harvest	72.66	3.33	21.68	2.33
T_2– 7 Days after harvest	78.67	3.67	15.33	2.00
T_3 –14 Days after harvest	80.33	3.00	15.00	1.67
T_4– 21 Days after harvest	85.00	2.33	11.33	1.67
T_5 – 28 Days after harvest	85.00	2.00	12.00	1.33
T_6 – 35 Days after harvest	85.33	2.00	11.33	1.33
T_7 – 42 Days after harvest	85.67	2.00	11.00	1.33
S.Em±	0.471	0.309	0.218	0.309
CD (p=0.05)	1.430	0.936	0.662	NS
CV(%)	0.998	20.409	2.785	32.07

Assessment of dormancy period in white quinoa

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