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EFFECT OF DROUGHT STRESS ON QUALITY AND VIGOUR OF PEA cv. KELVEDON WONDER

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Abstract

To examine the effect of drought stress on quality and vigour of pea seeds, the cultivar Kelvedon Wonder was selected. The experiment was carried out in green house in plastic pots during 2004-2005. There were three treatments i.e. early stress (when first pod was mature and started filling) late stress (when third pod was mature and started filling) where, as in control no stress was imposed. Analysis of variance regarding various parameters showed that although among treatments values were non significant but early stress affected the cultivar more as compared to some parameters in case of late stress treatment.

Key words: Pea, drought stress, quality, vigour

INTRODUCTION

Vegetables are an important source of vitamins, minerals and fiber for the diet of peoples (Koay and Loh, 1990). In-fact, vegetables are the most sustainable and affordable dietary source of micronutrients (Anonymous, 2004c). Vegetables are cultivated on an area of 25.4 thousand hectares excluding potato in Pakistan with an annual production of 2879.9 thousands tonnes (Anonymous, 2004a).

Environmental stress during seed production can affect subsequent seed quality. Stress occurring after physiological maturity, but before harvest, can cause reduction in soybean seed germination and vigour (Tekrony et al. 1980; Vieira et al. 1991 and 1992).

Water is essentially required at every stage of plant growth from seed germination to plant maturation. Therefore, regardless of the growth stage at which water deficiency occurs, it affects every aspect of plant growth and even temporary drought can cause substantial losses in crop yield. The worldwide losses in yield due to water stress sometimes may exceed those caused by all other factors (Ashraf and Khan, 1993).

In developing countries like Pakistan the availability of high quality seed is a problem. There may be insufficient seed producing organizations to meet the seed requirements, or farmers use their own seed from their commercial crop. They do not grow any specific seed crops. Weather during seed production and storage affects quality adversely (Copeland and Mcdonald, 1995). There are not good storage facilities because of lack of sufficient funds (John and Asianics, 1994). High quality of seeds is one of the most important components for crop production

(Castillo et al., 1993). Poor quality seed may cause delayed emergence and slower seedlings growth from which, in certain instances, crops may never fully recover.

Hence there was a need to develop improved methods to produce high quality seed so that they do not deteriorate quality in the prevailing unfavorable storage conditions. To fill this gap the experiment was undertaken to study the effect of drought stress on quality and vigour of pea cultivar kelvedon wonder.

MATERIALS AND METHOD

Experiment reported here is comprised of two components; first part involves the production of seed of pea as influenced by various treatments, where as second part would involve determination of quality and vigour of seeds harvested from these studies.

This experiment was designed to observe the effect of water stress on yield, quality and vigour of the pea seeds during 2004-2005. Experiment was carried out in greenhouse number 1 University of Wales, Bangor. Pea seeds of cultivar Kelvedon Wonder were sown in plastic trays and were transplanted with a single seedling in 1.5 liter capacity plastic pots filled with John Innes compost No. 1 on June 14, 2004. Pots were placed on iron benches without capillary matting.

Experiment was laid out according to Randomized complete block Design (RCBD) with four replicates. There were three treatments and each treatment comprised of ten plants. Treatments were as follows:

T_1: Control plants, no stress imposed.
T_2: Early stress, stress imposed when first pod was mature and started filling.
T_3: Late stress, stress imposed when third pod was mature and started filling

The early stress treatment was imposed by with holding water when the first pod was fully mature and had started filling. Plants were re-watered on July 12, 2004 when 50% of the treated plants showed the signs of wilting. The late stress was imposed on July 12, 2004 when the first two pods were almost filled and the third pod started to fill. Plants were re-watered on Jul 19, 2004 when 50% of the plants showed signs of wilting. Plants were harvested on August 12, 2004 and at the time of harvest morphological characters and reproductive attributes were recorded. Roots were not harvested in this experiment. Lateral branches were also harvested and added to the main stem components. Dry weight of the vegetative parts of the plants along with the outer shells of pods was oven dried at 70°C for 72 hours. Following observations were recorded.

- Plant height (cm)
- Leaf number per plant
- Pod number per plant
- Seed number per pod
- Mean seed weight (g)
- Seed weight per plant (g)
- Dry weight per plant (g)

Following tests for measuring the quality and vigour as influenced by the drought stress treatments were performed.

Germination test

Germination test was carried out by putting 25 seeds in each Petri dish on the top of two Whatman No. 1 filter papers in presence of adequate moisture and placed in an incubator at 20 ^{o}C without light as no light is necessary for germination .The germinated seeds were counted daily for eight days and the final germination percentage was recorded. A seed was defined as germinated when the length of the radical visible outside the seed coat was 3-4 mm (Fernandez and Johnston, 1995).Germinated test was initiated on September 19, 2004 and final count was done after 8 days.

Electrical conductivity test

To determine electrical conductivity (Hampton et al., 1994) 50 seeds for each replicate were weighed. An electrical conductivity meter was used (Mettler Toledo Analytical AG, Sonnenvergstrasse-74.CH- 8603. Schwerzenbach, Switzerland, made in USA). The electrical conductivity meter was then calibrated against 0.01N KCL solution, and 200 ml. distilled water was placed in a conical flask of 250 ml volume. The electrical conductivity of distilled water was noted and then seeds were soaked in it. The flasks were covered and placed in an incubator at a constant temperature of 20^{o}C. After 24 hours the flasks were taken out and shaken gently. Then sufficient amount of the solution was taken from the flask and placed in a small rinsed beaker and the electrical conductivity was measured by the electrical conductivity meter. The value of electrical conductivity of distilled water was subtracted from the electrical conductivity of the solution and then this was divided by the weight of 50 seeds of the respective replicates. Measurement was expressed as uS cm^{-1} g^{-1} according to the vigour test rules (ISTA, 1988; Perry, 1977).Electrical conductivity test was performed on 23rd March 2005.

Emergence test

Seeds from each replicate of each treatment was planted in a seedling growth chamber (Vindon). The minimum temperature was maintained 15-17°C with 8 hours day length. Ten seeds were sown about 3 cm deep in two plastic pots of 5 litre capacity. Emergence counts were made daily up to two weeks time. After that, harvesting was made for each replicate, separately. Each seedling was removed by cutting them at the surface of soil from the pot or trays. The following observation was recorded from the seedlings.

- Emergence percentage
- Shoot length (cm)
- Dry weight (g)

Emergence test was started on 24th January 2005 and final count was made on 15th February 2005 and seedlings were harvested for dry weight measurement.

Statistical analysis

Statistical analysis was performed using the ANOVA function of the MINITAB Statistical Package version 14. Significance levels are shown in results by *, ** and *** for 5%, 1% and 0.1% probability levels, respectively. The non significant differences were shown by NS. Tests were made at 5% probability level when a significant P value is obtained for treatment effects. L.S.D was calculated by using T Table, and Tukey's method (Clewer and Scarisbrick, 2001).

RESULTS

The effects of water stress treatments for various growth and yield components of pea cultivar Kelvedon Wonder are presented in Table 1.

Plant Height: There were non significant differences among drought treatments in relation to plant height. However, late stressed plants recorded the tallest plants as compared to control and early stressed plants. Early stressed plants were at the bottom and gave the minimum height of plants.

Leaf Number per Plant: The mean differences of leaf number were non significant among drought treatments. Late stressed plants produced maximum number of leaves whereas control and early stressed plants were at par in relation to leaf number per plant and were comparatively lower than late stress.

Pod Number per Plant: The number of pods showed non significant differences among treatment means. However, control plants had the lowest number of pods as compared to early and late stressed plants .Among stress treatments early stressed plants had lesser pods as compared to late stressed plants but was higher than control plants.

Table 1: Effect of drought stress on growth and yield of pea cultivar Kelvedon Wonder

	Control	Early Stress	Late Stress	S.E.D	L.S.D
Plant height (cm)	42.9	41.6	43.0	1.599	N.S
Leaf per plant (number)	11.8	11.7	11.9	0.340	N.S
Pod per plant (number)	4.80	4.70	4.80	0.350	N.S
Seed Weight (g)	0.26	0.26	0.24	0.008	N.S
Seed per pod (number)	4.39	2.95	3.62	0.185***	0.453
Seed per plant (number)	20.15	13.9	17.57	1.437***	3.518
Seed Wt. per plant (g)	5.21	3.69	4.24	0.326**	0.798
Dry Wt. per plant (g)	3.80	3.37	3.94	0.915	N.S
*Germination (%)	10.0 (100)	10.0 (100)	9.77 (95.5)	0.079	0.195
E.C uS/g	62.03	61.64	84.58	9.672	N.S

* Data is transformed for germination percentage, original values are in parenthesis

Mean Seed Weight: Analysis of variance showed that there were non-significant differences among treatment means. However, control and early stressed treatments were at par and gave the maximum weight of individual seeds as compared to late stressed plants.

Seed Number per Pod: There were highly significant differences regarding seed number over pod among treatment means. Control plants gave the maximum number of seeds per pod as compared to rest of the treatments .Early stressed plants had fewer seeds per pod than late stressed plants.

Seed Number per Plant: The treatment means showed significant differences regarding average total seed number per plant. The highest number of seeds was obtained from control plants whereas the lowest number of seeds per plants was obtained from early stressed plants. However, late stressed plants were in the middle regarding seed production.

Dry Weight per Plant: There were no significant differences between treatment means regarding dry weight. Later stress did not affect on dry weight and produced the heavier plants among all treatments. However, control plants were in the middle and early stressed plants were at the bottom in relation to dry weight per plant.

Germination (%): Treatments means reflected significant differences regarding germination percentage. Control and early stressed plants gave the maximum germination as compared to late stressed plants where minimum germination was recorded.

Electrical Conductivity: Stress treatments did not have any significant effect on electrical conductivity. The lowest values were obtained from late stressed plants as compared to control and early stressed plants which were at par with each other.

Emergence (%): The results for seedling emergence are presented in Table 2 which shows significant differences between treatment means regarding emergence percentage; seedling length and seedling dry weight. Emergence percentage, seedling length and dry weight were highest in control plants as compared to both of the stress treatments. Among stress treatments later stress gave the lowest values.

DISCUSSION

The studies described in this experiment investigated the effect of drought stress on quality and vigour of pea cultivar. Drought stress treatments affected the vegetative growth of most of plant parts; height and number of leaves were non significant in treated plants as compared to control. This was associated with a reduction of leaf and branch production along with smaller plants as compared to control Ibrahim, 1990 concluded similar results for chickpea where a greater reduction was seen in vegetative parts with decreased tiller production and the correspondingly the main shoot became a more dominant component of the total shoot biomass.

It is well known fact that drought stress during seed development will reduce yields. The stress shortens, the seed filling period which reduces the final seed size, drought during plant growth and development can affect subsequent. The major influence of water deficit conditions was to reduce yield, If it occurred during seed production period of any crop.

When plants are exposed to water stress near grain filling stage, leaf rolling reduces the effective leaf area and the reduced photo synthetic efficiency of plants poses detrimental influences on plant yield. The effects may be more pronounced when the photosynthetic products temporally stored in vegetative organs are being translocated to grain (Regan et al., 1993). At pre-anthsis stage as well exposure to crop plants to water stress considerably reduce leaf area index and simultaneously the plant yield (Robertson and Giuunta, 1994; Ravihandron and Mungse, 1995.

Table 2: Effect of drought stress on emergence of pea cultivar Kelvedon Wonder

	*Emergence (%)	Shoot length (cm)	Number of leaves	Shoot dry weight (mg)
Control	9.55(91.25)	10.50	3.50	142.50
Early stress	8.44(71.25)	8.00	3.00	87.50
Late stress	8.06(65)	6.50	3.00	67.50
SED	*0.670****	*0.333****	*0.235*	*19.977****
LSD	*0.273*	*0.815*	*N.S*	*8.163*

*Data is transformed for emergence percentage, original values are in parenthesis

Reproductive growth is very sensitive to water stress. Heatherly (1992) also observed that drought stress during seed production of soybean usually reduces the yield and quality of seeds. The effect of drought stress on yield and yield components are well known in various crops. However there is disagreement in the literature as the effects of drought stress on seed germination and vigour. It was evident that drought stress was established during seed development in pea, as the plants showed visible symptoms of wilting. Yield and seed number per plant was reduced by drought treatments is most of the stress treatments. All of these effects would be expected from moisture stress during seed filling (Vieira et al., 1992) a severe stress treatment that terminated seed development well before normal period.

Seed yield of pea was significantly affected by water deficit conditions; however a significant decrease in early stress was seen as compared to control. These reductions suggest that watering treatments were successful in establishing the various levels of stress. The most of the reduction in yield was decreased due to seed number per pod or fruit instead of reduction in individual seeds. The all of the stress treatment were imposed at the time of seed filling period in pea. Water stress during this period reduced seed yield by accelerating leaf senescence (de souza et al., 1997; Breveden and Egli, 2003) If the stress occurred early in seed filling than seed number was reduced but stress could shorten the seed filling period and reduced the yield without affecting seed number. The only visible effect of the stress was acceleration of senescence. Thus in the absence of a well watered plant for comparison, the stress may not be not until the plants are harvested. It is different to relate the level of stress and the response obtained in this greenhouse experiment to stress level that may occur in field (Braveden and Egli, 2003). It is was concluded by Dornbors et al. (1989) that drought stress in soybean plants produce fewer pods followed by Fewer seeds per pod; and smaller seed mass than well watered plants. Seed yield and yield components were reduced significantly by drought imposition at pod fill stage. Seed weight was reduced by drought at a similar rate. Each yield component decreased significantly as a result of stress (Dornbors et al., 1989) However, reproductive growth was very sensitive to water stress.

Little information is available concerning the effect of environmental stress on seed quality (Tekrony et al., 1980) However, adverse environmental conditions during seed development and maturation reduced viability and vigour (Tekrony et al., 1980) The effect of water stress on seed quality has been investigated in soybean (Simicklas et al., 1989) and in peas (Fougereux et al., 1997) They concluded that water deficit conditions during the seed filing period induced a reduction in seed quality as assessed by germination and conductivity results but this reduction was not seen in earlier or with no water stress from above discussion it can be concluded that water limitations during entire growth period could reduce the yield, quality and vigour of pea, these discussion are in partially agreement with Golezani et al., 1997) for maize and barley and Vieira et al. (1992) for soybean who reported that it seems unlikely that drought stress would have a direct effect on metabolic activity of the seed that would subsequently affect quality. However water stress ultimately can considerably reduce yield.

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