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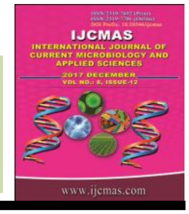


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# Effects of Waterlogging, Salinity and their Combination on Seed Germination and Vigour Index in Pigeonpea [*Cajanus cajan* (L.) Mill sp.] Genotypes

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**A B S T R A C T**

Thirty pigeonpea [*Cajanus cajan* (*L.*) Mill sp.] genotypes HO6-12, HO6-1, HO3-41, HO9-27, HO9-33, HO9-34, HO9-36, HO9-38, MANAK, PARAS, ICPH 2671, ICPH 2431, ASHA, MARUTI, ICPL 87051, ICP 5028, ICPL 20096, ICPL 87091, ICPL 20241, LRG 30, ICPL 20120, MAL 9, ICPL 20238, ICPL 20237, MAL 12, SIPS 2, SGBS 6, ICP 8857, UPAS 120 and ICP 7035 were screened for waterlogging, salinity (60mM) and WL + Salinity (30mM) tolerance in laboratory conditions. Germination percent and seed vigour index were observed eight days after sowing. On the basis of observations recorded genotypes ICPH 2431, PARAS, HO6-12, HO9-33, HO9-27 were found relatively tolerant while SGBS 6, UPAS 120, MAL 12, ICP 8857and ICPL 87091were found relatively sensitive under these stresses.

## Introduction

Pigeonpea [*Cajanus cajan* (*L.*) Mill sp.] is the sixth most important legume of tropics and subtropics which plays an important role in subsistence agriculture. It requires low moisture and performs well in poor soil (Kimani, 2001). In India, pigeonpea is mainly grown in the regions lying between $14^0$N and $29^0$N latitudes with mean annual rainfall ranging between 600 and 1500 mm. Majority of these areas are endowed with a dependable and high rainfall pattern. Soil waterlogging and salinity are major abiotic stress which imposes a marked effect on plant growth, development and yield by causing physiological and biochemical changes in plants (Munns, 2002). Pigeonpea is reported to be highly sensitive to water logging and salinity as water logging blocks oxygen supply to roots which hampers root permeability (Else *et al.*, 1995) and salinity impairs seed germination, reduces nodule formation, retards plant development and finally reduces crop yield (Singh *et al.*, 2016).Germination is sensitive to waterlogging and salinity which results in a significant reduction in the seed germination and also reduce the seedlings vigour (Orchard and Jessop, 1984; Misra and Dwivedi, 2004).

Much of the world's saline land is also subjected to waterlogging (saturation of the soil) because of the presence of shallow water-tables or decreased infiltration of surface water due to sodicity (Ghassemi *et al.*, 1995; Qureshi and Barrett-Lennard, 1998). The combination of waterlogging and salinity is much more deleterious than the individual stress and causes greater damage to plants, which imposes a major impact on yield (Barrett-Lennard, 2003). Therefore the present experiment was carried out to screen pigeonpea genotypes for tolerance to waterlogging, salinity and combined waterlogging + Salinity.

## Materials and Methods

Ten genotypes of pigeonpea HO6-12, HO6-1, HO3-41, HO9-27, HO9-33, HO9-34, HO9-36,HO9-38, MANAK, PARAS were obtained from Pulses Section, Department of Genetics and Plant Breeding, CCS HAU, Hisar and twenty genotypes ICPH 2671, ICPH 2431, ASHA, MARUTI, ICPL 87051, ICP5028, ICPL 20096, ICPL 87091, ICPL 20241, LRG 30, ICPL 20120, MAL 9, ICPL 20238,ICPL 20237, MAL 12, SIPS 2, SGBS 6, ICP 8857, UPAS 120, ICP 7035 were obtained from ICRISAT, Patancheru, Hyderabad. The experiment was carried out in seed germinator in laboratory condition in the Department of Botany and Plant Physiology, CCS HAU, Hisar. The seeds were surface sterilized with 0.1% mercuric chloride for 1-2 minutes and then ringed with distilled water several time to remove residual chlorine. Four treatments were given to plants T1 (Control), T2 (Waterlogging), T3 (Waterlogging + salinity 3omM) and T4 (Salinity 60mM). In treatments T1 and T4, the surface sterilized seeds were placed on filter paper in petriplates moistened with distilled water and 60mM saline water respectively. In treatments T2 and T3, the surface sterilized seeds were first submerged in water and saline water (30mM) for eight days in conical flask and then placed on moist filter paper in petriplates. These petriplates were placed in seed germinator and proper temperature (25±2$^{0}$ C) and relative humidity (60-70%) were maintained. Percent germination and seed vigour index were analyzed after 8 days.

### Germination percentage

The germinated seeds were counted (Figure 1). The seedlings with about 2 mm plumule were considered as germinated. The germinated seeds were expressed in the terms of percent germination.

### Seed vigour index

The seed vigour index was calculated on dry weight basis of the seedlings. The seedlings were dried in an oven at 70$^{0}$C till a constant weight was obtained. Seed vigour index was calculated according to the following method suggested by ISTA (2001):

Vigour index = Germination percentage × mean dry weight

## Results and Discussion

### Germination percentage

Seed germination (Table 1) of pigeonpea genotypes was significantly affected by waterlogging and salinity treatments. As compared to control 13% to 53% decline in germination was observed in waterlogging treatment. Highest decline was observed in UPAS 120 (53%) followed by SGBS 6 (50%), MAL 12 (40%), ICP 8857 (40%), ICPL 87091 (40%), ICPL 87051 (40%), ICPL 20237 (40%), ICPL 20096 (40%) and minimum decline was reported in PARAS (13%), ICPH 2431 (13%) followed by HO9-36 (17%), HO9- 33 (20%), HO6-12 (20%), HO3-41 (20%). Salinity (60mM NaCl) treatment was less deleterious and resulted in 0 to 30% decline in percent germination. The most sensitive genotypes were SGBS 6 (30%), ICPL 20237 (23%), UPAS 120 (20%), SIPS 2 (20%) and ICPL 87051 (20%). The effect of waterlogging and salinity treatment in combination was more deleterious and resulted in a 23% to 63% decline in percent germination. The genotypes which performed well were HO9-33 (23%), PARAS (27%), ICPH 2431 (27%), HO6-12 (27%), MARUTI (27%) and the poor performing genotypes were SGBS 6 (63%), UPAS 120 (60%), ICPL 20096 (50%), HO9-34 (50%), ICPL 87091 (47%).

## Seed vigour index

Seed vigour index was showed 17.6% to 58.3% decline in waterlogging treatment (Table 2) as compared to control. Highest decline was observed in SGBS 6 (58.3%) followed by UPAS 120 (56.8%), MAL 12 (50.5%), ICPL 87091 (49.7%), ASHA (48.7%), ICPL 87051 (48.3%) and minimum decline was reported in ICPH 2431 (17.6%) followed PARAS (21%), HO9-36 (17%), HO6-12 (22.6%), HO9-33 (23.8%). Salinity (60mM NaCl) treatments resulted in 5.2% to 21.2% decline in vigour index. The sensitive genotypes were UPAS 120 (21.2%), ICP 7035 (20%), SGBS 6 (19.9%), ASHA (18.8%), ICPL 20241 (18.6%). In combine WL + Salinity (30mM) 33.4% to 70.7% decline was observed with maximum reduction in UPAS 120 (70.7%), SGBS6 (67.3%), ICPL 20120 (65.3%), ICPL 87091 (61%) and minimum reduction in ICPH 2431 (33.4%), PARAS (34.8%), HO9-34 (36.7%), HO9-38 (37.3%), HO3-41 (38.6%).

Seed germination is the most crucial phase in the life history of plants. The success of this phase not only depends on the type of species but also on the prevailing environmental conditions. The reduction in seed germination due to waterlogging was in accordance with the previous studies done by Orchard and Jessop (1984) in sudangrass (*Sorghum sudanense* Stapf) and Zaidi *et al.*, (2012) in maize seedlings.

**Fig.1** Pigeonpea genotypes during laboratory experiments (A) waterlogging treatment (B) non-germinated seeds (C) germinated seeds

(A) (B) (C)

**Table.1** Effect of different treatments on percent germination of pigeonpea genotypes

| Genotypes | Germination Percentage | | | | |
|---|---|---|---|---|---|
| | Control | WL | WL+30mM NaCl | 60mM NaCl | Mean |
| **HO6-12** | 100 | 80 | 73 | 100 | 88 |
| **HO6-1** | 100 | 70 | 67 | 90 | 82 |
| **HO3-41** | 100 | 80 | 70 | 100 | 88 |
| **HO9-27** | 100 | 70 | 67 | 100 | 84 |
| **HO9-33** | 100 | 80 | 77 | 100 | 89 |
| **HO9-34** | 100 | 80 | 50 | 100 | 83 |
| **HO9-36** | 100 | 83 | 70 | 90 | 86 |
| **HO9-38** | 100 | 80 | 60 | 100 | 85 |
| **MANAK** | 100 | 77 | 60 | 90 | 82 |
| **PARAS** | 100 | 87 | 73 | 100 | 90 |
| **ICPH 2671** | 100 | 73 | 70 | 100 | 86 |
| **ICPH 2431** | 100 | 87 | 73 | 100 | 90 |
| **ASHA** | 100 | 63 | 50 | 90 | 76 |
| **MARUTI** | 100 | 80 | 73 | 100 | 88 |
| **ICPL 87051** | 100 | 60 | 53 | 80 | 73 |
| **ICP 5028** | 100 | 70 | 53 | 90 | 78 |
| **ICPL 20096** | 100 | 60 | 50 | 90 | 75 |
| **ICPL 87091** | 100 | 60 | 50 | 90 | 75 |
| **ICPL 20241** | 100 | 70 | 57 | 100 | 82 |
| **LRG 30** | 100 | 80 | 60 | 90 | 83 |
| **ICPL 20120** | 100 | 77 | 70 | 90 | 84 |
| **MAL 9** | 100 | 70 | 50 | 100 | 80 |
| **ICPL 20238** | 100 | 70 | 60 | 100 | 83 |
| **ICPL 20237** | 100 | 60 | 53 | 77 | 73 |
| **MAL 12** | 100 | 60 | 53 | 100 | 78 |
| **SIPS 2** | 100 | 70 | 60 | 80 | 78 |
| **SGBS 6** | 100 | 50 | 37 | 70 | 64 |
| **ICP 8857** | 100 | 60 | 50 | 100 | 78 |
| **UPAS 120** | 100 | 47 | 40 | 80 | 67 |
| **ICP 7035** | 100 | 70 | 60 | 100 | 83 |
| **Mean** | 100 | 71 | 60 | 93 | |
| C.D. at 5% level of significance | *Genotypes* = *6.12*<br>*Treatments* = *2.23*<br>*Genotypes* x *Treatments* = *12.23* | | | | |

**Table.2** Effect of different treatments on seed vigour index of pigeonpea genotypes

| Genotypes | Seed Vigour Index | | | | |
|---|---|---|---|---|---|
| | Control | WL | WL+30mM NaCl | 60mM NaCl | Mean |
| **HO6-12** | 1.12 | 0.87 | 0.66 | 1.03 | 0.92 |
| **HO6-1** | 1.18 | 0.85 | 0.60 | 1.03 | 0.92 |
| **HO3-41** | 1.14 | 0.82 | 0.70 | 1.02 | 0.92 |
| **HO9-27** | 1.22 | 0.90 | 0.73 | 1.06 | 0.98 |
| **HO9-33** | 1.25 | 0.95 | 0.73 | 1.13 | 1.02 |
| **HO9-34** | 1.04 | 0.78 | 0.66 | 0.97 | 0.86 |
| **HO9-36** | 1.12 | 0.77 | 0.68 | 1.00 | 0.89 |
| **HO9-38** | 1.18 | 0.89 | 0.74 | 1.10 | 0.98 |
| **MANAK** | 1.03 | 0.78 | 0.62 | 0.90 | 0.83 |
| **PARAS** | 1.30 | 1.03 | 0.85 | 1.23 | 1.10 |
| **ICPH 2671** | 1.28 | 0.98 | 0.77 | 1.18 | 1.05 |
| **ICPH 2431** | 1.31 | 1.08 | 0.87 | 1.20 | 1.12 |
| **ASHA** | 1.28 | 0.66 | 0.59 | 1.04 | 0.89 |
| **MARUTI** | 1.28 | 0.65 | 0.61 | 1.15 | 0.92 |
| **ICPL 87051** | 1.20 | 0.62 | 0.49 | 1.09 | 0.85 |
| **ICP 5028** | 1.28 | 0.80 | 0.54 | 1.08 | 0.92 |
| **ICPL 20096** | 1.07 | 0.66 | 0.55 | 0.91 | 0.80 |
| **ICPL 87091** | 1.18 | 0.59 | 0.46 | 1.04 | 0.82 |
| **ICPL 20241** | 1.18 | 0.65 | 0.72 | 0.96 | 0.89 |
| **LRG 30** | 1.08 | 0.71 | 0.49 | 0.91 | 0.80 |
| **ICPL 20120** | 1.20 | 0.67 | 0.42 | 1.01 | 0.82 |
| **MAL 9** | 1.16 | 0.75 | 0.52 | 0.98 | 0.85 |
| **ICPL 20238** | 1.26 | 0.75 | 0.61 | 1.07 | 0.93 |
| **ICPL 20237** | 1.20 | 0.72 | 0.47 | 1.05 | 0.86 |
| **MAL 12** | 1.21 | 0.60 | 0.50 | 1.08 | 0.85 |
| **SIPS 2** | 1.22 | 0.68 | 0.50 | 1.02 | 0.85 |
| **SGBS 6** | 1.13 | 0.47 | 0.37 | 0.91 | 0.72 |
| **ICP 8857** | 1.20 | 0.81 | 0.65 | 0.99 | 0.91 |
| **UPAS 120** | 1.12 | 0.48 | 0.33 | 0.88 | 0.70 |
| **ICP 7035** | 1.20 | 0.73 | 0.59 | 0.96 | 0.87 |
| **Mean** | 1.19 | 0.76 | 0.60 | 1.03 | |
| C.D. at 5% level of significance | *Genotypes* = *0.02*<br>*Treatments* = *0.05*<br>*Genotypes* x *Treatments* = *0.10* | | | | |

In plants treated with salinity less deleterious effects were observed. Similar findings were observed by Nasri *et al.*, (2015) in lettuce. They observed 30% reduction in germination percent at 100mM NaCl concentration in lettuce Vista variety. This was also agreed with results obtained in wheat (Gholamin and Khayatnezhad, 2010), sunflower (Mostafavi, 2011) and *Physalis* (Yildirim *et al.*, 2011). In case of salinity decline in percent germination was also observed Singh *et al.*, (2016) in pigeonpea genotypes. They observed 0-15% germination in sensitive genotypes and 75% germination in tolerant genotypes.

Seed vigour index is an important trait as it is the sum of all attributes supporting the early seedling growth. Seedling vigour values were declined due to low seedling dry weight as a result of less seedling growth after germination due to sensitivity to waterlogging and salinity stress. Similar results were reported at ICRISAT where 10 to 100% decline in vigour index was observed with eight days of water-logging treatments (ICRISAT Report, 2011). Wang *et al.*, (2011) reported decreased vigour index in sesame under waterlogging treatment. Tavili and Biniaz (2009) reported a significant decrease in seed vigour at salinity levels from 0-420 mM in barley. The decline in seedling vigour due to WL + Salinity was in accordance with the ICRISAT report, 2011 which stated that 35 to 100% declines in vigour index was observed with eight days of waterlogging + salinity treatments in pigeonpea.

On the basis of results obtained, the genotypes ICPH 2431, PARAS, HO6-12, HO9-33, HO9-27 were found relatively tolerant which showed better germination and seed vigour during various treatments while SGBS 6, UPAS 120, MAL 12, ICP 8857and ICPL 87091were found relatively sensitive. These tolerant genotypes can be further used by plant breeders to generate higher yielding varieties under waterlogging and salinity stresses.

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