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# Studies on Growth Parameters in Pigeonpea [*Cajanus cajan* (L.) Millsp.] Genotypes under Normal and Waterlogged Soil Conditions

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## ABSTRACT

*Experiments were undertaken to assess the effects of eight days waterlogging on growth parameters of 12 pigeonpea genotypes during kharif of 2011-12 and 2012-13 in Randomized Block Design replicated five times with normal conditions as control. KPBR 80-2-1, ICPB 2039 and ICPH 2431 accumulated the highest dry matter under normal and waterlogged conditions. A pattern of linear increase in LAI exhibited under all conditions. KPBR 80-2-1 attained higher LAI under both the conditions during most of the crop life span. ICPH 2740 and ICPL 20241 showed highest SLA at varying intervals under both the conditions. The RGR indicated higher magnitudes at very early stage of growth i.e. 30-60 DAS followed by reduction in remaining phase. KPBR 80-2-1 and ICPH 2431 had comparatively higher CGR during most of the growth period under both conditions respectively. Significant correlations were shown among the characters investigated under both the conditions. Due to waterlogging the highest reduction was observed in CGR (17.36%) followed by LAI (13.03%), RGR (8.19%), TDM (6.85%) and SLA (4.72%).*

***Key words:*** *Growth parameters, Dry matter, Waterlogging, Pigeonpea and Correlation*

## INTRODUCTION

Among the abiotic stresses waterlogging during is one of the important constraints in production of pigeonpea caused due to erratic and intense rainfall for a prolonged period and occurs when the soil water table attains a level during which the soil pores in the root zone get saturated and thus restricts normal air circulation. There is a decline in the oxygen level of the soil with an increased $CO_2$ concentration, which adversely affects root growth. Drastic reduction in oxygen level is the primary stress plants are exposed to under waterlogging conditions[12]. Pigeonpea is highly sensitive to waterlogging[15] and cannot withstand low oxygen conditions at the rhizosphere level, caused by waterlogging, resulting in substantial yield losses. During onset of short periods of excessive moisture conditions, obligate aerobic bacteria become inactive, and facultative/obligate anaerobic bacteria active in the inundated soils.

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Considering such huge losses caused by waterlogging, there is a need to develop waterlogging tolerant pigeonpea genotypes which is urgent need for today. Although some agronomic management options as the use of raised beds, planting on ridges, transplanting of seedlings, could be a partial solution to the waterlogging problem. There is a decline in available energy thus affecting cellular processes leading to water and nutrient imbalances or deficiency[6]. The investigations pertaining to growth parameters under waterlogging would be highly meaningful through screening of suitable genotypes which could be grown successfully under such conditions. The parameters identified in the study may also be utilized for in a breeding programme for developing waterlogging tolerant lines on the basis of morpho-physiological growth parameters.

## MATERIALS AND METHODS

Experiments were conducted at College of Agriculture, Jawaharlal Nehru Agricultural University, Jabalpur, Madhya Pradesh during *kharif* of 2011-12 and 2012-13, respectively in a Randomized Block Design replicated five times with normal conditions as control. The experimental material comprised of twelve pigeonpea genotypes *viz*, RG 188, ICP 8863, JKM 7, JP 10, C 11, ICPB 2039, ICPL 87051, ICPH 2740, ICPL 20241, ICPH 2431, ICPL 20128, KPBR 80-2-1. The selected seeds were treated with thiram at 3g $kg^{-1}$ prior to sowing at 2 kg $ha^{-1}$ by hand dibbling at a depth of three to four centimeters with the distance between plant to plant and row to row (30 x 75 cm).

**Waterlogging stress**: The whole experiments were conducted in two sets; the first set was kept as normal conditions while second set was grown under waterlogged conditions for eight days continuous after 40 days of sowing and the water level of five cm above the soil surface was maintained for the period of eight days. The root zone was subjected to completely drainout of water from plots after eight days of termination of waterlogging stress period.

**Growth parameters**: The LAI and SLA were worked out as per specifications of Gardner *et al*[7]. The leaf area was recorded by using laser area meter (Model LI-300). The CGR and the RGR were determined as per the formula suggested by Watson[27] 1952). For determining the leaf area and TDM five plants were removed from the field at fixed intervals of 30 DAS under both the conditions and partitioned into main stem, leaves and root and kept in an electric oven at 80 ºC for about 36 hrs till constant weight. The dry weight of individual plant part as well as total and measurement of leaf area were recorded separately.

## RESULTS AND DISCUSSION

**Leaf Area Index**: The study confirmed that KPBR 80-2-1 maintained significantly higher LAI which has been proved to the beneficial for yield point of view than C 11 which was lower as compared to other genotypes under both the conditions during most of the crop life span (Table 1). A pattern of linear increase in LAI was exhibited under all circumstances. Under normal conditions LAI possessed positive and significant correlation with total dry matter (r=0.789) however, under waterlogged conditions it had highly significant positive correlation with total dry matter (r=0.804) (Table 6). Significant reduction was observed in LAI per plant which may be attributing to reduction in number of leaflets per plant and individual area of leaflet. The lowest (5.83) reduction of leaf area index was shown by the genotype KPBR 80-2-1 and the highest (22.09) was noted in C11 (Fig. 1). Under waterlogged conditions, minimized leaflet number per plant was mainly due to enhanced senescence of lower leaves. According to Kumutha *et al*[12]., leaf senescence is induced and leaf area development is the most sensitive feature in pigeonpea under waterlogged conditions. Similarly, waterlogging tolerant genotypes maintained significantly higher leaf area compared with sensitive genotypes in mung bean[11]. Waterlogging treatment caused reduction in plant growth in terms of leaf area and growth rate in all the genotypes and the level of reduction was more pronounced in sensitive genotypes. Kozlowski[10] studied that flooding suppresses leaf formation and expansion of leaves and internodes, and causes premature leaf abscission and senescence. Ullah Md[24] recorded that the highest leaf number at all growth stages under non waterlogged condition and leaf number decreased with increasing waterlogging duration.

**Specific leaf area**: The results revealed that the SLA increased at 30-60 DAS and thereafter, declined sharply during 60-90 DAS which again rose during 90-120 DAS to maturity and it varied significantly among different genotypes during most of the intervals. The decrease during 60-90 DAS period of growth was associated with the decrease in magnitude of photoassmilatry area. The study confirmed that ICPH 2740, ICPL 20241 and ICP 8863 attained higher SLA at different intervals (Table 2) and registered positive significant correlation with total dry matter (r=0.156) and leaf area index (r=0.704) under normal conditions moreover, under waterlogged conditions C 11 and RG 188 noted the low values for SLA. Specific leaf area also had positive correlation with total dry matter (r=0.171) and leaf area index (r=0.699) (Table 6). The minimum (2.93) and maximum (10.53) reduction percent of specific leaf area was noted in ICPL 87051 and C 11, respectively (Fig. 1). Positive association was observed between grain yield and SLA[16]. The SLA represents a relative proportion of conductive, mechanical and assimilatory tissues in leaves. The higher magnitude of this parameter may be beneficial in increasing the productivity as these traits are associated with production and transport of food material in plants. Talbot *et al*[22]., reported in the rooted cuttings of *Salix caprea* L. and *S. cinerea sp*. oleifolia growing in soil exposed to waterlogging. Both species were harmed by waterlogging and specific leaf area was significantly reduced.

**Relative Growth Rate**: In the present study it was noted that the RGR varied significantly in all the tested genotypes as also reported by Sarkar *et al*[17]. The RGR indicated higher magnitudes at very early stage of growth i.e. 30-60 DAS followed by reduction. The higher magnitudes of RGR in the early growth phases and reduction in later growth phase was attributed to higher LAI and SLA in the early growth period and reduction of SLA in the later phase of growth. Under normal conditions ICP 8863 showed higher RGR at 30-60 DAS, ICPH 2431 at 60-90 DAS, ICPB 2039 at 90-120 DAS and JKM 7 at 120 to maturity and lower in ICPL 87051, JKM 7, C 11 and ICPL 87051 respectively (Table 3). It showed negative correlation with TDM (r= -0.136) and LAI (r= -0.029) and positively correlated with SLA (r=0.078) however under waterlogged conditions the higher RGR was recorded in ICP 8863, ICPH 2740, ICPB 2039 and JKM 7 while lower in ICPL 87051, JKM 7, C 11 and ICPL 87051 at different growth intervals. It possessed positive correlation with TDM (r=0.070), LAI (r=0.104) and SLA (r=0.070) (Table 6). The RGR exhibited high significant variations among different genotypes during the entire crop growth period except 120 DAS to maturity. ICPL 87051 had minimum (5.27) and JKM 7 maximum (11.83) reduction percent in RGR (Fig.1). Alamgir and Uddin[1] reported that waterlogging is a widespread limiting factor for wheat which restricts the growth, development and finally yield. Inhibition of growth during waterlogging observed in this study confirms earlier results of Singer *et al*[19].

**Crop Growth Rate**: The present study revealed that CGR showed differential pattern of growth rate under both conditions however, CGR had higher magnitudes at 30-60 DAS and it declined during 60-90 DAS thereafter it increased between 90-120 DAS and again declined with advancement of growth which suggested that the genotypes possessed the potential to maintain the higher growth rate even at the later phase. KPBR 80-2-1, ICPB 2039 and ICPH 2431 had comparatively higher CGR and C 11, JKM 7 and ICP 8863 and lower during most of the growth period under both conditions, respectively (Table 4). Under normal conditions CGR possessed positive significant correlation with TDM (r=0.912), LAI (r=0.634) and RGR (r=0.114) but it was negatively correlated with SLA (r= -0.034) moreover, under waterlogged conditions it indicated positive significant correlation with TDM (r=0.942), LAI (r=0.659), SLA (r=0.022) and RGR (r=0.233) (Table 6). Significant differences were noted with respect to crop growth rate in all the sampling intervals except 120 to maturity. Lowest (11.20) reduction percent of CGR was recorded in ICPB 2039 and highest (25.78) in C11 (Fig.1). The crop growth rate can be analyzed as the product of incident light efficiency, light penetration and efficiency of use of intercepted light in dry matter production[26]. The highest production rate was exhibited by the genotypes during the initial and the later growth stages. At these stages, the yield increased with the increase in net dry matter accumulation, and the crop growth rate was significantly and positively correlated with the yield[8]. The assessment of crop productivity per unit land area is an important parameter of crop growth and computation of CGR is always more appropriate as it is simple and an important index of agricultural productivity and rate of dry matter production. Cannell *et al*[3]., reported the effect of waterlogging on the growth of peas, during waterlogging stem growth rate was slowed and yield had decreased. Trought and Drew[23] reported waterlogging damage in wheat plants, especially affects growth and nutrient uptake by the shoots, slowed shoot fresh weight accumulation, and arrested the growth of the seminal roots. According to Coutts[5] shoot and root growth was suppressed due to waterlogging. Musgrave and Vanhoy[14] observed in Mung beans that growth rate and leaf area duration declined during the waterlogging period. Wang and Jiang[25] observed that waterlogging affects the growth and physiological responses of turf grass.

**Total dry matter production:** The dry matter production under given environment is a balance between photosynthesis and respiration which are the function of LAI, photosynthetic capacity per unit area and LAR. Takele and Mcdavid[21] reported that short duration waterlogging in pigeonpea resulted in reduced leaf area development, dry weight accumulation and partitioning. Kumutha *et al*[12] observed that the waterlogging decreased dry matter in pigeonpea. KPBR 80-2-1, ICPB 2039 and ICPH 2431 had higher dry matter production and lower in C 11, ICP 8863 and JKM 7 under normal and waterlogged conditions respectively (Table 5). Higher dry matter production is a desirable character for breeding purpose as long as the allocation of dry matter is in the economic parts. Minimum (4.97) reduction percent of TDM was observed in ICPH 2431 and maximum (9.63) in JKM 7 (Fig. 1). These observations were in agreement with the other study[9] (Irving *et al*. 2007). Similar kind of results have been reported by Talbot *et al*[22]., which showed that dry weight of root, stem and leaf was significantly reduced due to waterlogging. Wang and Jiang[25] observed that waterlogging affects the growth and physiological responses of turf grass. Liu *et al*[13]., in maize reported that weight of both shoot and root of all lines had significantly reduced at 6 days' time point of waterlogging, compared to control. Araki *et al*[2] observed that pot waterlogging reduced roots shoot and their weights. Shimono *et al*[18]., noted that the total dry weight at the end of the treatment was significantly reduced due to waterlogging. Stephen *et al*[20]., reported that the early waterlogging treatment suffered a significant reduction in total dry matter of 25%. Celik and Turhan[4] noted that the Leaf DW, root DW and leaf area may be used to assess the adverse effect of flooding on plant growth when compared with control.

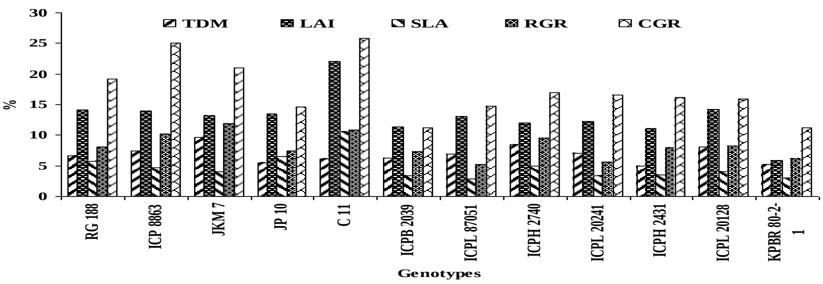


**Fig. 1: Reduction percentage of TDM, LAI, SLA RGR and CGR after eight days of drainout**

**Table 1: Effect of waterlogging on leaf area index at different growth stages of pigeonpea genotypes during 2011-12 and 2012-13 under normal (NL) and waterlogged (WL) conditions**

| Genotypes | 30-60 DAS | | 60-90 DAS | | 90-120 DAS | | 120-Maturity | |
|---|---|---|---|---|---|---|---|---|
| | NL | WL | NL | WL | NL | WL | NL | WL |
| RG 188 | 0.0182 | 0.0146 | 0.0556 | 0.0452 | 0.1141 | 0.0930 | 0.2597 | 0.2319 |
| ICP 8863 | 0.0318 | 0.0246 | 0.0818 | 0.0679 | 0.1712 | 0.1460 | 0.4234 | 0.3713 |
| JKM 7 | 0.0218 | 0.0165 | 0.0625 | 0.0488 | 0.1326 | 0.1169 | 0.3000 | 0.2664 |
| JP 10 | 0.0202 | 0.0174 | 0.0598 | 0.0500 | 0.1550 | 0.1369 | 0.3356 | 0.2899 |
| C 11 | 0.0150 | 0.0109 | 0.0432 | 0.0315 | 0.0882 | 0.0649 | 0.2113 | 0.1714 |
| ICPB 2039 | 0.0310 | 0.0265 | 0.0795 | 0.0670 | 0.1971 | 0.1754 | 0.5603 | 0.5007 |
| ICPL 87051 | 0.0362 | 0.0301 | 0.0890 | 0.0752 | 0.1784 | 0.1486 | 0.3951 | 0.3539 |
| ICPH 2740 | 0.0433 | 0.0352 | 0.1049 | 0.0880 | 0.2465 | 0.2121 | 0.5770 | 0.5201 |
| ICPL 20241 | 0.0423 | 0.0347 | 0.1006 | 0.0856 | 0.2128 | 0.1748 | 0.4748 | 0.4338 |
| ICPH 2431 | 0.0308 | 0.0266 | 0.0782 | 0.0679 | 0.1660 | 0.1420 | 0.4487 | 0.4065 |
| ICPL 20128 | 0.0348 | 0.0289 | 0.0928 | 0.0762 | 0.1827 | 0.1502 | 0.3681 | 0.3270 |
| KPBR 80-2-1 | 0.0445 | 0.0386 | 0.1068 | 0.0904 | 0.2577 | 0.2397 | 0.5696 | 0.5528 |
| Mean | 0.0308 | 0.0254 | 0.0796 | 0.0661 | 0.1752 | 0.1501 | 0.4103 | 0.3688 |
| SEm ± | 0.0013 | 0.0017 | 0.0021 | 0.0034 | 0.0031 | 0.0055 | 0.0071 | 0.0175 |
| LSD ($p \leq 0.05$) | 0.0027 | 0.0035 | 0.0044 | 0.0070 | 0.0065 | 0.0113 | 0.0147 | 0.0362 |

**Table 2: Effect of waterlogging on specific leaf area (SLA $cm^{-2}g^{-1}$) at different growth stages of pigeonpea genotypes during 2011-12 and 2012-13 under normal (NL) and waterlogged (WL) conditions**

| | 30-60 DAS | | 60-90 DAS | | 90-120 DAS | | 120-Maturity | |
|---|---|---|---|---|---|---|---|---|
| Genotypes | NL | WL | NL | WL | NL | WL | NL | WL |
| RG 188 | 2.68 | 2.28 | 3.05 | 2.88 | 3.38 | 3.28 | 3.16 | 3.12 |
| ICP 8863 | 4.62 | 4.21 | 4.33 | 4.13 | 4.82 | 4.69 | 5.49 | 5.33 |
| JKM 7 | 2.63 | 2.53 | 3.48 | 3.20 | 4.68 | 4.55 | 4.57 | 4.46 |
| JP 10 | 2.82 | 2.23 | 2.95 | 2.81 | 3.91 | 3.85 | 4.16 | 4.04 |
| C 11 | 2.30 | 2.08 | 2.25 | 1.93 | 2.84 | 2.46 | 2.96 | 2.79 |
| ICPB 2039 | 3.03 | 2.97 | 3.35 | 3.21 | 3.53 | 3.37 | 4.03 | 3.92 |
| ICPL 87051 | 3.00 | 2.82 | 3.68 | 3.57 | 3.89 | 3.81 | 4.11 | 4.05 |
| ICPH 2740 | 5.47 | 4.89 | 5.12 | 4.87 | 5.84 | 5.77 | 6.78 | 6.54 |
| ICPL 20241 | 5.23 | 4.90 | 5.05 | 4.90 | 5.03 | 4.97 | 4.97 | 4.83 |
| ICPH 2431 | 2.84 | 2.80 | 3.41 | 3.26 | 3.52 | 3.39 | 3.82 | 3.67 |
| ICPL 20128 | 3.89 | 3.68 | 4.20 | 4.06 | 4.16 | 4.07 | 3.95 | 3.74 |
| KPBR 80-2-1 | 3.74 | 3.52 | 4.03 | 3.84 | 4.14 | 4.08 | 4.50 | 4.48 |
| Mean | 3.52 | 3.24 | 3.74 | 3.55 | 4.15 | 4.02 | 4.37 | 4.25 |
| SEm ± | 0.25 | 0.24 | 0.14 | 0.26 | 0.23 | 0.26 | 0.19 | 0.28 |
| LSD ($p \leq 0.05$) | 0.52 | 0.51 | 0.30 | 0.54 | 0.47 | 0.53 | 0.39 | 0.58 |

**Table 3: Effect of waterlogging on relative growth rate (RGR g $cm^{-2}$ of ground area $day^{-1}$) at different growth stages of pigeonpea genotypes during 2011-12 and 2012-13 under normal (NL) and waterlogged (WL) conditions**

| | 30-60 DAS | | 60-90 DAS | | 90-120 DAS | | 120-Maturity | |
|---|---|---|---|---|---|---|---|---|
| Genotypes | NL | WL | NL | WL | NL | WL | NL | WL |
| RG 188 | 0.0736 | 0.0675 | 0.0278 | 0.0242 | 0.0227 | 0.0223 | 0.0105 | 0.0098 |
| ICP 8863 | 0.0794 | 0.0731 | 0.0331 | 0.0308 | 0.0119 | 0.0084 | 0.0078 | 0.0064 |
| JKM 7 | 0.0681 | 0.0630 | 0.0228 | 0.0184 | 0.0148 | 0.0113 | 0.0110 | 0.0102 |
| JP 10 | 0.0725 | 0.0647 | 0.0278 | 0.0280 | 0.0200 | 0.0191 | 0.0092 | 0.0080 |
| C 11 | 0.0780 | 0.0715 | 0.0289 | 0.0277 | 0.0115 | 0.0073 | 0.0087 | 0.0069 |
| ICPB 2039 | 0.0597 | 0.0544 | 0.0343 | 0.0316 | 0.0293 | 0.0287 | 0.0077 | 0.0068 |
| ICPL 87051 | 0.0515 | 0.0477 | 0.0273 | 0.0269 | 0.0170 | 0.0166 | 0.0047 | 0.0040 |
| ICPH 2740 | 0.0724 | 0.0654 | 0.0348 | 0.0335 | 0.0142 | 0.0110 | 0.0089 | 0.0080 |
| ICPL 20241 | 0.0652 | 0.0611 | 0.0294 | 0.0285 | 0.0224 | 0.0216 | 0.0088 | 0.0076 |
| ICPH 2431 | 0.0581 | 0.0540 | 0.0354 | 0.0327 | 0.0212 | 0.0191 | 0.0109 | 0.0098 |
| ICPL 20128 | 0.0615 | 0.0554 | 0.0315 | 0.0296 | 0.0185 | 0.0170 | 0.0104 | 0.0099 |
| KPBR 80-2-1 | 0.0528 | 0.0478 | 0.0334 | 0.0322 | 0.0284 | 0.0280 | 0.0065 | 0.0056 |
| Mean | 0.0661 | 0.0605 | 0.0305 | 0.0287 | 0.0193 | 0.0175 | 0.0088 | 0.0078 |
| SEm ± | 0.0012 | 0.0012 | 0.0014 | 0.0012 | 0.0013 | 0.0014 | 0.0012 | 0.0013 |
| LSD ($p \leq 0.05$) | 0.0025 | 0.0024 | 0.0029 | 0.0025 | 0.0027 | 0.0030 | NS | NS |

**Table 4: Effect of waterlogging on crop growth rate (CGR g $g^{-1}$day) at different growth stages of pigeonpea genotypes during 2011-12 and 2012-13 under normal (NL) and waterlogged (WL) conditions**

| | 30-60 DAS | | 60-90 DAS | | 90-120 DAS | | 120-Maturity | |
|---|---|---|---|---|---|---|---|---|
| Genotypes | NL | WL | NL | WL | NL | WL | NL | WL |
| RG 188 | 0.000651 | 0.000566 | 0.000950 | 0.000700 | 0.001630 | 0.001310 | 0.001790 | 0.001480 |
| ICP 8863 | 0.000711 | 0.000550 | 0.001190 | 0.001060 | 0.000860 | 0.000480 | 0.001270 | 0.000930 |
| JKM 7 | 0.000722 | 0.000546 | 0.000630 | 0.000620 | 0.000810 | 0.000510 | 0.001630 | 0.001320 |
| JP 10 | 0.000710 | 0.000606 | 0.001070 | 0.000940 | 0.001530 | 0.001260 | 0.001390 | 0.001210 |
| C 11 | 0.000676 | 0.000561 | 0.000980 | 0.000880 | 0.000710 | 0.000380 | 0.001300 | 0.000900 |
| ICPB 2039 | 0.000808 | 0.000646 | 0.001540 | 0.001450 | 0.003410 | 0.003150 | 0.002120 | 0.001750 |
| ICPL 87051 | 0.000790 | 0.000674 | 0.001270 | 0.001100 | 0.001470 | 0.001320 | 0.000940 | 0.000720 |
| ICPH 2740 | 0.000713 | 0.000594 | 0.001400 | 0.001270 | 0.001160 | 0.000770 | 0.001500 | 0.001330 |
| ICPL 20241 | 0.000711 | 0.000598 | 0.001170 | 0.000980 | 0.001820 | 0.001600 | 0.001750 | 0.001370 |
| ICPH 2431 | 0.000757 | 0.000620 | 0.001550 | 0.001480 | 0.002200 | 0.001740 | 0.002500 | 0.002030 |
| ICPL 20128 | 0.000746 | 0.000604 | 0.001300 | 0.001180 | 0.001610 | 0.001270 | 0.001880 | 0.001600 |
| KPBR 80-2-1 | 0.000826 | 0.000690 | 0.001690 | 0.001570 | 0.003620 | 0.003340 | 0.001950 | 0.001580 |
| Mean | 0.000735 | 0.000605 | 0.001230 | 0.001100 | 0.001740 | 0.001430 | 0.001670 | 0.001350 |
| SEm ± | 0.000008 | 0.000011 | 0.000070 | 0.000080 | 0.000130 | 0.000120 | 0.000180 | 0.000180 |
| LSD ($p \leq 0.05$) | 0.000016 | 0.000022 | 0.000150 | 0.000160 | 0.000270 | 0.000250 | NS | NS |

**Table 5: Effect of waterlogging on total dry matter (TDM g plant$^{-1}$) at different growth stages of pigeonpea genotypes during 2011-12 and 2012-13 under normal (NL) and waterlogged (WL) conditions**

| | 30 DAS | | 60 DAS | | 90 DAS | | 120 DAS | | Maturity | |
|---|---|---|---|---|---|---|---|---|---|---|
| Genotypes | NL | WL | NL | WL | NL | WL | NL | WL | NL | WL |
| RG 188 | 5.45 | 5.82 | 49.40 | 43.99 | 113.70 | 91.29 | 244.36 | 237.15 | 261.55 | 251.60 |
| ICP 8863 | 4.91 | 4.68 | 52.89 | 41.78 | 133.45 | 113.19 | 232.71 | 220.54 | 245.29 | 239.02 |
| JKM 7 | 7.27 | 6.58 | 56.01 | 43.46 | 97.69 | 86.13 | 210.47 | 187.33 | 227.23 | 217.50 |
| JP 10 | 6.17 | 6.85 | 54.07 | 47.77 | 126.29 | 111.24 | 261.55 | 252.71 | 279.26 | 268.83 |
| C 11 | 4.95 | 5.09 | 50.56 | 42.94 | 116.48 | 102.62 | 208.93 | 201.02 | 230.10 | 221.82 |
| ICPB 2039 | 10.94 | 10.64 | 65.46 | 54.26 | 169.32 | 152.15 | 479.72 | 445.02 | 523.95 | 509.25 |
| ICPL 87051 | 14.49 | 14.27 | 67.82 | 59.78 | 153.65 | 133.92 | 334.35 | 305.36 | 355.16 | 348.64 |
| ICPH 2740 | 6.20 | 6.64 | 54.34 | 46.75 | 148.61 | 132.39 | 289.02 | 248.02 | 370.32 | 361.19 |
| ICPL 20241 | 7.95 | 7.72 | 55.94 | 48.06 | 134.90 | 114.45 | 326.25 | 292.70 | 426.09 | 420.66 |
| ICPH 2431 | 10.92 | 10.29 | 62.05 | 52.16 | 166.82 | 152.18 | 347.13 | 337.78 | 366.92 | 354.01 |
| ICPL 20128 | 9.48 | 9.56 | 59.86 | 50.32 | 147.31 | 130.14 | 305.37 | 268.44 | 392.11 | 381.74 |
| KPBR 80-2-1 | 14.41 | 14.60 | 70.16 | 61.15 | 184.54 | 166.85 | 522.29 | 486.58 | 627.29 | 616.31 |
| Mean | 8.59 | 8.56 | 58.21 | 49.37 | 141.06 | 123.88 | 313.51 | 290.22 | 358.77 | 349.21 |
| SEm ± | 0.28 | 0.25 | 0.52 | 0.72 | 5.10 | 5.17 | 14.86 | 9.04 | 14.72 | 8.37 |
| LSD ($p \leq 0.05$) | 0.59 | 0.51 | 1.08 | 1.50 | 10.58 | 10.71 | 30.83 | 18.75 | 30.53 | 17.36 |

**Table 6: Correlation coefficients among characters for waterlogged conditions (above diagonal) and normal conditions (below diagonal)**

| Variables | TDM | LAI | SLA | RGR | CGR |
|---|---|---|---|---|---|
| TDM | 1.000 | 0.804** | 0.171 | 0.070 | 0.942** |
| LAI | 0.789** | 1.000 | 0.699* | 0.104 | 0.695* |
| SLA | 0.156 | 0.704* | 1.000 | 0.070 | 0.022 |
| RGR | -0.136 | -0.029 | 0.078 | 1.000 | 0.233 |
| CGR | 0.912** | 0.634* | -0.034 | 0.114 | 1.000 |

Correlation significant at the 0.01 level (**) and 0.05 level (*)

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