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Research Article

PHENOLOGICAL BASIS OF WATER LOGGING TOLERANCE IN PIGEON PEA [*Cajanus cajan* L. MILLSP.] GENOTYPES

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Abstract- Pigeon pea is an important and highly water logging sensitive legume crop in Madhya Pradesh. The investigations were carried out to examine the responses of pigeon pea genotypes under normal and waterlogged conditions in 12 pigeon pea (*Cajanus cajan*) genotypes to identify the susceptible and tolerant cultivars with the improvement strategies for them. The study of phenological traits indicated that the genotype ICPL 87051 took minimum days for 50% flowering (85.50 and 87.83 days) and C 11 required minimum days for physiological maturity (122.00 and 124.83 days) and field maturity (135.67 and 141.83 days) while genotype KPBR 80-2-1 had however late for (157.83 and 162.17 days), physiological maturity (195.83 and 196.33 days) and field maturity (212.00 and 215.00 days) under normal and waterlogged conditions respectively. Days to 50% flowering, days to physiological maturity and days to maturity were shown significant positive correlation among them under both the conditions.

Keywords- Abiotic stress, Correlation, Phone phases and pigeon pea.

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Introduction

Pigeon pea [*Cajanus cajan* (L.) Millsp.] is an important crop of legume crop and is belong to family Fabaceae is affected by water logging. Early pigeon pea varieties are more sensitive as compared to medium and late and the risk of crop failure or yield losses due to short term water logging [1]. Water logging during June-September pigeon pea growing season is caused by irregular and prolonged rains and represents an important production constraint and is becomes a serious problem [2] in India. Plants have to face suffocation throughout their life during water logging due to insufficient of oxygen is a common environmental challenge [3]. In flooded soils the gaseous rates of diffusion are 100 times lower than normal [4] and respiration of plant roots, soil micro-flora and fauna leads to rapid exhaustion of soil oxygen, thereby causing anaerobiosis. Pigeon pea is highly sensitive to water logging [5]. A recent comparative analysis of pigeon pea growing regions revealed that the area (3-38 million ha) under pigeon pea is affected by excess soil moisture, causing an annual loss of 25-30% in production [2].

Madhya Pradesh is third highest producer state having productivity 625 kg ha^{-1} and 0.33 million tons production from 0.53 million ha area, according to Directorate of Economics and Statistics, Department of Agriculture and Cooperation [6] India is a major pigeon pea producer country in the world. According to [7], the early saplings stage of pigeon pea is the most sensitive stage under water logging prone areas. Therefore, the objective of the present study was to evaluate the genotypic variability for water logging tolerance in pigeon pea and to identify genotypes capable of withstanding water logging stress conditions at the sowing and early seedling stages. Making an allowance for such huge losses caused by water logging in pigeon pea, there is a need to develop water logging tolerant pigeon pea genotypes which an urgent need of the day [8]. The investigations against water logging would be highly meaningful through screening suitable genotype, which can be grown successfully under such conditions. The traits identified in the study may also be utilized for further breeding programme in developing tolerant lines. The investigations pertaining to growth parameters under water logging would be highly meaningful through screening of suitable genotypes, which could be grown successfully under such conditions [9]. The parameters identified in the study may also be utilized for in a breeding programme [5] for developing water logging tolerant lines on the basis of morpho-physiological growth parameters [10a]. Keeping in view of the above mentioned facts the present trait was conducted.

Materials and Methods

An experiment was conducted at Jawaharlal Nehru Agricultural University, Jabalpur, Madhya Pradesh, India during rainy seasons of 2011-12 and 2012-13, respectively in a Randomized Block Design replicated five times with normal (no water logging) conditions as control. The experimental material comprised of twelve pigeon pea 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 3 g 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) respectively. The experimental field possessed a gentle slope, proper drainage with clay loam soil.

Water logging stress

The whole experiment was conducted in two sets; the first set was kept as normal conditions while second set was grown under waterlogged conditions for eight days continuous developed artificially after 40 days of sowing under natural field conditions 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 drain out of water from plots after eight days of termination of water logging stress period. Thereafter, all plots were kept under natural conditions for recording the observations eight days after drain out. The phenological observations were noted from five selected and tagged plants throughout the growth period through daily visual observations. The under mentioned characters pertaining to the phenology of pigeon pea genotypes were studied. Correlation studies was conducted in order to know the magnitude of correlation among various traits considering the possibility of high yield through yield attributes, as primary interest in crop improvement is crucial. Estimates of correlation coefficient at normal and waterlogged conditions are given in [Table-2]. The correlation coefficient was determined by using the formula suggested by [11].

Results and Discussion

Staggered of phenophases (Day's from sowing) affected by water logging

Phenology largely determines the adaptability of a cereal crop to a certain range of environmental conditions and may also strongly affect yield potential. Development traits in cereals are particularly significant in limiting abiotic stress condition of Mediterranean environments, where available water becomes increasingly scarce towards the end of the growing season [10b]. All phenological stages *viz.*, days to 50% flowering, physiological and physical maturity were significantly delayed in the waterlogged condition than normal condition.

The results revealed a significant variation among different genotypes in relation to days required for their phenological developments. In pulses, the time to flowering is strongly affected by photoperiod. In general, a short photoperiod accelerates and a long photoperiod delays flowering of pigeon pea plants [7]. The stress was given either throughout crop growth period or at of the three growth phases *viz.*, seedling to panicle initiation, panicle initiation to flowering and flowering to maturity where the result indicate that the warmer temperature hasten crop development, shortens the growth period and thus finally lower the grain yield in both crops wheat and rice [12].

Table-1 *Effects of water logging on days to 50% flowering, days to physiological maturity and days to maturity after recovering from water logging in pigeon pea genotypes*

Genotypes	Days to 50% flowering		Days to physiological maturity		Days to Maturity	
	Normal	WL	Normal	WL	Normal	WL
RG 188	106.67	108.33	125.00	128.83	142.83	147.00
ICP 8863	113.83	116.50	130.67	133.83	145.67	149.50
JKM 7	109.00	112.00	122.17	126.50	139.33	142.17
JP 10	102.50	107.50	123.50	130.17	141.17	144.50
C 11	96.50	102.00	122.00	124.83	135.67	141.83
ICPB 2039	93.83	97.67	133.17	140.83	153.00	157.50
ICPL 87051	85.50	87.83	135.50	136.83	148.83	150.33
ICPH 2740	132.83	133.67	180.33	185.83	196.33	199.50
ICPL 20241	110.17	111.83	162.00	163.50	176.50	189.33
ICPH 2431	97.33	100.50	143.33	145.67	159.33	163.83
ICPL 20128	138.67	142.00	182.83	185.17	199.67	203.17
KPBR 80-2-1	157.83	162.17	195.83	196.33	212.00	215.00
Mean	112.06	115.17	146.36	149.86	162.53	166.97
SEm ±	0.09	0.11	0.11	0.12	0.10	0.09
C.D. 5%	0.19	0.23	0.24	0.25	0.21	0.19

Days to 50 % flowering

The results indicated that it took minimum days for 50% flowering in genotype ICPL 87051 (85.50 and 87.83 days) while KPBR 80-2-1 (157.83 and 162.17 days) was late for days to 50 % flowering under normal and waterlogged conditions respectively. [Table-1] shows the performance of genotypes for days to 50% flowering, which indicated high significant variation among genotypes. This variation is attributed to the genetic makeup of the genotypes under normal condition but there was delay under waterlogged condition, which is in conformation to the findings of [13] in maize. Days to flowering exhibited maximum range of variation in maize crop [14] however, it was positively correlated with all the variables but significantly only with days to physiological maturity and days to maturity at both normal (r=0.835** and r=0.822**) and waterlogged (r=0.847** and r=0.855**) conditions [Table-2] the same findings were also observed by [15] in maize.

Table-2 *Correlation coefficients among the characters for waterlogged conditions (above diagonal) and normal conditions (below diagonal)*

Variables	50% flowering	Physiological maturity	Maturity	Plant Height	No of PB	No of Pods	Grain Yield
50% flowering	1.000	0.847**	0.855**	0.183	0.121	0.240	0.258
Physiological maturity	0.835**	1.000	0.998**	0.412	-0.004	0.616*	0.600*
Maturity	0.822**	0.993**	1.000	0.386	-0.029	0.594*	0.612*
PH (cm plant^{-1})	0.134	0.288	0.343	1.000	0.445	0.492	0.440
PB (plant^{-1})	0.085	-0.037	-0.034	0.579*	1.000	0.155	-0.091
Pods(plant^{-1})	0.168	0.560	0.599*	0.555	0.179	1.000	0.711**
GY(g plant^{-1})	0.196	0.573	0.606*	0.485	-0.050	0.793**	1.000

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

Days to physiological maturity

In the present study it was observed [Table-1] that genotype C 11 (122.00 and 124.83 days) significantly attained minimum days for physiological maturity while genotype KPBR 80-2-1 (195.83 and 196.33 days) was significantly inferior and late for physiological maturity under normal and waterlogged conditions respectively. Days to physiological maturity was showed positive correlation with maturity (r=0.993**), plant height (r=0.288), branch, pods per plant (r=0.560) and grain yield (r=0.573) and negatively with number of primary (R=-0.037) under normal condition while under waterlogged it was negatively correlated with number of primary branch [Table-2]. Similarly, the findings of [16] in respective of positive association of physiological maturity with plant height, number of branches, pods per plant and number of seeds per plant are in agreement with the present study. Physiological maturity is characterized by the stage when seeds/grains attain their maximum dry weight [17]. After this period, the assimilates do not partition from the source to the sink which may be attributed to the formation of abscission zone in vascular bundles, which inhibited the dry matter accumulation in seeds however, respiration continued at a higher rate causing the deterioration of reserve food material which may result in declined seed dry matter and subsequently yield [18]. However, in certain cases it was observed that the grain longevity continued to increase after physiological maturity, and the stage occurred before maximum grain quality was achieved. Similar result was found by [19].

Days to maturity

The results suggested that genotype C 11 took minimum time to reach the field maturity under normal (135.67 days) and waterlogged (141.83 days) conditions. Generally, late maturity was associated with higher economic yield in most of the crops, but in certain cases, it may leads to the shattering of the seeds/grains reported by [20]. However, genotype KPBR 80-2-1 took maximum days for field maturity as compared to other genotypes under normal (212.00 days) and waterlogged (215.00 days) conditions [Table-1]. Days to maturity was showed positive and significant association among the variables under both the condition except number of primary branch under normal condition and grain yield under waterlogged [Table-2]. These results also corroborate previous observations by [21]. This gives a clear indication that too early maturity could lead to reduction in yield and is in agreement with similar observation of [7].

Conflict of Interest: None declared

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