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EVALUATION OF MUNGBEAN (*VIGNA RADIATA*) GENOTYPES FOR PHENOLOGICAL PARAMETER AND PHYSIOLOGICAL PARAMETER UNDER DROUGHT STRESS CONDITION

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ABSTRACT

The present study was conducted to assess the phenological parameter and relative water content during different developmental stages in mungbean varieties subjected to drought stress, and to screen the varieties for drought tolerance. The present study was planned in the year 2021-2022 to investigate the implications of drought stress on eight genotypes *viz.* ASHA, MH-318, MUSKAN, PAU-911, PM-5, PUSA, SAMRAT and Satya with complete randomized design under control and +drought stress for phenology. According to combined analysis of variance, there were significant effects on phenological traits Days to 50% Flowering, Days to Pod Seating, Days to Physiological Maturity and Relative water content under the drought stress condition. Genotype PAU-911 followed by MH-318 showed maximum in Days to 50% Flowering (45.5 and 44.0), Days to Pod Seating (50.1 and 48.7), Days to Physiological Maturity (76.9 and 72.5). According to combine analysis of variance, there were significant effect on physiological traits Relative water content (92.9 and 85.4), Canopy temperature (34.2 and 32.7) and Chlorophyll content (48.4 and 46.6) under normal as well as drought stress condition. Effect of drought reduced phenological parameter and ultimately reduction in yield. Genotypes PAU-911 and MH-318 was found best and promising in overall performance.

***Keywords* :** Vigna radiata, Mungbean, drought, relative water content.

Introduction

Legumes are a basic part of a healthy and balanced human diet and play important role in preventing many critical diseases. Pulses are most important constituents in human diet of large number of people which benefit to supplement cereal diets. It is mainly cultivated across the Asian countries and has also expanded to some parts of Africa, Australia and South America (Pratap *et al*., 2020). Mungbean [*Vigna radiata* (L.) Wilczek] (2n = 2x = 22) goes to the family leguminosae and sub family papilionaceae. Fabaceae family is of much importance in terms of soil health and fertility alarms. There is a need to assess the member of this family under changing climatic conditions. Mungbean also known as green gram, is one of the significant grain legumes of India. It is a diploid, self-pollinating, fast-growing and short-duration crop and helps in the effective utilization of summer fellows to enhance the cropping intensity and crop production (Singh *et al*., 2016). It is an excellent source of vegetable proteins, micro-nutrients and antioxidants like flavonoids and phenolics (Foyer *et al*., 2016)and has different uses as a food (Arnoldi *et al*., 2015), feed (Boelt *et al*., 2015), fodder and green manure crop. In India, mung bean is grown in two seasons: during summer and winter. However, its large-scale adoption is affected by low yield potential accompanied with various biotic and abiotic factors (Talukdar, 2014). Symbiotic association of mung bean roots and *Rhizobium* bacterium helps in nitrogen fixation which increases soil fertility and crop productivity (Fuskhah *et al*., 2019). Hence this is independent of use of fertilizers. Mungbean is delicate to drought stress at all the crop growth stages, which hampers the crop yield (Pratab *et al*., 2020). Mungbean grows mostly in rain-fed conditions at high temperatures (27–30 °C), with low humidity and reasonable rainfall ranging from 60 to 80 cm. At the early stage, drought stress affects seed germination and reduced seedling establishment due to affected cell division and cell elongation, leading to poor crop growth (Hussain *et al*., 2008). It also limits cell growth due to the role of loss of turgor pressure (Taiz and Zeiger, 2010). Zare *et al*. (2013) observed 51% to 85.50% yield reduction due to drought stress in the mungbean. The flowering and the post-flowering stages have been found most sensitive than the vegetative stage in drought. (Ranwake *et al*., 2011).

Climate change has increased the susceptibility of cropping systems, which may trigger a loss of maintenances of poor communities in arid and semi-arid regions of the world (Leng and Hall, 2019). The imbalance in the temporal and spatial distribution of rainfall and the non-availability of the required amount of water during critical growth stages would seriously limit the productivity of major food crops in near future (Troy *et al*., 2015). Drought has been identified as one of the most important abiotic stresses that negatively affect crop growth and development. It is labeled as a major climatic event from both an agricultural and biological perspective that alters crop productivity and survivability. Plant response to drought is a complex process involving different morpho-physiological, biochemical, and molecular activities. Drought-induced variations in mung bean include reduced carbon fixation, repressed flowering time, increased pollen sterility, fewer pods, and poor seed set (Nadeem *et al.*, 2019).Based on the foregoing, the current study was designed to identify promising phenological and physiological features under drought stress.

Materials and Method

Seeds of eight mungbean genotypes, viz. ASHA, MH-318, MUSKAN, PAU-911, PM-5, PUSA, SAMRAT and SATYA, were taken from CCS Haryana Agricultural University, Hisar (IND) and grown under watered (Control (maintained pots in field condition) and drought conditions, with three replications in the pot house with Complete randomized design at Baba Mastnath University, Asthal Bohar, Rohtak during Kharif seasons of 2019-20 and 2021-22.

Days to 50% flowering: Considering the overview of each plot total number of days taken by the plant from the date of sowing to the period of 50% flowering was recorded.

Days to 50% podding: The number of days from seeding to the formation of 50% pods in the plots was recorded.

Days to physiological maturity: The number of days taken from seeding to physiological maturity in selected plants was recorded.

Relative water content: Relative water content (RWC) was measured by the method of Barrs and Weatherley, (1962) and calculation was done by the following formula:

$$\text{RWC (\%)} = \frac{FrW - DrW}{\text{TdW} - \text{DrW}} \times 100$$

Where, FrW = Fresh weight, DrW = dry weight and TdW = turgid weight.

Chlorophyll content (mg/g): The DMSO extraction technique of Hiscox and Israelstam (1962) was used for chlorophyll extraction and finally, chlorophyll a, b and total chlorophyll were calculated by Arnon's equations.

$$Chl\ (a) = \frac{(12.7(A663)\ 2.69(A645) \times V}{(1000 \times W)}$$

$$Chl\ (b) = \frac{(22.9(A645)\ 4.68(A663) \times V}{(1000 \times W)}$$

$$Chl\ (toal) = \frac{(20.2(A645)\ 8.02(A663) \times V}{(1000 \times W)}$$

W= weight of tissue and V- volume of extracting solvent

Canopy temperature (˚C): Canopy temperature (CT) measurement were made using hand held infrared thermometer (IRT), model AG-42, Tele temp crop Fullerton between 12:00 to 14;00 hours on cloudless, bright days.

Data presented in tabular form was analyzed using by op-stat (http://14.139.232.166/opstat/).

Result and Discussion

Days to 50% flowering

Result presented in table 1 showed a decreasing trend in days to 50% flowering with onset of drought. All tested genotype showed early days to 50% flowering under drought as compare to irrigated condition. Drought treatment resulted in a reduction in average days to flowering from 42.4 to 36.1 whereas mean reduction in genotype for days to flowering ranged between 42.4 and 36.1. Genotypes followed by PAU-311, MH-318 and Satya showed maximum days to 50% flowering whereas genotype PUSA and MUSKAN showed minimum days to 50% flowering under drought as well as control condition. Interaction effect between genotype, treatment and stress level were not statistically significant at 5% of CD level. Fathy *et al.* (2018) and Nadeem *et al.* (2019) reported yield loss in the range of 31 – 60% at flowering and 26% at post flowering/podding stages in mungbean due to drought stress (Ratnasekera *et al.*, 2015).

Table 1: Effect of drought condition on days to 50% flowering and days to pod seating in Moon bean genotypes.

Genotypes	Days to 50% Flowering			Days to Pod Seating		
	Control	**DR**	**Mean (G)**	**Control**	**DR**	**Mean (G)**
ASHA	41.2	34.7	38.0	38.4	32.6	35.5
MH-318	44.0	38.3	41.1	48.7	35.1	41.9
MUSKAN	40.7	33.1	36.9	36.6	30.4	33.5
PAU-911	45.5	39.2	42.4	50.1	36.2	43.2
PM-5	42.8	36.7	39.8	43.8	33.0	38.4
PUSA	39.8	32.4	36.1	36.8	32.5	34.7
SAMRAT	41.8	37.1	39.4	41.0	32.5	36.7
Satya	43.3	37.2	40.3	45.2	33.4	39.3
Mean (T)	42.4	36.1		42.6	33.2	
Factors	**C.D.**	**SE(d)**	**SE(m)**	**C.D.**	**SE(d)**	**SE(m)**
Treatment (T)	0.601	0.294	0.208	0.617	0.302	0.213
Genotypes (G)	1.202	0.587	0.415	1.234	0.603	0.427
Interaction (TxG)	0.450	0.831	0.587	1.745	0.853	0.603

DR= Drought, **T=** Treatment, **G=** Genotypes

Days to Pod Seating

Onset of drought stress on tested genotypes showed significant reduction in the days to pod seating compared to control condition (Table 1). Drought treatment resulted in a reduction in average days to pod seating from 42.6 to 33.2 whereas mean reduction in genotype for days to pod seating ranged between 43.2 to 33.5. The genotype PAU-911 followed by MH-318 and Satya showed days to pod seating whereas genotypes PUSA and MUSKAN showed days to pod seating under drought as well as control condition. Interaction effect between genotype and treatment were not statistically significant at 5% of CD level. Crop phenological events such as total crop duration, and grain filling (reproductive) period are largely influenced by agro-climatic conditions (Lamichaney *et al*., 2021). According to Ranawake *et al*. (2011) screened the mungbean genotypes against drought stress, and results revealed that the water stress significantly affects the flowering and pod filling period.

Days to Physiological Maturity

Data showed in (Table 2) a signification reduction in days to physiological maturity in all genotype along with control and drought condition. Drought treatment resulted in a reduction in average days to physiological maturity from 69.9 to 61.1 whereas mean reduction in genotype for days to physiological maturity ranged between 71.1 and 61.3.

The genotype PAU-911 followed by MH-318 and Satya showed maximum days to physiological maturity whereas genotypes PUSA and MUSKAN showed minimum days to physiological maturity under drought as well as control condition. Interaction effect between genotype and treatment were statistically significant at 5% of CD level. The effect of water stress is significant at vegetative, flowering and pod development stages of mung bean when grown in upland rice soil (Singh *et al*., 2013). Some studies also applied this range of days for evaluation of drought tolerance in mungbean, such as Iseki *et al*. (2018) (7 – 22 days) and Bangar *et al*. (2019) (15 days), suggesting the maximum time mungbean can stand for without irrigation. Phenology (time to flowering, podding and maturity) plays critical role in adaptation of chickpea cultivars to different environments (Berger *et al*., 2006).

Table 2: Effect of drought condition on days to physiological maturity and relative water content (%) in Moon bean genotypes.

Genotypes	Days to PM			Relative Water Content (%)		
	Control	DR	Mean (G)	Control	DR	Mean (G)
ASHA	68.5	58.1	63.3	81.2	74.2	77.7
MH-318	72.5	63.7	68.1	85.4	76.4	80.9
MUSKAN	65.2	57.4	61.3	80.9	72.1	76.5
PAU-911	76.9	65.3	71.1	92.9	85.4	89.2
PM-5	70.3	62.7	66.5	84.7	73.1	78.9
PUSA	65.2	58.4	61.8	72.8	67.1	70.0
SAMRAT	69.7	60.4	65.0	83.2	68.7	76.0
Satya	71.0	63.0	67.0	84.8	75.0	79.9
Mean (T)	69.9	61.1		83.2	74.0	
Factors	**C.D.**	**SE(d)**	**SE(m)**	**C.D.**	**SE(d)**	**SE(m)**
Treatment (T)	1.104	0.540	0.382	1.206	0.589	0.417
Genotypes (G)	2.208	1.079	0.763	2.412	1.179	0.833
Interaction (TxG)	1.200	1.526	1.079	3.411	1.667	1.179

PM= Physiological maturity; **DR**= Drought

Relative Water Content (%) was found almost similar under irrigated conditions in all genotypes (92.9% to 72.8%) in control condition (Table 2). Drought stress resulted in a reduction of mean relative water content in all genotypes ranged from 85.4% to 67.1% after stress. Genotypes PAU-911 followed by MH-318 and Satya showed maximum water content whereas genotype SAMRAT and PUSA showed minimum relative amount of water under drought as well as control condition. Interaction effect between genotype, treatment and stress level were statistically significant at 5% of CD level. Relative leaf water content has been considered a measure of plant water status, reflecting the metabolic activity in tissues and used as a most meaningful index for dehydration tolerance (Anjum *et al*., 2011). Such results apparently indicate that under decreasing soil moisture conditions, plants became unable to uptake sufficient water through the root system leading to decrease in relative water content. The finding is quite similar to the results supported by Hayatu *et al*., 2014. This phenomenon was also observed in previous studies (Bangar *et al*., 2019) and is probably due to the low water absorption capacity during the vegetative stage.

Canopy temperature:

Data showed in (Table 3) a signification increased in canopy temperature in all genotype along with control and drought condition. Drought treatment resulted in increased in average canopy temperature from 30.8 to 28.2 whereas mean reduction in genotype for canopy temperature ranged between 33.1 and 27.3. The genotype PAU-911 followed by MH-318 and Satya showed maximum canopy temperature whereas genotypes PUSA and MUSKAN showed minimum canopy temperature under drought as well as control condition. Interaction effect between genotype and treatment were statistically significant at 5% of CD level. Canopy temperature has been reported to have significant correlation with yield in wheat because genotypes with cooler canopy temperatures have better access to water due to presence of deeper root systems (Raina *et al*., 2019). Low canopy temperature can maintain high transpiration and photosynthetic rate as well as produce a high yield under stressed condition in mungbean (Kumar *et al*., 2014).

Table 3: Effect of drought condition on Canopy temperature and Chlorophyll content in Mungbean genotypes.

Genotypes	Canopy temperature			Chlorophyll content		
	Control	DR	Mean (G)	Control	DR	Mean (G)
ASHA	26.0	30.2	28.1	43.2	38.5	40.8
MH-318	29.9	32.7	31.3	46.6	43.1	44.8
MUSKAN	25.8	28.9	27.3	39.6	35.3	37.5
PAU-911	31.9	34.2	33.1	48.4	44.2	46.3
PM-5	29.0	31.3	30.1	43.4	39.5	41.5
PUSA	26.4	28.5	27.5	42.0	37.9	40.0
SAMRAT	28.1	30.0	29.0	44.3	40.7	42.5
Satya	28.7	30.9	29.8	44.9	36.3	40.1
Mean (T)	28.2	30.8		44.1	39.3	
Factors	**C.D.**	**SE(d)**	**SE(m)**	**C.D.**	**SE(d)**	**SE(m)**
Treatment (T)	0.45	0.22	0.156	0.629	0.308	0.218
Genotypes (G)	0.9	0.44	0.311	1.259	0.615	0.435
Interaction (TxG)	1.273	0.622	0.44	1.780	0.870	0.615

Chlorophyll content: was found almost similar under irrigated conditions in all genotypes (48.4 to 39.6) in control condition (Table 3). Drought stress resulted in a reduction of canopy temperature in all genotypes ranged from 44.2 to 35.3 after stress. Genotypes PAU-911 followed by MH-318 and Satya showed maximum chlorophyll content whereas genotype MUSKAN and Satya showed minimum chlorophyll content under drought as well as control condition. Interaction effect between genotype, treatment and stress level were statistically significant at 5% of CD level. The decrease in chlorophyll content under drought stress has been considered a typical symptom of pigment photo oxidation and chlorophyll degradation (Fathi *et al.*, 2016).

Conclusion

Effects of drought reduced crop phenology (days to flowering, days to pod seating and physiological maturity), relative water status and ultimately reduction in yield. Genotypes PAU-911 and MH-318 was found best and promising in overall performance may be used in order to improve yield for future breeding programme.

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