Assessment of Drought Stress of Two Genotypes of Sorghum (*Sorghun bicolor*L.) UsingPhysiological Parameters

ABSTRACT

The present experiment conducted in the period of rabi season at Sorghum Improvement Project, M.P.K.V., Rahuri, Maharashtra during the period of 2016 to 2017. During investigation to observed the physiological parameters under non stress and moisture stress condition with cross two genotypes SPV 1830 x IS 6427.In this study of mean performance of the basic generation P1, P2, F1, F2, B1 and B2 of the cross SPV 1830 x IS 6427was observed various physiological parameters viz. photosynthetic rate, rate of transpiration, stomatal conductance, relative leaf water content, SPAD reading, total chlorophyll content and chlorophyll stability index.The present results to observed the B_2 and F_1 generation recorded significantly highest photosynthesis rate (25.98 and 22.47 µ mole CO_2 m-^{2}s-^{1}) under non stress and moisture stress condition, respectively.The parent B_1 recorded highest transpiration rate (3.27 and 1.92 mmole H_2O m-^{2}s-^{1}) under non stress and moisture stress condition, respectively.The F_1 and B_1 generation recorded significantly the highest mean for stomatal conductance (0.24 and 0.18 mole m-^{2} s-^{1}) under non stress condition and moisture stress condition, respectively.The B_1 generation recorded the highest total chlorophyll content (3.30 and 2.08 %) under non stress and moisture stress condition, respectively. Therefore, present experimental study to observe physiological parameters of sorghum cross two genotype (SPV 1830 x IS 6427) directly affected in growth and grain yield under non-stress and moisture stress condition.

Key Words:-Non-Stress, Moisture Stress, Sorghum and Physiological Parameters.

1.INTRODUCTION

Sorghum (*Sorghum bicolour* (L.) Moench)is the fifth most important crop in the world. It is a staple food crop of millions of poor people in semi-arid tropics of Africa and Asia. It has gained increasing importance as a fodder (green/dry) and food crop in the last decades. It is cultivated as a majorcrop in areas with marginal growing conditions such as poor soil fertility and erratic rainfall by Bibi *et al.*[4].Dial HL [6] reported that drought reduces production of sorghum crop and risks the wellbeing, livelihood as well as food security in many developing countries.The drought stress effects on the physiology of plants by reducing water content, causing wilting, closing of stomata and decreasing cell enlargement and growth by Taiz and Zeiger[21]. Mostly the effect of drought depends up on its timing of occurrence, duration and intensity, it can accelerate leaf senescence and lead to death of leaf tissue Prasad *et al*.[17].Moreover, water deficit results in decreasing leaf expansion and leaf area which results from biophysical effect of turgor pressure Taiz and Zeiger [21].Drought tolerance mechanism can be studied based on the interpretation of relationship between leaf structure function and stress tolerance reported by Tambe *et al*.[22] and [24].As per the IPCC (Intergovernmental Panel on Climate Change-2021) mentioned that rainfall patterns in sorghum growing areas will be highly variable. In addition, Prasad *et al* [17] reported that the climate change effects would be abrupt change in rainfall patterns in the next four decades combined with the risk of high temperature, which will intensify the drought stress. The extensive adaptability has in sorghum and it can be grown in various series of environment including heat, drought, salinity and flooding mentioned by Ejeta and Knoll [7].

Among the abiotic stress, drought is most important yield limiting factor in *rabi* sorghum. Drought tolerance is a complex trait, expression of which depends on action and interaction of different morphological, physiological and biochemical traits, therefore it is necessary to know the genetics as well as morpho-physiological parameters related with drought tolerance. Despite the progress in sorghum breeding, only limited information is available on inheritance pattern and genetic basis of drought tolerance.During the past three decades high yielding varieties and hybrids have been developed in India. However, the desired increase in production could not be achieved due to erratic rainfall. In recent years research on plant response to water stress is becoming most important aspect Petit *et al.* [16]. The crop productivity and plant survival are threatening due to water deficit coupled with high temperature. With increasing aridity and growing population water will become an ever limiting factor in near future. A better understanding of effects of drought on plants is an important for management practices and breeding efforts in agriculture. A progress is made on the interpretation of relationship between leaf structure, function by Valladares and Pearcy, [25] and stress tolerance Jackson *et al.* [10].

Kadam *et al.*,[12] reported that soil moisture content decreased gradually from sowing to harvesting and it was negatively correlated with grain yield. However, some other physiological parameters as like photosynthesis rate, rate of transpiration, stomatal conductance, relative leaf water content, SPAD reading and total chlorophyll content or index are also effects on crops growth and yields. So, above mentioned facts indicate that the irregular water condition, water temperature and physiological properties are associated with effects on sorghum yield by Kadam *et al*,[12] and Tambe *et al*.[22]. For that reason, present study to understanding for mechanism that are directly and indirectly affected by physiological characters in sorghum. Moreover, it will also find out that physiological characters impressive parameter to improve and utilization in the sorghum variety or hybrids of breeding programs. The main aim of any plant breeding programme is to develop high yielding varieties or hybrids. To accomplish this, the breeding programme can efficiently be planned with prior knowledge of the genetic makeup of complex quantitative characters like yield and its attributes. It is therefore necessary to examine the genetic architecture of various quantitative characters in relation to breeding behaviour of the genetic material available. Therefore, present investigation to study the physiological parameters with cross SPV1830 x IS-6427 under two different conditions viz ., normal and moisture drought stress condition in the rabi sorghum. Moreover, it will also find out that physiological characters impressive parameter to improve and utilization in the sorghum variety or hybrids of breeding programs.

2.MATERIAL AND METHODS

The present research work was carried out in the Sorghum Improvement Project, M.P.K.V.,RahuriMasharashtra during the rabi season 2016-2017 under non stress and moisture stress condition. Present study of mean performance of the basic generations P1, P2, F1, F2, B1 and B2 of the two genotypes cross SPV 1830 x IS 6427 showed physiological parameters viz. photosynthetic rate, rate of transpiration, stomatal conductance, relative leaf water content, SPAD reading, total chlorophyll content and chlorophyll stability index.The experimental design employed arandomized complete block design (RCBD) with three replications and each replication has threerows. Present study following are the methods used for physiological parameters.

Photosynthetic rate, transpiration rate and stomatal conductance was estimated as per Tambe *et al*.[23].The photosynthetic rate (μ mole CO_2 m-2s-1), transpiration rate (mmole H_2O m-2s-1) and stomatal conductance (mole m-2 s-1) were measured using Infra-Red Gas Analyzer (IRGA; Model Portable Photosynthesis System LI6400, LI-COR® Inc, Lincoln, Nebraska, USA). Relative leaf water content was estimated as per Barrs and Weatherly, [3] at 50 percent flowering. Twenty leaf discs of third fully expanded leaf from the top were collected and weighted on an electronic balance, and fresh weight was determined. The relative leaf water content (RLWC) was calculated in percentage by using the following formula.

Fresh weight (g) – dry weight (g)

Relative Leaf water content (%) = --- x 100

Turgid weight (g) - dry weight (g)

SPAD (Soil Plant Analytical Development) chlorophyll meter reading (SPAD 502; Minolta Company Ltd) measures the greenness or relative chlorophyll content of the leaves. Measurements were taken at three points of each leaf (upper, middle and lower parts). Average of these three readings was considered as SPAD reading of the leaf .SPAD reading was carried out at 50% flowering in the third leaf to the top of the plant. The readings were taken between 10.00 to 12.00 hours of the day.Total chlorophyll content was determined by following DMSO method of Hiscox and Israeltam [9] at 50 percent flowering. The total chlorophyll content was calculated by using the following formula and expressed in mg g-1 fresh weight.

$$\text{Total chlorophyll} = 20.2\ (A645) + 8.02\ (A663) \times \frac{V}{1000 \times W}$$

Where,
A645 = Absorbance of the extract at 645 nm
A663 = Absorbance of the extract at 663 nm
W = Fresh weight of the sample (g)
V = Final volume of the chlorophyll extract (ml).

The chlorophyll stability index was computed by using the methodology proposed by Arnon [1].

ΔR = Reading without heating – Reading after heating at 560C.

Where, ΔR = CSI

3.RESULTS AND DISCUSSION

In the present investigation to observed the mean performance of the basic generations P1, P2, F1,F2, B1 and B2 of the cross SPV 1830 x IS 6427 showed physiological parameters viz. photosynthetic rate, rate of transpiration, stomatal conductance, relative leaf water content, SPAD reading, total chlorophyll content, chlorophyll stability index are presented in following tables 1 to 4.

3.1PHOTOSYNTHETIC RATE

The present study for cross SPV 1830 x IS 6427 the photosynthesis rate ranged from 20.97 to 25.98 with the mean of 22.91 μ mole CO_2 m-^{2}s-^{1} and 19.06 to 22.47 with the mean of 20.71 μ mole CO_2 m-^{2}s-^{1} under non stress and moisture stress condition, respectively(Table 1).The B_2 and F_1 generation recorded significantly highest photosynthesis rate (25.98 and 22.47 μ mole CO_2 m-^{2}s-^{1}) under non stress and moisture stress condition, respectively.The high yielding generation possessed higher rate of photosynthesis indicating the importance in determining the productivity. Similar findings were also reported by Tambe*et al*.,[23], Narkhede *et al.*[15] and Gadakh*et al.* [2013].

3.2TRANSPIRATION RATE

Transpiration rate is an important bio-physical trait which helped to gas exchange. It showed that the stressed leaves showed decline in transpiration rate over non stressed leaves of different *rabi* sorghum generations(Table 1). In the present investigation for cross SPV 1830 x IS 6427 the mean transpiration rate under non stress condition was 1.43 mmole H_2O $m^{-2}s^{-1}$and was reduced to 0.89 mmole H_2O $m^{-2}s^{-1}$ under moisture stress condition. The parent B_1 recorded highest transpiration rate (3.27 and 1.92 mmole H_2O $m^{-2}s^{-1}$) under non stress and moisture stress condition, respectively. The F_2 generation was recorded the lowest transpiration rate (2.47 and 1.66 mmole H_2O $m^{-2}s^{-1}$) under moisture stress condition, respectively.It showed that the stressed leaves showed decline in transpiration rate over non stressed leaves of different *rabi* sorghum generations (Table 1).The variations in transpiration rate were also reported by Tambe *et al*.[23], Narkhede *etal.*[15] and Shinde *et al.*[19].

3.3 STOMATAL CONDUCTANCE

The rate of stomatal conductance (Table 2)was observed more in non stress than that in moisture stress condition. The data also indicated that the generations differ significantly in respect of stomatal conductance rate under non-stress stress and moisture stress condition.For cross SPV 1830 x IS 6427, the stomatal conductance ranged from 0.20 to 0.24 and 0.15 to 0.18 mole m^{-2} s^{-1} under non stress and moisture stress condition, respectively. The F_1 and B_1 generation recorded significantly the highest mean for stomatal conductance (0.24 and 0.18 mole m^{-2} s^{-1}) under non stress condition and moisture stress condition, respectively. The high yielding generations possessed higher rate of stomatal conductance indicating the importance in determining the productivity. Tambe *et al*.[23] and Gadakh*et al*.[11] was observed a similar results in the stomatal conductance under non-stress and moisture stress condition.

3.4 RELATIVE LEAF WATER CONTENT (%)

The mean relative leaf water content for the cross SPV 1830 x IS 6427 the parents and different generations of sorghum under non stress was 76.11 % and it reduced to 66.82 % under moisture stress condition. The B_1 generation recorded significantly the highest relative leaf water content (81.74 and 71.74 %) and in different generations highest relative leaf water content was recorded in F_1 and B_2 generations (81.01 and 74.42 %) under non stress and moisture stress condition, respectively. Among the segregating generation, the per cent reduction in RLWC varied from as low as 9.73 % in B_2 generation to as high as 13.26 % in F_2 generation.The control of stomatal aperture is one of the major mechanism by which plant regulates water status. Water status of a plant is a measure of drought tolerance and it could be conveniently studied in term of relative leaf water content (RLWC). Relative leaf water potential is very important phenomenon as retention of water in the leaf under moisture stress condition is a major indication of drought tolerance. The present investigation (Table 2), revealed that in crossesSPV 1830 x IS 6427the moisture stressed plant has lower relative water content than non- stressed. These finding are in agreement with the findings of Tambe *et al* [23], Narkhede *et al* [14] and Kachare[11].

3.5 SPAD READING

In cross SPV 1830 x IS 6427, the mean SPAD reading at 50% flowering was recorded 51.27 and 41.92 under non stress and moisture stress condition, respectively(Table 3). The segregating generation F_2 recorded significantly the highest SPAD reading (53.24 and 43.35) under non stress condition and moisture stress condition, respectively. Amongst the segregating generations, the per cent reduction in SPAD reading varied from as low as 16.93 per cent in F_1 generation to as high as 21.59 per cent in B_2 generation.The variation in SPAD chlorophyll reading is depends on greenness of leaves. The stay green genotypes recorded higher reading than non-stay green. Tambe *et al*[23] was reported as exact SPAD reading in cross RSV 1237 x RSV 1703.Similar result was also reported by Subudhi *et al.*, [20].

3.5TOTAL CHLOROPHYLL CONTENT (MG G^{-1}FW)

Mean total chlorophyll content was less in water stress condition than non stress condition which may be due to adverse effect of water stress on plant metabolic processes (Table 3). In cross SPV 1830 x IS 6427, the mean total chlorophyll content at 50 per cent flowering was estimated 2.96 mg g-1FW and 1.87 mg g-1FW under non stress and moisture stress condition, respectively. Amongst the parents and different generations, the percent reduction in total chlorophyll content varied from as low as 35.82 per cent in P1 (SPV 1830) to as high as 37.46 per cent in B_2 generation. The B_1 generation recorded the highest total chlorophyll content (3.30 and 2.08 %) under non stress and moisture stress condition, respectively.According to Tambe *et al*.,[23], Vinita *et al*.,[26] and Deshmukh *et al*.,[5] water stress leads to decline in total chlorophyll content. Their findings were in agreement with the observations recorded in the present investigation.

3.6 CHLOROPHYLL STABILITY INDEX (%)

Chlorophyll stability is a function of temperature and found to correlate with drought tolerance. Chlorophyll stability index is a measure of integrity of membrane or heat stability of pigments under stress condition by Koleyoreas, [13]. The chlorophyll destruction commences rapid at control temperature of 55 to 56^0 C. Chlorophyll stability is an important trait which indicate an ability of genotype to survive under stress condition. The lower chlorophyll stability index is desirable parameter for drought tolerance in *rabi* sorghum genotypes. In the present investigation (Table 4), for cross SPV 1830 x IS 6427, the chlorophyll stability index (CSI) varied from 26.87 to 33.06 % under non stress and 23.40 to 30.04 % under moisture stress condition. Amongst the parents and different generations, the percent reduction in total chlorophyll content varied from as low as 35.82 per cent in P1 (SPV 1830) to as high as 37.46 per cent in B2 generation, indicate its drought tolerance capacity. The parent P_2 (IS 6427) recorded significantly the lowest chlorophyll stability index (26.87 and 23.40 %) under non stress and moisture stress condition respectively. Amongst the different generations, the percent reduction in chlorophyll stability index varied from as low as 9.13 per cent in B_1 generation to as high as 12.91 per cent in parent P_2 (IS 6427).Similar findings were also reported by Shinde and Narkhede [14] and Awari*et al*,[2].

4.CONCLUSION

In the present results, we concluded the some significant observation in this research work. We found that the B_2 and F_1 generation recorded significantly highest photosynthesis rate (25.98 and 22.47 µ mole CO_2 $m\text{-}^2s\text{-}^1$) under non stress and moisture stress condition, respectively. The parent B_1 recorded highest transpiration rate (3.27 and 1.92 mmole H_2O $m\text{-}^2s\text{-}^1$) under non stress and moisture stress condition, respectively. The F_2 generation was recorded the lowest transpiration rate (2.47 and 1.66 mmole H_2O $m\text{-}^2s\text{-}^1$) under moisture stress condition, respectively.The F_1 and B_1 generation recorded significantly the highest mean for stomatal conductance (0.24 and 0.18 mole $m\text{-}^2$ $s\text{-}^1$) under non stress condition and moisture stress condition, respectively.The B_1 generation recorded significantly the highest relative leaf water content (81.74 and 71.74 %) and in different generations highest relative leaf water content was recorded in F_1 and B_2 generations (81.01 and 74.42 %) under non stress and moisture stress condition, respectively.The segregating generation F_2 recorded significantly the highest SPAD reading (53.24 and 43.35) under non stress condition and moisture stress condition, respectively.The B_1 generation recorded the highest total chlorophyll content (3.30 and 2.08 %) under non stress and moisture stress condition, respectively.The parent B_2 generation recorded the highest chlorophyll stability index (34.49 and 32.08 %) under non stress and moisture stress condition, respectively. The parent P_2 (IS 6427) recorded significantly the lowest chlorophyll stability index (26.87 and 23.40 %) under non stress and moisture stress condition respectively.

Amongst the different generations, the percent reduction in chlorophyll stability index varied from as low as 9.13 per cent in B_1 generation to as high as 12.91 per cent in parent P_2 (IS 6427).

Table 1:- Rate of Photosynthesis and Rate of Transpiration in the leaves of different generations of rabi sorghum crossSPV 1830 x IS 6427under non stress and moisture stress condition.

Sr. No.	Generations	Rate of Photosynthesis (µ mole CO_2 $m^{-2}s^{-1}$)			Rate of Transpiration (mole H_2O $m^{-2}s^{-1}$)		
		Non stress	Moisture stress	Per cent decrese	Non stress	Moisture stress	Per cent decrese
1	P_1	21.77	19.73	9.37	2.95	1.90	35.59
2	P_2	22.25	19.99	10.16	2.75	1.70	38.18
3	F_1	24.54	22.47	8.43	3.11	1.87	39.87
4	F_2	20.97	19.06	9.11	2.47	1.66	32.79
5	B_1	23.06	21.96	4.77	3.27	1.92	41.28
6	B_2	25.98	19.98	23.09	2.86	1.79	37.00
	Mean	**22.91**	**20.71**		**1.432**	**0.89**	
	SE±	**0.19**	**0.21**		**0.021**	**0.02**	
	CD at 5%	**0.60**	**0.67**		**0.065**	**0.07**	

Table 2: Stomatal Conductance and Relative leaf water content (RLWC) in the leaves of different generations of rabi sorghum cross SPV 1830 x IS 6427under non stress and moisture stress condition.

Sr. No.	Generations	Stomatal Conductance (mole $m^{-2}s^{-1}$)			Relative leaf water content (RLWC) (%)		
		Non stress	Moisture stress	Per cent decrese	Non stress	Moisture stress	Per cent decrese
1	P_1	0.23	0.15	34.78	77.68	67.83	12.68
2	P_2	0.22	0.14	36.36	71.00	61.59	13.25
3	F_1	0.24	0.17	29.17	80.42	70.62	12.19
4	F_2	0.20	0.16	20.00	71.51	62.03	13.26
5	B_1	0.22	0.18	18.18	81.01	71.13	12.20
6	B_2	0.20	0.16	20.00	75.02	67.72	9.73
	Mean	**0.22**	**0.16**		**76.11**	**66.82**	
	SE±	**0.004**	**0.003**		**1.97**	**1.86**	
	CD at 5%	**0.01**	**0.01**		**6.22**	**5.86**	

Table 3: SPAD Value and Total Chlorophyll Content in the leaves of different generations of rabi sorghum cross SPV 1830 x IS 6427under non stress and moisture stress condition.

Sr. No.	Generations	SPAD Value			Total Chlorophyll Content (mg g^{-1}FW)		
		Non	Moistur	Per cent	Non	Moistur	Per cent

		stress	e stress	decrese	stress	e stress	decrese
1	P_1	50.68	42.01	17.10	2.68	1.72	35.82
2	P_2	50.45	41.37	17.99	2.66	1.68	36.84
3	F_1	51.08	42.43	16.93	3.29	2.06	37.39
4	F_2	53.24	43.35	18.58	2.87	1.83	36.24
5	B_1	52.01	43.05	17.23	3.30	2.08	36.97
6	B_2	50.16	39.33	21.59	2.99	1.87	37.46
Mean		**51.27**	**41.92**		**2.96**	**1.87**	
SE±		**0.50**	**0.59**		**0.07**	**0.05**	
CD at 5%		**1.58**	**1.87**		**0.23**	**0.16**	

Table 4: Chlorophyll Stability Index in the leaves of different generations of rabi sorghum cross SPV 1830 x IS 6427under non stress and moisture stress condition

Sr. No.	Generations	Chlorophyll Stability Index (%)		
		Non stress	Moisture stress	Per cent decrese
1	P_1	31.99	28.03	12.38
2	P_2	26.87	23.40	12.91
3	F_1	32.67	29.65	9.24
4	F_2	28.90	25.66	11.21
5	B_1	33.06	30.04	9.13
6	B_2	28.66	25.59	10.71
Mean		**30.36**	**27.56**	
SE±		**0.61**	**0.73**	
CD at 5%		**1.92**	**2.30**	

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