"A Study of Water Logging Tolerance on Soybean (*Glycine max* L.) Yielding and Quality in Vindhyan region of Madhya Pradesh"

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Abstract:

The National Commission on Agriculture assessed in 1976 that an area of about 6.0 million hectare was waterlogged in the country. A screening technique known as _cup method' was standardized and used for screening of soybean genotypes for tolerance to water logging conditions. Observation shows percent increase in plant height and per cent reduction in dry weight were taken as control for screening genotypes with comparatively better performances. Based on these values, few genotypes viz., showed relatively better tolerance among the genotypes under study, which can be used in breeding programme for the development of water logging tolerant varieties. Fifty soybean genotypes including popular varieties, germplasm lines and breeding lines were screened with this method for the assessment of their response to artificially created water logging conditions.

Key words: Cup method, germplasm, tolerance, screening, water logging, and breeding.

INTRODUCTION:

Agriculture continues to draw a major share (90%) of available water resources and the demand is likely to increase further [1]. MP has a unique distinction of having more than 87% soybean (Glycine max) [2] area of the country and is rightly designated as Soya State. Soybean is one of the major kharif crop in the rainfed agro ecosystem of central and peninsular India. The state Madhya Pradesh contributes 60% of the total area under soybean production in the country. Growing health consciousness on nutrition and export value of de-oiled cake from soybean has made crop potential for further expansion both horizontally and vertically. Soybean is an important oilseed crop cultivated under varying agro-climatic conditions across India. The crop is also visualized as future energy crop for the production of bio-diesel, an eco-friendly usage to meet the fuel energy requirements in several countries. Rapid growth of soybean in terms of area and production has resulted in crop exposed to many biotic and abiotic stresses. Along with drought, Salinity and nutrient deficiency, prolonged flooding due to heavy rains and low infiltration rate of the soils in which crop is grown (Vertisols), severely reduces the productivity of soybean in some of the major crop growing regions of India [3]. The National Commission on Agriculture assessed in 1976 that an area of about 6.0 million hectare was waterlogged in the country. Out of this, an area of 3.4 million hectare was estimated to be suffering from surface water stagnation and 2.6 million hectare through rise in water table. The Ministry of Agriculture estimated in 1984-85 that an area of 8.53 m ha was suffering from the problem of waterlogging including both irrigated and unirrigated areas. At present, as much as 40 per cent of irrigated area suffers from excess soil moisture conditions in India [4].

In water logged conditions the diffusion of gases is hampered thus restricting the roots to absorb available oxygen. Turbid flood water becomes anaerobic especially during night .Thus the plant growth is inhibited due to hypoxia or anoxia, finally leading to plant death. Soybean yields can reduce drastically due to water logging. Moreover, flooding during early vegetative (V2) and early reproductive (R1 to R3) stages is more damaging to seed yield than during other stages.[5] Plants adapted to water logged conditions, have mechanism to cope with this stress, such as aerenchyma formation, increased availability of soluble sugars, greater activity of glycolytic pathway and fermentation enzymes and involvement of antioxidant defence mechanism to cope with the post hypoxia/anoxia oxidative stress. Water logging tolerance is a complex trait conferred by many physiological mechanisms and complicated by confounding factors such as temperature, plant developmental stage, nutrient availability, severity of water logging stress, soil physical properties, *etc.*[6] Therefore, to overcome the losses on account of water logging, it is imperative to evaluate and identify genetic sources possessing relative tolerance/resistance to such conditions. Field trials conducted for screening genotypes for flooding tolerance are very difficult to manage, but they can be screened under simulated conditions. Thus, we have developed an easy method for this purpose, which was standardized so that a number of lines could be screened anytime depending upon need of the hour [7].

SOILS OF MADHYA PRADESH

Soils of Madhya Pradesh vary as per the structure, colour, texture and composition in the different regions. Madhya Pradesh is that part of the peninsular plateau of India where residual soils are found in an extensive area. The rock formation determines the soil structure and composition in this state. Madhya Pradesh comprises of a variety of soils ranging from rich clayey to gravelly [8]. The major groups of soils found in the state can be divided into five major categories namely:- Alluvial Soil, Black Soil or Regur Soil (medium and deep black, shallow and medium black, mixed red and black coloured), Clayey Soil, Mixed Soil Red and Yellow Soil. Soils of Madhya Pradesh [9] Medium and deep black coloured soil is extensively found it is distributed are nearly 47.6 percent of the land of Madhya Pradesh [10].

Such soils mainly consist of Iron and lime rocks. The presence of Iron gives it the Black colour and the presence of lime increases its moisture retention capacity therefore needs less irrigation. Cotton and soya bean are most suitable crops to be grown in such soil. The quantity of Calcium, Magnesium, Aluminum, Iron, Potassium and Magnesium Carbonate is more in black soil but it lacks in Nitrogen, Phosphorous and Carbonic elements [11].

MATERIAL AND METHOD

The aim of this study was to regulate the protocol for screening genotypes for water logging stress over a period of time, as well as to evaluate the available soybean genotypes for their response to artificially induced flooding conditions[12]. Thus, we have selected 50 soybean accessions including varieties and germplasm lines were evaluated using _cup method'(Table 1). In this method plants were grown in 10 cm x 10 cm pots with one plant per pot. Each genotype was replicated four times. Plants in the control treatment were watered normally to maintain stress free normal growth[13]. At the end of the flooding treatment, pots were drained and plants were allowed to continue normal growth and recovery up to maturity. Data was recorded for days to flower initiation, days to maturity, plant height and dry matter weight.[14]

Percent increase in plant height in controlled and water logged treatment was calculated as:[25]

Percent increase in height = (height at R4 - height at V5)/ height at R4 x 100.

Another dependent variable ―percent reduction in dry weight was calculated according to the formula[18]:

Reduction in dry weight = (control - flooding)/control x 100.

These two traits were taken as criteria for screening genotypes with comparatively better performances.

RESULTS AND DISCUSSION

A vast variety of variation was observed among the genotypes in treatment plot for plant height which angled from - 3.41 to 36.52 compared to the genotypes of control plot, in which value ranged rom 1.05 to 26.51[15]. It is clear that there were genotypes for which there was a reduction in plant height (Pusa 40 with per cent increase of - 3.41%), while there was also a significant increase of 36.52 per cent (Bhatt) and this has overcome the increase in height of genotypes from control plot (Fig. 1). The average per cent increase in height for control plot was 7.54 per cent, whereas it was 8.02 per cent for treatment plot (Table 2).[17] It means that most of these genotypes under water logged conditions are capable of maintaining, even surpassing the plant height to that under controlled conditions. Reduced plant growth due to water logging was also observed in tomato [21]. All of these plant species showed growth reduction to varying extents in waterlogged conditions.

SOYBEAN YIELD CAPACITY ON FIELD:

There were significant difference for days to flowering initiation and days to maturity for the genotypes under controlled as well as flooding conditions[19]. However, the average maturity for genotypes under flooding condition (97 days) was reduced than that of genotypes under controlled condition (98 days) (Table 2) (Fig. 2). Though the reduction is less, but it still reflects in the individual genotypes under both controlled and flooding conditions. The explanation behind this tendency is well given by Drew and Sisworo[22]. The nitrate uptake from soil is arrested due to microbial denitrification and damage to uptake mechanism (resulting from absence of oxygen), resulting the younger leaves takes nutrition from older leaves leading to premature senescence [23].

Dry matter weight was also considered as a criterion to distinguish genotypes for their response to flooding conditions. The average dry matter for control was 7.7 g, whereas for flooding treatment it was 5.35 g (Table 2). Therefore, the average dry matter reduction was found to be 30.5 per cent in flooding treatment. Overall reduction in dry weight was found to be in the range of 7.69 to 77.8 per cent, with lowest reduction in MACS 450 and highest reduction in PK 472 (Fig. 3). However, there were genotypes with no reduction in dry weight at all. Thus, the dry matter either reduced or remained unchanged[24], but never increased over control treatment. This shows that there was lot of variation among genotypes for their response to flooding treatment on dry matter.[23] Reduction in biomass yield in flooded genotypes and suggested that this was all due to reduced level of N2 accumulation during flooding conditions. Any limiting resource, availability within the plant decreases with distance from the site of uptake. This implies that under nutrition deficits, shoots are more starved than roots and decrease photosynthesis and overall dry matter accumulation, leading to reduction in dry weight.

The present study for standardizing screening protocol and evaluating soybean for water logging conditions demonstrated that the pot experiments under _cup method‘ whether conducted on season or offseason can be used as a tool to screen a large number of genotypes with much ease as compared to under field trials. This method can save time as well as space while conducting screening trials. With the use of this procedure, the results obtained indicated that there was a significant variation for the tolerance of genotypes to flooding conditions. Out of fifty, few genotypes were showing better performance and these five genotypes *viz.*, JS 95-60, JS 97-52, Bhatt, Cat 3299 and JS 93-05 were considered superior over the rest of genotypes for their performance under water logging conditions.

REFERENCES

1. Agarwal, D.K., Husain, S.M., Ramteke, R., Bhatia, V.K. and Srivastava, S.K. (2010). Soybean varieties of India. Directorate of Soybean Research, Indore.
2. Badal, P.S., Kumar, P., Billore, S. D., Sharma, A. N. and Joshi, O. P. (2000). Socio-economic impact of soybean cultivation in Madhya Pradesh. Project Report, Division of Agricultural Economics, Indian Agricultural Research Institute, New Delhi.
3. Bapna, S.L., Seetharaman, S. P. and Pichholiya, K. R. (1992). Soybean System in India. Oxford & IBH Publishing Co., Pvt. Ltd., New Delhi.
4. Bhatia, V.S., Singh, P., Wani, S.P., Chauhan, G.S., Kesava Rao, A.V.R., Mishra, A.K. and Srinivas, K. (2008). Analysis of potential yields and yield gaps of rainfed soybean in India using CROPGRO-Soybean model. Agricultural and Forest Meteorology, 148: 1252-1265.
5. Bhatia VS, Singh Piara, Wani SP, Kesava Rao AVR and Srinivas K. 2006. Yield Gap Analysis of Soybean, Groundnut, Pigeonpea and Chickpea in India Using Simulation Modeling. Global Theme on Agroecosystems Report no. 31. Patancheru 502 324, Andhra Pradesh, India: International Crops Research Institute for the Semi-Arid Tropics (ICRISAT). 156 pp.
6. Billore, S.D., Joshi, O.P. and Verma, S.K. (2011). Adoption of improved soybean production technology in Madhya Pradesh: A critique. Journal of Oilseeds Research, 28: 125-130.
7. Birthal, P.S., Parthasarathy Rao, P., Nigam, S.N., Bantilan, M. C. S. and Bhagavatula, S. (2010). Groundnut and soybean economies of Asia facts, trends and outlook. International Crops Research Institute for the Semi-Arid Tropics, Patancheru 502 324, Andhra Pradesh, India. Bisaliah, S. (1986).

8. Botta GF, Tolon-Becerra A, Lastra-Bravo X, Tourn M. Tillage and traffic effects (planters and tractors) on soil Int.J.Curr.Microbiol.App.Sci (2019) 8(8): 713-721 721 compaction and soybean (Glycine max L.) yields in Argentinean pampes. Soil Till Res. 2010; 110: 167-74. doi:10.1016/j.still.2010.07.001
9. Chauhan, G.S. and Joshi, O.P. (2005). Soybean (Glycine max)- the 21st century crop. Indian Journal of Agricultural Sciences, 75: 461-469.
10. Dovring, F., Jindia, J.R. and Misra, R.S. (1974). Economic production possibilities of soybeans in northern India: A preliminary study. Publication Series No. 1, University of Illinois, Urbana- Champaign Office of International Agriculture.
11. Dupare, B.U., Billore, S.D. and Joshi, O.P. (2010). Farmer's problems associated with cultivation of soybean in Madhya Pradesh, India. Journal of Agricultural Sciences and Technology, 4: 71-78.
12. Dupare, B.U., Billore, S.D. and Verma, S.K. (2013). A study of farmers' seed replacement rate of soybean and related problems in major soybean growing states. Soybean Research, 11: 58-65.
13. Ezin V, Robert De La Pena and Ahanchede A. 2010. Flooding tolerance of tomato genotypes during vegetative and reproductive stages. *Brazilian Journal of Plant Physiology* **22**(1): 131-42.
14. Iizumi, T., &Ramankutty, N. (2016). Changes in yield variability of major crops for 1981–2010 explained by climate change. Environmental Research Letters, 11(3), 034003.
15. Lal, M., Singh, K. K., Srinivasan, G., Rathore, L. S., Naidu, D., and Tripathi, C. N. (1999). Growth and yield responses of soybean in Madhya Pradesh, India to climate variability and change. Agricultural and Forest Meteorology, 93(1), 53-70.
16. Mohanty, M., Sinha, N. K., McDermid, S. P., Chaudhary, R. S., Reddy, K. S., Hati, K. M.,. and Patra, A. K. (2017). Climate change impacts vis-a-vis productivity of soybean in vertisol of Madhya Pradesh.
17. O.P. and Hussain, S.M. (2009). Soybean improvement and development in India. in Ali, M. and S. Kumar (eds.) Milestones in Food Legumes Research. Indian Institute of Pulses Research, Kanpur.
18. Qin, W., Wang, D., Guo, X., Yang, T., and Oenema, O. (2015). Productivity and sustainability of rainfed wheat-soybean system in the North China Plain: results from a long-term experiment and crop modelling. Scientific reports, 5, 17514.

19. Qin Wei, Wang Daozhong, GuoXisheng Yang Taiming, and OenemaOene. 2015. Productivity and sustainability of rainfed wheat-soybean system in the North China Plain: results from a longterm experiment and crop modelling. 5: 17514.

20. Rahimi, D., Khademi, S., and Nadafi, S. (2014). Estimation of Evaporation and Transpiration of Wheat Plant in Zaraghan Station Using CROPWAT Model. International Journal of Advanced Biological and Biomedical Research, 2(4), 1362-1370.

21. Singh, P. (2006). Potential Productivity, Yield Gap, and Water Balance of SoybeanChickpea Sequential Systematic Selected Benchmark Sites in India.

22. Singh, R., Singh, K., and Bhandarkar, D. M. (2014). Estimation of water requirement for soybean (Glycine max) and wheat (Triticum aestivum) under vertisols of Madhya Pradesh. Indian J AgrSci, 84, 190-197.

23. Soybean development in India. CGPRT Paper No.5. UN/ESCAP CGPRT Centre: Bogor, Indonesia. Chand, Ramesh. (2007). Agro-industries characterization and appraisal: soybeans in India. Agricultural Management, Marketing and Finance Working Document 20, Food and Agriculture Organisation of the United Nations, Rome.

24. VanToai T T, Hoa T T C, Nguyen T N H, Nguyen H T, Grover J, Shannon and Rahman, M A. 2010. Flooding tolerance of soybean [*Glycine max* (L.) Merr.] germplasm from Southeast Asia under field and screen house environments. *The Open Agriculture Journal* **4**: 38-46.

25. Vasiliades, L., Spiliotopoulos, M., Tzabiras, J., Loukas, A., and Mylopoulos, N. (2015). Estimation of crop water requirements using remote sensing for operational water resources management. In Third International Conference on Remote Sensing and Geoinformation of the Environment (RSCy2015) (Vol. 9535, p. 95351B). International Society for Optics and Photonics.

Table 1. List of genotypes used for waterlogging screening (cup method)

S.No	Genotype		S.No	Genotype
1.	**Ankur**		26.	**JS 71-05**
2.	**Bhatt**		27.	**JS 93-05**
3.	**Cat 198**		28.	**JS 2**
4.	**Cat 2718**		29.	**JS 76-205**

5.	**Cat 3299**		30.	**JS 80-21**
6.	**JS 90-41**		31.	**JS 79-81**
7.	**JS 97-52**		32.	**PUSA 40**
8.	**JS 335**		33.	**PUSA 16**
9.	**JS 95-60**		34.	**PUSA 97-12**
10.	**JS 20-29**		35.	**PUSA 98-14**
11.	**JS 20-36**		36.	**PK 262**
12.	**JS 20-38**		37.	**PK 472**
13.	**JS 20-69**		38.	**PS 1024**
14.	**JS 20-77**		39.	**PS 1042**
15.	**MAUS 17**		40.	**PS 564**
16.	**MAUS 26-1**		41.	**MAUS 2**
17.	**MAUS 47**		42.	**MAUS 32**
18.	**MAUS 59-1-1**		43.	**MAUS 61-2**
19.	**MAUS 199**		44.	**MAUS 61**
20.	**MAUS 423**		45.	**MAUS 81**
21.	**MAUS 449**		46.	**NRC 2**
22.	**MAUS 608**		47.	**NRC 12**
23.	**MAUS 704**		48.	**MACS 450**
24.	**NRC 7**		49.	**MACS 58**
25.	**NRC 37**		50.	**RKS 18**

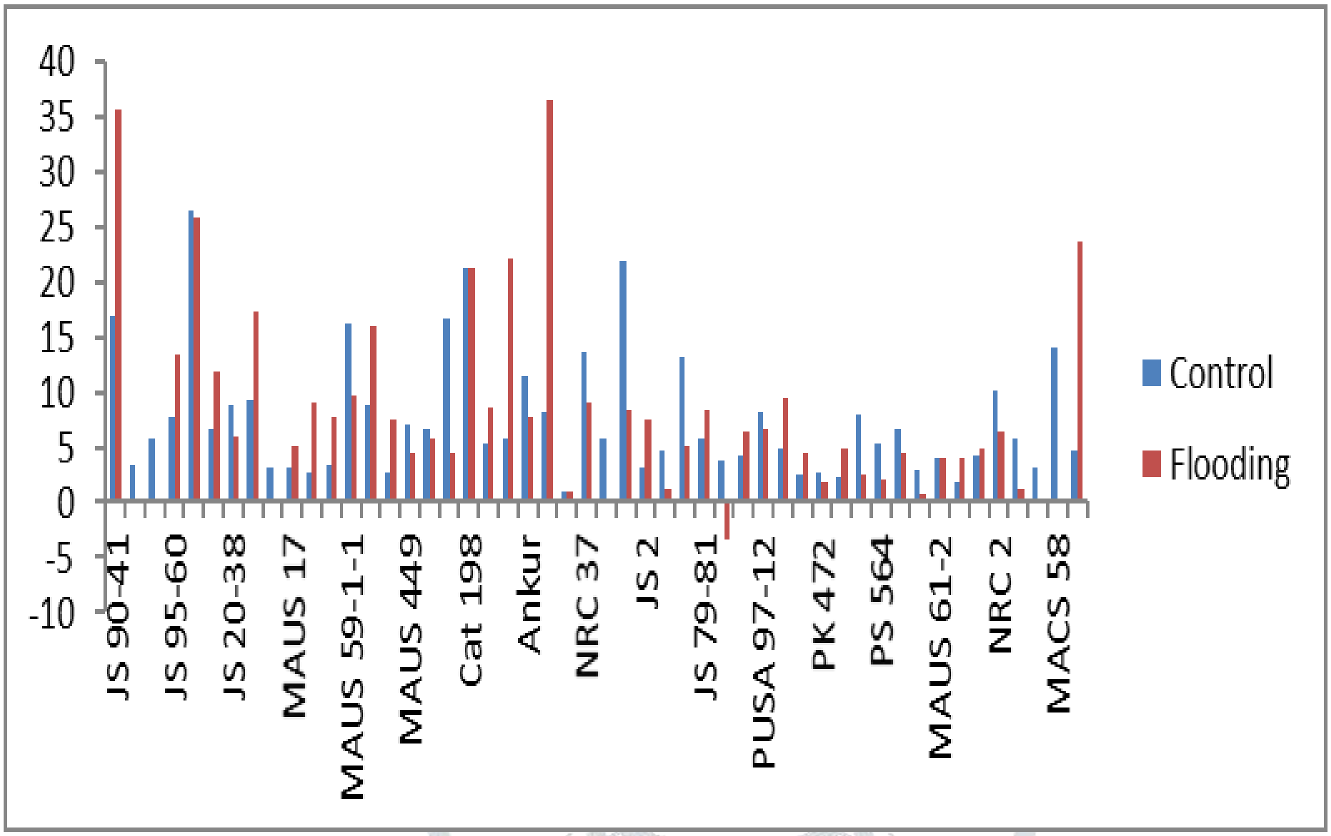

Fig. 1. Plant height for different genotypes under control and flooding conditions

Table 2. Average values for different characters under different treatments

Treatment	**Plant height (% increase)**	**Days to maturity (No)**	**Dry weight (g)**
Control	7.40	95	6.7
Flooding	8.02	97	5.10

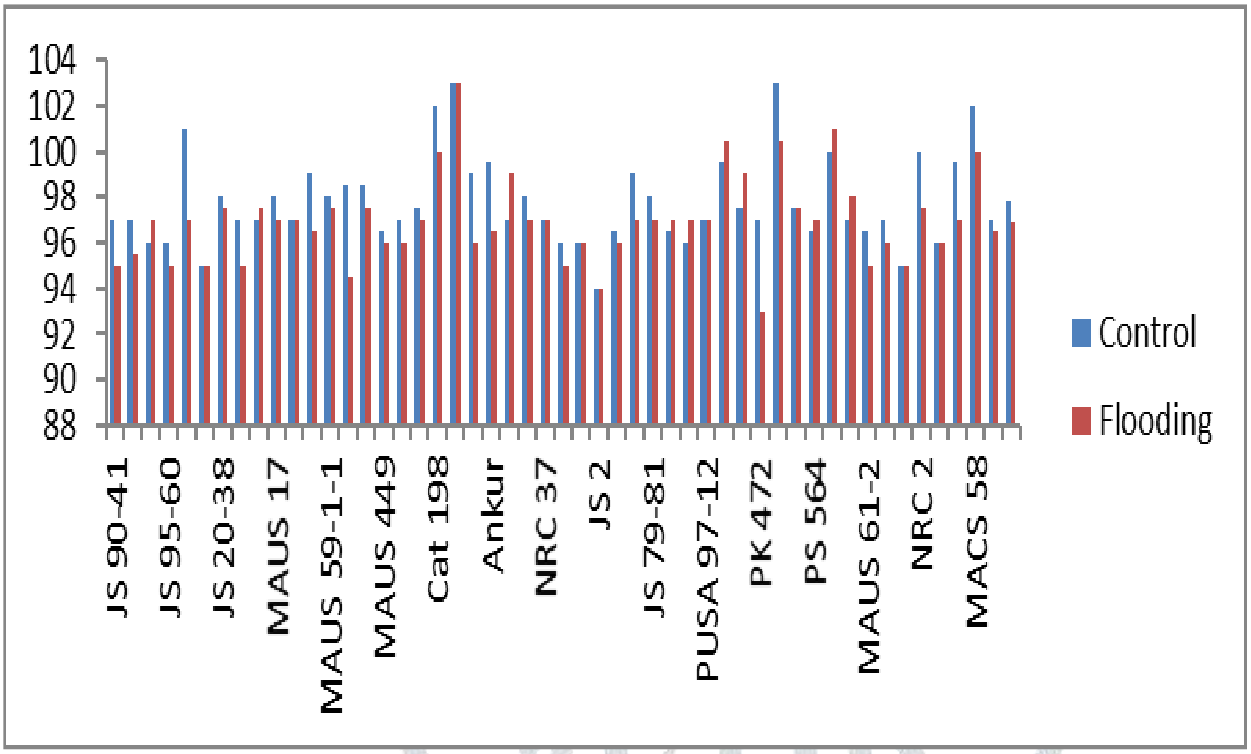

Fig. 2. Days to maturity for different genotypes under control and flooding conditions

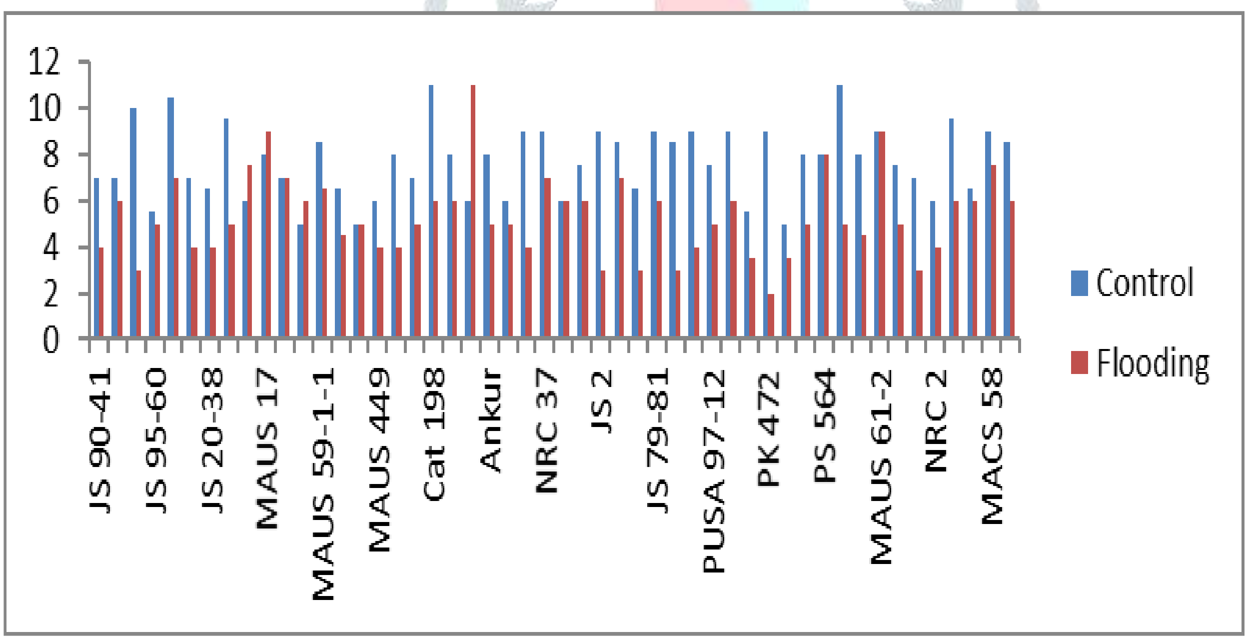

Fig. 3. Dry weight for different genotypes under control and flooding conditions