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EVALUATION OF ORGANIC AMENDMENTS IN ALLEVIATING THE ADVERSE EFFECT OF WATER DEFICIT STRESS ON SOYBEAN

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ABSTRACT

To assess the impact of different soil amendments in alleviating the adverse effects of water deficit stress on soybean, a field experiment was conducted at the Crop Physiology and Ecology research field of Hajee Mohammad Danesh Science and Technology University, Dinajpur during November 2020 to June 2021. The experiment was laid out in a randomized complete block design (RCBD) with three replications. The treatments were, T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2- RDF in water stress condition, T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition, T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition, T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry litter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Cattle manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) + RDF in water stress condition, T_{10}- Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition. Additional application of biochar, poultry litter based composed, cattle manure, vermicompost and humic acid improved plant height and leaves $plant^{-1}$, increased the greenness of leaf, improved leaf water status and relative leaf water content, increased leaf proline content and total plant dry weight, improved seed yield in different magnitude under water stress condition compared to application of recommended inorganic fertilizer alone. Additional application of biochar @ 20 t ha^{-1}, poultry litter based compost @ 10 t ha^{-1}, cattle manure @ 50 t ha^{-1} and humic acid @ 2.5 kg ha^{-1} performed better in alleviating the adverse effect of water deficit stress on soybean.

Keywords: Growth, organic amendments, physiology, soybean, water deficit stress, yield

INTRODUCTION

Climate change and global warming are two basic environmental issues that are caused by anthropogenic activities making agricultural crisis even more severe. Due to climatic changes, earth is becoming warmer and drier and ultimately resulting in water scarcity. Bangladesh is agriculture based country and its agricultural productivity and yield is adversely affected due to water shortage (Huaqi *et al*. 2002). Drought stress reduces plant growth by affecting various physiological and biochemical processes (Farooq *et al*. 2008). Soybean [*Glycine max* (L.) Merr] is grown mostly under rainfed conditions, so soil water deficits occurring during critical stages of crop development significantly limit soybean yield in most growing seasons (Earl 2012).

There are some soil amendments such as biochar, vermicompost, poultry compost, humic acid etc. that increase drought resistance for plants and also improve the Water use efficiency (WUE). Biochar is an example of such amendments which contains 80% of carbon that has the ability to conserve water and nutrients for plants and hence considered as drought enduring material (Major *et al*. 2010). Vermicompost was suggested to increase tolerance of plants to drought as an ecological alternative (Garcia *et al*. 2012). Application of compost derived from agricultural wastes, poultry and cattle manure can improve crop tolerance and increase plant growth (Tejada *et al*. 2006). Kulikova *et al*. (2005) reported that humic substances may work against environmental stresses. But information on effect of organic amendments in alleviating the adverse effect of water deficit stress on soybean in Bangladesh condition is scanty. Keeping in view the above consideration the present investigation was conducted to investigate the effect of different soil amendments on growth, physiology and yield of soybean under well water and water deficit condition and to assess the impact of different soil amendments in alleviating the adverse effects of water deficit stress on soybean.

MATERIALS AND METHODS

The experiment was conducted at the research farm and laboratory of Crop Physiology and Ecology Department, Hajee Mohammad Danesh Science and Technology University, Dinajpur during November 2020 to June 2021. The experimental field was a medium high land belonging to the non-calcarious dark gray floodplain soil under the agro-ecological zone (AEZ-1) of Old Himalayan Piedmont Plain. The experiment was laid out in a randomized complete block design with twelve treatments and three replications. The size of unit plot was 2.5 m x 1.5 m. The treatments were- T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2- RDF in water stress condition**,** T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition, T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition**,** T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry litter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Cattle manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) + RDF in water stress condition, T_{10}- Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition.

A recommended dose of fertilizer (32 kg N, 42.5 kg P and 70 kg K, 23 kg S, 2.5 kg Zn and 1.3 kg B per hectare) for soybean was applied (BARC 2005). All fertilizers were applied during the final land preparation and incorporated thoroughly into the soil as basal dose. Different organic amendments were also incorporated thoroughly into the soil as per treatment during final land preparation**.** Seeds of BARI Soybean-6 were sown on 13 December 2020 in a line of 30 cm apart. Seeds were sown in that way that it was possible to maintain plant to plant distance of 10 cm by thinning. Slight irrigation was given for uniform germination after sowing.Only the plots containing treatment T_1 were irrigated three times (at 30, 60 and 90 days after sowing) but the remaining plots (water stressed) were not irrigated throughout the growing period to maintain water deficit stress condition and the crop was protected from rainfall by rainout shelter. Necessary intercultural operations were done as when necessary. Data were recorded on soil moisture content (15 cm depth soil), growth parameters as plant height, number of leaves plant^{-1}, shoot dry weight and root dry weight. SPAD (Soil Plant Analyses Development) value was taken using SPAD meter. Water retention capacity was determined according to Barrs and Weatherly (1962). Relative leaf water content was determined according to Barrs and Weatherly (1962). Proline content was estimated according to Bates (1973). Data were recorded on yield and yield contributing data as number of pods plant^{-1}, pod length, number of grains per pod, 100 grain weight, total dry matter content, grain yield plant^{-1} and grain yield m^{-2}.

Statistical analysis: All the collected data were statistically analysed to find out the level of significance using Statistix10 program. The mean differences were compared by Tukey's test at 5% level of probability.

RESULTS AND DISCUSSION

Soil moisture content

The soil moisture content (0-15 cm depth) both at 60 and 100 DAS was significantly influenced by the different organic amendments along with water regimes (Table 1). Irrigated plots maintained higher soil moisture than non-irrigated plots both at 60 and 100 DAS. At 60 DAS, additional application of organic amendments in soil such as biochar @ 10 t ha^{-1} (T_3), poultry litter based compost @ 5 t ha^{-1} (T_6), cattle manure @ 50 t ha^{-1} (T_8), vermicompost @ 5 t ha^{-1} (T_{10}) and humic acid @ 2.5 kg ha^{-1} (T_{11}) under water stress condition significantly increased the soil moisture content compared to $T_{2.}$ At 100 DAS, the highest soil moisture content (10.13%) was recorded when recommended doses of inorganic fertilizer was applied in well water condition (T_1) and the lowest moisture content (7.01%) was recorded when additional 25 t ha^{-1} cattle manure was applied in water stress condition (T_7) which was statistically similar to all other treatments in water stress condition except addition of poultry litter based compost @ 10 t ha^{-1} (T_6), cattle manure @ 50 t ha^{-1} (T_8) and humic acid @ 5 kg ha^{-1} (T_{12}) under water stress condition in which soil moisture content was improved significantly compared to T_2. We found that soil moisture content increased with the addition of different organic amendments. Nazran *et al.* (2019) found similar findings. Therefore, all together these results suggest that soil moisture content significantly increase by using different organic amendments.

Table 1. Effect of organic amendments in relation to water regimes on soil moisture content of soybean field at 60 and 100 days after sowing

Treatment	Soil moisture at 15 cm depth	
	At 60 DAS	At 100 DAS
T_1	12.82 a	10.13 a
T_2	10.31 d	7.06 cd
T_3	11.57 b	7.10 cd
T_4	11.43 bcd	7.97 bcd
T_5	11.51 bc	7.66 bcd
T_6	10.39 cd	8.02bc
T_7	11.17 bcd	7.01 d
T_8	11.63 b	8.15 b
T_9	10.93 bcd	7.62bcd
T_{10}	11.61 b	7.55 bcd
T_{11}	11.68 ab	7.05 cd
T_{12}	10.79 bcd	8.01 bc
CV (%)	3.41	4.24
Level of significance	**	**

In a column, values having different letter(s) differed significantly at 5% level of probability by Tukey's test.** indicates significant at 1% level of probability, CV- Coefficient of Variation, T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2- Recommended dose of fertilizer (RDF) in water stress condition, T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition, T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition, T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry liter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Cattle manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) + RDF in water stress condition, T_{10}- Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition.

Plant height and Leaves plant^{-1}

Plant height and leaves plant^{-1}of soybean were significantly influenced by different organic amendments along with water regime treatments at 60, 75 and 100 days after sowing (Table 2). Additional application of biochar @ 20 t ha^{-1}, poultry litter based compost @ 10 t ha^{-1}, cattle manure @ 25 t ha^{-1}, cattle manure @ 50 t ha^{-1} and vermicompost @ 5 t ha^{-1} could improve the leaves plant^{-1} under water stress condition. Additional application of biochar @ 20 t ha^{-1}, poultry litter based compost @ 10 t ha^{-1} and cattle manure @ 50 t ha^{-1} could improve the height of plant under water stress condition. Plant height and leaves plant^{-1} of soybean were affected drastically due to water stress condition but additional application of organic amendments could improve these parameters under water stress condition. Plant height and leaves plant^{-1} of soybean significantly increase by using different organic amendments under water stress condition was also found by Mannan *et al.* (1992) and Ranawake *et al.* (2011).

Table 2. Effect of organic amendments in relation to water regimes on plant height and leaves plant^{-1} of soybean at different days after sowing

Treatment	Plant height (cm)			Leaves plant^{-1}		
	At 60 DAS	At 75 DAS	At 100 DAS	At 60 DAS	At 75 DAS	At 100 DAS
T_1	28.39 a	41.55 a	41.44 ab	8.78 a	10.56 a	16.00 a
T_2	22.22gh	36.11 bc	33.72 b	5.22 fg	6.89 ef	8.44 b
T_3	20.89 h	35.22 bc	36.17 ab	4.89 g	6.22 f	11.33 ab
T_4	24.78 cde	35.78 bc	40.92 ab	6.89 de	8.22 bcd	14.67 a
T_5	22.72fg	36.00 bc	34.32 b	4.89 g	7.33 de	9.44 b
T_6	25.56bc	39.67 a	41.83 ab	6.22 ef	9.22 b	17.11 a
T_7	25.22 bcd	35.22 bc	33.76 b	8.00 abc	7.00 ef	14.33 a
T_8	26.11bc	40.67 a	46.72 a	7.22 cde	10.44 a	16.00 a
T_9	23.00 fg	31.89 d	34.33 b	6.78 de	7.22 def	11.44 ab
T_{10}	26.44 b	36.89 b	37.00 ab	8.33 ab	8.44 bc	15.11 a
T_{11}	23.55 efg	34.11 cd	38.83 ab	7.56 bcd	7.56 cde	11.78 ab
T_{12}	23.89 def	35.44 bc	34.78 b	5.22 fg	7.56 cde	12.33 ab
CV (%)	2.14	2.05	10.16	5.38	4.54	12.55
Level of significance	**	**	**	**	**	*

In a column, values having different letter(s) differed significantly at 5% level of probability by Tukey's test. * indicates significant at 5% level of probability, ** indicates significant at 1% level of probability, CV- Coefficient of Variation, T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2- Recommended dose of fertilizer (RDF) in water stress condition, T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition, T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition, T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry litter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Cattle manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) + RDF in water stress condition, T_{10}- Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition

Shoot and root dry weight plant^{-1}

Shoot (at 75 DAS) and root dry weight plant^{-1} (at 60 and 75 DAS) was significantly influenced by different organic amendments along with water regime treatments except shoot dry weight plant^{-1} at 60 DAS (Table 3). The highest root dry weight plant^{-1} at 60 DAS (0.229 g) was recorded when additional vermicompost @ 5 t ha^{-1} was applied in water stress condition (T_{10}) which was statistically equal to those recorded in all other treatment except those recorded when additional biochar @ 10 t ha^{-1} was applied in water stress condition (0.105 g) and when poultry compost @ 5 t ha^{-1} was applied in water stress condition (0.115 g). The highest shoot (3.23 g) and root dry weight $plant^{-1}$ (0.546 g) at 75 DAS was recorded when additional cattle manure @ 50 t ha^{-1} was applied in water stress condition (T_8) which (3.23 g) was statistically equal to those recorded in all other treatment except some treatment for shoot dry weight $plant^{-1}$ (T_5-1.69 g and T_9-1.70 g) and root dry weight $plant^{-1}$ (T_2 -0.270 g, T_3 -0.249 g, T_5 -0.275 g, T_9 -0.306 g and T_{12} -0.310 g). Additional application of organic amendments could improve shoot and root dry weight $plant^{-1}$ of soybean under water stress condition. Ranawake *et al.* (2011) reported similar results.

Table 3. Effect of organic amendments in relation to water regimes on shoot and root dry weight of soybean at different days after sowing

Treatment	At 60 DAS		At 75 DAS	
	Shoot (g $plant^{-1}$)	Root (g $plant^{-1}$)	Shoot (g $plant^{-1}$)	Root (g $plant^{-1}$)
T_1	1.32 a	0.175 abc	3.02 ab	0.450 ab
T_2	0.80 a	0.118 abc	2.10 ab	0.270 b
T_3	0.77 a	0.105 c	2.72 ab	0.249 b
T_4	1.12 a	0.135 abc	2.65 ab	0.379 ab
T_5	0.73 a	0.115 bc	1.69 b	0.275 b
T_6	1.19 a	0.190 abc	2.80 ab	0.436 ab
T_7	0.99 a	0.222 ab	2.66 ab	0.413 ab
T_8	1.23 a	0.174 abc	3.23 a	0.546 a
T_9	0.97 a	0.129 abc	1.70 b	0.306 b
T_{10}	1.22 a	0.229 a	2.60 ab	0.375 ab
T_{11}	1.17 a	0.180 abc	2.44 ab	0.381 ab
T_{12}	0.83 a	0.156 abc	2.34 ab	0.310 b
CV (%)	27.6	23.42	19.75	20.52
Level of significance	NS	**	*	**

In a column, values having different letter(s) differed significantly at 5% level of probability by Tukey's test.^{NS} indicates insignificant, * indicates significant at 5% level of probability, ** indicates significant at 1% level of probability,CV- Coefficient of Variation,T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2- Recommended dose of fertilizer (RDF) in water stress condition, T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition , T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition, T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry litter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Catte manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) + RDF in water stress condition, T_{10}-

Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition.

SPAD value

SPAD value was significantly influenced by different organic amendments along with water regime treatments at 75 and 100 DAS except at 60 days (Table 4). Additional application of biochar @ 10 and 20 t ha^{-1}, poultry litter based compost @ 10 t ha^{-1}, cattle manure @ 25 t ha^{-1}, cattle manure @ 50 t ha^{-1}, vermicompost @ 5 t ha^{-1} and humic acid @ 2.5 and 5 kg ha^{-1} could improve leaf SPAD value under water stress condition. We observed that SPAD value of soybean was affected due to water stress condition but additional application of organic amendments could improve the greenness of leaf under water stress condition were also reported by Ashraf *et al.* (1994), Keyvan (2010) and Farshadfar *et al.* (2014).

Table 4. Effect of organic amendments in relation to water regimes on leaves SPAD value of soybean at different days after sowing

Treatment	SPAD value at different DAS		
	At 60 DAS	At 75 DAS	At 100 DAS
T_1	31.52 a	31.43 b	38.37 a
T_2	32.08 a	29.42 cd	27.77 c
T_3	32.32 a	30.27 bcd	38.27 a
T_4	29.23 a	30.94 bc	35.20 ab
T_5	32.08 a	33.53 a	30.60 bc
T_6	30.95 a	30.88bc	32.97 abc
T_7	31.52 a	28.80 d	30.73 bc
T_8	33.18 a	30.94bc	35.87ab
T_9	32.64 a	29.09 cd	30.93 bc
T_{10}	30.91 a	30.72 bc	32.37 abc
T_{11}	27.48 a	31.60 b	32.53 abc
T_{12}	29.87 a	26.11 e	33.63 abc
CV (%)	7.38	2.13	6.96
Level of significance	NS	**	**

In a column, values having different letter(s) differed significantly at 5% level of probability by Tukey's test.^{NS} indicates insignificant, ** indicates significant at 1% level of probability,CV-Coefficient of Variation, T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2-Recommended dose of fertilizer (RDF) in water stress condition, T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition, T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition, T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry litter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Cattle manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) +

RDF in water stress condition, T_{10}- Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition.

Water retention capacity, Relative leaf water content and Leaf proline

Water retention capacity, relative leaf water content and leaf proline content were significantly influenced by different organic amendments along with water regime treatments (Table 5). Additional application of biochar @ 20 t ha^{-1}, poultry litter based compost @ 5 and 10 t ha^{-1}, cattle manure @ 25 and 50 t ha^{-1}, vermicompost @ 2.5 and 5.0 t ha^{-1} and humic acid @ 2.5 kg ha^{-1} could significantly improve water retention capacity under water stress condition compared to T_2. Again, Leaf proline content was increased in all treatments under water stress condition (T_2 – T_{12}) compared to well water condition (T_1) but the increment was not found significant with additional application of poultry litter based composed @ 5 t ha^{-1}, cattle manure @ 50 t ha^{-1} and humic acid @ 5.0 kg ha^{-1}. Again, additional application of biochar @ 20 t ha^{-1}, poultry litter based composed @ 10 t ha^{-1}, cattle manure @ 25 and 50 t ha^{-1},vermicompost @ 2.5 and 5.0 t ha^{-1} and humic acid @ 2.5 and 5.0 kg ha^{-1} could significantly improve relative leaf water content under water stress condition compared to T_2. In our current enquiry, we observed that additional application of biochar, poultry litter based compost, cattle manure, vermicompost and humic acid improved leaf water status as indicated by water retention capacity and relative leaf water content and also increased leaf proline content under water stress condition. Physiological amelioration through additional organic amendments under water stress condition was also observed by Banger *et al.* (2019) and Nazran *et al.* (2019) that are supportive to our findings.

Yield and yield contributing attributes

Plant height, total plant dry weight, Pods $plant^{-1}$, Seeds pod^{-1},100 seed weight, Seed yield $plant^{-1}$ and Seed yield m^{-2} of soybean were significantly influenced by different organic amendments along with water regime treatments except pod length (Table 6). The highest plant height (43.90 cm) was recorded when additional cattle manure @ 50 t ha^{-1} was applied under water stress condition which was statistically similar to those measured in all other treatments except T_3 (31.78 cm) and T_7 (30.05 cm). Additional application of organic amendments could significantly improve total plant dry weight and pods $plant^{-1}$ (except in T_7) under water stress condition compared to T_2. Again, The highest seeds pod^{-1}(2.21) was recorded when additional cattle manure @ 50 t ha^{-1} was applied under water stress condition which was statistically similar to that (2.08) measured when recommended dose of fertilizer was applied in water stress condition (T_2). Additional application of biochar @ 10 and 20 t ha^{-1}, poultry litter based compost @ 5 t ha^{-1} and humic acid @ 2.5 and 5.0 kg ha^{-1} could significantly increase 100 seed weight under water stress condition compared to T_2. Again, additional application of organic amendments (biochar @ 10 and 20 t ha^{-1}, poultry litter based compost @ 10 t ha^{-1}, cattle manure @ 50 t ha^{-1}, vermicompost @ 2.5 and 5 t ha^{-1}, and humic acid @ 2.5 and 5.0 kg ha^{-1}) could significantly increase seed yield $plant^{-1}$ and seed yield m^{-2} under water stress condition compared to T_2. Our research findings revealed that additional application of organic amendments significantly increased the physiological and yield attributes of soybean under water stress condition. It might be due to improved physiological processes that eventually increases plant growth and development leading to increase in yield and yield components (Kammann *et al.* 2011). Improvement of yield contributing attributes and yield under water deficit stress through application of additional organic amendments was also reported by Vaccari *et al.* (2011) and Graber *et al.* (2010) which agree to the findings of the present study.

Table 5. Effect of organic amendments in relation to water regimes on tissue water retention capacity, relative water content and proline content of leaf of soybean at 100 days after sowing

Treatment	Water retention capacity at 24 hour after leaf detachment (% of water at start)	Relative leaf water content (%)	Leaf proline content (µmole g^{-1} FW)
T_1	18.0 a	81.8 abc	0.50 f
T_2	8.0 g	75.3 c	0.96 bc
T_3	5.7 h	80.9 abc	0.87 cd
T_4	16.7 ab	78.7 bc	0.61 e
T_5	15.3 bc	78.6 bc	0.60 ef
T_6	13.3 de	79.9 abc	0.99 b
T_7	11.3 f	82.7 ab	0.85 d
T_8	15.0 bcd	80.5 abc	0.57 ef
T_9	13.0 ef	81.6 abc	1.15 a
T_{10}	15.0 bcd	85.3 a	0.90 bcd
T_{11}	14.3 cde	80.3 abc	1.16 a
T_{12}	9.0 g	82.6 ab	0.60 ef
CV (%)	5.22	2.75	4.4
Level of significance	**	**	**

In a column, values having different letter(s) differed significantly at 5% level of probability by Tukey's test. ** indicates significant at 1% level of probability, CV- Coefficient of Variation, T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2- Recommended dose of fertilizer (RDF) in water stress condition, T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition, T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition, T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry litter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Cattle manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) + RDF in water stress condition, T_{10}- Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition.

Table 6. Effect of organic amendments in relation to water regimes on yield contributing attributes and yield of soybean

Treatment	Plant height (cm) at harvest	Total dry weight (g $plant^{-1}$) at harvest	Pods $plant^{-1}$	Pod length (cm)	Seeds pod^{-1}	100 seed weight(g)	Seed yield $plant^{-1}$	Seed yield m^{-2}
T_1	41.32 abc	8.32 b	21.33 de	3.36 a	1.92 bcd	8.795 bc	4.63 a	97.12 bc
T_2	32.62 abc	5.31 d	13.50 f	3.32 a	2.08 ab	8.450 d	2.53 e	59.32 g
T_3	31.78 bc	7.16 c	20.23 e	3.56 a	1.71 ef	9.310 a	3.31 bc	71.74 e
T_4	35.03 abc	8.31 b	27.40 ab	3.48 a	1.92 bcd	8.996 b	4.43 a	103.85 a
T_5	33.47 abc	6.60 c	20.07 e	3.06 a	1.65 f	8.805 bc	3.15 cd	49.47 h
T_6	42.24 ab	10.00 a	29.10 a	3.23 a	1.84 cde	8.675 cd	4.49 a	99.56 ab
T_7	30.05 c	4.05 e	14.27 f	3.31 a	1.71 ef	7.458 f	3.01 d	55.15 g
T_8	43.90 a	9.97 a	24.57 c	3.56 a	2.21 a	8.865 cd	4.48 a	99.15 abc
T_9	33.15 abc	6.73 c	20.20 e	3.06 a	1.85 cde	8.112 e	3.02 d	65.88 f
T_{10}	37.21 abc	7.50bc	22.33 d	3.60 a	1.99 bc	8.430 d	3.41 b	73.78 de
T_{11}	39.13 abc	9.81 a	26.83 b	3.25 a	1.93 bcd	9.018 ab	4.47 a	93.91 c
T_{12}	36.25 abc	7.07 c	19.77 e	3.48 a	1.82 de	9.050 ab	3.13 cd	78.18 d
CV (%)	10.74	4.49	2.92	6.7	2.87	1.16	2.2	2.36
Level of significance	**	**	**	NS	**	**	**	**

In a column, values having different letter(s) differed significantly at 5% level of probability by Tukey's test. NS indicates insignificant, ** indicates significant at 1% level of probability, CV-Coefficient of Variation, T_1- Recommended dose of fertilizer (RDF) in well water condition, T_2-Recommended dose of fertilizer (RDF) in water stress condition, T_3- Biochar (10 t ha^{-1}) + RDF in water stress condition, T_4- Biochar (20 t ha^{-1}) + RDF in water stress condition, T_5- Poultry litter based compost (5 t ha^{-1}) + RDF in water stress condition, T_6- Poultry litter based compost (10 t ha^{-1}) + RDF in water stress condition, T_7- Cattle manure (25 t ha^{-1}) + RDF in water stress condition, T_8- Cattle manure (50 t ha^{-1}) + RDF in water stress condition, T_9- Vermicompost (2.5 t ha^{-1}) + RDF in water stress condition, T_{10}- Vermicompost (5.0 t ha^{-1}) + RDF in water stress condition, T_{11}- Humic acid (2.5 kg ha^{-1}) + RDF in water stress condition and T_{12}- Humic acid (5.0 kg ha^{-1}) + RDF in water stress condition

CONCLUSION

Additional application of organic amendments could mitigate the adverse effect of water deficit stress on soybean and improve the growth, physiological traits, yield contributing attributes and yield of the crop under water deficit stress condition. Additional application of biochar @ 20 t ha^{-1}, poultry litter based compost @ 10 t ha^{-1}, cattle manure @ 50 t ha^{-1} and humic acid @ 2.5 kg ha^{-1} can alleviate the adverse effect of water deficit stress on soybean effectively.

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