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Dry matter content and physiological parameters of soybean as influenced by application of biofertilizers

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ABSTRACT

A field experiment was conducted in the field during kharif season of 2023 at Post Graduate Institute Farm, MPKV, Rahuri to investigate the "Studies on physiological responses and yield of soybean influenced by application of biofertilizers" with objectives, to study the physiological responses of soybean to the application of biofertilizer sand yield influenced by the application of biofertilizers. The experiment was laid out in split plot design with three replications. There were 14 treatment combinations comprised with 7 biofertilizer treatments and two varieties viz., KDS-726 and KDS-753. The results of field experiment revealed that, with respect to growth parameters the variety KDS-726 had shown statistically significantly superior results than the variety KDS-753 while the biofertilizer treatment T_5 i.e. Seed inoculation of Rhizobium + PSB + KMB @ 25 g each kg^{-1} +100% RDF recorded the significantly superior leaf area, leaf area index (LAI), crop growth rate (CGR), absolute growth rate (AGR) and net assimilation rate (NAR), dry matter content and SPAD chlorophyll meter reading (SCMR), whereas treatment T_6 i.e. Seed inoculation of Rhizobium + PSB + KMB @ 25gm each kg^{-1} + 75% RDF recorded leaf area, leaf area index, crop growth rate, absolute growth rate, net assimilation rate, dry matter content and SPAD chlorophyll meter index (SCMR) which was found statistically at par with treatment T_5.

Keywords: Soybean, Biofertilizers, Leaf area, Physiological, Growth rate

INTRODUCTION

Soybean [*Glycine max* ((L. Merrill)] belongs to family *Fabaceae* and is one of the most important oilseed legume crops in India. Soybean seeds are an exceptional nutritive and very rich in protein. Its oil is one of the most popular edible oil used in India. It is emerging as a leading oilseed legume crop in India due to its high productivity, profitability and vital contribution towards maintaining soil fertility. India ranks fifth in area and production of soybean. Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka, Chhattisgarh and Gujarat are the leading states of India in soybean production (Kumar *et al.,* 2020). Nitrogen and phosphorus are important elements for effective production of groundnuts. Low soil N is one of the major constraints to crop production in Sudan. Therefore, adequate supply of nitrogenous fertilizer is essential for growth and yield of crops. Nitrogen from *rhizobium*-legume symbiosis may be the only renewable soil fertility input that the farmer can acquire without significant investment. By maximizing biological nitrogen fixation through biofertilization, farmer can raise their yield and income. It was estimated that seed legume could fix about 15-210 kg N ha^{-1} season ally in Africa (Dakora and Keya, 1997).

MATERIAL AND METHODS

A field trial "Studies on Physiological responses and yield of soybean influenced by application of biofertilizers" was conducted at the Agricultural Botany Field, Post Graduate Institute, Mahatma Phule Krishi Vidyapeeth, Rahuri during *Kharif* season of 2023. The plot selected for the experiment had a uniform soil depth. The topography of field was uniform and leveled. The soil was medium and well drained with medium black colour. In the present investigation two varieties of soybean KDS-726 and KDS-753 were sown on field by applying different biofertilizer treatments. Seven treatment combinations were made as given in Table 1. There were three number of replications. Experimental design used for the plot was split plot design according to that layout of field was made.

The data collected on individual

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characters were subjected to the method of analysis of variance commonly applicable to the Split plot design (Panse and Sukhatme, 1985).

Table 1: Different biofertilizer treatments

T_1	Recommended Dose of fertilizer NPK
T_2	Seed inoculation of *Rhizobium* @ 25 g /kg + 100% RDF.
T_3	Seed inoculation of PSB @ 25 g /kg + 100% RDF.
T_4	Seed inoculation of KMB @ 25 g /kg + 100% RDF.
T_5	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each/kg + 100% RDF
T_6	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each/kg + 75% RDF
T_7	Control Absolute

Results and Discussion

1. Dry Matter content (g plant^{-1})

The total dry matter content of soybean as influenced statistically significant due to different treatments is presented in Table 2. The dry matter content increased progressively up to harvesting. The mean dry matter content at 30, 60, 90 DAS and at maturity were 2.99, 14.73, 21.55 and 23.35 g plant^{-1}, respectively.

From the data it is revealed that, there was significant difference of dry matter content at all growth stages between two varieties. At 30, 60, 90 DAS and at maturity KDS-726 was found significantly superior in dry matter content 3.13, 15.04, 22.07, 24.01 g, respectively over KDS-753.

KDS 726 is specifically bred for higher biomass production and better adaptation to certain climates, which can lead to increased dry matter accumulation compared to KDS 753. KDS 726 may have a more efficient root system or better nutrient uptake capability, allowing it to utilize soil nutrients more effectively, resulting in higher dry matter content. Differences in flowering and maturation times can influence how long the plant has to accumulate biomass before harvest, potentially favouring the KDS 726 variety.

Table 2: Dry matter content (DMC) (g plant^{-1}) as influenced by different treatments in soybean

Factors		Dry Matter Content (DMC) (g plant^{-1})			
		30 DAS	60 DAS	90 DAS	At Maturity
A.	Main plots: Variety (V)				
V_1	KDS-726	3.13	15.04	22.07	24.01
V_2	KDS-753	2.85	14.42	21.05	22.69
	S.E. (m) ±	0.04	0.09	0.16	0.18
	CD at 5%	0.26	0.57	0.98	1.07
B.	Sub plots: Treatments (T)				
T_1	Recommended Dose of fertilizer NPK	2.53	13.43	20.52	22.30
T_2	Seed inoculation of *Rhizobium* @ 25gkg^{-1} + 100% RDF.	2.57	14.85	21.39	22.91
T_3	Seed inoculation of PSB @ 25 gkg^{-1} + 100% RDF.	3.03	14.81	21.14	22.90
T_4	Seed inoculation of KMB @ 25 gkg^{-1} + 100% RDF.	2.88	14.75	21.00	22.69
T_5	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 100% RDF	3.83	17.02	24.18	26.29
T_6	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 75% RDF	3.72	15.93	23.82	25.89
T_7	Absolute Control	2.37	12.32	18.84	20.47
	S.E. (m) ±	0.13	0.66	0.93	1.05
	CD at 5%	0.38	1.93	2.71	3.07
C.	Interaction (V x T)				
	S.E. (m) ±	0.18	0.93	1.31	1.49
	CD at 5%	NS	NS	NS	NS
	General Mean	2.99	14.73	21.55	23.35

The total dry matter content at 30, 60, 90 DAS and at maturity were influenced significantly due to different biofertilizer treatments. The dry matter content at 30, 60, 90 DAS and at maturity 3.83, 17.02, 24.18 and 26.29 g plant^{-1}, respectively, were recorded statistically significantly superior in treatment T_5 (seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1}+ 100% RDF (50:75:45 $N:P_2O_5:K_2O$) kg ha^{-1}) than rest of the treatments except treatment T_6. The treatment T_6, seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1}+ 75% RDF recorded the dry matter content at 30, 60, 90 DAS and at maturity were 3.72, 15.93, 23.82 and 25.89 g $plant^{-1}$ which was at par with treatment T_5. The lowest total dry matter content was observed in Absolute Control (T_7). *Rhizobium*, PSB, KMB improves nutrient availability in the soil. For example, *Rhizobium* enhances nitrogen fixation, leading to increased nitrogen levels in the plant, which is crucial for protein synthesis and biomass accumulation. *Mycorrhizal* fungi form symbiotic relationships with biofertilizers, soybean roots, improving root structure and function. This enhances the plant's ability to uptake water and nutrients, contributing to higher dry matter production (Rai *et al.,* 2018). The results are in agreement with Singaravel *et al.,* (2008). The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of total dry matter content at all stages of growth.

2. Leaf Area

The leaf area of soybean as influenced statistically significant due to different treatments is presented in Table 3. The leaf area increased progressively up to 90 DAS. The mean leaf area at 30, 60, 90 DAS and at maturity were 2.67, 20.72, 24.31 and 22.69 dm^2, respectively.

From the data it is revealed that, there was statistically significant difference observed in leaf area at all growth stages between two varieties. Variety KDS-726 recorded significantly higher leaf area of 2.76, 21.36, 25.28 and 23.61 dm^2 at 30, 60, 90 DAS and at maturity respectively, over variety KDS-753. The KDS 726 showed higher leaf area might be due to their superior canopy spread, more efficient root system or better nutrient utilization. A crucial determinant fostering more expansive and efficient leaf arrangement for photosynthetic processes. These findings resonate with the results reported by Vyas and Khandwe (2014).

The leaf area at 30, 60, 90 DAS and at maturity were influenced significantly due to different biofertilizer treatments. At 30, 60, 90 DAS and at maturity, treatment T_5 (seed inoculation of *Rhizobium*+ PSB + KMB @ 25g each kg^{-1}+ 100% RDF (50:75:45 $N:P_2O_5:K_2O$) kg ha^{-1}(T_5) recorded statistically significantly superior leaf area 3.05, 22.63, 26.93 and 25.74 dm^2 than rest of the treatments except treatment T_6, respectively. The treatment T_6 (Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 75% RDF) has recorded the leaf area 2.89, 22.15, 26.41 and 25.21 dm^2 which was at par with the treatment T_5. The lowest leaf area was observed in Absolute Control (T_7).

Soybean plants that have a high leaf area, that affect the results of photosynthesis. This shows the response of soybean plants in utilizing additional N from *Rhizobium* to form chlorophyll explained that plants that were applied to *Rhizobium* isolates had a greener color than plants without *Rhizobium* isolates due to the presence of more N candles produced from N fixation by *Rhizobium* isolates (Herliana *et al.,* 2019), Singh *et al.* (2018) has been reported the similar results.

The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of leaf area at all stages of growth.

3. Leaf area Index

The leaf area index of soybean as influenced statistically significant due to different treatments is presented in Table 4. The leaf area index increased progressively upto 90 DAS. The mean leaf area index at 30, 60, 90 DAS and at maturity was 0.79, 6.09, 7.15 and 6.67, respectively. From the data it is revealed that, there was significant difference in leaf area index at all growth stages between two varieties. At 30, 60, 90 DAS and at maturity KDS-726 was found significantly superior leaf area index of 0.81, 6.28, 7.44 and 6.94 over KDS-753, respectively.

Table 3: Leaf area (LA) (dm^2 $plant^{-1}$) and Leaf area index (LAI) as influenced by different treatments in soybean

	Factors	Leaf area (LA) dm^2plant^{-1}				Leaf area index (LAI)			
		30 DAS	60 DAS	90 DAS	At Maturity	30 DAS	60 DAS	90 DAS	At Maturity
A.	Main plots: Variety (V)								
V_1	KDS-726	2.76	21.36	25.28	23.61	0.81	6.28	7.44	6.94
V_2	KDS-753	2.59	20.10	23.35	21.78	0.76	5.90	6.87	6.41
	S.E. (m) ±	0.02	0.09	0.29	0.28	0.01	0.02	0.09	0.08
	CD at 5%	0.11	0.54	1.78	1.73	0.03	0.14	0.52	0.51
B.	Sub plots: Treatments (T)								
T_1	Recommended Dose of fertilizer NPK	2.55	19.59	23.59	21.57	0.75	5.76	6.94	6.34
T_2	Seed inoculation of *Rhizobium* @ 25 g kg^{-1} + 100% RDF.	2.68	20.43	24.07	22.42	0.79	6.01	7.08	6.59
T_3	Seed inoculation of PSB @ 25 g kg^{-1} + 100% RDF.	2.65	20.36	23.97	22.38	0.78	5.99	7.04	6.57
T_4	Seed inoculation of KMB @ 25 g kg^{-1} + 100% RDF.	2.57	20.37	23.96	22.36	0.76	5.97	7.05	6.58
T_5	Seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1} + 100% RDF	3.05	22.63	26.93	25.74	0.90	6.65	7.92	7.57
T_6	Seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1} + 75% RDF	2.89	22.15	26.41	25.21	0.85	6.51	7.77	7.42
T_7	Absolute Control	2.33	19.56	21.24	19.15	0.68	5.71	6.25	5.63
	S.E. (m) ±	0.11	0.73	0.92	0.91	0.03	0.22	0.27	0.26
	CD at 5%	0.32	2.14	2.69	2.65	0.09	0.63	0.79	0.78
C.	Interaction (V x T)								
	S.E. (m) ±	0.16	1.04	1.30	1.28	0.05	0.30	0.38	0.36
	CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS
	General Mean	2.67	20.72	24.31	22.69	0.79	6.09	7.15	6.67

The KDS 726 had shown superior leaf area index due its higher leaf area, a greater number of branches and vigorous growth. Jadhav *et al.* (2021) observed that the variety KDS 726 has recorded the more vigorous growth as compare to variety KDS 753, so superior LAI recorded in KDS 726. The leaf area index at 30, 60, 90 DAS and at maturity were influenced significantly due to different biofertilizer treatments. At 30, 60, 90 DAS and at maturity, treatment T_5 (seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1}+ 100% RDF (50:75:45 $N:P_2O_5:K_2O$) kg ha^{-1} recorded significantly superior leaf area index 0.90, 6.65, 7.92 and 7.57, respectively than rest of the treatments except treatment T_6. At 30, 60, 90 DAS and at maturity, the treatment T_6 (seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 75% RDF) has recorded the leaf area index 0.85, 6.51, 7.77 and 7.42, respectively which was at par with treatment T_6. The lowest leaf area was observed in Absolute Control (T_7).

The significantly superior leaf area index observed in seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1}+ 100% RDF (50:75:45 $N:P_2O_5:K_2O$) kg ha^{-1} (T_5). It might be due to application of biofertilizers stimulated light interception by the crop which contributed towards the vegetative growth of crop plants leading to higher LAI values (Aduloju *et al.,* 2009). The combined effect of biofertilizer's and chemical fertilizers produced higher leaf area index (LAI) in soybean plants. There was synergistic effect of biofertilizers with each other leads to more nutrient availability to plants that leads to higher leaf area index (LAI) in soybean. Results are in agreement with Banerjee *et al.,* (2012). The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of leaf area index at all stages of growth.

4. Crop Growth Rate (CGR)

The crop growth rate of soybean as influenced significantly due to different treatments is presented in Table 3. The crop growth rate increased progressively upto 60 DAS. The mean crop growth rate at 30-60, 60-90 DAS and 90 DAS-at maturity was 1.04, 0.63, and 0.069 respectively. From the data it is revealed that, there was statistically significant difference of crop growth rate upto 60 DAS between two varieties. Between 30-60 and 60-90 DAS, KDS-726 has shown significantly higher crop growth rate 1.08 and 0.65 g cm^{-2} day^{-1} over KDS-753, respectively. The variety KDS 726 has produced more dry matter content as compare to other variety KDS 753, so the higher crop growth rate was showed by the variety KDS 726.

Due to biofertilizer treatments there was statistically significant differences in the crop growth rate of soybean upto 60 DAS. Between 30-60 DAS, the treatment T_5 (seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1}+100% RDF) had shown crop growth rate 1.19 g cm^{-2} day^{-1}, which was significantly superior than rest of treatments except treatment T_6. Between 30-60 DAS, Treatment T_6 had shown crop growth rate of 1.11g cm^{-2} of ground area day^{-1} which was at par with treatment T_5. The lowest crop growth rate was observed in treatment T_7 that was absolute control. After 60 DAS treatment T_6 had shown numerically higher crop growth rate than rest of treatments. Biofertilizers, which are living microorganisms that enhance soil fertility and promote plant growth, have been shown to positively influence the crop growth rate of soybean (Kumar *et al.,* 2020). It might be due to nitrogen fixation, nutrient mobilization and soil structure improvement by the application of bio fertilizers (Sharma *et al.,* 2021). Similar results were observed by (Ghosh *et al.,* 2020), (Bhardwaj *et al.,* 2014) and (Ramesh *et al,* 2019). Interaction was not observed between the varieties and biofertilizer treatments in respect of crop growth rate.

Table 4: Crop Growth Rate (CGR) (g cm^{-2} day^{-1}) and Absolute Growth Rate (AGR) (g $plant^{-1}$ day^{-1}) as influenced by different treatments in soybean

	Factors	Crop Growth Rate (CGR) (g $cm^{-2}day^{-1}$)			Absolute Growth Rate (AGR) (g $plant^{-1}$ day^{-1})		
		30-60 DAS	60-90 DAS	90-At Maturity	30-60 DAS	60-90 DAS	90-At Maturity
A.	Main plots: Variety (V)						
V_1	KDS-726	1.08	0.65	0.06	0.397	0.234	0.127
V_2	KDS-753	1.00	0.57	0.07	0.385	0.221	0.084
	S.E. (m) ±	0.01	0.01	0.01	0.004	0.005	0.021
	CD at 5%	0.07	0.04	NS	NS	NS	NS
B.	Sub plots: Treatments (T)						
T_1	Recommended Dose of fertilizer NPK	0.93	0.56	0.065	0.363	0.236	0.085
T_2	Seed inoculation of *Rhizobium* @ 25 g kg^{-1} + 100% RDF.	1.08	0.64	0.064	0.409	0.218	0.094
T_3	Seed inoculation of PSB @ 25 g kg^{-1} + 100% RDF.	1.04	0.59	0.056	0.393	0.211	0.089
T_4	Seed inoculation of KMB @ 25 g kg^{-1} + 100% RDF.	1.05	0.56	0.061	0.396	0.208	0.088
T_5	Seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1} + 100% RDF	1.19	0.69	0.075	0.440	0.239	0.099
T_6	Seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1} + 75% RDF	1.11	0.72	0.076	0.407	0.263	0.109
T_7	Absolute Control	0.88	0.52	0.060	0.332	0.217	0.078
	S.E. (m) ±	0.04	0.06	0.016	0.018	0.027	0.039
	CD at 5%	0.12	NS	NS	0.054	NS	NS
C.	Interaction (V x T)						
	S.E. (m) ±	0.06	0.09	0.02	0.026	0.038	0.006
	CD at 5%	NS	NS	NS	NS	NS	NS
	General Mean	1.04	0.63	0.069	0.396	0.228	0.10

5. Absolute Growth Rate (AGR) (g $plant^{-1}day^{-1}$)

The absolute growth rate of soybean as influenced significantly due to different treatments is presented in Table 3. The absolute growth rate increased progressively upto 60 DAS. The mean absolute growth rate at 30-60, 60-90 DAS and 90 DAS-at maturity was 0.396, 0.228 and 0.10 g $plant^{-1}day^{-1}$, respectively.

Between varieties, there was statistically non-significant difference in absolute growth rate of soybean. Biofertilizers play a significant role in enhancing the absolute growth rate of soybean (*Glycine max* L.) by improving various physiological and biochemical processes. There was statistically significant difference had seen in different treatments of biofertilizer. The treatment T_5 i.e. seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 100% RDF has shown statistically significant superior absolute growth rate of 0.440 g $plant^{-1}day^{-1}$ upto 60 DAS among the other treatments except traeatment T_6. Treatment T_6 i.e. Seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1}+ 75% RDF has absolute growth rate of 0.407 g $plant^{-1}day^{-1}$ which was at par with treatment T_5. After 60 DAS treatment T_6 i.e. seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1}+ 75% RDF had shown the numerically higher absolute growth rate of 0.263, 0.109 g $plant^{-1}day^{-1}$. The lowest absolute growth rate was observed in treatment T_7 i.e. absolute control. The results shown during the experiment might be due to effect of *mycorrhizal* biofertilizers which enhance the uptake of essential nutrients such as phosphorus and potassium, which are vital for root development, energy transfer, and photosynthesis. Improved nutrient uptake directly contributes to increased biomass and growth rates (Bhardwaj *et al.,* 2014). Similar results were obtained by Islam *et al.* (2017). The interaction effect between varieties and biofertilizer treatments were non-significant in respect of absolute growth rate.

6. Net Assimilation Rate (NAR) (g $dm^{-2}day^{-1}$)

The data revealed that there were statistically significant differences in the net assimilation rate of soybean influenced by different treatments. Between 30-60, 60-90 and 90-at maturity the mean values of net assimilation rate were 0.044, 0.0138 and 0.0095 g $dm^{-2}day^{-1}$, respectively. NAR presented in Table 4. The difference between net assimilation rate of KDS-726 and KDS-753 were found non-significant at all stages of growth. The net assimilation rate between 30-60, 60-90 DAS and 90 DAS-at maturity were influenced significantly due to different biofertilizer treatments. Between 30-60, 60-90 and 90-at maturity, treatment T_5 (seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1}+ 100% RDF (50:75:45 $N:P_2O_5:K_2O$) kg ha^{-1}) recorded the net assimilation rate of 0.048, 0.0171 and 0.0122 g dm^{-2} day^{-1}, respectively which was found statistically significantly superior than rest of the

Table 4: Net Assimilation Rate (NAR) (g dm^{-2} day^{-1}) as influenced by different treatments in soybean

	Factors	Net Assimilation Rate (NAR) (g cm^{-2} day^{-1})		
		30-60 DAS	60-90 DAS	90-At Maturity
A.	Main plots: Variety (V)			
V_1	KDS-726	0.044	0.014	0.0096
V_2	KDS-753	0.045	0.014	0.0106
	S.E. (m) ±	0.0004	0.0002	0.0003
	CD at 5%	NS	NS	NS
B.	Sub plots: Treatments (T)			
T_1	Recommended Dose of fertilizer NPK	0.043	0.0124	0.0094
T_2	Seed inoculation of *Rhizobium* @ 25 g kg^{-1} + 100% RDF.	0.046	0.0138	0.0100
T_3	Seed inoculation of PSB @ 25 g kg^{-1} + 100% RDF.	0.045	0.0137	0.0098
T_4	Seed inoculation of KMB @ 25 g kg^{-1} + 100% RDF.	0.042	0.0125	0.0096
T_5	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 100% RDF	0.048	0.0171	0.0122
T_6	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 75% RDF	0.047	0.0147	0.0109
T_7	Absolute Control	0.041	0.0122	0.0087
	S.E. (m) ±	0.0013	0.0009	0.0006
	CD at 5%	0.0037	0.0025	0.0017
C.	Interaction (V x T)			
	S.E. (m) ±	0.002	0.0012	0.0008
	CD at 5%	NS	NS	NS
	General Mean	0.044	0.0138	0.0095

treatments except treatment T_6. Between 30-60, 60-90 and 90 DAS-at maturity, treatment T_6 (seed inoculation of *Rhizobium* + PSB + KMB @ 25 g each kg^{-1}+ 75% RDF) recorded net assimilation rate of 0.047, 0.0147 and 0.0109 g dm^{-2} day^{-1}, respectively which was at par with treatment T_5. The lowest net assimilation rate was observed in Absolute Control (T_7). This might be happened due to nitrogen fixation, phosphate solubilization and potash mobilization which enhanced the nutrient availability to soybean plants. There might be synergistic effect of fertilizers and biofertilizers (Ravnskov *et al.,* 2019). Munda *et al.,* (2013) and Pote C. K. (2020) has been recorded the similar results. The interaction effect between varieties and biofertilizer treatments were non-significant in respect of net assimilation rate.

7. SPAD chlorophyll meter reading (SCMR)

The SCMR reading of soybean as influenced significantly due to different treatments is presented in Table 4.10. and graphically depicted in Fig 4.11. The SCMR increased progressively up to 90 DAS. The mean values of SCMR at 30, 60, 90 DAS and at maturity were 34.76, 43.82, 28.58 and 21.55, respectively. From the data it is revealed that, there was statistically non-significant difference in SCMR at all growth stages between two varieties. The SCMR at 30, 60, 90 DAS and at maturity were influenced significantly due to different biofertilizer treatments. The SCMR at 30, 60, 90 DAS and at maturity 40.01, 50.52, 32.84 and 24.95, respectively, were recorded statistically significantly superior in treatment T_5 (seed inoculation *Rhizobium*+ PSB + KMB @ 25g each kg^{-1}+ 100% RDF (50:75:45 N: P_2O_5: K_2O) kg ha^{-1}) than rest of the treatments except treatment T_6. At 30, 60, 90 DAS and at maturity treatment T_6 (seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 75% RDF) recorded the SCMR index of 39.12, 49.02, 31.86 and 23.85, respectively and it was at par with treatment T_5. The lowest chlorophyll content was observed in Absolute Control (T_7).

Table 5: SPAD chlorophyll meter reading (SCMR) as influenced by different treatments in soybean

Factors		SCMR values			
		30 DAS	60 DAS	90 DAS	At Maturity
A.	Main plots: Variety (V)				
V_1	KDS-726	35.39	44.38	28.84	21.63
V_2	KDS-753	34.14	43.27	28.32	21.46
	S.E. (m) ±	0.31	0.21	0.09	0.06
	CD at 5%	NS	NS	NS	NS
B.	Sub plots: Treatments (T)				
T_1	Recommended Dose of fertilizer NPK	30.97	39.65	25.77	19.33
T_2	Seed inoculation of *Rhizobium* @ 25gkg^{-1} + 100% RDF.	37.01	46.65	30.32	22.74
T_3	Seed inoculation of PSB @ 25 gkg^{-1} + 100% RDF.	32.38	40.82	26.53	19.90
T_4	Seed inoculation of KMB @ 25 gkg^{-1} + 100% RDF.	33.69	41.82	27.18	20.39
T_5	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 100% RDF	40.01	50.52	32.84	24.95
T_6	Seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 75% RDF	39.12	49.02	31.86	23.85
T_7	Absolute Control	30.17	38.29	25.56	19.67
	S.E. (m) ±	1.55	2.17	1.51	1.03
	CD at 5%	4.52	6.33	4.41	3.00
C.	Interaction (V x T)				
	S.E. (m) ±	2.19	3.07	2.14	1.45
	CD at 5%	NS	NS	NS	NS
	General Mean	34.76	43.82	28.58	21.55

Biofertilizers may enhance chlorophyll synthesis and retention by nutrient mobilization, particularly nitrogen fixation, which are crucial for chlorophyll synthesis, may contribute to the differences. Availability of nutrients can influence photosynthetic efficiency, leaf structure, and overall plant vigour. *Rhizobium* forms symbiotic relationships with soybean roots, fixing atmospheric nitrogen and making it available to the plant. Increased nitrogen levels enhance chlorophyll synthesis, leading to greener, more vigorous plants (Ghosh *et al.,* 2021). PSB solubilize phosphorus in the soil, making it more accessible to plants. Phosphorus is essential for energy transfer and chlorophyll synthesis, thus higher availability leads to increased chlorophyll production (Rai *et al.,* 2018). KMB help in the solubilization of potassium, an essential nutrient that plays a vital role in various physiological processes, including photosynthesis and chlorophyll formation. Adequate potassium levels enhance overall plant health and chlorophyll content (Ahlawat *et al.,* 2019). Similar results were obtained by Shete *et al.,* (2019) and Chauhan *et al.,* (2023). The interaction effect between different varieties and biofertilizer treatments were found non-significant in respect of chlorophyll content at all stages of growth.

CONCLUSION

- The variety KDS 726 had shown better performance in physiological parameters as compare to the variety KDS-753.
- Although treatment T_5 i.e., seed inoculation of *Rhizobium* + PSB + KMB @ 25g each kg^{-1} + 100% RDF brought significant improvement in physiological parameters whereas seed inoculation of *Rhizobium* + PSB + KMB @ 25gm each kg^{-1} + 75% RDF is also found at par with it.

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