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QUANTIFICATION OF PHYSIOLOGICAL TRAITS IN SOYBEAN (*Glycine max* (L.) MERRIL L.) UNDER DIFFERENT TILLAGE AND DRAINAGE METHODS

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ABSTRACT

A field experiment was conducted during Kharif season at the Research Farm, Department of Agronomy, JNKVV, Jabalpur (M.P) and treatments comprised of twelve tillage and drainage methods in soybean (genotype JS 97-52). The result shows that the treatment T_1 (Indian No till + open drainage channel + sub-soiler) recorded the maximum chlorophyll content index (24.49).Treatment T_{11} (Conventional tillage + ridge and furrow) recorded significantly highest photosynthetic rate (58.08 µmol/m^2/s^{-1}), carboxylation efficiency (0.05 µ/mol m^{-2}/s^{-1} (µmol/mol^{-1}), quantum efficiency (0.604) and mesophyll efficiency (676.476 µmol/mol^{-1} (mol/m^{-2}/s^{-1})$^{-1}$. T_{10} (Conventional tillage + Modified ridge and furrow system) recorded higher stomatal conductance (0.106 mol/m^2/s) is associated with the higher transpiration rate. Treatment T_{11} (Conventional tillage + ridge and furrow) possessed the highest canopy temperature (44.24) is negatively correlated with the transpiration rate (4.71 mmol/m^2/s). T_{12} (Conventional tillage + broad bed furrow) possessed significant more water use efficiency (3.13 µmol/mmol) indicated better CO_2 assimilation rate per unit of water transpired. The higher carboxylation efficiency indicates the better CO_2 fixation by the Rubisco enzyme, which clearly revealed influence of tillage and drainage methods on Physiological traits in soybean.

Key words : *Tillage, ridge and furrow, photosynthetic, carboxylation.*

The soybean (*Glycine max (L.)* Merrill) is a member of family leguminosae, sub-family papilionaceae. It is one of the most important protein and oilseed crops throughout the world. At present soybean ranks first among world in oilseed. Its oil is the largest component of the world's edible oil. It is native of China and was introduced to India in 1968, from USA. It has emerged very fast since early eighty's and occupied vital place in agriculture, edible oil economy, foreign exchange and upliftment of socio-economic status of soybean farmers. Soybean is rained crop of kharif season. In India soybean occupies an area of 120.327 lakh ha with an production of 122.345 lakh MT in the year 2013. Madhya Pradesh is the soybean bowl of India contributing 70 percent of country soybean production followed by Maharashtra, Rajasthan and Karnataka. Conventional tillage has been practiced for a long time and it is a common practice among small holder farmers (1).

Soybean seed contains 18-20 per cent oil, 40 per cent protein, 30 per cent carbohydrates, 4 per cent saponins and 5 per cent fiber. The seeds have highest protein as compared to other legumes some genotypes have as much as 50 per cent and its protein has a high nutritive value especially after it has been heated to inactive anti metabolites.

Proper tillage choices (including no-till planting) can enhance rapid, extensive root growth and improve water infiltration. No-tillage production of soybean is often less successful in poorly-drained soils, in part because of cooler and wetter soil conditions at planting. Tillage methods have varied effects, which on one hand conventional till though still widely practiced is being associated with increased soil erosion, loss of soil organic matter and destruction of soil structure (2). On the other hand no till is said to have beneficial effects on soil moisture storage, soil temperature and soil carbon (4, 5).

Development of the plant type to enhance photosynthetic efficiency is a major task of crop physiologists. Improving crop efficiency of solar energy utilization up to 3-5% of PAR would be a breakthrough in increasing productivity. The photosynthetic active radiation (PAR) was reduced significantly from full daylight at 1 m from the tree (*Juglansregia* L.) row and the diurnal variations of photosynthetic rate (Pn) of soybean (6). The distance of drainage furrow (DF) effect on growth of soybean and the photosynthetic rate decreased in the more extensive field by distance of DF at V5 (vegetative stage) and R^2 (mid flowering) stages (7). The photosynthesis is important parameter that determines the photosynthetic capability and status of a photo-synthetic organ and AQY reflects the potential photo-chemical activity of PSII (8).

Soil moisture stress is a primary limiting factor in crop production as it affects many physiological and biochemical processes of the plants (9). In no-tillage soybean the yield was reduced by 41-73% and water use efficiency by 36-73% (10). The permanent raised beds are effective in increasing water use efficiency and reducing compaction of the cropping zone (11). The effect of tillage and raised bed planting on yield, water use efficiency (WUE) and profitability. Soybean planted on

Table-1 : Quantification of physiological traits and mechanisms in different treatments.

Treatments	Chlorophyll content Index	Canopy Temp. (ºc)	Photosynthetic Rate (μ mol/m²/s)	Stomatal conductance (mol/ m²/s)	Transpiration Rate (mmol/m²/s)	WUE (μmol/ mmol)	Mesophyll Efficiency (μmol/mol /(mol/m²/s)	Quantum efficiency	Carboxylation efficiency (μmol/m²/s/ (μmol/ mol)
T_1	24.49	40.388	33.59	0.054	2.15	1.70	604.487	0.159	0.032
T_2	24.03	40.079	36.74	0.036	1.55	2.20	371.285	0.163	0.023
T_3	23.52	40.136	40.72	0.061	2.48	1.64	186.887	0.092	0.043
T_4	24.13	40.260	55.56	0.038	1.57	2.49	356.052	0.198	0.034
T_5	23.68	40.481	38.99	0.079	3.41	1.12	367.143	0.294	0.041
T_6	19.23	37.498	56.21	0.063	2.33	2.76	211.181	0.233	0.008
T_7	18.86	40.362	40.14	0.041	1.78	2.41	574.253	0.390	0.010
T_8	22.74	41.251	56.73	0.095	3.80	1.53	820.034	0.190	0.046
T_9	17.71	40.472	57.20	0.091	3.56	1.63	186.407	0.260	0.017
T_{10}	17.50	37.213	57.32	0.106	4.49	1.38	741.607	0.204	0.048
T_{11}	16.82	44.248	58.08	0.081	4.71	1.23	676.476	0.510	0.052
T_{12}	20.86	37.969	48.59	0.042	1.65	3.13	262.555	0.604	0.012
SEm±	1.598	2.8236	0.0087	0.0130	0.519	0.355	126.76	0.0822	0.008
CD at 5%	4.687	0.9627	0.0257	0.0382	1.524	1.043	371.78	0.2412	0.025

raised beds recorded about 17% and 23% higher WUE, respectively, than in flat layout (Hari *et al.,* 2013).Soybean genotypes planted in fields with different soil types and drainage systems respond differently for physiological traits and productivity.

Soybean needs good surface drainage. Field surface smoothing and forming can improve the surface drainage of a field. Drain furrows are commonly used to improve a field's surface drainage. Furrows are shallow and narrow and can be constructed with several different types of equipment's.Tillage and drainage methods may have a high impact on the morpho-physiological traits influencing productivity. Though a few physiological traits have been carried out to evaluate the performance of soybean under various tillage and drainage methods.

MATERIALS AND METHODS

The experiment was conducted at Research Farm, Department of Agronomy, J.N.K.V.V., Jabalpur (M.P.) during Kharif season. The experiment was lead out in a randomized block design (RBD) replicated thrice.

Pre sowing operations and sampling : The field was prepared by tilling the land with tractor drawn cultivator followed by two harrowing with disc harrow to develop fine tilth. The field was then finally levelled by using tractor operated leveller. Other operations performed as per recommended agricultural practices. Seed where sown by the seed drill in all treatments by different sowing methods. The sampling was done at 10 days interval after Flowering (DAF) till maturity. Five plants were randomly selected from each treatment per replication.

Physiological observations :

Chlorophyll content index : The hand held chlorophyll meter (CCM-200) was used for rapid and non-destructive estimation of chlorophyll in leaves. Chlorophyll content was measured in upper fully developed 3rd and 4th trifoliate leaf and expressed as SPAD unit (Soil Plant Analysis Development). Three measurements were taken per plant of each genotype. The results were than averaged, resulting in a single value to represent that genotype.

Gaseous observations with help of Infra-Red Gas Analyzer (IRGA) : The physiological observations were recorded on photosynthesis, transpiration, stomatal conductance, in soybean crop at pod filling stage by using IRGA as per method out lined by (LI 6400, USA).

Derivatives parameters : The water use efficiency, mesophyll efficiency and carboxylation efficiencies were determined as per specification of (12). The quantum use efficiency was also determined as per method outlined by (13).

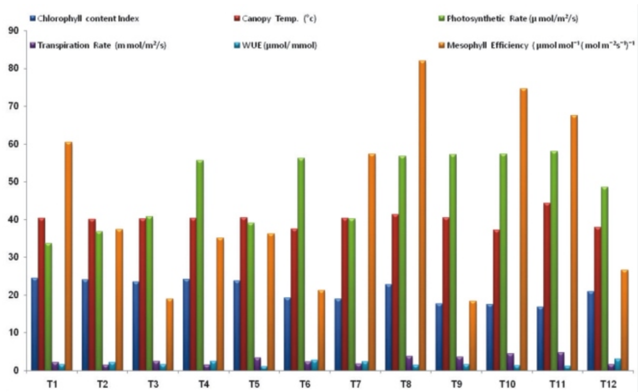

Fig.-1 : Quantification of physiological traits and mechanisms in various sowing systems.

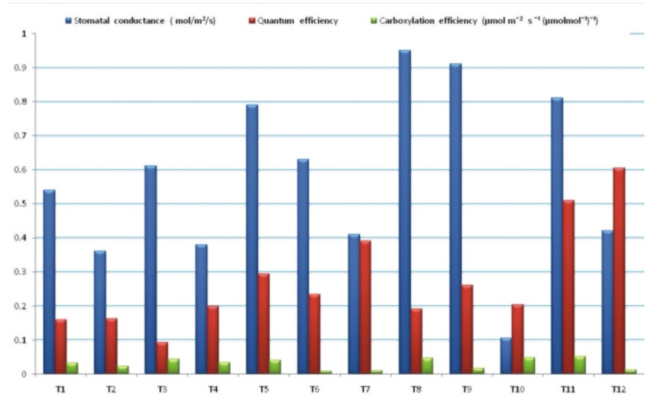

Fig.-2 : Quantification of physiological traits and mechanisms in various sowing systems.

Statistical analysis : Analysis of observations were taken on different variables was carried out to know the degree of variation among all the treatments. The data was statistically analyzed through completely randomized block design.

RESULTS AND DISCUSSION

Chlorophyll content index : The two cultivars (JS 95-60 and JS 97-52) showed more chlorophyll content. The supplemental UV-B radiation adversely affected Chlorophyll content and electron transport activity in PSII and consequently decreased the photosynthetic efficiency of soybean plants (14, 15).

Chlorophyll content index (Table-1, fig.-1) observed that the treatment T_1 (24.49), T_4 (24.13) and T_2 (24.03) recorded the higher chlorophyll content index. This may be result of Different Tillage and Drainage methods (Indian No till + open drainage channel + sub-soiler) might have a high impact on chlorophyll content index by influencing soil compaction, disrupt soil layers, root development, water infiltration, incorporate fertilizers, herbicides and plant residues facilitating the rapid and early nutrient uptake and enhancing magnitude of assimilatory surface area. T_{11} (16.82) recorded the minimum chlorophyll content index.

Canopy temperature (ºc) : The canopy temperature measurement with infrared thermometers has been an effective tool for semi-arid and arid conditions. The soybean temperature thresholds were based on the optimum canopy temperatures for peak photosynthetic enzyme activity, which were found to be 27ºC (15, 16).

The treatment T_{11} recorded (Table-1, Fig.-1) the significantly highest canopy temperature (44.24)over rest of the treatments. Though the treatment T_8 (41.25) possessed the higher magnitudes for canopy temperature. The higher canopy temperature is negatively correlated with the transpiration rate as the transpiration causes the cooling of canopy. The canopy temperatures have the greatest effect on yield. Temperatures above 35°C can inhibit pollen germination and pollen tube growth. Treatment T_{10} indicated the lowest (37.21) canopy temperature.

Photosynthetic rate (µmol/m^2/s) : The distance of drainage furrow (DF) effect on growth of soybean and the photosynthetic rate decreased in the more extensive field by distance of DF at V5 (vegetative stage) and R2 (mid flowering) stages (7). The two cultivars (JS 95-60 and JS 97-52) showed higher photosynthesis rate (17, 18).

The distance of drainage furrow (DF) effect on growth of soybean and the photosynthetic rate decreased in the more extensive field by distance of DF at V5 (vegetative stage) and R2 (mid flowering) stages. The two cultivars (JS 95-60 and JS 97-52) showed higher photosynthesis rate. The treatments T_{11} (58.08), T_{10} (57.32) and T_9 (57.20) exhibited the higher photosynthetic rates (Table-1, fig.-1) as compared to other treatments despite of quite lower LAI which may be attributed the higher per unit area photosynthates production in these treatments.

Stomatal conductance (mol/m^2/s) : The lower CO^2 concentration ci may result from reduced stomatal conductance, increased mesophyll conductance (18, 19). The two cultivars (JS 95-60 and JS 97-52) showed more stomatal conductance (16).

The treatments T_{10} (0.106), T_8 (0.095), T_9 (0.091), T_{11} (0.081) and T_5 (0.079) recorded the higher stomatal conductance (Table-1, fig.-2) though they did not differ significantly among them. The stomatal conductance is closely associated with opening and closing of stomata thereby affecting the CO_2 assimilation. T_2 (0.036) recorded the minimum.

Transpiration rate (m mol/m^2/s) : The photosynthetic active radiation (PAR) was reduced significantly from full daylight at 1 m from the tree (*Juglansregia* L.) row and the diurnal variations of transpiration rate (Tr) of soybean (1).

The treatments T_{11} (4.71), T_{10} (4.49), T_8 (3.80), T_9 (3.56) and T_5 (3.41) had the higher magnitudes for transpiration rates (Table-1, fig.-1) but they did not show any significant variation among them. Beneficial trait in areas with optimum supply of water. However, there are certain conditions under which the higher transpiration may leads to the wilting of the plant if the plant is unable to meet out its transpirational demands. T_2 (1.55) recorded the minimum.

Water use efficiency (µmol/mmol) : The effect of tillage and raised bed planting on yield, water use efficiency (WUE) and profitability. Soybean planted on raised beds recorded about 17% and 23% higher WUE, respectively, than in flat layout (15, 20, 21).

The treatment T_{12} (3.13) was at par with T_6 (2.76), T_4 (2.49), T_7 (2.41) and T_2 (2.20) but possessed significant more water use efficiency (Table-1, fig.-1) as compared with rest of the treatments. The higher WUE in treatmentConventional tillage + broad bed furrow, Japanese No till + open drainage channel + sub-soilerindicated better CO_2 assimilation rate per unit of water transpired which also depends upon canopy architecture and leaf orientation. The higher water use efficiency is a beneficial trait in drought prone areas. T_5 (1.12) had the minimum magnitude for this character.

Mesophyll efficiency (µmol/mol/(mol/m^2/s) : The mesophyll conductance (gm) limit photosynthesis significantly and consequently, apart from gm are also a physiological process that could affect leaf water use efficiency (WUE) (15, 20, 22).

The treatment T_8 (820.034) possessed the maximum mesophyll efficiency though did not vary significantly with T_{10} (741.607), T_{11} (676.476), T_1 (604.487) and T_7 (574.253). The higher mesophyll efficiency (Table 1, fig. 1) in treatment Indian No till + open drainage channel + sub-soiler and Conventional tillage + Modified ridge and furrow system indicates the better CO_2 use which is a desirable character for higher economic yields. T_9 noted the minimum.

Quantum efficiency : The content of total quantum yield (Phi) of soybean crop increased and light compensation point (LCP), light saturation point (LSP) decreased with increasing degree of shade (6). In the branching-flowering and pod-setting stages, maximum quantum yield of photosystem (PS) II photochemistry (Fv/Fm) decreased by 6.1% (P=0.001) and 3.0% (P=0.009), respectively. Supplemental UV-B radiation significantly decreased the effective quantum yield (Y) (14).

The quantum efficiency represents the efficiency of crop plants in converting solar energy absorbed by the plant to the chemical energy. The treatment T_{12} had the (Table-1, fig.-2) highest QUE (0.604) though was at par with T_{11} (0.510) and T_7 (0.390) but significantly superseded rest of the treatments. The higher quantum efficiency in treatments Conventional tillage + broad bed furrow + ridge and furrow represents better utilization of solar energy for converting it into chemical energy. The treatment T_3 (Conventional tillage + raised bed + open drainage channel) (0.092) was found to be associated with the minimum quantum efficiency.

Carboxylation efficiency (µmol/m^2/s/(µmol/mol) : The decreased leaf carbon isotope fractionation with increased Chl levels suggests an enhanced carboxylation capacity in these leaves (23).

The treatment T_{11} (0.05) though was at par with T_{10} (0.048), T_8 (0.046), T_3 (0.043), T_5 (0.041), T_4 (0.034) and T_1 (0.032) but possessed significant more carboxylation efficiency (Table 1, fig. 2) over rest of the treatments Conventional tillage + ridge and furrow + Modified ridge and furrow system indicating better utilization of intercellular CO_2 for converting it into photo-assimilates. The higher carboxylation efficiency indicates the better CO_2 fixation by the Rubisco enzyme. Treatment T_6 (0.008) recorded the minimum.

REFERENCES

1. Chen Y., Liu S., Li H., Li X.F., Song C.Y., Cruse R.M., Zhang, X.Y. (2011). Effects of conservation tillage on corn and soybean yield in the humid continental climate region of Northeast China. *Soil and Tillage Research, 115(116):* 56-61.
2. Ferreira M.C., Andrade D.S., Chueire L.M., Takemura S.M. and Hungria M. (2000). Tillage method and crop rotation effects on the population sizes and diversity of bradyrhizobian odulating soybean. *Soil Biology and Biochemistry, 32:* 627-637.
4. Gicheru P. Gachene C., Mbuvi J. and Mare E. (2004). Effects of soil management practices and tillage systems on surface soil water conservation and crust formation on a sandy loam in semi-arid Kenya. *Soil and Tillage Research, 75:* 173-184.
5. Landers J.N. (2008). Environmental impacts and social dimensions of zero tillage conservation agriculture in tropical Brazil. In: Goddard T., Zoebisch M.A., Gan Y.T, Ellis W., Watson A., Sombatpanit S., (eds) No-till farming systems. World Association of Soil and Water Conservation, Bangkok.
6. Bang P., Wang, XinJun, Zhang and ShuoXin (2011). Photosynthetic characteristics of soybean and mungbean in an agroforestry eco-system in the Loess area. [Chinese]. *Acta Botanica Boreali-Occidentalia Sinica 31(2) :* 363-369
7. Cho JW, Lee J.J., Oh Y.J., So J.D., Won J.Y. and Kim C.H. (2006). Soybean growth and yield as affected by spacing

of drainage furrows in paddy field. *Korean Journal of Crop Science, 51(1):* 26-31.

8. Zhang L.X. and Qiang H. (2010). Effects of enhanced atmospheric ammonia on photosynthetic characteristics of two maize (*Zea mays* L.) cultivars with various nitrogen supply across long-term growth period and their diurnal change patterns. *Photosynthetic, 48(3) :* 389-399.
9. Purcell L.C., Edwards J.T. and Brye K.R. (2007). Soybean yield and biomass responses to cumulative transpiration: Questioning widely held beliefs. *Field Crops Research, 101:* 10-18.
10. Zhu J.C., Gantzer C.J., Anderson S.H., Beuselinck P.R. and Alberts E.E. (1991). Water use evaluation of winter cover crops for no-till soybeans. *Journal of Soil and Water Conservation, 46(6):* 446-449.
11. Talukder A., Sufian M., Meisner C., Duxbury J., Lauren J. and Hossain A. (2002). Rice, wheat and mung bean yields in response to N levels and management under a bed planting system. *Proc 17th World Congress of Soil Sci.,* Bangkok Thailand *1:* 11-351.
12. Warrier C.S. and Vankataramanan K.S. (2010). Gas exchange characteristics in eucalyptus clones. *Indian Journal of Plant physiology, 15(3):* 226-233.
13. Pandey D.M.C., Goswami L. and Kumar B. (2001). Effect of plant growth Regulators on photosynthesis in cotton (*Gossypium hirsutum* L.) under water Logging. *Indian Journal Plant Physiology, 6:* 90-94.
14. Hu Z., Li H. Chen and Yang S. (2013). Chlorophyll content and photosystem-II efficiency in soybean exposed to supplemental ultraviolet-B radiation. *Photosynthetica. 51(1) :* 151-157.
15. Bhardwaj Ravi and Khali D.P. (2018). Effect of different phenol formaldehyde resin content level on properties of particle board from *Dendrocalamus strictus*. *Progressive Research-An International Journal, Vol. 13(3) :* 234-237.
16. Evett S.R., Howell T.A., Schneider A.D., Upchurch D.R. and Wanjura D.F. (2000). Automatic drip irrigation of corn and soybean. National irrigation symposium. *Proceedings of the 4th Decennial Symposium,* Phoenix, Arizona, USA, November. 14-16 pp : 401-408.
17. Kumar Vinod, Swaroop Narendra, David A. Arun and Thomas Terence (2018). Effect of normal and saline WATER irrigation on maize production in district Kannauj, Uttar Pradesh. *Progressive Research-An International Journal, Vol. 13(3) :* 225-228.
18. Vyas M.D. and Rupendra K. (2014). Effect of row spacing and seed rate on morphophysiological parameters, yield attributes and productivity of soybean (*Glycine max* L. Merrill) cultivars under rainfed condition of vindhyan plateau of Madhya Pradesh. *Soybean Research. 12(Special issue):* 82-91.
19. Earl H.J. (2002). Stomatal and non stomatal restrictions to carbon assimilation in soybean (*Glycine max*) Lines differing in water use efficiency. *Environmental and Experimental Botany, 48(3):* 237-246.
20. Kasana B.S., Dixit J.P. and Tomar R.K.S. (2018). Effect of sowing method, variety and weed management practices on yield attributes of pearl millet in gird zone of Madhya Pradesh. *Progressive Research-An International Journal, Vol. 13(3) :* 202-205.
21. Hari R., Yadvinder S., Saini K.S., Kler D.S. and Timsina J. (2013). Tillage and plantinh methods effects on yield, water use efficiency and profitability of soybean-wheat system on a loamy sand soli. *Experimental Agriculture.*1-19.
22. Tomas M., Medrano H., Brugnoli E., Escalona J.M., Martorell S., Pou A., Ribas-Carbo M. and Flexas J. (2014). Variability of mesophyll conductance in grapevine cultivars under water stress conditions in relation to leaf anatomy and water use efficiency. *Australian Journal of Grape and Wine Research, 20(2):* 272-280.
23. Soundararajan M. (2012). Relationship between leaf chlorophyll content and carbon Isotope discrimination in soybean. *International Proceedings of Chemical Biological and Environmental Engineering (IPCBEE), 31:* 22-27.

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