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EFFECT OF ORGANIC AND INORGANIC NUTRIENTS ON PHYSIOLOGICAL TRAITS OF SOYBEAN (*GLYCINE MAX* (L.) MERR)

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SUMMARY

An experiment was conducted to study the effect of organic and inorganic nutrients on physiological traits of soybean during *kharif* 2009. The results indicated that chlorophyll and carotenoids are positively influenced by organic manures, the same trend was found for oil and protein content in seeds. Further, the secondary metabolites like total phenols were also positively affected by organic manures in comparison to inorganic fertilisers. Lower oxidative stress in organic manures applied plants supported the beneficial effect of organic manures on the physiological processes of soybean. However, the inconclusive outcome for free aminoacids warrants further investigation. Nonetheless, the quality parameters like oil and protein contents in soybean were improved under organic manures regime.

***Key words*: Organic manures, oxidative stress, physiological traits, soybean, total phenols**

INTRODUCTION

Organic food is the bewitching word in the contemporary world. In the pollution-ridden environment, farm produces are being heavily contaminated with agri-chemicals (Benbrook and Baker, 2001). Over the last few decades, a rapid expansion of organic farming is palpable (Hansen *et al*. 2001) across the world. Consumers generally perceive organic foods to be healthier and safer for themselves and environment (Lockie *et al.* 2004). Some authors claim that organic food is no way superior to inorganically grown food (Dangour *et al.* 2009). However, the controversy over the nutritional quality of the organically grown crop is supported by substantive scientific evidence to take firm stand. It has been reported that organically produced plant foods are more health-promoting than conventional foods (Brandt and Molgaard 2001). The growing condition influences the phenols content in soybean (Kim *et al.* 2006). Organically grown soybean is known to contain higher level of phenolic metabolites in seeds (Hanan *et al.* 2008). Other crops grown organically are reported to contain more protein (wheat-Nitika *et al.* 2008), carotenoids (yellow plums - Lombardi-Boccia *et al.* 2004), total free amino acids (soybean - Stanley *et al.* 1978) and total polyphenols (strawberry and corn - Asami *et al*. 2003). Very few studies have been conducted in soybean on above aspects and limited information is available. Thus, the experiment was planned to investigate the differential response of organic and inorganic fertilization on chlorophyll, carotenoids, oil, total phenols, protein, free amino acids in soybean.

MATERIALS AND METHODS

A field experiment was conducted in the experimental fields of Division of Agronomy at Indian Agricultural Research Institute, New Delhi during *kharif* 2009 to analyse the influence of different organic and inorganic nutrients on physiological traits of soybean

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(*Glycine max* (L.) Merr). Seven treatments were laid down in Randomized Block Design (RBD) with three replications for each treatments. The area of each sub plot was of 8.1 m^2 (1.8 m x 4.5 m). The details of treatments are: T1 - No nutrients were supplied (control), T2 - Farm Yard Manure (FYM), T3 - Vermicompost (VC), T4 - *Rhizobium japonica* (RJ), T5 - FYM+VC+RJ, T6- 50% (FYM + VC + RJ) + 50% (Urea + Single super phosphate + muriate of potash), T7 - Urea + Single super phosphate + Muriate of potash. FYM and Vermicompost were procured from the Agronomy Division of IARI, while *Rhizobium japonica* was procured from Division of Microbiology, IARI, New Delhi. P_2O_5, the naturally available rock phosphate, was applied and obtained from the Rajasthan State Phosphate Mines Corporation, Udaipur, Rajasthan. The calculated quantity of each manure was applied as per the crop requirement. Chlorophyll content in the leaf sample was estimated using DMSO method (Hiscox and Isrealstam, 1979). The carotenoids content in the leaves was determined by procedure of Bajracharya (1999) using 80% acetone as extraction medium. Oil in seeds was determined by cold percolation method given by Kartha and Sethi (1957), total phenol content was measured by Singleton *et al.* (1999) method and protein content in seeds was determined spectrophotometrically as per Lowry *et al.* (1951). Free amino acid in seeds was estimated by Lee and Takahashi (1966) method. Oxidative stress was determined as described by Chaitanya and Naithani (1994). The experimental data for each parameter were subjected to statistical analysis by using the analysis of variance and their significance was tested by 'F=test' (Cochran and Cox 1967).

RESULTS AND DISCUSSION

Data on various physiological parameters in soybean grown under different nutrients (Table 1) revealed the positive effect of organic manures on the photosynthetic pigments in soybean. Highest increase in chlorophyll were observed under organic nutrients (T7 treatments). Similar results have been reported by Alam *et al.* (2009). The increased pigments may be due to more availability of macro and micronutrients through organic manures. Carotenoids are the important accessory photosynthetic pigments and a nonenzymatic antioxidant in plants (Husain *et al.* 1987, Edge *et al.* 1997). Carotenoids also varied significantly between organic and inorganic nutrients treated plants (Table 1). Hanan *et al.* (2008) reported increased isoflavanoids (carotenoids related compounds) and other antioxidants in organic manures applied soybean. This increased carotenoids content could be due to efficient functioning of metabolic system involved in carotenoids biosynthesis under the influence of liberal supply of micronutrients through organic manures compared to inorganic fertilisers. Soybean is unique in having considerable quantity of oil besides protein. The protein and oil content of soybean indicate

Table 1. Chlorophyll and carotenoid content in the leaves and oil content in soybean

Treatments	Chl (mg g^{-1} fw)	Chl b (mg g^{-1} fw)	Total Chl (mg g^{-1} fw)	Carotenoids (mg g^{-1} fw)	Oil (%)
T1	2.428	0.875	3.303	0.72	18.36
T2	2.658	0.890	3.548	0.71	19.10
T3	2.530	0.900	3.430	0.81	18.80
T4	2.649	0.940	3.589	0.79	19.48
T5	2.937	1.150	4.087	1.00	19.72
T6	2.680	0.990	3.670	1.058	19.91
T7	2.640	0.980	3.620	1.022	19.40
SEm ±	0.077	0.035	0.073	0.0301	0.16
CD @ 5%	0.237	0.107	0.226	0.0926	0.48

T1- No nutrients-control, T2- Farm Yard Manure (FYM), T3- Vermicompost (VC), T4- *Rhizobium japonica* (RJ), T5- FYM+VC+RJ, T6- 50% (FYM + VC + RJ) + 50% (Urea + Single super phosphate + muriate of potash), T7- Urea + Single super phosphate + Muriate of potash. fw = fresh weight

its seed quality parameter (Sarker *et al.* 2002). Thus, increase in protein and oil contents may be the way of increasing quality of soybean. The data in our study showed that there was an apparent increase in oil content of treated plants compare to control. Further, all the organic manures applied plants product higher oil in seeds compared to inorganic fertilizers. There was a significant increased oil content in Farm Yard Manure (FYM), *Rhizobium japonica* (RJ), FYM+VC+RJ and 50% (FYM + VC + RJ) + 50% (Urea + Single super phosphate + muriate of potash) over the Urea + Single super phosphate + Muriate of potash (Table 1). Similarly, increased oil in organic manures applied soybeans has been reported by Alam *et al.* (2009), Mekki and Ahmed (2005). The possible explanation for increased oil in organically grown soybean is that the organic manures may provide plants with essential nutrients elements required for oil biosynthesis.

Free amino acids (Table 2) were estimated in the mature pods and no clear pattern in data was obtained. Conventionally grown soybean pods contained highest free amino acids and in other treatments, no specific trend was noticed. Free amino acids in the cytoplasm result from breakdown/turnover of proteins during the specific metabolic process in cell. In soybeans, free amino acids were noticed significantly higher in the germinating beans (Stanley *et al.* 1978). Thus, we speculate that, to see the effect of organic nutrients on the free amino acids pool of soybean, the studies should include germination stage too. Phenolic compounds are the secondary metabolites with high antioxidative and antiaging properties (Chen and Ho 1997). The significantly lower total phenols in control (Table 2) indicates that supply of nutrients play role in determining phenolics content in soybean. Further, apparent higher phenols in 50% organic+50% inorganic (T_6) treatment beckons the positive effect of organic manure in enhancing the antioxidants level of soybean.

Soybean is known for its high protein content in seeds. There was apparent increase in the protein of organic manures treated and conventionally grown soybean seeds (especially farm yard manure (FYM) and 50% (FYM + VC + RJ) + 50% (Urea + Single super phosphate + muriate of potash (Table 2). Similar finding have been earlier reported by Mekki and Ahmed (2005). Further, the increased protein in the 100% organic treatment compared to inorganic treatment is in agreement with Saber *et al.* (1989), Schimidt *et al.* (2000). Possible cause of increased protein in the organic manures applied plants could be either due to increased nitrogen content in seeds or availability of essential nutrient required for protein synthesis. The oxidative stress is induced by the formation of reactive oxygen species (ROS) under various biotic and abiotic stresses in the plants. In our study, the highest oxidative stress in control (no nutrients) shows that nutrients deficient

Table 2. Free amino acids, total phenols, protein and oxidative stress level in the leaves of soybean

Treatments	Free amino acids (mg g^{-1} fw)	Total phenols (mg Ga Eq g^{-1} fw)	Protein (%)	Oxidative stress (Δ_{540} min^{-1} g^{-1} fw)
T1	1.09	6.61	37.4	0.3607
T2	1.00	11.12	38.4	0.2470
T3	1.18	9.90	38.3	0.2642
T4	0.76	12.75	38.5	0.2360
T5	1.03	14.19	40.2	0.2421
T6	0.84	15.55	40.4	0.2624
T7	1.84	15.30	38.9	0.2822
SEm ±	0.06	0.19	0.327	0.0122
CD @ 5%	0.190	0.58	1.009	0.0376

[b]TG: Tetra Guaicol formed, T1- No nutrients-control, T2- Farm Yard Manure (FYM), T3- Vermicompost (VC), T4- *Rhizobium japonica* (RJ), T5- FYM+VC+RJ, T6- 50% (FYM + VC + RJ) + 50% (Urea + Single super phosphate + muriate of potash), T7- Urea + Single super phosphate + Muriate of potash. fw = fresh weight

situation may deteriorate the plants health. Further, the decreased oxidative stress in farm yard manure (FYM), vermicompost (VC), *Rhizobium japonica* (RJ), FYM+VC+RJ, 50% (FYM + VC + RJ) + 50% (Urea + Single super phosphate + muriate of potash) and Urea + Single super phosphate + Muriate of potash indicated the beneficial influence of organic manures on the health status of plants. This decreased oxidative stress in organic manures applied plants may be because of any one of the two reasons. First, the enhanced antioxidants might have protected the cells from detrimental effect of any possible ROS. Second, the micronutrients furnished through the organic manures might have played role in improving the chemical and biochemical properties of cell to rid of any possible effect of ROS.

Findings of this study indicate that the application of organic manures to soybean has a positive effect on the plant health and on various physiological traits. It is now possible to give the physiological evidences to the increased yield of organically produced crops reported by many studies. As our results showed such increased yield could be due to increased photosynthetic pigments content and increase in secondary metabolites like total phenols and carotenoids. Further, our findings also throw light on the nutritional quality of organic soybean. Increased protein and oil content and reduced oxidative stress beckons the improved quality of organically grown soybean over the conventionally grown soybean. Thus, we conclude that application of organic manures have an added advantage in soybean cultivation when compared to application of inorganic chemical fertilisers.

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