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PHOTOSYNTHESIS AS INFLUENCED BY SOIL APPLICATION OF OXYGENATED PEPTONE IN ORGANICALLY GROWN BRINJAL (*SOLANUM MELONGENA* L. CV. AJAY)

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An experiment was conducted in P.G. Research Centre, Department of Botany, Tuljaram Chaturchand College, Baramati (M.S.) India to study the effect of soil application of oxygenated peptone on photosynthetic process in the leaves of brinjal (*Solanum melongena* L. cv. Ajay) grown using pot culture method under organic farming conditions. The leaf analysis of experimental plants exhibited an elevated level of relative water content, osmotic potential of cell sap and membrane stability. This was followed by increase in the level of photosynthetic pigments like chlorophyll a, chllorophyll b, total chlorophylls, carotenoids and xanthophylls along with higher level of chlorophyll stability index. The photosynthetic enzymes like dichlorophenol indophenol reductase (Hill Reaction), ribulose biphosphate carboxylase, phosphoenolpyruvate carboxylase and photorespiratory enzyme glycolate oxidase exhibited significant enhancement in enzyme activity. This was reflected in the elevated level of biochemical constituents like soluble proteins, total carbohydrates, polyphenols and proline. So, it is concluded that soil application of oxygenated peptone enhanced photosynthetic capabilities of brinjal under organic farming condition.

Keywords : Brinjal; Organic farming; Oxygenated peptone; Photosynthesis; Water relations.

Introduction

There is growing concern about the adverse effects of chemical fertilizers and synthetic agrochemicals on the pollution of soil, air and water. Such environmental pollution leads to health problems of human being and decrease in soil fertility and crop productivity. So policy makers are interested in promoting sustainable agriculture with organic farming to maintain the soil health which leads to crop health giving natural food (green food) promising better human health. Consumers have become health conscious and are ready to spend more money for natural food grown in organic way. In 2001, the total market value of certified organic products was $ 20 billion while it was US $ 23 billion in 2002 and US $ 33 billion in 2005. In 2006, it reached US $ 40 billion. In general, it is found that the increase in the demand for organic food is steady with annual average growth rate of 20-25%. The prices of organic food are in the tune of 1.5 to 5 times higher than the conventional food[1]. Unfortunately, the yield of organic farming system is low[2], so farmers hesitate to take organic farming for food crops.

Photosynthesis is the process of absorption of solar energy which fixes it in the form of primary metabolites. It monitors the plant growth. The level of photosynthetic pigments, rate of activity of carbon fixation enzymes and water relations of leaf precisely control the rate of photosynthesis. If the rate of photosynthesis is elevated, it definitely leads to enhancement in yield[3].

Plant body contains about 44% of oxygen[4]. Moreover, oxygen is also required for the synthesis of cytokinin and transport of auxin. Soil application of oxygenated peptone supplies oxygen and peptone to roots and soil microbes which is in tune with the theme of organic farming "Feed the soil and not the crop." Patil[5] showed that soil treatment with oxygenated peptone is useful to enhance vegetative and reproductive growth of plants. Patil *et al.*[6] further showed that such a treatment can be used in organic farming system. However, they have not studied the effect of soil application of oxygenated peptone on photosynthetic process which finally leads to yield. To fill this gap, it is intended to study the influence of soil application of oxygenated peptone on photosynthesis in the leaves of organically grown brinjal.

Material and Methods

The experiments were conducted at P. G. Research Center, Botany Department, Tuljaram Chaturchand College, Baramati, Dist. Pune during 2007-2009 using pot culture method. Seeds of brinjal *cv.* Ajay were sown on raised *e.g.* chlorophyll a (91.6%), chlorophyll b (60.0%), total chlorophylls (77.2%), carotenoids (44.4%) and xanthophylls (50.0%). The ratio of chlorophyll a to chlorophyll b was enhanced by 19.1% and chlorophyll stability index by 42.2%. The activity of photosynthetic enzymes is depicted in Fig. 1. The Hill Reaction enzyme DCPIP reductase, RuBP carboxylase and PEP carboxylase showed an increase of 30.7%, 46.6% and 50.0%, respectively. Concurrently, photorespiratory enzyme glycolate oxidase showed an enhancement of 37.5%.

Water is the important participant of photosynthesis. About 95% of water is lost by plant through transpiration and about only 5% of water is available to plant body to carry out metabolic processes. So 10.0% increase in RWC obtained under experimental condition is very significant. Increase in OP of cell sap is useful for osmotic adjustment which requires regulation of intracellular levels of several compounds collectively known as osmolytes[21]. Electrical conductivity of cell is the basis for studying membrane stability in terms of percent membrane injury. According to Sairam[22], decrease in percent membrane injury is correlated to higher RWC. In the present investigation, increase in RWC and OP has significant role in increasing membrane stability. The increase in biochemical constituents like soluble proteins, total carbohydrates, polyphenols and proline in the present experimental conditions suggests an enhanced level of metabolic activities indicating healthy condition of the plant.

Chlorophyll is the most important organic compound, enabling the green plant to fix solar energy in the form of chemical energy. Pigment content is a good index to meet an overall evaluation of any crop for its photosynthetic ability. The level of photosynthetic pigments, rate of activity of carbon fixation enzymes and water relations of leaf precisely control the rate of photosynthesis[23]. Chlorophylls act as functional pigments required for photosynthesis while carotenoids have two major functions as accessory light harvesting pigments and as photoprotective agents preventing photo-oxidation damage[24]. The first function allows the plant to utilize light over a wider spectral range while the second function is essential because without carotenoids, there would be no photosynthesis in presence of light. The chlorophylls and carotenoids should be arranged precisely in very close proximity to each other. In deed, both pigments are attached to the same protein forming a complex called as photosynthin[25]. In present investigation, total chlorophylls show 77.2% increase while carotenoids and xanthophylls show 44.4% and 50.0% increase respectively. This

seed beds. The watering was done by using water can as per need. The clay pots were filled with soil and vermicompost (9 kg : 1 kg). 21 days old seedlings of brinjal were transplanted in fifty pots (1 seedling / pot) and watered daily. Twenty five pots were kept as treated and twenty five pots were kept as control. In treated pots 2 g oxygenated peptone containing oxygen (100 mg/g), peptone (650 mg/g) and silicate based inert filler compound (250 mg/g) was applied at the depth of 10 cm and buried. All necessary intercultural operations like weeding and pest control were performed as and when required. No chemical fertilizers and pesticides were used. Leaf analysis was done 60 DAS. All the experiments were done in five replicates and are expressed as mean ± S.D. Statistical comparisons were made by means of student's t-test and $p < 0.05$ is considered as significant.

Relative Water Content (RWC) and Osmotic potential of cell sap (OP) were determined by using the method described by Hsiao[7] and Janardhan *et al.*[8], respectively. Membrane stability in terms of percent membrane injury was determined by the method of Premchandra *et al.*[9]. The soluble proteins, total carbohydrates, polyphenols and proline content were estimated by using the method described by Lowry *et al.*[10], Sadasivam and Manickam[11], Malick and Singh[12] and Bates *et al.*[13], respectively. Chlorophylls were estimated by using the method described by Arnon[14]. Chlorophyll stability index, carotenoids and xanthophyll content were estimated by using the method described by Henkel[15], Jensen[16] and Neogy *et al.*[17], respectively. The Hill reaction was studied as the light dependent evolution of oxygen by isolated chloroplasts using DCPIP reduction technique[18]. The activity of an enzyme Ribulose Biphosphate Carboxylase (RuBPC) and Phosphoenol Pyruvate Carboxylase (PEPC) were measured as per the method described by Kluge and Osmond[19]. The activity of an enzyme glycolate oxidase was measured using the method described by Hess and Tolbert[20].

Results and Discussion

Effect of soil application of oxygenated peptone on water relations and biochemical constituents in the leaves of brinjal are presented in Table 1. RWC increased by 10.0% and OP of cell sap by 11.7% while membrane injury decreased by 27.2% under experimental conditions. Soluble proteins showed 33.3% increase while total carbohydrates showed 28.5% increase. Polyphenols and proline showed increase by 42.8% and 31.1%, respectively. Table - 2 exhibits the effect of soil application on photosynthetic pigments in the leaf of brinjal. The overall picture showed an increase in the pigment content

Table 1. Effect of soil application of oxygenated peptone on water relations and biochemical constituents in leaf of brinjal (*Solanum melongena* L. *cv.* Ajay) at 60th DAS.

Parameter	Control	Treated	Increase (%)
Relative Water content (RWC) (%)	50.0 ± 0.50	55.0* ± 0.54	10.0
Osmotic potential of cell sap (OP) (- bar)	-3.82 0.04	-3.37* ± 0.02	11.7
Membrane injury (%)	11.0 ± 0.10	8.0* ± 0.05	- 27.2
Soluble proteins (g 100^{-1}g fresh wt.)	9.6 ± 0.50	12.8* ± 0.60	33.3
Total carbohydrates (g 100^{-1}g fresh wt.)	14.0 ± 1.0	18.0* ± 1.2	28.5
Polyphenols (g 100^{-1}g fresh wt.)	1.40 ± 0.10	2.0* ± 0.14	42.8
Proline (g 100^{-1}g dry wt.)	0.45 ± 0.04	0.59* ± 0.06	31.1

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' represents significance at $p < 0.05$.

Table 2. Effect of soil application of oxygenated peptone on photosynthetic pigments in leaf of brinjal *(Solanum melongena* L. cv. Ajay) at 60th DAS.

Parameter	Control	Treated	Increase (%)
Chlorophyll a (mg / 100 g fresh wt.)	120.0 ± 0.50	230.0** ± 0.52	91.6
Chlorophyll b (mg / 100 g fresh wt.)	100.0 ± 0.12	160.0** ± 0.67	60.0
chl. a / chl. b	1.20	1.43	19.1
Total chlorophylls (mg / 100 g fresh wt.)	220.0 ± 1.4	390.0** ± 1.8	77.2
Chlorophyll Stability Index (CSI)	0.45 ± 0.01	0.64* ± 0.05	42.2
Carotenoids (mg / 100 g fresh wt.)	72.0 ± 0.18	104.0* ± 0.20	44.4
Xanthophylls (mg / 100 g fresh wt.)	64.0 ± 0.12	96.0* ± 0.15	50.0

Data are mean values (n=5) followed by ± standard deviation. Statistical comparisons are made by means of Student's 't' test and $p < 0.05$ is considered as significant. '*' and '**' represent significance at $p < 0.05$ and $p < 0.01$, respectively.

indicates that the chlorophylls are well protected under experimental conditions so that there is less degradation of chlorophylls by photo-oxidation. This is the reason why there is increase in chlorophyll stability index.

Under experimental condition, there is increase in the rate of Hill Reaction, as evidenced by increase in DCPIP reduction. In addition, the activity of photosynthetic enzymes RuBPC and PEPC also increases. Nichiporovich *et al.*[26] stated that during photosynthesis, not only carbohydrates but proteins and amino acids are being synthesized. So in addition to water and CO_2, simple nitrogenous compounds must be included among the substrates needed for photosynthesis. In the present experimental condition, the increased photosynthetic rate, as evidenced by higher rate of photosynthetic enzyme activity and synthesis of soluble proteins, total carbohydrates, polyphenols and proline may be due to availability of soluble nitrogen in the form of peptone as a result of soil application of oxygenated peptone. As such, nitrogen is important in photosynthesis as indicated by higher nitrogen content in the chloroplast[27]. Brinjal, being a C_3 plant, shows higher level of RuBPC than that of PEPC, which is apparent in present investigation. As a matter of fact, the percent increase in the activity of both the enzymes is more or less similar (46.6% and 50.0%).

The activity of RuBPC is regulated by cellular water level. In the present investigation, relative water content increases under experimental condition which may

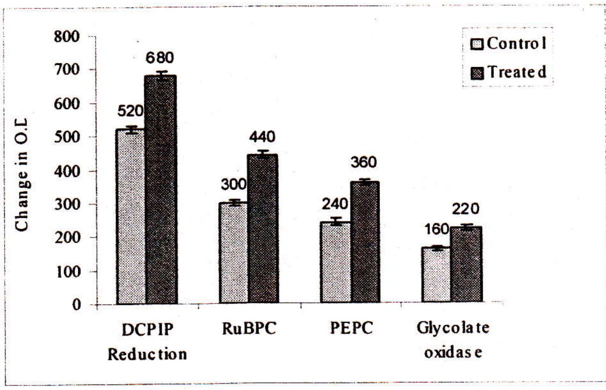

Fig.1. Effect of soil application of oxygenated peptone on activity of enzymes of photosynthesis and photorespiration in leaf of brinjal (*Solanum melongena* L. cv. Ajay) at 60th DAS.
Values are mean of five determinations and the error bars represent standard deviation.

be one of the factor enhancing the activity of RuBPC. RuBISCO initiates photosynthetic carbon metabolism by determining the rate at which CO_2 is incorporated into sugar phosphate through carboxylation of RuBP. A co-ordinate regulation of RuBP utilization in carboxylation / oxygenation, light absorption and use of captured energy for RuBP regeneration are essential for effective photosynthesis in dynamic natural environments[28]. Gimenez *et al.*[29] found that large RuBP pool size with faster rate of RuBP synthesis or the ability to maintain large concentration of RuBP are major factors which support greater CO_2 assimilation. This view is further supported by Karadge and Thombare[30], who studied photosynthesis in *Aptenia cordifolia* and indicated that high rate of $^{14}CO_2$ assimilation, could be contributed to high level of carboxylating enzymes in C_3 plants where RuBP is dominant.

Photorespiration is a group of processes by which C_3 plants release CO_2 in presence of light at the cost of photosynthesis[31]. The activity of glycolate oxidase serves as an index of rate of photorespiration. In the present investigation, the activity of photorespiratary enzyme Glycolate oxidase was much lower as compared to that of RuBPC and PEPC (160, 300 and 240, respectively) in control plants while the treated plants show the activity to the tune of 220, 440 and 360, respectively. According to Garrete[32], low photorespiration is the key to better crop as it tends to have more availability of RuBP for carboxylation rather than for oxygenation. However, Lorimer *et al.*[33] argued that the photorespiration is not an essential process but it functions as safety valve against photo-oxidative destruction of chloroplasts by photorespiratary consumption of toxic oxidants. An alternative mechanism is available to plant cells that enable toxic oxidants to be degraded without the wasteful photorespiration process in the form of carotenoids that protect chlorophylls from photo-oxidation. The increase in chlorophylls, CSI and carotenoids found in the present experimental condition is noteworthy in this respect.

Thus, the overall picture shows that the soil application of oxygenated peptone increases the level of RWC and OP and reduces membrane injury in leaf of eggplant. It increases the pigment content (chlorophylls, carotenoids, xanthophylls and chlorophyll stability index) as well as activity of photosynthetic enzymes (RuBPC and PEPC) and photorespiration enzyme (Glycolate oxidase). All this leads to enhancement in the level of biochemical constituents like soluble proteins, total carbohydrates, polyphenols and proline which are related to yield.

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