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SHORT COMMUNICATION

INFLUENCE OF OIL PALM SHADE ON THE PHYSIOLOGY OF GALANGA

P.C. JESSYKUTTY*, B.K.JAYACHANDRAN AND BALAKRISHNAN ASAN

Kerala Agricultural University, College of Agriculture, Vellayani, Thiruvananthapuram-695522, Kerala

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A study on the influence of different oil palm shade conditions on growth and physiology of galanga (*Kaempferia galanga* L.), grown as an intercrop, showed that it could perform well under shade. The highest PAR was recorded in plants under open condition and the values decreased with increasing shade levels. Specific leaf weight, leaf water potential and stomatal conductance decreased with shade while there was an increase in chlorophyll content. Dry matter production was significantly higher in the intercropped plants. The highest yield was under young palms closely followed by medium and mature palms. Volatile oil content was the highest under young palms while oleoresin, under open condition. The results clearly depict the adaptability of galanga under different oil palm shade conditions.

Key words **: Dry matter production, galanga, PAR, SLW, stomatal conductance, volatile oil**

Galanga also known as galangal (*Kaempferia galanga* L.) is a highly priced medicinal and aromatic plant indigenous to tropical Asia. The aromatic rhizomes are considered stimulatory, diuretic, stomachic, carminative and expectorant (Panicker *et al.* 1926). The rhizomes contain about 2.5 to 4 per cent essential oil which finds use in perfumery, folk medicine and curry flavorings. *Kaempferia* forms a component of over 59 ayurvedic medicines. Galanga is cultivated as a medicinal and aromatic herb, in the states of Kerala, Karnataka, Tamilnadu and West Bengal under coconut to a very small extent (Sivaraman *et al*. 2002). Various studies conducted in Kerala revealed the suitability of galanga as an intercrop in coconut and rubber plantations (Anonymous 1989, Nair *et al*. 1991). Experiments conducted to study the feasibility of intercropping medicinal plants in oil palm plantations showed that galanga is a profitable intercrop in oil palm plantations of different age groups (Jessykutty 2003). Knowledge of physiological adaptations and growth requirements is important in the successful cultivation and sustained utilization of shade plants (Middleton *et al*. 2001). In the present paper the physiological basis of shade tolerance in galanga grown as an intercrop in oil palm plantations is analysed.

Field experiments were conducted in the Kulathupuzha oil palm estate of Oil Palm India Limited, Kerala, during the period from May 2002 to December 2002. The experiment was laid out in randomized block design and the treatments consisted of four shade situations, i.e. in the inter rows of oil palms of age groups below five years (young), between five and eleven years (medium), above eleven years (mature) and in the adjacent open area. Uniform seedlings of galanga produced by sprouting rhizome bits in polythene bags were planted in raised beds of 5.5 m length and 1.2 m width taken in the oil palm inter rows leaving 2.5 m from the base of the palms. Only organic manures were applied to the plants. The crop was raised under rain fed condition however; life saving irrigation was given during the drought periods. Random sampling was done at full vegetative growth (120 days after planting) and a total of twenty plants were harvested from each treatment and

* Corresponding author, E-mail: pcj@india.com

observations on morphological parameters like number of tillers, leaves, leaf area and fresh weight of different plant parts were recorded from these plants. Physiological parameters such as leaf area index and specific leaf weight were computed from these observations. For computing the dry matter content, the uprooted plants were separated into leaves, rhizomes and roots and dried to constant weight at 70-80^{o}C in a hot air oven and expressed as g plant^{-1}. Spectrophotometric method as described by Starnes and Hadley (1965) was used to estimate the chlorophyll content of fresh leaves. Leaves were selected at random from each treatment and stomatal conductance and photosynthetically active radiation were measured during the mid day hours using AP4 porometer (Delta - T type), average worked out and recorded. Water potential of fresh leaf tissue was estimated using Chardakov's falling drop method. From 1 molal stock solution of sucrose, known volumes of solutions of different dilutions were prepared and 10 ml each of these solutions were transferred to test tube sets of two each and labelled. In one set of test tubes leaf tissues were put to which methylene blue was also added. After 20 minutes, using a micropipette a drop each of the solutions was transferred to the corresponding solutions in the other set of tubes. Based on the movement of the droplet, the water potential of the tissue was calculated using the formula, $\Psi = - nRT$ where, n is the molality at constant temperature and pressure and expressed in Mpa. The crop was harvested seven months after planting and the rhizome weight of three plants from each treatment per replication after sun drying was recorded, average worked out and expressed as yield plant^{-1}. The volatile oil and oleoresin content of the rhizome was estimated by Clevenger distillation method and Soxhlet extraction method (AOAC 1975) respectively and expressed as percentage (v/w) on dry weight basis.

Preliminary analysis of the shade condition in the plantation had revealed that young palms allowed more sun light penetration compared to medium and mature palms (Sarada 2000). In general, lower PAR values were recorded by the galanga plants under all conditions. The highest PAR was recorded in plants grown under open condition and the values decreased with increasing shade levels with the lowest value under medium oil palm canopy (Table 1). The amount of light penetrating through the canopy is affected by the LAI and the pattern of leaf display. The upper leaves receive both direct and diffuse radiation, while the leaves lower in the canopy receive a smaller portion of direct radiation (Gardner *et al*.1988). In galanga plants there is no pseudo stem and the leaves are arranged spirally in a rosette close to the ground. The overlapping leaves might have caused mutual shading resulting in lower PAR values under all shade situations. The average percentage of incoming radiation incident on the pasture in a 5.5 year old oil palm plantation comes to around 47 per cent (Chen and Bong 1983). In the present study, light interception in the young palms (below five years) was recorded to be around 36 per cent of the PAR measured in the open. Since the canopies of the palm were not closed, there was moderate light transmission. In the medium and mature oil palm plantation, the light transmission was less (only 26 and 28 per cent of the open respectively) because the canopy was closed. In the mature plantation, even though the leaf orientation was slightly changed, poor light transmission was observed because the leaves were still closed and the trees were not very high.

Galanga plants grown under young oil palms produced highest number of tillers followed by those under open condition which in turn was on par with that under medium palms and the lowest tiller number was noticed under mature palms (Table 1). No significant difference in leaf area index was noticed under different shade conditions and open (Table 1). Same trend was noticed in the number of leaves and total leaf area of the plants. Plants belonging to zingiberaceae family are generally shade loving. Galanga being a zingiberaceous crop exhibited better vegetative growth under different shade conditions. Bai (1981) also reported that leaf area index was not influenced by shade intensities in ginger, turmeric and coleus. Specific leaf weight however, decreased with shade and the highest SLW was recorded under open condition (Table 1). Leaves in shady environment typically have lower SLW than leaves grown in sunny conditions. Low SLW represents a complement of leaf characteristics including decreased leaf thickness, decreased palisade cell development, lower photosynthesizing cells per unit leaf area, decreased assimilatory apparatus per unit area, lower light saturation

Table 1. Effect of oil palm shade conditions on morphological and physiological parameters of galanga

Parameter	Shade condition				
	open	under young palms	under medium palms	under mature palms	CD at 5%p
PAR (µmol $m^{-2}s^{-1}$)	625.44	223.89	164.00	274.67	15.252
No. of tillers ($plant^{-1}$)	8.33	11.44	8.22	6.56	1.208
No. of leaves ($plant^{-1}$)	9.11	10.67	10.56	10.67	NS
Total leaf area (cm^2 $plant^{-1}$)	89.87	109.48	111.77	115.41	NS
Leaf area index	0.30	0.37	0.37	0.39	NS
Specific leaf weight (g cm^{-2})	0.03	0.02	0.02	0.02	0.003
Chlorophyll b (mg g^{-1})	0.04	0.06	0.06	0.04	0.011
Total chlorophyll (mg g^{-1})	0.06	0.12	0.21	0.07	0.008
Water potential (-M pa)	0.10	0.16	0.23	0.20	0.015
Stomatal conductance (mol $m^{-2}s^{-1}$)	0.10	0.07	0.02	0.04	0.006
Dry matter content of leaves (g $plant^{-1}$)	1.79	1.78	1.84	1.88	NS
Dry matter content of roots (g $plant^{-1}$)	0.58	1.86	1.05	0.77	0.120
Dry matter content of rhizome (g $plant^{-1}$)	11.84	15.63	10.99	13.21	1.316

point and/ or decreased respiration rate (Boardman 1977). Ajithkumar (1999) reported higher SLW under open and low shade levels in ginger. SLW is a good indicator of photosynthetic efficiency, growth of plant and of relative ability to adapt to shade (Neerakkal *et al*. 2003).

One of the major effects of shade on shade adapted plant is the increase in concentration of chlorophyll pigments in leaves. In the present study, there was increase in chlorophyll b and total chlorophyll which was directly proportional to the degree of shade (Table 1). This is in conformity with the report of Sondergaard and Bonde (1988) that chlorophyll b can harvest light prevailing in shaded habitats more efficiently than chlorophyll a. Higher content of chlorophyll a, b and total chlorophyll in galanga under shade has been reported earlier (Anonymous1999). Leaf water potential decreased with shade and the lowest water potential was recorded under medium oil palm canopy where the shade level was the highest (Table 1). This is because evaporation will be greatly reduced in the shaded environment; at the same time soil water availability for the intercrop will be maintained at a higher level compared to open, through the combined effect of less evaporation from the soil and lower transpiration from the intercrop (Wilson and Wild 1991). Xiang *et al*. (2000) have reported increased relative water content and chlorophyll content of leaves with increasing shade intensity in ginkgo. In *Encelia farinosa*, dark respiration decreased with decreasing leaf water potential in sun plants, but remained unchanged in shade plants (HeHui *et al*. 1995).

Table 2. Effect of oil palm shade conditions on yield, volatile oil and oleoresin content of galanga

Parameter	Shade condition				
	open	under young palms	under medium palms	under mature palms	CD at 5%p
Yield (g $plant^{-1}$)	14.77	17.10	15.42	15.63	NS
Volatile oil content of rhizome (%)	1.58	1.91	1.48	1.11	0.134
Oleoresin content of rhizome (%)	4.66	4.53	4.41	4.35	0.136

Stomatal conductance was found to be the highest under open condition and the lowest under medium oil palm canopy (Table 1). Stomatal conductance was reduced under shading due to lower availability of PAR. Usually stomatal conductance is inversely related to light level. Studies conducted in Sri Lanka to examine the variation of leaf stomatal conductance and leaf water potential in selected forest trees under varying levels of shade, revealed that there was a positive relationship between leaf water potential and stomatal conductance under open, medium and full shade. However, the relationship was the strongest under open condition and become weaker with increasing shade. Under full shade, variation in stomatal conductance was brought about by leaf temperature and light intensity (Costa *et al*. 2000). Absolute biomass gain and relative growth rate (RGR) had significant positive correlation with water potential and stomatal conductance and leaf chlorophyll content. Multiple regression analysis identified leaf water potential and stomatal conductance as the factors, which contributed the most to the observed variation of absolute biomass gain and RGR (Costa and Rozana 2000).

No significant difference in the dry matter content of leaves was noticed under different shade conditions. However, dry matter production of roots and rhizome were significantly higher in the intercropped plants (Table 1).This showed that the photosynthetic efficiency of the plants were more under the oil palm shade conditions and the plants efficiently partitioned the assimilates to the storage organs. Total dry matter production was the highest under the partial shade of young oil palm canopy, because the plants produced higher number of leaves and tillers under this shade level (Table 1). Increased leaf area per plant enhances the total photosynthetic out put per plant, which in turn caused increased dry matter production under low irradiance.

Statistically no significant difference in the per plant yield of rhizome was noticed under the four shade situations. However, the highest yield was for plants grown under young palms closely followed by medium and mature palms and the lowest yield was under open condition (Table 2). This clearly indicated that galanga plants were much adapted to the shade conditions provided by the oil palm canopies and hence can be recommended as a suitable intercrop in oil palm plantations. Better performance of galanga under the deep shade of rubber and coconut has been reported earlier (Anonymous 1989, Nair *et al*. 1991). Higher volatile oil content of galanga rhizomes was recorded under the partial shade of young oil palm canopy. However, at higher shade intensity the oil content decreased and was equal to that under open condition (Table 2). Maheswarappa *et al.* (1998) also reported higher volatile oil content of intercropped galanga in coconut plantations. Kurian *et al*. (2000) observed slightly lower oil content for galanga intercrop compared to pure crop. Oleoresin content was the highest under open condition, which was on par with that under young oil palm canopy (Table 2). This is in conformity with the findings of Kurian *et al.* (2000) who reported slightly higher oleoresin content in galanga pure crop compared to intercrop.

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