

避雨棚膜 Coverlys TF150[®]对葡萄植株 生长发育及光合特性的影响

李中瀚¹, 刘明慧¹, 唐美玲², 郑秋玲², 徐鲁成¹, 高振¹, 杜远鹏¹

(¹山东农业大学园艺科学与工程学院·作物生物学国家重点实验室·山东果蔬优质高效生产协同创新中心,
山东泰安 271018; ²山东省烟台市农业科学研究院, 山东烟台 265500)

摘要:【目的】探究避雨棚膜 Coverlys TF150[®]对葡萄植株生长发育及光合特性的影响。【方法】以1年生巨峰和赤霞珠葡萄盆栽自根苗为试材, 在盆栽苗上方设置 Coverlys TF150[®]和PO膜材料避雨棚。【结果】与PO膜相比, Coverlys TF150[®]降低了光照度, 透射率比PO膜低8.82%, 降低了08:00和16:00赤霞珠和巨峰叶片最大光化学效率(F_v/F_m)和光合能力, 缓解了强光胁迫对葡萄造成的伤害, 10:00—14:00 Coverlys TF150[®]下赤霞珠和巨峰叶片 F_v/F_m 降幅较小, 增加了叶绿素吸收的光能用于光化学反应的比例, 有利于电子传递的进行; 显著提高了10:00—14:00赤霞珠和巨峰叶片净光合速率(P_n), 缓解了“光合午休”, 净光合速率日变化面积分别比PO膜高13.80%和14.39%, 胞间二氧化碳浓度(C_i)、气孔导度(G_s)以及蒸腾速率(T)均有一定程度的提升; Coverlys TF150[®]显著提高了赤霞珠和巨峰叶片质量、面积和叶绿素含量及植株生物量, 促进了新梢生长, 提高了根冠比与枝条可溶性糖含量、淀粉含量。【结论】Coverlys TF150[®]较PO膜提高了葡萄叶片光合能力, 减轻了“光合午休”, 有利于葡萄植株生长发育, 促进了枝条贮藏营养的积累。

关键词:葡萄; 避雨棚膜; 光合作用; 叶绿素荧光; 生物量; 生长发育

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Effects of Coverlys TF150[®] on the growth and photosynthetic characteristics of grape plants

LI Zhonghan¹, LIU Minghui¹, TANG Meiling², ZHENG Qiuling², XU Lucheng¹, GAO Zhen¹, DU Yuanpeng¹

(¹College of Horticulture Science and Engineering, Shandong Agricultural University/State Key Laboratory of Crop Biology/Collaborative Innovation Center of Fruit & Vegetable Quality and Efficient Production in Shandong, Tai'an 271018, Shandong, China; ²Yantai Academy of Agricultural Sciences, Yantai 265500, Shandong, China)

Abstract:【Objective】China has a marked continental monsoonal climate. The rainfall and heat appear during the same season. So fungal vine diseases caused by high rainfall are important concerns in China. Rain-shelter cultivation is a common kind of canopy management to reduce disease, and has been widely used in many places in China so far. In this article, the effects of the shelter film Coverlys TF150[®] on the growth and photosynthetic characteristics of grape plants were studied.【Methods】One year old potted Kyoho and Cabernet Sauvignon grape nursery trees were put under the Rain shelter covered with PO film and Coverlys TF150[®], the rain shelter height was 2 m. Then the chlorophyll fluorescence, photosynthesis indicators, and leaf and branch growth and development indicators of the leaves of Kyoho and Cabernet Sauvignon were determined.【Results】The value of the F_v/F_m , Φ_{PSII} , ETR and qP of the Kyoho and Cabernet Sauvignon leaves under Coverlys TF150[®] treatment peaked at 10:00 and 14:00, and the value at 10:00 was generally higher than that at 14:00. Compared with the PO film, the Coverlys TF150[®] significantly increased the F_v/F_m of the Kyoho and Cabernet Sauvignon leaves from

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作者简介:李中瀚,男,在读硕士研究生,主要从事葡萄抗逆栽培生理方向的研究。E-mail:541895467@qq.com

*通信作者 Author for correspondence. Tel:13455815780, E-mail:duyuanpeng001@163.com

10:00 to 14:00, but decreased the F_v/F_m at 08:00 and 16:00. At 10:00, 12:00 and 14:00, the F_v/F_m of Kyoho was increased significantly by 7.41%, 5.00% and 3.61%, respectively under the Coverlys TF150[®] treatment, and the F_v/F_m of the Cabernet Sauvignon was increased significantly by 4.76%, 5.00% and 6.17%, respectively. From 10:00 to 14:00, the Φ_{PSII} , ETR and qP of the Kyoho and Cabernet Sauvignon leaves under the Coverlys TF150[®] were higher than that under the PO film, and lower than that under the PO film at 08:00 and 16:00. Compared with the value under the PO film, the Φ_{PSII} of the Kyoho leaves under the Coverlys TF150[®] treatment was increased by 7.14%, 13.64% and 17.39%, respectively, at 10:00, 12:00 and 14:00; The Φ_{PSII} of the Cabernet Sauvignon leaves was increased by 7.14%, 8.70% and 12.50%, respectively. The net photosynthetic rate (P_n), intercellular carbon dioxide (C_i), stomatal conductance (G_s) and transpiration rate of the grape leaves (T_r) under the Coverlys TF150[®] were higher than those under the PO film from 10:00 to 14:00, and lower than those under the PO film at 08:00 and 16:00. The net photosynthetic rate of the leaves of Kyoho under the Coverlys TF150[®] treatment was 18.80%, 24.65% and 25.34% higher than that under the PO film at 10:00, 12:00 and 14:00 and the net photosynthetic rate of Cabernet Sauvignon was 20.00%, 30.18% and 20.00% higher than that under the PO film, respectively. The diurnal variation area of the net photosynthetic rate under the Coverlys TF150[®] treatment was 13.80% and 12.21% higher than that under the PO film, respectively; At 12:00 and 14:00, the intercellular carbon dioxide concentration under the Coverlys TF150[®] treatment significantly was increased by 27.35% and 19.31%, respectively in Kyoho, and significantly was increased by 21.30% and 14.76% in Cabernet Sauvignon, respectively. At 10:00, the leaf stomatal conductance of Kyoho and Cabernet Sauvignon under the Coverlys TF150[®] was significantly increased by 27.75% and 38.06% compared with that under the PO film, respectively. And transpiration rate was significantly increased by 50.94% and 27.31%, respectively. At 12:00, the stomatal conductance of the Kyoho and Cabernet Sauvignon leaves under the Coverlys TF150[®] was significantly increased by 38.34% and 36.40% compared with that under the PO film. The leaf transpiration rate under the Coverlys TF150[®] was increased by 15.48% and 24.81%, respectively. Compared with the values under the PO film, the leaf weight, leaf area and chlorophyll content of Kyoho and Cabernet Sauvignon under the Coverlys TF150[®] were significantly increased by 31.60% and 10.35%, respectively, and leaf area was significantly increased by 8.77% and 15.01%. The leaf chlorophyll content was increased by 31.45% and 9.41%, respectively. Meanwhile, the Coverlys TF150[®] significantly increased the leaf thickness by 14.81% in Kyoho, while the leaf thickness of the Coverlys TF150[®] treatment had no significant difference with that of the PO film treatment in Cabernet Sauvignon. Compared with the PO film, the Coverlys TF150[®] significantly improved the fresh shoot mass and fresh root mass of the grape plants, the fresh shoot mass and root mass were increased by 10.73% and 17.83% in Kyoho, and they were increased by 19.33% and 19.96% in Cabernet Sauvignon, respectively, and the root-shoot ratio was also improved. Compared with the PO film, the TF150[®] significantly increased the length the Kyoho shoots by 14.49%, and the new shoots diameter was significantly increased by 19.96% in Cabernet Sauvignon. The Coverlys TF150[®] treatment also increased the soluble sugar and starch content in the shoots, the content of soluble sugar was increased by 25.00% in Kyoho, and the content of starch was increased by 25.00% and 21.21%, respectively in Kyoho and Cabernet Sauvignon. 【Conclusion】Compared with the PO film, the Coverlys TF150[®] improved the photosynthetic capacity of the grape leaves and reduced the photosynthetic inhibition, which was beneficial to the growth and development of the grape plants and promoted the accumulation of storage nutrients in the branches.

Key words: Grape; Rain shelter film; Photosynthesis; Chlorophyll fluorescence; Biomass; Growth and development

我国属于大陆性季风气候,夏季雨热同季,葡萄病害发生严重,避雨栽培是隔离雨水减少病害发生的有效途径^[1]。目前,避雨栽培技术在我国多地得到了广泛应用,推广应用面积已超过26.67万hm²,特别是在长江中下游地区^[2]。近年来,北方地区也有一定应用^[3],该技术已被作为山东省果茶站的主推技术。

目前应用的避雨棚膜材料主要有聚氯乙烯(PVC)、聚乙烯(PE)、聚乙烯-聚醋酸乙烯酯共聚物(EVA)以及聚烃烯(PO)膜等^[4],以PO膜应用最为广泛。不同棚膜材料透光和保温性能均存在差异,进而影响葡萄叶片光合能力,主要体现在光合日变化上,晴天露地栽培光合日变化主要呈单峰曲线,叶片净光合速率中午最低且下午得不到恢复^[5]。避雨栽培葡萄叶片光合速率日变化呈双峰型变化曲线^[6],上午随光照度和温度上升,叶片净光合速率快速升高,10:00左右达到峰值,中午受强光和高温胁迫的影响,出现“光合午休”现象^[7],随着光照度和温度的降低,16:00出现第二个高峰,但第二个高峰一般小于第一个高峰。而阴雨天或者温度较低的多云情况下,葡萄叶片净光合速率日变化也会出现单峰的情况,峰值出现在10:00左右^[8]。虽然避雨栽培具有遮光作用,但避雨棚内光照度仍然高于葡萄的光饱和点,处于强光照带^[9]。因此,调控避雨棚内的光照度和温度是缓解高温强光胁迫、避免或者缓解植物光合午休、提高净光合速率的重要措施。

Coverlys TF150®是一种内部涂有防雾滴PE涂层的新型机织物,该棚膜材料耐拉强度大,抗撕裂性强,不需要钢管或者钢丝拱梁,直接在树干上方跨过立柱顶端形成三角形覆盖,操作简便,可实现无骨架覆盖,较常规避雨棚大大降低了钢管或者钢丝骨架成本及外加压膜绳固定的劳动力成本。目前,Coverlys TF150®尚未在我国葡萄避雨栽培上应用,其对葡萄光合特性和生长发育的研究未见报道。因此,笔者在山东地区开展Coverlys TF150®对赤霞珠和巨峰植株生长发育及光合特性的影响研究,以期为该棚膜材料在我国葡萄避雨栽培上的应用提供理论依据。

1 材料和方法

1.1 试验材料

试验于2021年5—9月在山东农业大学园艺试

验站进行,选用1年生巨峰和赤霞珠自根苗为试材,于3月初定植在外口径37 cm、内口径34 cm、盆高24.5 cm的塑料盆中,基质为中性壤土、河沙及有机肥按照2:1:1的体积比配制而成,待生长到6~7枚叶片时,每个处理分别选取长势相同的30株赤霞珠和巨峰苗,在盆上方分别搭建避雨棚,棚的肩高为1.2 m,棚顶距地面2 m,避雨棚分别用PO膜和Coverlys TF150®膜覆盖,Coverlys TF150®购自博优纺织品(威海)有限公司,8元·m⁻²。经测定,Coverlys TF150®的透射率为65.23%,PO膜的透射率为74.05%。

1.2 试验方法

1.2.1 葡萄叶面积、叶厚度和叶质量的测定 于7月中旬分别采集赤霞珠和巨峰不同处理下第6节位叶片10枚,将叶片平铺在坐标纸上,拍照并用Digimizer软件测定叶面积;用天平测量叶片质量,精确到0.01 g;用游标卡尺测量叶片厚度,精确到0.01 mm。

1.2.2 葡萄叶片叶绿素含量的测定 参照赵世杰等^[10]的方法,用打孔器取第9节位葡萄叶片测定,每个处理3次生物学重复。

1.2.3 葡萄叶片光合作用测定 参照管雪强等^[11]的方法,选择7月中旬的晴天,分别在2种棚膜下随机选择第6节位叶片,用Ciras-3(PPSystems,英国)光合仪08:00—16:00每隔2 h测定1次,测定净光合速率(P_n)、气孔导度(G_s)、胞间CO₂浓度(C_i)、蒸腾速率(T_r)等指标,每个处理10次重复。

1.2.4 葡萄叶片叶绿素荧光参数的测定 参照付晴晴等^[12]的方法,选择7月中旬的晴天,用FMS-2型便携脉冲调制式荧光仪(Hansatech,英国)对葡萄第6节位叶片叶绿素荧光参数日变化(08:00—16:00)进行测定。测定程序如下:对光适应下(活化光照度约1000 μmol·m⁻²·s⁻¹)的各株系葡萄叶片先打60 s作用光(1000 μmol·m⁻²·s⁻¹),然后打测量光(<0.05 μmol·m⁻²·s⁻¹)测得叶片最小荧光(F_0'),再打饱和脉冲光(12 000 μmol·m⁻²·s⁻¹)测得光适应下的最大荧光值(F_m'),作用光下Ft稳定后即为稳态荧光(F_s),关闭叶夹对叶片进行30 min的暗适应后测定初始荧光(F_0),打12 000 μmol·m⁻²·s⁻¹的饱和脉冲光,使原初电子受体QA全部处于还原状态,测定暗适应下的最大荧光(F_m)。

1.2.5 葡萄植株鲜质量、新梢长度和粗度测定 每

个处理随机取 10 株葡萄植株,用天平测定地上部和地下部的鲜质量,精确到 0.01 g;用卷尺测量新梢长度,精确到 0.1 cm;用游标卡尺测量茎粗,精确到 0.01 mm。

1.2.6 葡萄枝条贮藏营养的测定 于休眠季节 1 月中旬,每个处理随机取 10 株葡萄植株,选取第 3 节位枝条,烘干研磨,参照赵世杰等^[10]的方法,用蒽酮比色法测定枝条可溶性糖含量和淀粉含量,3 次重复。

1.3 数据统计与处理方法

使用 Microsoft Excel 2016 处理数据和作图,利用 SPSS 26.0 软件对数据进行独立样本 T 检验分析,用 LSD 法进行差异显著性检验。

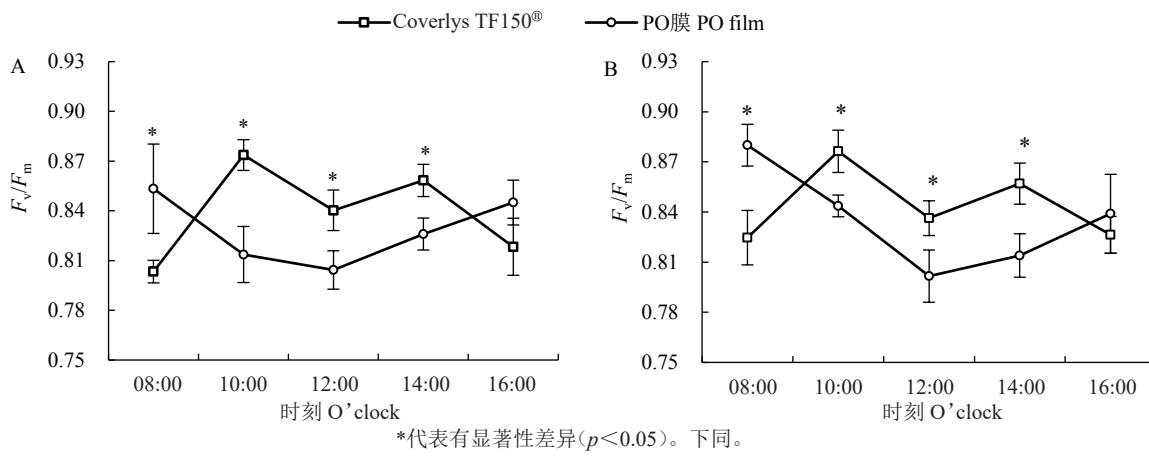


图 1 Coverlys TF150® 对巨峰 (A) 和赤霞珠 (B) 叶片最大光化学效率 (F_v/F_m) 影响

Fig. 1 Effects of Coverlys TF150® on the maximum photochemical efficiency of PS II (F_v/F_m) of leaves of Kyoho (A) and Cabernet Sauvignon (B)

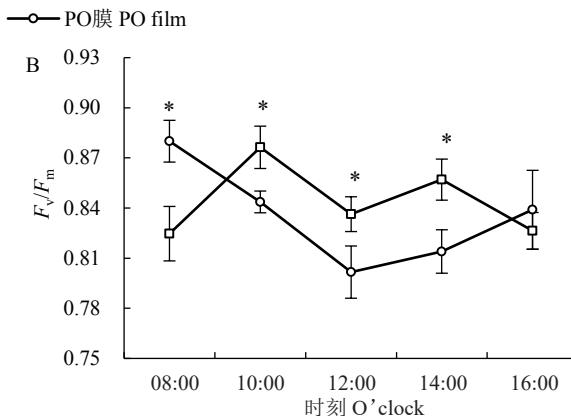
TF150® 下巨峰叶片 F_v/F_m 分别升高了 7.41%、5.00% 和 3.61%, 赤霞珠叶片 F_v/F_m 分别显著提高了 4.76%、5.00% 和 6.17%。

2.1.2 Coverlys TF150® 对葡萄叶片实际光化学效率 (Φ_{PSII})、光化学淬灭系数 (qP)、电子传递速率 (ETR) 的影响 Φ_{PSII} 表示在光照条件下 PS II 反应中心部分关闭后的实际光化学效率, 反映叶片在光下用于电子传递的能量占吸收光能的比例; qP 是光化学猝灭系数, 反映 PS II 天线色素捕获光能用于光化学电子传递的份额; ETR 代表光合量子子传递效率。如图 2 所示, Coverlys TF150® 下巨峰和赤霞珠叶片 Φ_{PSII} 、ETR 和 qP 日变化均为双峰曲线, 在 10:00 和 14:00 达到高峰, 并且 10:00 一般高于 14:00。10:00—14:00 Coverlys TF150® 下巨峰和赤霞珠叶片 Φ_{PSII} 、ETR 和 qP 均高于 PO 膜, 08:00 和 16:00 低于 PO 膜。与 PO 膜相比,

2 结果与分析

2.1 Coverlys TF150® 对葡萄叶片荧光参数的影响

2.1.1 Coverlys TF150® 对葡萄叶片最大光化学效率 (F_v/F_m) 的影响 由图 1 可见, Coverlys TF150® 下巨峰和赤霞珠叶片最大光化学效率 (F_v/F_m) 均为双峰曲线, 10:00 达到一天中最高, 08:00 最低。PO 膜下巨峰和赤霞珠叶片 F_v/F_m 08:00 为一天中最高, 12:00 最低, 随后逐渐升高, 但在 16:00 前均低于 Coverlys TF150®。Coverlys TF150® 较 PO 膜显著提高了 10:00—14:00 巨峰和赤霞珠叶片的 F_v/F_m , 但 08:00 和 16:00 F_v/F_m 有所降低。与 PO 膜相比, 10:00、12:00、14:00 Coverlys



10:00、12:00、14:00 Coverlys TF150® 下巨峰叶片 Φ_{PSII} 分别显著提高 7.14%、13.64% 和 17.39%, 赤霞珠叶片 Φ_{PSII} 分别提高 7.14%、8.70% 和 12.50%, 也达到了显著水平。

2.2 Coverlys TF150® 对葡萄叶片光合作用的影响

2.2.1 Coverlys TF150® 对葡萄叶片净光合速率 (P_n) 的影响 由图 3 所示, Coverlys TF150® 下巨峰和赤霞珠葡萄叶片的净光合速率为双峰曲线, 10:00 和 14:00 为葡萄叶片的净光合速率的两个峰值, 高于一天中其他时间, 且 10:00 净光合速率显著高于 14:00。PO 膜下 6 节位葡萄叶片净光合速率呈先下降后上升的趋势, 12:00 净光合速率一天中最低, 08:00 为 PO 膜一天中净光合速率最高的时间。10:00—14:00 Coverlys TF150® 下葡萄叶片的净光合速率显著高于 PO 膜, 巨峰叶片净光合速率分别比 PO 膜高

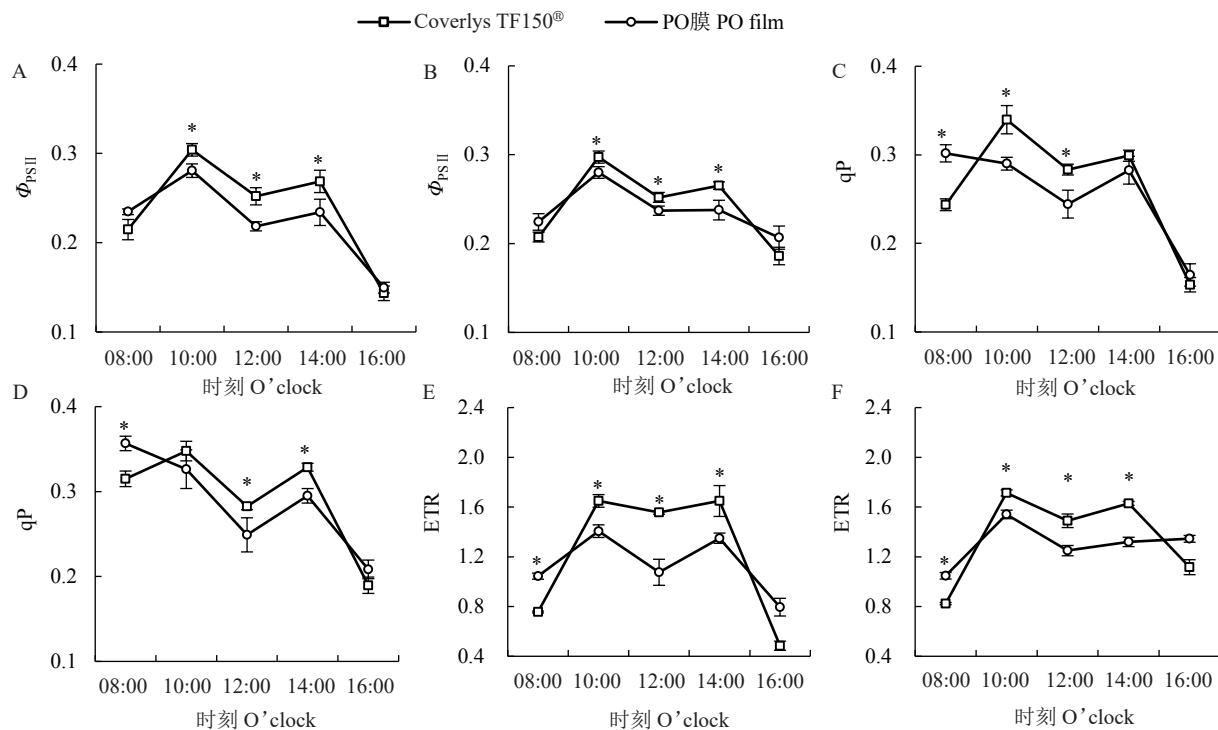


图2 Coverlys TF150®对巨峰(A、C和E)和赤霞珠(B、D和F)叶片 Φ_{PSII} 、qP、ETR的影响

Fig. 2 Effects of Coverlys TF150® on actual PS II efficiency (Φ_{PSII}), photochemical quenching coefficient (qP) and electron transport rate (ETR) of leaves of Kyoho (A, C and E) and Cabernet Sauvignon (B, D and F)

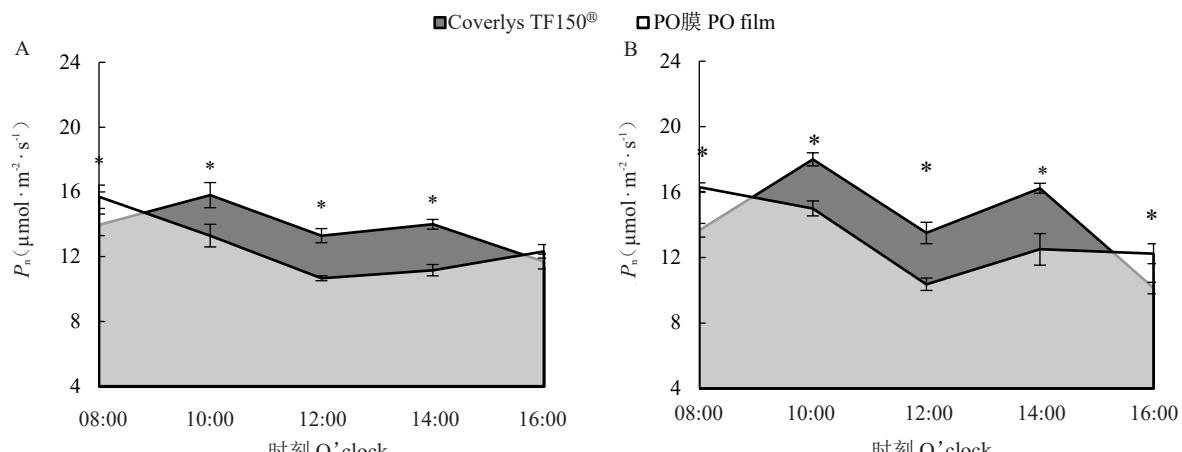


图3 Coverlys TF150®对巨峰(A)和赤霞珠(B)葡萄叶片净光合速率(P_n)的影响

Fig. 3 Effects of Coverlys TF150® on net photosynthetic rate (P_n) of Kyoho (A) and Cabernet Sauvignon (B) grape leaves

18.80%、24.65%和25.34%，赤霞珠叶片净光合速率分别比PO膜高20.00%、30.18%和20.00%，08:00和16:00低于PO膜。葡萄叶片光合日变化面积图经积分可得，Coverlys TF150®下巨峰和赤霞珠叶片净光合速率日变化面积分别为402 720 $\mu\text{mol} \cdot \text{m}^{-2}$ 和4 293 620 $\mu\text{mol} \cdot \text{m}^{-2}$ ，分别比PO膜增加了13.80%和14.39%。

2.2.2 Coverlys TF150®对葡萄叶片胞间二氧化碳浓度(C_i)的影响 由图4可见，12:00—14:00 Cover-

lys TF150®下巨峰和赤霞珠叶片 C_i 均显著高于PO膜，而10:00无显著差异，但08:00和16:00显著低于PO膜。与PO膜相比，12:00和14:00巨峰叶片 C_i 分别提高了27.35%和19.31%，赤霞珠叶片 C_i 分别提高了21.30%和14.76%。

2.2.3 Coverlys TF150®对葡萄叶片气孔导度(G_s)和蒸腾速率(T_r)的影响 如图5所示，10:00—14:00 Coverlys TF150®下巨峰和赤霞珠叶片 G_s 和 T_r 高于PO膜，而08:00和16:00低于PO膜。10:00 Coverlys

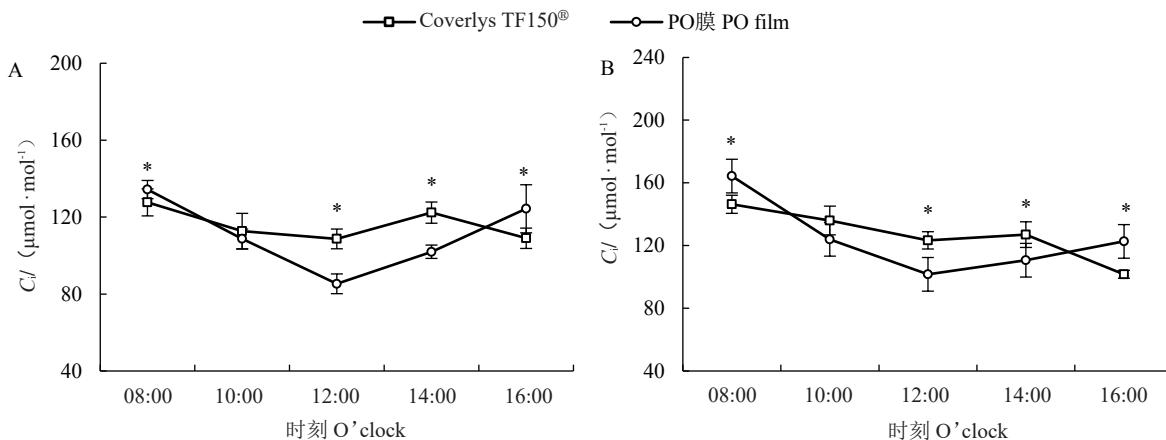


图4 Coverlys TF150®对巨峰(A)和赤霞珠(B)葡萄叶片胞间二氧化碳浓度(C_i)的影响

Fig. 4 Effects of Coverlys TF150® on the intercellular carbon dioxide concentration (C_i) of grape leaves of Kyoho (A) and Cabernet Sauvignon (B)

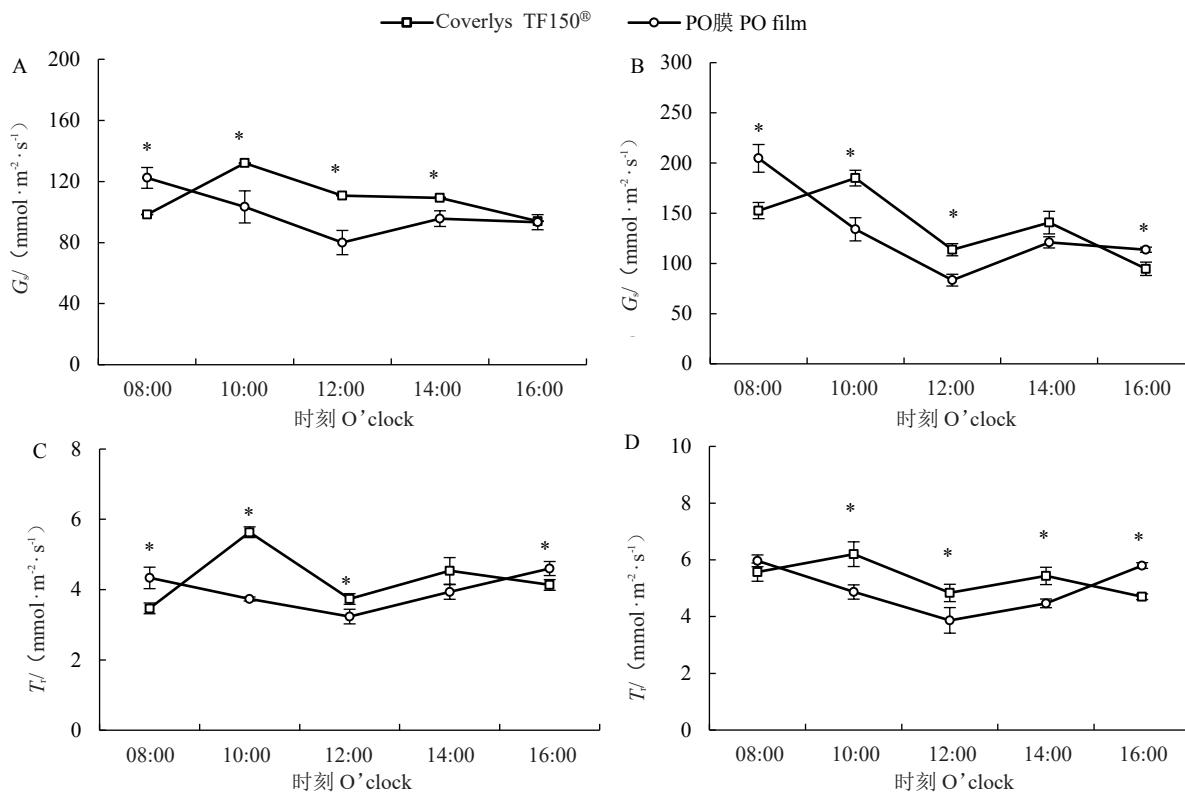


图5 Coverlys TF150®对巨峰(A和C)和赤霞珠(B和D)叶片气孔导度(G_s)和蒸腾速率(T_r)的影响

Fig. 5 Effects of Coverlys TF150® on stomatal conductance (G_s) and transpiration rate (T_r) of leaves of Kyoho (A and C) and Cabernet Sauvignon (B and D)

TF150®下巨峰和赤霞珠叶片 G_s 较 PO 膜分别显著提高 27.75% 和 38.06%； T_r 分别显著提高 50.94% 和 27.31%。12:00 Coverlys TF150®下较 PO 膜下巨峰和赤霞珠叶片 G_s 分别显著提高 38.34% 和 36.40%， T_r 分别显著提高 15.48% 和 24.81%。

2.3 Coverlys TF150®对葡萄叶片生长的影响

如图6所示,与 PO 膜相比,Coverlys TF150®覆盖处理下巨峰和赤霞珠葡萄叶片质量、叶面积和叶

绿素含量显著增加,叶片质量分别提高了 31.60% 和 10.35%,叶面积分别提高了 8.77% 和 15.01%,叶片叶绿素含量分别提高了 31.45% 和 9.41%。同时,Coverlys TF150®覆盖显著提高了巨峰叶片厚度,提高了 14.81%,赤霞珠叶片厚度无显著差异。

2.4 Coverlys TF150®对葡萄植株生长发育和枝条贮藏营养的影响

由表1可见,Coverlys TF150®覆盖较 PO 膜显著

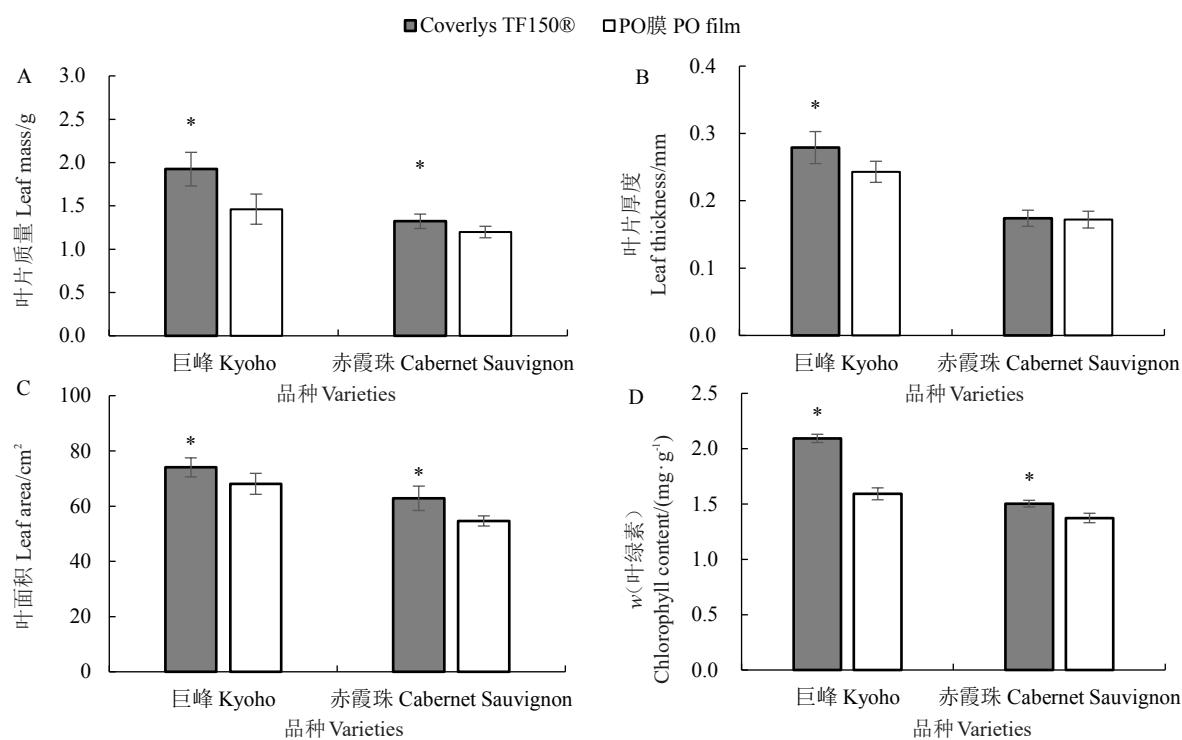


图 6 Coverlys TF150®对葡萄叶片质量 (A)、厚度 (B)、面积 (C) 以及叶绿素含量 (D) 的影响

Fig. 6 Effect of Coverlys TF150® on leaf mass (A), leaf thickness (B), leaf area (C) and chlorophyll content (D) of grape leaves

表 1 Coverlys TF150®对葡萄生长发育及枝条贮藏营养的影响

Table 1 Effects of Coverlys TF150® on grape growth and nutrient storage in branches

品种 Varieties	处理 Treatment	地上部鲜质量 Fresh shoot mass/g	地下部鲜质量 Fresh root mass/g	根冠比 Root shoot ratio	新梢长度 New shoot length/cm	新梢粗度 New shoot roughness/mm	w(可溶性糖) Soluble sugar content/(mg·g⁻¹)	w(淀粉) Starch content/(mg·g⁻¹)
巨峰 Kyoho	Coverlys TF150®	65.71±1.16 a	105.79±5.77 a	1.61±0.11 a	84.00±2.43 a	4.82±0.26 a	0.20±0.02 a	0.40±0.02 a
	PO膜	58.66±3.27 b	86.90±2.80 b	1.48±0.13 a	68.47±3.15 b	4.57±0.14 a	0.16±0.01 b	0.32±0.03 b
赤霞珠 Cabernet Sauvignon	Coverlys TF150®	59.40±1.87 a	83.11±5.81 a	1.40±0.11 a	74.20±5.20 a	4.69±0.13 a	0.23±0.02 a	0.40±0.01 a
	PO膜	47.92±1.28 b	66.52±4.55 b	1.39±0.10 a	71.80±0.36 a	3.74±0.34 b	0.20±0.02 a	0.33±0.03 b

注:不同小写字母代表差异显著($p<0.05$)。

Note: Different small letters indicate significant difference at $p<0.05$.

提高了葡萄植株地上部和地下部鲜质量,巨峰地上部和地下部鲜质量分别提高了10.73%和17.83%,赤霞珠地上部和地下部鲜质量分别增加了19.33%和19.96%,并提高了盆栽葡萄的根冠比,以巨峰更为明显,较PO膜提高了8.78%,但未达到显著水平。Coverlys TF150®覆盖显著提高了巨峰新梢长度,较PO膜提高了14.49%;显著增粗了赤霞珠新梢,增幅19.96%,巨峰新梢粗度也有一定程度的提高,但无显著差异。与PO膜相比,Coverlys TF150®覆盖使盆栽植株枝条可溶性糖含量升高,巨峰达到显著水平,提高了25.00%;显著增加了盆栽植株枝条淀粉含量,巨峰和赤霞珠分别提高了25.00%和21.21%。

3 讨 论

叶绿素荧光是研究光合作用的探针,能辅助说明光合作用的强弱。PS II是最初发生光抑制的部位^[13-14], F_v/F_m 反映了光系统II(PS II)受损伤的程度,当植物受到胁迫时 F_v/F_m 会降低^[15]。10:00—14:00 Coverlys TF150®下巨峰和赤霞珠叶片 F_v/F_m 显著高于PO膜,有研究表明,田间强光天气下葡萄叶片09:00即发生光抑制^[5],Coverlys TF150®较PO膜透射率降低,由此表明,Coverlys TF150®减轻了10:00—14:00植株受胁迫的程度。强光胁迫不是直接破坏PS II,而是通过产生ROS来降低植物PS II的修复能力^[16-17],通过抑制植物的最大光修复速率来降低PS II

整体活性,从而导致净光合速率下降。强光胁迫会使PS II 受到损伤,光反应受到抑制,光化学效率降低,电子传递受到阻碍^[18]。与PO 膜相比,10:00—14:00 Coverlys TF150®提高了巨峰和赤霞珠叶片实际光化学效率(Φ_{PSII})、光化学淬灭系数(qP)和电子传递速率(ETR)。由此可见,10:00—14:00 Coverlys TF150®提高了葡萄叶片PS II 活性,增加了叶绿素吸收的光能用于光化学反应的比例,有利于电子传递,进一步提高净光合速率。

光合作用是葡萄生长发育以及生物量积累的基础^[19],主要由叶片发育状况和环境因素共同影响。叶片发育状况主要包括叶片质量、厚度、面积及叶绿素含量等。叶绿素是光合作用的基础^[19],Coverlys TF150®下巨峰和赤霞珠叶片叶绿素含量显著高于PO 膜,这与Coverlys TF150®降低了透光率有关,说明Coverlys TF150®能够有效缓解午间强光胁迫,减轻强光胁迫对叶绿素含量的影响^[20]。叶片结构组成与光合性能密切相关^[21],Coverlys TF150®下巨峰和赤霞珠叶片叶面积较大,能截获更多的光能,有利于增强葡萄的光合作用。环境条件光照、温度、湿度会影响光合作用,其中光照最为显著。光是光合作用的能源,光照不足会使同化力短缺,导致光合作用的关键酶没有充分活化而限制光合作用,而光照度过高会造成植物吸收的光能超过其自身能够利用的能力,导致过剩激发能的累积^[15],产生ROS,造成严重的光抑制。10:00—14:00 外界温度较高并伴随着强光,强光对高温胁迫具有加剧作用^[22]。Coverlys TF150®下巨峰和赤霞珠叶片净光合速率日变化面积分别比PO 膜高13.80%和12.21%,可能由于Coverlys TF150®降低了10:00—14:00 光照度,缓解了强光胁迫,延长了光合有效时间,并提高了蓝光所占比例^[23],有利于增强光合作用。

强光胁迫不仅会降低葡萄叶片净光合速率,而且减少光合作用的同化物,限制葡萄生长发育^[24]。研究表明强光胁迫会抑制植物生长发育,降低植物生物量,尤其是对叶片生物量的影响最大^[25]。Coverlys TF150®较PO 膜缓解了10:00—14:00产生的强光胁迫,从而提高了巨峰和赤霞珠新梢的长度和粗度,显著提高了生物量,且增加了巨峰和赤霞珠枝条可溶性糖和淀粉含量,为树体越冬和来年的生长发育奠定了基础^[26]。

4 结 论

Coverlys TF150®较PO 膜缓解了“光合午休”现象,减轻了10:00—14:00 叶片PS II 光抑制的程度,显著提高了巨峰和赤霞珠叶片质量、面积以及叶绿素含量,增强了光合能力,增加了葡萄植株生物量和枝条贮藏营养的积累量。

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