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# Photosynthesis Efficiency of Culm Habit Near-Isogenic Lines Rice (*Oryza sativa* L.) to Different Planting Densities

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***Abstract*** **– The cultivars of Near-isogenic lines (NILs) are characterized by identical genetic makeup except one or few loci of genes and dissimilar morphological culm habits. Trial was conducted in Japan and an attempt has been made, to investigate the impact of planting density on the photosynthesis efficiency and discover a correlation between photosynthesis parameters, culm habits and grain yields of NILs rice. An effort to bargain photosynthesis efficiency methods for improving culm habits and grain yield, photosynthesis parameters have been measured on two near-isogenic lines rice, two population densities and two plant spacings. The short culm erect (SC-E) cultivar produced significantly higher photosynthesis rate, poor stomatal conductance, maximum PAR, higher canopy photosynthesis and grain yield than short culm open (SC-O) cultivar for planting density treatments. SC-E NILs were attained maximal photosynthesis rate with 3 seedlings population density and 0.25*0.25m$^2$ spacing but SC-O with 3 seedlings population density and 0.2*0.2m$^2$ spacing had found comparative photosynthesis rate. PAR interception was boosted in SC-E interacted with low population density and wider plant spacing. Yield of two NILs rice were strongly correlated with canopy photosynthesis such that they yielded prudent on SC-E with 3 seedlings planting density and 0.2*0.2m$^2$ spacing (334.2g m$^{-2}$) and poorly on SC-O with 1 seedling density and 0.25*0.25m$^2$ spacing (105.66 g m$^{-2}$). To conclude that culm habit NILs rice photosynthesis efficiency and grain yield generally influenced by population density and spacing due to open (≤60$^0$) and erect (<30$^0$) canopy architecture and self-shading effect for interception of PAR and canopy photosynthesis.**

***Keywords*** **– Culm Habit, NILs, Planting Density, Photosynthesis.**

## I. Introduction

In Ethiopia rice production is a recent activity and growing up fast compared with other crops both in area coverage and production. However, discovery the right planting density is plays critical role to achieve the expected goal in rice production and productivity. Harmonizing the planting density with photosynthesis efficiency for biomass production and to improve yield and yield components. Culm habit of rice is an important factor for improving photosynthesis through the improvement of light interception and self-shading effect during active tillering and flowering stage. Leaf and stalk morphological features are vital on interception, extinction and recovery of photosynthetic active radiation incident on canopy. Those characteristics are essential for plants reach high photosynthetic efficiency (Singels *et al.,* 2005; Long *et al.,* 2006). Most of the plant biomass originates directly from photosynthesis, the process in which photon energy is converted to chemical energy. Photosynthesis is the only natural conversion mechanism of photon energy to chemical energy and its responsible for 90-95% of the plant accumulation (Gomez *et al.,* 2005). The crop photosynthetic rate of plant is dependent on the absorption of photo synthetically active radiation (PAR), by the leaves as well as the green actively growing plant parts that contains chlorophyll pigments. Thus, the photosynthetic rate of plant is a function of canopy architecture as defined in terms of area and distribution of leaf, leaf angle, leaf surface characteristics as well as intensity of photo synthetically active radiation. However, the response of plant to PAR is the genetic character of the plant species regulated by number of biophysical factors like temperature, humidity, concentration of $CO_2$ etc.

For an accurate prediction of canopy photosynthesis from leaf measurements, it is necessary to have data on multiple leaf characteristics including physical orientation, positioning and physiological characteristics, such as photosynthetic acclimation and nutrient status (Burgess *et al.,* 2015, 2016). In dense canopies, steeper leaf angles potentially lead to an improvement in whole day carbon gain by enhancing light absorption at low solar angles. Erect leaf stature is also associated with reduced susceptibility to photo inhibition and reduced risk of overheating (Burgess *et al.,* 2015). Upscaling the leaf photosynthesis to canopy level has always been challenging task considering the complex distribution pattern of PAR and microclimatic variability with in the crop stand.

Improving canopy photosynthetic capacity is the main approaches to enhance crop productivity since canopy, rather than individual leaf, because photosynthesis is closely related to crop yields (Song *et al.,* 2013)**.** The culm inclination angle with different population density and spacing plays crucial role for photosynthesis and yield. Evidences concerning about culm habit and photosynthesis efficiency of NILs rice still uncertain. So, the objective of this study is to determine if genotypes having same genetic make except one or few loci of genes but different morphological culm habits (erect and open) then what is their photosynthesis efficiency to the response of different population density and spacing.

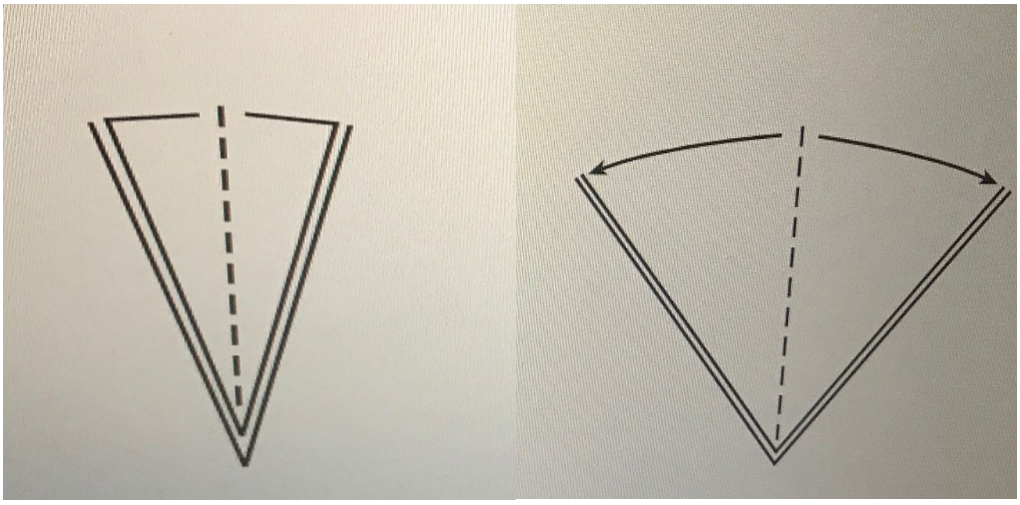
## II. Materials and Methods

### 2.1 *Cultivars and Plant Material*

Selection of cultivars (SC-E and SC-O) tested in this experiment was based on different morphological culm habits and identical genetic makeup except one or few loci of gene.

Table 1. Near-isogenic lines rice (SC-E and SC-O) genetic back ground, culm habit and country of origin.

| Cultivar | Genealogy | Culm habit | Country of origin |
|---|---|---|---|
| SC-E | TN1 cross with Norin29($BC_5Fn$) | Erect (<$30^0$) | Japan |
| SC-O | TN1 cross with Norin29($BC_5Fn$) | Open (≤$60^0$) | Japan |



Erect (<$30^0$) Open (≤$60^0$)

The study was carried out at Tokyo University of Agriculture, Setagaya campus, Tokyo, Japan (N $35^0$ 39'; E $139^0$ 50') in 2017. The experiment deals with two NILs each of which carry a semi-dwarfing allele derived from semi-dwarf cultivars, Taichung Native 1 (TN 1) harboring the allele of a Taiwan landrace Dee-geo-woo-gen. A semi-dwarfing allele of respective donor parents was transferred a common recurrent parent, Norin 29 (N29). Two near-isogenic lines was designed as SC-O (open culm habit N29/TN1//5*N29) and SC-E (erect culm habit, N29/TN1//5*N29). Plants were grown in a concrete plot net house according to a three-factorial experimental design with two replications. The experimental plot was cultivated and puddled properly before transplanting and clay soil was used in this experiment. The recommended rate of fertilizer at the experimental site was 100:40:40kg $ha^{-1}$ of nitrogen, phosphorus and potassium (N: P: K) respectively. Basal fertilizer application was done at a recommended rate of 40:40:40kg $ha^{-1}$ of N: P: K respectively. The remaining 60kg$N_2$ $ha^{-1}$ was applied at panicle initiation stage. Irrigation of water and weed control was done regularly for all plots.

### 2.2 *Planting Density Treatments and Growth Conditions*

Near-isogenic lines rice (SC-E and SC-O) were studied in two plant spacings (20cm*20cm and 25cm*25cm) and two planting populations (1 seedling per hill and 3 seedlings per hill).

### 2.3 *Morphological and Physiological Parameter Measurements*

Measuring of culm habit was carried out at the end of flowering stage using protractor from five hills.

Chlorophyll content assessed during vegetative and reproductive stages on ten plants per vegetative plots, on the 2nd, 3rd fully developed top leaves and flag leaf of 160 plants in total for all treatments by SPAD-502 plus (KONICA MINOLTA, made in Japan).

Photosynthesis Active Radiation intercepted in the canopy appraised by Accu PAR model LP-80, PAR/LAI Ceptometer. PAR interception due to the variation of culm architecture of NILs rice determined to verify the significate impact of culm shape in relation with population density and planting space. Photosynthesis active radiation interception in the canopy measured on three different spots i.e. ten cm above the ground surface, mid and top of canopy height.

Leaf Area Index (LAI) was calculated from the ratio of total projected leaf area (one side only) per unit ground area.

Photosynthesis parameters of near-isogenic lines rice were recorded from ten plants single leaf per vegetative plot by Bio scientific Ltd, LCi-SD embarking from the panicle initiation stage to milking stage of rice growth.

#### 2.3.1 *Photosynthesis Rate*

Rate of $CO_2$ exchange in the leaf chamber) is calculated using the following calculation:

A ($\mu$mol$m^{-2}s^{-1}$) = $\mathbf{u_s \Delta c}$

Where, $\mathbf{u_s}$ mass flow of air per $m^2$ of leaf area, mol $m^{-2}$ $s^{-1}$

$\Delta\mathbf{c}$ difference in $CO_2$ concentration through the chamber, dilution corrected, µmol $mol^{-1}$.

#### 2.3.2 *Transpiration Rate (E)*

$$E\ (\text{mol}m^{-2}s^{-1}) = \Delta \boldsymbol{e}\ \mathbf{u_s}/\mathbf{p}$$

Where, $\Delta e$ differential water vapour concentration, mbar, dilution corrected

**$u_s$** mass flow of air into leaf chamber per square meter of leaf area, mol $s^{-1}$ $m^{-2}$

**p** atmospheric pressure, mBar

2.3.3 *Stomatal Conductance of Water Vapour (gs)*

**gs** ($molm^{-2}s^{-1}$) $=1/\mathbf{r_s}$

where, $r_s$ stomatal resistance to water vapour, $m^2s^{-1}$ $mol^{-1}$

2.3.4 *PAR Incident on Leaf Surface ($Q_{leaf}$)*

$Q_{leaf} = Q*Tr_w$

Where, **Q** photon flux density incident on leaf chamber window, µmol $m^{-2}$ $s^{-1}$

$Tr_w$ Leaf chamber window transmission factor to P.A.R.

## III. Statistical Analysis

The photosynthetic parameters of near-isogenic lines rice were correlated with culm habits and grain yield of rice. Difference between treatments and cultivars and their interaction were tested by the analysis of variance, F-test and t-test (P<0.05; P<0.01) using R-software.

## IV. Results

### 4.1 *Morphological and Physiological Traits to Population Densities and Spacing*

As the analysis of variance revealed, photosynthesis rate of near-isogenic lines rice had significant difference at (p<0.05). Short culm erect culm habit near-isogenic lines rice had produced the highest photosynthesis rate. The rate increased drastically on the first, $2^{nd}$, $3^{rd}$ and $4^{th}$ weeks and decreased at the $5^{th}$ weeks. The cause to decrease photosynthesis rate might be due to the decrease rate of chlorophyll content of leaves and either by ribulose 1,5 biophosphate (RuBP) carboxylation (Vcmax) or by RuBP regeneration in response to $CO_2$ concentration (Jmax). Because that Chlorophyll levels are strongly synchronized with photosynthesis rate so, provide the photosynthetic apparatus which permit plants to absorb energy from light and transfer it to the chlorophyll a. and this result is in line with the finding of Kura-Hita et al. 1987, sophisticated amount of chlorophyll in the leaves can maintain higher photosynthesis rate. The higher the planting density had augmented photosynthesis rate of leaf and lower planting density was declined the photosynthesis rate of leaf near-isogenic lines rice (Fig. 3&4). Small increases in the rate of net photosynthesis can translate into large increases in biomass and hence yield, since carbon assimilation is integrated over the entire growing season and crop canopy (Long et al., 2006). The wide canopy can increase the penetration of light to reach the lower leaves of the plant in a high light environment, thus maximizing opportunity for all the leaves to perform photosynthesis optimally (Terashima & Hikosaka 1995).

The transpiration rate had increased with increasing the photosynthesis rate. SC-E NILs with 3 seedlings by $0.2*0.2m^2$ loses more water (Figure 8). Lower planting density had produced decreased rate of transpiration rate. SC-O NILs rice out yielded low rate of photosynthesis as well as transpiration rate. However, the designed plant spacing, and population density compelled non-significant different for culm length between NILs (Table 2). Culm habits of NILs had prejudiced by population density and plant spacing. SC-O NILs interacted with 3 seedlings population density and extensive plant spacing ($0.25m^2$) were returned augment culm habits ($60.8^0$). Rebelliously, SC-E NILs colluded with 3 seedlings and subordinate plant spacing ($0.2m^2$) had scored lower culm habits ($27.7^0$) (Table 2).

The orientation and angle of leaves present on a single leaf of NILs rice acquired non- significant variation between population densities and plant spacings. Leaf Area Index had led significant difference between population densities and non-significant difference recorded between spacings. Yet, SC-E genotypes interacted with 3 seedlings population densities with $0.25m^2$ between hills and rows had yielded greater (4.7) results followed by SC-E with 3 seedlings population densities and $0.2m^2$ spacings between hills and rows (3.8) (Table 2).

Stomatal conductance presented significant variations between days of measurements and treatment effects. SC-E with 3 seedlings and $0.25m^2$ spacing had provided ceiled up stomatal conductance (gs) from the verge to the end measurements. However, on the 90 Days after Transplanting (DAT) measurements, stomatal conductance was reduced (Fig. 5 and 6). This might be due to that stomatal conductance is highly harmonized with the capability for $CO_2$ fixation and regulated by the $CO_2$ level in the intercellular air space and decrease in NCO2ias caused by photosynthesis leading to an increase in gCO2st, which then lets more $CO_2$ into the leaf under a photosynthetic photon flux and other conditions favorable for photosynthesis. Patchiness of stomatal conductance is almost always detrimental to instantaneous water use efficiency and is not consistent with an optimal behavior of stomata (Buckley *et al.*, 1999).

Canopy photosynthesis was affected by culm habits, population density and spacing. Higher Canopy photosynthesis was attained by the interaction effect of SC-E, 3 seedlings population density and $0.25*0.25m^2$ spacing followed by the interaction effect of SC-E with 3 seedlings population density and $0.2*0.2m^2$ spacing. However, reduced Canopy photosynthesis potential was found from SC-O NILs rice compared from erect and open NILs rice (Fig. 11 and 12) and this finding is in line with the statement of Nobel et al. 1993; Lawlor 1995; Long et al. 2006, plants with canopy structure that allows Q incidence at bottom canopy positions exhibit greater overall photosynthesis.

Table 2. ANOVA using means of NILS, Population density and spacing on morphological and physiological traits.

| NILs | Spacing | Population density | CA (o) | CL (cm) | LA (o) | LAI | PAR in |
|---|---|---|---|---|---|---|---|
| SC-E | 25cm * 25cm | 1 seedling | 31.2de | 61.9a | 6bc | 2.6c | 76.5a |
| | | 3 seedlings | 37.1d | 61.0a | 8.7abc | 4.7a | 25.5d |
| | 20cm * 20cm | 1 seedling | 29.0ef | 56.5a | 7.7abc | 2.4c | 41.0b |
| | | 3 seedlings | 27.7f | 56.1a | 5.5c | 3.8b | 16cd |
| SC-O | 25cm * 25cm | 1 seedling | 54.2 b | 64.2a | 9.7ab | 2.5c | 20c |
| | | 3 seedlings | 60.8a | 55.4a | 9.8ab | 3.7b | 11d |
| | 20cm * 20cm | 1 seedling | 45.3c | 58.4a | 9.7ab | 2.1d | 5.5e |
| | | 3 seedlings | 53.6b | 55.9a | 10a | 2.6c | 20c |
| | | CV (%) | 2.8 | 6.4 | 20 | 3.1 | 10 |
| | | LSD (0.05) | ** | Ns | Ns | * | ** |

Means followed by the same letters are not significant different p<0.05. where, CA = Culm Habit, CL = Culm Length, LA = Leaf Angle, LAI = Leaf Area Index, Photosynthesis Active Radiation intercepted. *, Significant at 5% probability, **, significant at 1% probability level.

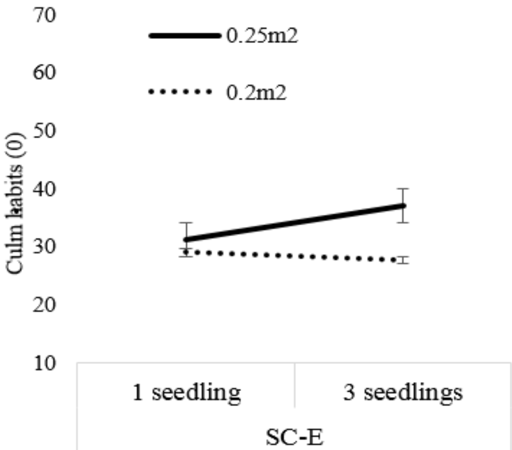



Fig. 1. Culm habits of SC-E NILs to different population densities and spacing after flowering stage.

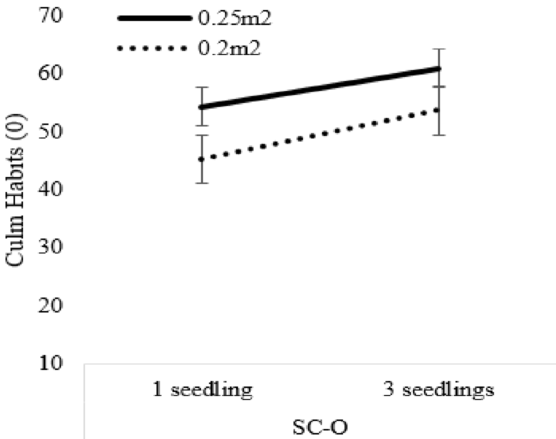



Fig. 2. Culm habits of SC-O NILs to different population densities and spacing after flowering stage.

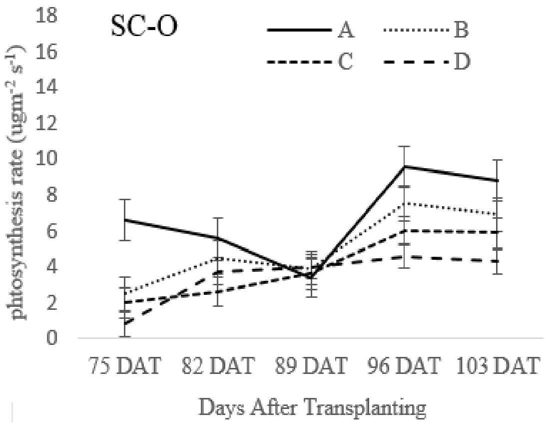



Fig. 3. Effect of population density and spacing on a single leaf photosynthesis rate of SC-O NILs.

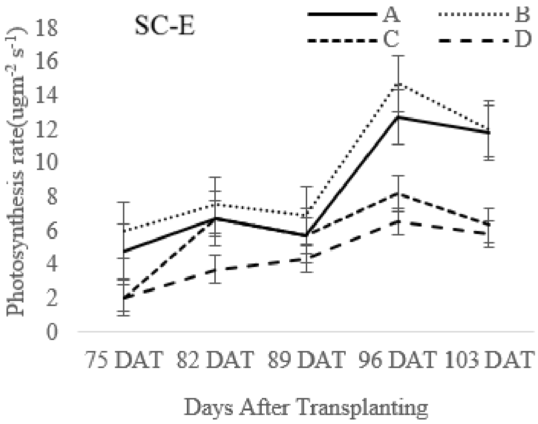



Fig. 4. Effect of population density and spacing on a single leaf Photosynthesis rate of SC-E NILs rice.

Where, A:3 seedlings and 20cm*20cm. B, 3 seedlings and 25cm*25cm, C, 1 seedling and 20cm*20 cm. D, 1 seedling and 25cm*25cm.

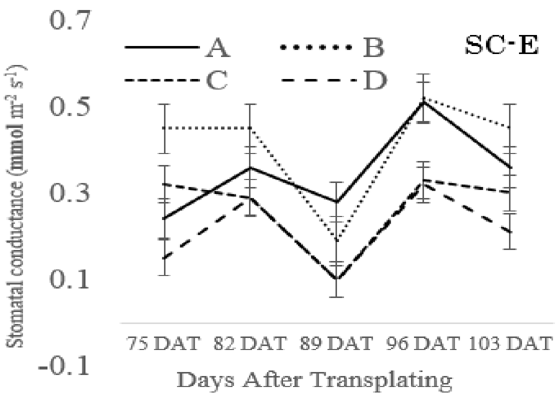



Fig. 5. Stomatal conductance of SC-E NILs with different population densities and spacings.

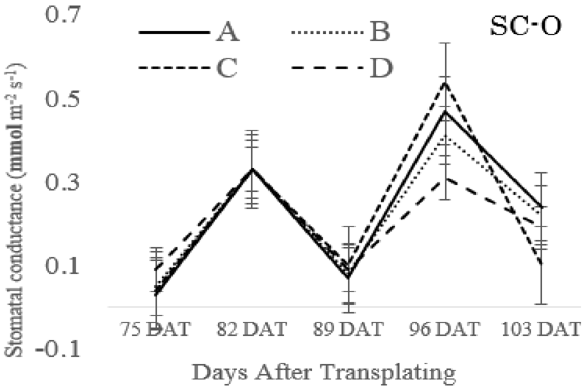



Fig. 6. Stomatal conductance of SC-O NILs with different population densities and spacings.

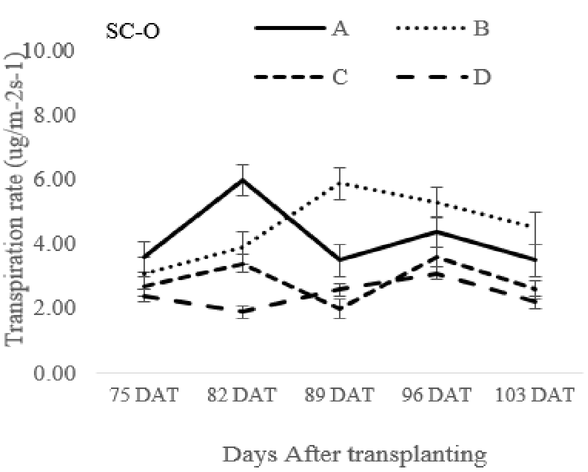



Fig. 7. Influence of population density and spacing on transpiration of SC-O NILs rice.

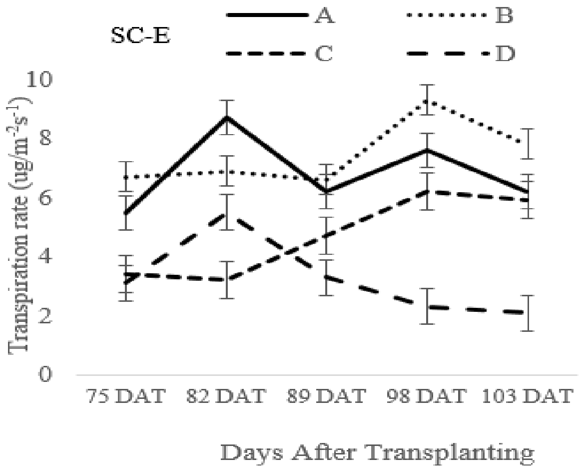



Fig. 8. Influence of population density and spacing on transpiration of SC-E NILs rice.

Where A = 3 seedling*20cm*20cm, B = 3 seedling*25cm*25cm, C = 1 seedling*20cm*20cm, D = 1 seedling* 25cm*25cm.

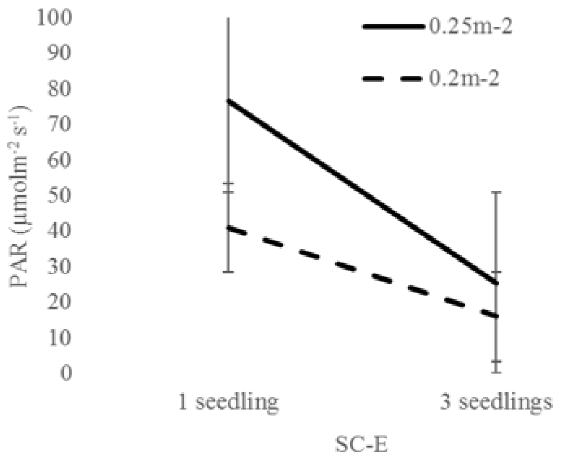



Fig. 9. Variation of PAR interception with in the canopy of SC-E NILs due to erect culm habits.

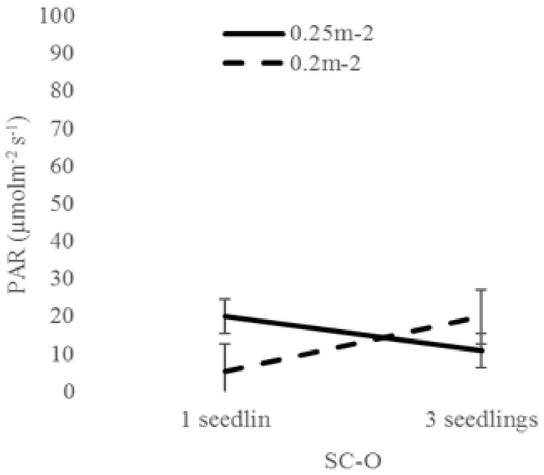



Fig. 10. Variation of PAR interception with in the canopy of SC-O NILs due to open culm habits.

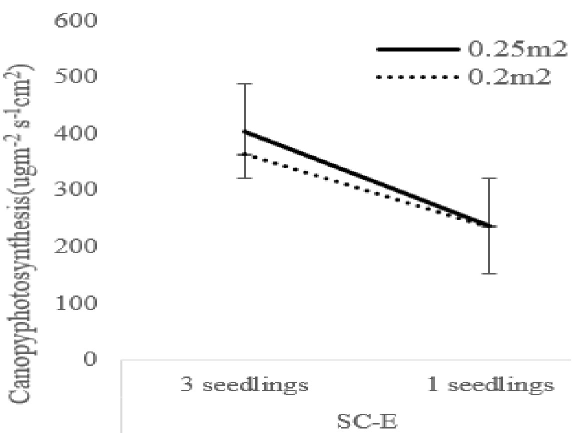



Fig. 11. Influence of population density and spacing on canopy photosynthesis of SC-E NILs rice.

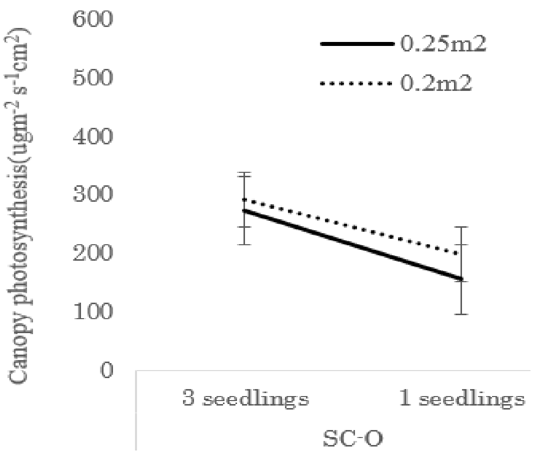



Fig. 12. Influence of population density and spacing on canopy photosynthesis of SC-O NILs rice.

### 4.2 *Yield and Yield Components to Population Densities and Spacing*

Table 3 shows yield and yield components of NILs prejudiced by population densities and spacing. In SC-E, SC-O, 0.2*0.2m$^2$, 0.25*0.25m$^2$, 1 seedling population density and 3 seedlings population density yields were shown by ANOVA to be significantly different between NILs, population densities and spacings. However, the yields of 0.2 * 0.2m$^2$ spacing was higher at 3 seedlings population density in both SC-E and SC-O NILs (334.27 gm$^{-2}$) and (280.41 gm$^{-2}$) respectively. Drastically declined grain yield was observed from SC-O with 1 seedling population density and 0.25* 0.25m$^2$ (105.66 gm$^{-2}$) and SC-E with 1 seedling population density and 0.25*0.25m$^2$ (114.56 gm$^{-2}$). Mean panicle numbers were ranged from 155 to 280m$^{-2}$ and mean spikelet numbers from 100.9 to 166 per panicle. Mean 1000-grain weights were found non-significant variation between population densities and spacing, but SC-E and SC-O had produced highly significant variation. Spacings had significant impact on mean of filled spikelet's while no variation between SC-E and SC-O as well as between 1 seedling and 3 seedlings population density.

Table 3. Yield and yield components of culm habit NILs rice to different population densities and spacing.

| NILs | Spacing | Density | PL(cm) | NGP(No) | FGP(No) | Pw(g) | NBP (No) | PN(No)/m$^2$ | 1000-wt(g) | Gyg/m$^2$ |
|---|---|---|---|---|---|---|---|---|---|---|
| SC-E | 25cm * 25cm | 1 seedling | 18.72 | 100.9 | 157.8 | 3.98 | 10.2 | 176.25 | 25.5 | 114.56 |
| | | 3 seedling | 18.4 | 156.1 | 149.3 | 3.6 | 10 | 262.5 | 25 | 253.25 |
| | 20cm * 20cm | 1 seedling | 17.3 | 144.3 | 139.1 | 3.28 | 9.6 | 155 | 25 | 127.84 |
| | | 3 seedling | 15.5 | 164.4 | 97 | 2.3 | 8.3 | 257.5 | 25 | 334.27 |
| SC-O | 25cm * 25cm | 1 seedling | 18.1 | 124.7 | 153.4 | 3.3 | 11.2 | 180 | 23.5 | 105.66 |
| | | 3 seedling | 17.1 | 163.5 | 153.2 | 3.2 | 10.9 | 248.75 | 23 | 160.92 |
| | 20cm * 20cm | 1 seedling | 16.3 | 133.5 | 126.2 | 2.7 | 10 | 203.75 | 23 | 145.93 |
| | | 3 seedling | 15.9 | 166 | 118.1 | 2.4 | 10.2 | 285 | 22.5 | 280.41 |
| | | ANOVA (F-ratio) | | | | | | | | |
| | | NILs | 6.26* | 0.77 | 0.1 | 10.99** | 19.44** | 0.05 | 26.27** | 2.3 |
| | | Density | 12.48** | 6.27* | 6.03* | 11.19** | 2.59 | 17.25** | 0.82 | 35.12** |
| | | Spacing | 50.01** | 34.02** | 30.94** | 41.86** | 19.44** | 0.16 | 0.82 | 7.92* |
| | | NILs*Density | 0.47 | 2.57 | 3.12 | 4.22 | 1.96 | 0.12 | 0.09 | 2.96 |
| | | NILs*Spacing | 1.47 | 0.03 | 0.13 | 1.75 | 0.22 | 0.01 | 0.09 | 10.52** |
| | | NILs*Density*Spacing | 3.77 | 1.3 | 11.14** | 0.80 | 12.59** | 0.5 | 0.09 | 15.03** |

Where, PL, panicle length, NGP, number of grains per panicle, FGP, Fertile grains per panicle, PW, panicle weight, NBP, number of branches per panicle, PN, panicle number, 1000-wt, 1000 grain weight, GY- grain yield.

### 4.3 *Correlation between Grain yield, PAR and Canopy Photosynthesis*

Figure 13 and 14 shows correlations between grain yield with canopy photosynthesis and PAR respectively. Grain yield of culm habit NILs rice strongly correlated with canopy photosynthesis of culm habit NILs rice. This implies that grain yield of NILs rice can be predicted from canopy photosynthesis during the growth period and decline canopy photosynthesis due to culm shape effects (culm habits) and that produce yield variation. However, grain yield $m^{-2}$ were negatively correlated with PAR with in the canopy of culm habit NILs rice (Fig 14).

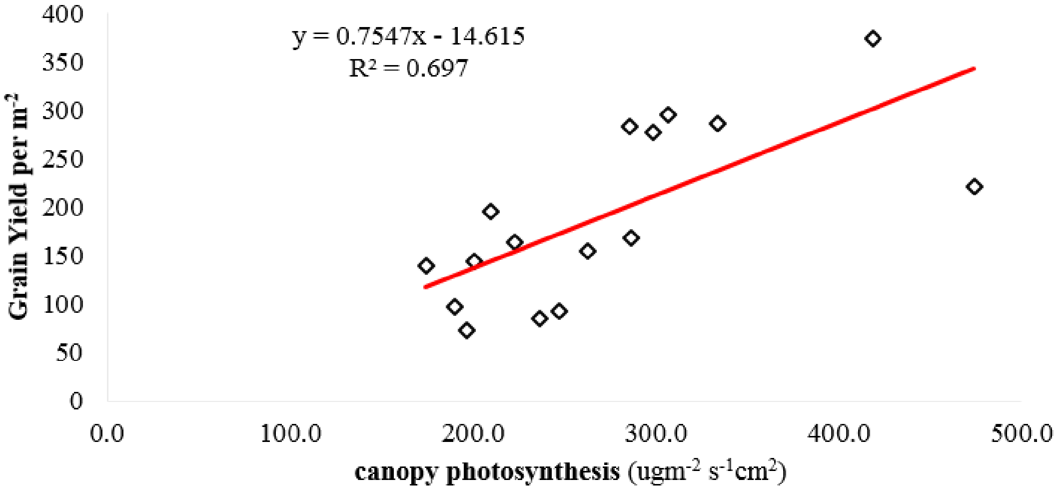



Fig. 13. Correlations between grain yield and canopy photosynthesis of culm habit NILs rice influenced by population densities and spacings.

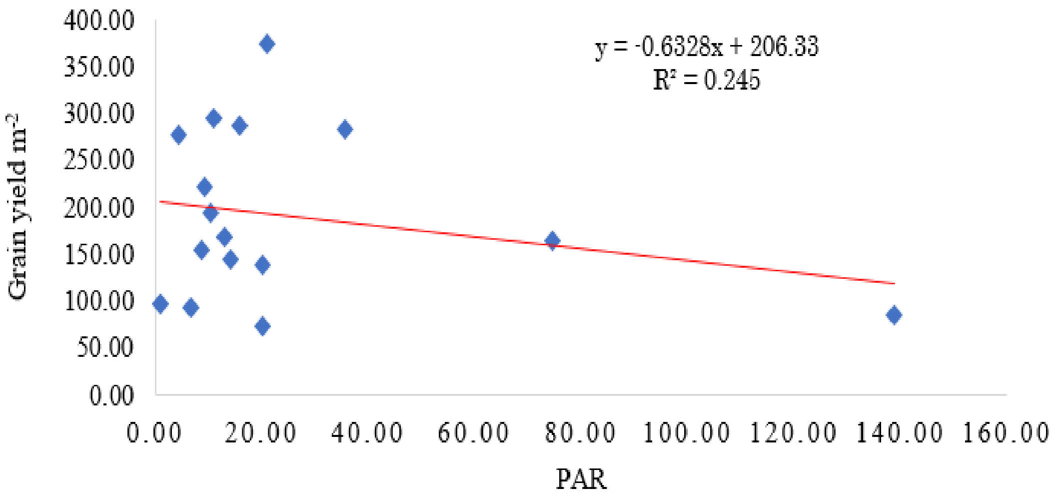



Fig. 14. Negative correlation between grain yield $m^{-2}$ and PAR interception in the culm habit of NILs feign population density and spacings.

## V. Discussion

Wide variation in light transmittance to the soil surface in the interrow zone points out the need to manage plant and management properties such as leaf area, plant density, and row spacing to take best advantages of light in the solar corridor.

Photosynthesis Active Radiation (PAR) interception induced by canopy structure of the genotypes habit. Population density and spacing between hills and rows significantly feign the amount of PAR interception consequently the nature of genotypes. Extensive plant spacing, and subordinate population density was conceded to intercept supreme amount of PAR in the canopy of SC-E NILs rice. However, interaction effect of SC-E, $0.25m^2$ and 1 seedling population density had permitted to intercept peak PAR followed by the interaction effect of SC-E, $0.2m^2$ and 1 seedling population density. NILs rice having erect culm habits, had fashioned higher PAR interception than SC-O (Table2). This finding is in line with Sinoquet H, Thanisawanyangkura S, Mabrouk H, Kasemsap P (1998) canopy structure significantly influences plant radiation interception through regulating the light distribution within the canopy. As the canopy is irregular and discontinuous, spatial heterogeneity effects should be taken into consideration when studying light distribution and interception characteristics in plant canopies.

The photosynthesis rate is getting limited when the population density reduces and plant spacing becomes wider. This might be happening due to that high senescence of leaf and poor chlorophyll content. Erect culm habit NILs rice develop good photosynthesis rate than open culm habit NILs rice. This indicates that the photosynthesis rate is influenced by culm angle which is $30^0$ erect and $60^0$ open beyond the leaf chlorophyll content, planting population density and spacing. The photosynthetic performance changes as the density increases (Ren et al., 2017). As light intensity is increased further the rate of photosynthesis is eventually limited by some other factors. For instance, at very high light intensity, chlorophyll may be damaged and the rate drops steeply. The more photons of light that fall on a leaf, the greater the number of chlorophyll molecules that are ionized and the more ATP and NADPH are generated. Increase in $CO_2$ concentration increases the rate at which carbon is incorporated in to carbohydrate through the light adapted reaction which increase the rate of photosynthesis. If carbon dioxide and light levels are high, when the population density increase and narrow spacing but temperature is low, increasing temperature and this will have the greatest effect on reaching a higher rate of photosynthesis. In the case of SC-O culm habit NILs rice the rate of photosynthesis is higher when the population density is higher (3 seedlings population density and $0.2*0.2m^2$ spacing) where as in SC-E the photosynthesis rate higher when the population density is reduced to 3 seedlings population density and $0.25*0.25m^2$ spacing.

The stomatal conductance highly influenced by population densities and spacing. However, the effect of culm habits clearly observed on the stomatal conductance, to out generated varied result between SC-E and SC-O NILs rice. In SC-E NILs rice 3 seedlings population density and $0.25*0.25m^2$ spacing generated maximum stomatal conductance particularly from 75 to 82 Days After Transplanting (DAT) and 96 DAT while in SC-O culm habit NILs rice treatments provided almost the same between 75 and 82 days after transplanting but at 96 DAT 1 seedling population density and $0.2*0.2m^2$ spacing produced the peak stomatal conductance. Canopy photosynthesis of culm habit NILs rice positively correlated with grain yield. Population density and spacing strongly affect culm habits of NILs rice photosynthesis and yield. SC-E NILs rice enhanced yield than SC-O culm habits due to increase PAR absorption, Chlorophyll content and LAI boost during the reproductive crop growth stage.

## VI. Conclusion

Photosynthetic activity of the leaf differed not only with cultivar but also with its position of culm architecture and Short culm erect culm habit near-isogenic lines rice had yielded maximum PAR, photosynthesis rate and canopy photosynthesis. Culm habits carry on yield variation between NILs rice by influencing photosynthesis efficiency and yield components. SC-E culm habit NILs rice increase yield than SC-O NILs rice. Culm habits and photosynthesis efficiency of NILs rice strongly affected by planting density.

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