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Research Paper

Growth Response of Culm Habit Near-Isogenic Lines Rice (*Oryza sativa* L.) to Different Planting Densities and Nitrogen Regimes

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ABSTRACT

Cultivars of culm habit NILs rice achieved from the crossing of Taichung Native 1 and Norin 29 after four successive back crossing display different morphological culm habits. The trial initiated on ambitions to satiate the gaps about the enactment of culm habit Near-Isogenic Lines rice SC-E and SC-O under different planting densities and nitrogen regimes and to characterize the impact of planting densities and Nitrogen regimes on the growth response of culm habit NILs rice. NILs rice SC-E and SC-O were subjected two population densities, two plant spacing's and two nitrogen regimes. Culm architecture resulted variation in yield and photosynthetic activity. Higher nitrogen fertilizer application increased grain yield and bio-mass production. Higher planting density had obtained higher leaf area index and Photosynthesis Active Radiation absorption. Higher planting density and 300 kg N ha^{-1} had gained strong correlation with grain yield of SC-E and SC-O. NILs rice at 3 seedlings planting population with 0.2*0.2m^2 spacing and 300 kg ha^{-1} nitrogen fertilization were showed significantly higher positive correlation between leaf area and grain yield. SC-E had showed high chlorophyll content even during physiological maturity stage under high planting density and 300 kg N ha^{-1}. Canopy photosynthesis potential increase for medium planting population density in SC-E culm habit NILs rice. Generally, culm architecture of Near-Isogenic Lines affects canopy photosynthesis and yield by influencing PAR, chlorophyll content, Leaf Area Index, Leaf Area and yield components. The growth and culm architecture of culm habit NILs rice strongly influenced by planting densities and nitrogen regimes.

Keyword: Culm habit NILs, planting density, Nitrogen regime, PAR, Canopy photosynthesis

1. INTRODUCTION

Rice in Ethiopia is a premeditated food security commodity to improve the lives of the poor and its expansion is linearly expanding in different parts of the country (MoA, 2010). The planting density, rate of nitrogen fertilizer plays fundamental role to increase the biomass and produce healthier plant. Fertilizer application times and rates have vital function in influencing plant growth and nutrient uptake (Sun L., 2012). However, excess nitrogen applications may not improve the population productivity fittingly, resulting in reduced nitrogen use efficiency and even in acidification of the soil (Guo JH, Zhang FS. 2010, Habtegebrial K, Singh BR, Haile M. 2007). Nitrogen is an essential component of both chlorophyll and Rubisco, the enzyme facilitating photosynthesis. A high nitrogen content in the leaf tissue allows the plant to have more chlorophyll and Rubisco, triggering a higher rate of photosynthesis (Osaki et al. 1995).

The crop plants depend largely on temperature, solar radiation, moisture and soil fertility for their growth and nutritional requirements. The tiller formation, solar radiation interception, total sunlight reception, nutrient uptake, rate of photosynthesis and other physiological phenomena and ultimately affects growth and development of rice plant. The photosynthetic enactment improves as the density intensifications (Ren B et al., 2017). A decreased rate of apparent photosynthesis in higher density due to decreased PAR (photosynthetically active radiation) and decreased chlorophyll concentration in higher densities *(*M Franic., 2015*)*. Erect leaves (large LIA) reduce shading by the upper leaves, allowing more light interception into the canopy for higher photosynthesis, denser planting with a higher leaf area index, and thus higher grain yield in rice (Kumura, 1995; Morinaka et al., 2006; Sakamoto et al., 2006; San-Oh, Yoshita, Ookawa, & Hirasawa, 2006; Sinclair & Sheehy, 1999). Increased plant density is unavoidable plorefrations of mutual plant shading which causes depression and greater competition for water and nutrients (Sangoi 2001, Marchiori et al.,2014). The rate of biomass production is determined by the rate of canopy photosynthesis, which consists of single leaf photosynthesis, leaf area index, and light interception efficiency. Light interception can be influenced by our choice of crops, row spacing, and planting geometry.

Culm habits of rice causes biomass accrual and yield due to the light interception and Photosynthesis Active Radiation (PAR). According to IRRI descriptor 1980 rice culm habits characterized by five general classifications of erect (<30^0), Semi-erect or intermediate (≤45^0), Open (≤60^0), Spreading (>60^0 < 80^0), procumbent (Culm angles rests on the ground). Culm habit regulates the genotype for responsiveness of nitrogen and light interception. Erect culm (< 30^0) allows to intercept light with in the canopy and avoid self-shading effect between individual plants. However, open culm (<=60^0) leads to protect the intercepted light within the canopy and decrease the responsiveness of nitrogen. Open culm habit strongly influences the tiller mortality rate by enhancing maximum self-shading and accelerating leaf senescence between individual plants. Genotype and plant type affect photosynthetic production by changing the canopy structure in crops. Optimizing crop canopy structure can improve canopy photosynthetic productivity and thereby crop yield potential (Feng et al.,2012).

2. MATERIALS AND METHODS

2.1 plant materials

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 transferred a common recurrent parent, Norin 29 (N29). NILs rice are the results from same strains after four successive back crossing of TN 1 and N29 are genetically identical except one or few loci and designated as SC-E and SC-O. However, obtained from the same strains of TN1(BC_5Fn) cross with N29(BC_5Fn) displayed different morphological culm habit characteristics.

Table 1. NILs rice genetic back ground, culm habit, and country of origin are described below.

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

2.2 Methodology

The experiment was carried out as a factorial combination of NILs rice (SC-E & SC-O), population densities (1 seedling and 3 seedlings), spacing ($0.2*0.2m^2$ & $0.25*0.25m^2$) and Nitrogen regimes (150 & 300 kg/ha). Seed treatment was done using both hot water (60^0c) for 10 minutes and fungicide (5g/lit) for three days. After a month growth in a nursery, 1 and 3 seedlings were transplanted in rice paddy field a spacing of 25 hills m^{-2} (20cm *20cm) and 16 hills m^{-2} (25cm *25cm). Nitrogen application was conducted with a level of

150 and 300 kgha^{-1}. Urea 46 % was asserted as a source of mineral nitrogen at transplanting and panicle initiation stage (PI). The experiment was laid out in a factorially arranged Randomized Complete Block Design (RCBD) with two replications.

Data Collection

3.1 Culm habit

Measuring of culm habit was carried out after flowering stage using protractor from five hills following IRRI descriptor. Treatment effects on culm habits of NILs rice cultivars used to characterize the impact of culm shape effects on light interception and grain yield.

Photosynthesis Active Radiation (PAR)

Photosynthesis Active Radiation (PAR) below canopy assessed at every 10cm height embarking from nethermost (10 cm height from the ground surface of plant), middle and top of the canopy using Accu PAR model Lp-80, PAR/LAI Ceptometer in a distinct crop growth stages to predict impact of culm shape due to different planting densities and nitrogen regimes on growth response and light interception of culm habit NILs rice. PAR measurement has been made in every 10cm of plant height for a total of 20 measurements and below and above canopy PAR interception reading completed at once in 1minute interval using external sensor.

Leaf Area Index (LAI)

Leaf area deliberation was carried out using portable area meter. The leaves of rice plants per plot were sampled and then area of these green leaves was determined by portable area meter (LI-COR, LI-3000A) and dried in an oven 70 ºC for 72 hours to evaluate specific leaf area (SLA). LAI for each plot was calculated using the ratio of green leaf area to dry mass. Total leaf per plot area were collected and dried in an over for 72 hrs. at 70 ^{0}C. LAI were conducted using the area of specific leaf (cm^2) and weight (g).

Chlorophyll content sampling

Chlorophyll relative content (SPAD value) was measured with a SPAD-502 Plus chlorophyll meter (Minolta, Japan), on a young and fully expanded functional rice leaf. Data was unhurried at vegetative and reproductive stages on ten plants per vegetative plots, on the 2nd, 3rd fully developed top leaves and flag leaf on 160 plants in total for all treatments by SPAD-502 plus (KONICA MINOLTA, made in Japan).

Data analysis

Collected data was analyzed using SPSS v16.02 software through analysis of variance (ANOVA). Difference between treatments and cultivars and their interaction were tested by the analysis of variance, F-test and t-test ($P<0.05$; $P<0.01$).

3. RESULTS

3.1 Culm habits

The analysis of variance revealed culm habits of NILs rice strongly relied on and influenced by Planting population, spacing and nitrogen. SC-O NILs had provided the highest culm habit followed by short culm erect. The synergy between planting population, spacing and nitrogen were showed significant ($P \leq 0.05$) difference on culm habits (Table 2). Rate of nitrogen fertilizer had strong significant impact on culm habits but weak association were found between planting population and spacing. Rate of nitrogen fertilizer 300kgha^{-1} had produced higher culm habits. Culm habits inclination ranged from 31.8^0 to 70.1^0 to the impacts of planting density and nitrogen regime treatments (Table 2). Increasing planting density 75 seedlings per m^2 and 300 kgha^{-1}N had increased culm shape inclination in open culm NILs rice. The result clarifies that overlapping of culm shape enhanced through the application of higher nitrogen and planting density. Erect morphology NILs was not significantly feigned when planting density and nitrogen amount reduce but a little change on culm shape inclination was observed increasing planting density and nitrogen regime.

3.2 Chlorophyll content

Low planting density and high nitrogen regime enhance the chlorophyll content. SC-E had obtained high chlorophyll content with the synergy of low plant density and high nitrogen fertilizer application (Table 2). Nitrogen application improved all the chlorophyll pigments, water related attributes and yield components. Insufficient nitrogen application and high plant density clues to a decrease in chlorophyll content and biomass production these results harmonize with inadequate N application leads to a decrease in leaf area (Fernandez et al.,1996), chlorophyll contents, leaf photosynthesis, biomass production (Zhao and Oosterhuis, 2000), and the loss of yields and qualities (Hu yang et al.,2014). Chlorophyll content influenced not only by nitrogen application and planting density relied on variety, growth stage, leaf thickness, leaf position and measurement point on the leaf. There was recorded significantly higher chlorophyll content between NILs rice SC-E and SC-O due to low plant density and high nitrogen application. The coaction of 1 seedling planting density per hill and application of 300kgha^{-1} were produced significantly higher chlorophyll content in NILs rice. However, SC-E was maintained high chlorophyll content on the synergy of low plant density and high nitrogen fertilizer application than open culm habit NILs rice. The variation of chlorophyll content between NILs may be due to leaf thickness afar morphological culm habits.

3.3 PAR

Interception and utilization of solar radiation in rice crop canopies and dry matter accumulation and yield influenced by leaf area. The relative PAR was maximum when nitrogen regime and planting density increase to the optimum level. Erect canopy NILs allows to intercept higher solar radiation to the soil surface in the interrow zone points. Light distribution and PAR interception modified by plant density, row spacing, orientation and plant architecture (culm habits). Due to the transmittance of high solar radiation to the lower strata individual plants verge to initiate more productive tiller and ceil biomass production. The interception and reflectance of PAR with in the canopy not only affected by management of plant but also predisposed by leaf area, plant density and row spacing. The extinction coefficient and azimuth angle also play a role to influence the transmittance and reflectance of PAR in the canopy. However, leaf area index plays an important role to maximize canopy light interception. Application of 300 kg N ha^{-1} was produced maximum relative photosynthesis Active Radiation in SC-O and SC-E NILs rice (Fig 1 and 2). In both SC-O and SC-E lower planting density interacted with 300 kg N ha^{-1} had increased PAR. However, in SC-O higher planting density and 300 kg/ha N_2 produced higher PAR similar to lower planting density and 300 kg/ha N_2 (Fig. 2). This result is supported by Mehdi Dahmardeh report in 2011, light interception was increased with increased plant density, under high plant density increased plant heights as well as light interception. Photosynthesis Active Radiation interception is strongly influenced by culm habit NILs rice, erect culm habit near-isogenic lines intercepted maximum PAR to the lower strata of the canopy than open culm habit NILs rice. PAR absorption strongly affected by planting density in erect culm habit NILs rice, particularly when the application of nitrogen regime decreases from 300 kg N ha^{-1} to 150 kg N ha^{-1}. Culm habit NILs rice, open and erect morphological traits strongly influence the absorption of PAR in response to planting densities and nitrogen regimes. SC-E culm habit NILs had produced significantly higher PAR from lower and higher planting densities with the application of 300 kg N ha^{-1}, but PAR absorption was declined on 150 kg N ha^{-1}. SC-O culm habit NILs rice had reduced PAR absorption at higher planting density and 150 kg N ha^{-1} application. This signposts that Photosynthesis Active Radiation absorption powerfully linked with culm architecture in addition to different planting densities and nitrogen regimes. PAR absorption is affected by the canopy in both NILs rice open and erect morphological culm habit characteristics, at the lower canopy diminished and the interception ceiled perpendicular to the canopy height. Relative percentage of PAR was similar between 1 seedling population density at 0.2*0.2m^2 spacing and 300 kg N ha^{-1}, 1 seedling population density at 0.25*0.25m^2 and 300 kg N ha^{-1} and 3 seedlings population density and 300kg N ha^{-1}. The interception of relative PAR (%) has reached steadiness 100% interception on the above canopy. The distribution of PAR in the leaf is affected by culm architecture and leaf angle distribution and this directly impact yield. NILs rice morphology and canopy structure, influence light interception and distribution in the canopy which is a determinant factor for crop yield production. This indicates that the culm habit characteristics improved by row planting and planting geometry to intercept light efficiently and to enhance the light intensity this improves the net photosynthesis rate per single leaf and photosynthesis efficiency.

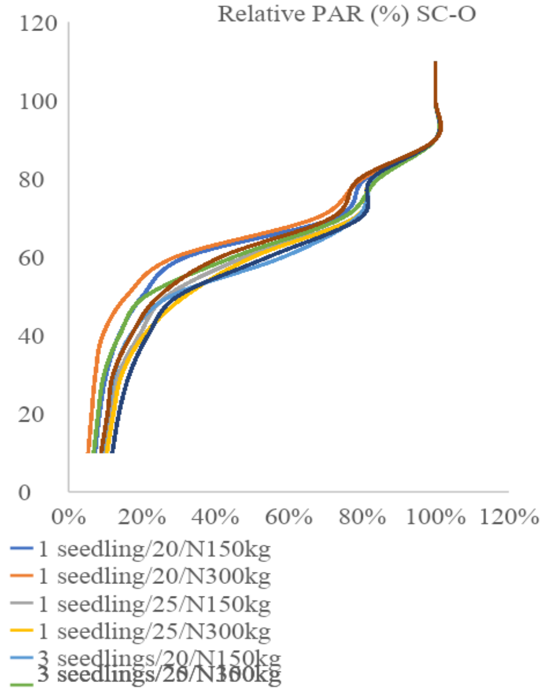

Fig. 1. Relative (%) of Photosynthesis Active radiation (PAR) in SC-O culm habit NILs rice chronicled to different planting densities and nitrogen regimes

Generally, relative photosynthesis Active Radiation of culm habit NILs rice SC-E and SC-O strongly linked with planting densities and nitrogen regimes, particularly 300 kg N ha^{-1} improves the absorption of PAR by improving leaf area and canopy height this enhance the physiological growth indices.

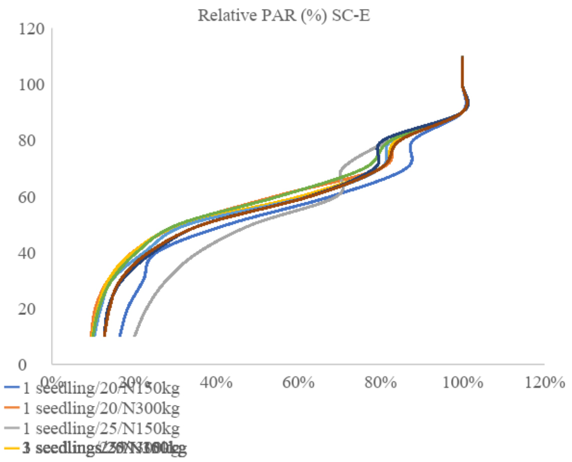

Fig. 2. Relative (%) Photosynthesis Active Radiation (PAR) in SC-E chronicled different planting densities and nitrogen regimes.

3.4 LAI

Leaf area index increased with nitrogen application and higher planting density. The increased LAI to high planting density and nitrogen regime might have been due to increase the number of shoots and top dry weight during maximum tillering stage. Nitrogen deficiency may also influence the development of canopy and light interception as it decreases the leaf area. The result responds that LAI increased on erect culm habit NILs, when the plant density increase and higher nitrogen application. However, low planting density and high nitrogen application had yielded reasonable LAI to high plant density and nitrogen application. The decrease of LAI in SC-O NILs in high plant density and nitrogen application may be due to open culm and high self-shading effect which enhance senescence of lower leaf during active tillering stage. The optimal leaf area index values depend on growth stage, plant type and PAR (Tanaka et al., 1966), cultivars with erect leaves have a higher optimum LAI than those with horizontal leaves (Yoshida, 1981). However, the LAI between SC-E and SC-O had fashioned similar trend of increasing from the optimum planting density (48 seedlings per m^2) and 300 kg N ha^{-1} and slight increase was showed on SC-E NILs rice and the results in line with the report from Yan et al. (2012) erect leaves increase leaf area index, this may increase the capture of light for photosynthesis and nitrogen use in dense planting.

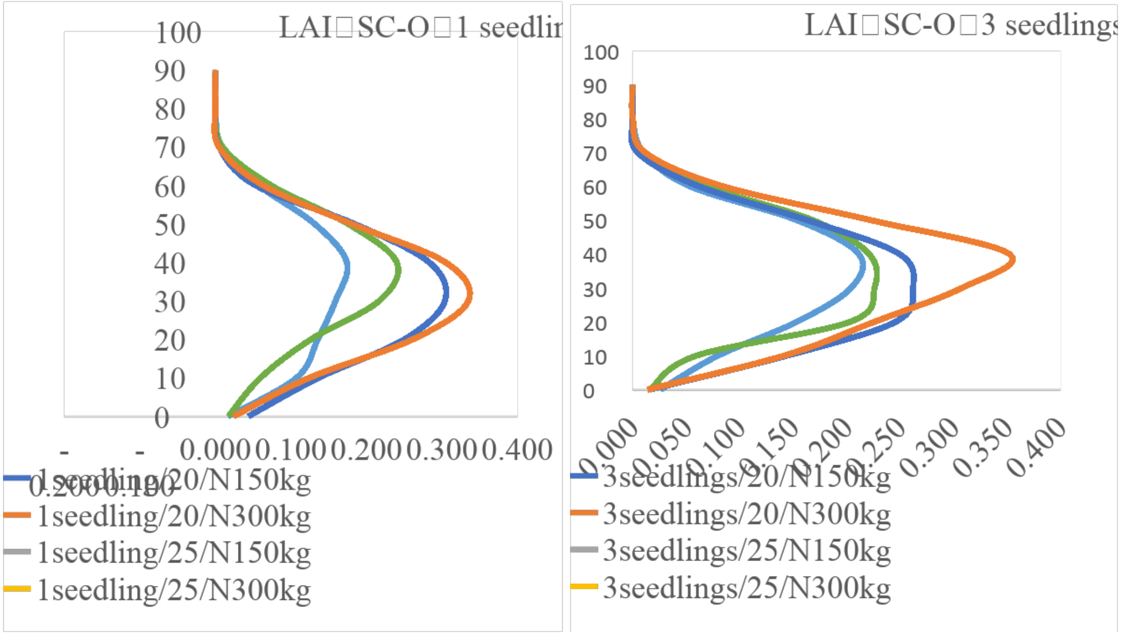

Fig. 3. LAI of SC-O NILs response to different planting densities and nitrogen regimes conducted active tillering stage

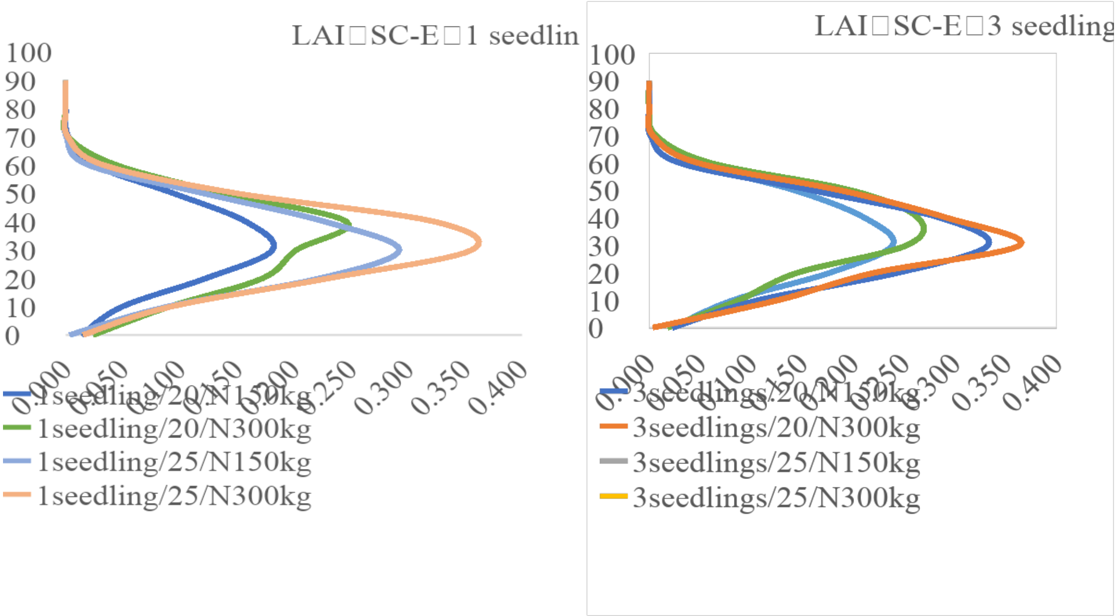

Fig. 4. LAI of SC-E NILs response to different planting densities and nitrogen regimes conducted at active tillering stage.

NILs and nitrogen were produced highly significant ($P \leq 0.01$) difference for leaf area, whereas planting density found non-significant variation (Fig 3 and 4). There was significantly ($P \leq 0.01$) higher leaf area produced from erect morphology NILs rice. The inclusive synergy of NILs, Planting density and nitrogen had recorded significant difference for leaf area. SC-E had raised (52.9cm^2) leaf area for high planting density and nitrogen regime, whereas SC-O was found 43.6cm^2 for high planting density and nitrogen regime. Biomass yield and plant height have been found to increase with increase in plant density and N rate, thus increasing the leaf area (Modarres et al., 1998; Catherine et al., 2016). The increase in leaf area may be due to high rate of nitrogen application that clues to more rapid leaf area development, prolong life of foliage, increase leaf area duration after flowering and enhance on the whole crop assimilation.

3.5 Plant height

NILs, SC-E and SC-O had recorded strong significant variation for plant height. Nitrogen application (300 kg ha^{-1}) presented a significant increment of plant height in NILs rice growth (Table 2). However, a significant reduction of growth was observed on culm habit NILs rice due to the application of 150 kg ha^{-1} nitrogen.

3.6 Culm length

Significantly higher culm length difference between NILs and nitrogen regimes but plant density produce non-significant difference (Table 2). High fertilizer application nitrogen vastly examined to increase the growth of internode length at early growth stage of rice. Synergy of planting density and NILs were obtained highly significant difference but inclusive synergy of NILs, planting density and nitrogen regime were showed non-significant difference ($P \leq 0.05$). The non-significance difference of culm length between NILs rice may be due to nitrogen effect on lengths of the internodes, final number of leaf primordia on the main culm and number of elongated internodes which develops short photoperiods.

3.7 Tiller number

NILs had strong significant change for the number of tillers between planting density and nitrogen regimes. There was an observed reduction in tiller number under low fertilizer regimes and planting density between varieties (Table 2). SC-O and SC-E reduce tiller number on the interaction of low planting density and nitrogen may be due to incapability of biomass production per unit area and leaf area index closely linked with culm shape which influence light intensity and CO_2 concentration (Zhong et al., 2002). Leaf area index probably affects tillering by attenuation of light intensity and /or by influencing light quality at the base of the canopy where tiller buds and young tillers are located. Higher planting density and nitrogen regime increase tiller number by improving the uptake of water and sufficient food and initiating cell division for meristematic tissue. SC-E NILs rice formulate maximum tiller number in increasing planting density and nitrogen due to erect canopy stature, leaf insertion angle and success full interception of solar radiation to the lower strata. Numbers of tillers per M^2 were significantly increased by interaction effect of 3 seedlings planting population and 0.2*0.2m^2 spacing and 300 kg ha^{-1} N fertilization in SC-E NILs rice. Non-significant variation was observed between nitrogen regimes at 0.25*0.25 m^2 spacing and 3 seedlings planting population for number of tillers per m^2 in SC-E NILs. Similarly, in SC-O NILs variety there was highly significant variation between planting density and nitrogen regimes, however, under high planting population and high nitrogen fertilizer application spacing had resulted non-significant difference $P \leq 0.05$. Furthermore, the inclusive interaction effect of planting densities and nitrogen regimes were provided significant difference.

Yield and yield components

SC-E had given significantly higher yield (18.4) between the synergy of higher planting density (3 seedlings with 0.2*0.2m^2) and 300kgha^{-1} N regime application. Under high planting density and nitrogen regime SC-O showed a high significant difference in yield (16.1) following by high planting density and nitrogen regime in SC-E NILs rice. The results revealed 3 seedlings planting density and 0.25*0.25m^2 spacing with presentation of high nitrogen regime had boosted yield. These might have been the highest number of tillers which maintained productive tillers and filled spikelets for a fundamental contribution of yield improvement. However, dwindled yield (10.1) was established from SC-E with the coaction effect of 3 seedlings planting density and 0.25*0.25m^2 spacing and low planting regime. The yield of NILs rice to high planting density synergized with low and high nitrogen regimes differed significantly P≤0.05 with the respective treatments low planting density with low and high nitrogen regimes. NILs had given non-significate difference P≤0.05 for panicle number, whereas planting density and nitrogen regimes produced significantly higher panicle number per unit area. However, the coaction of planting density, NILs and nitrogen regimes has no effect on panicle number per m^2. Significantly higher filled spikelets were found from the synergy effect of planting density, NILs and nitrogen regimes. Filled spikelets were maximum from SC-O NILs rice. However, filled spikelets per panicle were boosted (137.3) from low planting density and high nitrogen regimes and higher planting density and low nitrogen regime application (137.2). SC-E had recorded low filled spikelets per panicle (95.6) for high planting density and low nitrogen regime. Higher planting density and nitrogen regime had decreased yield (105.8) in SC-E compared with filled spikelets yield (131.6) in SC-O for higher planting density and nitrogen application. Percentage of filled spikelets was provided non-significant difference between planting density and nitrogen regimes. However, the general interaction effect between planting density, nitrogen regimes and NILs had yielded significant difference P≤0.05. This is due to that grain filling is determined not only by total availability of carbohydrates during the grain filling period but also by sink ability for accumulating carbohydrates. The 1000-grain weight was strongly influenced by NILs and planting density. SC-E had showed higher 1000-grain weight (25.5) and SC-O had provided the lowest (23.1). However, nitrogen regimes were showed non-significant difference P≤0.05. Generally, the coaction effect of planting density, nitrogen regimes and NILs rice were recorded non-significance differences.

Correlation between number of panicles and grain yield

A strong significant positive relationship was spotted between number of panicles per unit area and grain yield (r=0.88**). The correlation implies that the number of panicles has pronounced significance impact to improve grain yield of culm habit NILs due to planting densities and nitrogen regimes.

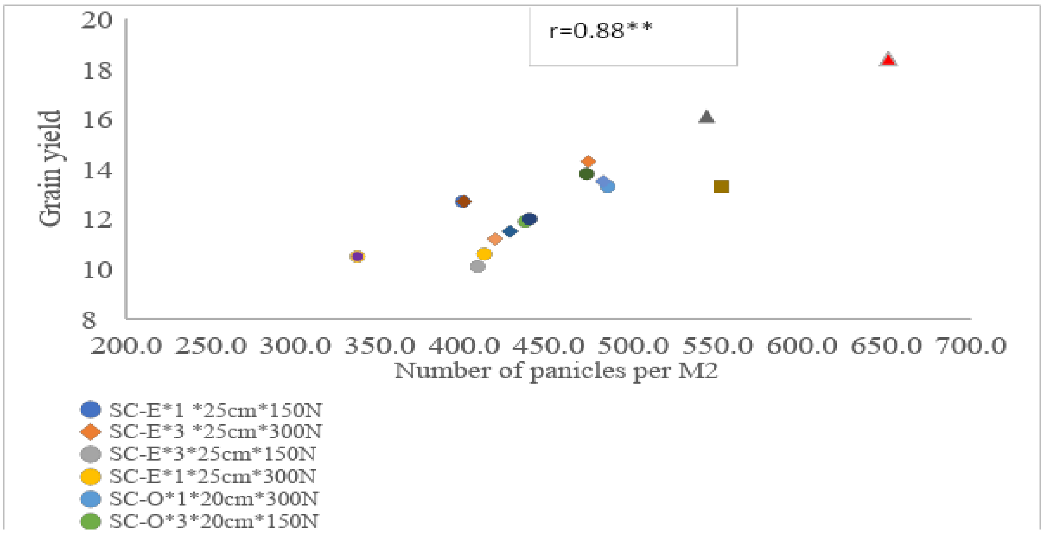

Fig. 5. Relationship between number of panicles per unit area and grain yield for the response of planting densities and nitrogen regimes. ** indicates that correlation is highly significant at 0.01 probability level.

Correlation between leaf area and grain yield

There was a significant positive correlation (r= 0.54*) between leaf area and grain yield due to the impact of planting densities and nitrogen regimes. The area of leaf culm habit NILs rice was improved by 300 kg N ha^{-1} application and this plays a vital role to improve the physiological growth indices.

Table 2. ANOVA for comparison means synergy effect planting density and nitrogen regimes on growth parameters.

NILs	Density	Spacing	Nitrogen	PH (cm)	TN(No)	CL (cm)	Ch (0)	LL (cm)	LW (cm)	LA (cm^2)	Chl (SPAD)
SC-E	1 seedling	25cm*25cm	150kg	76.9	24.6	51.3	31.8	41.8	0.9	28.3	37.4
			300kg	81.5	25.8	54.1	40.2	42.8	1.1	36.3	41.1
		20cm*20cm	150kg	78.5	17.4	51.7	32.1	41.6	1.1	33.1	35.8
			300kg	81.0	18.9	54.0	35.7	42.5	1.2	36.6	37.9
	3 seedlings	25cm*25cm	150kg	82.4	25.1	52.8	36.5	42.8	1.0	32.8	36.8
			300kg	80.8	25.0	54.6	33.4	45.5	1.0	35.0	37.4
		20cm*20cm	150kg	76.8	21.1	52.2	32.7	42.0	1.1	35.6	36.5
			300kg	82.9	28.5	54.9	33.5	50.7	1.4	52.9	38.4
SC-O	1 seedling	25cm*25cm	150kg	83.7	16.9	54.1	57.9	44.9	1.2	41.1	38.7
			300kg	78.6	24.7	55.4	66.4	44.7	1.4	45.3	40.2
		20cm*20cm	150kg	81.6	18.6	55.5	55.7	45.3	1.3	44.1	37.2
			300kg	84.1	19.4	57.3	65.1	44.5	1.1	37.8	38.4
	3 seedlings	25cm*25cm	150kg	81.1	20.1	54.3	56.1	41.6	1.3	39.6	33.8
			300kg	86.2	25.2	60.1	63.5	46.5	1.3	44.7	36.3
		20cm*20cm	150kg	82.1	21.5	53.8	45.0	41.5	1.3	40.2	32.6
			300kg	82.1	25.4	54.5	70.1	45.4	1.3	43.6	37.8
		Interactions		P≤0.05							
		NILs		**	**	**	**	ns	**	**	ns
		Density		**	*	ns	**	*	**	ns	**
		Spacing		ns	**	ns	**	ns	**	ns	ns
		Nitrogen		**	**	**	**	**	**	**	**
		NILs*Density		*	**	**	*	**	**	ns	**
		NILs*Spacing		ns	ns	ns	ns	ns	ns	*	ns
		NILs*Nitrogen		**	ns	ns	ns	ns	**	*	ns
		Density*Spacing		**	**	*	ns	ns	**	ns	ns
		Density*Nitrogen		ns	**	ns	ns	**	**	ns	ns
		Spacing*Nitrogen		**	ns	ns	ns	ns	ns	ns	*
		NILs*Density*Spacing		ns	ns	*	ns	ns	ns	ns	*
		NILs*Density*Nitrogen		**	*	ns	*	ns	ns	ns	*
		NILs*Spacing*Nitrogen		ns	*	ns	ns	*	**	*	ns
		Density*Spacing*Nitrogen		ns	ns	ns	ns	ns	**	*	ns
		NILs*Density*Spacing*Nitrogen		**	*	ns	ns	*	ns	*	*

Where, PH= plant height, TN=Tiller number, CL= Culm length, Ch= Culm habit, CHll=chlorophyll content, LL=leaf length, LW=leaf width, LA=leaf area, ns=non-significant, *=significant (P≤0.05), **= significant(P≤0.01)

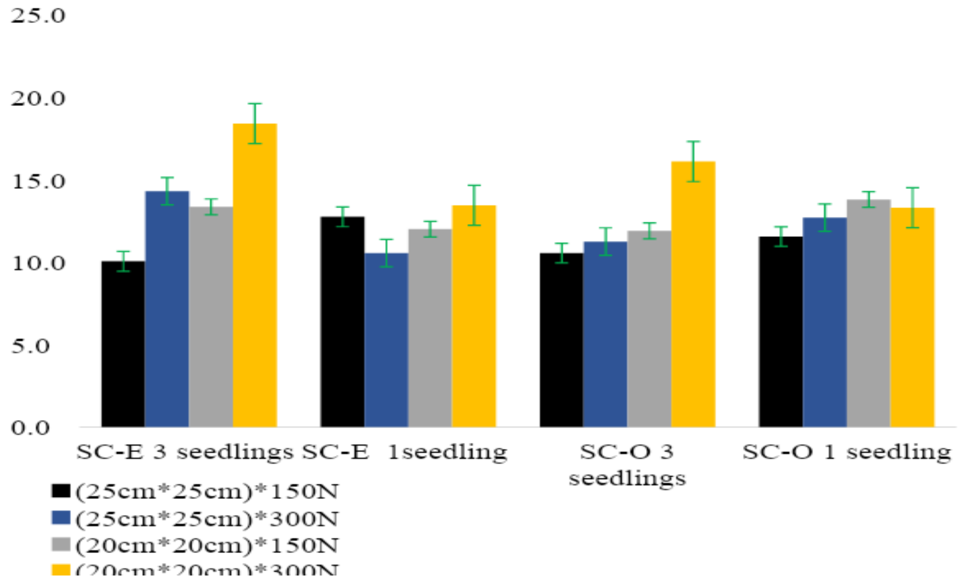

Fig. 6. Impact of planting density and nitrogen regimes on grain yield of culm habit near isogenic lines rice.

DISCUSSION

Culm habit NILs rice variety SC-E grown under high planting density (75 seedlings per m^2) and nitrogen regime ($300kgha^{-1}$) produced virtuous yield but SC-O under the same planting density and nitrogen regime reduced. Culm architecture with high planting density and nitrogen regime certainly reduced yield of rice. Upright leaf architecture, a trait that sustains efficient light capture under denser planting performs (Duncan,1971; lambert and Johnston,1978) led to significant improvements in grain yield (Pendleton et al., 1968; Duvick, 2005; Josh et al., 2017). Planting densities have been found to contribute towards significant increase in grain yield (Cardwell, V. B., 1992). Nitrogen can affect crop yields through its influence on the yield components per unit area. Grain yield and yield components were significantly hiked by the application of 300 kg N ha^{-1}; however, in SC-E yield and yield components between high planting density (75 seedlings planting density and low planting density (16 seedlings) with application of 300 kg N ha^{-1}. Previous studies demonstrate that Planting density has proven a very effective agronomic strategy to improve grain yield (Ciampitti and Vyn,2012). The yield improvements were realized by adopting more efficient technologies and improved N fertilizer management (Zhang et al., 2015). SC-E required high LAI than SC-O and this may have complemented its ability to generate yield under high planting density and nitrogen. This might have been due to the response to nitrogen fertilizer and light interception and slower leaf senescence. Previous findings support this result grain yield advantage in erect habit independent of efficiency of converting solar radiation into dry matter, crop growth rate, extinction coefficient, and leaf area index (Apichart., 1990). Leaf architecture directly influences canopy structure, consequentially affect yield (Josh et al.,2017). Grain yield (16.1) was boosted from SC-O on interaction effect of higher planting density and 300kg N ha^{-1}. Generally, SC-E produced significantly higher grain yield on the synergy effect of higher planting density and nitrogen regime. NILs, planting density and nitrogen fertilizer application were produced highly significant difference for culm habits. The inclusive synergy effect of NILs, Planting density and nitrogen regime were not significant difference $P \leq 0.05$. Culm habits was maximum on SC-O but lower culm habits were recorded from SC-E. Therefore, there was highly significant difference between 1 seedling and 3 seedlings population density and highly significant variation was found between 150 and 300 kg N ha^{-1}. Maximum culm habit (70.1^0) was recorded from SC-O with the synergy effect of 3 seedlings population density and $0.2*0.2m^2$ spacing and application of 300 kg N ha^{-1}. The maximum culm habit was obtained from the interaction effect of 1 seedling population density and $0.25*0.25m^2$ spacing and 300 kg N ha^{-1} application. Higher nitrogen fertilization had increased culm inclination of NILs, this might have been due to that N has effect on increment of internode length and biomass accumulation. Nitrogen fertilization has effect on alteration of culm architecture on NILs particularly increasing nitrogen fertilizer until optimum level increase culm inclination and overlapping of individual plants this increase the depletion of Rubisco and chlorophyll content which fasten leaf senescence. PAR interception strongly related and affected by morphological and physiological response of culm habit NILs rice. Improving morphology is the main factor to promote light use efficiency per plant which influence canopy morphology, light interception and ultimately yield. PAR absorption was maximum on SC-E culm habits due to erect morphological canopy that allows to receive more light to the lower strata, but SC-O culm habits inhibit distribution of PAR to the lower strata. In a crop canopy factors such as plant shape, plant populations, and row width affect leaf distributions, PAR interception and yield

(Stewart et al., 2003). PAR absorption increased under higher planting density due to a decrease in leaf area, leaf sheath and internode mass. The interaction effect between higher planting density (75 seedlings per m^2) and nitrogen regime (300kg N ha^{-1}) boosted PAR absorption at mid-canopy of plant height in SC-E NILs rice. Higher planting density had no effect on the improvement of chlorophyll content of NILs rice. Increasing nitrogen fertilizer to the optimum level has significant effect on the amendment chlorophyll content NILs. SC-O had recorded stumpy chlorophyll content on interaction effect of lower planting density and higher nitrogen fertilizer application. The chlorophyll content of SC-E was boosted (41.1) on synergy effect of 1 seedling planting population and 0.25*0.25m^2 spacing and 300 kg N ha^{-1} application. Nitrogen leaf statue has a closely relationship with photosynthesis rate and biomass production and it can control the photosynthesis and crop growth rate but chlorophyll content affected by fertilizer management and application time, variety type, plant density, light intensity in growth season, diseases and environmental stresses (Hussain et al., 2000; Stevens et al., 1999; Turner and Jund,1994). The minimum chlorophyll content (32.6) was obtained from SC-O by the synergy effect of 3 seedlings planting population and 0.2*0.2m^2 spacing and application of 150 kg N ha^{-1}. LAI was higher in treatments containing higher planting density (75 seedlings per m^2 and nitrogen regime (300 kg N ha^{-1}). The availability or deficiency of nitrogen also determines the leaf area index of crops, since it is very essential for proper leaf formation, and thus very important in the determination of the photosynthetic ability of the crop, and hence productivity. Higher nitrogen rate application had increased LAI particularly during active tillering and heading stage in SC-E NILs rice. SC-O had generated stumpy LAI for high planting density and nitrogen application probably due to degraded Rubisco and chlorophyll content during heading stage. Ren B, et al., 2017 reported that LAI increased with increasing plant density. The leaf area of NILs grown under higher planting density and nitrogen regime was adversely affected since the values of leaf area grown under higher planting density and nitrogen higher than lower planting density and nitrogen regime. This finding has in line with Valentinuz et al.,2006 who studied effect of genotypes, planting density, spacing and nitrogen regime on maize reported that leaf area may be decreased by N deficiency, depending on the severity and leaf breadth decreased under high soil nitrogen level and high plant density, while leaf area and yield increased with a higher rate of nitrogen. NILs rice SC-E and SC-O reduced significantly leaf area to lower planting density and nitrogen regime. This implies that higher nitrogen fertilizer application has higher ability to produce more leaf area per plant. The leaf area was reduced (28.3) on SC-E by the synergy effect of l seedling planting population and 0.25*0.25m^2 spacing and 150 kg ha^{-1} N fertilization. On the other hand, leaf area was increased (50.7) from SC-E by coaction effect of 3 seedlings planting population and 0.2*0.2m^2 spacing and 300 kg N ha^{-1}. Treatments in SC-O had led significantly higher leaf area yield compared with the treatment effects on SC-E even if the maximum was recorded from SC-E. This finding agrees with that an increase in leaf area can be due to the production of an enlarged primordium during the initiation at the meristem and/or to a progressive increase in size resulting from a faster and/or a prolonged growth period as reported by Nathalie et al., 2010.

Positive correlations between leaf area and grain yield for NILs, planting densities and nitrogen regimes. Significantly positive ($r=0.54^*$) correlation was recorded from 3 seedlings planting population with 0.2*0.2m^2 spacing’s and 300 kg ha^{-1} nitrogen regimes in SC-E followed by 3 seedlings planting population with 0.2*0.2m^2 spacing’s and 300 kg ha^{-1} nitrogen application for SC-O. Berdahl et al., 1972; Ahmad et al., 2015 reported that larger leaf area constitute higher grain yield by improving photosynthesis rate when its conducted under field conditions. Another finding reported by Gallagher et al., 1978; Jiang et al., 2015, Driever., 2014 leaf area and its position in the canopy influence the relationship between yield, cereal growth, and photosynthesis and maximizing photosynthetic rate could be achieved by expanding leaf area in wheat and rice. SC-E NILs rice variety with 3 seedlings planting population and 0.2*0.2m^2 by the application of 300kg N ha^{-1} had exhibited strong correlation for grain yield and number of panicles. However, grain yield and panicle number also revealed a strong positive correlation in SC-O with an increasing planting density and Nitrogen regime.

CONCLUSION

Application of nitrogen fertilizer increase grain yield of NILs rice. This is because, presence of nitrogen reliefs in developing leaf area and canopy height because of increase in the physiological growth indices. Nitrogen fertilizer increase culm habits and interception of PAR in NILs rice. Photosynthesis Active Radiation interception boost in SC-E NILs rice and within the canopy height the response of PAR relative interception varies. Photosynthesis Active Radiation absorption at the lower strata of Pant height reduce and increase at the middle and top of plant height. NILs rice which display various morphological culm habits respond yield cyst when the planting density increase to the limit and nitrogen regime 300 kg N ha^{-1}. Higher planting density contributes a role to grain yield by increasing absorption of PAR. Application of higher rate of 300 kg N ha^{-1} achieves maximum biomass and PAR absorption. NILs rice SC-E and SC-O increase yield on the interaction effect of 75 seedlings planting density per unit area (3seedlings planting population with 0.2*0.m^2 spacing) and conducting 300 kg ha^{-1} nitrogen fertilizer. SC-E NILs rice enhance yield than SC-O culm habits due to hike PAR absorption, Chlorophyll content and LAI during the reproductive crop growth stage. Planting density improves intensity of light this leads to enhance, canopy photosynthesis and grain yield. Canopy photosynthesis strongly correlated to grain yield of SC-E NILs rice to medium planting densities. Higher nitrogen rate application hike LAI particularly during active tillering and heading stage in SC-E NILs rice. SC-O generate stumpy LAI for high planting density and nitrogen application due to degraded Rubisco and chlorophyll content during heading stage. Larger leaf area constitutes higher grain yield by improving photosynthesis rate when its conducted under field conditions with proper fertilizer application and planting population. Culm habits has important role for light interception to the lower strata of plant canopy and to speed up leaf senescence and shading effect of NILs rice for planting density above optimum and nitrogen regime.

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REFERENCES

1. Cardwell, V. B. Fifty years of Minnesota corn production: sources of yield increase. Agron. J. (1992), 74, 984–995.
2. Ciampitti, I. A., and Vyn, T. J. Physiological perspectives of changes over time in maize yield dependency on nitrogen uptake and associated nitrogen efficiencies: a review Field Crops Res (2012), 133, 48–67.
3. Driever, S.M.; Lawson, T.; Andralojc, P.J. Raines, C.A.; Parry, M.A.J. Natural variation in photosynthetic capacity, growth, and yield in 64 field-grown wheat genotypes. J. Exp. Bot. 2014, 65, 4959–4973.
4. Gallagher, J.N.; Biscoe, P.V. Radiation absorption, growth and yield of cereals. J. Agric. Sci (1978), 91, 47–60.

5. International Rice Research Institute (IRRI) descriptor (1980).
6. Jiang, D.; Fang, J.; Lou, L.; Zhao, J.; Yuan, S.; Yin, L.; Sun, W.; Peng, L.; Guo, B.; Li, X. Characterization of a null allelic mutant of the rice nal1 gene reveals its role in regulating cell division (2015).
7. Marchiori, P.E.R., Machado, E.C., Ribeiro, R.V. Photosynthetic limitations imposed by self-shading in field-grain sugarcane varieties field crops research (2014), 155: 30-37.
8. Mehdi Dahmardeh. Effect of Plant Density and Nitrogen Rate on PAR Absorption and Maize Yield. American Journal of Plant Physiology (2011), 6: 44-49.
9. Ministry of agriculture (2010).
10. Modarres, A. M., Hamilton, R. I., Dijak, M., Dwyer, L. M., Stewart, D. W., Mather, D. E., Smith, D. L. Plant density effects on maize inbred lines grown in short season environments. Crop Science (1998), 38, 104–108.
11. Modarres, A. M., Hamilton, R. I., Dijak, M., Dwyer, L. M., Stewart, D. W., Mather, D. E., Smith, D. L. Plant density effects on maize inbred lines grown in short season environments. Crop Science (1998), 38, 104–108.
12. Nathalie Gonzalez, Stefanie De Bodt, Ronan Sulpice, Yusuke Jikumaru, Eunyoung Chae, Stijn Dhondt, Twiggy Van Daele, Liesbeth De Milde, Detlef Weigel, Yuji Kamiya, Mark Stitt, Gerrit T.S. Beemster, Dirk Inzé. Increased Leaf Size: Different Means to an End, systems biology, molecular biology, and gene regulation (2010), Vol. 153, pp. 1261–1279.
13. Oaks, A., Hirel, B. Nitrogen metabolism in roots. Annu. Rev. plant physiol (1985). 36, 345- 365.
14. Ren B, Liu W, Zhang J, Dong S, Liu P, Zhao B. Effects of plant density on the photosynthetic and chloroplast characteristics of maize under high-yielding conditions (2017), 104(3-4):12.
15. Valentinuz, O. R., Tollenaar, M. Effect of genotype, nitrogen, plant density and row spacing on the area-per-leaf profile in maize. Agron. J (2006), 98, 94–99.
16. Wolf J., Ouattara K., & Supit I. Sowing rules for estimating rainfed yield potential of sorghum and maize in Burkina Faso. Agricultural and Forest Meteorology (2015), 214–215,208-218.
17. Zhang L., van der Werf W., Bastiaans L., Zhang S., Li B., Spiertz J.H.J. Light interception and utilization in relay intercrops of wheat and cotton. Field Crops Res (2008), 107: 29–42.

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