論　文　の　内　容　の　要　旨

生産・環境生物学　専攻
平成 18 年度博士課程　入学
氏　　　名　　張　丙林
指導教員名　　山岸　順子

論文題目　**Studies on panicle characters and yield in relation to panicle numbers in rice cultivars**

（イネ品種における穂形質と収量およびその穂数との関係に関する研究）

The yield in cereals is determined by the yield components, panicle number, spikelet number per panicle, percentage of ripened grain and 1000-grain weight, and the achievement for high yield in rice is necessary and effectively through the improvement in these yield components. However, the relations among the components always have the strains each other on the achieving high yields, especially the relation between the panicle number (tiller number) and grain (spikelet) number per panicle. And spikelet number per panicle would influence on the grain ripening and single grain weight. So it is essential that to clarify the relations among the yield components, specially the relations between the tiller number and the spikelet number per panicle before heading stage since the panicle number per m^2 and spikelet number per panicle have been determined before anthesis. The spikelet number per panicle is the difference between differentiated spikelet number per panicle and aborted spikelet number per panicle before anthesis. The increase of differentiated spikelet number per panicle and decrease of aborted spikelet number per panicle are necessary to increase the spikelet number per panicle. So the response of differentiated or aborted spikelet number per panicle to panicle number should be studied in rice. On the other side, the variation of spikelet number per panicle within plant is another factor influencing on the average spikelet number per panicle, since the differences about the spikelet number per panicle among the tillers are exist. In this thesis, the determination of spikelet number per panicle in relation to panicle number was studied from (1) the response of spikelet number per panicle on each panicle within plant to panicle number variation; (2) the response of spikelet number per panicle on each panicle within plant to transplanting density; (3) the effects of spikelet number per panicle on the grain yield and yield components

Chapter 1 The spikelet number per panicle and its variation within plant in 16 rice cultivars

The average spikelet number per panicle (SPP), differentiated spikelet number per panicle (D-SPP), and preflowering aborted spikelet number per panicle (A-SPP) in a plant, and their variations within plant on the each panicle were investigated in 16 rice cultivars in 2005 and 2006. There was magnificent genetic difference about SPP, D-SPP, and A-SPP on both averages and on main stems. The cultivars with larger panicle on main stems always had larger panicle on average in SPP, D-SPP and A-SPP, indicating that there were closely positive relations between the main stem and tillers about SPP, D-SPP, and A-SPP. The negative relationships were observed in panicle number hill $^{-1}$ and SPP, D-SPP, and A-SPP. According to the panicle order, relative SPP on tillers to that panicle on main stem, D-SPP were declined, however, the spikelet abortion percentages were increased. The SPP and D-SPP reduced on average to 35% and 46% of respective main stem panicles. Panicles on tillers showed greater variation in SPP than D-SPP, due to the high variation in A-SPP. Larger SPP on main stem increased the variation of SPP within hill, but not D-SPP, and the lower A-SPP on main stem reduced the variability of A-SPP in tillers. This indicated that the assimilates supplying relations among the tillers would affect on the spikelet number per panicle.

Chapter 2 The response of spikelet number per panicle to transplanting density and its influence on yield in rice

Spikelet number per panicle (SPP), differentiated spikelet number per panicle (D-SPP), and preflowering aborted spikelet number per panicle (A-SPP) were examined in five rice cultivars (Akihikari, IRAT109, Nipponbare, Akenohoshi, IR65564-44-51 (NPT65)) under three planting densities (HD; high, MD; medium, LD; low planting density) in the field condition. Rice plants at LD produced a higher panicle number per plant but lower panicle number per unit area, accompanied by higher D-SPP and SPP, on average. A-SPP and the ratio of A-SPP to D-SPP (A%) showed no consistent trends. There was a broader range of D-SPP values at LD than at HD because of higher D-SPP in lower order panicles. D-SPP declined as panicle order increased in all cultivars and years, whereas A% increased. D-SPP and SPP of each panicle were positively correlated with tiller size (tiller height, leaf area, and neck internode diameter).

Spikelet production efficiency for D-SPP or for SPP (D-SPP or SPP per leaf area) of each tiller was higher in NPT65 and Akihikari than other cultivars, indicating a greater capacity of tillers to produce spikelet or support spikelet growth. In each cultivar except NPT65, spikelet production efficiency for D-SPP increased as panicle order increased, whereas spikelet production efficiency for SPP remained constant or decreased. This finding indicates that, irrespective of planting density, higher order panicles produce more spikelets than they can afford physiologically, but they were regulated downward to a nearly constant value in four cultivars. In NPT65, different from other cultivars, spikelet production efficiency for D-SPP decreased with panicle order increase.

Spikelet number per panicle was larger in LD than in HD. This was because of the larger tiller size in leaf area, shoot dry matter in LD than in HD. There was clear compensation of spikelet number per panicle increase to the panicle number m^{-2} reduction. So the spikelet number per m^2 and grain number per m^2 kept stable on varying transplanting density. The filled grain percentage was constant. There was a little higher yield production in HD than in LD, because of higher 1000 grain weight. The yield and its components showed clearly higher on primary rachis branch than on secondary rachis branches. As a conclusion, although the grain number per m^2 kept constant, the more grain number on the secondary rachis branch should be responsible for the lower yield in low transplanting density.

Chapter 3 The response of spikelet number per panicle and yield to transplanting density with root restriction in rice

As the indication of Chapter 2, the smaller tiller size in terms of tiller height, leaf area per tiller and dry matter per tiller due to the dense planting density resulted into the smaller spikelet number per panicle in high transplanting density (HD) than in low transplanting density (LD), so the possible root function in this response was studied by the root restriction treatment (RRT), a horizontal restriction treatment on root rhizosphere size. The spikelet number per panicle, yield and nitrogen accumulation were examined under two planting density with RRT using two Japonica cultivars, Akihikari and IRAT109, in 2007 and 2008. The above ground dry matter, yield, nitrogen accumulation per unit area were not differed in both planting density without RRT. However, RRT reduced above ground dry matter, yield, nitrogen accumulation, and panicle number per unit area evidently in LD, though the reductions were very weak in HD. Spikelet number per panicle was decreased significantly by RRT in LD than in HD, through the reduction in differentiated spikelet number per panicle (D-SPP). These reductions of above ground dry matter, yield and spikelet number per panicle were elucidated by the amount of nitrogen accumulation. Therefore, it is indicated that the effects of planting density on spikelet number per panicle and yield were by the nitrogen accumulation with below ground parts than the light shading on aerial parts. The different responses were observed in two cultivars in yield related characteristics in LD with RRT indicated that the strategies to limited nitrogen availability were dependent on cultivars.

Chapter 4 QTLs analysis for spikelet number per panicle under two nitrogen conditions

As the indications from Chapter 2 and 3, the planting density had effects on the spikelet per panicle, mainly through effecting on the nitrogen accumulations from soil. And also, in Chapter 3, it was verified that there was genetic difference in the response of spikelet per panicle to nitrogen condition in the soil. So in this Chapter, by using BC_1F_8 and BC_1F_9 of a 105BILs, inbred lines from a cross of Akihikari (temperate *Japonica*) × IRAT109 (tropical *Japonica*)**,** QTLs for spikelet number per panicle (SPP), and their components: primary rachis branch per panicle (BPP), spikelet number per primary rachis branch (SPB), and spikelet abortion percentage before flowering (A%) were identified under two nitrogen application conditions, low nitrogen (LN) and high nitrogen (HN), in 2006 and 2007. The results showed that 11 QTLs and 12 QTLs totally were detected in LN and HN in two years. Among them, QTLs for SPP(3), BPP(7), SPB(2) and A% (6) were identified. Stable QTLs for SPP(2), BPP(1), and A% (2) were detected in two years under both nitrogen conditions, therefore, control mechanism of them were common under different nitrogen conditions. Co-location of QTLs on chromosome 6 was observed which could indicate strong relation between SPP and SPB under high nitrogen applied condition.

Therefore, in this study, it was shown clearly that (1) The spikelet number per panicle on each panicle within plant were declined with the increase of panicle orders. This is because of the decline of the leaf area, neck internode diameters and tiller height: (2) The spikelet production efficiency (spikelet number per leaf area) of each tiller within plant for D-SPP increased as panicle order increased, whereas spikelet production efficiency for SPP remained constant or decreased, with irrespective variation of tiller number per hill variation due to the planting density. Higher order panicles produce more spikelets than they can afford physiologically, but they were regulated downward to a nearly constant value: (3) Panicle number per hill had positive effects on the spikelet number per panicle through the differentiated spikelet number per panicle. This is mainly through the influence of the nitrogen accumulation by roots from soil: (3) The genetic control mechanism of spikelet number per panicle response to nitrogen were common under different nitrogen application conditions.