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主論文の要旨

論文題目　Narrowing yield gaps in rice production in the Philippines using genotype by environment by management approach
（遺伝子型×環境×栽培管理アプローチによりフィリピンにおけるイネ生産の収量ギャップを狭める）
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論文内容の要旨

The Philippines is the world's 8th largest rice producer, with area harvested to rice at about 825,000 hectares, and volume of production of 17.93 Million Metric Tons. The average country's average rice yield is 4.1 t ha^{-1} (FAO, 2019). Rice Self-sufficiency is low and was even observed declined to 79.8% in 2019 from 86.2% in 2018 (PSA 2020). Low average yield and rice self-sufficiency can be due to the variations of rice grain yield across growing areas resulting to lower average yield.

Philippine rice growing areas has varying climatic and edaphic characteristics, resulting to differences in rice productivity across agroclimatic domains. Grain yield of rice (*Oryza sativa* L.) vary with genotypes and growing environment and their interactions (GxE), which can be further modified by the imposed cultural management (GxExM). Analysis of these interactions could be a basis in identifying genotypes with high stability across environments, most adaptable environment, and most suitable farm management. These interactions can also be used in identifying genotypes and management to alleviate abiotic stress such a salinity stress.

In Chapter 2, the GxE interactions were analyzed to determine the contribution of season, location and genotype and their interactions to grain yield under varying growing environments, to identify the determinants of grain yield variations in rice genotypes across environments and to assess the influence of solar radiation and temperature variations as function of season and location on the growth and development of lowland rice genotypes under irrigated condition in major rice growing areas in the Philippines. Grain yield variations in PSB Rc18, NSIC Rc222 (inbred) and NSIC Rc202H (hybrid) were determined across growing environments as a function of cropping seasons and locations in rice producing areas in the Philippines. Contribution of location to variation in grain yield was 61.0%, while 12.7% for season, and 6.1% for genotype and this must be due location by season by genotype interactions. Dry season cropping in Nueva Ecija produced the highest mean grain yield. On the other hand, wet season cropping in Davao del Sur produced the least mean grain yield. The genotypes differed in their response to varying growing environments. NSIC Rc202H was the highest yielder among genotypes during dry season in Nueva Ecija. NSIC Rc222 was the most stable, having relatively high and constant grain yield across environments. High grain yield was associated with aboveground biomass particularly in NSIC Rc202H (R^2=0.8615). Harvest index of NSIC Rc222 had less variations across growing environments, hence, one reason for its relative stability. Among yield components, spikelets per panicle and percent filled spikelets were highly correlated with grain yield (r=0.85 and r=0.82 respectively). Grain yield was highly influenced by solar radiation and temperature. Growing degree days (GDD) accumulated by genotypes are generally lower during wet season than dry season. While genotypes with different growth durations may require different GDDs, the higher the GDD accumulated by a particular genotype, regardless of growth duration resulted in higher grain yield, and variations in accumulated GDD is affected directly by temperature and indirectly by solar radiation, contributed to the variations in grain yield across growing environments.

In Chapter 3, attainable and actual yields, and yield-limiting constraints in irrigated growing areas that causes variations rice grain yield were analyzed. This was done to be able to bridge the yield gaps between attainable and farmer’s field. The attainable and actual yields obtained from the actual farmer’s field were observed to be lower compared to the attainable yield across all locations and seasons. This can explain the yield gap to, which is the gap between the attainable and actual yields. The yield gap during wet season ranged from 11.1% to 22.2%, while the yield gap during dry season ranged from 19.6% to 22.0%. The actual yield gap during wet season ranged from 0.5 t ha^{-1} up to 1.2 t ha^{-1}, while during dry season ranged from 0.9 t ha^{-1} to 1.3 t ha^{-1}. Across sites and seasons, the amount of nitrogen (N) applied was the most important factor in determining the yield. Different cultural practices such as water management practice, seeding rate, weeds and diseases were also important factors affecting yield which were included in different models specific to each environment.

In Chapter 4, above-ground biomass of four rice genotypes under salinity stress in varying N level application was analyzed to be able to know the effect of salinity on the biomass and yield of the rice genotypes; effect on N application on the salt-stressed rice genotypes; and the response of the genotypes with different tolerance to salinity to application of N under salt-stressed conditions.

Above ground biomass of the rice genotypes significantly varied among treatments salinity treatments, N treatments, and genotypes. It can be observed that the biomass reduction due to salt stress is almost the same among the N treatments. It was observed that N application increased the biomass both under control and salt-stressed conditions. Among the genotypes, FL478 was observed to have higher biomass under high salinity stress when applied with higher N. DPPH scavenging activity, a measure of non-enzymatic antioxicant activity, was significantly affected by salinity stress treatments and N application. The DPPH scavenging activity was increased with increasing salinity and with decreasing N application. Ascorbate peroxidase was not significantly affected by the salinity treatments, N application, and genotype used, while catalase activity was only significantly affected by N application. Salt-tolerant genotype such as FL478 performed better under salt-stressed conditions but still needed to be supplied with N to produce higher biomass and express salt tolerant. This means that using salt-tolerant genotypes under salt-stressed environment also requires proper management such as N application to have higher yield.

This study focused on the GxExM approach to give recommendations to narrow the yield gaps. For between potential and attainable ones, I could recommend location-specific varietal recommendations based on superiority and stability. For between attainable and potential yields, I could identify the most important management practices in the farmer’s field as recommendations. Finally, concerning the yield gap between the actual farmer’s yield under non-stressed conditions and salt-stressed conditions, recommendations were given by analyzing the effect of nitrogen application on the biomass of different rice genotypes under salt-stressed environment. These findings will be useful information in narrowing yield gaps in rice production in the Philippines.