Chapter 1

Introduction

The problem of simultaneously comparing p test treatments with a control in the set up of block designs and completely randomized designs in diallel cross experiments is considered. Design of experiments for diallel crosses are used in plant and animal breeding experiments to study the genetic properties of inbred lines. Suppose there are $p + 1$ inbred lines, and are denoted as 0, 1, … , p, with 0 denotes the control line, and 1, … , p denote the p test lines, respectively. For $i < j = 0, 1, \dots, p$, let a cross between lines i and j be denoted as (i, j), and the lines are to be compared with respect to their general combining abilities. Complete diallel crosses which includes all possible crosses among $p+1$ inbred lines are considered, and all bk crosses are to be arranged in b blocks of size k each.

The study of optimal designs for diallel cross experiments has been receiving considerable attention recently. Most of the attentions, however, are focused on finding optimal designs for all pairwise comparisons among the p test lines with no control line. Gupta and Kageyama (1994) prove the optimality of complete diallel crosses in incomplete blocks by using p inbred lines rather than $p(p-1)/2$, the total number of distinct crosses in the experiment, as treatments, and hence, the size of the experiment is reduced considerably and optimal designs with one

replication of the complete diallel cross are proved. These designs can be derived from nested balanced incomplete block designs. Dey and Midha (1996) further derive optimal complete diallel crosses in incomplete block designs by using triangular partially balanced incomplete block designs with two associate classes. Das, Dey, and Dean (1998) obtain families of optimal designs for diallel crosses from nested balanced incomplete block design with sub-block size two, and show that triangular partially balanced incomplete block designs when certain conditions are satisfied are optimal. As for optimal partial diallel crosses, that is, not all $p(p-1)/2$ crosses are included in the experiment, Gupta, Das, and Kageyama (1995) propose a method in constructing single replicate incomplete block designs for partial diallel crosses. Their construction method bases on the algorithm of generating circulant partial diallel crosses by Singh and Hinkelmann (1990). Mukerjee (1997) is the first to investigate the optimality of partial diallel crosses, and shows the E-optimality of unblocked partial diallel crosses under a certain class of group divisible designs, and also derives the D- and A-optimal designs for saturated case. The problem of optimal or efficient blocking for partial diallel crosses has been discussed, too. Chai and Mukerjee (1999) investigate the optimal designs for diallel crosses when specific combining abilities are included in the model, and show that partially balanced incomplete block designs with the triangular association scheme can be used to obtain optimality and admissibility.

The problem of finding optimal diallel crosses for test line versus control

comparisons is not under investigation until Choi, Gupta, and Kageyama (2002). In their paper, a table of completely randomized designs that estimate the test line versus control contrasts with the minimum variance is given, They also define type *S* block design and tabulate its efficiency, which is computed by comparing to the best unblocked type *S* design, for up to 24 test lines. The "best" design means that the design estimates the test line versus control comparisons with the minimum constant variance. Das (2002) derives a sufficient condition for diallel cross experiments to be A- and MV-optimal in the set up of a completely randomized design. Das, Gupta, and Kageyama (2002) focus on the setting of block designs for test line versus control comparisons in diallel cross experiments, and derive a sufficient condition for designs to be A-optimal. They define type S_0 block designs, a special group of type *S* block designs satisfying certain conditions, and show that these designs are either optimal or with high efficiency .

In this thesis, families of A-optimal and efficient diallel cross experiments for comparing test lines with a control under the block design model and the completely randomized design model are derived. Construction methods for different values of *p*, *b*, *k* are also developed. The thesis is organized as follows. Chapter 2 contains preliminaries, definitions, a revised lemma for Lemma 2.4 of Das, Gupta and Kageyama (2002) and a needed theorem. In Chapter 3, families of A-optimal and efficient type S_0 block designs for $p = 3$, and for $p \geq 4$, $k = 2$ are given. Construction methods are also provided. The efficiencies and the

construction of efficient type S_0 block designs when $p = 2$ are also presented. For $p \geq k \geq 3$, and $p \geq 4$, general results on the families of A-optimal type S_0 block designs with the control line appearing *tb* times, where $t \geq 1$ is an integer, in the design are proved in Chapter 4. Construction methods and examples are also provided. In Chapter 5, diallel cross experiments in the set up of completely randomized designs are considered, and A-optimal type *S* designs for $p = 2, 3$ are given. For $4 \leq p \leq 6$, a more efficient method is provided to find A-optimal type *S* designs. Some examples are also presented.