RESEARCH ARTICLE

GENETIC VARIATION AND PATH ANALYSIS ON AGRONOMIC TRAITS OF RECOMBINANT INBRED LINES IN RICE (Oryza sativa L.).

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Abstract
Genetic variability, heritability of traits, their association and direct and indirect effects on yield are essential for crop improvement. Therefore, forty nine recombinant inbred lines (RILs) were studied to evaluate these parameters, and to select the potential RILs with good agronomic characters among the tested lines. Significant genotypic variation was found in days to first flowering, days to 50% flowering, plant height, panicle length and total grains plant\(^{-1}\). Selection can be done among the RILs for these traits. These characters also showed a small difference between phenotypic coefficient of variation and genotypic coefficient of variation, and had high heritability indicating that the characters were less influenced by environment. Effective yield plant\(^{-1}\) showed significant positive correlation with effective tillers plant\(^{-1}\), number of total grain plant\(^{-1}\) and 1000 grain weight. This showed that direct selection on effective tillers plant\(^{-1}\), number of total grain plant\(^{-1}\), and 1000 grain weight would result yield improvement. The highest and positive direct effect on effective yield plant\(^{-1}\) was found in total grain plant\(^{-1}\) followed by effective tillers plant\(^{-1}\) and 1000 grain weight. Therefore, these three characters should be given priority for yield improvement. According to the heterosis, three RILs such as YAU 1215-B-B-B-168-1, YAU 1215-B-B-B-193-3 and YAU 1215-B-B-B-78-1 should be selected as promising lines.

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Introduction:
Plant breeders have to develop high yielding cultivars with desirable agronomic traits to meet the required demand for increased population and attend rice self-sufficiency. The development of new genotypes requires some knowledge about the genetic variability presents in the germplasm of the crop to build efficient breeding...
programme. The magnitude of variation due to heritable component is very important because, it would be a guide for selection of parents for crop improvement. Therefore, selection for high yield requires knowledge about genetic variability and good understanding of correlation between yield and yield components regarding to the genetic material that is on hand. Genetic variability for agronomic traits is the key component of breeding programme for broadening the gene pool of rice (Dutta et al., 2013).

Most important criteria in any crop improvement programme is the selection of genotypes with all possible desirable yield contributing traits (Vanaja and Babu, 2006). In selection methods, bulk method is one of the most popular methods in rice breeding program. Bulk population method of breeding in self-pollinated crop is also known as mass method or population method of breeding. It refers to a species is grown in bulk plot (from F1 to F5) with or without selection, a part of the bulk seed is used to grow the next generation and individual plant selection is practiced in F6 or later generation. In this method duration of bulking may vary from 6-7 to 30 generations.

Bulk method is simple and cheap and involves less work than pedigree selection in the earlier generations. It is necessary to plant large populations to ensure that the best segregates are selected when selection starts. Segregating generations are subjected to another single plant selection step. Fewer records are kept during earlier generations than with pedigree selection. This type of selection is especially carried out with crops which are usually planted at high planting densities, e.g. small grain crops. Bulk population method eliminates undesirable types and increases the frequency of desirable types by artificial selection.

Recombinant inbred lines are one of the useful methods to create the genetic variability. Recombinant inbred lines that during several generations from selfing of progeny from crosses between two divergent parents, due to different recombination of parental genes, are considered as desirable genetic resources for the production of new varieties (Esch et al., 2007). However, multiple or poly genes control traits are difficult to select. Grain yield is a complex trait and is highly influenced by many genetic factors and environmental fluctuations (Prasad et al., 2001). In a plant breeding programme, direct selection for yield could be misleading. Therefore, plant breeders require knowing the relationship between yield and its component characters.

Path coefficient analysis has been widely used in crop breeding to determine the nature of relationships between grain yield and its contributing components, (Kumar et al., 2014). This analysis has been used to define the best criteria for selection in biological and agronomic studies (Mishra and Droolsom, 1973; Williams et al., 1990). Path coefficient analysis separates the direct effects from the indirect effects through other related characters by partitioning the correlation coefficient (Dixit and Dubey, 1984).

Therefore, to fulfill these requirements, this study was carried out with the following objectives: (1) to evaluate the genotypic variability and heritability of rice recombinant inbred lines based on agro-morphological traits and (2) to find out the direct and indirect effects of yield component characters to yield, and (3) to select the potential recombinant inbred lines with good agronomic characters among the tested lines.

**Materials and Methods:**

**Experimental site:**
The experiment was conducted in the research field of Department of Plant Breeding, Physiology and Ecology, Yezin Agricultural University, Yezin, Nay Pyi Taw, Myanmar from 2016 (monsoon season).

**Experimental materials:**
The experimental materials consisted of 36 recombinant inbred lines derived from a cross of Long 8 which is a tall, medium maturing and high yielding variety with Shwe Thwe Yin which is a semi-dwarf, early maturing and high yielding rice variety, and 13 recombinant inbred lines derived from a cross of Long 6 which is a tall, medium maturing and high yielding variety with Shwe Thwe Yin. The RILs population which comprised of 49 individuals was developed using bulk population method. The 49 individuals, their parents and one check variety (Manaw Thu Kha) were used in this study (Table 6).

The rice genotypes were raised in a randomized complete block (RCB) design with three replications. Each plot consisted of ten rows, each row 2.3m long adopting a spacing of 25.4 cm × 25.4 cm. The fully five-leaf aged seedlings were transplanted from nursery to the plots with a single seedling per hill.
Data collection:
The data were collected in each of the genotypes for each replication. The nine agronomic characters, days to first flowering, days to 50% flowering, plant height, effective tillers plant$^{-1}$, panicle length, total grain plant$^{-1}$, filled grain %, 1000 grain weight, and effective yield plant$^{-1}$, were recorded by the Standard Evaluation System for Rice (IRRI, 2002) in this study.

Statistical analysis:
The data were statistically analyzed according to STAR 2014 for simple analysis of variance, correlation and path analysis.

Estimation of genetic parameters:
The phenotypic and genotypic coefficients of variation were computed by the formula suggested by (Singh and Chaudhary, 1985).

$$\text{Genotypic coefficient of variation (GCV \%) = } \frac{\sqrt{\sigma_G^2}}{\bar{x}} \times 100$$

$$\text{Phenotypic coefficient of variation (PCV \%) = } \frac{\sqrt{\sigma_P^2}}{\bar{x}} \times 100$$

where,
- $\sigma_P^2 =$ Phenotypic variance
- $\sigma_G^2 =$ Genotypic variance
- $\bar{x} =$ Grand mean

Estimation of heritability:
Heritability in broad sense (Hbs) was computed by the formula suggested by (Singh and Chaudhary, 1985).

$$\text{Heritability (Hbs)} = \frac{\sigma_G^2}{\sigma_P^2}$$

Estimation of heterosis:
Heterosis was computed by the formula suggested by (Shull, 1914).

$$\text{Standard Heterosis (%) } = \frac{\text{F1-check variety}}{\text{check variety}} \times 100$$

Results and Discussion:
Analysis of variances for yield and yield component characters of recombinant inbred lines:
The mean squares obtained from the analysis of variance (ANOVA) for yield and yield components of recombinant inbred lines (RILs) are presented along with coefficient of variation (CV\%) in Table (1). According to the table shown below, days to first flowering, days to 50% flowering, plant height, panicle length and total grain plant$^{-1}$ are highly significant. Filled grain %, 1000 grain weight and yield are non-significant. Effective tiller is only significant among them. Therefore, there was much genetic variation among genotypes in days to first flowering, days to 50% flowering, plant height, panicle length, effective tillers plant$^{-1}$ and total grain plant$^{-1}$.

Genotypic and phenotypic coefficients of variation and heritability for quantitative traits:
Different parameters such as the phenotypic variance, genotypic variance, phenotypic coefficients of variation (PCV), and genotypic coefficients of variation (GCV), and heritability estimates for all the characters are presented in Table 2. The genotypic variance was high in days to first flowering, days to 50% flowering, total grain plant$^{-1}$ and plant height. This indicated that selection can be done in among the RILs for those traits.

The phenotypic coefficient of variation (PCV) was greater than genotypic coefficient of variation (GCV) for all characters. This indicated that the environment had an important role in the expression of these characters. There was a small difference between PCV and GCV estimates for days to first flowering, days to 50% flowering, plant height, panicle length and total grain plant$^{-1}$ indicating that the characters were less influenced by the environment.
Therefore, selection on the basis of phenotype alone can be effective for the improvement of these traits. Plant height, effective tillers plant\(^{-1}\), panicle length, total grain plant\(^{-1}\) and 1000 grain weight showed high PCV and GCV estimates. This value is enough scope for selection based on these characters, and the diverse genotypes can be provided materials for a sound breeding program. The broad sense heritability estimates obtained were high for all the characters studied except effective tillers plant\(^{-1}\) and 1000 grain weight which recorded medium heritability. Therefore, it indicated that a predominance of additive gene effect and low environmental variation.

**Correlation coefficient between yield and yield component characters:**

Correlation coefficient between yield and yield component characters in rice genotypes were shown in Table 3. Correlation coefficient analysis measures the mutual relationship between various characters and is used to determine the component character on which selection can be done for improvement in yield. Total grain plant\(^{-1}\) was positively and significant correlation with days to first flowering (0.322*), days to 50% flowering (0.387**) and panicle length (0.465**) this showed that the longer days to flowering, the higher number of grain per panicle can get. While negative and significant association with effective tillers plant\(^{-1}\)(-0.356*) was found and this indicated that the lower the effective tillers plant\(^{-1}\), the higher total grain plant\(^{-1}\) will be found.

Days to 50% flowering was positively and significant correlation with days to first flowering (0.733**). The 1000 grain weight, effective tillers plant\(^{-1}\) and plant height were non-significant correlation with all characters. Filled grain % was negatively and significant correlation with total grain plant\(^{-1}\) (-0.474**).

Effective yield plant\(^{-1}\) showed significantly positive correlation with effective tillers plant\(^{-1}\) (0.436**), total grains plant\(^{-1}\) (0.413**) and 1000 grain weight (0.403**). This showed that indirect selection on effective tiller, total grains plant\(^{-1}\), 1000 grain weight will improve grain yield. (Chandra et al., 2009) studied on correlation show that effective tillers plant\(^{-1}\) and 1000 grain weight showed positive and significant association with effective yield plant\(^{-1}\) and also among themselves indicating that simultaneous selection for these characters would result in improvement of yield.

**Path analysis in recombinant inbred lines:**

Path analysis revealed that days to first flowering, days to 50% flowering, effective tillers plant\(^{-1}\), panicle length, total grain plant\(^{-1}\), filled grain % and 1000 grain weight had positive direct effect on yield (Table 4 and 5). It means when there is an increase in the performance of these characters; effective yield plant\(^{-1}\) can also increase. However, plant height showed negative effect on yield. Total grain had high positive correlation with yield (1.0359) compared to the other characters. Its direct effect on yield was also positive (2.7731) and higher than its correlation coefficient. The direct effect of the effective tillers plant\(^{-1}\), total grain plant\(^{-1}\) and 1000 grain weight were higher than the indirect effects of the characters so that direct selection can be done for that particular character which had highest direct effect on yield. Hence, utmost importance should be given to this character during selection for single plant yield improvement. Selection of plants on the basis of this trait would certainly lead to improvement in grain yield. Effective tillers plant\(^{-1}\) (1.5868) has positive and direct effect on effective yield plant\(^{-1}\). It means that increase in effective tillers plant\(^{-1}\), effective yield plant\(^{-1}\) can be high and therefore direct selection through this trait will be effective for yield improvement. Filled grain (%) had high positive direct effect on yield (0.3557). This direct influence of this character was a signal of its importance in defining yield. However, these characters had negative association and significant with yield (-4.387). This finding are in agreement with (Gopikannan and Ganesh, 2013), they found that effective tillers plant\(^{-1}\) and filled grain % had high and positive direct effect on grain yield plant\(^{-1}\).

The 1000 grain weight had negative correlation with yield (-0.0247) and positive direct effect on yield (1.0662). The indirect effect of this character via plant height, effective tillers plant\(^{-1}\) and total grain plant\(^{-1}\) were negative. This suggested that the direct selection for 1000 grain weight would likely be effective in increasing yield. Plant height had high negative correlation with yield (-0.0366) and negative direct effect on yield (-0.1305). This means that increasing the plant height will not affect the improvement of effective yield plant\(^{-1}\). Therefore, direct selection on the basis of plant height would not be more effective in improving yield.

The present study observed that days to 50% flowering had high positive correlation with yield (1.1992) and exhibited positive direct effect on yield (0.0604). Panicle length had positive direct effect on yield (0.0803) and highly positive correlated with yield (1.0759). Panicle length had positive indirect effect via on total grain plant\(^{-1}\) and 1000 grain weight toward yield. Therefore, correlation explained the true relationship between the traits and a direct selection of this character would be effective for yield improvement. The residual effect was 0.344 and this indicated
that the contribution of component characters on grain yield was 65.6%. by the seven characters studied in path analysis, the rest 34.4% was the contribution of other factors, characters not studied.

**Estimation of heterosis:**
Standard heterosis was calculated by using Manaw Thu Kha as check variety. In heterosis of effective tillers plant, 39 inbred lines were observed positive heterosis and 10 inbred lines were negative heterosis (Figure 1). Among these lines, 22 inbred lines were higher than the check variety. Therefore, YAU 1215-B-B-113-1, YAU 1215-B-B-168-1 and YAU1215-B-B-78-1 were shown highest heterosis for effective tillers plant.

In total grain plant, 47 inbred lines showed positive heterosis and 2 inbred lines were negative heterosis (Figure 2). The 40 inbred lines showed higher heterosis than the check variety. Among these 40 inbred lines YAU1214-B-B-1-2, YAU 1214-B-B-51-1 and YAU 1214-B-B-51-2 have highest heterosis for total grain than the other RILs. As a result, all the inbred lines show better performance than the local check variety for effective yield plant except the 4 lines, YAU 1215-B-B-B-55-1, YAU 1215-B-B-B-91-3, YAU 1214-B-B-B-122-1 and YAU1214-B-B-B-67-2 (Figure 3). While there were 4 inbred lines with low value of standard heterosis, there were also 4 recombinant inbred lines whose standard heterosis percentage is highest. High standard heterosis percentage means that these RILs have better performance and better vigour than the check variety. These 4 RILs are YAU 1215-B-B-168-1 (90%) the one that has the highest standard heterosis %, YAU 1215-B-B-B- 53-1, YAU 1215-B-B-B-78-1 (70%), YAU 1214-B-B-B-51-2, YAU 1215-B-B-B-193-3. These RILs with highest vigour can be selected to be used in further breeding program.

**Conclusion:**
As in the presence study, days to first flowering, days to 50% flowering, effective tillers plant, panicle length and total grain plant were significant and these characters have high genetic variation. Therefore, these traits can be used for selection of yield improvement. The PCV was greater than GCV for all characters. Days to first flowering, days to 50% flowering, plant height, panicle length and total grain plant have a small difference between PCV and GCV indicating that the characters were less influenced by the environment. High heritability such as days to first flowering, days to 50% flowering, plant height, panicle length and total grain plant suggest high components of heritable portion of variation that can be exploited by breeders in the selection of superior genotype on the basis of phenotypic performance. Medium heritability observed in effective tillers plant indicates greater role of environment on the expression of this trait. Therefore direct selection for these traits will be ineffective.

Among the agronomic traits, effective tillers plant, total grain plant and 1000 grain weight are significantly and positively correlated with effective yield plant. The higher in effective tillers plant, total grain plant and 1000 grain weight and effective yield plant can also be increased. Therefore, progeny selection among these traits can also be effective for yield improvement. From the view of path analysis, The 1000 grain weight and effective tillers plant are high positive direct effect on yield; this positive direct effect show that indirect selection on these traits leads to yield improvement.

For effective tiller per plant, YAU1215-B-B-B-113-1, YAU1215-B-B-B-168-1 and YAU1215-B-B-B-78-1 showed the higher standard heterosis among the RILs. YAU1214-B-B-B-1-2, YAU1214-B-B-B-51-1 and YAU1214-B-B-B-51-2 have the higher heterosis for total grain plant. The four highest RILs for heterosis of effective yield plant were found in YAU1215-B-B-B-55-1, YAU1215-B-B-B-91-3, YAU1214-B-B-B-122-1 and YAU1214-B-B-B-67-2. These lines should be selected as promising lines due to higher heterosis than Manaw Thu Kha check variety.
### Table 1: Mean square for agronomic characters of rice recombinant inbred lines derived from bulk:

| Source          | d.f. | FFW   | HFS   | PH    | EffTill | PL   | TG    | FGP   | TSW   | YLD   |
|-----------------|------|-------|-------|-------|---------|------|-------|-------|-------|-------|
| Replications    | 1    | 2.000 | 34.327| 115.650| 17.153  | 6.055| 248.295| 2.282 | 30.800| 47.018|
| Treatments      | 1    | 57.495| 58.434| 454.421| 9.417   | 8.564| 1987.217| 62.192| 18.008| 26.310|
| Error           | 48   | 9.646 | 14.077| 101.246| 5.461   | 6.073| 376.150| 56.691| 11.731| 112.203|
| CV              | 3.291| 3.618 | 9.251 | 17.094 | 10.099  | 12.784| 9.303 | 12.375| 23.498|

" ** " and " ns " Significant at 1% probability level and Non-significant

FFW= days to first flowering, FPF= days to 50% flowering, PH= plant height,
EffTill= effective tiller plant\(^{-1}\), PL= panicle length, TG= total grain plant\(^{-1}\),
FGP= filled grain\%, TGW= 1000 grain weight, YLD= effective yield plant\(^{-1}\)

### Table 2: Genetic viability for yield and yield related characters of recombinant rice inbred lines

|                          | Days to first flowering | Days to 50% flowering | Plant height | Effective tiller plant\(^{-1}\) | Panicle length | Total grain plant\(^{-1}\) |
|--------------------------|-------------------------|------------------------|--------------|---------------------------------|----------------|---------------------------|
| \(\sigma^2_G\)           | 23.925                  | 22.179                 | 176.587      | 1.978                           | 6.246          | 805.534                   |
| \(\sigma^2_P\)           | 28.748                  | 29.217                 | 227.210      | 4.708                           | 9.282          | 993.609                   |
| PCV %                    | 5.682                   | 5.213                  | 13.858       | 15.872                          | 12.485         | 20.778                    |
| GCV %                    | 5.183                   | 4.542                  | 12.217       | 10.286                          | 10.242         | 18.708                    |
| \(H\)                    | 0.832                   | 0.759                  | 0.777        | 0.420                           | 0.673          | 0.811                     |

### Table 3: Phenotypic correlation coefficients of yield and yield related characters of rice recombinant inbred lines

|                          | HFS | PH    | EffTill | PL   | TG    | FGP   | TSW   | YLD   |
|--------------------------|-----|-------|---------|------|-------|-------|-------|-------|
| FFW                      | 0.733**| -0.030| -0.129  | 0.190| 0.322*| -0.173| -0.018| 0.100 |
| HFS                      | -0.103| -0.043| 0.144   | 0.387**| -0.269| 0.043 | 0.222 |
| PH                       | -0.171| 0.122 | -0.053  | 0.103| 0.185 | -0.067|       |
| EffTill                  | -0.256| -0.356*| 0.096  | -0.210| 0.436**|       |       |
| PL                       | 0.465**| -0.228| 0.206   | 0.239|       |
| TG                       | -0.474| 0.023 | 0.413**|       |
| FGP                      | -0.004| 0.052 |       |
| TSW                      |       | 0.403**|       |

" ** " and " * " Significant at 1% and 5% probability level respectively

FFW= days to first flowering, FPF= days to 50% flowering, PH= plant height,
EffTill= effective tillers plant\(^{-1}\), PL= panicle length, TG= total grain plant\(^{-1}\),
FGP= filled grain\%, TGW= 1000 grain weight, YLD= effective yield plant\(^{-1}\)

### Table 4: Direct and indirect effect of yield components and their correlation with yield of recombinant rice inbred lines

|                  | Effect of Association | Estimate |
|------------------|-----------------------|----------|
| Days to First Flowering | Direct Effect          | 0.0181   |
|                   | Indirect Effect Via 50% Flowering | 0.0504   |
|                   | Indirect Effect Via Plant Height | 0.0012   |
|                   | Indirect Effect Via Effective Tillers | -0.2156  |
|                   | Indirect Effect Via Panicle Length | 0.023    |
|                   | Indirect Effect Via Total Grains | 1.2774   |
|                   | Indirect Effect Via Fill Grain Percent | -0.3505  |
|                   | Indirect Effect Via 1000 Grain Weight | 0.1933   |
| Total Effect      | 0.9973                |          |
| Days to 50% flowering | Indirect Effect Via First Flowering | 0.0152   |
|                   | Direct Effect          | 0.0604   |
|                   | Indirect Effect Via Plant Height | 0.0163   |
|                   | Indirect Effect Via Effective Tillers | 0.0335   |
| Traits              | Effect of Association | Estimate  |
|--------------------|-----------------------|-----------|
| Panicle Length     | Indirect Effect Via First Flowering | 0.0052    |
|                    | Indirect Effect Via 50% Flowering    | 0.0118    |
|                    | Indirect Effect Via Plant Height    | -0.0111   |
|                    | Indirect Effect Via Effective Tillers | -0.3558  |
|                    | Direct Effect               | 0.0803    |
|                    | Indirect Effect Via Total Grains | 1.1718    |
|                    | Indirect Effect Via Fill Grain Percent | -0.4496  |
|                    | Indirect Effect Via 1000 Grain Weight | 0.6232   |
|                    | Total Effect                | 1.0759    |
| Total Grains       | Indirect Effect Via First Flowering | 0.0084    |
|                    | Indirect Effect Via 50% Flowering    | 0.03      |
|                    | Indirect Effect Via Plant Height    | -0.0018   |
|                    | Indirect Effect Via Effective Tillers | -0.9528  |
|                    | Indirect Effect Via Panicle Length | 0.0339    |
|                    | Direct Effect               | 2.7731    |
|                    | Indirect Effect Via Fill Grain Percent | -0.6639  |
|                    | Indirect Effect Via 1000 Grain Weight | -0.191    |
|                    | Total Effect                | 1.0359    |
| Filled Grain %     | Indirect Effect Via First Flowering | -0.0179   |
|                    | Indirect Effect Via 50% Flowering    | -0.103    |
|                    | Indirect Effect Via Plant Height    | 0.0162    |
|                    | Indirect Effect Via Effective Tillers | 0.4925   |
|                    | Indirect Effect Via Panicle Length | -0.1015   |
|                    | Indirect Effect Via Total Grains | -5.1755   |
|                    | Direct Effect               | 0.3557    |
|                    | Indirect Effect Via 1000 Grain Weight | 0.1465   |
|                    | Total Effect                | -4.387    |
| 1000 Grain Weight | Indirect Effect Via First Flowering | 0.0033 |
|-------------------|-------------------------------------|--------|
|                   | Indirect Effect Via 50% Flowering   | 0.0163 |
|                   | Indirect Effect Via Plant Height    | -0.0766|
|                   | Indirect Effect Via Effective Tillers | -0.633 |
|                   | Indirect Effect Via Panicle Length  | 0.047  |
|                   | Indirect Effect Via Total Grains    | -0.4968|
|                   | Indirect Effect Via Fill Grain Percent | 0.0489 |
|                   | Direct Effect                       | 1.0662 |
|                   | Total Effect                         | -0.0247|
|                   | Residual Effect                      | 0.3442 |

**Figure 1:** Heterosis of effective tillers plant⁻¹ in recombinant inbred lines compared with check variety (Manaw Thu Kha)
Figure 2: Heterosis of total grain plant$^{-1}$ in recombinant inbred lines compared with check variety (Manaw Thu Kha)
Figure 3: Heterosis of effective yield plant \(^1\) in recombinant inbred lines compared with check variety (Manaw Thu Kha)

Table 6: List of fifty-three rice genotypes and their original sources

| No. | Genotypes              | Source | Remarks                  |
|-----|------------------------|--------|--------------------------|
| 1   | Long 6                 | DAR    | R line                   |
| 2   | Manaw Thu Kha          | DAR    | High yielding variety    |
| 3   | Long 8                 | DAR    | R line                   |
| 4   | Shwe Thwe Yin          | DAR    | Early maturity variety   |
| 5   | YAU 1214-B-B-B 105-2   | YAU    | Breeding lines           |
| 6   | YAU 1214-B-B-B 1-1     | YAU    | Breeding lines           |
| 7   | YAU 1214-B-B-B 1-2     | YAU    | Breeding lines           |
| 8   | YAU 1214-B-B-B 122-1   | YAU    | Breeding lines           |
| 9   | YAU 1214-B-B-B 123-1   | YAU    | Breeding lines           |
| 10  | YAU 1214-B-B-B 33-1    | YAU    | Breeding lines           |
| 11  | YAU 1214-B-B-B 33-3    | YAU    | Breeding lines           |
| 12  | YAU 1214-B-B-B 51-1    | YAU    | Breeding lines           |
| 13  | YAU 1214-B-B-B 51-2    | YAU    | Breeding lines           |
| 14  | YAU 1214-B-B-B 53-1    | YAU    | Breeding lines           |
| 15  | YAU 1214-B-B-B 53-2    | YAU    | Breeding lines           |
| 16  | YAU 1214-B-B-B 67-1    | YAU    | Breeding lines           |
| 17  | YAU 1214-B-B-B 67-2    | YAU    | Breeding lines           |
| 18  | YAU 1215-B-B-B 10-1    | YAU    | Breeding lines           |
| 19  | YAU 1215-B-B-B 1-1     | YAU    | Breeding lines           |
| 20  | YAU 1215-B-B-B 110-1   | YAU    | Breeding lines           |
| No. | DARS 1215-B-B-B- | YAU | Breeding lines |
|-----|-----------------|-----|----------------|
| 21  | YAU 1215-B-B-B- | 113-1 |              |
| 22  | YAU 1215-B-B-B- | 123-1 |              |
| 23  | YAU 1215-B-B-B- | 123-3 |              |
| 24  | YAU 1215-B-B-B- | 124-1 |              |
| 25  | YAU 1215-B-B-B- | 133-1 |              |
| 26  | YAU 1215-B-B-B- | 134-1 |              |
| 27  | YAU 1215-B-B-B- | 135-3 |              |
| 28  | YAU 1215-B-B-B- | 137-3 |              |
| 29  | YAU 1215-B-B-B- | 138-3 |              |
| 30  | YAU 1215-B-B-B- | 139-1 |              |
| 31  | YAU 1215-B-B-B- | 139-3 |              |
| 32  | YAU 1215-B-B-B- | 140-1 |              |
| 33  | YAU 1215-B-B-B- | 141-3 |              |
| 34  | YAU 1215-B-B-B- | 153-1 |              |
| 35  | YAU 1215-B-B-B- | 156-1 |              |
| 36  | YAU 1215-B-B-B- | 168-1 |              |
| 37  | YAU 1215-B-B-B- | 181-1 |              |
| 38  | YAU 1215-B-B-B- | 193-3 |              |
| 39  | YAU 1215-B-B-B- | 197-1 |              |
| 40  | YAU 1215-B-B-B- | 197-2 |              |
| 41  | YAU 1215-B-B-B- | 197-3 |              |
| 42  | YAU 1215-B-B-B- | 52-2  |              |
| 43  | YAU 1215-B-B-B- | 53-1  |              |
| 44  | YAU 1215-B-B-B- | 55-1  |              |
| 45  | YAU 1215-B-B-B- | 63-1  |              |
| 46  | YAU 1215-B-B-B- | 66-1  |              |
| 47  | YAU 1215-B-B-B- | 67-1  |              |
| 48  | YAU 1215-B-B-B- | 67-2  |              |
| 49  | YAU 1215-B-B-B- | 73-3  |              |
| 50  | YAU 1215-B-B-B- | 76-1  |              |
| 51  | YAU 1215-B-B-B- | 77-3  |              |
| 52  | YAU 1215-B-B-B- | 78-1  |              |
| 53  | YAU 1215-B-B-B- | 91-3  |              |

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