Land Levelling under Direct Seeding Rice Culture in Malaysia

Hideto FUJII[a)] and Meng Chang CHO[b)]

[a)] *Crop Protection and Postharvest Technology Division, Japan International Research Center for Agricultural Sciences 1-2, Ohwashi, Tsukuba, Ibaraki, 305 Japan*

[b)] *Pilot Project, Muda Agriculture Development Authority Ibu Pejabat MADA, Ampang Jajar, Alor Setar, 05990, Kedah, Malaysia*

Received May 8, 1995

Abstract

Direct seeding culture of rice has spread rapidly since the 1980s and it became the predominant method of rice cultivation, surpassing transplanting in 1986 in the Muda irrigation area in Malaysia. The improvement of the field surface configuration by land levelling is an important measure for weed control and adequate seedling establishment which are the major constraints on stable direct seeding culture. In the study, land levelling experiments were carried out in farmers' fields in the Muda area by using a motor grader and tractor to analyze the difference in the improvement depending on the type of machines along with the field configuration level required for stable seedling establishment. The field configuration was improved (S.D. 3.8cm) through land levelling by using a motor grader coupled with a laser machine control system (LMCS). On the other hand the field surface level was improved (S.D.:2.2-3.2cm) by using a tractor with rear bucket in the absence of a laser machine control system. Thus, by using the tractor which is very common in this area, it was possible to reach a S.D. value of 2.5cm without a laser machine control system. Furthermore the analysis of the relationship between the S.D. value and the percentage of vacant spot areas, revealed that in wet direct seeding, adequate seedling establishment, in which the percentage of vacant spot areas was less than 4%, could be achieved when the S.D. value of the field surface level was 2.5cm and field ditches were provided. Theoretically a S.D. value of 2.0cm which can be obtained by using a bulldozer coupled with LMCS is suitable. Based on the fact that (1) it is difficult to obtain a S.D. value of 2cm without the use of a laser bulldozer and that (2) by the improvement of the field surface with a S.D. value of 2.5cm a percentage of vacant spot areas of less than 4% can be attained, a S.D. value of 2.5cm for the field surface level is recommended as the standard of land levelling in the Muda area.

Additional key words : Malaysia, Vacant spot, Motor grader, Tractor, Seedling establishment

Introduction

The Muda irrigation area (96,000 ha) often referred to as the rice bowl of Malaysia, contributes to about 40% of the total production of rice in Malaysia. Due to labour shortage and lack of irrigation water, direct seeding has been rapidly disseminated since the early 1980's and is presently the predominant method of rice cultivation in the Muda area. In the first season of 1991, it was implemented in 99.6% of the total area and in 83.2% in the second season (Fig.1). With the spread of direct seeding culture, yields have become less stable, especially in the 1st season. Weed control and improvement of seedling establishment are important objectives for the adoption of the direct seeding[2]. The improvement of the field surface configuration by land levelling is an important measure for weed control and adequate seedling establishment. If the field surface is uneven, herbicides are not effective in higher areas of the field due to the absence of a water layer. On the other hand, in lower areas, water for puddling remains on the field surface and forms a ponding spot where water temperatures can easily exceed 40℃. As a result, the seeds do not germinate, leading to the formation of vacant spots[1].

Direct Seeding Method in the Muda Area

The Muda area is a rice double cropping area located in the northwestern lowland area of Peninsular Malaysia. The average cultivated area by each farmer is 1.7 ha and the farm size is 0.5-1.0 ha. Large tractor 51.5 KW(70 PS), and combine harvester with a cutting width of 4m are used based on a contractor system. Two direct seeding methods, wet direct seeding and dry direct seeding (including volunteer seedlings) are commonly applied in the Muda area. In the wet direct seeding method, the sequence of the first half of farm operations is normally as follows : tillage, initial supply of irrigation water, puddling, drainage of field water, sowing under wet conditions, seedling establishment and resumption of irrigation. On the other hand, under dry seeding, the sequence of farm operations is as follows: tillage, sowing under dry conditions, germination, seedling establishment by initial supply of irrigation. In the dry seeding method , since puddling water is not necessary, water from rainfall is used to promote seedling establishment. Therefore, the irrigation period is shorter and irrigation water can be saved.

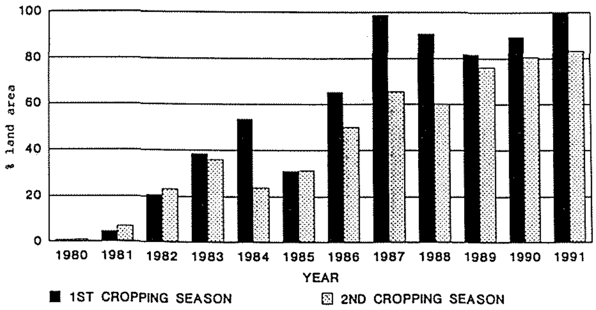

Fig. 1. Chronological development of direct seeding rice culture in the Muda area, Malaysia (Source : MADA)

Advantages and methods of land levelling

The following advantages are associated with the improvement of the field surface configuration: (a) Reduction of percentages of vacant spot areas; (b) Uniform growth of paddy; (c) Improved efficacy of herbicide application; (d) Improved flow of irrigation and drainage water ; and (e) Water saving because only a shallow depth of water is required.

The land levelling methods can be classified into minor land levelling and major land levelling. Minor land levelling method is carried out within each lot. Major land levelling method involves the consolidation of a few lots to obtain larger lots by removing the bunds and adjusting the gradient. Top soil treatment is sometimes carried out to keep the top soil under the same conditions as that before land levelling. The machines used for land levelling consist of a motor grader, a tractor with a rear bucket or a bulldozer. The laser machine control system (LMCS) is sometimes used for land levelling together with the bulldozer.

The land levelling performance can be evaluated by calculating the standard deviation (S.D.) of the field surface level surveyed at 10 m grid points[5]. The improvement of the field surface configuration is evaluated by comparing the S.D. value before and after land levelling. In general a value of 7 cm for S.D. is required for manual transplanting, 5cm for mechanical transplanting and a higher degree of field surface levelling is required for direct seeding[4]. However, the degree of field surface levelling required for adequate seedling establishment under direct seeding has not yet been determined.

Experimental method

Three kinds of experiments were carried out in three irrigation blocks (ACRBD4, ACLBD4b, ACRBD5) in different ways. In each experiment a 10 m grid survey was conducted before and after land levelling and the performance was evaluated based on the standard deviation. The target S.D. value of 2.5 cm was adopted in the experiments. In the experiment the index of deviation (LI-2.5 cm, LI-5 cm) was also used as performance index of land levelling which is expressed as percentage within the value fixed at 2.5 cm or 5.0 cm.

1) Experiment 1 : Major and minor land levelling using a motor grader

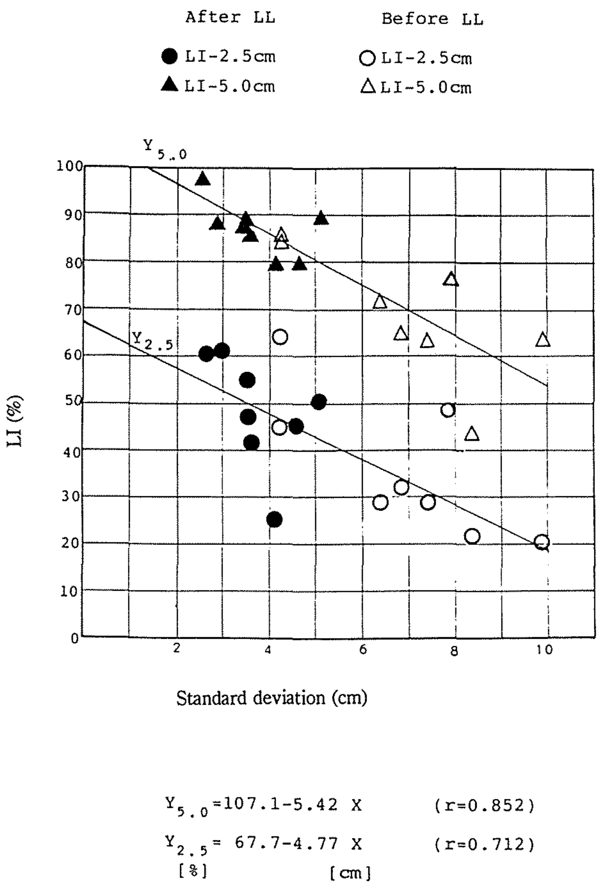

Fig. 2. Relationship between S.D. and LI (Experiment 1)

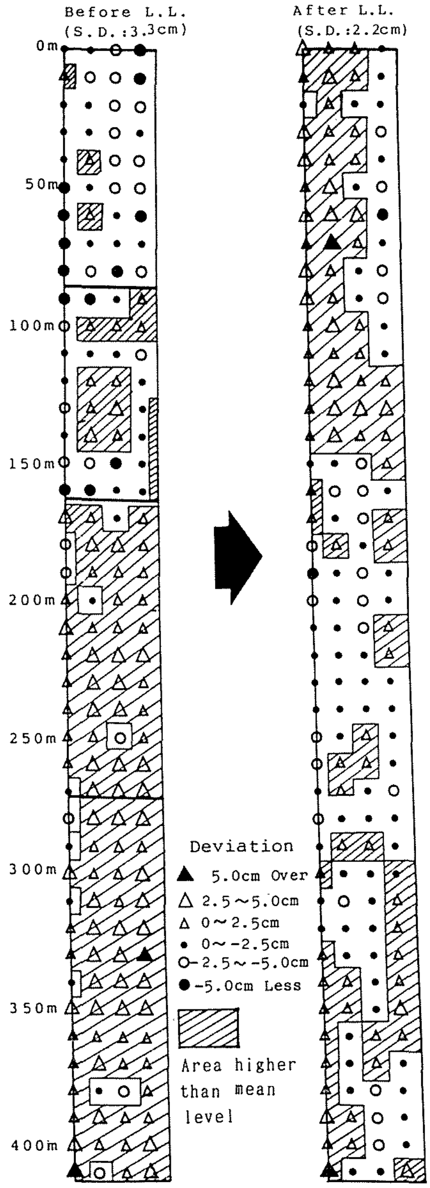

Fig. 3. Field surface level at 10m grid survey points (Experiment 3)

Major and minor land levelling was carried out by using a motor grader coupled with the laser machine control system. The experimental area covered 6.3 ha involving 8 lots in the ACRBD4 irrigation block.

2) Experiment 2 : Minor land levelling using a tractor with a rear bucket

Minor land levelling was carried out using a tractor with a rear bucket. Three lots were selected for the experiment in the ACLBD4b irrigation block. The area of each lot was 0.86ha, 0.61 ha and 1.07 ha and the S.D. values before land levelling in each field level were 3.6cm, 3.2cm and 4.2cm, respectively; these values were considerably improved compared with those obtained in the fields in Experiment 1.

3) Experiment 3 : Major land levelling using a tractor with a rear bucket

Major land levelling experiment was carried out in the ACRBD5 irrigation block. The experimental field, 414 m in length and 35m in width, was divided into 4 lots by bunds before land levelling (Fig. 3). The shorter side of the field was bordered by the tertiary canal at one end and the tertiary drain at the other. Three bunds were removed in this experiment to obtain a larger field (Plate 1).

Results

1) Land levelling

(1) Experiment 1

The results obtained by the use of the motor grader are shown in Table 1. The S.D. value (average of 8 lots) was improved from 6.9 cm to 3.8 cm. However, this value was still far from the target value of 2.5 cm. The LI-2.5 cm was improved from 36% to 48%, LI-5 cm from 69% to 88%. The relationship between the standard deviation and the LI (LI-2.5 cm and LI-5 cm) is shown in Fig. 2. The following equations were obtained from the correlation analysis between LI and S.D. value.

$$Y_{5.0} = 107.1 - 5.42\,X \quad \text{———} \quad (1)$$

$$Y_{2.5} = 67.7 - 4.77\,X \quad \text{———} \quad (2)$$

where, $Y_{5.0}$ [%] : Grid point percentage within ± 5.0 cm [LI-5 cm]

$Y_{2.5}$ [%] : Grid point percentage within ± 2.5 cm [LI-2.5 cm]

X [cm]: Standard deviation of the field surface level for 10 m grid points

The LI-5 cm shows a better correlation with the standard deviation than the LI-2.5 cm.

(2) Experiment 2

The results obtained are shown in Table 2. The S.D. value (Average of 3 lots) was improved from 3.65cm to 2.75cm, but still did not reach the expected target value of 2.5cm. In this experiment the tractor operator was only instructed to move the soil from higher to lower areas as the operator was very experienced in land levelling. However, the outcome of the work was fast and rough. Therefore, the results of this experiment were not as accurate as those of the Experiment 3.

(3) Experiment 3

The results are shown in Table 3. The S.D. value was improved from 3.3 cm to 2.2 cm. It was even better than the expected target of 2.5 cm. Fig. 3 shows the deviation of the level at each grid point before and after land levelling. The shaded area shows the parts higher than the mean level of the field. The grid points were classified into six groups according to the deviation within 2.5cm , 2.5-5 cm and over 5 cm. There were only two grid points over 5 cm after land levelling. That is, the LI-5cm was improved from 91.1% to 96.4%. Four tractors were used for this experiment , three with rear buckets and one with a rotovator. After shallow tillage of the higher areas , the soil was

Plate 1. Land levelling by tractor with rear bucket

Table 1. Results of land levelling by motor grader with laser control system (Experiment 1)

Lot No.	Area (ha)	S.D.(cm)		Working rate (ha/h)	LI(%)				Vacant spot 1989 (%)
		Before L.L.	After L.L.		Before L.L.		After L.L.		
					2.5cm	5.0cm	2.5cm	5.0cm	
1+2	1.25	4.2	3.6	-	45	84	42	87	10.3
3	0.60	4.2	2.6	0.32	64	86	60	98	-
4+5+6	0.60	8.3	4.2	-	22	44	25	80	11.6
7+8+9	0.71	6.3	3.5	-	29	72	54	90	2.3
10+11	0.57	6.8	2.9	-	32	65	63	88	7.5
12	0.57	9.8	5.2	0.32	21	64	51	89	12.8
13	1.33	7.9	4.6	0.34	49	76	45	80	7.0
14	1.26	7.4	3.5	0.31	28	63	47	88	-
Avg.	0.86	6.9	3.8	0.32	36	69	48	88	8.58

(ACRBD4 : 1988)

Table 2. Results of minor land levelling by tractor with rear bucket (Experiment 2)

Lot No.	Area (ha)	Size(m) (W)×(L)		Working rate (ha/h)	S.D.(cm)		LI(%)			
					Befor L.L.	After L.L.	Before		After	
							2.5cm	5.0cm	2.5cm	5.0cm
444	0.86	51m	169m	0.21	3.56	2.65	50.9	86.1	63.6	96.4
506-A	0.61	35m	164m	0.09	3.16	2.38	60.0	82.4	68.2	87.6
506-B	1.07	39m	255m	0.13	4.22	3.21	34.3	76.7	59.9	85.4
Avg.	0.85			0.14	3.65	2.75	48.4	81.73	63.9	93.1

(Pantai Johor in ACLBD 4b : March 1992)

Table 3. Results of major land levelling by tractor with rear bucket (Experiment 3)

Lot No.	Area (ha)	Size(m) (W)×(L)		Working rate (ha/h)	S.D.(cm)		LI(%)			
					Befor L.L.	After L.L.	Before		After	
							2.5cm	5.0cm	2.5cm	5.0cm
2244-B	1.45	35m	414m	0.05	3.31	2.20	55.4%	91.1%	63.6	96.4
2244-C	1.46	33m	442m	-	3.46	-	55.6%	83.9%	-	-

(Matang Pinang in ACRBD 5 : March 1992)

moved to the lower areas by using the rear bucket. Shallow tillage enabled to avoid removing too much top soil. This method appeared to have been developed by the contractor who had ten years of experience in land levelling and performed a good job.

2) Working rate

The working rate achieved by the motor grader using the turn back method was 0.32 ha/h (Experiment 1). On the other hand the working rate achieved by the tractor with rear bucket was 0.14 ha/h in Experiment 2 and 0.05 ha/h in Experiment 3. The working rate in Experiment 3 , which took 21 hours for soil moving by the rear bucket and 7 hours for tillage, with a total of 28 hours for major levelling of a field with an area 1.45

ha, was the slowest but the accuracy was the highest among the three experiments.

Discussion

1) Suitable degree of land levelling in the Muda area

The Japanese standard for plannity and design of land consolidation in paddy fields, stipulates that it is preferable that 100% of the grid points show a deviation within ± 10 cm and over 80% of grid points within ± 5 cm[3]. The latter part of this standard is equivalent to a S.D. value less than 5 cm, based on the equation (1) obtained from the experiment (Fig. 2) , although a S.D. value of 5 cm is not sufficient for stable seedling establishment in direct seeding.

The experiment carried out by using the motor grader showed that the standard deviation was improved to 3.8cm. On the other hand, the results using a tractor with a rear bucket were better as the value of the standard deviation ranged from 2.2 cm to 3.2 cm. The experiments revealed that although it was difficult to attain a standard deviation of 2.0 cm, it was possible to attain the target level of 2.5 cm by using a tractor with a rear bucket without having to use the bulldozer coupled with the laser machine control system.

2) Relationship between field configuration and percentages of vacant spot areas

In direct seeding, only with the improvement of the standard deviation of the field level, the percentage of vacant spot areas usually decreases. After the completion of the experiment on land levelling, the values of the standard deviation of the field level and the percentage of vacant spot areas were monitored in the field of Experiment 1 in the 1st season of 1989 and 2nd season of 1990[1]. The relationship between the percentage of vacant spot areas and the value of the standard deviation is shown in Fig.4. A correlation coefficient of 0.75 was obtained between the S.D. value and percentage of vacant spot areas. The equation $Y=2.80X-2.71$ was obtained from the correlation analysis, where, Y: vacant spot area (%), X: S.D.(cm). According to the equation, an improvement of 1cm of S.D. led to a decrease of the percentage of vacant spot areas about 2.8% and to ensure that no vacant spots occur, the S.D. value should be less than 1cm.

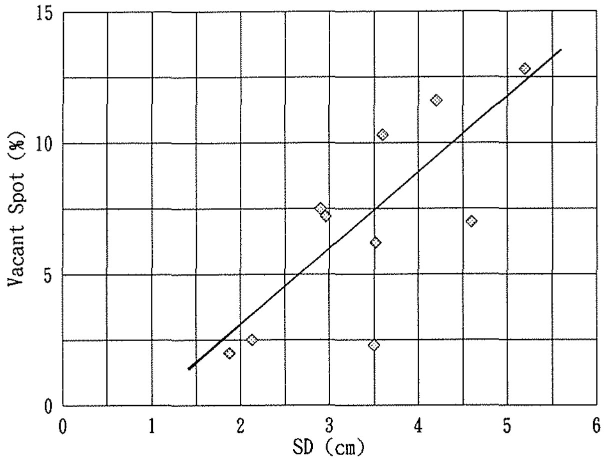

Fig. 4. Relationship between S.D. value and percentage of vacant spot areas

3) Suitable standard of land levelling in direct seeding

It was shown that the standard deviation value should be less than 2.0cm to ensure that the incidence of vacant spot areas is less than 3% that may not be necessary to perform supplemental transplanting in the vacant spot areas. It was reported that a standard deviation of less than 2 cm could be attained by using a bulldozer coupled with a laser machine control system[5]. Although theoretically the above standard deviation of 2.0cm should be achieved, certain factors must be taken into account: (1) It is difficult to attain a standard deviation value of 2 cm without using the laser beam/bulldozer method; and (2) With a standard deviation value of 2.5cm for the field level, the percentage of vacant spot areas can be reduced to less than 5%. Therefore in practice a value of 2.5 cm for standard deviation is advocated as the minimum requirement for land levelling under direct seeding cultivation in the Muda area.

4) Cost of land levelling

The rental cost of a motor grader including operator was 380 M\$/d (1M\$≒¥50 in 1992) in Experiment 1. Assuming that the working rate is

2.24 ha/d (0.32 ha/h×7h), the cost should be M$170 /ha. The cost for minor land levelling by tractor in Experiment 2 was 265 M$ /ha. On the other hand, the cost for major land levelling including tillage was M$563 /ha in Experiment 3. Normally, the cost for the 1st and 2nd tillings is M$125 /ha and M$71 /ha in the Muda area (1992). If the tilling cost is excluded, then the cost of land levelling by tractor would amount to M$367 /ha. The cost for land levelling by tractor with rear bucket is higher than that of motor grader , although the level of S.D. attained by using a tractor with rear bucket is higher than that by using a motor grader.

Acknowledgement

This study was carried out under the MADA/JIRCAS cooperative programme entitled "Production systems under direct seeding rice culture in the Muda area (1988-1993)". The authors wish to express their appreciation to all the staff members of MADA, JIRCAS for the kind cooperation extended during the study.

References

1) Fujii,H. & Hiraoka,H. et al. (1993). A comparison of tractor wheel rut ditch and traditional ditch method of field drainage in wet seeding rice culture, *JSIDRE, Journal of Irrigation and Rural Planning* **24** :19-31.
2) Kawasaki,K. (1989). Paddy field size and mechanized operation, Jour. JSIDRE, 57 (3) : 29-34. [In Japanese]
3) Ministry of Agriculture and Forestry of Japan (1977). Standard of plan and design of the land improvement project (Paddy field consolidation). [In Japanese]
4) Sasano,N., & Hassan,A.D. et al. (1988). Land leveling guided by a laser machine control system in Malaysia. *JARQ*, **22**: 242-246.
5) Yamaji,E. (1989). Land levelling of large scale lot. *Jour. JSIDRE*, **57(3)**:17-22. [In Japanese]

マレイシアの水稲直播栽培における圃場均平

藤井秀人[a)]，CHO Meng Chang[b)]

[a)]国際農林水産業研究センター
〒305　茨城県つくば市大わし1－2

[b)]マレイシア・ムダ農業開発庁
Ibu Pejabat MADA, Ampang Jajar, Alor Setar,
05990, Kedah, Malaysia

摘　要

マレイシア最大の稲作地帯であるムダ灌漑地区においては，1980年代に入り急速に直播栽培が普及し，1986年には移植栽培面積を上回るようになった。直播栽培では雑草の抑制と苗立の不安定が重要な問題となるが，それらの解決には圃場均平度の改善が必要である。圃場均平が悪い（圃場が凸凹である）と凸部分では水掛りが悪く除草剤の効果が薄れるため雑草が繁茂する。凹部分では排水が悪いため水溜りが残存し，播かれた種は苗立ちができず欠苗となる。本報ではムダ灌漑地区内の3地区の農家圃場で実施したモーターグレーダおよびトラクタによる圃場均平度（10m格子点標高のＳＤ値で評価），作業効率，経費の違いについて分析した。また均平度と欠苗面積の関係を調査し，良好な苗立確保に必要な圃場均平度について分析した。試験の結果，モーターグレーダではレーザーコントロールシステムを使用したが，ＳＤ値は3.8cmにしか改善されなかった。一方トラクタ（リアバケット装着）では，レーザーシステムなしでＳＤ値は2.2～3.2cmに改善された。ＳＤ値2.0cmの達成はむつかしいが，2.5cmであれば，作業に熟練していれば，ムダ地区で一般に普及しているトラクタ（レーザーシステムなし）で達成できることが確認された。また，均平度と欠苗面積の関係の調査の結果，潤田直播栽培では，ＳＤ値が2.5cm以下であれば，ほぼ良好な苗立と考えられる欠苗面積を4％以下にできることが示された。これらの結果から今後ムダ灌漑地区の圃場均平水準としてＳＤ値2.5cmを目標に均平作業を実施することが望まれる。

キーワード：マレイシア，欠苗面積，モーターグレーダ，トラクタ，苗立

[a)]現在：農業工学研究所　水工部
〒305　茨城県つくば市観音台2－1－2