STUDIES ON INCREASING GRAIN YIELD OF BUCKWHEAT IN TAIWAN[1]

Sheng-Hsiung Tseng and Sheng-Chung Huang[2]

ABSTRACT

Little information is available on increasing buckwheat yield by adopting optimum sowing time as well as planting density in buckwheat in Taiwan. The present study was conducted to determine the proper sowing date and seeding rate for different genotypes of buckwheat growing in fall and winter seasons. Experimental results suggested that the proper sowing time for large and mid-sized seed buckwheat varieties was around the end of October which was 10 days earlier than the usual sowing time in Taiwan. The most suitable seeding rates for the large and mid-sized seed varieties were determined to be 90 kg/ha and 70 kg/ha, respectively. The Miyazaki Ootsubu variety was found to have the best yield performance in these trials.

Key words: buckwheat, sowing time, seeding rate, grain yield.

INTRODUCTION

Common buckwheat (*Fagopyrum esculentum* Moench) is considered to be photoperiodically indeterminate, since it will produce flowers over a wide range of photoperiods.(9) It is known that the photoperiod will influence on the time and rate of flowering as well as the number of branches and inflorescences.(8) Therefore, the sowing time may influence on the grain yield of buckwheat. The productivity of buckwheat is also connected with planting density, width of rows and the method of sowing.

Buckwheat has long been cultivated by farmers as the green manure in central Taiwan. It is also generally used as cattle feed, and only a small part of it is used as the food for human consumption. In Taiwan, buckwheat is mainly cultivated in Eriin and Chutong of Changhua Prefecture.(3) The buckwheat has long been investigated by Taichung District Agricultural Improvement Station (DAIS) with regard to their performances of yielding capacity, grain quality, food processing, and medical use etc.(5) In comparison with other cereals, previous work indicated that buckwheat has better protein quality in terms of lysine content.(7) The technology of processing buckwheat into buckwheat noodle and instant buckwheat powder developed by Taichung DAIS has already been transferred to farmers for practical use.(10) The small amount of buckwheat grains were exported to Japan recently. Because of this,

[1] Contribution No. 0266 from Taichung DAIS.

[2] Associated Agronomists of Taichung DAIS.

buckwheat is now widely grown in fall and winter seasons as a catch crop. The grain yield of buckwheat was rather low under the present way of cultivation practice. Increasing the grain yield by a proper method, therefore becomes the most important task of buckwheat researchers in Taiwan. Attempts to increase the yield of buckwheat were made by establishing the most advantageous relationship among varieties, sowing time, and planting density. It is considered that the typical large seed buckwheat variety should have a higher yield potential than the mid-sized seed buckwheat under the high density planting condition. The cultivars of different seed sizes may also respond differently to different seeding rates and sowing time. This study was conducted to determine the optimum sowing time and seeding rate for buckwheat cultivars of different seed sizes in Taiwan.

MATERIALS AND METHODS

Two experiments -- sowing time (Exp. 1) and seeding rate (Exp. 2) were carried out in the fall crop season 1989 to spring season 1990. The materials were grown on the experimental field of Taichung District Agricultural Improvement Station. Soil was silt clay loam. Two genotypes -- Miyazaki Ootsubu, Shinshu Oosoba representing the large seed variety together with one genotype of mid-sized seed -- Hitachi Akisoba were used in the trials.

A split plot design with four replications was used in both Exp. 1 and 2. The main plots were consisted of three varieties. In Exp. I, each main plot was divided into seven sowing dates from October 5 to December 5 at intervals of 10 days. Planting rate was 90 and 70 kg/ha for large seed variety and for mid-sized seed variety, respectively. In Exp. 2, above three varieties were also set in the main plot, and a factor of seeding rate was made in subplot. Row spacing was 30 cm. Seeding rates were 50, 60, 70, 80, and 90 kg/ha.

In the field experiments, a plot of 10 m^2 (2.5m x 4m) in size was utilized. Each plot was consisted of eight rows with 0.3m between rows within a plot and 0.5m between rows in adjacent main plots. Ten plants for each plot were randomly selected to determine the number of branch and flower cluster. The plants in central four rows per plot were hand-harvested to determine grain yield. Seeds were threshed from the plants, dried, and weighed.

The performance of grain yield and agronomic characters of the tested varieties were recorded and analyzed. Agronomic data collected included growing period, plant height, the number of branches, the number of flower cluster, 1,000-seed weight, and grain yield. The data were analyzed by using the ANOVA procedure described by SAS Institute, Inc. When the F-test indicated statistical significance at the P=0.05 level, the Duncan's multiple range test was used to compare the difference of the means. In addition, the multiple linear regression analysis was made to establish the relationships among various buckwheat growth duration, yield component, and grain yield.

RESULT AND DISCUSSION

Performance of grain yield infield

At the harvesting time yield data were collected and statistically analyzed. The results of variance analyses for grain yield examined in Exp. 1 and 2 in the field are given in Table 1. As shown in Table I, the various effects of varieties, sowing time, and seeding rate were significantly different ($P < 0.01$) for grain yield in two experiments. The effects of above mentioned treatments varied greatly. The interaction between sowing time and variety was nonsignificant for grain yield, but the interaction between seeding rate and variety was significant.

Table 1. Mean squares for buckwheat yield in two experiments -- sowing time and seeding rate

Experiment	Source	df	Grain yield (x 10^4)[1]
Sowing time (Exp. 1)	Blocks	3	0.08
	Varieties [Var]	2	666.42**[2]
	Error (a)	6	3.05
	Sowing times [ST]	6	127.33**
	Var x ST	12	3.42
	Error (b)	54	2.57
Seeding rate (Exp. 2)	Blocks	3	1.23
	Varieties [Var]	2	172.39**
	Error (a)	6	1.85
	Sowing times [SR]	4	25.01**
	Var x SR	8	6.31**
	Error (b)	36	1.28

[1] Reported value must be multiplied by 10* to obtain actual value.
[2] ** Significant at I % level.

Sowing time and grain yield

The means of grain yield and of different varieties from Exp. I are listed in Table 2. As shown in Table 2, Miyazaki Ootsubu gave the best yield performance among three varieties. The results indicated that the highest grain yield was obtained when buckwheat was planted on October 25. Therefore the end of October seems to be the best time for sowing buckwheat in central Taiwan (Table 3).

Table 2. Means of grain yield of varieties in Experiment 2

Variety	Grain yield (kg/ha)	Index
Miyazaki Ootsubu	2142a[1]	108.2
Hitachi Akisoba	1980b	100
Shinshu Oosoba	1228c	62.2

[1] Means with the same letter of a column are not significantly different at 5% level by Duncan's multiple range test.

Table 3. Comparison of grain yield due to different sowing times

Sowing time	Grain yield (kg/ha)	Index
Oct. 5	1,824b[1]	100.5
Oct. 15	1,907b	105.1
Oct. 25	2,340a	128.2
Nov. 5	1,815b	100.0
Nov. 15	1,679c	92.5
Nov. 25	1,515d	83.5
Dec. 4	1,322e	72.8

[1] Means with the same letter of a column are not significantly different at 5 % level by Duncan's multiple range test.

Yield and other characteristics were found to be affected by change of sowing time. As indicated in Table 4, the growing duration, plant height, number of branch, number of flower cluster, 1000-seed weight, and grain yield were significantly different when sown at different times in all varieties studied. Buckwheat sown on November 15 had a longer growth duration, while those sown on October 5 had the shorter growth duration. No differences among varieties were observed in growth duration. However, some differences in growth duration within a variety due to the change of sowing time were observed indicating the heterogeneity of genotype in this characters. Plant growth could be delayed in the cold winter when buckwheat was lately planted. The values of plant height, number of branch, and number of flower cluster for buckwheat planted on October 25 were apparently higher than those plants sown on other planting times.

In order to examine how different traits interact with the yield performance under different sowing times, simple correlation coefficients were calculated. It was observed that grain yield was positively correlated with the number of branch and number of flower cluster (Table 5). It seems that the number of branch and number of flower cluster were the major factors responsible for the increase of grain yield. The growth duration, plant height, and 1,000-seed weight were found to correlate negatively with grain yield.

Seeding rate and grain yield

In Experiment 2, varieties Hitachi Akisoba and Miyazaki Ootsubu gave 41-45% higher grain yield than Shinshu Oosoba (Table 6). In order to know what planting density will give the maximum grain yield, the seeds were sown at the rates of 50, 60, 70, 80, and 90 kg/ha. The results indicated that no prominent differences in grain yield among planting densities of 70, 80, and 90 kg/ha were obtained. This indicated that the optimum rate of seeds for planting of buckwheat was 70-90 kg/ha (Table 7).

The optimum seeding rate for the mid-sized seed variety -- Hitachi Akisoba was found to be 70 kg/ha while the large seed variety Miyazaki Ootsubu needs a larger quantity of seeds ie., 90 kg/ha (Fig. 1).

Table 4. Effects of sowing time on the agronomic characters and yield of buckwheat

Varieties	Sowing time (days)	Growing period (cm)	Plant height	No. of branch	No. of flower cluster	1,000- seed wt. (g)	Grain yield (kg/ha)
Miyazaki Ootsubu	Oct. 5	76e[1]	72.4c	3.9b	31b	44.2b	2,268b
	Oct. 15	77de	76.2b	4.4a	34a	44.9ab	2,348b
	Oct. 25	77de	80.4a	4.7a	36a	45.2a	2,710a
	Nov. 5	78d	68.3d	4.0b	29be	45.4a	2,258b
	Nov. 15	92 a	67.7d	3.8be	28bed	43.1c	2,075c
	Nov. 25	85b	57.4e	3.5cd	27cd	42.2d	1,813d
	Dec. 5	81c	55.8e	3.3d	25d	40.0e	1,425e
Shinshu Oosoba	Oct. 5	75e	60.8c	3.7be	23a	45.2c	1,280b
	Oct. 15	76de	64.3b	3.9b	24a	45.8be	1,370b
	Oct. 25	76de	71.0a	4.2a	25a	46.4b	1,758a
	Nov. 5	77d	58.0c	3.6cd	19b	47.9a	1,235be
	Nov. 15	91a	52.3d	3.4de	18be	47.2a	l,113cd
	Nov. 25	84b	47.1e	3.2ef	16cd	46.3b	988de
	Dec. 5	80c	44.8e	3.0f	15d	43.8d	853e
Hitachi Akisoba	Oct. 5	73e	79.5b	4.0be	29be	35.7be	1,925bed
	Oct. 15	74de	84.0b	4.3ab	31b	35.9be	2,003be
	Oct. 25	74de	90.8a	4.6a	35a	36.2b	2,553a
	Nov. 5	75d	74.6c	3.9c	28be	37.2a	1,953bed
	Nov. 15	89a	72.2c	3.7cd	26cd	36.3b	1,848bed
	Nov.25	82b	56.2d	3.5d	23de	35.0c	1,743cd
	Dec. 5	78c	54.3d	3.2e	21e	33.9d	1,588d

[1] Means with the same letter of a column are not significantly different at 5% level by Duncan's multiple range test.

Table 5. Correlation coefficient between grain yield and agronomic characteristics under different sowing times

	Growth period	Plant height	No. of branch	No. of fl. cluster	1,000- seed wt.
Grain yield	-0.2705	-0.8424**	0.8274**	0.9605**	-0.3967
Growth period		-0.4668*	-0.4739*	-0.3637	0.1004
Plant height			0.9226**	0.8976**	-0.3607
No. of branch				-0.8789**	-0.0756
No. of flower cluster					-0.3619

*,**: Significant at 5% and I % levels, respectively.

Table 6. Means of grain yield of varieties used for seeding rate experiment

Variety	Grain yield (kg/ha)	Index
Hitachi Akisoba	1,708 a[1]	145
Miyazaki Ootsubu	1,671 a	141
Shinshu Oosoba	1,182 b	100

[1] Means with the same letter of a column are not significantly different at 5 % level by Duncan's multiple range test.

Table 7. Comparison of grain yield due to different seeding rates

Seeding rate (kg/ha)	Grain yield (kg/ha)	Index
50	1,279 c[1]	100
60	1,493 b	116.7
70	1,628 a	127.3
80	1,589 a	124.2
90	1,610 a	125.9

[1] Means with the same letter of a column are not significantly different at 5 % level by Duncan's multiple range test.

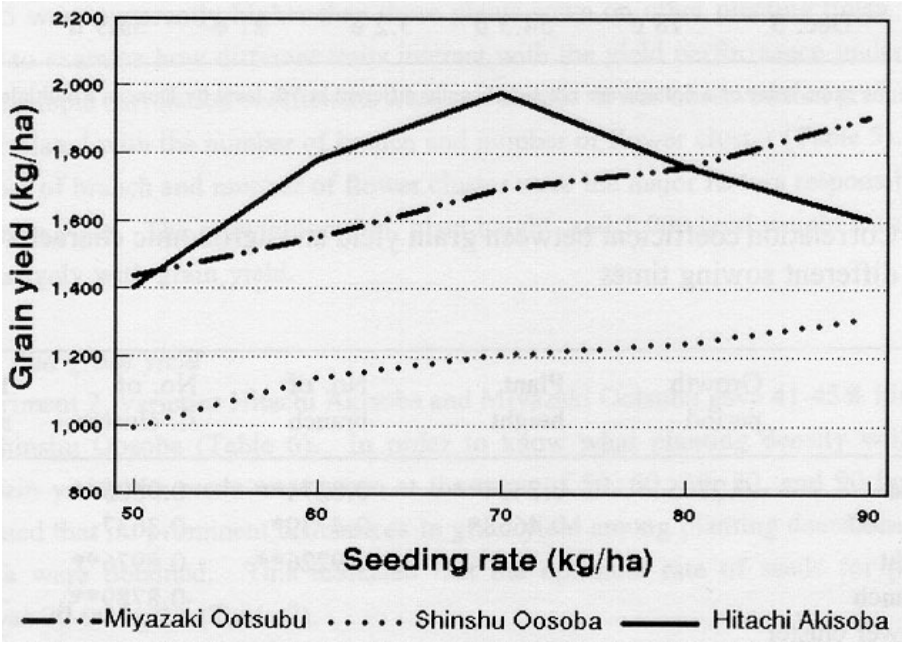


Fig. 1. Change in grain yield of buckwheat as affected by different seeding rates.

A significant differences in the number of branch, number of flower cluster, 1,000 seed weight, and grain yield were observed in the Experiment 2 as indicated in Table 8, and only the yield data were plotted in Fig. 2. The number of branch, number of flower cluster, and 1,000- seed weight ranged from high in the plants grown under low planting density, to low in the plants grown under high density planting conditions. The change in the value of yield component in this fashion apparently due to different competition pressures of plant growth under the different planting density conditions. Under the high density condition, the growth of yield components of each plant would be reduced. However, because of the increased number of plants, the total yield in a plot would be increased. Under the low density planting condition, the yield components would be increased to compensate the lower grain yield in some crops. However, this situation was not observed in case of buckwheat as far as the present experiment was concerned.

Table 8. Effects of seeding rate on the agronomic characters and yield of the buckwheat

Varieties	Seeding rate (kg/ha)	Growing period (days)	Plant height (cm)	No. of branch	No. of flower cluster	1,000- seed wt. (g)	Grain yield (kg/ha)
Miyazaki Ootsubu	50	76a[1]	54.2a	4.1a	30a	43.1a	1,438c
	60	76a	55.0a	4.0a	29a	41.7b	1,553be
	70	75a	55.5a	3.8b	28ab	40.8b	1,695b
	80	75a	55.9a	3.7b	27ab	39.1e	1,760b
	90	75a	56.7a	3.6b	25b	37.9d	1,908a
Shinshu Oosoba	50	75a	46.6b	3.7a	19a	45.5a	995c
	60	74a	47.2b	3.5ab	18ab	45.3ab	1,143b
	70	74a	49.6ab	3.4be	17be	44.7ab	1,210ab
	80	74a	50.6a	3.3be	16c	44.4b	1,245ab
	90	74a	52.3a	3.2e	14c	43.1c	1,315a
Hitachi Akisoba	50	73a	54.6b	4.1a	25a	35.0a	1,405d
	60	72a	57.3a	4.0a	24a	34.9a	1,783b
	70	72a	58.0a	3.7b	23ab	34.4ab	1,980a
	80	72a	58.7a	3.6b	21b	34.1ab	1,763be
	90	72a	59.8a	3.4b	17c	33.8b	1,608c

[1] Means with the same letter of a column are not significantly different at 5% level by Duncan's multiple range test.

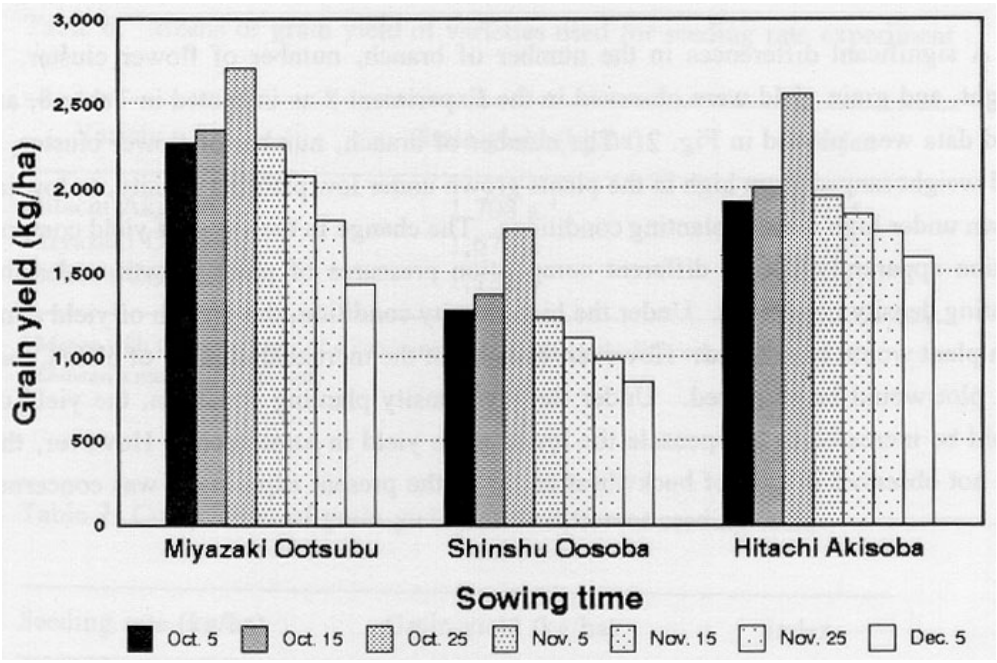


Fig. 2. Effect of sowing time on grain yield of buckwheat.

It is concluded from the present studies that genotypes, date of planting, and planting densities are very essential in determining the grain yield of buckwheat. In Taiwan, buckwheat can be grown twice a year. It is recommended that buckwheat should be grown before the end of October. The large seed variety Miyazaki Ootsubu seems to be a good variety to be widely recommended to grow in the central Taiwan with a planting rate 90 kg/ha. This variety has an excellent quality for making buckwheat noodle, therefore, further studies should be made regarding the grain quality and yielding potential.

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提高蕎麥生產力之研究[1]

曾勝雄　黃勝忠[2]

爲提高本省秋冬裡作蕎麥單位面積產量，於78年秋裡作在彰化縣大村鄉本場實驗農場，利用二個大粒品種及一個中粒品種進行播種期及播種量試驗，由結果得知蕎麥之適當播種期宜由慣行之11月上旬提早至10月下旬，此爲提高蕎麥產量最有效之方法。其適當播種量，大粒型品種爲每公頃90 kg，中粒型品種爲70 kg。大粒型品種中以宮崎大粒之產量表理較佳。

關鍵字：蕎麥、產量、播種期、播種量。

[1] 台中區農業改良場研究報告第 0266 號。

[2] 台中區農業改良場作物改良課副研究員。