4. ANALYSIS OF THE GROWTH OF SOYBEAN AS AFFECTED BY PLANT POPULATION DENSITY

Hideo Takagi*, Suprapto Sumadi** and Kanenori Nakayama***

Soybean is one of the important food crops, as a souce of protein such as tofu, tempe, tauco and kecap for the Indonesian people.

A major problem of indonesian soybean production, is a fairly high loss in plant population during the growing season. This loss depress yields and prevents development of inherent potential that soybean crop has for food production and capital formation. This problem of plant stand is a complex one and needs special attention.

Numerious workers have investigated the effect of variation in row width and plant spacing in the row on agronomic traits of soybean, while little attention was given to the physiological response of the population.

Although growth analysis is techniques have been used for approximately 50 years and have made a substancial contribution to current concept of physiological basis of crop yield, there have been few attempts to apply these techniques to the Indonecian soybean.

Therefore, the purpose of this study is to investigate the differences in dry matter production and growth parameters of Indonecian soybean as affected by plant population at various growing stage.

MATERIALS AND METHODS

The experiment was carried out at Muara Substation of CRIFC, in Bogor where after rice was cultivated during dry season, 1980. The design of the experiment was randmized block method with three replications.

Soybean variety "ORBA" was planted 2 seeds per hill on July 8 and was thinned 2-3rd tri-foliate stage to give plant population. Row width was 45 cm and hill space within row varied from 25, 20, 15 cm to 10 cm and these plants populations were 200, 250, 350 and 500 thousands per ha, respectively. Each plot size is 4.0 x 4.8 m and all plots were applied with 500 kg CaO/ha by broad-casting before tillage, N 40 kg, P 60 kg, K 50 kg per ha were applied in a band 7.5-10 cm away from the seedling rows. Azodrin was applied 2 times. Plant samples were taken from each plots about 10-days intervals through out the growing season, and those samples used for growth analysis.

Determinations of the dry weight of various parts of the plant and of the total leaf area were made 10-days intervals. At each sampling periods, plant hight, branch number, node number, etc, were measured for 5 hills.

The root system was dug out by a shovel with soil clod attached to a depth of about 15 cm, and washed with water, and collect for the subsequent drying and weighting.

Plant samples consisting of all parts above cotyledonary node were separated into leaves, petioles, stems, pods and beans. Leaf area was measured by using the Automatic Leaf Area Meter (manufactured by Hayashi Denko Co., Tokyo, Japan). All of the plant parts were dried in a forced-air oven at 70°C for more than 48 hours and then weighted.

Growth analysis was conducted by Wattson's method. Relative growth rate (R G R), net assimilation rate (N A R) and the other growth parameters were calculated by the following equations;

1. $CGR = \frac{W_2 - W_1}{t_2 - t_1}$, g/m².day

2. $RGR = \frac{\log_e W_2 - \log_e W_1}{t_2 - t_1}$, g/m². day

3. $LAI = \frac{A_2 - A_1}{(\log_e A_2 - \log_e A_1)}$, m²/m²

4. $NAR = \frac{W_2 - W_1}{t_2 - t_1} \times \frac{\log_e A_2 - \log_e A_1}{A_2 - A_1}$, g/m². day

Where W_1, W_2 and A_1, A_2 are plant dry weight and *leaf area in sampling date 1 (t_1) and sampling date 2* (t_2).

RESULTS AND DISCUSSION

(1) Dry matter production

Dry matter accumulation of the various parts of soybean plant are presented in Fig. 1. The weight of total dry matter production increased until leaf fall which began at 72 days after planting, but thereafter,

*) Crop Research Division, Hokkaido Nat. Agric. Expt. Sta. Hitsujigaoka, Toyohira-ku, Sapporo, Hokkaido, JAPAN.
**) Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.
***) Department of Farm Mechanization, Agricultural Research Center, Yatabe, Tsukuba, Ibaraki, JAPAN.

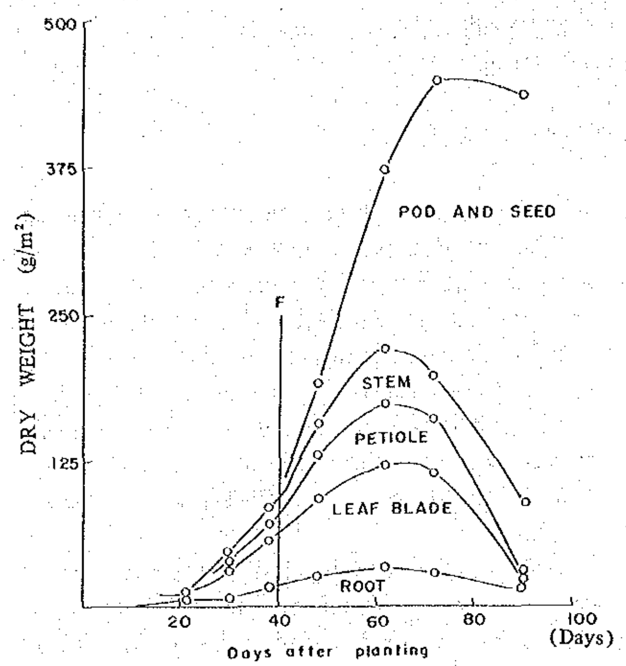


Fig. 1 **Dry matter accumulation in the different parts of soybean plants.**

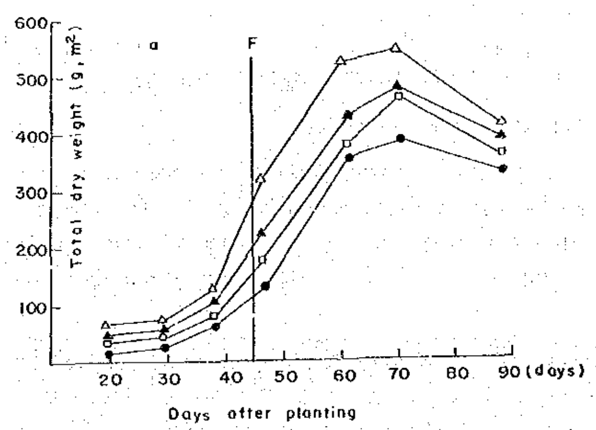
Note; Whole plant does not include leaf and petiole fall.

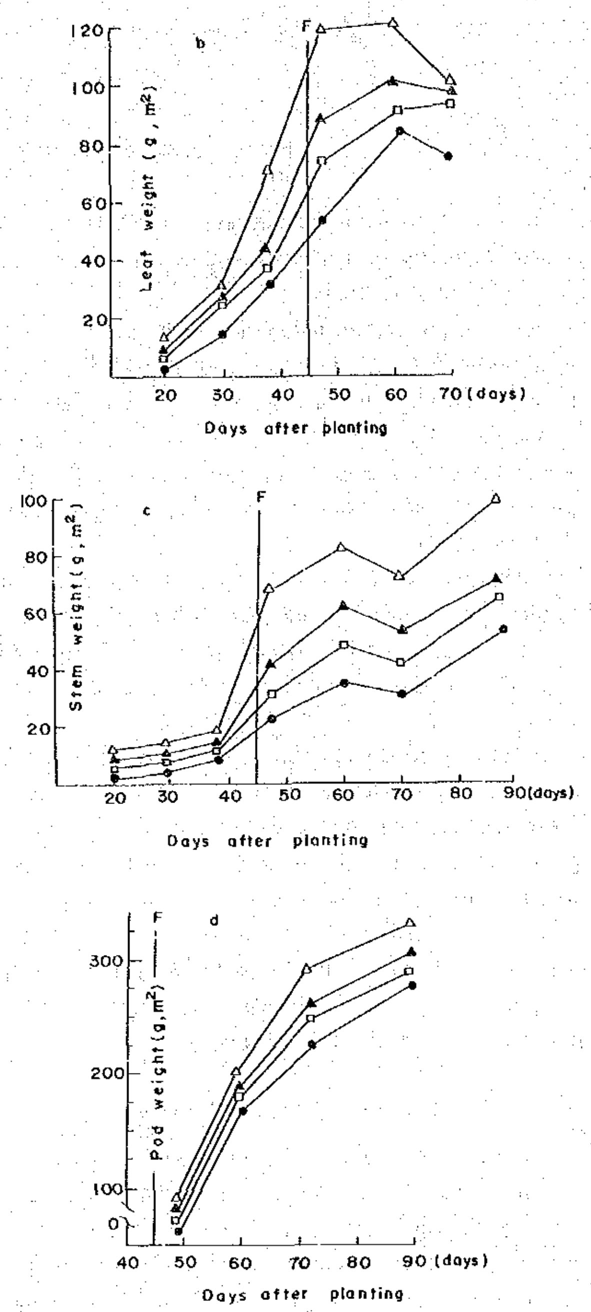
F= Flowering period

C Plot (40 x 15) cm

dry matter production decrease until at the harvest time.

The increase of leaf weight was rapid from early stage reaching the maximum at the top-most-expanding stage and decreasing gradually thereafter. The relationship between plant density and dry matter production per unit area is illustlated in Fig. 2. The efficiency of dry matter production on leaf weight at low population densities was less than that of high population. The changes of stem weight is similar to that of leaf weight, with a large increased until 60 days after planting.





Note; ● 40 x 25 cm F ; Flowering time

□ 40 x 20 cm

▲ 40 x 15 cm

△ 40 x 10 cm Whole plant does not include leaf fall.

Fig. 2 **Effect of population density on dry matter weight, leaf weight, stem weight and pod weight**

The differences among populations become more marked with decreasing intra-row widths at 60 days after planting. The pods-plus-seeds formation began increase about 50 days after planting and continuied to increase until maturity period.

(2) Growth parameters

Values of crop growth rate (CGR), net assimilation rate (NAR), leaf area index (LAI), and relative growth rate (RGR) are given in Fig. 3, and Fig. 4.

These data indicated that CGR values for soybeans increased to early September and then declined quite sharply in late September. This period of maximum CGR corresponded to the reproductive growth stage (mid-seed-filling). High density generally showed higher CGR values, but values had considerable variability. Maximum CGR values was obtained 19.0 g/m^2 ·day (Aug 25 - Sep 7) at the highest density plot (Fig. 4-a).

The hightest RGR values were found early in the growing season and generally declined as growth progressed (Fig. 4-b).

Changes of LAI with stage and population indicated that leaf area increased essentially lineally with time until 62 days after planting. Decrease in leaf area from 62 days after planting was due to leaf fall from lower portion of the canopies. Leaf loss increased with higher populations.

Values of Max. LAI was obtained 4.56 (Sep. 8) at the highest density plot (Fig. 4-c).

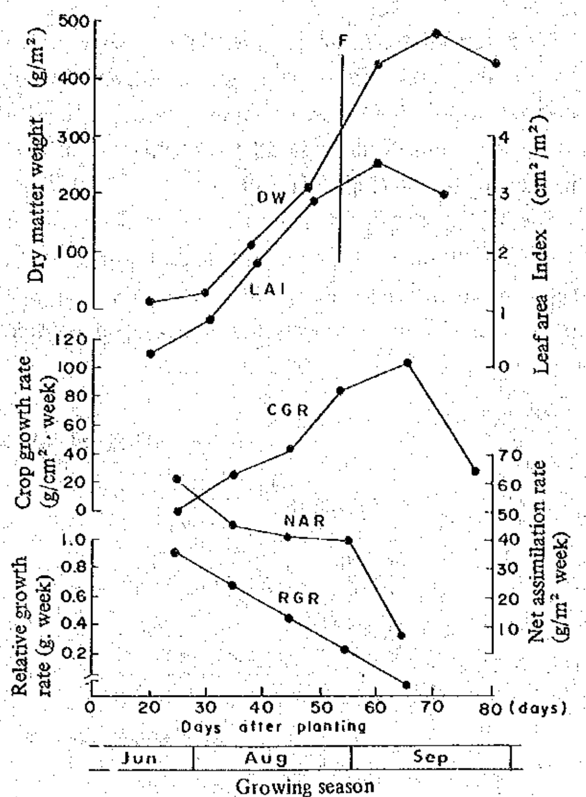


Fig. 3 Changes of some growth parameters in growing season.

Note; C Plot (40 x 15) cm
F= Flowering stage

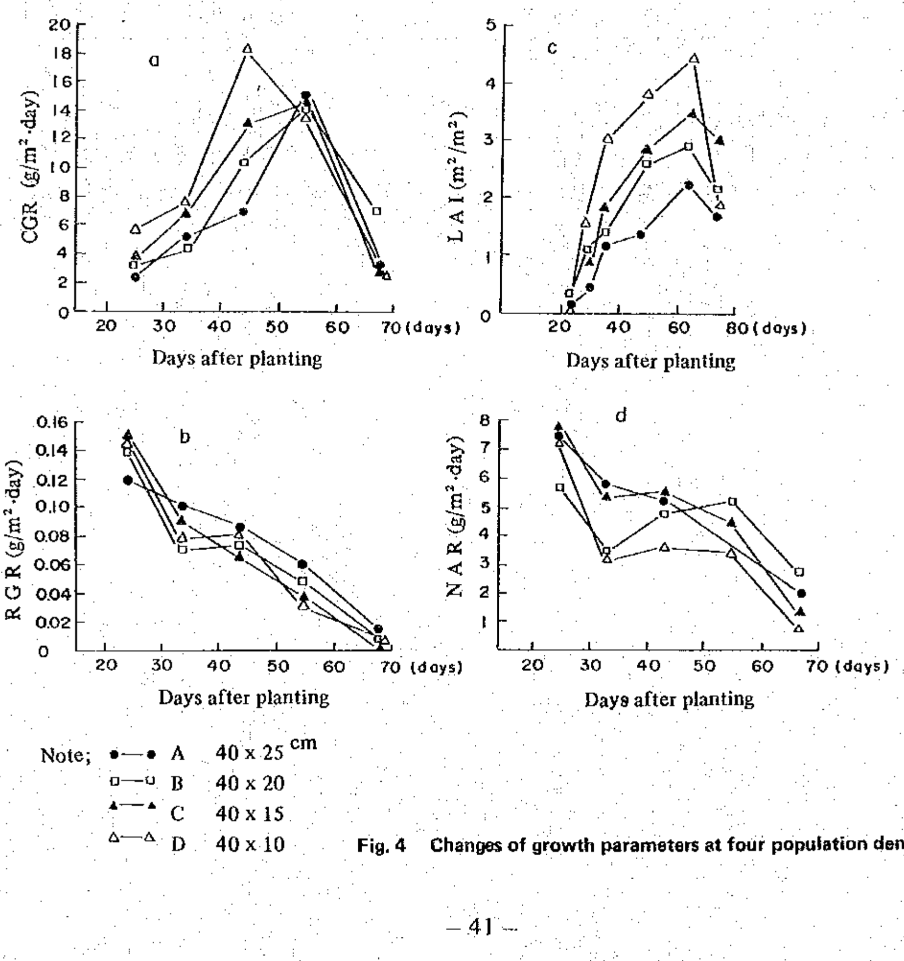


Fig. 4 Changes of growth parameters at four population densities.

NAR tended to be lower in the late growing period than in the earlier ones, owing to the interception of solar radiation. NAR was decreased by higher density of planting, and declined in all treatments throughout the growing period (Fig. 4-d).

The highest-density increased plant height of main stem and number of pods than low density plants. The decrease in yield and the increase in dry weight at higher plant densities suggest the competition occured in these treatment. The effect of density on bean yield was not significant among the treatments (Tab. 1).

The results of chemical analysis suggested that the nitrogen content of leaf blades in the early growth stage tended to have high percentage and gradually declined as growth progressed. There is no significant effect of plant population on nitrogen content of leaf blade (Tab. 2).

Table 1 Yield and yield components in different plant population

Treatment	Plant height (per plant) cm	No. of node (per plant)	No. of pods (per m^2)	Seeds yield (kg/a)	Seeds weight (g/100 seeds)
A 40 x 25 cm	52.2	14.7	92.5	12.5	13.5
B 40 x 20	56.7	14.8	104.3	13.7	12.3
C 40 x 15	54.7	13.7	119.1	13.5	12.7
D 40 x 10	63.6	13.5	127.0	13.2	12.7

Table 2 Changes of nitrogen percentage in leaves

Treatment	Sampling date				
	July 28	August 7	August 16	September 8	September 18
A 40 x 25 cm	3.25	2.28	2.90	2.72	2.37
B 40 x 20	2.96	3.43	2.87	2.75	2.37
C 40 x 15	2.63	3.65	2.31	2.68	2.40
D 40 x 10	3.22	3.40	2.81	2.68	2.60

摘　　　要

栽植密度が大豆の生育に及ぼす影響の生育解析

高城英雄・Suprapto Sumadi・中山兼徳

大豆はインドネシアではトーフ，テンペイ等の食品に利用され，国民のタンパク給源として重要な食用作物の一つである。

インドネシア大豆作における重要な課題として栽培上，適正な栽植密度の決定と保持に対して関心をはらう必要があると言われている。近年，栽植密度試験において生育解析手法を用いた解析的研究が行われているが，インドネシアにおいては，これらについての知見がなく南方ダイズに対する生育解析に関する基礎データを得る目的で試験を行った。

試験方法は１９８０年乾季にＣＲＩＦＣのムアラ試験地の水田後作地で行った。品種は「ＯＲＢＡ」を供試，７月８日に播種，７月２６日に２本立とした。試験処理区は，畦幅４０cm，株間を１０，１５，２０，２５cmの４水準，乱かい法，３反復，施肥，防除を行った。サンプリングは約１０日間毎に行い，乾物重，葉面積の測定を行った。生育解析の各パラメータはワットソンの式より算出した。

試験結果

(1) 乾物生産の推移

単位当り乾物重の生育に伴なう推移と密度効果について各器官（部位）別に調査した。全乾物重は播種後７２日目の時期で最大でその後，減少を示し最大乾物重は最密植区（４０×１０）cm区で３４６.８g/m^2であった。また密度効果は最密植区が粗植区より高かった。

(2) 生長パラメータの推移

個体群生長速度（ＣＧＲ）・相対生長率（ＲＧＲ）・葉面積指数（ＬＡＩ）および純同化率（ＮＡＲ）の推移についてみた。ＣＧＲは播種後６２日まで高くなり，生育の後期には急激に減少を示した。密度の効果は生育の前期で密植区ほど高く，開花期以降密度間差は少なかった。ＣＧＲの最大値は１９.０g/m^2・day　でこの値は日本のＩＢＰ研究班で得られた２６.７g/m^2・dayに比べ少なかった。

ＲＧＲは生育初期に高く，生育に伴って減少を示した。密度間差異は僅かで明らかな傾向は示さなかった。

ＬＡＩは生育初期に高く生育に伴って減少するが，密植区が高く推移する傾向を示した。

ＬＡＩの最大値は最密植区で４.５６が得られた。

ＮＡＲは生育初期に高く，生育に伴って減少するが，密度効果は密植区で減少の傾向を示した。

(3) 収量・化学分析

子実収量に及ぼす栽植密度の効果は処理間に有意な差が認められなかった。葉の生育中のＮ含有率は生育の初期で高く，生育に伴って減少の傾向を示した。栽植密度による効果は認められなかった。

5. STUDIES ON DRAINAGE DURING THE RIPENING OF LOWLAND RICE

Sutjipto Partohardjono, H.,* Hendrik, V., and N. Ishikura *****

For cropping patterns which combine lowland rice with upland crops, surface drainage during the grain filling period of lowland rice affects the ripening of the rice grains and the sowing time of succeeding crops.

This paper described an experiment designed to examine the effect of time of drainage during the grain filling period on the yield and yield components of rice.

Materials and Methods

Three week old seedlings of rice variety Semeru (110 days maturity) were transplanted at a spacing of 20 cm x 20 cm, with 3 plants per hill on 10 May 1980 at Muara Station near Bogor. The experiment was arranged in a split-plot design with three replications. Fertilizers applied were 30 kg N/ha, 60 kg P_2O_5/ha, 60 kg K_2O/ha as basal dressing, and 30 kg N/ha as top dressing at the active tiller stage and the panicle formation stage. The drainage treatments were carried out at heading time, at one week, 2 weeks, and 3 weeks after heading and at flooding.

Results and Discussions

The results obtained are indicated in Tables 1 and 2. The soil moisture content indicated in Table 1 shows the values at 10 cm below the soil surface and 22 days after the beginning of the drainage treatments. As shown in Table 1, there were significant differences among the plots.

Table 1. Yield components under 4 drainage treatments

	Wt. paddy (t/ha)	Wt. winnowed paddy (t/ha)	Wt. rough hulled rice (t/ha)	Wt. perfectly grains (t/ha)	Wt. 1000 grains (g)	% ripened grains
W_0	6.86 ± 0.71	6.70 ± 0.78	5.29 ± 0.54	4.99 ± 0.50	20.1 ± 0.5	73.1 ± 5.0
W_1	6.68 ± 0.49	6.52 ± 0.54	5.11 ± 0.04	4.79 ± 0.31	20.1 ± 0.2	73.1 ± 1.3
W_2	6.84 ± 1.64	6.67 ± 1.51	5.10 ± 1.30	4.80 ± 1.24	20.1 ± 0.4	75.1 ± 6.2
W_3	5.73 ± 1.69	5.82 ± 1.63	4.33 ± 1.13	4.10 ± 1.01	19.9 ± 0.9	74.5 ± 15.0
W_4	6.46 ± 0.91	6.35 ± 0.96	4.80 ± 0.71	4.50 ± 0.66	20.1 ± 0.9	75.2 ± 4.2

Note 1. W_0 : usual flooding, W_1 : drinage at 3 weeks later from heading time, W_2 : 2 weeks later, W_3 : 3 weeks later, W_4 : heading time.

Note 2. Perfectly ripened grains were counted with the naked eye.

	Nos. panicles per m²	Nos. spikilets per panicle	Nos. spikilets per m² (x 10²)	% sterility	% water content in soil
W_0	307 ± 44	85.5 ± 13.1	339 ± 28	13.5 ± 3.8	161 ± 17
W_1	370 ± 7	87.3 ± 4.9	333 ± 22	9.6 ± 0.4	116 ± 36
W_2	357 ± 86	88.9 ± 15.5	319 ± 104	8.5 ± 1.9	66 ± 17
W_3	330 ± 80	84.2 ± 22.1	279 ± 116	9.1 ± 5.2	47 ± 15
W_4	339 ± 61	88.0 ± 9.8	298 ± 42	7.8 ± 1.5	42 ± 5

* Agronomist, Chief of Rice Agronomy Section, Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.

** Assistant agronomist, Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.

*** Agronomist, Crop Division, Chugoku Nat. Agric. Expt. Sta., 450, Nishi-Fukatsu-cho, Fukuyama, Hiroshima, JAPAN.

Table 2. Dry weight at full heading time

	Leaf wt. (g.m²)	Panicle wt. (g.m²)	Total wt. (g.m²)	LAI
W_0	159 ± 41	192 ± 124	749 ± 168	3.85 ± 0.97
W_1	142 ± 20	168 ± 112	728 ± 151	3.44 ± 0.48
W_2	136 ± 63	197 ± 34	742 ± 128	3.68 ± 1.68
W_3	124 ± 47	155 ± 44	619 ± 117	2.91 ± 1.54
W_4	114 ± 48	161 ± 66	648 ± 241	2.62 ± 1.09

Note 1. W_0 : usual flooding, W_1 : drainage at 3 weeks later from heading time, W_2 : 2 weeks later, W_3 : 3 weeks later, W_4 : heading time.

Note 2. Total weight : summing up, weight of leaf (living) Panicle, died leaves, culm and sheath.

Yields (paddy weight and perfectly ripened grains (brown rice)) did not significantly differ under varying times of drainage. Also, varying drainage treatments gave no significant differences in yield components; number of spikelets per unit area, 1000 grain weight and percentage of ripened grain. Since the weight of *perfectly ripened grain was closely correlated with* the number of spikelets per unit area, it appears that the difference among drainage treatments caused variability in the number of spikelets per unit area. Yet, it has been shown that number of spikelets and panicles are factors which are determined before heading time.

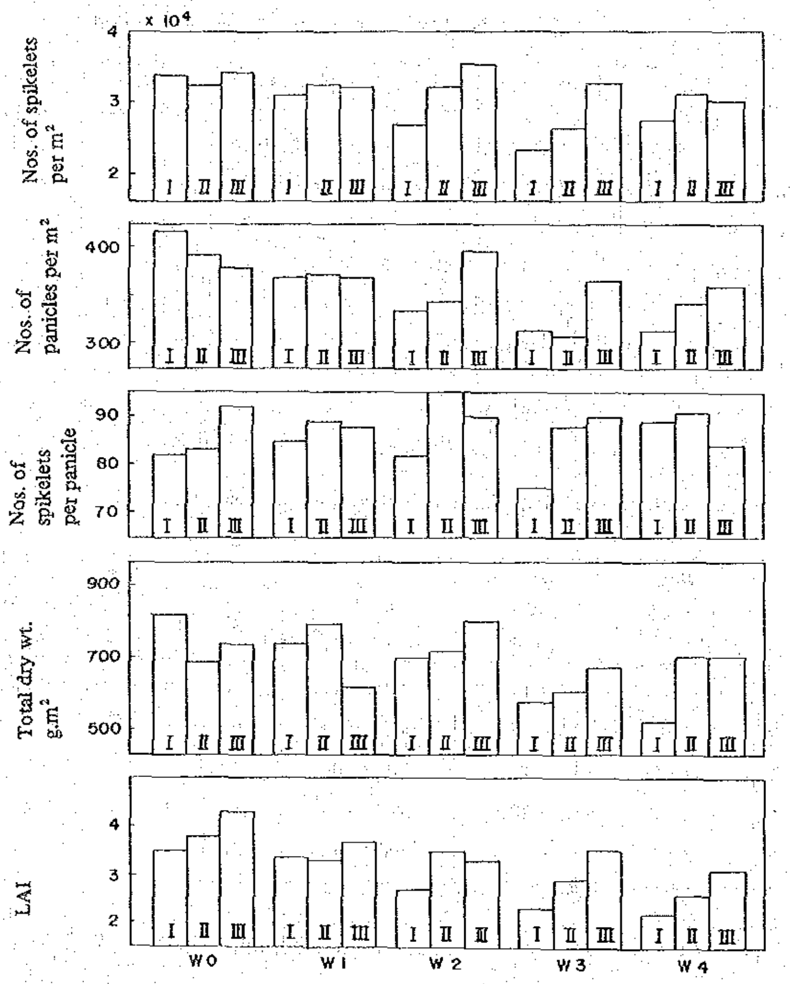


Fig. 1 The difference of growth and yield components among plots at the heading time.

It appears the difference among the plots were greater than the difference among the treatments.

The growth (total dry weight and LAI) and yield components of each plot at heading time are illustrated in Fig. 1 and the experiment plots which were laid out are shown in Fig. 2. From comparing Fig. 1 with Fig. 2, it is clear that the figure of characters on rice plant at heading time increased the closer to the inlet irrigation water and the farther from the footpaths between rice fields.

One of the reasons that the drainage treatments did not differ may be that there was much rainfall (292 mm) and many rainy days during the ripening period.

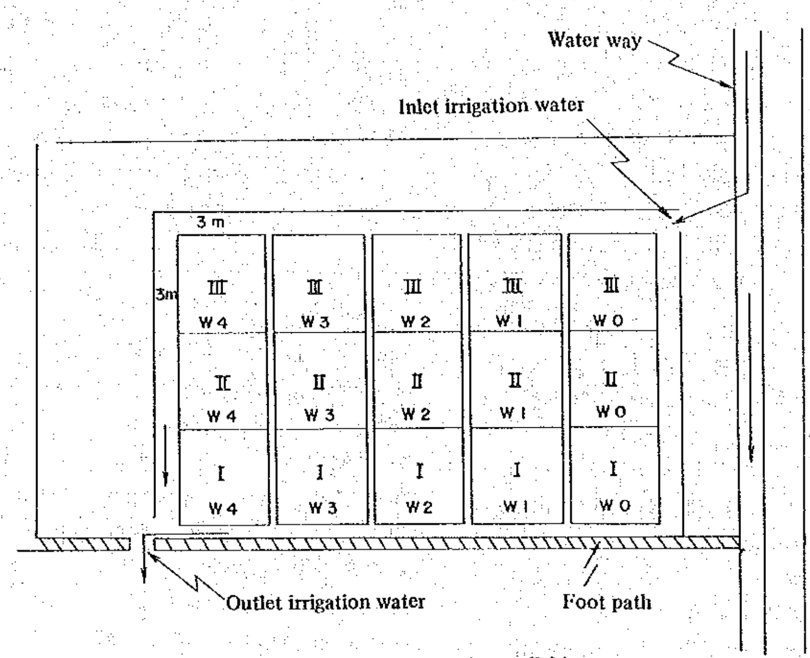


Fig. 2 The map of experiment field

摘　　　要

水稲登熟期の落水が収量・収量構成要素に及ぼす影響

Sutjipto P. H. , Hendrik V. , N. Ishikura

１９８０年５月，中央農業研究所Muara試験地で水稲品種Semeruの21日苗を栽植密度２０×２０*cm*・３本植で移植し，落水開始期まで常時湛水栽培した。落水処理は，出穂期から１週間ごとに落水開始時期をずらし成熟期まで落水を続けた区および常時湛水区を設けた。１０a当り施肥量は窒素9*kg*，燐酸6*kg*，加里6*kg*とした。

登熟期における落水処理は，精籾重，精玄米重，面積当り総穎花数，千粒重，登熟歩合などいずれも処理間に統計的な有意差は認められなかった。

これは登熟期間中の降雨日数が７日，総計 ２９２*mm*の降雨量を観測しており，落水の影響が発現されなかったこと，さらに圃場整備が不完全で不均一のため落水処理間差よりも，地力ムラが大きく影響したことにあると考察された。

6. EFFECT OF NITROGEN FERTILIZER ON THE YIELD AND YIELD COMPONENTS OF LOWLAND RICE FOLLOWING SOYBEAN CROP

S. Partohardjono,* Hendrik, V.,* L. Sukarno,** and N. Ishikura ***

ABSTRACT

Rice yield and yield components of rice after soybean cropping as affected by different level of nitrogen were studied in the field experiment by using the rice variety IR-36, which was transplanted on 25 August 1980, at Muara experiment station near Bogor. Amount of 0, 60, 120, and 180 kg N/ha were applied to two fields, one which had previously been cropped with soybeans, and one with fallow.

A previous cropping resulted in increased weight of paddy and perfectly ripened grain, and approximately 7 % of average yield increase. Increasing nitrogen application resulted in higher yields, up to a maximum of 8.5 t/ha as winnowed paddy. Higher nitrogen application and previous cropping resulted in larger numbers of spikelets per unit area, which in turn resulted in higher yields. The percentage of ripened grain and 1000 grains weight did not always affect yields. About 60 % of the yield was produced during ripening stage. Higher yields with greater nitrogen application with previous cropping were due to greater LAI and NAR during the ripening stage.

INTRODUCTION

Generally, crop rotation may aid in maintaining the supply of organic matter in the soil and may aid in the maintenance of the soil nitrogen supply. Rice cropping following soybean cropping results in high yields. Gardner and Robertson[2] stated that alfalfa in a rotation proved very beneficial in supplying nitrogen in Colorado, USA. But this result obtained is in upland and not on soybean. There is little informations on growth and yield components of lowland rice following soybean cropping in INDONESIA.

This experiment was carried out to clarify the effect of nitrogen fertilizer application on yield and yield components of lowland rice preceded by soybean cropping.

MATERIALS AND METHODS

Soybean cultivation before rice cropping was as follows:

Variety No. 29 was sown at the spacing of 40 x 20 cm on 7 April 1980 at Muara experiment station near Bogor. Fertilizer was applied at 22.5 kg N/ha, 45 kg P_2O_5/ha and 50 kg K_2O/ha as a basal dressing. Harvesting was on 15 July 1980 ; the yield was 200 kg/ha and the dry weight of plant residues of soybean (excluding yield) was 480 kg/ha.

Rice Cultivation was as follows:

During the land preparation of rice after harvesting the soybean, the leftover of 480 kg/ha were incorporated in the plot B, while in plot A there was no preceding crop. Rice variety IR-36 was used in this experiment. Transplanting took place on 25 August 1980, at the spacing of 20 x 20 cm and with three plants per hill. The seedlings were 3 weeks old. Fertilizers were applied at 60 kg P_2O_5/ha, 60 kg K_2O/ha as a basal dressing, and nitrogen application were shown in Table 1. In each plot 1.5 m^2 of rice crop was harvested and yield and yield components were determined. Rice plant from 5 hills in each plot were taken during the ripening phase for determination at dry-matter weight. These were over-dried at 75°C to a constant weight. The experiment was laid out in a split-plot design with three replication.

Table 1. Amount of nitrogen fertilizer application

Basal kg/ha	Top* kg/ha	Top** kg/ha	Total kg/ha
0	0	0	0
30	0	30	60
60	30	30	120
100	40	40	180

* at 3rd weeks after transplanting
** at the primordia initiation stage

* Agronomist and assistant agronomist, Agronomy Division, Bogor Research Institute for Food Crop, Central Research Institute for Food Crop, Jl. Merdeka No. 99, Bogor, INDONESIA.
** Chemical analyst, Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.
*** Agronomist, Crop Division, Chugoku National Agricultural Experiment Station, 450, Nishi-Fukatsu-cho, Fukuyama, Hiroshima, JAPAN.

RESULTS

1. Growth of rice plant

The results obtained during the ripening phase are given in Tables 2, 3, 4 and 5. An increasing amount of nitrogen application resulted in greater plant height and panicle length, but preceding cropping did not affect these characters. There were, however, significant differences in nitrogen content between the plant from the two fields (Table 2). Leaf nitrogen content in the field after soybean cropping was higher than in the field without soybean cropping.

Different treatments resulted in slight variation in the internodal length on the stem (Table 3). The field with preceding soybean cropping and high nitrogen applications increased length of the upper four internodes on the stem. Length and width of leaf blades of the upper three leaves are given in Table 4. Preceding cropping and higher nitrogen application resulted in longer leaf blades, but did not affect the width of the leaf blades.

Table 2. Percentage of nitrogen content in leaf blade, plant height, and panicle length at heading time.

Treatment	N content %	Plant height cm	Panicle length cm
A[2] 0	1.16^{a} [1]	71.1^{a}	17.1^{a}
A 60	1.09^{ab}	81.6^{b}	20.2^{b}
A 120	1.33^{ab}	89.0^{c}	21.4^{c}
A 180	1.49^{b}	93.6^{d}	22.3^{c}
Average	1.27^{a}	$83.8^{n.s.}$	$20.8^{n.s.}$
B[3] 0	1.07^{a}	73.6^{a}	19.8^{a}
B 60	1.31^{ab}	81.1^{b}	20.8^{b}
B 120	1.33^{ab}	90.1^{c}	21.9^{c}
B 180	1.65^{b}	97.7^{d}	22.4^{c}
Average	1.34^{b}	$85.6^{n.s.}$	$21.2^{n.s.}$

1) Any two means followed by the same letter are not significantly different at 5 % level.

2) A = no preceding crop.

3) B = soybean cropping preceding rice cropping.

Table 3. Length of internode on the stem at 10 days after heading time.

Treatment	Stem position					
	Neck-node cm	2nd cm	3rd cm	4th cm	5th cm	6th cm
A 0	24.3	14.0	4.7	2.9	1.5	1.0
A 60	25.6	14.4	7.3	3.7	1.9	1.3
A 120	28.9	17.2	7.5	4.1	2.1	1.2
A 180	25.8	15.9	8.1	4.8	2.0	1.0
B 0	26.9	15.3	5.1	3.3	1.5	1.0
B 60	26.5	15.7	6.7	4.2	2.1	1.1
B 120	28.1	16.4	9.0	4.7	1.6	0.9
B 180	26.9	16.8	9.7	5.0	2.1	0.9

Table 4. Length and width of leaf blade on the upper three leaves.

Treatment	Leaf position on the stem					
	Flag leaf		2nd leaf		3rd leaf	
	length cm	width cm	length cm	width cm	length cm	width cm
A 0	17.6	0.8	24.5	0.7	27.5	0.6
A 60	19.0	1.0	25.9	0.8	30.0	0.8
A 120	24.9	1.2	28.5	0.9	30.9	0.8
A 180	23.6	1.2	34.2	1.0	35.9	0.9
Average	21.3	1.1	28.3	0.9	31.1	0.8
B 0	18.4	0.9	26.6	0.8	31.2	0.7
B 60	21.1	1.0	29.9	0.9	32.7	0.8
B 120	25.9	1.2	36.3	1.0	37.3	0.8
B 180	30.1	1.3	40.8	1.0	38.7	1.0
Average	23.9	1.1	33.4	0.9	35.0	0.8

2. Dry weight accumulation of rice plants during the ripening period

Both the weight of living leaf and total weight (total of living and dead leaves, culm, sheath and panicle, excluding root) at heading time significantly varied with varying nitrogen applications (Table 5). Though there were not necessarily statistical significant differences on leaf and total weight between with and without preceding cropping. We observed higher LAI in the field with preceding soybean crop, compared to the field without preceding crop.

Table 5. Dry weight of rice plant and leaf area index (LAI) at heading time, third week after heading, and harvesting time

Treatment	Heading			3rd week			Harvesting	
	Leaf g/m²	Total g/m²	LAI	Leaf g/m²	Total g/m²	LAI	Leaf g/m²	Total g/m²
A 0	59[a] 1)	360[a]	1.32	30	483	0.57	22[a]	521[a]
A 60	114[b]	614[b]	2.57	47	793	0.89	19[ab]	837[b]
A 120	159[c]	772[c]	3.48	71	991	1.35	23[abc]	1044[c]
A 180	194[d]	806[d]	4.40	110	1071	2.10	27[c]	1125[d]
Average	130[n.s.]	638[n.s.]	2.95	64	835	1.22	23[n.s.]	881[a]
B 0	62[a]	384[a]	1.38	31	545	0.59	19[a]	560[a]
B 60	119[b]	647[b]	2.68	59	857	1.12	22[ab]	921[b]
B 120	155[c]	785[c]	3.50	76	1021	1.45	27[abc]	1079[c]
B 180	205[d]	912[d]	4.65	124	1028	2.37	40[c]	1264[d]
Average	135[n.s.]	682[n.s.]	3.05	73	903	1.39	27[n.s.]	919[b]

1) Any two means followed by the same letter are not significantly different at 5 % level.

3. Yield and yield components

Weight of paddy and weight of perfectly ripened grain were approximately 7 % greater in the field with preceding cropping than in the field without preceding cropping. Increasing nitrogen application resulted in higher yields. A maximum yield of about 8.5 ton/ha as winnowed paddy was obtained in the field with preceding cropping and treated with 180 kg N/ha (Table 6).

Table 6-1. Yields and yield components

Treatment	Wt. of paddy t/ha	Wt. of winnowed paddy t/ha	Wt. of rough hulled rice t/ha	Wt. of perfectly ripened grain t/ha	Nos. of spikelets 10³/m²
A 0	3.52[a] 1)	3.47[a]	2.58[a]	2.31[a]	16.2[a]
A 60	5.51[b]	5.45[b]	4.03[b]	3.53[b]	26.2[b]
A 120	7.02[c]	6.91[c]	5.10[c]	4.40[c]	34.8[c]
A 180	7.96[d]	7.81[d]	5.58[d]	4.76[d]	36.9[d]
Average	6.00[a]	5.91[a]	4.32[a]	3.75[a]	29.9[a]
B 0	3.83[a]	3.77[a]	2.92[a]	2.49[a]	17.7[a]
B 60	6.14[b]	6.06[b]	4.45[b]	3.92[b]	30.4[b]
B 120	7.52[c]	7.36[c]	5.35[c]	4.53[c]	38.3[c]
B 180	8.60[d]	8.45[d]	6.12[d]	5.18[d]	46.7[d]
Average	6.52[b]	6.41[b]	4.71[b]	4.03[b]	33.3[b]

Continued on the Table 6-2

1) Any two means followed by the same letter are not significantly different at 5 % level.

Table 6-2. Yields and yield components

Treatment	Nos. of panicle per m²	Nos. of spikelets per panicle	Wt. of 1000 grain	% of ripened grain	% of sterility
A 0	199^{a 1)}	81.6^{a}	19.2^{a}	73.8^{a}	6.8^{a}
A 60	271^{b}	96.5^{b}	20.2^{bc}	66.8^{b}	9.5^{b}
A 120	337^{c}	103.2^{bc}	20.4^{b}	62.1^{bc}	11.5^{b}
A 180	387^{d}	109.6^{c}	19.9^{c}	56.2^{c}	10.6^{b}
Average	299^{n.s.}	97.7^{n.s.}	19.9^{n.s.}	64.7^{n.s.}	9.6^{n.s.}
B 0	214^{a}	83.0^{a}	19.6^{a}	71.6^{a}	7.6^{a}
B 60	300^{b}	101.7^{b}	20.1^{bc}	64.0^{b}	12.2^{b}
B 120	356^{c}	107.4^{bc}	20.2^{b}	59.0^{bc}	12.6^{b}
B 180	399^{d}	117.0^{c}	19.6^{c}	56.7^{c}	12.0^{b}
Average	317^{n.s.}	102.3^{n.s.}	19.9^{n.s.}	62.8^{n.s.}	11.1^{n.s.}

1) Any two means followed by the same letter are not significantly different at 5 % level.

As well known, yield is composed of number of spikelets per unit area (number of panicle per unit area x number of spikelets per panicle), 1000 grain weight and percentage of ripened grains. Number of spikelets per unit area were significantly higher in the field with preceding cropping than in the field without preceding cropping. It appears that the greater number of spikelets per unit area in the field with preceding crop was caused by a greater number of panicle and spikelets per panicle. In both fields increased nitrogen application resulted in a higher number of spikelets per unit area resulting from a larger number of panicles per unit area rather than an increased number of spikelets per panicle.

Differing nitrogen treatments significantly affected the number of panicle per unit area, but not always the number of spikelets per panicle. If we refer to Table 1, we can postulate that the number of panicles per unit area and the number of spikelets per panicle were controlled by nitrogen application at the primordia initiation stage. It seems that a greater number of panicles per unit area resulting from greater nitrogen application at the vegetative stage results in higher yields.

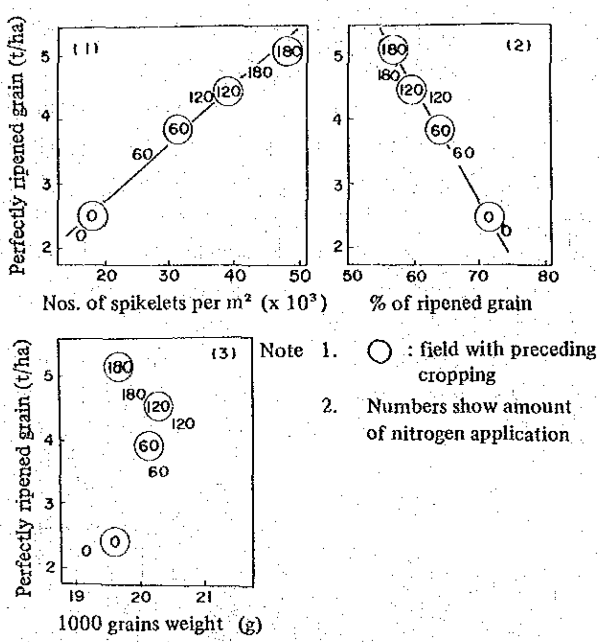


Fig. 1 Relation between yield and nos. of spikelets, % of ripened grain, and 1000 grains weight

DISCUSSIONS

As shown in Fig. 1-(1), 1-(2), and 1-(3), yield was controlled by the number of spikelets per unit area, but not percentage of ripened grain and weight of 1000 grains. Although number of spikelets per unit area is yield determining factor, it as Matsushima[4] stated would be determined before heading stage.

The accumulated matter in panicle is composed partly of matter accumulated before heading and partly of matter produced during the ripening stage. Matsushima and Wada [3] reported that the percentage of carbohydrates accumulated before heading to the total carbohydrates in the grain is between 20 % and 40 % in most case. And Murayama et al.[5] stated that the percentage of the weight of starch translocated from straw to panicle to that of the harvest kernel yield would be approximately 40 % in plots receiving a light basal dressing of nitrogen, 30 % in plots receiving a normal basal dressing of N and 8 % in plots receiving a heavy basal dressing of N. The weight of accumulated matter before heading is estimated by subtracting the increased weight of panicle from the total increased weight during the ripening stage.

This accumulated matter weight is shown in Table 7. Increased nitrogen applications and preceding cropping results in higher values. It seems that the accumulated panicle matter of about 40 % depended partly on accumulated matter before heading.

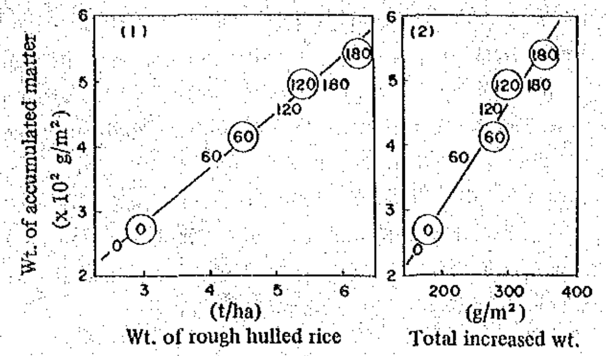


Fig. 2 Relation between weight of accumulated matter in panicle and weight of rough hulled rice and total increased weight of rice plant

Table 7. Weight of accumulated matter before heading time

Treatment	0		60		120		180	
	g/m²	%	g/m²	%	g/m²	%	g/m²	%
A	90	41	165	43	193	42	177	36
B	103	37	146	35	211	42	194	36

Note : Percentage of weight of accumulated matter before heading time to weight of accumulated matter of panicles.

We will discuss the factors which controlled yield during the ripening period. As shown in Fig. 2-(1) and (2), weight of rough hulled rice was closely correlated

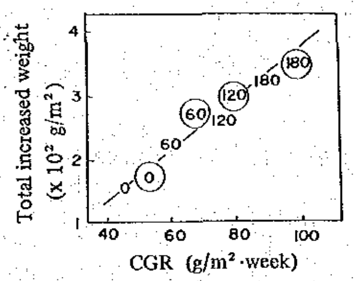


Fig. 3 Relation between total increased weight during the ripening phase and CGR for 3 weeks after heading

to weight of accumulated panicle material (the difference of panicle weight at heading and harvesting time). And the weight of accumulated material in panicles also was closely correlated to the total increased weight of rice plant during the ripening phase (from heading till harvesting time). In the other words yield was controlled by dry matter production during the ripening phase. Fig. 3 shows there is a close relationship between total increased weight during the ripening phase and the crop growth rate (CGR) for 3 weeks after heading. The relationship between the CGR

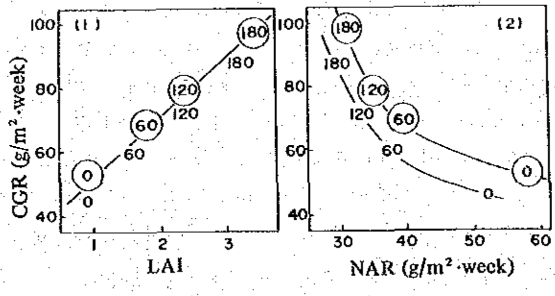


Fig. 4 Relation between CGR and, LAI and NAR for 3 weeks after heading

and the leaf area index (LAI) and the net assimilation rate (NAR) are illustrated in Fig. 4-(1) and (2). It appears that the CGR during the ripening phase was firmly controlled by the LAI, but the NAR. It seems that increased nitrogen application results in increased LAI and CGR during ripening phase and results in higher yields. Higher CGR in the field with preceding soybean crop was caused by greater LAI and NAR compared to the field without preceding crop.

According to the result [1] of crop production experiment in cropping pattern at Genteng substation CRIFC in INDONESIA, lowland rice following mungbean or yang long bean cropping show higher yield as compared with following rice cropping. As mentioned above, rice following soybean cropping resulted in increased yields about 7 %, and over a range of 0 to 180 kg N/ha of fertilizer application. Since there were no data on the nitrogen contents of soil as affected by soybean cropping, we could not discuss here about the residual effect of applied soybean plant in soil on the rice. Greater amount of nitrogen application resulted in a maximum of winnowed paddy of 8.5 t/ha. It seems that this high yield was due to a greater number of spikelets per unit area, and higher LAI and NAR during the ripening period.

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摘　　　　要

大豆作跡水稲の窒素施肥について

S. Partohardjono, V. Hendrik, L. Sukarno, 石倉教光

１９８０年，中央農業研究所のＭｕａｒａ試験地（ボゴール市）で，大豆作跡地および無作付跡地の水田に水稲品種IR−３６の２１日苗を２０×２０*cm*，３本植で８月，移植した。水稲への窒素施用量（成分総量）は0,60，120，１８０*kg*／*ha*とした。なお，前作の大豆は，系統№２９の種子を４０×２０*cm*の播種密度で４月に播種し，７月に収穫した。大豆穀実収量は２００*kg*／*ha*であった。

前作大豆の有無ならびに窒素施肥量が水稲の収量に及ぼす影響について検討した。得られた結果は次のとおりである。

1. 大豆作跡地水稲の収量は無作付跡地に比べ，約７％の収量増となった。
2. 窒素施用の増量は収量増をもたらしたが，精籾重８.５ｔ／*ha*の最高収量は大豆作跡地・窒素１８０*kg*／*ha*区で得られた。
3. 窒素の増施および大豆作跡地の収量増は面積当総穎花数が増加したことに起因し，登熟歩合ならびに玄米千粒重の影響はほとんど見られなかった。
4. 窒素の増施，大豆作跡地の増収は登熟期間の葉面積ならびに純同化率が他の区に比べて大きく，乾重増加量が大であったことに起因した。

7. EFFECT OF SOWING DATES ON RICE SEEDING CHARACTERS

S. Partohardjono,* Hendrik, V.,* L. Sukarno,** and N. Ishikura ***

ABSTRACT

The effect of sowing date on seedling characters, avoiding the effect of mutual shading were examined. Four hundred grains per m^2 of rice variety IR-36 were sown at weekly intervals from September 1979 until September 1980.

Leaf age, tiller number, leaf area, plant weight/height ratio, and total weight of 19 day-old-seedlings showed lower values in the rainy season than in the dry season. Plant height was not related to seasons. Total dry weight of seedling controlled by the NAR which was affected by the amount of solar radiation.

INTRODUCTION

When the rice cropping pattern combined with other crops is be made, the effect of cropping season on seedling characters must be made clear.

Hitherto, studies on the rearing of rice seedlings have been conducted from the practical stand point. It seems that twenty-one-day-old seedlings have been recommended without giving any attention to rearing season or area.

This experiment was conducted to obtain fundamental data on the raising of seedlings, i.e. the effect of sowing date on seedling charactor while avoiding the effect of mutual shading.

MATERIALS AND METHODS

Seedlings were soil-cultured in a concrete pot with inside dimension of 50 x 50 x 40 cm and filled with *latosol soil from Cikeumeuh Experiment Station.* The rice variety IR-36 was used.

The seeds which germinated like the pigeon-breasted by soaking with water for three days were sown in 4 rows seeding at weekly intervals from September 1979 until September 1980. The seedling density was 400 grains per m^2.

Fertilizer was applied as follows: 10 g of annonium sulfate, 5 g of triple superphosphate and 5 g of potassium chloride were applied per pot as a basal dressing.

The seed beds were submerged 4 days after sowing and soil surface was always flooded until the seedling were uprooted. The seedlings were uprooted 12 and 19 days after sowing, and measurements of various characters were taken. Meteorological observations were made at Muara Experiment Station near Cikeumeuh Experiment Station of CRIFC in Bogor. This experiment was carried out at Cikeumeuh Experiment Station of CRIFC.

RESULTS AND DISCUSSION

1. Variation of 19 day-old-seedlings characteristics with sowing date.

As shown in Fig. 1, seedling characters showed complicated trends with varying sowing date. If we compare Figure 1 and Figure 2 in which seasonal change of temperature and solar radiation are illustrated, we can see that temperature and solar radiation appear to affect all the seedling characters except plant height. That is to say, it appear that the lower air temperature and solar radiation values in the raining season especially from December until February, resulted in lower values of seedling characters as compared to the dry season.

2. Relationship between mean air temperature and solar radiation and seedling characters.

As shown in Fig. 3 and 4, there were close correlation between temperature or radiation and leaf-age, tiller number, plant weight/height ratio (dry seedling weight/plant height), leaf area, and dry seedling weight. There was no correlation between either temperature or radiation and plant height. In the other words, the plant height of seedling was not affected by temperature or radiation. These results mean that characters of seedling raised under lower radiation and temperature

* Agronomist and assistant agronomist, Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.

** Chemical analyst, Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.

*** Agronomist, Crop Division, Chugoku Nat. Agric. Expt. Sta., 450, Nishi-Fukatsu-cho, Fukuyama, Hiroshima, JAPAN

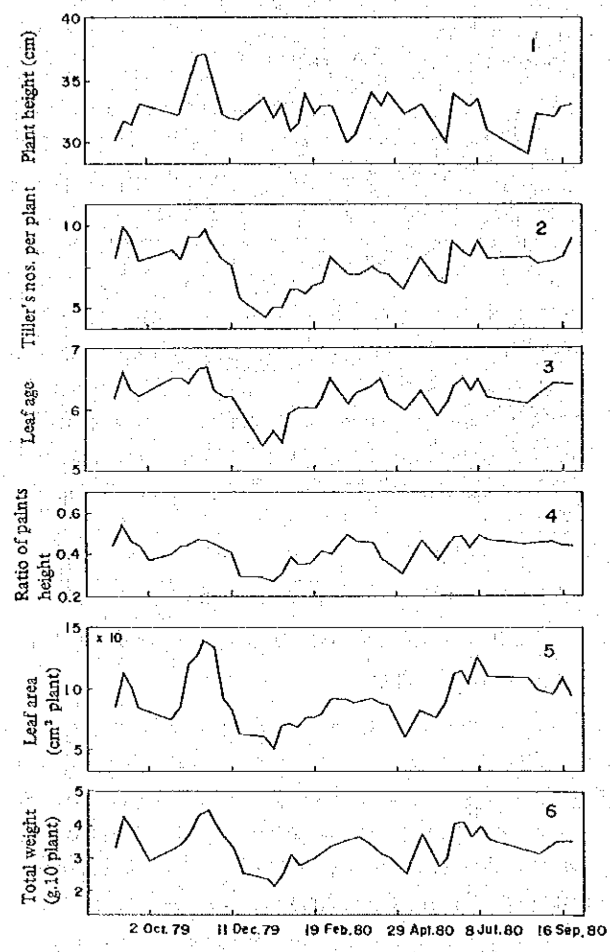

Fig. 1 Seasonal change of chracters of 19 days old seedlings

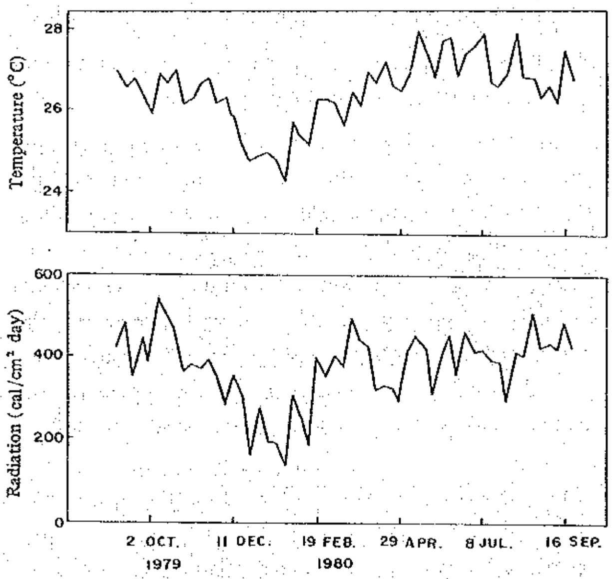

Fig. 2 Seasonal change of weekly mean air temperature and amount of solar radiation.

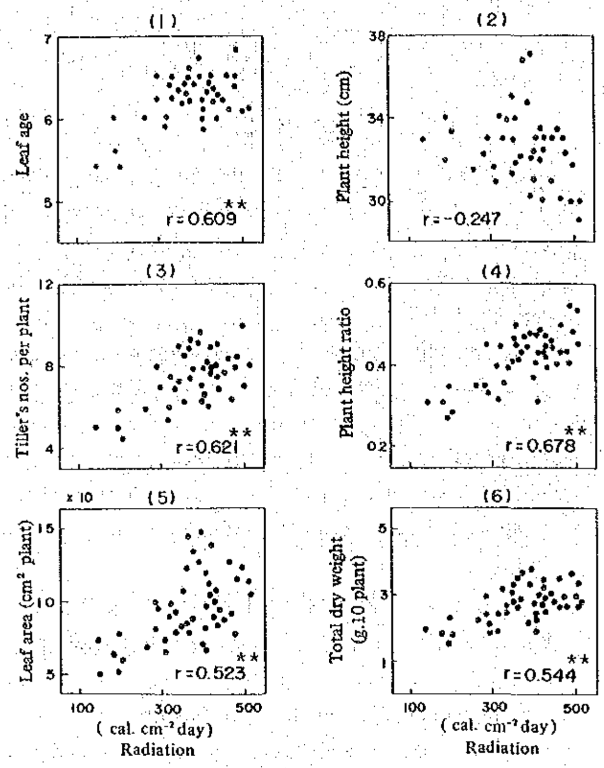

Fig. 3 Relationship between amount of solar radiation and characters of 19 days old seedling

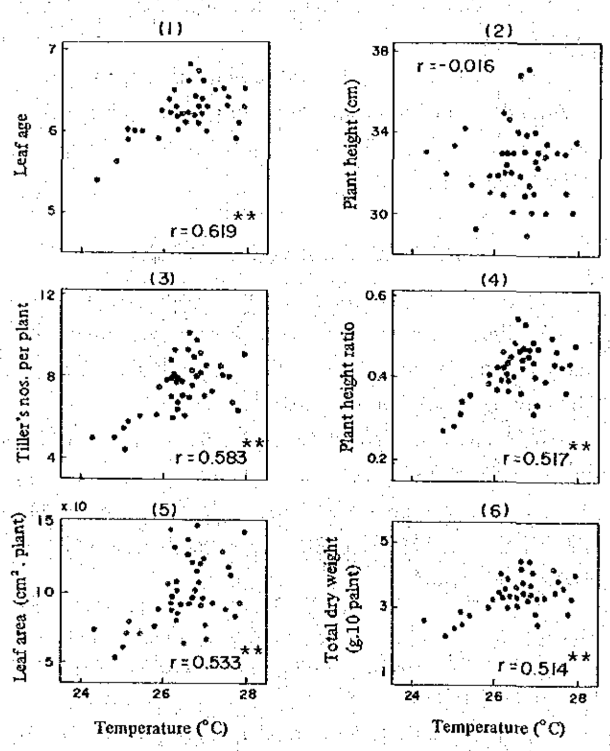

Fig. 4 Relationship between daily mean air temperature and characters of 19 days-old seedlings

conditions are inferior to those raised under high radiation and temperature condition.

In a similar experiment in Tailand [4,5], plant height of 21 day-old seedlings sown during the low temperature month of December and January were shorter than those sown in higher temperatures. And Murakami et al. [3] cultured rice at various lacation in northern Japan and found that the plant height at tillering stage were much more affected by temperature. But it is possible that the difference between the results obtained in Thailand and Japan and by us was caused by differing rice variety and other experimental conditions.

3. Dry matter production during the raising of seedling

The relative growth rate (RGR), net assimilation rate (NAR), amount of solar radiation, mean air temperature, nitrogen content in the leaf blade, C/F ratio (ratio of non-photosynthetic organ to photosynthetic organ) were measured from September 1979 until September 1980 and are shown in Table 1.

As shown in Fig. 5, the dry-matter weight of 19 day-old seedlings was closely related to the relative growth rate (RGR) over one week before the seedling was uprooted.

The relative growth rate is composed of NAR and LWR (ratio of leaf weight to total weight). The relationship between NAR and LWR and RGR is shown in Fig. 6. Here we can see that the RGR was not always controlled by LWR, but was firmly controlled by NAR.

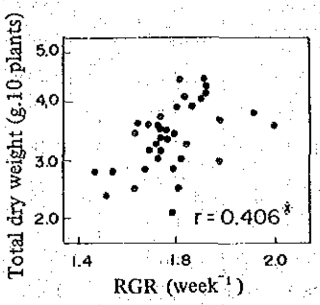

Fig. 5 Relationship between RGR and total dry weight of 19 days old seedlings

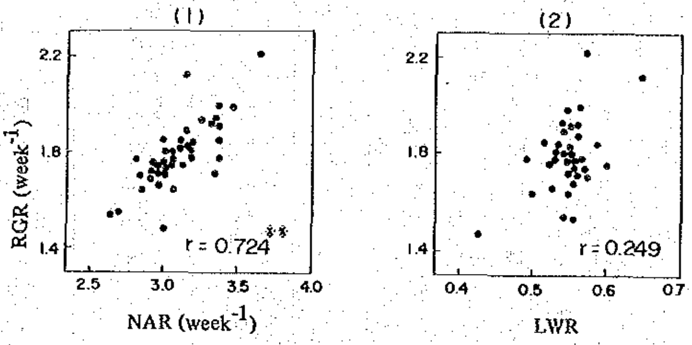

Fig. 6 Relationship between RGR and NAR and LWR

Note: LWR = 1/2 (LW1/W1 + LW2/W2) ; $g.g^{-1}$, where W1, W2 : and LW1, LW2 are dry weight and leaf dry weight, respectively, t1 and t2.

The relationships between NAR and factors affecting it are shown in Fig. 7. NAR was positively correlated with radiation and temperature (Fig. 7-(2), (3)). NAR is thought to be controlled by nitrogen content of the leaf blade, C/F ratio and leaf weight and so on, but there were no close correlations between NAR and these variable (Fig. 7-(1), (4), (5)). In other words it seems that NAR in this experiment was controlled by radiation and temperature rather than nitrogen content, C/F ratio or leaf weight.

In sowing date experiment in Japan of temperate zone similar to the present one using rice, it was found [2] that NAR was correlated highly with radiation at temperature range, 24-27°C. And it was found [3] that NAR attained its maximum value with about 400 cal. cm^{-2} day $^{-1}$ of solar radiation. In a temperature range of 15-21°C, the value of NAR is affected by both temperature and solar radiation, while in a temperature range of 21-31°C NAR is affected only by the amount of solar radiation. These result are similar to ours although do not exactly agree with them. The differences among these results may be caused by experimental conditions which cannot be clarified here.

As has been mentioned above, growth of seedlings is affected by the amount of solar radiation and the temperature.

This means that even if the seedling durations are the same, the characteristics of the seedlings will be different depending upon the environmental conditions.

Our results were obtained from measurements of individual plant only for one year. This work must be followed by an investigation of seedling characters in community of plants and the effect of these on rice yield.

TABLE 1. : Relative growth rate (RGR), net assimilation rate (NAR) mean air temperature, nitrogen content of leaf and C/F ratio.

Mos date	RGR week-1	NAR week-1	Radiation cal. cm-2 day-1	Temperature °C	N %	C/F
1. Sept. 4 – Sept. 11	1.80	3.18	424	26.9	4.77	0.681
2. Sept. 11 – Sept. 18	1.92	3.31	486	26.6	5.40	0.704
3. Sept. 18 – Sept. 25	1.98	3.36	350	26.8	5.40	0.780
4. Sept. 25 – Oct. 2	1.71	2.90	450	26.4	4.82	0.781
5. Sept. 23 – Oct. 30	1.77	3.33	475	27.0	4.59	0.808
6. Oct. 30 – Nov. 6	1.78	3.05	366	26.2	3.42	0.743
7. Nov. 6 – Nov. 13	1.87	3.14	382	26.3	4.26	0.768
8. Nov. 13 – Nov. 20	1.82	3.13	372	26.6	4.44	0.801
9. Nov. 20 – Nov. 27	1.92	3.33	392	26.8	4.17	0.774
10. Nov. 27 – Nov. 4	1.81	3.12	352	26.2	4.50	0.770
11. Dec. 4 – Dec. 11	1.74	2.97	285	26.3	4.10	0.806
12. Dec. 11 – Dec. 18	1.77	3.05	358	25.9	3.42	0.801
13. Dec. 18 Dec. 24	1.47	2.96	306	25.1	4.17	0.767
14. Jan. 9 – Jan. 15	1.53	2.64	198	25.0	4.56	0.892
15. Jan. 15 – Jan. 22	1.78	3.18	188	24.8	4.32	0.908
16. Jan. 22 – Jan. 29	1.63	2.84	141	24.3	4.11	0.735
17. Jan. 29 – Feb. 5	1.82	3.18	311	25.8	4.56	0.772
18. Feb. 5 – Feb. 12	1.68	2.87	257	25.4	4.26	0.706
19. Feb. 12 – Feb. 19	1.79	3.03	188	25.2	4.62	0.731
20. Feb. 19 – Feb. 26	1.98	3.43	399	26.3	4.95	0.748
21. Mar. 4 – Mar. 11	1.74	2.91	403	26.2	4.11	0.689
22. Mar. 18 – Mar. 25	2.20	3.64	495	26.5	4.06	0.906
23. Mar. 25 – Apr. 1	1.69	2.80	440	26.2	4.41	0.668
24. Apr. 8 – Apr. 15	2.12	3.12	321	26.7	4.17	0.942
25. Apr. 15 – Apr. 22	1.70	2.97	331	27.2	4.05	0.744
26. Apr. 22 – Apr. 29	1.73	2.91	326	26.6	3.81	0.716
27. May 6 – May 13	1.81	3.09	403	27.0	4.17	0.760
28. May 20 – May 27	1.74	3.01	425	27.5	3.24	0.820
29. June 3 – June 10	1.54	2.67	398	27.7	3.42	0.781
30. June 10 – June 17	1.71	2.95	464	27.8	4.47	0.837
31. June 17 – June 24	1.91	3.34	357	26.9	3.54	0.866
32. June 24 – June 1	1.84	3.34	464	27.4	3.51	0.787
33. July 1 – July 8	1.72	2.94	414	27.6	4.35	0.771
34. July 8 – July 15	1.91	3.24	419	27.9	3.78	0.747
35. July 15 – July 22	1.65	2.94	398	26.7	3.97	0.763
36. Aug. 19 – Aug. 26	1.84	2.98	505	26.8	3.97	0.812
37. Aug. 26 – Sep. 2	1.73	3.14	425	26.3	3.97	0.848
38. Sep. 9 – Sep. 16	1.79	3.00	420	26.1	3.91	0.821
39. Sep. 16 – Sep. 23	1.76	2.78	475	27.5	3.79	0.739
40. Sep. 23 – Sep. 30	1.63	3.05	425	26.7	3.60	0.755

Note : RGR : (ln W2 – ln W1)/(t2 – t1), g, g^{-1} $week^{-1}$; NAR : (W2 – W1)(ln LW2 – ln LW1)/(t2 – t1)(LW2 – LW1), g, g^{-1} $week^{-1}$, where W1, W2, LW1, LW2 are dry weight and leaf dry weight, respectively, at t1 and t2.

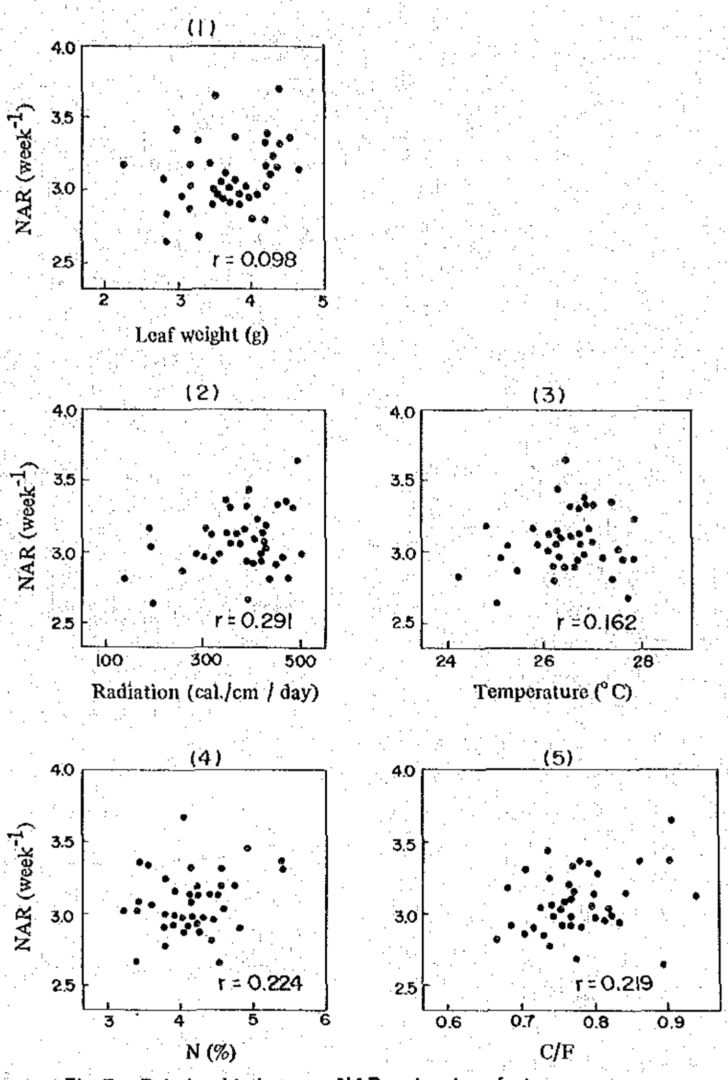

Fig. 7 Relationship between NAR and various factors

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The authors would like to express their appreciation to Dr. E. Suryatna, chief of the agronomy division CRIA and Dr. S. Toda, team leader of JICA Japan-Indonesia Research Program. And the authors are also grateful to stuff of physiology division CRIA for providing the meteorological data.

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摘　　　要

水稲の播種期が苗質に及ぼす影響

S. Partohardjono, V. Hendrik, L. Sukarno, 石倉教光

中央農業研究所（ボゴール市）のチッケム試験地圃場の土壌（Latosol soil）を充塡した５０×５０×４０cmのコンクリート槽に，水稲品種 IR－３６の催芽種子を１９７9年9月から１９８０年９月まで毎週播種（播種様式：4列，２cm間隔，１粒播），１９日間栽培して苗質に及ぼす播種期の影響を調査した。得られた結果は大要，次のとおりである。

1. 草丈には，気象要因の季節変化の影響はみられなかった。
2. 苗の葉数，茎数，葉面積，乾重／草丈，全乾重はいずれも日射の比較的少い１１月～２月（雨季）が日射の多い他の時期（乾季）に比べて低い値を示した。
3. 育苗期間中の苗の乾物生長は，日射量の多少に影響された純同化率の支配的影響を受けた。

8. EFFECT OF TRANSPLANTING TIME ON YIELD AND YIELD COMPONENTS

S. Partohardjono,* Hendrik, V.,* and N. Ishikura **

ABSTRACT

Rice yield and yield components as affected by cropping season were studied in field experiments by using the rice variety IR-36, which was transplanted every month between August 1979 and July 1980.

Lower yields were obtained from the October, November and December transplanting. Number of spikelets per unit area and the 1000 grain weight did not significantly affected yields obtained from different transplantings. On the other hand, yields were affected by the ripened grain percentage and grain sterility. The ripened grains percentage was controlled by dry matter production, which were affected by solar radiation and by the net assimilation rate during the ripening period.

INTRODUCTION

To establish cropping pattern of combination of crops, we need to know the effect of cropping season on the growth and yield of each crop. It is very important to establish rice cropping method which confirms to each cropping season.

In Indonesia, previous report indicated the increase of percentage of grain sterility in the rainy season as affected by transplanting time (CRIA, Annual Report, 1976), but the effect of cropping season on the other yield components was not known.

The present study examined the effect of rice cropping season on yield and yield components.

MATERIAL AND METHODS

Rice variety IR 36 was used in this experiment. Two week old seedlings were transplanted at a spacing of 20 cm x 20 cm each month ever the year from August 1979 until July 1980. Fertilizer was applied as follows: 60 kg N/ha, 50 kg P_2O_5/ha and 50 kg K_2O/ha as a basal dressing, and 30 kg N/ha at the panicle formation stage as a top dressing.

The experiment was laid out in a split-plot design with three replications. All plot were irrigated until harvesting. The management of the others were carried out as usual. Harvesting was carried out from October 1979 to September 1980. Plant materials were sampled at the full heading time and harvesting time, 5 hills each plot and oven-dried at 75°C to a constant weight.

This experiment was carried out at the experiment stations Muara and Singamerta.

RESULTS AND DISCUSSION

Results of the experiment are shown in Table 1 and Table 2.

As shown in Table 1, the transplanting dates resulting in highest yields of winnowed paddy, rough rice and hulled rice were August 1979, June and July 1980 at Muara and Singamerta. The lowest yield of hulled rice was obtained from the seedling transplanted in April 1980 at Singamerta. Seedling transplanted in October, November, December 1979 and March and April 1980 showed low yields.

The effect of transplanting date on yield components were as follows : Yields of hulled rice were not affected by the number of spikelets per unit area (Fig. 1-1) or 1000 grains weight (Fig. 1-2), but were closely controlled by percentage of ripened grain (Fig. 1-3) and the sterility percentage (Fig. 1-4). It seems that the cropping season affects rice yield rather through the production of matter and shifting of assimilated materials during the ripening phase (from flowering to maturity) than through vegetative growth before the heading period.

As shown in Fig. 2, there is a low correlation between the accumulated weight of panicle per unit area and total weight (leaf, culm, and sheath) or rice plants per unit area during the ripening stage (r = 0.332). However, if we exclude the aberant value of April 1980 in Singamerta where the spike neck and glumous flower of lower rachis-branches were damaged by diseases this correlation becomes higher (r = 0.521*). The October,

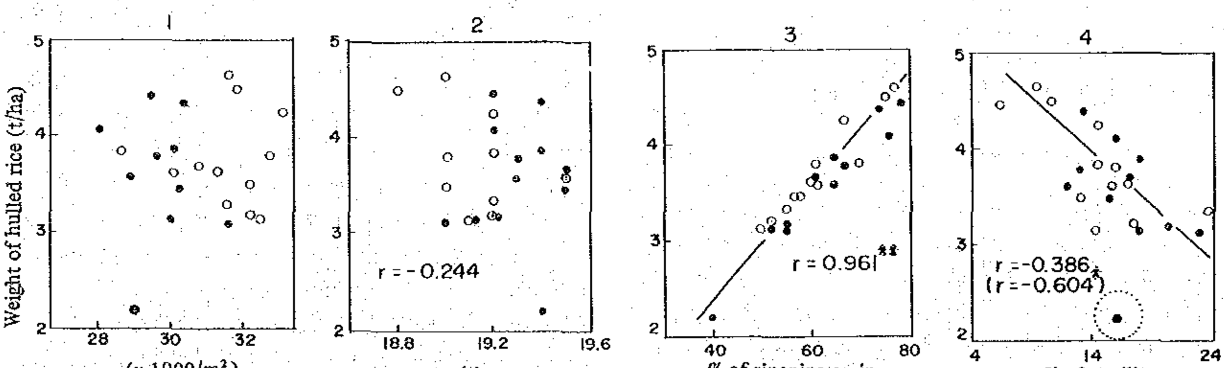
* Agronomist and assistant agronomist, Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.

** Agronomist, Crop Division, Chugoku Nat. Agric. Expt. Sta., 450, Nishi-Fukatsu-cho, Fukuyama, Hiroshima, JAPAN.

Table 1. Yields and yield components as affected by transplanting time

Transplanting time	1979	Aug.	Sept.	Oct.	Nov.	Dec.	1980 Jan.	Feb.	Mar.	Apr.	May	June	July
Harvesting time	1979	Nov.	Dec.	1980 Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.
Weight of winnowed paddy (t/ha)	M	6.22	5.43	-	4.33	4.94	5.66	5.45	5.40	4.94	5.51	6.50	6.40
	S	6.22	5.51	4.93	4.93	4.88	5.34	5.69	5.31	3.77	5.78	5.57	6.19
Wt. of rough hulled rice (t/ha)	M	4.69	4.05	-	3.80	3.73	4.22	4.19	3.92	3.57	3.87	4.96	4.92
	S	4.69	4.04	3.72	3.65	3.43	4.05	4.33	3.86	2.60	4.31	4.07	4.81
Wt. of hulled rice (t/ha)	M	4.26	3.62	-	3.33	3.19	3.80	3.84	3.63	3.13	3.49	4.64	4.51
	S	4.38	3.67	3.18	3.12	3.15	3.49	3.87	3.61	2.22	4.10	3.80	4.45
Nos. of panicles per m²	M	356	342	-	325	310	335	324	326	336	322	326	346
	S	369	406	386	351	349	368	347	344	372	346	371	350
Nos. of spikelets per m² (x 1000)	M	33.1	30.8	-	31.5	32.2	32.8	28.8	31.3	32.6	32.2	31.6	31.8
	S	30.3	30.9	30.1	31.6	30.0	31.6	30.2	28.9	29.0	28.0	29.6	29.4
% of sterility	M	14.7	15.6	-	23.9	17.4	16.0	14.5	16.9	14.1	13.1	9.4	10.6
	S	13.7	17.1	20.2	23.0	17.9	15.6	17.9	11.9	16.2	16.1	12.8	6.5
% of ripened grains	M	67.0	60.2	-	55.0	52.0	61.0	69.5	60.8	50.6	57.0	77.3	75.5
	S	74.5	60.9	55.0	52.0	54.9	56.7	65.0	64.7	39.4	76.3	66.6	78.9
Weight of 1000 grains (g)	M	19.2	19.5	-	19.2	19.2	19.0	19.2	19.1	15.2	19.0	19.0	18.8
	S	19.4	19.5	19.2	19.0	19.1	19.5	19.4	19.3	19.4	19.2	19.3	19.2

Note : M : Muara, S : Singamerta



LEGEND : ○ MUARA
● SINGAMERTA

Fig. 1. Relation between weight of hulled rice (yield) and yield components

Table 2. Dry weight of rice plant (g/m²) as affected by transplanting time

Transplanting time		Exp. Sta	Heading time			Harvesting time		
			Leaf	Panicle	Total[1]	Leaf	Panicle	Total[1]
1979	August	M	134	199	802	26	644	1067
		S	145	125	683	22	553	962
	September	M	167	192	835	41	595	1043
		S	169	175	821	26	570	1149
	October	M	-	-	-	-	-	-
		S	197	166	771	30	576	1078
	November	M	155	146	756	31	514	864
		S	134	117	614	11	461	776
	December	M	119	140	715	19	473	814
		S	135	129	761	14	528	912
1980	January	M	135	162	695	37	558	871
		S	110	104	751	58	471	992
	February	M	151	152	771	20	518	871
		S	129	154	751	18	493	975
	March	M	95	173	535	32	504	788
		S	113	170	677	36	516	966
	April	M	132	134	544	25	483	764
		S	194	113	636	41	347	903
	May	M	126	129	540	15	529	809
		S	189	115	548	7	544	890
	June	M	138	145	723	21	588	1019
		S	141	137	597	14	509	838
	July	M	120	161	622	17	615	912
		S	164	146	670	6	568	983

Note : 1) Total means sum of leaf, panicle culm and sheath.

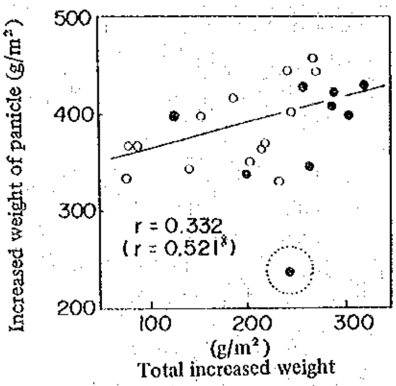


Fig. 2. Relation between total increased weight and increased weight of panicles during the ripening stage

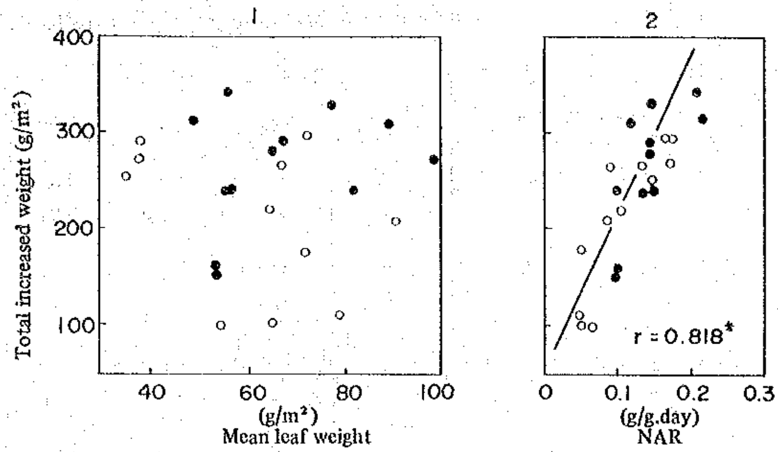


Fig. 3. Relation between total increased weight and mean leaf weight and NAR

November and December 1979 transplanting were full heading in December, January and February, respectively.

Thus, it seems that the lower yields of seedlings transplanted in October, November and December 1979 result from lower radiation in December, January and February 1980 as shown in Fig. 4.

The dry matter production during the ripening period es estimated by method of growth analysis was not affected by the amount of leaf per unit area, but by the net assimilation rate (NAR), Fig. 3-1 and 3-2. As well known, NAR is affected by radiation, nitrogen content of the leaf, the light intercepting characteristics of the leaf and so on. There was a close correlation (r = 0.739*) between the radiation during ripening period and the NAR as measured at Muara (Fig. 5). But because data on nitrogen content and other factors were not measured, the effect of these factors on NAR cannot be shown here.

It seems that variation of yield due to different transplanting dates were the result of variation in radiation during the ripening stage. In the April 1980 transplanting at Muara and Singamerta, lower yields were obtained despite of the high radiation input of the dry season. As stated above, this is thought to be caused by diseases attacks during the ripening period.

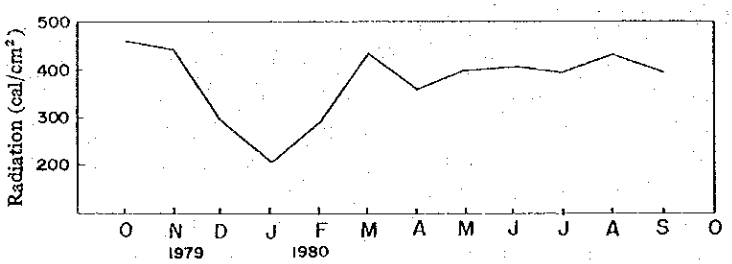


Fig. 4. Average monthly radiation at MUARA

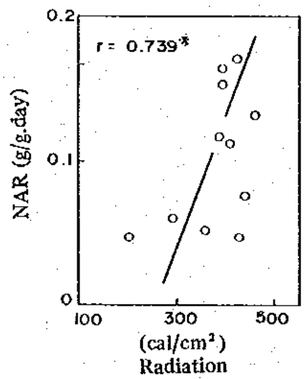


Fig. 5. Relation between the radiation and NAR

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The authos would like to express their appreciation to Dr. E. Suryatna, chief of the agronomy division CRIA and Dr. S. Toda, team leader of JICA Japan-Indonesia Research Program. And the authors are indebted to Mr. Ir. Iwin, chief of the Muara research station and Mr. Jahid, chief of the Singamerta research station CRIA, for the field experiment.

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摘　　　　要

移植期が水稲の収量・収量構成要素に及ぼす影響

S. Partohardjono., V. Hendrik，石倉教光

中央農業研究所（CRIA）のMuara試験地（ボゴール市）およびSingamerta試験地（ジャカルタ西方約100Km）で1979年8月から1980年7月まで毎月，水稲品種IR-36の14日苗を栽植密度20×20 *cm*で移植し，水稲の収量および収量構成要素に及ぼす移植時期の影響を検討した。なお，水管理は全生育期間，常時湛水とした。結果の大要は次のとおりである。

1. 1979年10月（出穂期1980年1月）から12月（出穂期3月）までの移植期の精玄米収量は3.1～3.3 t／*ha*であり，他の時期の収量3.5～4.6 t／*ha*に比べて低収であった。
2. 10月から12月までの移植期が低収であったのは，他の移植期に比べて面積当総穎花数ならびに玄米千粒重が大差なく，登熟歩合が52～55％と低いことに起因した。
3. 10月から12月移植の出穂・登熟期は1月～3月の低い日射条件下にあって，純同化率の低いことによる少い乾物生産に原因した。

9. INFLUENCE OF TILLAGE, FERTILIZATION AND IRRIGATION ON THE OCCURRENCE OF WEEDS IN SOYBEAN FIELD AFTER LOWLAND RICE

Kanenori Nakayama*, Agus Sudiman** and Adisarwanto***

ABSTRACT

Influence of intensive working as tillage, fertilization and irrigation on the occurrence of weeds was investigated in soybean field after lowland rice.

Quantity of weeds increased remarkably by application of tillage, fertilization or irrigation. Quantity of weeds in tilled with fertilizer was more three times than that in untilled without fertilizer, and tilled with irrigation was about two times to untilled without irrigation. Weed community changed to dominance of gramineous weed from mixed community by application of tillage or fertilization.

INTRODUCTION

Most soybean in Java is cultivated in dry season after lowland rice. They are planted without tillage, without fertilizer or pesticide. At present, the introduction of intensive cultivation method with tillage, *fertilizers and pesticides applications has encouraged* to improve the traditional cultivation method. The introduction of intensive cultivation method have possibility for increasing yields, while give cause for anxiety of weed and pest occurrence.

This study was conducted to clarify the influence of intensive working as tillage, fertilization and irrigation on the occurrence of weeds in soybean field after lowland rice. Two experiments were carried out at Mojosari substation in 1980. The purpose of the experiments are as follows:

Exp. 1 Influence of tillage, seedling and fertilization on the occurrence of weeds.

Exp. 2 Influence of tillage and irrigation on the occurrence of weeds.

Further, the experimental fields for Exp. 1 and Exp. 2 were also used fields for the study "The Cultivation Method of Soybean Planted After Lowland Rice" (3).

MATERIALS AND METHODS

(Exp. 1)

Soybean variety, ORBA was sown after rice cropping in a paddy field on 3 May, 1980.

A split-plot design with three replications was applied.

The treatments were as follows:

Main plot : (1) No tillage + Broadcast seeding
(2) No tillage + Dibbled seeding
(3) Tillage + Dibbled seeding

Sub plot : (i) No fertilization
(ii) No fertilization + Azodrin application to control *Ophiomyia phaseoli.*
(iii) Fertilization + Azodrin application to control *O. phaseoli.*
(iv) Fertilization + Azodrin application to control *O. phaseoli* + Kalphos application to control pod insect.

The size of the subplot was 5.6 x 5 meters.

Seeding was conducted without tillage after rice harvest for treatment (1) and (2), and with tillage to a depth of 10 to 15 cm using a hoe for treatment (3). For treatment (1), seeds were broadcasted at 479 gm per 100 m^2. Seeds were dibbled for treatment (2) and (3) at a spacing of 40 x 15 cm with two seeds per hill. Fertilizers in treatment (iii) and (iv) were 40 kg/ha N + 60 kg/ha P_2O_5 + 50 kg/ha K_2O using urea, TSP and potassium chloride respectively. Azodrin was sprayed twice (one and two weeks after seeding) and Kalphos also twice after flowering. Irrigation was given just after seeding and there was 20.4 mm of rainfall the day after seeding. After that the weather was dry, so the plants were irrigated from May 18 at ten to sixteen days interval.

Investigation of weeds was carried out on May 23, twenty days after seeding. Two investigated plots of

* Agronomist, Department of Farm Mechanization, Agricultural Research Center, Yatabe, Tsukuba, Ibaraki, JAPAN.

** Agronomist, Agronomy Division, BORIF, CRIFC, Jl. Merdeka No. 99, Bogor, INDONESIA.

*** Agronomist, Agronomy Division, Malang Research Institute for Food Crop, CRIFC, Malang, Jawa Timur, INDONESIA.

Table 1 : Quantity of weeds as affected by fertilizer, tillage, insecticide and seeding method (Exp. 1, 1980).

g/m²

Treatment*) Main plot	Sub plot	*E. colonum*	*Cynodon dactylon*	*C. rotundus*	*Marsilea crenata*	Others	Paddy rice	All weed included rice	All weed excepted rice
No T B.S	No F, No In	38	2	77	8	0	21	146	125
	No F, Azodrin	8	20	103	21	0	54	206	152
	F, Azodrin	57	24	82	3	0	140	306	166
	F, Azodrin & Kalphos	89	41	182	5	0	45	362	317
No T D.S	No F, No In	24	18	47	2	2	67	160	93
	No F, Azodrin	32	7	48	11	0	64	162	98
	F, Azodrin	80	36	122	14	1	175	428	253
	F, Azodrin & Kalphos	130	9	146	8	4	115	412	297
T, D.S	No F, No In	146	14	62	0	0	63	285	222
	No F, Azodrin	131	26	79	0	0	70	306	236
	F, Azodrin	324	28	82	0	0	82	516	434
	F, Azodrin & Kalphos	334	45	73	0	0	87	539	452
Main plot	No T, B.S	48	22	111	9	0	65	255	190
	No T, D.S	67	18	91	9	2	105	292	187
	T, D.S	234	28	74	0	0	76	412	336
Sub plot	No F, No In	69	11	62	3	1	50	196	146
	No F, Azodrin	57	18	77	11	0	63	226	163
	F, Azodrin	154	29	95	6	0	132	416	284
	F, Azodrin & Kalphos	184	32	134	4	1	82	437	355
Main plot	Significant 5%	58.2	21.7	75.7	11.2	-	51.3	142.5	138.1
	Significant 1%	96.5	36.1	125.5	18.6	-	85.1	236.4	229.0
Sub plot	Significant 5%	53.9	12.1	37.0	6.0	-	34.7	73.1	61.6
	Significant 1%	73.9	16.6	50.6	8.2	-	47.6	100.2	84.4

*) No T : no tillage
B.S : broadcast seeding
No F : no fertilization
No In : no insecticide application
Azodrin : application Azodrin to control *O. phaseoli*
Kalphos : application Kalphos to control pod insect pest
T : tillage
D.S : dibbled seeding
F : fertilization

Table 2 : Quantity of weeds as affected by irrigation and tillage (Exp. 2, 1980)

g/m²

Treatment*) Main plot	Sub plot	*E. colonum*	*Cynodon dactylon*	*C. rotundus*	Others	Paddy rice	All weed included rice	All weed excepted rice
Ir (1)	No T (i)	430	427	50	17	487	1,411	924
	No T (ii)	549	136	25	16	409	1,135	726
	T (iii)	1,550	43	16	9	37	1,655	1,618
	T (iv)	1,366	42	50	28	30	1,516	1,486
No Ir (2)	No T (i)	379	295	44	17	143	878	735
	No T (ii)	223	285	33	6	158	705	547
	T (iii)	846	29	18	1	11	905	894
	T (iv)	809	24	6	0	16	855	839
Main plot	Ir (1)	974	162	35	18	241	1,430	1,189
	No Ir (2)	564	158	25	6	82	835	753
Sub plot	No T (i)	405	361	47	17	315	1,145	830
	No T (ii)	386	211	29	11	284	921	637
	T (iii)	1,198	36	17	5	24	1,280	1,256
	T (iv)	1,088	33	28	14	23	1,186	1,163
Main plot	Significant 5%	175.1	347.7	40.6	-	212.2	246.2	200.7
	Significant 1%	294.2	802.1	93.6	-	489.3	568.0	463.0
Sub plot	Significant 5%	155.7	197.7	21.5	-	128.6	164.6	245.5
	Significant 1%	218.3	277.2	30.1	-	180.3	230.7	344.2

* Ir : irrigation
T : tillage
No Ir : no irrigation
No T : no tillage

1 x 1 meters were set up in all plots. The weeds in the investigated plots were pulled out, classifed into species and measured top weights (fresh).

(Exp. 2)

Soybean variety, No. 29 was sown after rice cropping in a paddy field on 30 July, 1980.

A split-plot design with three replications was applied. The treatments were as follows:

Main plot : (1) Irrigation
(2) No irrigation
Sub plot : (i) No tillage + Weeding
(ii) No tillage + No weeding
(iii) Tillage + Weeding
(iv) Tillage + No weeding

The size of the sub plot was 6 x 5 meters.

Seeding was conducted without tillage after rice harvest for treatment (i) and (ii), and with hoe-tillage to a depth of 10 to 15 cm for treatment (iii) and (iv). Seeds were dibbled in all plots at a spacing of 40 x 10 cm with two seeds per hill. Fertilizers were applied as same as Exp. 1 to all plots. Irrigation was given just after seeding for all plots. After that, the weather was dry, so the plants for irrigating plots (1) were irrigated from August 10 at ten days interval.

Investigation of weeds was carried out on August 20, twenty-one days after seeding. The investigation method was the same as Exp. 1. Weeding for treated plots (i) and (iii) was conducted after investigation of weeds.

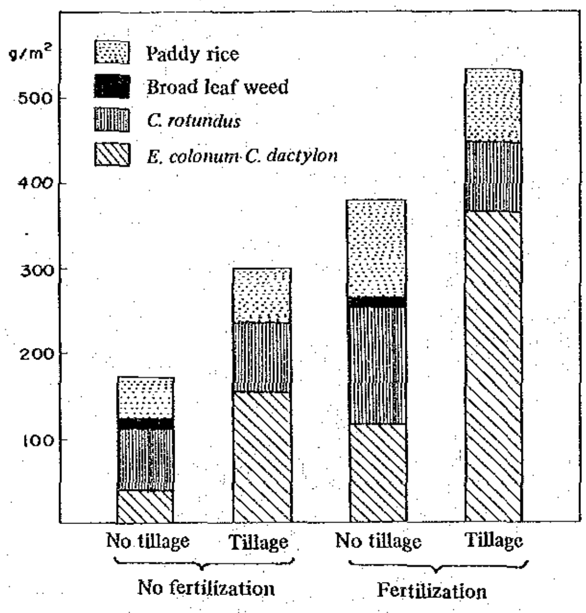

Fig. 1 Influence of tillage and fertilization on the occurrence of weed (Exp. 1, 1980)

RESULTS

(Exp. 1)

The results of weed investigation are shown in Table 1. *Echinochloa colonum*, *Cynodon dactylon* (the above, gramineous weed) and *Cyperus rotundus* (sedge weed) were dominant in the experimental field. There were a few occurrence of *Marsilea crenata* and *Fimbristylis miliacea*. And, occurence of rice plant caused by falling grain of preceding rice was found.

Weed quantity and composition of weed community were different by tillage or fertilization (Fig. 1 and Fig. 2), while influence of seeding method or insecticide application on the weed occurrence was not found.

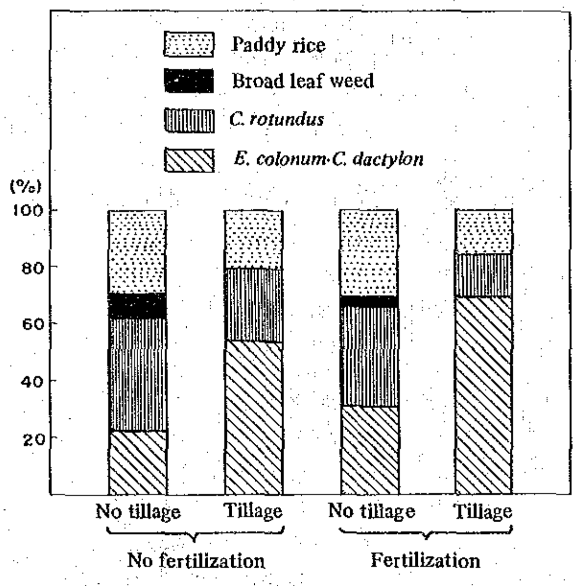

Fig. 2 Influence of tillage and fertilization on the composition of weed community (Exp. 1, 1980)

The quantity of weed increased remarkable by fertilization, especially *E. colonum* increased. Though the quantity of *C. rotundus* increased by fertilization, the composition rate to all weed quantity decreased relatively. Occurrence of rice plant with fertilization was similar to that of *C. rotundus*.

Tillage gave increase of weed quantity, also. Quantity of gramineous weeds, especially *E. colonum* in tilled plots increased remarkable to that of untilled plots. While quantity of *C. rotundus* in tilled plots was less than untilled plots. Appearance of rice plant and broadleaf weed by tillage showed similar to *C. rotundus*.

In general, by fertilization and tillage, the quantity of weed increased, and the composition of weed community changed to the dominance of gramineous weed from the mixed weed community.

(Exp. 2)

The results of weed investigation are shown in Table 2. There were dominant of gramineous weeds, namely, *E. colonum* and *C. dactylon* in the experimental field. And there were a few occurrence of *C. routundus* and broadleaf weed, and occurrence of rice plant caused by falling grain of preceding rice was found.

Weed quantity and composition of weed community were different by tillage and irrigation (Fig. 3). The quantity of weed increased remarkable by irrigation, especially, *E. colonum* increased. The quantity of rice plant increased in untilled with irrigation plots. Tillage gave increase of weed quantity also, especially *E. colonum* increased remarkable. The percentage of *E. colonum* mount up to more than 90 % in tilled plots as compared with 38 % in untilled plots. However, quantity of other weeds were decreased by tillage.

By irrigation and tillage, the quantity of weed increased, and the composition of weed community changed to the dominance of *E. colonum* from the mixed weed community.

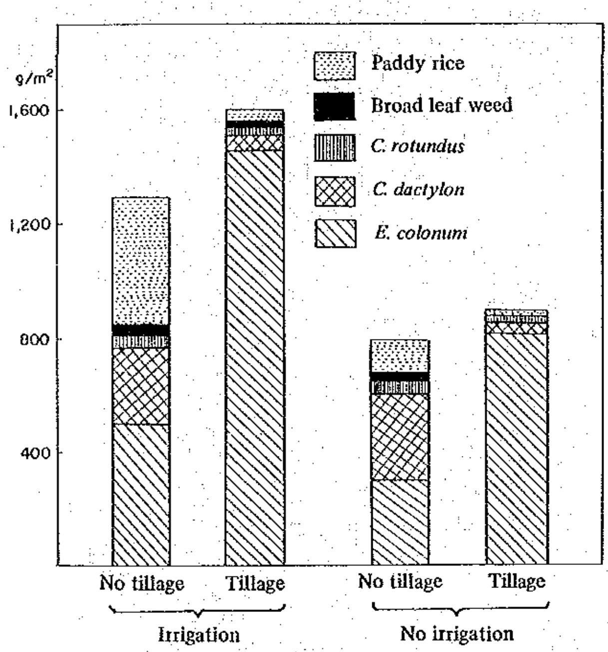

Fig. 3. Influence of tillage and irrigation on the occurrence of weed (Exp. 2, 1980)

DISCUSSION

Two experiments were carried out to clarify the influence of intensive working as tillage, fertilization and irrigation on the occurrence of weeds in soybean field after lowland rice. Generally, *E. colonum, C. dactylon* and *C. rotundus* were dominant in the experimental fields. There were a few occurence of broadleaf weed and sedge weed except. *C. rotundus*. And occurrence of rice plant caused by falling grain of preceding rice was found.

By application of tillage, fertilization or irrigation, quantity of weeds increased remarkable. For example, from the date of about twenty days after seeding, the quantity of weeds in tilled with fertilizer was more three times than that in untilled without fertilizer, and tilled with irrigation was about two times to untilled without irrigation.

The increase of weeds by application of tillage, fertilization or irrigation was mainly due to increase of gramineous weeds, especially *E. colonum*, as the results, composition rates of *C. rotundus*, broadleaf weeds and rice plant to all weeds quantity for intensive working treated plots were decreased relatively. It was not clear either the increase of weeds as above was due to increase of individual growth increment or increase of number of weeds, because number of weeds did not investigated. However, increase of weeds by irrigation will be mainly caused by increase of individual growth increment, because all plots including unirrigated plots were irrigated just after seeding and for irrigated plot irrigation only gave ten days after seeding until weed investigation. And increase of weeds by fertilizer application will be mainly caused by increase of individual growth increment (4). While, increase of weeds by tillage will be surmised mainly due to increase of number of weeds. It is generally known that tillage is useful to kill weeds occurred, while has influence to stimulate occurrence of weeds (2, 5 and 6), because many species of weeds including *Echinochloa crus-galli* var. *praticola* have light sensitivity for germination (1 and 7). It is probable that many seeds of *E. colonum* under ground came up surface by tillage and germinated in response to light.

The results as above show that intensive cultivation as tillage, fertilization and irrigation give increase of weed quantity remarkably as compared with traditional extensive cultivation, and give change dominant community of gramineous weed from mixed community. Judging from these results, it is necessary to establish a weed control measure for the introduction of intensive cultivation.

SUMMARY

At present, the introduction of intensive cultivation has encouraged to improve the traditional method in

upland farming. This study was conducted to clarify the influence of intensive working as tillage, fertilization and irrigation on the occurrence of weeds in soybean field after lowland rice.

The experiments were carried out at Mojosari sub-station in 1980.

The results were as follows:

1. There were occurrence of *E. colonum, C. dactylon, C. rotundus* and rice plant caused by falling grain of preceding rice, and few broadleaf weeds in the experimental field.
2. Quantity of weeds increased remarkable by application of tillage, fertilization or irrigation. From the date of about twenty days after seeding, the quantity of weeds in tilled with fertilizer was more three times than in untilled without fertilizer, and tilled with irrigation was about two times to untilled wihtout irrigation.
3. Weed community changed to dominance of gramineous weed from mixed community by application of tillage or fertilization.

ACKNOWLEDGEMENT

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摘　　要

水稲後大豆作における耕起・施肥・灌がいが雑草の発生に及ぼす影響

中山兼徳・アグススディマン・アジサルワント

ジャワの大豆作の多くは不耕起，無施肥などの粗放栽培である。現在，増収対策として集約技術の導入がすすめられている。集約技術の導入は増収に役立つが，反面，雑草や病害虫の多発生を促す要素をもっている。本研究は，このような集約技術導入の問題点を明らかにするために実施したものである。すなわち，水稲後の乾季大豆作における耕起，施肥および灌がいの技術が雑草の発生にどのような影響を及ぼすかを検討した。

研究は１９８０年にジャワ東部のモジャサリ試験地において，下記のような二つの試験によって行なった。

試験1.　耕起・施肥が雑草の発生に及ぼす影響

試験2.　耕起・灌がいが雑草の発生に及ぼす影響

得られた結果の概要は次のとおりである。

1.　試験1.，2をとおし，試験期間（４～８月）における供試圃場の主要雑草はイネ科のコヒメビエ，ギョウギシバとカヤツリグサ科のハマスゲであり，広葉雑草は少なかった。前作稲の脱粒籾による稲の発生，雑草化もかなり見られた。

2.　耕起，施肥，灌がいのいずれによっても雑草の発生は著しく増えた。播種２０日後における調査において，施肥・耕起区の雑草量は慣行栽培の無肥・不耕起区に比べ約3倍量であり，同じく灌がい・耕起区は無灌がい・不耕起区の約2倍量であった。

3.　耕起，施肥及び灌がいによる雑草の増加は主にイネ科雑草とくにコヒメビエの増加によるものであり，全雑草に占めるイネ科雑草の比率が増えた。

4.　以上の結果から明らかなように，耕起，施肥および灌がいの技術は雑草の発生量の増大を促す。したがって，これら集約技術を導入する場合には十分な雑草対策を用意しておく必要のあることを指摘できる。

10. EFFECT OF 2,4-D ON THE GROWTH OF INDICA AND JAPONICA RICE VARIETIES IN DIFFERENT TEMPERATURE CONDITIONS

Mass Sundaru * and Kanenori Nakayama **

ABSTRACT

A field experiment was conducted in 1979/1980 wet Season at the Central Research Institute for Food Crop (Bogor) to study the growth respons of 3 indica and 2 japonica rice varieties to 2,4-D application. Three locations as sites of the experiment were chosen namely Sta. Pacet, Muara and Pusakanegara with respectively low, medium and high temperature conditions. Levels of 2,4-D applied were 0, 0.4 and 0.8 kg/ha active. Significant inhibition of tiller forming was observed for the indica IR-36 at 2 and 4 weeks after 2,4-D application in all locations. For 0.4 kg/ha it appeared mostly at 2 weeks after application, while for 0.8 kg/ha it was observed at 4 weeks. Retardation of plant growth at 2 weeks and 4 weeks after 2,4-D application was remarkable for both indica and japonica varieties at Muara while at Pacet it was shown by the indica Gebang and the japonica Hawara Batu. Plant growth inhibition occurred at the same dosage and same time of observation as for the tiller forming. Wider angles between outmost stem of the rice plants were only performed at Pacet by the indica varieties. Tubular leaves as one of the hyperplastic symptoms of 2,4-D responses were shown by the japonica varieties at Pacet, less at Muara. Yellowing of upper leaves affected by 2,4-D was observed only at Pacet on the indica varieties. A trend of decreasing in grain yield by 2,4-D was obtained by the indica varieties at Pacet, while in the other two locations no significant difference in yield was recorded.

INTRODUCTION

The use of 2,4-D in newly reclaimed areas in Sumatera and Sulawesi in Indonesia is increasing due to labour shortage. By the expanding use of high yield varieties with short culms, high yielding potential and high response to nitrogen, the use of fertilizers is increasing.Consequently weed growth becomes abundant. And it is presumed that the use of 2,4-D would be higher in the near future in those areas. Therefore it is expected that some fundamental research with practical experiments and tests will be conducted to make an appropriate recommendation of 2,4-D application to farmers adaptable to each region. Since experimental data and information on 2,4-D are only available on Japanese varieties, while those on indica varieties adaptable to tropical regions are few.

This study was conducted to find the effect of 2,4-D on the growth of Indonesian indica and japonica rice varieties under low, medium and high temperature conditions.

This experiment was carried out at CRIFC Bogor in 1979 to 1980.

MATERIALS AND METHODS

Three locations were chosen for this field experiment: 1) Exp. Sta. Pacet with a low temperature conditions (an annual temp. 21°C), 2) Exp. Sta. Muara with a medium temperature conditions (an annual temp. 25°C) and 3) Exp. Sta. Pusakanegara with a high temperature condition (an annual temp. 27.5°C). Three indica varieties: IR 36, Citarum and Gebang and two japonica ones: Sukanandi and Hawara Batu, were used.

Seeding and transplanting time for each location were as follows:

Exp. Sta. Pacet : seeding December 20, 1979
transplanting January 12, 1980

Exp. Sta. Muara : seeding December 15, 1979
transplanting January 9, 1980

Exp. Sta. Pusakanegara : seeding December 20, 1979
transplanting January 15, 1980

Levels of 2,4-D amine were 0, 0.4 and 0.8 kg/ha active. The design applied was a split plot design with 3 replications. The varieties were put in the mainplot, with the 2,4-D treatments in the subplot. Plot size of the

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* Agronomist, Head of Agronomy Division, Bogor Research Institute for Food Crop, Central Research Institute for Food Crop, Jl. Merdeka No. 99, Bogor, INDONESIA.

** Agronomist, Department of Farm Mechanization, Agricultural Research Center, Yatabe, Tsukuba, Ibaraki, JAPAN.

subplot was 2 x 2 square meter, plant spacing was 25 x 25 cm with 2 seedlings per hill. Fertilizers applied were 90 kg/ha N + 45 kg/ha P + 45 kg/ha K using urea, triple superphosphate and potassium chloride respectively. 2,4-D was applied at 3 weeks after transplanting using a knapsack sprayer with tee-jet nozzles.

RESULTS

1. Exp. Sta. Pacet
Temperature range : 18.0 - 29.4°C.
Altitude : 1,140 m.

(1) Number of tillers

Number of tillers of IR 36 at 2 weeks after 2,4-D application decreased highly significant, and for Gebang the decrease was significant, both at 0.4 and 0.8 kg/ha of 2,4-D. No significant effect of the different levels of 2,4-D was observed. At 4 weeks after 2,4-D application on all varieties, except that Gebang showed a slight decrease in number of tillers. At 6 weeks after application and harvesting time, the effect of 2,4-D had disappeared and no difference in number of tillers and productive tillers was recorded (Table 1).

(2) Plant height

Decreased plant height was shown by Gebang with increasing dosages of 2,4-D at 2 weeks after 2,4-D spraying, while for Hawara Batu only 0.8 kg/ha of 2,4-D decreased height of rice plant. At 4 weeks after herbicide treatment, the plant height of all varieties increased with 0.4 kg/ha of 2,4-D, while at 0.8 kg/ha only Citarum and Hawara Batu showed a decrease but this was not significant. Later at 6 weeks after 2,4-D spraying, there was almost no difference in plant height for all varieties; it seemed that the effect of 2,4-D has already disappeared. The same was observed at harvesting time (Table 1).

(3) Top and root

Some tendency was observed in the varieties IR 36, Citarum and japonica Sukanandi, at the middle stage of growing period of rice plant. For 0.4 kg/ha of 2,4-D to increase the fresh weight of top, whereas 0.8 kg/ha decreased it. For Gebang the fresh weight of top decreased at 0.4 and 0.8 kg/ha of 2,4-D. For the dry weight of top a decrease was observed at 0.8 kg/ha only for the indica IR 36 and Citarum.

No significant difference by 2,4-D application in fresh and dry weight of roots was found for all varieties. A decrease of fresh and dry weight was observed in IR 36, Citarum, Sukanandi and Hawara Batu only at 0.8 kg/ha 2,4-D, while for Gebang it dropped already at 0.4 kg/ha. Also no significant difference in length of top and root was recorded at 6 weeks after 2,4-D application for both dosages of 2,4-D. The length of top tended to decrease with increasing dosage of 2,4-D for IR 36, Gebang and Hawara Batu. An increase in length of root for IR 36, Gebang and Sukanandi was observed with increased dosages of 2,4-D, while decrease occurred on Citarum and Hawara Batu.

(4) Angle between outmost stems

IR 36, Citarum, Gebang and Sukanandi at 0.4 kg/ha 2,4-D showed an increase in the angle of outmost stems of the rice plant, but at 0.8 kg/ha the angle decreased in these varieties.

(5) Tubular leaves

Japonica varieties were more susceptible than indica ones to the forming of tubular leaves when affected by 2,4-D spraying. Sukanandi showed the highest number of tubular leaves at 0.4 kg/ha 2,4-D, while for Hawara Batu it occurred at 0.8 kg/ha. Among the indica varieties IR 36 and Gebang were more susceptible than Citarum.

(6) Yield

No after-effect of 2,4-D spraying was recorded on the grain yield and yield components of all varieties like length and weight of panicle, number of spikelets per panicle, dry grain weight and percentage ripened grain (Table 2, Fig. 1).

2. Exp. Sta. Muara
Temperature range : 21.5 - 30.0°C.
Altitude : 250 m.

(1) Number of tillers

A highly significant decrease in number of tillers was shown at 2 weeks after 2,4-D treatment by IR 36 and Citarum at 0.4 and 0.8 kg/ha 2,4-D. A slightly decrease was observed for Gebang and Hawara Batu. At 4 weeks after 2,4-D application, a highly significant decrease of number of tillers for IR 36 at 0.8 kg/ha and a significant decrease at 0.4 kg/ha were observed, while for Citarum a significant decrease occurred at 0.8 kg/ha. At 6 weeks after 2,4-D spraying and at harvesting time, no clear difference in the effect of 2,4-D on the productive tillers was observed, since the effect had already disappeared (Table 1).

Table 1. Effect of 2, 4-D application on no. of tillers and plantheight of several Indonesian rice varieties in 2, 4-D field experiment. CRIA, Bogor, 1980.

Location	Time of obser-vation	Dosage of 2, 4-D kg/ha	No. of tillers					Plant height (cm)				
			IR 36	Citarum	Gebang	Suka-nandi	Hawara Batu	*IR 36*	Citarum	Gebang	Suka-nandi	Hawara Batu
PACET	2W	0	21.1	15.4	12.3	7.8	5.8	37.40	38.46	57.00	52.67	54.50
		0.4	15.1**	15.0	8.6*	7.4	4.7	36.96	40.03	53.93	54.23	58.07
		0.8	15.4**	13.5	8.0*	6.0	3.5	37.57	36.43	52.96	52.06	50.63
	4W	0	28.3	22.9	15.4	11.9	7.6	51.63	54.13	72.87	72.47	73.60
		0.4	29.7	28.3	12.9	10.5	7.6	53.63	56.43	75.60	76.40	78.27
		0.8	29.2	25.8	13.2	10.7	6.9	56.47	54.03	76.00	76.40	75.80
	6W	0	20.4	20.1	13.0	14.1	11.1	77.07	73.73	116.67	106.13	110.60
		0.4	24.9	20.7	11.3	15.0	11.1	76.67	75.67	110.60	102.87	105.33
		0.8	19.1	22.1	14.1	15.5	11.4	71.47	76.27	93.60	106.60	106.60
LSD	0.05		2W:3.283 4.478	4W:5.717 7.797		6W:6.897 9.289		2W:7.995 10.834	4W:7.818 10.662		6W:15.714 21.431	
MUARA	2W	0	33.3	28.7	11.8	8.8	8.0	63.17	60.60	62.83	66.60	72.43
		0.4	22.9**	21.0**	10.6	7.5	5.0	55.80**	52.90**	53.37**	56.60**	61.03**
		0.8	18.9**	18.7**	9.4	7.3	4.9	52.33**	53.13**	54.23**	55.33**	57.17**
	4W	0	29.8	28.1	13.8	8.9	7.7	73.67	68.53	75.33	79.27	88.13
		0.4	25.6*	24.6	13.7	8.4	6.4	68.10	65.13	68.07	78.93	82.33
		0.8	21.5**	24.1*	13.2	8.5	6.1	67.30	64.13	67.73*	70.80*	78.67*
	6W	0	35.6	38.0	17.6	15.4	9.0	67.13	69.47	101.33	94.07	99.07
		0.4	32.6	37.0	17.2	16.6	10.0	69.20	69.80	99.27	97.53	96.40
		0.8	36.6	36.6	13.8	14.8	11.4	68.60	71.13	96.27	90.20	91.60
LSD	0.05		2W:3.765 5.061	4W:3.670 4.934		6W:6.691 9.126		2W:5.247 7.054	4W:7.539 10.135		6W:14.151 19.300	
PUSAKA-NEGARA	2W	0	25.8	20.9	14.5	10.5	6.9	66.47	65.53	87.80	83.93	108.93
		0.4	17.9**	19.7	10.5	7.0	5.9	63.80	69.33	92.87	80.93	103.20
		0.8	21.3	16.5	11.4	5.5*	5.5	65.00	64.60	97.53	77.73	107.87
	4W	0	26.3	20.3	12.6	10.6	8.2	77.73	77.47	122.27	92.07	116.80
		0.4	24.1	20.1	12.3	8.1	6.7	78.33	79.80	121.87	97.27	114.67
		0.8	20.6**	19.5	11.7	7.7	5.9	80.67	77.80	125.87	94.40	118.87
	6W	0	24.5	21.0	12.3	10.4	7.5	97.83	95.00	147.07	114.67	139.97
		0.4	25.0	21.8	10.9	8.1	6.2	98.13	114.67	149.00	114.43	127.00
		0.8	21.3	20.7	10.6	8.4	5.7	101.10	94.33	141.73	113.13	138.37
LSD	0.05		2W:4.708 6.421	4W:3.455 4.713		6W:3.805 5.190		2W:8.641 11.786	4W:6.061 8.266		6W:16.975 23.152	

Note : 2W = 2 weeks after 2, 4-D application — * = significant 5 %
4W = 4 weeks after 2, 4-D application — ** = significant 1 %
6W = 6 weeks after 2, 4-D application

Table 2. Effect of 2, 4-D application on yield components and yield of several rice varieties of 2, 4-D field experiment. CRIA, Bogor, 1980.

Location	Variety	Dosage of 2, 4-D kg/ha	No. of panicle	No. of spike-lets per panicle	Percen-tage of ripened grain	Dry grain weight per hill	1,000 grain weight	Grain yield (gr/m²)
PACET	IR 36	0	20.4	167.9	87.75	28.50	21.92	331.37
		0.4	24.9	161.2	90.57	31.80	22.53	327.85
		0.8	19.1	160.9	89.35	25.98	22.04	231.67
	Citarum	0	20.1	122.7	90.39	32.94	30.68	373.76
		0.4	20.7	123.7	89.13	33.02	30.87	328.10
		0.8	22.1	111.2	86.35	28.48	30.65	280.64
	Gebang	0	13.0	241.0	87.75	27.80	22.34	412.92
		0.4	11.3	219.2	85.69	25.92	23.03	429.50
		0.8	14.1	218.9	88.94	35.06	22.32	394.16
	Sakanandi	0	14.1	244.7	91.08	36.80	21.88	460.88
		0.4	15.1	237.3	91.36	38.19	21.11	478.41
		0.8	15.5	260.7	90.91	39.35	22.05	431.49
	Hawara Batu	0	11.1	232.5	86.36	29.11	25.16	342.94
		0.4	11.1	233.8	78.26	24.28	24.08	323.70
		0.8	11.4	237.7	86.54	32.35	24.04	338.96
	LSD 0.05		6.89	62.24	13.06	14.65	NS	NS
	0.01		9.28	83.82	17.59	19.73		
MUARA	IR 36	0	21.0	–	93.64	33.60	21.67	527.61
		0.4	19.3	–	91.65	31.53	21.25	513.34
		0.8	18.9	–	93.94	32.21	21.13	537.65
	LSD 0.05		3.49	–	6.71	6.84	NS	NS
	0.01		4.89	–	9.41	9.60		
PUSAKA-NEGARA	IR	0	18.7	181.1	94.97	36.71	18.15	514.92
		0.4	16.9	187.5	94.59	32.34	17.61	462.36
		0.8	17.6	186.5	96.02	39.94	19.85	544.12
	Citarum	0	15.5	132.1	89.74	23.04	19.75	310.81
		0.4	12.9	148.5	86.92	19.39	26.71	330.64
		0.8	12.6	140.5	87.71	17.86	22.12	305.93
	Gebang	0	10.6	349.0	86.84	33.56	21.89	175.10
		0.4	11.1	322.5	89.31	37.92	23.10	201.35
		0.8	9.0	336.9	90.41	35.60	22.06	238.36
	Sukanandi	0	10.7	277.9	90.03	28.00	23.41	291.03
		0.4	8.6	300.0	89.49	24.12	23.38	244.96
		0.8	9.2	279.7	87.09	24.00	22.61	249.16
	Hawara Batu	0	6.7	310.5	80.42	18.82	24.67	151.83
		0.4	5.9	303.1	82.65	18.78	27.31	170.92
		0.8	5.9	308.7	85.49	20.63	26.87	217.51
	LSD 0.05		4.67	60.99	4.79	12.09	NS	NS
	0.01		6.98	91.10	7.16	18.06		

Note : NS = non significant

(2) Plant height

Retardation in top growth of rice was found at 2 weeks after 2,4-D application at the dosage of 0.4 and 0.8 kg/ha of 2,4-D for all varieties tested. The differences between test and control plots were highly significant. At 4 weeks after herbicide spraying, retardation in top growth was still observed at 0.8 kg/ha 2,4-D, but significant differences were shown only by Gebang, Sukanandi and Hawara Batu. Observations at 6 weeks after 2,4-D treatment and at harvesting time showed that the effect of 2,4-D has disappeared and no differences in plant height were recorded (Table 1).

(3) Top and root

At the middle stage of the growing period, 6 weeks after 2,4-D spraying, no clear difference was seen in the fresh and dry weight of top. But there was still a tendency for lower weights of top for all varieties, except for Sukanandi.

The fresh and dry weight of roots at this stage did not show any clear differences between the 2,4-D treatments and control plot. Also no difference was observed in the length of roots among the three treatments with 2,4-D.

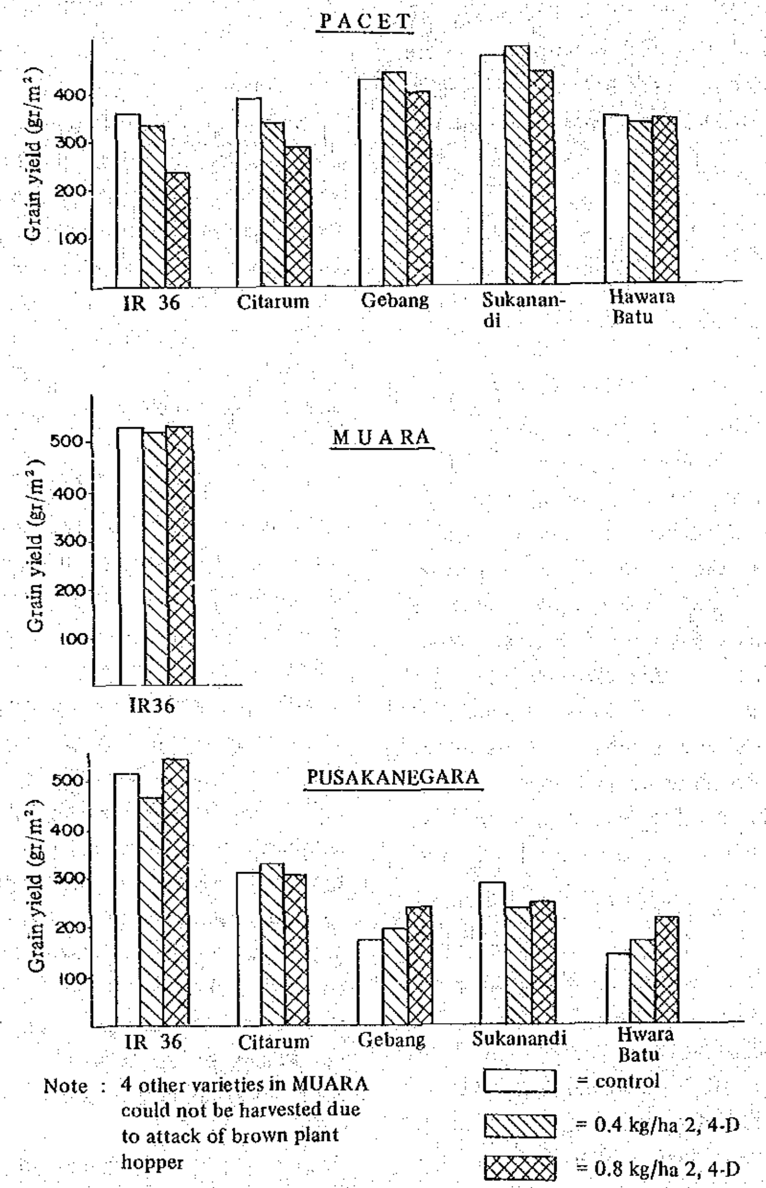

Fig. 1 Grain yield (gr/m²) of 2, 4-D field experiment with 5 varieties and 3 levels of 2, 4-D on 3 different locations. CRIA, Bogor. 1980.

(4) Angle between outmost stems

Only in the indicas IR 36 and Citarum the angle between outmost stems become wider with increased dosages of 2,4-D.

(5) Tubular leaves

High numbers of tubular leaves resulting from 2,4-D spraying were observed in Gebang, Sukanandi and Hawara Batu, with no significant differences in the other varieties.

(6) Yield

Only IR 36 could be evaluated for its yield components, since the other varieties could not be harvested due to attack by brown planthopper. No clear differences in grain yield and yield components were recorded among the 3 levels of 2,4-D, since it seemed that the effect of 2,4-D had disappeared from the rice plant (Table 2, Fig. 1).

3. Exp. Sta. Pusakanegara
Temperature range : 23.5 - 30.0°C.
Altitude : 5 m.

(1) Number of tillers

A highly significant decrease in number of tillers was shown by IR 36 at 0.4 kg/ha 2,4-D ; for the other varieties at 2 weeks after 2,4-D application a slight decrease was observed. At the dosage of 0.8 kg/ha only Sukanandi showed a significant decrease in number of tillers. Later at 4 weeks after 2,4-D treatment, it was observed that IR 36 has a smaller number of tillers with highly significant difference than the control at 0.8 kg/ha, while for the other varieties only slight decreases were recorded. At 6 weeks after, 2,4-D spraying no clear difference in number of tillers among the 3 levels of 2,4-D was observed, and only for IR 36 was the decrease clearer at 0.8 kg/ha. A clear decrease in productive tillers was shown only by IR 36 and Citarum (Table 1).

(2) Plant height

No significant difference was observed in plant height among the 2,4-D treatments in each variety tested at 2 weeks after 2,4-D application. A slight decrease was observed in IR 36, Sukanandi and Hawara Batu. At the later stage 4 weeks and 6 weeks after 2,4-D treatment the plant height of each variety was not affected any more by 2,4-D, to which effect gradually disappeared from the rice plant (Table 1).

(3) Top and root

At the middle stage of the growing period of rice no significant difference was observed for the fresh and dry weight of top among the 3 treatments of 2,4-D. The same was also observed for the fresh and dry weight of roots for all varieties. A decrease in fresh and dry weight of roots with increasing dosages of 2,4-D was found for Citarum, Gebang and Sukanandi.

(4) Angle between outmost stems

It was observed that 2,4-D application caused an increase in the angle between the outmost stems between 2,4-D treatment and control. Among the varieties only Gebang showed some significant increase in width of the angle.

(5) Yield

No remarkable difference was found among the 2,4-D treatments in grain yield or in yield components. Only in the number of panicles in each variety was a decrease with increasing dosage of 2,4-D. Gebang and Hawara Batu showed an increase in grain yield as the dosage of 2,4-D was increased. Lodging occurrence in the control plot of these 2 varieties caused a reduction in yield, while in the plots treated with 2,4-D no lodging was observed (Table 2, Fig. 1).

DISCUSSION

Many experiments were conducted in Japan and the U.S.A. to study the effect of 2,4-D and MCPA on the growth of rice plants when these herbicides were used for the early time in rice fields. The inhibiting effect on root development, the retardation in plant growth and tiller forming caused by 2,4-D, MCPA were reported by Kaufman (1953), Arai, Kawashima and Kumazaki (1954, 1955), Shibayama and Noda (1977) and Ryuichi, Ikai and Adachi (1978). However another important aspects was not mentioned, namely the varietal response of the indica and japonica varieties to 2,4-D treatment, which was considered very important in developing countries, where farmers apply low cost herbicides 2,4-D and MCPA in their rice fields. Kaufman (1953) in his pot experiment also stated the importance of air temperature conditions during the 2,4-D spraying, which could cause greater severity of injury.

In this experiment some differences were observed in the effect of 2,4-D on indica and japonica varieties under low, medium and high temperature conditions.

Table 3. Resume of the results of 2, 4-D field experiment on rice. CRIA, Bogor, Indonesia, 1980

Response to 2, 4-D \ Locations	PACET Temperature: 18.0–29.4°C Altitude: 1,140 m.			NUARA Temperature: 21.5–30.0°C Altitude: 250 m.			PUSAKANEGARA Temperature: 23.5–30.0°C Altitude: 5 m.		
	2W	4W	6W	2W	4W	6W	2W	4W	6W
1. Inhibition of tiller forming	IR 36$^{a)**}$ Gebang$^{a)*}$	Gebang$^{a)}$		IR 36$^{a)**}$ Citarum$^{a)**}$ Gebang Hawara Batu	IR 36$^{b)**}$ Citarum$^{b)*}$		IR 36$^{a)**}$ Sukanandi$^{b)*}$	IR 36$^{b)**}$ Sukanandi Hawara Batu	IR 36$^{b)}$
2. Retardation in top growth	Gebang$^{a)}$ Hawara Batu$^{b)}$	Citarum$^{b)}$ Hawara Batu$^{b)}$		IR 36$^{a)**}$ Citarum$^{a)**}$ Gebang$^{a)**}$ Sukanandi$^{a)**}$ Hawara Batu$^{a)**}$	Gebang$^{b)*}$ Sukanandi$^{b)*}$ Hawara Batu$^{b)*}$		IR 36 Sukanandi Hawara Batu		
3. Decrease of fresh weight of top			IR 36$^{b)}$ Citarum$^{b)}$ Sukanandi$^{b)}$ Gebang$^{a)}$			IR 36 Citarum Gebang Hawara Batu			
4. Decrease of fresh weight of root			IR 36$^{b)}$ Citarum$^{b)}$ Sukanandi$^{b)}$ Hawara Batu$^{b)}$ Gebang$^{a)}$						Citarum Gebang Sukanandi
5. Increase of angle between stems			IR 36$^{a)}$ Citarum$^{a)}$ Gebang$^{a)}$ Sukanandi$^{a)}$			IR 36$^{b)}$ Citarum$^{b)}$			Gebang$^{a)*}$
6. Tubular leaves			Sukanandi$^{a)}$ Hawara Batu$^{b)}$ IR 36$^{b)}$			Sukanandi$^{a)}$ Hawara Batu$^{a)}$ Gebang$^{a)}$			
7. Grain yield			Non sign.			Non sign.			Non sign.

Note : 2W = 2 weeks after 2, 4-D application
4W = 4 weeks after 2, 4-D application
6W = 6 weeks after 2, 4-D application

a) = 0.4 kg/ha 2, 4-D
b) = 0.8 kg/ha 2, 4-D

* = significant 5%
** = significant 1%
Underlined varieties mean slight inhibition/retardation/decrease

It has been shown that with herbicidal treatment, in this case 2,4-D, the morphology of the rice plant can be changed as a result of changes in the metabolism of the treated plants. Temperature conditions had a great influence on the morphological changes in indica as well as japonica varieties. The inhibited growth of the young shoot at the time of 2,4-D spraying, also reported by Shibayama and Noda (1977), caused retardation in tiller forming for the indicas, primarily IR 36 which was more susceptible than the japonicas. In low temperature conditions these symptoms lasted longer than in high temperature conditions. The inhibiting effect in the young rice shoot, which appeared to have an influence on the elongation of the stem internodes, caused a retardation in plant growth under medium temperature conditions, where during the early stage of rice growth, most days were clouded. In high temperature conditions with mostly clear skies at the same stage, the effect of 2,4-D was observed in a slight retardation of top growth, which was limited only at the early stage in the susceptible variety IR 36 and the japonicas Sukanandi and Hawara Batu.

At the middle stage of the growing period of rice, the effect of 2,4-D began to decrease and no significant differences for the herbicide treatment were observed for all locations. In high temperature conditions the recovery of plant growth was earlier. In Pacet, with low temperature conditions, however, the recovery of the rice plant was late. Effects of 2,4-D were still visible at 6 weeks after 2,4-D was applied. This was similar as the results of the temperature experiment conducted at Tokyo University of Agriculture in Tokyo (1980). Decrease in top and root weight was observed mostly at the high dosage, 0.8 kg/ha of 2,4-D.

One of the abnormalities affected by 2,4-D was the tendency for a divergence of tillers from the vertical axis of the plant, the same symptoms as observed by Vega (1954). Widest angles between outmost stems were observed at low temperatures, while at medium and high temperature conditions, the width of the angle decreased as the temperature increased. These symptoms occurred in the indica varieties in Pacet and Muara, while in Pusakanegara it was observed in Gebang and Hawara Batu varieties. Tubular leaves, another abnormality caused by 2,4-D were observed mostly in low temperature conditions in the japonica varieties.

No significant differences in grain yield were recorded in the 3 locations among the 2,4-D treatments, but in Pusakanegara the treated plots of Gebang and Hawara Batu higher than the control plot. This was caused the occurrence of lodging for about 80 % of plants, on the control plot, while on the 2,4-D treated plots the degree of lodging was about 50 %. The spraying of 2,4-D appeared to increase the breaking strength of lower internodes of those two varieties.

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CONCLUSION

1. Tiller forming of the indica varieties, primarily IR 36, was inhibited at 2 weeks and 4 weeks after spraying in the 3 locations, while for the japonica the inhibition appeared in Pusakanegara only for Sukanandi. Inhibition at 2 weeks after spraying mostly appeared at 0.4 kg/ha, while at 4 weeks after spraying it was observed at 0.8 kg/ha 2,4-D.

2. Retardation of plant growth at 2 weeks after 2,4-D treatment was remarkable for both indica and japonica varieties in medium temperature conditions, while at low temperatures it happened only in Gebang and Hawara Batu. In high temperature conditions, however, plant retardation was not clear. At 4 weeks after 2,4-D spraying, plant growth inhibition was still observed in Muara and Pacet for both indica and japonica varieties. Growth inhibition at 2 weeks after spraying occurred at the dosage of 0.4 kg/ha, while that at 4 weeks was observed at 0.8 kg/ha 2,4-D.

3. A decrease in top and root weight was observed more clearly in Pacet at 0.8 kg/ha for the indicas IR 36, Citarum and Gebang and the japonica Sukanandi.

4. Wider angles between outmost stems of rice were measured mostly in low temperature conditions in the indica varieties, which were more susceptible than the japonicas.

5. Tubular leaves, one of the hyperplastic symptoms of 2,4-D responses, were observed on the japonica in Pacet, and to a lesser extent, in Muara.

6. Yellowing of upper leaves after 2,4-D application occurred in low temperature conditions, mostly in indica varieties.

7. However, no significant difference in grain yield among 2,4-D treatments in the 3 locations was observed.

摘　　要

異なる温度条件における水稲品種(インド型・日本型)の生育に及ぼす２，４－Ｄの影響

マススンダル・中山兼徳

インドネシアの水稲作では矮性の多収品種の導入と施肥による集約栽培の普及により，雑草発生量が増え，雑草防除対策確立の必要性が高まっている。その対策の一つとして，労働力の少ないスマトラ，スラウエシなどで使われはじめている除草剤２，４－Ｄによる方法の導入が考えられる。2,4－Ｄ使用は安価で，環境汚染の心配がなく，除草効果も高いからである。水稲作における２，４－Ｄ使用の研究は温帯の日本を中心に日本型品種に対するものは多いが，熱帯における研究あるいはインド型品種に対する研究は極めて少ない。

以上の情勢に基づき，インドネシアの水稲作に対する２，４－Ｄ使用の基準資料を得るため，異なる温度条件におけるインド型・日本型品種の生育に及ぼす２，４－Ｄの影響について検討した。

試験は１９７９年から８０年にわたり，インド型品種（ＩＲ３６，Citarum，Gebang）と日本型品種（Suka－nandi，Hawara Batu）を用い，Pacet（標高1.140m，年平均気温２１℃），Muara（２５０m，２５℃）及びPusakanegara（５m，２7.5℃）の試験地において行った。２，４－Ｄ（アミン塩）の散布量（成分）は*ha*当り０，0.4，0.8*kg*とした。

得られた結果の要約とそれに基づく「まとめ」は以下のとおりである。

1. ２，４－Ｄを散布した２週間後には薬害がみられ，全品種とも分げつが抑制され，とくにインド型のＩＲ３６が著しかった。草丈も全品種が抑制を受け，その回復は温度の低い高地ほど遅れた。
2. ２，４－Ｄ散布６週間後には草丈，分げつの抑制はほとんど回復したが，若干の薬害症状が残った。症状の一つである株の開張は高地では日本型のＨａｗａｒａ Ｂａｔｕ を除く全品種にみられ，中間地，低地ではインド型品種のみにみられた。また，綺形葉が高地，中間地においてインド型，日本型両品種にみられた。
3. ２，４－Ｄ散布６週間後の調査において，処理による地上部および地下部重の減少は，0.8*kg*／*ha*処理において，高地ではほとんど全品種に認められた。中間地ではインド型３品種と日本型１品種で地上部重の減少が僅かに認められた。低地では全品種とも減少はなかった。
4. 収量については，各試験地，品種をとおして２，４－Ｄ処理の有無による差異は認められなかった。
5. 以上の結果から次のことが推定できる。
   ① インド型品種は日本型品種に比べて２，４－Ｄの感受性がやゝ高い。
   ② 水稲の２，４－Ｄ感受性は温度条件により異なり，高温ほど障害が少なく，回復も早い。

①は新しい発見である。②は既知の事実であるが，収量に影響がみられなかった*ha*当り0.8*kg*（成分）の散布量は，日本の暖地における基準散布量の0.5～0.6*kg*よりかなり高い。

これらの結果から，低地から高地まで水稲作が行われ，日本型（ブル），インド型（チレ）品種の混在するインドネシアにおける２，４－Ｄの普及に際しては，地域ごと，品種群ごとの使用基準の作成が必要であることを明らかにできた。

注：本論文はスンダル氏が東京農業大学において研修，作成した学位論文「２，４－Ｄがインドネシア稲品種および水田雑草の生育・生理に及ぼす影響ならびにそのエチレンとの関係」の一部を構成するものである。また，インド型品種が日本型品種に比べて２，４－Ｄの感受性が高いことは，東京農業大学教授，馬場赳博士の指導のもとに確認された。

11. EFFECT OF UREA APPLICATION ON GROWTH, YIELD AND NITROGEN UPTAKE OF SOYBEANS

T. Fujimoto,* A. Choliludin,** M. Fatchurochim,** and M. Ismunadji**

ABSTRACT

Pot and field experiments were carried out in order to investigate the effects of nitrogen fertilizer application on the growth and nitrogen uptake of soybean plants using urea labelled with ^{15}N.

Urea was applied at the rate of 0.3-2.1 g N/pot at intervals of 0.3 g N. The rate of absorption of urea nitrogen ranged between 57 and 75 %. Seed yield increased almost linearly up to 1.2 g N/pot and gradually from 1.5 to 2.1 g N/pot. The yield increase was attributed to the increase of pod number and positive correlation between the seed yield and the amount of nitrogen accumulation at the initial flowering stage was recognized which showed the importance of the basic dressing of urea.

Field experiment was carried out to know the effect of the application method of urea on the growth and nitrogen uptake of soybeans. Basic dressing of urea was found effective for yield increase, however, application of 30 and 60 kg N/ha showed similar effect. Top dressing of urea was not effective.

INTRODUCTION

In Indonesia, soybeans are cultivated mostly in paddy fields during dry season, following wet season rice. The average yield is 0.8 ton/ha and the harvested acreage is 660 thousand ha (1).

Usually farmers do not apply fertilizer for soybean cultivation. The average amount of fertilizer used for soybean is 15.1 kg/ha (physical weight) (2).

Soybean is a very important secondary crop as a source of protein for Indonesian people. The nitrogen requirement of soybeans is one of the highest of the agronomic crops (3).

The amount of nitrogen required to produce 100 kg of grain is about 7 kg for soybean while it is 2 kg for rice, whereas that of phosphorus is almost the same.

Soybean utilizes nitrogen from different sources, i.e., nitrogen applied as fertilizer, fixed by root module and released from soil. Nitrogen fertilization of soybean is not a common practice as it tends to depress nitrogen fixation. The basic information on the role of each nitrogen source is indispensible for the improvement of soybean cultivation, however, it is not yet available in Indonesia.

Experiments were carried out to investigate the efficiency of urea nitrogen under different application methods.

MATERIALS AND METHODS

1. Pot experiment

The aim of this experiment is to clarify the effect of urea application on growth, yield and nitrogen uptake of soybeans using urea labelled with ^{15}N.

Experiment was carried out using plastic pots filled with 8 kg of latosol soil taken from Muara substation of CRIA, Bogor. PH, T-N and CEC of the soil were 5.9, 0.28 % and 15.9 me/100 g respectively.

Urea labelled with ^{15}N (5.33 atomic %) was applied at the rate of 0.3 to 2.1 g N/pot at intervals of 0.3 g N. TSP and KC1 were applied at the rate of 1.0 g/pot as P_2O_5 and K_2O each. Fertilizers were mixed with the upper layer soil up to 10 cm. Ten pots were prepared for each treatment, 3 pots were used for the first and the second sampling and 4 pots for harvesting.

Soybean seeds (var. Orba) were sown at the rate of 2 hills per pot, 4 seeds per hill and thinned to 2 plants per hill 7 days after sowing. The soybeans were grown in greenhouse, rain water was used for watering.

The plants were sampled 3 times, i.e., at initial flowering, pod filling and harvesting, respectively. The plants were separated into leaves, stems, roots, root nodules and (pods). Dry matter weight, yield and its components were recorded. Total nitrogen

* Plant Physiologist, Upland Farming Division, Hokkaido National Agricultural Experiment Station, Memuro-cho, Kasai-gun, Hokkaido, JAPAN.

** Plant Physiologist, Plant Physiology Division, BORIF, CRIFC, Sindangbarang, Bogor, INDONESIA.

Table 1. Effect of nitrogen application on dry matter production of soybean.

(g/pot)

Plot	Days after sowing							
	32		60			79		
	Leaf	Stem	Leaf	Stem	Pod+ Seed	Stem	Pod	Seed
0	6.16	4.98	12.39	13.11	22.71	8.35	12.73	26.56
0.3	7.03	5.84	13.60	15.35	25.67	9.67	14.01	30.96
0.6	7.65	6.16	15.85	18.60	25.91	9.96	14.80	32.64
0.9	7.79	6.14	16.18	18.75	30.00	10.67	15.35	34.78
1.2	7.15	5.56	16.82	19.32	31.18	11.28	15.91	36.28
1.5	7.30	5.37	17.76	19.84	30.10	10.62	15.94	36.92
1.8	7.91	5.66	18.55	18.82	29.77	10.43	16.26	37.49
2.1	7.55	5.20	18.71	17.81	30.71	9.87	17.07	38.00

content of each plant part was determined by Kjeldahl method. The analysis of ^{15}N was conducted by Hikari Kogyo, Japan.

2. Field experiment

Soybean plants (Var. Orba) were grown in the field of Muara substation of CRIA, Bogor. Soybean seeds were dibbled at the rate of 4 seeds per hole and thinned to 2 plants per hill 7 days after sowing. The plant spacing was 20 x 20 cm.

Treatment in the experiment is shown in Table 3. Urea labelled with ^{15}N (5.33 atomic %) was applied to the subplot of 1 x 1 m prepared in the middle of each plot. ^{15}N-urea was applied as basic dressing for plots B and C, as top dressing for plots D and E and as foliar application six times once every week between 4 and 9 weeks after sowing for plot F. TSP and KC1 were applied at the rate of 60 kg/ha as P_2O_5 and K_2O each.

The plants were sampled 3 times; at initial flowering, pod filling and harvesting, the date being 32, 60 and 90 days after sowing respectively. Plant samples were treated in the same way as the pot experiment.

RESULTS AND DISCUSSION

1. Pot experiment

Growth, yield and its components; The seedling emergence was observed 2 days after sowing. Soybean plants showed very vigorous growth and the damage by insect and disease was not observed throughout the growth period.

Although the plant growth of N-0 plot was slightly inferior to N-applied plots, it showed comparatively good growth as shown in Table 1. The weight of seeds showed increasing tendency as the amount of urea application increased. The seed weight of N-0 plot was 26.6 g/pot while those of N-applied plots varied between 31.0 and 38.0 g/pot. The yield increase was mainly due to the increase of the number of pods. The number of seeds per pod showed a slight decrease as the amount of urea application increased and the difference in the weight of 100 seeds was not recognized among the treatments (Fig. 1).

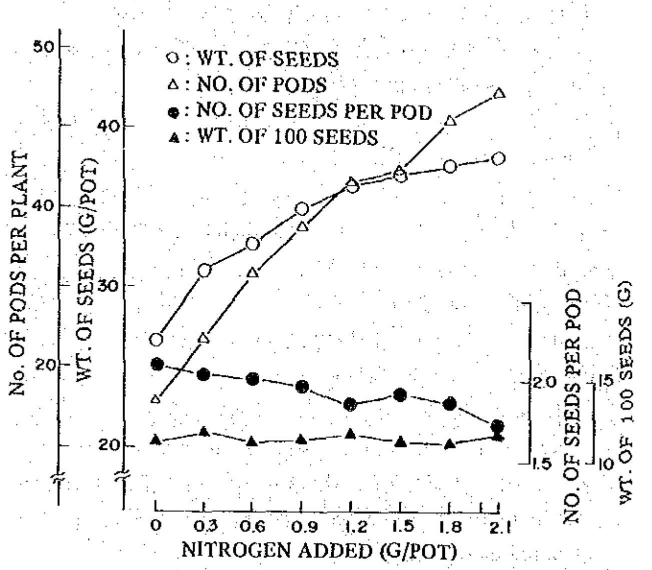

FIG. 1 EFFECTS OF NITROGEN APPLICATION ON THE YIELD AND ITS COMPONENTS OF SOYBEAN.

It is widely recognized that the root nodule development is reversely related to the amount of nitrogen fertilizer application (4, 5). The number and the weight of the root nodule were observed to decrease as the amount of urea application increased. As shown in

Fig. 2, at initial flowering stage, the number and the weight of the root nodule was highest in N-0 plot, being 91 and 0.1 g/pot respectively and it did not develop in the plots fed more than 1.5 g N by this time. The root nodule began to develop about 2 weeks after sowing and it was supposed that its contribution as nitrogen source is still negligibly small at the initial flowering stage. At pod filling stage, the root nodule could be observed in all plots, its development was affected severely by the amount of urea application.

Nitrogen uptake; Table 2 shows the nitrogen concentration of different plant parts. The effect of nitrogen application on nitrogen concentration of each plant part was clearly recognized especially at the early growth stage. At 32 days after sowing, the nitrogen concentration in the stem was 2.08 % for N-0 plot, wheareas those for N-applied plots ranged between 2.38 and 3.59 %, showing an increasing tendency if the urea application increased. The nitrogen concentration in the leaves were relatively high ranging between 5.52 and 6.38 %. As the development of root nodule initiates about 2 weeks after sowing, it is supposed that the effect of root nodule was still very small at the initial floweing stage. Therefore, the nitrogen concentration of the plant was affected more by nitrogen fertilizer application.

Table 2. Effect of nitrogen application on nitrogen concentration of soybean.

(N%)

Plot	Days after sowing							
	32		60			79		
	Leaf	Stem	Leaf	Stem	Pod+ Seed	Stem	Pod	Seed
0	5.52	2.08	1.18	0.72	3.32	0.33	0.40	7.15
0.3	5.69	2.38	1.13	0.67	3.58	0.29	0.38	6.08
0.6	5.76	2.63	1.18	0.64	3.73	0.28	0.40	5.79
0.9	5.97	2.79	1.23	0.70	3.63	0.27	0.38	5.88
1.2	6.08	3.07	1.17	0.61	3.57	0.26	0.39	5.79
1.5	6.25	3.13	1.23	0.67	3.71	0.26	0.40	5.90
1.8	6.38	3.33	1.42	0.89	3.80	0.29	0.40	5.78
2.1	6.28	3.59	1.49	1.21	3.86	0.29	0.43	6.08

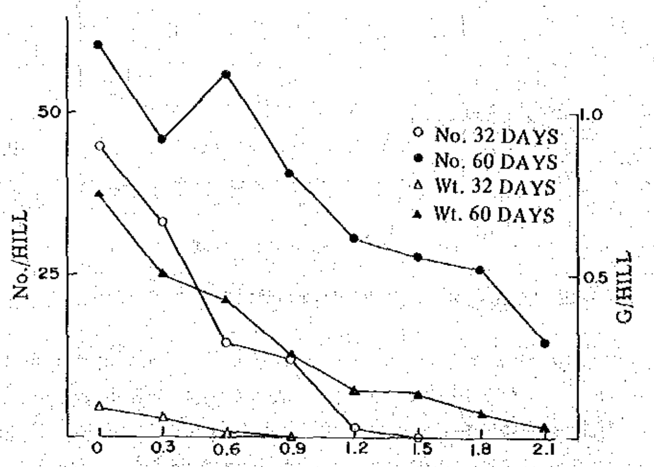

FIG. 2 EFFECT OF UREA APPLICATION ON THE NUMBER AND THE WEIGHT OF ROOT NODULES.

Table 3. Experimental design.

(N kg/ha)

Plot	Weeks after sowing						
	0	4	5	6	7	8	9
A	0	0	0	0	0	0	0
B	30*	0	0	0	0	0	0
C	60*	0	0	0	0	0	0
D	30	30*	0	0	0	0	0
E	30	0	0	30*	0	0	0
F	30	5*	5*	5*	5*	5*	5*

*: ^{15}N

5* : foliar application

Fig. 3 gives the nitrogen accumulation from each source in soybean plants. At initial flowering stage, the amount of nitrogen accumulation of N-0 plot was 0.46 g/pot, seemingly rather high. The amount of nitrogen derived from soil and fixed nitrogen was between 0.19 and 0.41 g/pot, showing a gradual decrease as the application level of urea increased. That from fertilizer nitrogen was 0.16-0.5 g/pot and the rate of absorption of fertilizer nitrogen ranged between 24 and 53 %.

At harvesting time, as the application level of urea increased, marked increase of nitrogen derived from fertilizer and marked decrease of nitrogen derived from soil and fixed nitrogen were recognized. The rate of absorption of fertilizer nitrogen ranged between 59 and 75 %. The amount of nitrogen uptake from soil and fixed nitrogen of N-0 plot was 1.98 while that of N-applied plots was 1.79 for N-0.3 and 0.84 g/pot for N-2.1.

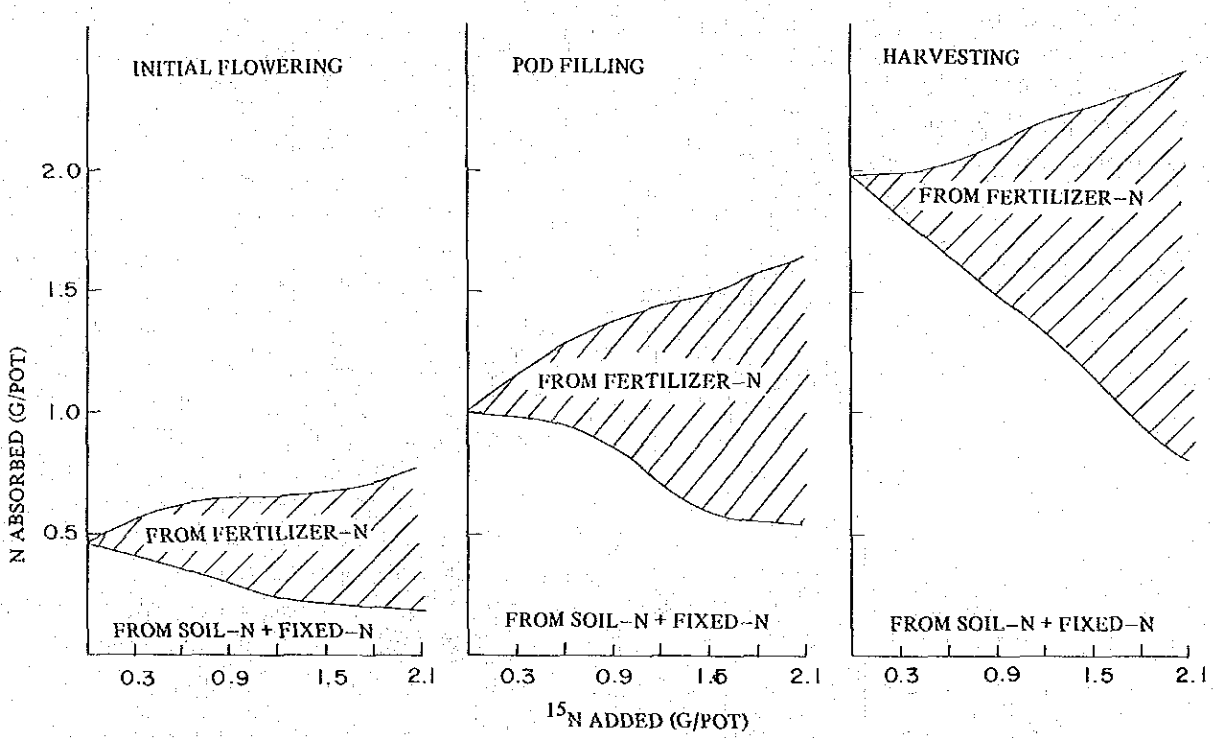

FIG. 3. EFFECTS OF APPLICATION LEVEL OF NITROGEN ON NITROGEN ACCUMULATION IN SOYBEAN PLANTS.

The supply of combined nitrogen during the early period of the growth was effective to attain high yield due to the improvement of the vegetative growth, especially the increase in node number of the branches, even though the plants were well nodulated (6). The supply of nitrogen after flowering is important to increased pod number and 100-seed weight for obtaining high yield (7). The number of pods and the weight of seeds were both closely related to the amount of nitrogen uptake at the initial flowering stage. There was a correlation between the weight of seeds and nitrogen accumulation at each sampling time and the highest correlation coefficient (r=0.939**) was found between the weight of seeds and nitrogen accumulation at initial flowering stage (Fig. 4). This fact indicates that basic dressing of nitrogen fertilizer is very important to increase the number of pods.

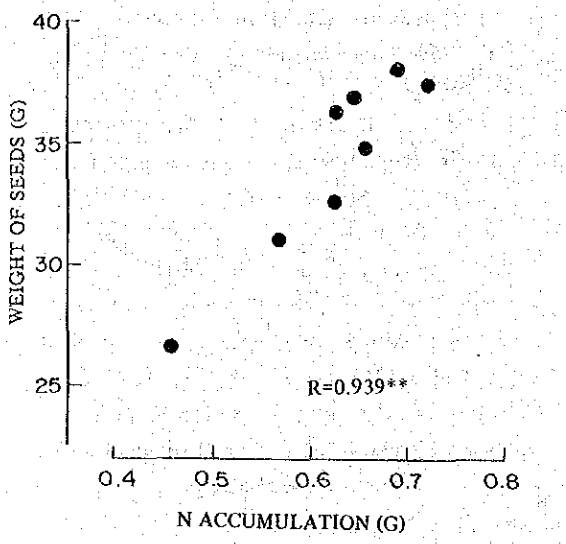

FIG. 4 RELATION BETWEEN NITORGEN ACCUMULATION AT INITIAL FLOWERING STAGE AND WEIGHT OF SEEDS.

2. Field experiment

The soybean plants showed very vigorous growth. Effect of basic dressing of urea on plant growth and nitrogen uptake at initial flowering stage is shown in Table 4. At initial flowering stage, soybean plants fed 60 kg N/ha showed the best growth, LAI being 1.76 while that of N-0 was 0.98. The initial growth of soybean plants was markedly affected by basic dressing of urea, although even in N-0, the nitrogen defficiency symptom was not observed and the plant growth was comparatively good. Total nitrogen accumulation of A, B and C plots was 14.8, 19.4 and 27.2 kg/ha, respectively. Increase in nitrogen accumulation by basic dressing of 30 and 60 kg N/ha was 4.6 and 12.4 kg N/ha, of these 2.4 and 4.7 kg/ha were derived from ^{15}N. This means that by the application of nitrogen fertilizer, soybean plants could absorb more of the soil

Table 4. Effect of basic dressing of urea on the initial growth and nitrogen uptake of soybeans (32 days).

Plot	Dry matter weight (g/hill)		LAI	N(%)			T-N (kg/ha)	^{15}N (kg/ha)
	Top	Root		Leaf	Stem	Root		
A	1.51	0.36	0.98	4.49	1.76	1.72	14.8	–
B	2.21	0.52	1.43	4.22	1.32	1.86	19.4	2.4
C	2.93	0.65	1.76	4.43	1.46	1.98	27.2	4.7

Table 5. Nitrogen accumulation of soybeans at pod filling stage.

	A	B	C	D	E	F
Leaf N(%)	4.84	4.48	4.57	4.52	5.12	4.96
T-N(kg/ha)	146.7	217.0	244.3	203.5	157.1	237.5
^{15}N(kg/ha)	—	13.9	40.4	22.7	17.8	16.3
^{15}N Recovery (%)	—	46	67	76	59	65

Table 6. Yield and its components

	A	B	C	D	E	F
Wt. of seeds(t/ha)	1.33	2.01	2.02	1.91	1.55	2.03
No. of pods(/pl.)	45.2	60.6	66.0	57.6	52.6	63.2
Wt. of 100 seeds(g)	12.5	12.5	13.2	12.3	12.1	12.2

and fixed nitrogen as compared with N-0. As the nodule development was still poor at this stage, the basic dressing of urea played a very important role as starter nitrogen.

The data of nitrogen uptake at pod filling stage are presented in Table 5. Nitrogen concentration in leaves increased by the top dressing of urea at 6 weeks after sowing and foliar fertilization. Accumulation of total nitrogen was generally high, even in N-0 plot it was 147 kg N/ha. By the basic dressing of 30 and 60 kg N/ha, it increased to 217 and 244 kg N/ha. Of these, the fertilizer nitrogen was 13.9 and 40.0 kg N/ha. Recovery of fertilizer nitrogen differed by the amount of basic dressing. In plot D, nitrogen accumulation from fertilizer was 22.7 kg N/ha, the recovery percentage was highest among treatments.

The data of the seed yield were slightly disturbed by the damage by pod borer. The basic dressing of urea was found to be very effective for yield increase which was accompanied by the increase of pod number.

With regard to the foliar application of urea, many research results have been reported, it seems that it is not always positive for yield increase. In this experiment, urea was sprayed as 1 % solution and the scorching effect was not recognized at all. Accumulation of foliar applied nitrogen was 16.5 kg N/ha and the recovery percentage was 65 %. However, the effect was not positive, it did not appear practicable for increasing yields.

From the results mentioned above, it may be concluded that urea should be applied as basic dressing only and its application as top dressing is not profitable.

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摘　要

大豆の生育・収量に及ぼす尿素の施用効果

藤本堯夫・A・Cholilудin・M. Fatchurochim・M. Ismunadji

大豆は，子実生産のために，多量の窒素を必要とする。大豆は，施肥窒素，土壌窒素の他に，根粒固定窒素を利用でき，根粒固定窒素の果す役割が非常に大きいので，大豆に対する施肥は重要視されていないようである。農家では，とうもろこしに対しては施肥を行うが，大豆に対する施肥は，ほとんど行われていない。

大豆の生育，養分吸収に対する尿素の施用効果を調べるため，重窒素尿素を用いて，ポット及び圃場試験を行った。

1．ポット試験

尿素の基肥施用量をかえて（N 0.3～2.1 *g*／pot）大豆をポットで栽培した。大豆の収量は，N 1.2 *g*／pot までは施用量にほゞ比例して増大，N 1.5 *g*／pot 以上でもゆるやかに増加した。収量増は，莢数増によるものであり，子実収量と開花初期の窒素吸収量との間には高い正の相関（r＝0.939**）が認められた。尿素施用量の増加に伴い，土壌窒素，固定窒素への依存度が低下した。施肥窒素の利用率は，59～75％であった。

2．圃場試験

尿素の施用量，施用時期および施用方法をかえて大豆を圃場で栽培した。子実収量に対する基肥の施用効果は明らかに認められた。しかし，基肥窒素量30と60 *kg*／*ha*の間に差はなかった。基肥を30 *kg*N／*ha*施用し，これに追肥を行った場合，子実収量は無追肥と同等またはそれ以下であり，窒素追肥の効果は認められなかった。施肥窒素の利用率は，基肥47～67％，追肥59～76％，葉面散布65％であった。

12. VARIETAL DIFFERENCES IN PLANT GROWTH AND NUTRIENT UPTAKE OF SOYBEANS IN INDONESIA

T. Fujimoto,* A. Cholilludin,** M. Fatchurochim,** and M. Ismunadji,**

ABSTRACT

Five soybean varieties (Orba, No. 945, No. 29, Balong and Ijo) were grown in the field with and without fertilizer application and the varietal differences in plant growth and nutrient uptake were investigated.

The growing period ranged between 86 and 108 days. The time course of dry matter accumulation varied with variety. The growth characteristics of recommended varieties (Orba, No. 945) was characterized by the shorter growing period with higher CGR in the early growth stage. At harvesting time, the dry matter weight of stem was in the same order as the growing period.

Increase in the nutrient uptake by fertilizer application was higher in recommended varieties. Recommended varieties absorbed more nutrient elements than local varieties under no fertilizer treatment.

INTRODUCTION

In Indonesia, soybean varieties cultivated in farmer's fields are mostly the so-called local varieties with small seed size. The 100 seeds weight of soybeans cultivated in Indonesia ranges between 5 and 12 and that of local ones is between 5 and 7 g.

The recommended varieties with big seed size such as Orba are scarecely cultivated in farmer's field because big sized seeds are not suitable to the process of making soybean products such as tahu and tempei.

Knowledge of the characteristics of plant growth and nutrient uptake is basic to the development of improved varieties and the increase of crop yields. The dry matter accumulation, the growing pattern and the photosynthetic activities of soybeans differ with varieties (1, 2, 3). In order to clarify the varietal differences in plant growth and nutrient uptake of soybeans in Indonesia, five soybean varities were cultivated with and without fertilizer application.

MATERIALS AND METHODS

Five soybean varieties were grown in the field of Muara substation of CRIA, Bogor, during wet season, 1979.

Soybean varieties used were Orba, No. 945, No. 29, Balong and Ijo. Orba is an improved variety with big seed size. No. 29 is an introduced variety from Taiwan and the most popular variety in East Java, Balong and Ijo are local varieties in Central Java.

There were two treatments;

A. Standard fertilizer (N, P_2O_5, K_2O each 60 kg/ha)

B. No fertilizer.

Urea, TSP and KC1 were used. Urea was applied as basic and top dressing at initial flowering stage at the rate of 30 kg N/ha each. TSP and KC1 were applied as basic dressing.

Four seeds were dibbled with the plant spacing of 20 x 40 cm and thinned to 2 plants per hill 7 days after sowing.

The soybean plants were sampled at 15, 30, 45, 60 days after sowing and harvesting time. Sampled plants were separated into leaves, petioles, stems and (pods) and dried at 70 C. The seasonal variation of the plant growth and nutrient accumulation was investigated. Nitrogen, phosphorus and potassium were determined by Kjeldahl method, spectrophotometry and flamephotometry, respectively.

RESULTS AND DISCUSSION

Plant growth: The seedling emergence was recognized 3 days after sowing. The initial growth of Ijo was affected by overhumidity of the soil due to water leak from the adjacent canal and the seedling emergence was inferior to other varieties. Soybean plants showed comparatively good growth, however, in pod filling stage damage by pod borer was recognized although it was not so severe.

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* Plant Physiologist, Upland Farming Division, Hokkaido Nat. Agric. Expt. Sta., Memuro-cho, Kasai-gun, Hokkaido, JAPAN.

** Plant Physiologist, Plant Physiology Division, BORIF, CRIFC, Sindangbarang, Bogor, INDONESIA.

The data on plant growth of soybeans were collected until 60 days after sowing.

The growing period differed according to variety, being 86 days for No. 945 and Balong, 96 days for Orba, 106 days for Ijo and 108 days for No. 29. The seasonal variation of plant height is shown in Table 1. The varietal difference in plant height was clearly recognized. In the early growth stage, the growth of No. 945 was the most vigorous, however at 60 days after sowing, the plant height of Orba was the highest and that of No. 945 was the lowest both in standard and no fertilizer plots.

With regard to the seasonal variation of dry matter production, varietal difference and its increase by fertilizer application were recognized at each sampling date. The dry matter accumulation of Orba, No. 945 and Balong reached to the maximum at 60 days after sowing, while the top leaves of No. 29 and Ijo did not develop well by that time.

Dry matter production of Orba and No. 945 was higher than the other varieties at 60 days after sowing in both fertilizer treatments, however at harvesting time the stem weight was in the order of No. 29 > Ijo > Orba > Balong > No. 945, showing the same order as the growing period (Fig. 1).

Table 1. Seasonal variation of plant height

(cm)

Variety	Treatment							
	Standard fertilizer				No fertilizer			
	Days after sowing							
	15	30	45	60	15	30	45	60
Orba	10	19	38	64	9	17	35	60
No. 945	11	20	38	45	10	19	34	40
No. 29	8	13	30	59	7	12	26	53
Balong	10	19	39	48	9	16	37	49
Ijo	8	16	26	54	9	15	28	67

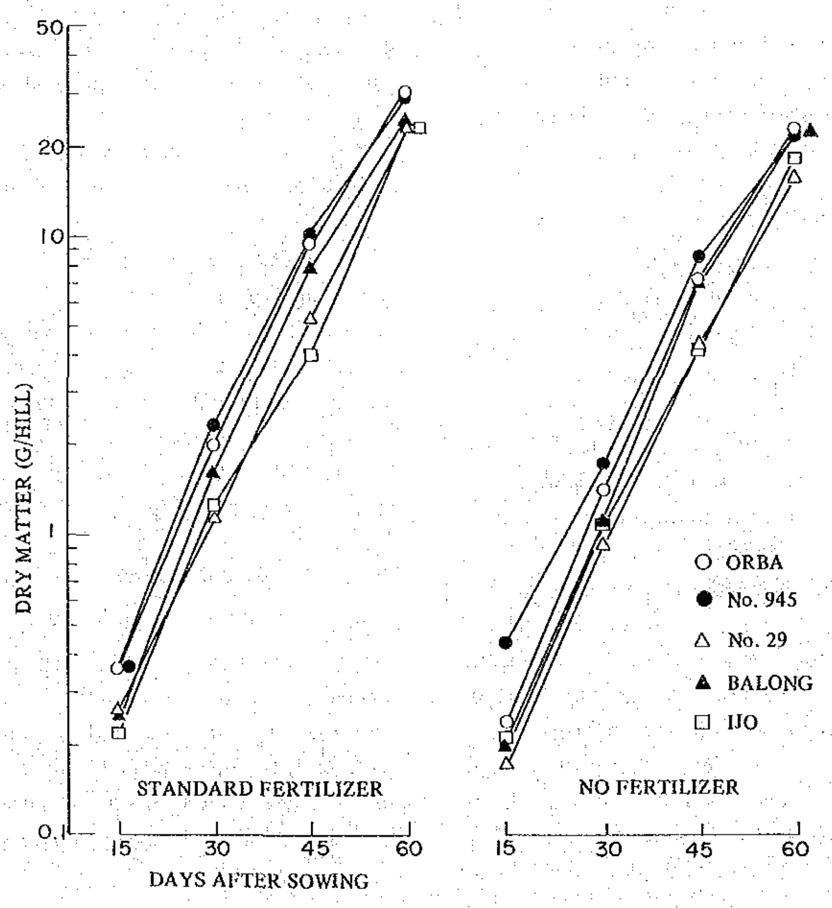

FIG. 1 SEASONAL VARIATION OF DRY MATTER PRODUCTION.

The data of CGR (Crop Growth Rate) as a parameter of plant growth are presented in Fig. 2. In the early growth stage, CGR of Orba and No. 945 was higher than the others. That of No. 29 and Ijo was lower in the early stage, however that of Ijo increased sharply from 45 to 60 days. CGR of No. 29 from 45 to 60 days after sowing was the lowest. In standard fertilizer plots, CGR ranged between 2.3 and 6.3 from 30 to 45 days, 13.5 and 17.1 ($g/m^2/day$) from 45 to 60 days after sowing. In no fertilizer plots, it ranged between 2.6 and 5.7 from 30 to 45 days, 9.2 and 12.7 from 45 to 60 days. Increase of CGR by fertilizer application from 15 to 30, 30 to 45 and 45 to 60 days after sowing was 0.3, 0.7 and 3.6 $g/m^2/day$ which corresponded to 39, 16 and 32 % increase as compared with no fertilizer treatments, respectively.

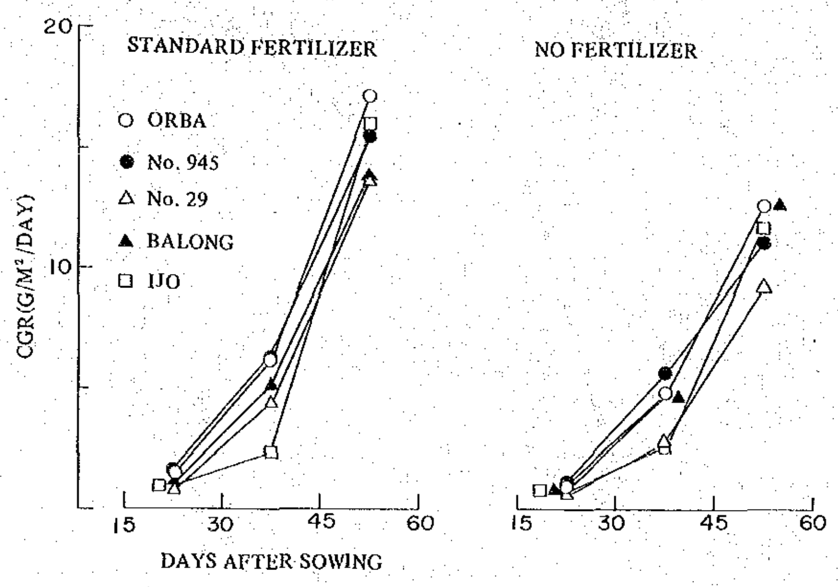

FIG. 2 SEASONAL VARIATION OF CGR.

LAI (Leaf Area Index) at 60 days after sowing ranged between 1.44 and 2.50 in standard fertilizer plots and 1.16 and 1.93 in no fertilizer plots. LAI of the late maturing varieties, No. 29 and Ijo, was higher than the early maturing varieties.

The pattern of root nodule development differed by variety (Fig. 3). The root nodule increased remarkably from 30 to 45 days after sowing. The number and the dry matter weight of the root nodule of Orba and No. 945 were generally higher until 45 days and showed decrease after 45 days. However, those of No. 29 and Ijo increased until 60 days. It is generally recognized that the nodule development is depressed by fertilizer application (4). However, in this experiment, that was only slightly affected by fertilizer application. In experiment 11, the nodule development was only slightly affected when 0.3 g N/pot (60 kg/ha) was applied. In this experiment, nitrogen was applied at the rate of 30 kg/ha as basic and top dressing each, this amount is regarded as that which does not disturb the nodule development remarkably although the fertilizer placement might affect it.

Nitrogen; The seasonal variation of nitrogen accumulation is presented in Fig. 4. The fertilizer application promoted nitrogen uptake by soybeans.

At 15 days after sowing, nitrogen concentration in leaves ranged between 5.0 and 5.2 % for standard fertilizer treatment and 4.6 and 4.7 % for no fertilizer treatment, thus the differences among 5 varieties was not remarkable by this time.

The differences in the amount of nitrogen accumulation were apparent between fertilizer treatments and among varieties. Orba and No. 945 accumulated more nitrogen than the others in both treatments.

At 60 days after sowing, the amount of nitrogen uptake of Orba and No. 945 was about 110 kg/ha for standard fertilizer plots and its increment by fertilization was about 30 kg/ha.

Soybean is a crop which requires nitrogen in large quantity, as the seed is rich in protein. The seasonal variation of nitrogen accumulation is characterized by intensive uptake after the flowering period (5).

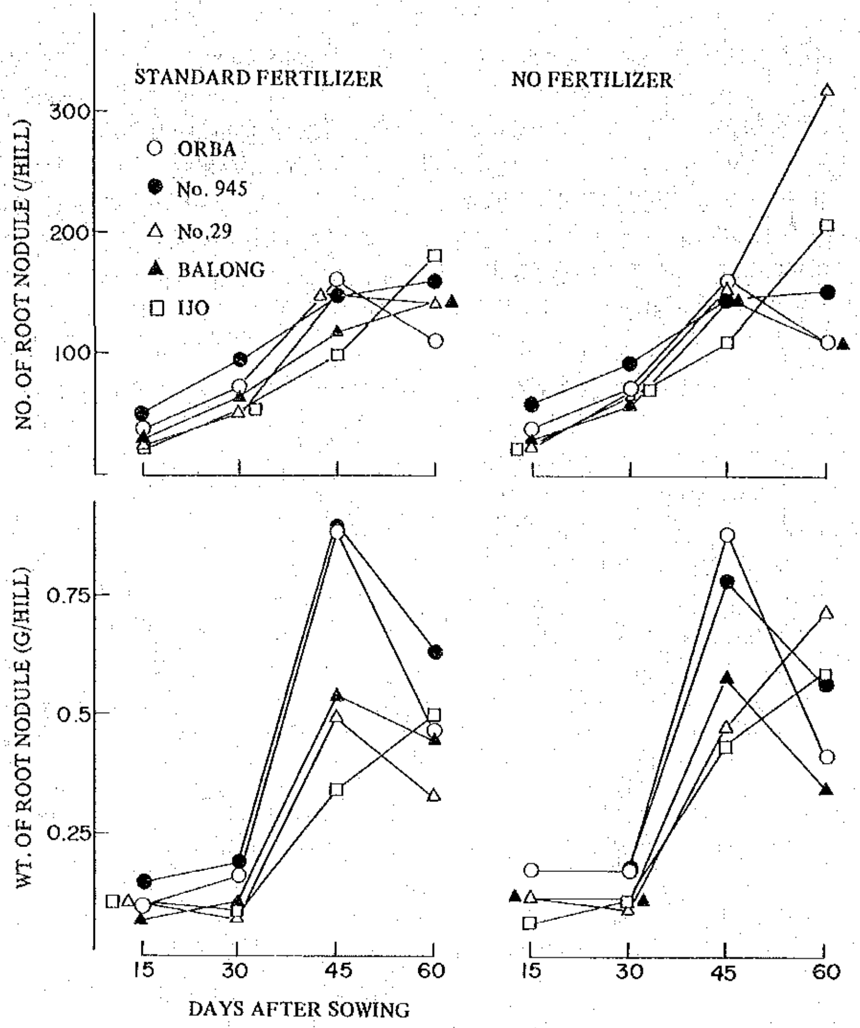

FIG. 3 SEASONAL CHANGES IN ROOT NODULE DEVELOPMENT.

As seen in Fig. 4, the most active uptake of nitrogen was observed between 45 and 60 days after sowing. During this period, more than two-thirds of the nitrogen to total nitrogen uptake was absorbed. In case of Orba, the amount of nitrogen accumulated during this period was 80 kg/ha for standard fertilizer treatment and 54 kg/ha for no fertilizer treatment respectively.

In the experiment mentioned in 11, it was recognized that the top dressing at 4 weeks after sowing was most effective. In this experiment, urea was applied as basic and top dressing 30 days after sowing, nitrogen fertilizer proved to be effective for the promotion of its uptake. The amount of nitrogen accumulation in standard and no fertilizer treatments at 60 days after sowing ranged between 80 and 111, 48 and 82 kg/ha respectively. They were generally on low level.

Phosphorus; Effect of fertilizer application on phosphorus concentration in each plant part was not clearly recognized. However, the amount of phosphorus uptake showed increase by fertilizer application in every varieties.

The amount of phosphorus uptake varied with variety, that of Orba and No. 945 was higher than the others in both treatments. Increase in phosphorus uptake by fertilizer application was highest for Orba. The amount of phosphorus uptake at 60 days after sowing ranged between 16.5 and 26.9 kg/ha for standard fertilizer plots and 12.0 and 22.4 kg/ha for no fertilizer plots (Fig. 5).

Potassium; With regard to potassium uptake the same tendency as phosphorus was observed. The amount of potassium uptake at 60 days after sowing ranged between 63.9 and 82.5 kg/ha for standard fertilizer plots and 46.7 and 61.7 kg/ha for no fertilizer plots. Its increase by fertilizer application was between 8.7 and 23.7 kg/ha (Fig. 6).

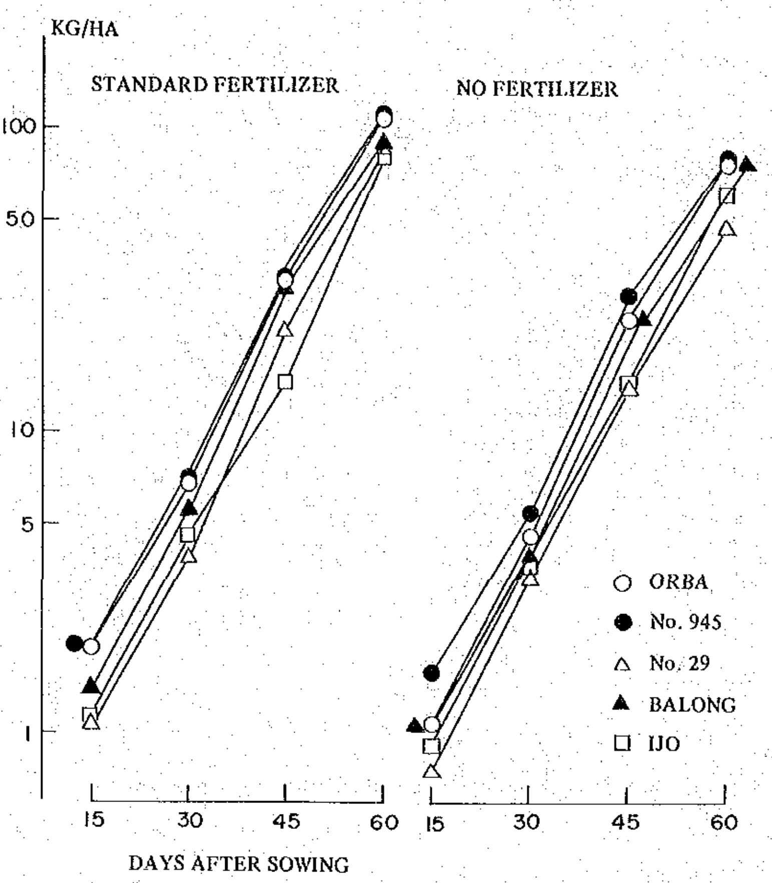

FIG. 4 SEASONAL VARIATION OF NITROGEN ACCUMULATION

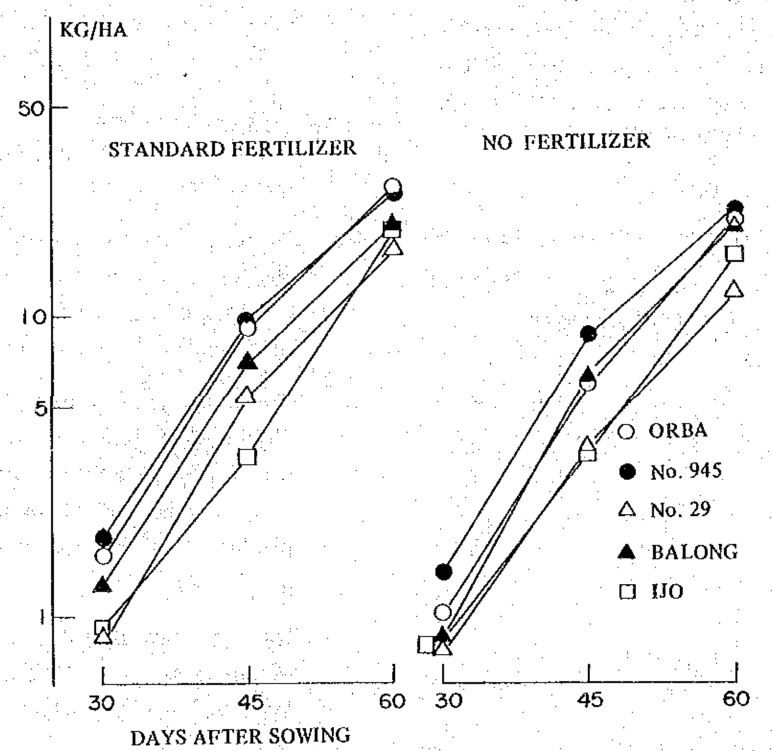

FIG. 5 SEASONAL VARIATION OF PHOSPHORUS ACCUMULATION

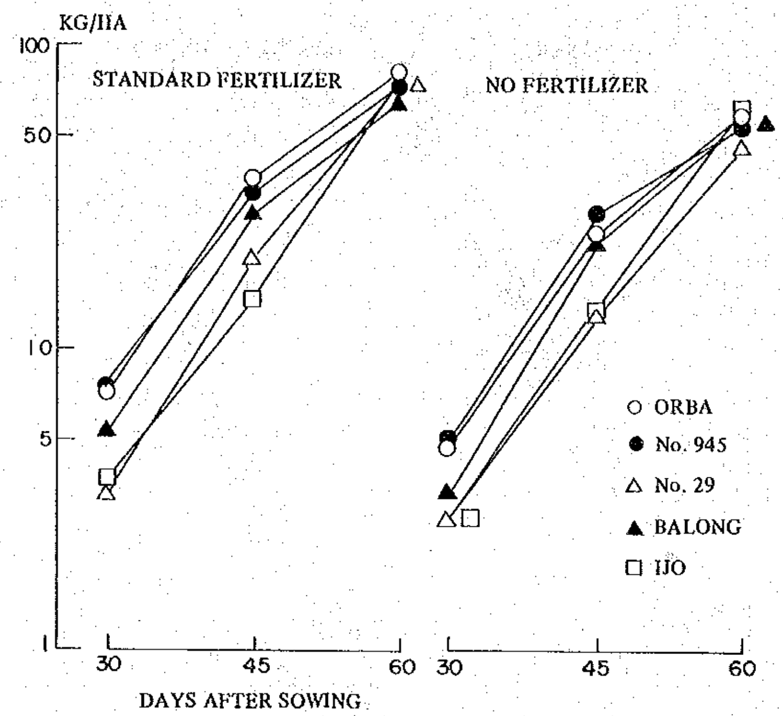

FIG. 6 SEASONAL VARIATION OF POTASSIUM ACCUMULATION

Increased amounts of nutrient elements uptake by fertilizer application is shown in Table 2. In case of recommended varieties its amount was higher than local varieties which shows that recommended varieties are more responsible to fertilizer application. Recommended varieties absorbed more nutrient elements than local ones under no fertilizer treatment.

Table 2. Increase in nutrient uptake by fertilizer application

(kg/ha)

	Orba	No. 945	No. 29	Balong	Ijo
N	31	29	38	8	18
P_2O_5	6.1	3.3	4.5	0.6	4.0
K_2O	24	18	27	9	16

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摘　　　要

インドネシアにおける大豆の生育，養分吸収の品種間差異

藤本堯夫・A. Cholil udin, M. Fatchurochim and M. Ismunadji

大豆の品種の生育，養分吸収特性を知ることは，施肥法改善のうえで非常に重要である。インドネシアで栽培されている大豆の品種は非常に多く，農家では，百粒重が5～7g程度の小粒種が栽培されている。これら品種の生育，養分吸収特性については，未だ充分解明されていないので，大豆5品種を選び，施肥および無施肥栽培し，播種後15，30，45，60日目に抜き取り，生育・養分吸収を調べた。

供試品種はOrba，№945，№29，Balong，Ijoである。№29は大豆の主産地である東部ジャワで最も多く栽培されている。Balong，Ijoは中部ジャワで栽培されている。これら3品種は，ローカル品種と呼ばれており，百粒重が5～7gである。Orba，№945は，農家ではほとんど栽培されていないが，奨励品種で，百粒重はそれぞれ12，10gである。

生育：生育期間は，№945，Balongは86日，Orba 96日，Ijo，№29は106－108日であった。

Orbaは，初期の乾物生産が大で，草丈は最も高く推移した。№945は，初期生育は最も旺盛であったが，生育後半には草丈が低く，収穫期の茎重は最も劣った。ローカル品種は，いずれも，Orba，№945に比べ生育前半の乾物生産は劣った。収穫期の茎重は，生育期間に比例した。

LAI（播種後60日）は，施肥系列では1.4～2.5，無肥系列では1.2～1.9であった。№29とIjoのLAIは，他の品種より大きかった。

根粒着生数および量の推移は，生育期間を反映し，品種による差がみられた。

養分吸収：60日後の窒素吸収量は，施肥系列では 80～111*kg/ha*で，Orbaと№945が最高であった。無施肥系列では，48～82*kg/ha*であった。窒素吸収は，45～60日の間に最も旺盛となり，この期間に全吸収量の約2／3が吸収された。

燐酸の吸収量（60日目）は，施肥系列17～27*kg/ha*，無施肥系列12～22*kg/ha*であった。品種別には Orba，№945で多く，№29，Ijoでは少なかった。

加里吸収量（60日目）は，施肥系列で64～83*kg/ha*，無施肥系列では47～62*kg/ha*であり，Orba，№945で多かった。

各品種とも，施肥により養分吸収量は増加するが，その増加割合は品種によって異なり，Orba，№945に比べ，無施肥での養分吸収量が少なかった。