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Effect of Land Preparation Methods on Growth, Seed Yields of Jasmine 105 Paddy Rice (*Oryza sativa* L.) and Growth of Weeds, Grown in Northeast Thailand

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Abstract: This experiment was carried out on a grower's paddy field, Ban Som Hoeng Village, Kantarawichai, Mahasarakham Province, Northeast Thailand with the use of Roi-Et soil series (Oxic Paleustults) in the rainy season of the 2006 (May to November) to investigate effect of land preparation methods on rice plant heights, amounts of weeds and seed yields of Jasmine 105 aromatic paddy rice (*Oryza sativa* L.). The experiment was laid in a Randomized Complete Block Design (RCBD) with four replications. The results showed that plant height due to treatments was significantly highest for T_3 but T_3 was similar to T_2, whilst T_1 (control) was the least. Mean values of dry weight of narrow leaf type of weeds, in most cases, were significantly lowest with T_3 followed by T_2 and T_3, particularly at the final two sampling periods. Broad leaf type of weeds was significantly highest with T_2 throughout the experimental period, whilst T_1 and T_3, in most cases, were similar. Unfilled seeds were significantly highest with T_3 but similar to T_1 but T_2 was the lowest, whilst filled seeds were significantly highest with T_3, both T_1 and T_2 gave a similar weight. Numbers of panicles m^{-2} were significantly highest with T_3 but T_3 was similar to T_2, whilst T_1 was the least. Seed size or 1000-seed weight was significantly highest with T_3, whilst T_2 and T_1 were similar. Seed yield was highest and highly significant with T_3 (1,136.25 kg ha^{-1}) but T_3 was similar to T_2 (1,083.31 kg ha^{-1}), whilst T_1 was the lowest (487.50 kg ha^{-1}). Land preparation method of T_3 treatment may be recommended as the first choice, whilst T_2 may be used as an alternative choice.

Key words: Conventional practice, Jasmine 105 aromatic paddy rice, land preparation methods, rotavator, seed yields, weed dry weights

INTRODUCTION

Rice (*Oryza sativa* L.) is an important crop being cultivated for man daily diets in many countries around the world, particularly Asian countries where rice grains have been used for daily diets for many centuries. It is a cash crop for growers in Thailand where a considerable amount of rice yield has been harvested annually, particularly during the middle of the cold season (November-January) apart from dry season harvests of the second crop in April or May. It is generally known to the Thai people that there are more or less three methods of cultivation being used depending on level of land elevation and labour inputs, i.e., (1) upland rice culture, (2) lowland transplanting of rice seedlings, (3) broadcasting or drilling of rice seeds. The latter method is applicable to both low and upland paddies where the growers must choose depending on their investments. The practices in growing rice have been orientated from generation to generation, i.e., the Thai growers attained their experiences on different conventional practices from their ancestors such as those growers who live in the Central Plane region grow rice in their prepared paddy fields mostly with the use of broadcasting method of rice seeds (method 3) where their paddy fields were ploughed once or twice followed by harrowing once whereas growers in northeastern region obviously ploughed their paddy fields twice within a few weeks followed by harrowing once and then transplant rice seedlings into rows by hand (method 2), which could be carried out when rice seedlings reached an age of 25-30 days after emergence (Anonymous, 2006). However, within this decade such conventional practice has been, more or less, changed due to lack of labours when a large number of factories employed young efficient workers into their factories, thus broadcasting of rice seeds to paddy fields seems to replace the conventional method.

It is well justified that villagers in all regions of Thailand annually grow rice mostly for their own consumption apart from an enormous amount sold out annually mostly for overseas markets, e.g., the exportation of rice production during the 2007 reached a figure of 982.77 millions US Dollars (http://www.dft.moc.go.th). It should be stated that paddy land area of each region of the country has its different elevations above sea level, e.g., the paddy fields in the Central Plane area of Thailand has a lower elevation above sea level than those of northeastern region where most paddy fields in northeastern region located approximately 200 mabove sea level (Suksri, 1999). Furthermore, the high elevated

paddy soils in northeastern region mostly contain a large amount of sandy soil particles, thus growers face problems in many respects such as poor soil fertility, i.e., most of the soils possess low percentages of field capacity, high degree of soil acidity, low percentages of soil organic matter, poor water retention and many others. Growers in Northeast Thailand normally separated their paddy fields into blocks of both different sizes and elevations with the use of ridges where the ridges of each block prevent the flow out of rainwater to the lower elevated blocks when each block could always fill up with rainwater in the rainy season (May-October). Under conditions of erratic rainfall pattern, the higher elevated paddy blocks could not retain adequate amount of water then transplanting of rice seedlings may not be possible. Thus broadcasting or drilling of rice seeds could possibly be the most appropriate methods to be used in growing rice plants within that season. A number of workers attempted to find some suitable land preparation methods in growing rice crop, e.g., Srisa-ard (1982) carried out rice experiment under rain-fed conditions with the use of different land preparation methods. He reported that a high frequency in ploughing and harrowing had no significant effect on rice seed yield but an increase in weeding frequency significantly increased seed yield. Romyen *et al.* (1986) showed that ploughing of paddy field once and left out for a few weeks and then carried out ploughing again once followed by broadcasting of rice seeds by hand and harrowing once gave significantly higher seed yields than other methods of land preparation. They attained seed yield of 2,918.75 kg ha^{-1}. Furthermore, they stated that ploughing once gave significantly lower amount of weeds than a high frequency in ploughing. Singh *et al.* (2001) carried out rice experiment in comparing seed yields between tillage and none tillage and between broadcasting of rice seeds and transplanting of seedlings, he reported that transplanting of rice seedlings gave significantly higher seed yield than broadcasting. Tillage gave significantly higher seed yield than none tillage. With the work on weed management of direct-seeded rice in Malaysia, Vietnam and Thailand, Azmi *et al.* (2004) reported that no single control measurement could effectively control weeds in weedy rice growing. An integrated approach involving cultural, physical and chemical interventions is expected to be the most effective method in managing the weeds of weedy rice problem. They further stated that rice seed yield losses as affected by weeds could be enormous (weedy rice of 35% infestation could reduce rice seed yield up to 60%). Another work on rice cultivation reported by McDonald *et al.* (2006) showed that the transplanting of rice seedlings gave the highest seed yield ha^{-1} than other sowing methods. However, 1000-seed weights were similar in all treated plants.

The present work aims to prove current villagers' practices whether their accepted method in preparing paddy land areas (method 3) could be comparable to other two methods (methods 1 and 2) in terms of growth, seed yield of Jasmine 105 rice and amounts of weed dry weights in each land preparation method.

MATERIALS AND METHODS

In order to justify the method normally used by growers in sowing rice seeds of the northeastern region of Thailand, an experiment was carried out on a villager's paddy field, Ban Som Hoeng village, Kantarawichai District, Mahasarakham province, Northeast Thailand in the rainy season of the 2006 (10th May to 20th November) to investigate effects of land preparation methods on plant heights and seed yields of Jasmine 105 aromatic paddy rice (*Oryza sativa* L.) and also the amounts of weed dry weights in each treatment. The elevation of the paddy field being used was similar to upland rice area where ridges were established to prevent the runaway of rainwater from rice plants, i.e., with normal conditions in the rainy season, there shall always be some certain amount of rainwater available on the paddy field throughout the season. Roi-Et soil series (Oxic Paleustults) of the paddy field was used where the paddy field has been added with a minimum amount of chemical fertilisers annually, i.e., only with an approximate amount of 62.50 kg ha^{-1} of a complete chemical fertilizer 16-20-0 (N, P_2O_5, K_2 O) was applied to the paddy field annually. This amount of chemical fertiliser was applied again for this experiment at the beginning of the experimental period. The experimental design used was a Randomised Complete Block Design (RCBD). The paddy field preparation methods used in the experiment were: ploughing once and left out for a few weeks and then rice seeds were evenly broadcasted by hand followed by ploughing again once with the use of a rotavator blades that fixed to a small Kubota tractor unit (T_1). Ploughing once and left out for a few weeks followed by a broadcasting of rice seeds by hand and then ploughing again once (T_2). Ploughing once and left out for a few weeks followed by a broadcasting of rice seeds by hand and then ploughing and raking together at the same time once (T_3). A raking tool made from steal of several pieces was used [each piece of steal stick has a length of approximately 20 cm and all of them fixed in row (approximately 10 cm apart) to a solid steal with a length of approximately 1.5 m]. The steal pieces could collect weeds when the tractor is at work and then growers could pull out weeds from time to time during the raking

process. This tool has been designed and made by growers and it is normally attached or fixed to a small tractor unit. Land preparation of T_3 has been widely accepted by growers in Northeast Thailand. A small Kubota tractor unit was used for both ploughing and rotavated ploughing of the paddy land area. The plot size used was a 3×6 m with a 2 m walking path between the plots, each treatment has 4 replications and each replication was duplicated 5 times for 5 sampling periods of rice plant heights and weeds, i.e., at days 15, 30, 45, 60 and at the final harvest for seed yields at day 156 after emergence. Seeds of Jasmine 105 aromatic rice at a rate of 60 kg ha^{-1} were evenly broadcasted by hand to all plots accordingly. Weed dry weights (hot air oven dried at 80°C for 4 days) of both broad and narrow leaf types were separated into their categories where appropriate. Seed yield components were determined, i.e., (1) number of panicles m^{-2}, (2) number of seeds panicle^{-1}, (3) number of filled seeds panicle^{-1}, (4) number of unfilled seeds panicle^{-1}, (5) 1,000-seed weight and (6) finally seed yield ha^{-1} was also recorded. Seeds of all treatments were dried under the sun for 4 days and then weighed out for seed yield determinations. The obtained data were statistically analysed using an MSTAT-C Computer Programme (Nissen, 1989).

RESULTS

Rice plant height, dry weights of broad and narrow leaf types of weeds: At day 15 after emergence, rice plant heights were not significantly different from each other with plant heights ranged from 15.13 to 15.49 cm for T_1 and T_3, respectively (Table 1). Similarly, the differences due to treatments were not found with all sampling periods except at day 156 where this final harvest for rice seed yields was carried out. At day 156 after emergence, the results showed that mean values of rice plant height of the rotary blade ploughing treatment (T_1, control) gave significantly lower plant height than T_2 and T_3. T_3 was the highest with mean values of 89.68, 98.96 and 100.78 cm for T_1, T_2 and T_3, respectively.

For narrow leaf type of weeds, the results showed that at day 15 after emergence, weed dry weight m^{-2} was highest with T_2 followed by T_1 and T_3 with mean values of 165.16, 60.02 and 8.16 g, respectively (Table 2). The differences were large and highly significant. At day 30 after emergence, weed dry weight of T_2 was highest, whilst both T_1 and T_3 were similar with mean values of 223.83, 47.02 and 21.57 g for T_2, T_1 and T_3, respectively. The differences were large and highly significant. At day 45 after emergence, weed dry weights of T_1 and T_2 were similar but T_3 became least with mean values of 116.48, 112.73 and 24.29 g, respectively. The differences were large and highly significant. At day 60 after emergence, weed dry weight was highest with T_1 followed by T_2 and T_3 with mean values of 309.46, 189.29 and 106.16 g, respectively. The differences were large and highly significant. At the final harvest for rice seed yield (day 156), the results showed that amounts of weeds were highest for T_1 followed by T_2 and T_3 with mean values of 420.47, 15.76 and 7.62 g for T_1, T_2 and T_3, respectively. The differences were large and highly significant.

For broad leaf type of weeds, the results showed that at day 15, the amounts of weed dry weights of all treatments were relatively small with mean values ranged from 0.85 to 5.19 g for T_3 and T_2, respectively. The differences were large and highly significant (Table 3). At

Table 1: Mean values of plant heights (cm) of Jasmine 105 aromatic rice as affected by paddy land preparation treatments, grown on a paddy field, Roi-Et soil series (Oxic Paleustults) at Mahasarakham Province, Northeast Thailand

	Days after emergence				
Treatments	15	30	45	60	156
T_1 (control)	15.13	25.97	39.46	61.60	89.68^b
T_2	15.49	27.75	37.15	62.76	98.96^a
T_3	16.46	28.48	37.28	64.24	100.78^a
CV (%)	5.43	5.49	3.20	4.13	4.61
F-test	NS	NS	NS	NS	*
LSD (0.05)	-	-	-	-	7.69

Letter(s) in the column at day 156 after emergence indicate Least Significant Differences (LSD) at probability (p) ** = 0.05, NS = Non Significant

Table 2: Mean dry weights (g^2 m^{-1}) of narrow leaf type of weeds in plots of Jasmine 105 aromatic rice as affected by paddy land preparation treatments, grown on a paddy field, Roi-Et soil series (Oxic Paleustults) at Mahasarakham Province, Northeast Thailand

	Days after emergence				
Treatments	15	30	45	60	156
T_1 (control)	60.02^b	47.02^b	116.48^a	309.46^a	420.47^a
T_2	165.16^a	223.83^a	112.73^a	189.29^b	15.76^b
T_3	8.16^c	21.57^b	24.29^b	106.16^c	7.62^b
CV (%)	27.39	22.60^2	11.89	13.36	9.12
F-test	**	**	**	**	**
LSD (0.05)	36.90	88.22	17.38	46.63	23.34

Letter(s) in each column and row indicate Least Significant Differences (LSD) at probability (p) ** = 0.01

Table 3: Mean dry weights (g^2 m^{-1}) of broad leaf type of weeds in plots of Jasmine 105 aromatic rice as affected by paddy land preparation treatments, grown on a paddy field, Roi-Et soil series (Oxic Paleustults) at Mahasarakham Province, Northeast Thailand

	Days after emergence				
Treatments	15	30	45	60	156
T_1 (control)	0.87^b	1.25^c	1.51^c	1.98^b	0.40^b
T_2	5.19^a	8.06^a	19.90^a	22.52^a	1.60^a
T_3	0.85^b	3.59^b	4.60^b	5.60^b	0.09^b
CV (%)	21.18	27.45	13.15	21.97	30.74
F-test	**	**	**	**	**
LSD (0.01)	0.86	2.04	1.97	3.74	0.36

Letter(s) in each column and row indicate Least Significant Differences (LSD) at probability (p) ** = 0.01

Table 4: Mean values of yield components of filled and unfilled seeds, number of panicles m^{-2}, 1000-seed weights and seed yields ha^{-1} of Jasmine 105 aromatic rice as affected by paddy field preparation treatments, grown on paddy field, Roi-Et soil series (Oxic Paleustults) at Mahasarakham Province, Northeast Thailand

Treatments	Unfilled seeds panicle^{-1}	Filled seeds panicle^{-1}	No. panicles panicles m^{-2}	1000-seed weight (gm)	Seed yield kg ha^{-1}
T_1	5.85^a	46.60^b	38.00^b	25.14^b	487.50^b
T_2	2.43^b	41.70^b	100.00^a	25.48^b	1,083.31^a
T_3	6.95^a	81.60^a	113.00^a	26.26^a	1,136.25^a
CV (%)	29.92	20.48	17.93	1.69	24.48
F-test	**	**	**	*	**
LSD	2.80	20.07	26.00	0.91	59.00

Letter(s) in each column and row indicate Least Significant Differences (LSD) at probability (p) * = 0.05, ** = 0.01

day 30 after emergence, weed dry weight was highest with T_2 followed by T_3 and least with T_1 with mean values of 8.06, 3.59 and 1.25 g for T_2, T_3 and T_1, respectively. The differences were large and highly significant. At day 45, T_2 gave the highest followed by T_3 and T_1 was the least with mean values of 19.90, 4.60 and 1.51 g, respectively. The differences were large and highly significant. At day 60, again weed dry weight of T_2 was highest followed by T_1 and T_3 where both T_1 and T_3 were similar with mean values ranged from 1.98 to 22.52 g for T_1 and T_2, respectively. The differences were large and highly significant. At the final harvest for rice yield (at day 156 after emergence), the results showed that weed dry weights of all treatments became smaller than any other previous sampling periods, i.e., T_2 gave the highest followed by T_1 and T_3 where T_1 and T_3 were similar with mean values ranged from 0.09 to 1.60 g for T_3 and T_2, respectively.

Yield components, number of panicles ha^{-1}, 1000-seed weight and seed yields: For rice seed yield components, the results showed that number of unfilled seeds panicle^{-1} was highest with T_3 followed by T_1 and T_2 with mean values of 6.95, 5.85 and 2.43 seeds, respectively. The differences were large and highly significant (Table 4). With filled seeds panicle^{-1}, the results revealed that filled seeds were highest with T_3 followed by T_1 and T_2 with mean values of 81.60, 46.60 and 41.70 seeds, respectively. However, T_2 was not significantly different from T_1. With number of panicles m^{-2}, the results showed that T_2 and T_3 were similar but T_1 was the least with mean values of 100, 113 and 38 panicles, respectively. The differences were large and highly significant. For 1000-seed weight, the results showed that T_3 was the highest followed by T_2 and T_1 with mean values of 26.26, 25.48 and 25.14 g, respectively. However, T_1 and T_2 were not significantly different from each other. For seed yields, seed yield ha^{-1} was highest with T_2 followed by T_3 and the lowest was with T_1 with mean values of 1136.25, 1083.31 and 487.50 kg ha^{-1}, respectively. The differences were large and highly significant.

DISCUSSION

In growing rice crop under rain-fed conditions, growers of lowland paddy in Northeast Thailand normally cultivate their rice plants in the rainy season, i.e., starting from May to November. Within the months of the rainy season, monsoon normally comes and then cool weather with short day-length follows in October. Most growers in Northeast Thailand normally plough their paddy fields once and left them out for a few weeks to allow all buried grasses or plant materials after ploughing to decompose and then they plough the paddy fields again once follow by broadcasting of rice seeds and a raking follows. They usually broadcast rice seeds to their paddy fields in May or June to obtain a dense amount of young seedlings and when the seedlings reach an age of 25-30 days after emergence then growers pull out their seedlings for transplanting into their paddy fields. The paddy field being used for transplanting of rice seedlings must be ploughed again followed by raking once. The method in transplanting rice seedlings has been practiced for many decades and it is known as a conventional practice in rice culture in Northeast Thailand. This method in rice culture normally provides a considerable amount of seed yields at the final harvest if a severe drought condition was not occurred during the growing period (Tongkamdee, 2006). The high seed yield attained with transplanting of rice seedlings was also found with the work of Singh *et al.* (2001) where he compared seed yields among other treatments used.

In Thailand, now a days the practice in transplanting rice seedlings has been declined due to lack of labour inputs as a result of industrialization of many products such as clothing, food processing, electronic components and many others where a number of youngsters stay away from their paddy fields but migrated to many factories of industrial zone instead. This phenomenon has caused a huge problem for villagers who grow rice although some sorts of mechanization have been employed during the past decades but it is rather expensive to invest and many growers could not afford it

but hiring a tractor unit to work on their paddy fields where the hiring cost for paddy preparation could be relatively high with a small margin of profit at the final harvest. Thus large numbers of growers have shifted themselves from the conventional method of transplanting rice seedlings to broadcasting of rice seeds to their paddy fields instead. In practicing this way, nowadays growers realized that their annual harvests of rice seed yields became relatively small compared with that of the transplanting method due to many reasons such as (1) broadcasting method creates a tremendous amount of weeds, particularly when erratic rainfall occurred, i.e., a few centimeters of water above ground level was not available for rice plants since no rainwater filled up the paddy fields. This condition normally favours the germination of weed seeds and it is generally found with many higher elevated paddy areas in Northeast Thailand, (2) poor growth of rice plants with, more or less, no tillers could be produced due to small spaces available for rice plants to develop tillers, (3) it may be possible that a large amount of roots of rice plants could not be developed due to perhaps a high competition for nutrients among rice plants and weeds and also the competition for radiant energy or even CO_2 uptake.

It was found with the results of this work that there were no significant differences on plant heights due to the three methods of paddy land preparation, i.e., commencing from the first up to the fourth sampling periods except at the end of the experimental period (at day 156 after sowing) when the final sampling of all treatments were harvested, i.e., T_3 gave a mean value of plant height significantly higher than control (T_1) but similar to T_2. The results suggested that the use of rotavator blades for digging or ploughing the paddy land after the broadcasting of rice seeds of T_1 may not be a suitable method in growing rice due to perhaps some amounts of seeds did not bury into the soil or some could have been buried at a considerable depth thus poor germination could have been occurred and perhaps birds and insects could have taken away some amounts of the seeds those left out on the soil surface. It was found that a moderate amount of annual rainfalls was attained during the experimental period. Therefore, the method used for T_1 may not be an appropriate method for growers to practice. The method used with T_2 could probably be better although T_2 gave seed yield not significantly different from T_3 but highly significant over T_1. There should be some advantages derive from T_2 under a condition that if it is so happened that in a year when erratic rainfall pattern occurs when rainwater may not plentiful then high percentages of germination of seeds of T_2 could have been achieved due to a moderate amount of soil moisture content in soil aided germination of seeds, particularly those buried in soil at a considerable depth. However, a reverse condition may be resulted if rainwater could have been plentiful in that year then a condition on water-logging could have been occurred, hence the germination of seeds may not be possible thus the practice of T_2 may not be of advantage (Srisa-ard, 1982).

It was found that narrow leaf type of weeds of T_3, in most sampling periods, were relatively smaller than the rest. However, with broad leaf type of weeds of T_3, in most cases, was significantly higher than control (T_1), particularly at days 30 and 45 after emergence but later both became similar. The results indicated that the use of rotavator blades in rotavating or ploughing the paddy soil of T_1 may have caused some relative effects on weed seeds of broad leaf type perhaps by buried seeds into the soil at a considerable depth where the seeds were not able to germinate hence the amount of collected weeds were relatively smaller for T_1 than T_3. Another reason for this could have been due to previous availability of weed plants in the chosen plots, which were perhaps lesser for T_1 than T_3. A better result on weed problems among the treatments with respect to seed yields was found with T_3 where growers recognised the preparation of land of this method as a replacement of the conventional method. It seems more likely that growers must have had experiences or tested this method for several seasons long before they decided to choose this method as the most appropriate method for their land preparation.

When it comes to yield components, the results showed that unfilled seeds were similar for T_1 and T_3 but with filled seeds, it was found that T_3 gave the highest where T_1 and T_2 became similar. This could possibly be attributable to perhaps the small amount of weeds of both types (narrow and board leaves) and the rapid growth of both roots and leaves of the rice plants of T_3 as a result of the lesser amounts of weeds than the other two treatments favoured the rapid filling up of seeds. Romyen *et al.* (1986) stated that broadcasting of rice seeds created weed problems enormously and rice seed yields decreased significantly. The lesser amounts of weeds with T_3 than the rest could have been due to the raking practices when most grown weeds were taken away by hand at the time of raking. Tindall *et al.* (2005) reported that high amount of weeds significantly affected rice seed weight than the effect due to the damages caused by rice stink bug where this type of insects affected quality of rice grains rather than seed yield. A large amount of weeds in the paddy field area could always affect growth and yields of rice plants as reported by Srisa-ard

(1982) where he attained only a maximum seed yield of 967 kg ha^{-1} with direct seeding. Similarly, Watanabe *et al.* (1997) and Azmi and Abdullah (1998) carried out experiments on paddy rice they stated that weeds of many kinds severely and significantly reduced rice yields at harvests.

Some considerable amount of paddy rice seed yield (2077.50 kg ha^{-1}) derived from direct seeding was attained with the experiment reported by Karnjana (2001) where he added cattle manure to the paddy field at a rate of 6,250 kg ha^{-1} together with a complete chemical fertiliser at 30-30-15 (N-P_2O_5-K_2O) kg ha^{-1}. He stated that most paddy field requires some large amounts of animal manure, particularly cattle manure. The highest seed yield (kg ha^{-1}) found with this work was relatively lesser than the experiment reported by Tongkamdee (2006) where he obtained an average seed yield of rice in northeastern region of Thailand up to 1,875.00 kg ha^{-1} with the use of transplanting of rice seedlings. With the present work, the highest seed yield was attained with T_3 (1,136.25 kg ha^{-1}). However, this amount of seed yields may be recognised as a high level of seed yield. This could possibly be attributable to the low amount of chemical fertiliser applied to the paddy soil (62.50 kg ha^{-1} N, P_2O_5, K_2O) and above all this soil series is one of many poor soil series found in Thailand. Thus poor soil fertility apart from the effect due to the high amount of weeds tremendously affected rice seed yield. The seed yield of T_3 may be improved largely if some amounts of chemical fertiliser had been added again to the rice plants, at least of the same amount as applied with initial application, particularly during the vegetative stage or perhaps the application should be done at approximately a few weeks prior to booting stage. Thus land preparation method of T_3 could be most appropriate if soil fertility could be relatively high. The method used with T_2 could be another choice for growers to choose when erratic rainfall occurs but it could be rather risky and it is difficult to forecast the conditions of the weather. For the results of this study, it may be possible to state that the practice of T_3 could be somewhat of a retrospective explanation of what and why growers practice this method rather than other methods. It may be of important value to find some further means and ways to eliminate weeds in paddy fields before broadcasting of rice seeds such as the use of ploughing twice at 3 week intervals and the sowing of dense legume crops right after each harvest of rice yield. The practice in crop rotation or the rotating crop patterns may be off help, particularly the use of legume crops of a high leaf density to cover the ground areas such as soybean, cowpea, mung bean, African sesbania and others where shading of leaves of legume crops could avoid the germination of weed seeds and at the same time the plant materials of these legume crops could help in improving soil fertility, particularly soil nitrogen. The growth of legume crops could largely increase soil nitrogen has been reported by Russell (1988), Garrity and Flinn (1988), Lizhi (1988), Miller and Donahue (1990), Rekhi and Bajwa (1993), Suksri (1999) and Srisa-ard (2007).

From this investigation, one may find that there is an urgent need to establish an intensive long-term fertility programme for paddy land areas perhaps not only with the land area being used for this work but with all paddy rice fields in Northeast Thailand so that average annual rice seed yields ha^{-1} could be largely improved and seed yields could be comparable to other countries.

To sum up, the results showed that rice plant height was significantly highest with T_3 but T_3 was similar to T_2, whilst T_1 was the lowest. Dry weights of narrow type of weeds were significantly highest with T_1, whilst T_2 was similar to T_3. Dry weights of broad leaf type of weeds were highest with T_2, whilst T_1 and T_3 were similar. Amount of unfilled seeds $panicle^{-1}$ was highest with T_3 but T_3 gave highest amounts of filled seeds $panicle^{-1}$ and also T_3 gave the highest number of panicles m^{-2}. 1000-seed weight was significantly highest with T_3, whilst seed yield ha^{-1} was highest with T_3 but T_3 was similar to T_2. T_3 treatment was considered to be the best land preparation method.

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